IRRIGATION AND INTEGRATED NUTRIENT MANAGEMENT FOR SUSTAINABLE SUGARCANE PRODUCTION

BY

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THESIS

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DECLARATION

I hereby declare that the thesis entitled "**Irrigation and integrated nutrient management for sustainable sugarcane production**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"Irrigation and integrated nutrient management for sustainable sugarcane production"** is a record of research work done independently by Sri. Thomas Mathew under my guidance and supervision and it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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THOMAS MATHEW

Dedicated to my parents

Late Sri. M.V. Mathews

&

Smt. Kunjamma Mathews

Manampurethu Vazhaparampil

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Abbreviations used in this thesis

%	::	::	per cent
@	::	::	at the rate of
^0C	::	::	degree celsius
cc	::	::	cubic centimetre
cm	::	::	centimetre
d	::	::	day
Fig	::	::	Figure
g	::	::	gram
h	::	::	hour
ha	::	::	hectare
ha-cm	::	::	hectare-centimetre
kg	::	::	kilogram
kwh	::	::	kilowatts hour
mg	::	::	milligram
m ha	::	::	million hectare
m t	::	::	million tonnes
MJ	::	::	Mega Joules
mm	::	::	millimetre

INTRODUCTION

INTRODUCTION

Sugarcane is one of the important commercial crops of India which supports the second largest agro-based industry in the country. The sugar industry plays a dominant role in the national economy of our country. Sugarcane occupies 2.23 per cent of the total cropped area and 9.5 per cent of the irrigated area in India constituting 4.08 m ha and with a cane production of 295.72 m t (N.F.C.S.F., 2001).

In Kerala the scenario of sugarcane cultivation is confined to the deltaic belts of rivers viz., Pampa, Manimala and Achenkovil coming under Alleppey, Pathanamthitta and Kottayam districts; semi-arid tracts of Palghat district where it is grown in Chittoor, Kozhinjenpara and Attappady and in the high ranges of Idukki district consisting of Marayoor, Kanthalloor and Vattavada. The area under sugarcane in Kerala is 5467 ha with a productivity of 78 t ha^{-1} (F.I.B., 2001).

However, there is a big gap between the genetic potential yield and actual yield achieved. The physiological yield potential of a 12 month old sugarcane crop is worked out to be 340 t ha^{-1} (Hapase, 1999). This yield gap between potential and actual, have to be narrowed and bridged. The major constraints experienced in achieving the potential yield are environmental constraints like water stress, edaphic constraints viz., soil fertility and productivity and biological constraints like varietal potential, insect-pests and diseases.

Sugarcane, being a long duration crop, requires constant supply of moisture during the entire period of growth. When soil moisture becomes a limiting factor, the initial vigour, growth and other physiological activities of the cane is affected along with inadequate nutrient uptake. Despite its ability to tolerate drought to some extent, water stress during the formative phase affects the yield drastically. The water requirement of sugarcane varies from 2000 to 2500 mm depending upon crop duration, soil type and climatological factors. It has been estimated that about 250000 litres of water is required to produce one tonne of dry matter (Veeraputhiran *et al.*, 1999). Hence, water management in sugarcane during the formative phase is very crucial for its higher productivity. Adoption of water conservation practices like mulching and improved surface irrigation methods not only saves irrigation water without any compromise in crop yields, but also meet the future demand of water for sustainable production of cane.

In Kerala, about 80 per cent of the area under sugarcane is irrigated. The crop is irrigated with river water in deltaic regions and from ground water in the semi arid tracts, for a period of 5 to 6 months, depending upon the onset of south west monsoon and the time of planting. In the high altitude areas of Idukki, the crop is irrigated from springs and streams originating from mountains by the surface method of irrigation.

Intensive agriculture with the launching of green revolution has resulted in manifold increase in the productivity of farm commodities. After enjoying the fruits of green revolution, a decline in the rate of growth of food grain production was noticed during the recent past due to low productivity and input response. Reports on the stagnation of crop productivity combined with the possible deterioration of soil health have raised doubt on the long term consequences of the existing fertilizer practice (Singh and Biswas, 2000).

The long term experiments conducted on manures and fertilizers in sugarcane have conclusively proved that neither the chemical fertilizer alone nor the organic sources exclusively can achieve the production sustainability of soil and crop, under intensive and exhaustive cropping pattern of sugarcane that spreads over for a minimum period of two years duration. However, the integrated use of organics with inorganics can restore and sustain soil fertility and productivity. It also checks the emerging deficiencies of secondary and micronutrients and favourably enriches the bio physico-chemical environs of soils.

The different components of integrated nutrient management in sugarcane include the combined use of inorganic fertilizers with (i) legumes, (ii) organic manures, (iii) crop residues, (iv) factory by-product/effluents and (v) biofertilizers (Dey and Yadav, 1999).

Legumes are grown either in sequence or as intercrops for green manuring in the sugarcane. Growing of legumes as intercrops or companion crop in sugarcane for green manuring is considered as a very useful innovation in economising the resources (Yadav, 2000).

Organic manures have got a direct role for supplying macro and micro nutrients and an indirect role by improving the physico-chemical and biological environment of the soils. The decline in cane yield observed with time can be arrested to a certain extent by the integrated application of FYM or compost with mineral fertilizers.

Cane trash is estimated to be 10 to 20 per cent of the total cane. The positive value of trash lies in its capacity to minimise N losses from the soil and to increase the organic matter level of the soil (Yadav *et al.*, 1987).

Press mud cake (PMC) is a by-product of sugar industry and it is produced at 3 to 7 per cent of the cane crushed in a sugar factory. Several research workers have reported that the integrated use of SPMC with mineral fertilizers enable us to economise 50 to 75 kg N ha^{-1}. The N use efficiency is also increased by 4-8 per cent (Yadav, 2000).

Some of the species of *Azospirillum*, *Acetobacter*, *Azotobacter* and *Bacillus* have been found to economise fertilizer N by 25 per cent of its quantity applied to sugarcane. Therefore, biofertilizer have a promise for N economy in sugarcane farming. However, the response of biofertilizer is not universal. There exist a varietal specificity for biofertilizers which have to be established and exploited for integrated nutrient management.

In short, integrated nutrient management appears to be a potential tool for sustaining and restoring the soil fertility and crop productivity in sugarcane agro-ecosystem. The limitation seems to be the lack of appreciation for the real value of different organics.

Taking into account the above facts and information, the experiment entitled "Irrigation and integrated nutrient management for sustainable sugarcane production' was undertaken with the following objectives.

(i) To economise the use of irrigation water through improved method of irrigation.

(ii) To study the influence of surface methods of irrigation and trash mulching on growth, yield attributes, cane yield and juice quality.

(iii) To economise the use of mineral fertilizers through integrated nutrient management.

(iv) To formulate a sustainable production technology by integrating organic, inorganic and biological sources of nutrients for maximum cane yield, juice quality and jaggery yield.

(v) To work out the economics and energetics.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Sugarcane is one of the most important cash crops of India which is being cultivated in 26 States. It is grown under varied agrometeorological conditions ranging from tropical to sub tropical climate. Majority of the area under sugarcane has to undergo severe stress conditions during January to June in the year due to hot summer and depletion of ground water sources. Sugarcane being a heavy feeder removes large quantities of nutrients from the soil. The crop responds very well to the application of chemical inputs. But the indiscriminate use of chemical inputs had caused deleterious effects to the soil health and productivity. The above constraints in cane production can be alleviated and overcome through water management and integrated plant nutrient supply system. A brief review of the literature pertaining to the above aspects are presented in this chapter.

2.1. Standardisation of irrigation management in sugarcane

In Kerala spring planting is followed both in deltaic tracts as well as in semi-arid regions. The irrigation source is often limited during pre-monsoonic periods for supplemental irrigation. Sugarcane being long duration crop requires constant supply of moisture during the entire period of growth. It has been estimated that the amount of water utilized by the crop have got a linear relationship with the final production of cane (Durai, 1996).

The soil-water-crop-relationships depends upon the methods of irrigation and the types of soil in which the crop is grown (Zende, 1988). Under limited water resource conditions, irrigation scheduled at narrow intervals during tillering and grand growth phases and at wider intervals during maturity phase reduced the water requirement with a marginal increase in yield (Panchanathan *et al.*, 1987). Efficient water management is the key factor involved in the production of sugarcane. Irrigation through alternate furrow, skip furrow or paired row method of surface irrigation are important under water scarce situations for economising the water use without affecting cane yield or its quality (Sundarsingh, 1989).

In the present study entitled 'Standardisation of irrigation management in sugarcane', the relevant literature pertaining to the above topic is reviewed and given below:

2.1.1. Root growth and water relations

The roots that appear and initiate during the germination of setts are called as sett roots. The sett roots serve the plant until the primary shoots produce new roots called shoot roots. The growth of sett roots ceases after 11 days and attains a root length of 20 cm. Bulk of the roots of irrigated sugarcane are found in upper surface of the soil. More than 80 per cent of the total root is present at a depth of 40 cm.

Srivastava and Ghosh (1970) found no root extension below 30 cm depth until after the monsoonic showers begin. The growth of roots during tillering phase is one tenth of maximum attained during the grand growth stage.

Venketaramana and Naidu (1989) evaluated the growth of sett roots and shoot roots under normal irrigation and water stress conditions. It was found that there was 59.6 per cent reduction in total root weight and 49.9 per cent reduction in root length after 150 days under stress conditions. The water stress plants indicated a low shoot-root ratio.

2.1.2. Critical periods for water demand

Sugarcane comes under the category of high water demanding crops. Based on the water requirement, the growth phases of sugarcane can be divided into four distinct physiological phases namely: (i) germination and emergence (ii) tillering and canopy development (iii) grand growth and (iv) maturation. Consumptive use of water is fairly low prior to full canopy development due to smaller LAI (Yadav, 1993).

2.1.3. Water requirement of sugarcane

Dillewijn (1952) reported that 250 g of water is required for the production of one gram of dry matter. Clements (1980) estimated that 1500 to 2000 kg of water is required to produce 1 kg of sugar.

According to Perumal (1986) the requirement of water to produce one kg of sugar varied from 1000 to 2000 kg. It has been estimated that to produce 100 t of cane and 14-15 t of sugar from one hectare, the water requirement would be around 15,000 t. Veeraputhiran *et al.* (1999) stated that the water requirement of sugarcane varied from 2000 to 2500 mm.

2.1.4. Effect of moisture stress on sugarcane

The stress condition generally denotes a condition in which a crop is unable to get adequate soil moisture (Parthasarathy, 1983). Water scarcity during germination, tillering and formative phase will affect final cane and sugar yield. Naidu and Reddy (1976) revealed that the soil moisture stress during formative phase decreased the cane growth. Singh and Reddy (1980) reported that elongation was proportional to the quantity of irrigation water applied to the sugarcane crop. Durai (1996) concluded that water stress condition at the formative phase affects the cane elongation.

Sadaphal and Sharma (1980) observed that cane yield was adversely affected by soil water stress at any stage. The stress that occurred during the critical period of crop growth especially during the tillering phase in sugarcane caused mortality of tillers and final yield was reduced (Sanjeevi, 1983).

Singh and Reddy (1980) stated that a greater reduction in sucrose per cent in juice and with an enhancement in reducing sugars under moisture stress conditions. Under optimum soil moisture conditions, the quality was found to be ideal as compared to stress condition (Parameswaran and Ramakrishnan, 1988).

2.1.5. Effect of irrigation on sugarcane

2.1.5.1. Effect of irrigation on growth attributes

Tillering is influenced by environmental factors like light, irrigation and manuring (Rao, 1966). Singh *et al.* (1960) observed that adequate supply of irrigation water during the pre-monsoon period tended to increase the tillering. Favourable soil moisture conditions enhanced the number of tillers and nutrient uptake (Srinivasan and Mariakulandai, 1969 and Sethi and Parshar, 1981).

Phulare and Upadhyay (1978) reported that growth in terms of stalk length had increased at higher irrigation regimes in the pre-monsoonic periods. Decreasing the available soil moisture from 60 to 20 per cent reduced the cane height at all stages of growth (Singh and Reddy, 1980).

Dry matter production is a good index of cane growth. Dry matter production per plant was increased by irrigating at 75 mm CPE at all stages as compared to irrigation at 125 mm, 175 mm and 225 mm CPE (Chavan *et al.*, 1979). Lakhdive *et al.* (1979) reported that irrigation scheduled at 50 mm during the formative and elongation phase had resulted in higher DMP. According to Sharma and Gupta (1991) DMP was significantly increased by scheduling irrigation at 1.5 IW/CPE ratio, than lower ratios.

2.1.5.2. Effect of irrigation on yield attributes

Scheduling irrigation at 75 mm CPE (Phulare and Upadhyay, 1978) and 50 mm CPE (Lakhdive *et al.*, 1979) increased the cane length. According to Singh and Mohan (1994) scheduling irrigation at an IW/CPE ratio of 1 has recorded maximum cane length and cane weight.

Scheduling irrigation at 50 per cent ASM had favourable influence on the girth and weight of cane (Bose and Thakur, 1977 and Chavan *et al.*, 1980).

Bhoj (1962) and Robinson (1963) noticed more number of millable canes at high soil moisture by scheduling irrigation at 75 mm CPE (Phulare and Upadhyay, 1978) and at 50 mm CPE (Lakhdive *et al.*, 1979). Singh and Mohan (1994) observed that scheduling irrigation at an IW/CPE ratio of 1 recorded maximum number of millable canes.

2.1.5.3. Effect of irrigation on cane and sugar yield

The results obtained by Bose and Thakur (1977) and Phulare and Upadhyay (1978) revealed that irrigation scheduled at 75 mm CPE resulted in higher cane and sugar yield. According to Lakhdive *et al.* (1979) scheduling irrigation at 50 mm CPE recorded maximum cane and sugar yield. Gulati *et al.* (1995) reported that irrigation scheduled at 1.2 IW/CPE ratio produced maximum cane and sugar yield

2.1.5.4. Effect of irrigation on juice quality

Soil moisture at maturity phase had a negative correlation with all quality parameters (Rais Ahmed and Abdul Qayyam Khan, 1988). Shen *et al.* (1992) reported that withholding irrigation at the beginning of the maturity phase could facilitate cane ripening and an increase in sucrose content.

Durai (1990) and Singh and Mohan (1994) reported that different irrigation levels scheduled did not show a significant variation in the commercial cane sugar per cent. Soil moisture levels had no impact on commercial cane sugar per cent (Pandian *et al.*, 1989).

The foregone discussion indicates that moisture stress during the formative phase is very crucial as far as the growth, yield and quality parameters are considered. Irrigation influences the growth attributes and yield parameters but has got less effect on quality attributes.

2.1.6. Effect of methods of irrigation on sugarcane

The choice of irrigation method depends on the topography, type of crop, soil infiltration, water holding capacity, water availability, salt content, climate and availability of labour. More than 90 per cent of the irrigated land in the world is still irrigated by surface methods. Under such methods water use efficiency (WUE) is only 30 per cent as compared to pressurised system of irrigation. The efficiency of surface irrigation depends on the proper design and construction of water distribution system.

Alternate furrow irrigation is a modification of furrow irrigation where irrigations are given in alternate furrows in the first irrigation and subsequent irrigation on other alternate furrows which do not receive irrigation in the first instance. Irrigations are continued repeating the above cycle. About 50 per cent saving of water is expected by this method. Alternate furrow irrigation tried in Jamaica in sugarcane showed better WUE and water usage was reduced to one-third (Ram Dial and Chinloy, 1973). Prasad *et al.* (1980) reported that alternate furrow method of irrigation offers scope for economising the water needs of the crop.

About 30 per cent saving of irrigation water could be achieved by alternate furrow method in sugarcane.

Prasad *et al.* (1983) revealed that germination, yield and quality of sugarcane were not influenced by the different methods of irrigation tried. Water saving was in the order of 40 per cent for drip irrigation, 30 per cent for skip furrow irrigation and 41 per cent for alternate furrow irrigation. Under limited water availability, irrigation during the third order of tillering gave the best results. While comparing the 3 methods of irrigation ie. flood, furrow and skip furrow, cane yield was found highest with skip furrow method (Yadav, 1986).

Results of the field experiments conducted at Madurai revealed that irrigation through alternate furrow up to 90 days after ratooning and thereafter through all furrow method recorded higher yield as compared to irrigation through all furrow method (C.P.R.W.M., 1986).

Prasad *et al.* (1987) reported that irrigation with skip furrows prepared in the wider inter row spaces of 75:105 cm and 60:120 cm staggered row planting system revealed significantly higher yield than that of skip furrow prepared in the narrow inter row spacing with a saving of 25 to 33 per cent irrigation water compared to normal planted crop with flood irrigation.

Studies carried out by Prasad *et al.* (1988) on the efficient utilization of irrigation water in skip furrow method through trash mulching revealed that trash cover over skip furrows with 150 kg N ha^{-1} resulted in maximum WUE. Mulching saved 30 per cent irrigation water and increased cane yield by 10 per cent and sugar yield by 9 per cent as compared with no mulching. Irrigation through alternate furrow, skip furrow or paired row method of surface irrigation were important under water scarce situations for economising the water use in sugarcane without any adverse effect on the yield and quality (Sundarsingh, 1989).

Mann and Chakor (1989) opined that trash mulching in all ridges and irrigation through alternate rows had increased the millable cane count, yield attributes and cane yield. According to Patel *et al.* (1989) alternate furrow irrigation had shown better WUE. Motiwale *et al.* (1989) reported that skip furrow system of irrigation was better than flood irrigation. In skip furrow irrigation a saving of water economy was noticed as compared to ordinary surface method.

Studies conducted on the efficient utilization of irrigation water in sugarcane, alternate furrow irrigation has recorded higher number of millable canes and better cane yield than normal irrigation. Water use efficiency was invariably higher in alternate furrow irrigation than that of all furrow irrigation (Pandian *et al.*, 1992 and Kanwar *et al.*, 1992).

Singh *et al.* (1995) reported that under limited availability of water, irrigation scheduled at an IW/CPE ratio of 0.75 with alternate furrow irrigation and mulching of coir pith at the rate of 15 t ha^{-1} recorded a remarkable increase in cane yield than other combinations of irrigation schedules.

Experimental results showed that total water use in all furrow methods of irrigation was 1466 mm where as it was only 1061 mm for alternate furrow irrigation. Hence, it is possible to save irrigation to the tune of 27.6 per cent, while in skip furrow method, water is saved up to 33 to 36 per cent (Veerapuuthiran *et al.*, 1999, Ramesh, 1999 and Thanki *et al.*, 1999).

On the contrary, it was also reported that all furrow irrigation had registered maximum cane yield as compared to alternate or skip furrow irrigation (Ghugare *et al.*, 1994 a, Ghugare *et al.*, 1994 b and Sharma and Verma, 1996).

2.1.7. Effect of mulching on sugarcane

Mulching is the practice of covering soil surface with extraneous materials primarily to prevent loss of water by evaporation and to check temperature fluctuations and to promote soil productivity. Gosnell and Lonsdale (1977) reported that utilization of cane trash available from the previous crops had beneficial influence on the subsequent cane cultivation in terms of cane growth and effective moisture utilization.

According to Yadav (1986) trash mulching had high WUE due to its effectiveness of economising irrigation water and enhancing sugar yield. Kathiresan and Balasubramanian (1991) and Channabasavanna and Setty (1994) observed that combined application of trash mulch with additional dose of K_20 had pronounced beneficial effect in minimising drought injury in sugarcane during early growth phase.

Mulching with cane trash improves moisture conservation and increase cane yield. It also suppress weed growth and reduce soil temperature (Kannappan *et al.*, 1994, Durai, 1996, Thind, 1996 and Swamy *et al.*, 1998).

It can be concluded from the review that sugarcane is a water demanding crop. Water stress conditions during the formative phase is very crucial. Stress conditions depressed the root growth and development affecting the growth attributes and yield parameters resulting in the drastic reduction of cane and sugar yield. The juice quality is often affected. Under limited water supply alternate furrow or skip furrow irrigation with trash mulching is an effective method of surface irrigation in sugarcane. It is also possible to economise the use of water to the tune of 30 to 36 per cent without any noticeable decrease in cane yield and juice quality.

2.2. Integrated nutrient management in sugarcane

Sugarcane is a nutrient exhaustive long duration crop and it requires heavy dose of major nutrients. Application of chemical fertilizer play an important role in increasing the cane yield and sugar production. The nitrogen (N) requirement of the crop varies from 100 to 400 kg ha^{-1}. Besides N, application of phosphorus (P) and potassium (K) are considered important for enhancing the quality and yield of the crop. An average crop of sugarcane with an yield of 100 t ha^{-1} removes about 208, 53 and 210 kg ha^{-1} of NPK respectively from soil (Singh *et al.*, 1999).

Soil fertility is the major factor that determines the productivity of sugarcane. Indiscriminate and excessive use of chemical fertilizers had paved the way for the deterioration of soil health. The importance of soil organic matter in maintaining soil health for sustainable production has been well recognised. In this context, it is necessary to develop an integrated nutrient management practices involving conjunctive use of chemical fertilizers with organic manures, legumes, crop residues, industrial by-products and biofertilizers. The judicious mix of inorganic with organic and biological sources of nutrients would give maximum output from the soil without depleting its inherent fertility (Sagwal and Kumar, 1998 and Yadav, 2000).

In the present study entitled 'Integrated nutrient management in sugarcane' the available information relevant to the following topics are reviewed and presented below:

2.2.1. Influence of major nutrients on sugarcane

2.2.1.1. Nitrogen

Nitrogen constitutes only a fraction around one per cent of total dry matter in sugarcane. However, it is as important as carbon, hydrogen and oxygen which constitute more than 90 per cent of dry matter (Dillewijn, 1952) in sugarcane.

The influence of N on growth of cane in relation to height was well documented by several workers (Panwar *et al.*, 1980; Sethi and Parshar, 1981 and ABD-EL-Latif *et al.*, 1999). Singh (1978) and Sharma *et al.* (1981) reported that cane girth increased with N application from 75 to 225 kg ha^{-1}. According to Jayabal and Chockalingam (1990), Mishra and Mathur (1991), Singh *et al.* (1996) and Singh *et al.* (1999), the enhancement of N from 75 to 225 kg or even at 375 kg ha^{-1} had increased the tiller numbers in sugarcane.

According to Panwar *et al.* 1980; Kannappan *et al.* (1988) and Singh *et al.* (1999) N fertilization increased millable cane count at 225 kg and 250 kg ha^{-1} respectively over lower doses of N. Further increase in N was not reflected in the millable cane count. Sathyavelu *et al.* (1999) obtained positive response for N application up to 375 kg ha^{-1} for increasing the number of millable canes.

According to ABD-EL-Latif (1999) application of N up to 210 kg ha^{-1} had increased cane and sugar yield. But Baluswamy and Shanmugasundaram (1999) observed that cane yield increased with increased rate of N up to 413 kg ha^{-1}. Selvan and Nadanam (1999) obtained the highest cane yield with N application at 281 kg ha^{-1}. Clindagave (1999) revealed that cane and sugar yield enhanced with increasing rate of N from 187.5 to 375 kg ha^{-1}. In a recent study, it was reported that cane and sugar yield increased only up to 150 kg N ha^{-1} (Hamullah-Azim *et al.*, 2000).

Sathyavelu *et al.* (1999) reported that the juice quality especially the CCS per cent was not altered with N application up to 350 kg ha^{-1}. Singh *et al.* (1999)

revealed that juice quality parameters were found to be optimum at 225 kg N ha^{-1}. Purity coefficient and sucrose content was not altered at N rates up to 210 kg ha^{-1} (ABD-EL-Latif *et al.*, 1999) and highest CCS per cent was obtained with 150 kg N ha^{-1} (Hamullah Azim *et al.*, 2000).

2.2.1.2. Phosphorus

Phosphorus plays an important role in the nutrition of sugarcane with respect to growth and quality. P is also essential for sugar clarification. Application of 200 kg of P_2O_5 ha^{-1} had improved the tillering capacity of sugarcane and its high conversion to millable canes (Sharanappa *et al.*, 1977, Pannu *et al.*, 1985, Jafri, 1986 and Ali, 1997).

The inadequate supply of P resulted in the lowering of stem girth in sugarcane (Dillewign, 1952 and Perumal, 1989). However, Patil and Shingte (1990) indicated that cane height and cane weight were not influenced by the variation in P levels.

Chandy *et al.* (1989) reported that sugarcane responded up to 100 kg P ha^{-1} and recorded maximum number of millable cane. Jayabal and Chockalingam (1990) reported that the millable cane count in sugarcane was influenced by P application only up to 32 kg ha^{-1}. Application of P had produced favourable influence on the number of millable canes (Bangar, 1995).

Chandy *et al.* (1989) and Patil and Shingte (1992) obtained higher cane and sugar yield with P application at 100 to 110 kg ha^{-1}. Sundara and Subramanian (1989), Bangar (1995) and Singh *et al.* (1999) observed that P application at 75 kg or 80 kg ha^{-1} had resulted in higher cane and sugar yield as compared to the control. However, Dang *et al.* (1996) reported that P is required for cane yield build up and P fertilization at 33 kg ha^{-1} had increased cane and sugar yield.

Phosphorus fertilization increased Brix, sucrose, purity and CCS per cent (Dagade and Randive, 1983, Jafri, 1986, Jayabal and Chockalingam, 1990 and Swamy *et al.*, 1993).

Several workers have reported that P application at various levels could not influence the juice parameters like Brix, sucrose and purity per cent and failed to increase the CCS per cent (Chandy *et al.*, 1989, Kumaraswamy *et al.*, 1992, Patil and Shingte, 1992 and Kumaraswamy and Rajasekaran, 1993).

2.2.1.3. Potassium

Potassium is required for the synthesis and translocation of proteins and carbohydrates and also for the accumulation of sugars (Clements, 1980).

The number of tillers enhanced appreciably by the increased rates of potassium application as compared to control (Rathore *et al.*, 1996). According to Subramanian *et al.* (1992) graded levels of K had resulted in the variation in plant height at grand growth and maturity phase. Bangar and Sharma (1992) observed that cane length was influenced by different fertility level. Application of K was found to increase the girth of millable cane and it was highest when K was applied at 125 kg ha^{-1} (Rani Perumal *et al.*, 1989 and Subramanian *et al.*, 1992).

Application of K at higher levels had registered maximum number of millable canes (Chandy *et al.*, 1989, Rani Perumal *et al.*, 1989 and Subramanian *et al.*, 1992). Yaduvanshi and Singh (1999) indicated that millable cane increased with K application up to 60 kg ha^{-1}.

Chandy *et al.* (1989) observed maximum cane yield at 100 kg K ha^{-1}, while Devi *et al.* (1992) noticed the K response upto 125 kg ha^{-1}. Yadav (1993) reported that sugarcane requires 1.95 to 2.57 kg of K for producing one tonne of millable cane. Significant increase in cane and sugar yield with K application upto 60 kg ha^{-1} was observed by Bangar (1995) and Yaduvanshi and Singh (1999).

Patil and Shingte (1992) reported that sucrose content in cane juice significantly increased with K_20 application upto 165 kg ha^{-1}. However, Asokraja *et al.* (1988) reported that K_20 application beyond 100 kg ha^{-1} did not exert any positive influence on juice quality. Yaduvanshi and Singh (1999) noticed that the juice quality was improved only up to 60 kg ha^{-1} of K_20.

2.2.2. Uptake of nutrients

2.2.2.1. Nitrogen uptake

Several workers have reported that the amount of N removed by each tonne of cane varied widely ranging from 0.5 to 1.57 kg (Humbert, 1968, Gupta, 1973, Zende and Kibe, 1983 and Zende, 1984).

Singh (1978) reported that 50.7 per cent of the total N was taken up during tillering phase, 32.2 per cent during elongation and 9 per cent at sugar accumulation, where as the crop utilized almost 41.3 per cent of available N during tillering, 28.1 per cent during elongation and 20.2 per cent during sugar accumulation. Yaduvanshi and Singh (1999) observed that the uptake of N increased significantly with its enhanced rate of application.

2.2.2.2. Phosphorus uptake

The uptake of P by plants increased with increased level of P status in soil and not hindered by the extra application of N (Parthasarathy and Perumal, 1978). Under Indian conditions it was reported that the uptake of P was found to be around 37.3 kg ha^{-1} (Parthasarathy *et al.*, 1979).

2.2.2.3. Potassium uptake

The uptake of K increased significantly with increasing levels of K upto 100 kg K_20 ha^{-1} (Dagade and Randive, 1983, Singh *et al.*, 1992 and Singh *et al.*, 1997).

Parthasarathy *et al.* (1979) estimated that 168.5 kg of K_20 ha^{-1} was removed by a crop producing 125 t of cane ha^{-1}. Yaduvanshi and Singh (1999) reported that the uptake of K increased significantly with applied nutrients.

2.2.3. Effect of integrated use of chemical fertilizers with press mud on sugarcane

Press mud is a residual waste material obtained during the clarification process of cane juice in sugar mills. It consist of sugar cane fibres, coagulated colloids, inorganic salts, soil particles, small amount of sucrose and 50 to 70 per cent moisture. Press mud has got great manurial potential and can be used along with chemical fertilizers. Durai (1997) reported that the establishment of chip bud seedlings was more than 80 per cent with press mud application.

Application of 100 per cent of the recommended dose of fertilizers and enriched press mud with biofertilizers recorded the highest DMP (S.B.I., 1998). Rakkiyappan and Saminathan (1999) reported that press mud application at 37.5 t ha^{-1} had increased cane girth, cane length, number of internodes and cane weight over the control. According to Sharma *et al.* (1999) application of 180 kg N ha^{-1} through press mud cake and urea in 1:1 ratio significantly increased the number of tillers and shoot production. Addition of press mud cake (PMC) at 4 t ha^{-1} alone or with Azotobacter in conjunction with 100 per cent N registered maximum tillering capacity and total shoots (Nagaraju *et al.*, 2000). Bangar *et al.* (2000) observed that

N with press mud application had strong positive correlation with different growth parameters and dry matter accumulation.

Singh and Yadav (1992) reported that application of 30 t of PMC with 150 kg N ha^{-1} increased the number of millable canes by 29.3 per cent. According to Durai (1997) basal incorporation of press mud at the rate of 25 t ha^{-1} with recommended dose of NPK had recorded higher number of millable canes compared to control. Sharma *et al.*, (1999) observed that application of 180 kg N ha^{-1} through press mud and urea in 1:1 ratio increased the number of millable canes by 10.96 per cent over 180 kg N alone. According to Nagaraju *et al.* (2000) integrated use of press mud at 4 t ha^{-1} and Azotobacter at 5 kg ha^{-1} with 100 per cent N fertilization resulted in higher MCC.

Integrated use of N at 150 kg with 30 t press mud ha^{-1} increased cane yield to the tune of 65 per cent over the control (Yaduvanshi and Yadav, 1991). According to Juwarkar *et al.* (1993) combined application of press mud at 20 t ha^{-1} along with 75 per cent of the recommended dose of NPK had resulted in 21 to 43 per cent increase in cane yield as compared to 100 per cent NPK application. Bangar *et al.* (1995) observed that conjunctive use of 225 kg N with 6 t PMC saved 75 kg N ha^{-1} while producing a cane and sugar yield similar to that of 300 kg N ha^{-1}. Combined use of N at 84 kg ha^{-1} with 6 t of press mud ha^{-1} gave an economy of 28 kg N ha^{-1} with cane and sugar yield almost equal to that of 112 kg N ha^{-1} (Swamy *et al.*, 1995).

Sharma *et al.* (1999) concluded that application of 180 kg N through press mud and urea in 1:1 ratio increased cane and sugar yield significantly. Kapur and Kanwar (1999) observed that application of press mud cake along with 217 kg urea ha^{-1} was found to increase cane and sugar yield equivalent to that of

325.5 kg urea ha^{-1}. According to Nagaraju *et al.* (2000) integrated use of fertilizer N with sulphitation press mud and Azotobacter had recorded the highest cane and sugar yield.

Application of press mud at 3 t ha^{-1} along with 150 kg N + 60 kg P_2O_5 + 45 kg K_2O ha^{-1} had recorded maximum CCS per cent (Singh *et al.*, 1991b). Nema *et al.* (1995) and Kapur and Kanwar (1999) reported that N application along with press mud had increased the sucrose per cent, but decreased with N application alone.

According to Bangar *et al.* (1994) increasing rate of press mud upto 6 t with or without Azotobacter had enhanced the quality parameters. However, the quality parameters decreased with increasing rates of N. Bhanavase *et al.* (1996) also obtained cane juice with superior quality by the use of press mud cake alone.

Perumal (1999) concluded that sugarcane grown under organic base consisting of press mud and trash with release of earthworms recorded higher CCS per cent as compared to cane grown with chemical fertilizers. Press mud application alone exhibited higher values for sucrose per cent, CCS per cent, purity coefficient and juice Brix (Durai, 1997; Sharma *et al.*, 1999 and Rakkiyappan and Saminathan, 1999). Bangar *et al.* (2000) indicated that N application without press mud from 0 to 300 kg ha^{-1} had shown negative correlation with quality attributes.

Kapur and Kanwar (1989) reported that available N and P contents of the soil increased with sulphitation press mud application compared to FYM application. Integrated use of press mud at 10 t ha^{-1} along with 75 to 100 kg N ha^{-1} was found to increase organic carbon and availability of N, P, K, Zn and Mn in the soil (Yaduvanshi and Yadav, 1991). Inclusion of press mud with chemical fertilizers had increased infiltration rate from 4.7 to 5.6 cm hr^{-1} and approximately doubled the contents of organic matter, available N, P and K (Juwarkar, 1993). Application of enriched press mud either alone or in combination with biofertilizers improved the available nutrient status and organic carbon of soil (S.B.I., 1998).

Perumal (1999) revealed that except available K, all other nutrients Mn, Fe, Zn, Ca were higher in soil which received organic manure consisting of press mud and trash as compared to the soil received chemical fertilizer. Nagaraju *et al.* (2000) found that the available N at harvest in the soil increased with N fertilization, addition of PMC and Azotobacter.

It can be inferred from the above review that press mud has got great manurial potential. Conjunctive use of press mud with chemical fertilizers result in increased cane and sugar yield. It also enables to improve the juice quality parameters like sucrose content and CCS per cent. It's application enriches the fertility status of soil.

2.2.4. Effect of integrated use of chemical fertilizers with biofertilizers

Harnessing of bacteria and other organisms for fixing N and efficient utilization of N and P assumes great importance in the context of the search for an alternative source for the build up of soil fertility through renewable sources. It is therefore, possible to meet large part of the total N demand through proper management of microorganism in crop production systems.

Several diazotropic bacteria belonging to the genera Azospirillum, Azotobacter, Bacillus, Enterobacter, Erwinia and Klebsiella were isolated from sugarcane roots without knowing the N contribution by individual genus. Rushel *et al.* (1975) maintained sugarcane seedlings grown in compost in a ^{15}N atmosphere for 30 hours and obtained the first evidence of N fixation.

Azospirillum is an associate of N fixing bacteria that colonises the root mass of cane and fixes N in loose association with plants. It has shown positive interaction with an average response equivalent to 15-20 kg ha^{-1} of applied N.

Acetobacter diazotrophicus was found to occur in the roots, stems, leaves (Cavalcante and Dobereiner, 1988 and Gillis *et al.*, 1989) rhizosphere soil and even in cane juice (Muthukumarasamy *et al.*, 1994). This bacteria excreted almost half of the N fixed in a form potentially available to plants (Cojhi *et al.*, 1993). Nitrogen fixing Acetobacter colonise sugarcane and are capable of supplying high levels of fixed N to the plant even at pH less than 3 (Ureta *et al.*, 1995).

Azoculture inoculation either alone or with phosphatic fertilizers had increased tillering and shoot population (Agarwal *et al.*, 1977). Application of biofertilizers were found beneficial in increasing cane growth. Inoculated plants assimilated more N resulting in significant increase in dry matter production compared to uninoculated canes (Yadav, 1987 b, Shinde *et al.*, 1989 and Kaur *et al.*, 1993). According to Joshi and Zende (1998), Azospirillum application had influenced the cane height and cane girth and recorded maximum values compared to Azotobacter and FYM application.

Srinivasan and Hari (1999) reported that inoculation of Azospirillum significantly improved the biomass and root biomass. Azospirillum inoculated plants produced the highest root biomass of 72.8 g per pot.

According to Jayakumar and Thangaraju (1996), Acetobacter inoculation had put forth beneficial effects on cane growth and development as compared to Azospirillum and Azotobacter. However, the combination of Acetobacter with Azotobacter was found better than other biofertilizer combination. Thopate and

Jadhav (1999) reported that application of Acetobacter along with 50 per cent of the recommended dose of mineral N had recorded the highest tillering ratio and cane girth.

Durai and Manickam (1991) observed that application of 225 kg N ha^{-1} along with 7 kg Azospirillum ha^{-1} recorded higher number of millable canes and was on par with N application at 300 kg ha^{-1}. Integrated use of inorganic fertilizers with Azospirillum and phosphobacteria recorded significantly higher MCC. While N application at 280 kg ha^{-1} recorded lower MCC (Kathiresan *et al.*, 1993).

Azospirillum inoculation either alone or with fertilizers increased the cane population (Shinde *et al.*, 1987, Yadav, 1987 b and Shah *et al.*, 1991). Joshi and Zende (1998) observed that Azospirillum application at 10 kg ha^{-1} produced the highest millable cane population compared to FYM application and Azotobacter inoculation.

According to Thopate and Jadhav (1999) integrated application of Acetobacter culture with 50 per cent of the recommended N recorded significantly the highest number of millable canes compared to control.

The beneficial effects of biofertilizers in sugarcane was reported by several workers (Ahmed *et al.*, 1976, Ahmed, 1978 and Agarwal *et al.*, 1977). The favourable influence of Azospirillum to enhance growth and cane yield was reported by Rangiah *et al.* (1988) and Pandey and Kumar (1989). Among the biofertilizers evaluated, Azospirillum was found to be the best for sugarcane. The beneficial effect of this fertilizer could result in a saving of around 60 kg N ha^{-1} (Srinivasan, 1983 and Michael Raj, *et al.*, 1984).

Misra and Naidu (1990) observed that integrated use of mineral N at 112.5 kg ha^{-1} with soil application of Azospirillum recorded cane and sugar yield comparable with N application at 150 kg ha^{-1} alone. Durai and Manickam (1991) revealed that supplemental application of Azospirillum produced marginal increase in cane and sugar yield in addition to saving of 75 kg N ha^{-1}. Studies made by Singh and Yadav (1992) indicated that soil inoculation of Azospirillum at 2 kg ha^{-1} with 75 per cent of the recommended dose of N recorded similar yield levels with 100 per cent N application.

Integrated application of inorganic N at 225 kg ha^{-1} along with soil inoculation of Azospirillum recorded cane and sugar yield comparable with N application at 300 kg ha^{-1} and it was possible to economise 75 kg N ha^{-1} (Bangar *et al.*, 1993 and Bangar and Sharma, 1997).

According to Kathiresan *et al.* (1993) integrated approach using inorganic, organic and Azospirillum with trash cover could boost the cane and sugar yield and reduced the N levels to the tune of 25 per cent. In another study Kumaraswamy and Rajesekaran (1994) reported that application of N at 210 kg ha^{-1} with 10 kg each of Azospirillum and phosphobacteria was found to be optimum for satisfactory levels of cane and sugar yield.

According to Thakur and Singh (1996) integrated use of fertilizer N at 70 kg ha^{-1} with Azospirillum had increased the cane yield by 12.64 per cent over the application of 70 kg N ha^{-1} alone.

Joshi and Zende (1998) reported that soil inoculation of Azospirillum at 10 kg ha^{-1} had given the highest cane yield as compared to Azotobacter and phosphate solubilizing bacteria. According to Kathiresan and Manoharan (1999) cane yield was equal between Azospirillum applied with 200 kg N ha^{-1} and inorganic N applied at 280 kg ha^{-1}, thereby saving 80 kg N ha^{-1}. Muthukumarasamy *et al.* (1999) observed that Azospirillum in association with VAM indicated promising results in reducing N fertilization and recorded equivalent or greater yields supported by chemical N fertilizer.

Muthukumarasamy *et al.* (1994) reported that *A. diazotrophicus* increased cane yield by 17.5 to 25.0 t ha^{-1} with 50 per cent reduction in the recommended dose of N. Jayakumar and Thangaraju (1996) reported that Acetobacter in combination with 50 per cent of the recommended dose of mineral N recorded cane and sugar yield on par with N applied at 100 per cent of the recommended dose. Srinivasan and Hari (1997) stated that inoculation of Acetobacter improved the cane yield by 5.0 per cent over the control. Acetobacter in association with VAM have promising results for reducing N fertilization in sugarcane with cane yield equivalent or greater than the yields supported by chemical fertilizer (Muthukumarasamy *et al.*, 1999). Thopate and Jadhav (1999) stated that Acetobacter inoculation at 10 kg ha^{-1} with 50 per cent of recommended N increased cane yield and sugar yield with a saving of 50 per cent in organic N.

The integrated use of mineral N with Azospirillum did not exert any influence on the quality of the cane juice. The CCS per cent remained unchanged and there was no improvement in juice quality with reference to sucrose content (Misra and Naidu, 1990, Durai and Manikam, 1991, Durai and Rammohan, 1991, Kumaraswamy and Rajasekaran, 1994 and Bangar and Sharma, 1997). Joshi and Zende (1998) reported that treatments with Azospirillum and Azotobacter did not show any beneficial effect on CCS per cent. However, the P solubilizing bacteria recorded the highest value for CCS per cent.

Muthukumarasamy *et al.* (1994) reported that using Acetobacter as a biofertilizer improved juice quality and increased sugar recovery from 0.5 to 1 per cent. According to Thopate and Jadhav (1999) combined use of Acetobacter with 50 per cent recommended dose of N recorded significantly higher CCS per cent over the control.

Yadav and Sharma (1981) made a rough estimate of N balance in sugarcane. They indicated that there was an increase in N in the soil even in no fertilizer control. The net gain of the soil N was in the order of 10 to 14 kg ha^{-1}. Detailed investigation conducted at Padegon also revealed that cane growing in the Deccan canal tract had not exhausted the soil so far as the total N is considered.

Studies conducted by Kathiresan and Manoharan (1999) reported that Azospirillum either sett or soil inoculation with 200 kg N ha^{-1} recorded same amount of available N in soil as that of 280 kg N ha^{-1} as inorganic fertilizer. They also revealed that sett treatment and soil application of Azotobacter recorded the highest value of available N in loamy soil having low value of available N.

It can be concluded from the above review that use of Azospirillum with inorganic N economises the use of mineral N without compromise in cane and sugar yield. However, Azospirillum inoculation do not exert any effect on the juice quality. Whereas integrated use of Acetobacter with mineral N increased cane yield as well as improved the quality of cane juice.

2.2.5. Effect of integrated use of chemical fertilizers with sugarcane trash

Sugarcane trash is the major crop residue that is left over the field in large quantities. It constitutes 10 to 20 per cent of the weight of the cane grown. It's management requires special attention. It is usually burnt in the field after the harvest resulting in the loss of nutrients. The nutrients in the trash can be recycled through its direct incorporation in the soil or can be made into biologically decomposable material like compost. The incorporation of trash in combination with fertilizer N increases the cane yield. The additive effect of trash lies in its capacity to minimise the losses of N apart from conserving soil moisture and improving soil environs.

Incorporation of trash into the soil has recorded higher values for growth attributes as well as yield parameters (Parkhe and Shinde, 1981 and Jadhav *et al.*, 1985). Sundara (1985) reported that trash mulching with 2.5 per cent urea spray had influenced the initial crop stand, cane length and single cane weight compared to control. Trash mulch with additional dose of K increased cane length, cane thickness and cane weight (Yadav *et al.*, 1986) and it has also recorded maximum number of shoots (Kathiresan *et al.*, 1991).

Shinde *et al.* (1990) and Shinde *et al.* (1992) reported that incorporation of chopped trash at 7.5 t ha^{-1} along with decomposing fungal culture had shown maximum growth and influenced cane height, cane girth and tillering ratio. While the unchopped trash incorporation had recorded comparatively lesser values for growth parameters, but was superior to FYM application and control.

According to Swamy *et al.* (1998) mulching cane trash at 3 t ha^{-1} with 10 kg urea had remarkably increased the cane length, cane girth and cane weight.

Sundara (1985) observed that trash mulching with 2.5 per cent urea sprays increased the number of millable canes. Kathiresan *et al.* (1991) revealed that trash mulching to a thickness of 10 cm on the ridges and additional dose of 60 kg K_20 ha^{-1} recorded significantly higher number of millable canes as compared to control.

Durai and Ravichandran (1999) reported that trash mulch at 10 t ha^{-1} had registered higher cane population as compared to other organic mulches.

The incorporation of chopped trash at 7.5 t ha^{-1} along with decomposing fungal culture recorded maximum number of millable canes and the increase was 13.85 per cent over the control (Shinde *et al.*, 1990 and Shinde *et al.*, 1992). According to Boramanikar *et al.* (1993) chopped trash at 10 t ha^{-1} with fungal culture recorded highest number of millable canes.

Trash mulching in sugarcane has resulted in higher cane and sugar yields (Mathur, 1975, Sundara, 1986, Mann and Chakor, 1989, Manoharan *et al.*, 1992, Kannappan *et al.*, 1994 and Swamy *et al.*, 1998).

Soil incorporation of chopped or unchopped sugarcane trash at 7.5 t ha^{-1} supplemented with 8 kg urea, 10 kg single superphosphate and cellulose decomposing fungal culture at 1 t^{-1} tonne increased cane yield by 12.2 to 12.8 t ha^{-1}. Chopped and unchopped trash were on a par with respect to yield parameters (Jadhav *et al.*, 1985, Shinde *et al.*, 1990 and Shinde *et al.*, 1992). Boramanikar *et al.* (1993) reported that incorporation of chopped trash at 10 t ha^{-1} with fungal culture recorded the highest cane and sugar yield. Rao (1997) opined that recycling of sugarcane trash through soil incorporation using suitable fungal culture enhanced cane yield. Incorporation of trash mulch at 10 t ha^{-1} was found superior to organic mulching with cowpea, sunnhemp and daincha with respect to cane and sugar yield (Durai and Revichandran, 1999).

Trash mulching with additional dose of K_20 increased cane and sugar yield (Yadav *et al.*, 1986 and Kathiresan *et al.*, 1991). Soil incorporation of trash at 5 t ha^{-1} along with 75 kg N ha^{-1} recorded an yield increase of 37.5 per cent as compared to N application alone (Yadav *et al.*, 1987). Verma (1996) observed that combined use of N at 300 kg with trash mulching at 3.5 t ha^{-1} registered maximum cane yield. According to Yadav (2000) integrated use of N at 175 kg ha^{-1} along with 5 t trash ha^{-1} had recorded cane yield equal to that of 250 kg N ha^{-1} alone and N economy to the extent of 75 kg ha^{-1} was obtained.

Trash mulching at 45 DAP and trash mulching at planting with urea sprays had increased the sucrose percentage (Sundara, 1985 and Sundara, 1986). According to Manoharan *et al.* (1992), Boramanikar *et al.* (1993) and Swamy *et al.* (1998) trash mulching increased CCS per cent as compared to unmulched check. Durai and Ravichandran (1999) reported that trash mulching and its incorporation registered higher values for CCS percentage as compared to organic mulching. Peurmal (1999) observed that integrated use of press mud with cane trash and earthworms resulted in improving Brix, sucrose and purity per cent.

On contrary Shinde *et al.* (1990) and Shinde *et al.* (1992) reported that incorporation of chopped or unchopped trash at graded levels did not exert any influence on juice quality. Similar observations were made by Devaraj and Chockalingam (1991) and Kannappan *et al.* (1994).

According to Yadav *et al.* (1987) organic carbon, available K, Zn, Fe, Mn and Cu increased with trash application alone or with N. The soil pH tended to decrease with trash addition either alone or with N.

Trash incorporation either chopped or unchopped at the rate of 7.5 t ha^{-1} with fungal culture increased the organic carbon content, available N, available P_2O_5 and available K_2O status of soil as compared to FYM application at 5 t ha^{-1} and control (Shinde *et al.*, 1990 and Shinde *et al.*, 1992). When trash was retained as a mulch for 3 consecutive years it has improved the soil organic carbon by 0.13 per cent, available N by 37 kg ha^{-1} and available P by 10 kg ha^{-1} (Yadav *et al.*, 1994 and Yadav, 1995).

Sagwal and Kumar (1998) indicated that application of trash had significantly increased the infiltration rate from 0.9 to 1.2 cm h^{-1}, moisture retained at field capacity from 17.1 to 20.0 per cent and reduced bulk density from 1.52 g cc^{-1} to 1.45 g cc^{-1}.

From the foregone discussion it can be concluded that recycling of sugarcane trash either as mulch or soil incorporation along with inorganic sources sustains the cane productivity through moisture conservation, release of nutrients and addition of organic matter.

2.2.6. Effect of integrated use of chemical fertilizers with green manure

Several leguminous crops due to their stature and duration can be introduced as intercrops in widely spaced nonleguminous crops. These intercrops may be grown for grain, fodder or as a green manure. The intercrops besides increasing total productivity of the system, also plays an important role in economising the use of resources like N.

Sugarcane being a long duration and widely spaced crop offers scope for intercropping upto 90 days as its growth is very slow with little canopy spread. Growing leguminous green manuring crop like cowpea as an intercrop in sugarcane is an effective practice of nutrient recycling to increase soil fertility status and to sustain the productivity of sugarcane. The integrated use of legumes like cowpea as intercrop or companion crop for green manuring has to be assessed for its N accretion and effect on the yield of main crop.

Bhadauna and Mathur (1973) reported that intercropping *Crotalaria juncea* as a green manure crop in sugarcane had no adverse effects on cane growth. Intercropping with pulses in sugarcane has increased the germination, tillering capacity, cane length, cane weight and cane girth as compared to sole culture (Narwal and Malik, 1981, Kathiresan and Rajasekaran, 1990 and Gana *et al.* 2000).

Verma and Bhoj (1980) and Narwal and Malik (1981) reported that the survival of tillers were maximum in intercropped cane and tiller mortality was more in pure stand.

Combined use of mineral N at 275 kg ha^{-1} along with *in situ* incorporation of daincha registered maximum cane length and increased the cane weight by 35 per cent as compared to pure stand (Kathiresan and Ayyamperumal, 1996). Srinivas (1996) observed that application of green manure like daincha or sunhemp at 15 t ha^{-1} along with 75 per cent of the recommended dose of N recorded higher values for cane girth, cane length and number of internodes as compared to 100 per cent of the recommended dose.

Verma *et al.* (1999) concluded that intercropping greengram as a green manure in sugarcane along with the inoculation of biofertilizer and mineral N recorded maximum tiller formation as compared to sole crop.

Many workers have reported the negative influence of intercropping on the growth of sugarcane. Studies revealed that raising sunhemp or pulses as intercrops in sugarcane reduced tillering and affected the yield attributes adversely (Kumaraperumal *et al.*, 1975, Jayabal and Sankaran, 1991, Singh *et al.*, 1993 and Ahmed, 1999).

Companion cropping with either green gram or blackgram increased the millable cane population as compared to monoculture of sugarcane (Narwal and Malik, 1981, Kathiresan and Rajasekaran, 1990 and Kannappan *et al.*, 1990). Verma *et al.* (1999) concluded that intercropping greengram for green manure with inoculation of Azotobacter and N applied at 150 kg ha^{-1} had produced maximum number of millable canes. According to Ahmed (1999) continuous sowing of sunhemp on the ridges with 100 per cent N registered the highest millable cane population as compared to sole crop of sugarcane. However, there are some reports stating that intercropping has reduced the millable cane population in sugarcane (Venkataraman *et al.*, 1978 and Chakor *et al.*, 1996).

Raising greengram as an intercrop and *in situ* incorporation at 45 DAP has resulted in maximum cane yield than sole crop (Jayabal *et al.*, 1989). Intercropping either blackgram or greengram in sugarcane had significantly enhanced the cane yield and sugar yield as compared to pure stand (Narwal and Malik, 1981, Kannappan *et al.*, 1990, Kathiresan and Rajasekaran, 1990). According to Singh *et al.* (1993) and Kathiresan and Ayyamperumal (1996) raising daincha as an intercrop for green manuring in sugarcane with N application produced the highest cane and sugar yield. Srinivas (1996) reported that integrated use of daincha as a green manure at 14 t ha^{-1} along with 75 per cent of the recommended dose of N recorded the highest cane yield over 100 per cent of the recommended dose of N alone.

According to Verma *et al.* (1999) intercropping greengram and burying it as an green manure along with the application of Azotobacter at 5 kg ha^{-1} and inorganic N at 150 kg ha^{-1} significantly outyielded the sole cropping of sugarcane.

Growing sunhemp as an intercrop in sugarcane either in continuous rows or at 30 cm apart with 100 per cent or 75 per cent N was found to be beneficial in enhancing the cane yield to the tune of 6.2 per cent as compared to N application alone (Ahmed, 1999). Gana *et al.* (2000) stated that intercropping sesbania or cowpea for *in situ* incorporation had shown better results for cane yield than the sole crop.

A few reports are also available stating that intercropping in sugarcane has decreased the cane yield as compared to sole cropping (Jayabal and Sankaran, 1991, Sharma *et al.*, 1993 and Chakor *et al.*, 1996).

Growing sunhemp or cowpea or blackgram or greengram in sugarcane for *in situ* green manuring was found to improve the juice quality parameters compared to sole culture (Bhadauna and Mathur, 1973, Jayabal *et al.*, 1989 and Kannappan *et al.*, 1990).

Studies also revealed that intercropping greengram or blackgram or soyabean or groundnut in sugarcane have increased total solids, sucrose content, purity coefficient and CCS per cent as compared to non-intercropping canes (Sinha *et al.*, 1984, Sathyavelu *et al.*, 1990 and Sinha *et al.*, 1994). According to Jayabal *et a*l. (1990) sequential intercropping in sugarcane has influenced the quality parameters and improved the sucrose content, total solids and CCS per cent. Srinivas (1996) reported that the quality attributes such as juice per cent Brix and sucrose per cent were improved numerically with the application of sunhemp or daincha at 14 t ha^{-1} as green manure in conjunction with N at graded levels.

Intercropping sunhemp as a green manure and its *in situ* incorporation combined with N application at 75 or 100 per cent of the recommended dose showed comparatively higher values for sucrose content and significantly higher values for CCS per cent in comparison with NPK application alone (Ahmed, 1999).

Yadav (1987 b) reported that legumes in companion cropping system improved soil fertility by fixing atmospheric N benefitting sugarcane grown in association or succession.

Integrated use of fertilizer N with *in situ* green manuring significantly decreased soil pH with an increase in the organic carbon content and available N, P and K in the soils producing favourable effects in improving the soil fertility (Singh *et al.*, 1993). Srinivas (1996) reported that the organic content and available N in the soil after the experiment increased substantially with decreasing soil pH compared to initial soil fertility status in treatments where combined use of green manuring with inorganic N application was taken up. The results of the experiment conducted at S.R.S., Melathur (2000) showed that *in situ* incorporation of green manures improved the major nutrient availability in post harvest soils with N, P, K at 169, 18 and 229 kg ha^{-1} and organic matter at 0.66 per cent. Whereas it was 153, 12 and 220 kg N, P, K kg ha^{-1} and organic matter at 0.62 per cent with inorganic fertilizers. Growing sunhemp as intercrop and ploughed *in situ* at 45 DAP along with 75 or 100 per cent N made marginal improvement in soil pH, EC and organic content of soil. The available N, P and K of the soil after the harvest were in the increasing trend compared to N, P and K application at recommended dose (Ahmed, 1999).

From the above review it is quite clear that in the case of sugarcane it is possible to accommodate a leguminous green manuring crop as intercrop. Its incorporation and conjunctive use with chemical fertilizers influence the growth and yield attributes of sugarcane resulting in increased cane and sugar yield. It also produces favourable effects in soil health by improving the physico-chemical properties of soil.

It can be inferred from the review carried out that mineral nutrition with N, P and K has got great impact on growth and development of sugarcane. The application of nitrogen exert positive influence on all growth characters, yield attributes and cane yield as it is a crop with very high biomass production. The other major nutrients viz., P and K also plays a pivotal role in improving the quality parameters of cane juice in addition to its influence on the growth and yield parameters. It is also brought to the notice that press mud has got great manurial potential and the combined use of press mud with chemical fertilizers remarkably increased the cane and sugar yield with improvement in physico-chemical properties of soil. The integrated use of mineral nutrients with biofertilizers enable to economise the use of nitrogenous fertilizers without compromise in cane and sugar yield. It also tends to improve the juice quality parameters. Soil incorporation of trash along with inorganic sources sustains cane productivity and enhance the fertility status of soil. It is also possible to accommodate a green manure crop in the interspaces of sugarcane during the early stages of growth. Its incorporation and conjunctive use with major nutrients appreciably increase the cane growth with substantial improvement in cane and sugar yield without any deterioration in soil health and productivity.

MATERIALS AND METHODS

MATERIALS AND METHODS

Two separate field experiments were conducted during the crop seasons of 1998-'99 and 1999-2000 at Sugarcane Research Station (S.R.S.) Thiruvalla with an objective to economise the use of irrigation water in sugarcane and to formulate a sustainable production technology by integrating organic, inorganic and biological sources of nutrients for maximum cane yield, juice quality and jaggery recovery. The materials used and the methods adopted for the investigation are presented in this chapter.

3.1. Materials

3.1.1. Experimental site

The experimental site was located in the III and IV blocks of Sugarcane Research Station, Thiruvalla situated at $9^0 5'$ N latitude and $76^0 5'$ E longitude at an altitude of 2.5 m above MSL on the deltaic belts of Manimala river in Pathanamthitta district.

3.1.2. Season

Field experiments consisting of 'Standardisation of irrigation management' in sugarcane (Expt. No. I) and 'Integrated nutrient management' (Expt. No.II) were undertaken during the crop season (January to January) of 1998-'99 as the first plant crop and as the second plant crop during 1999-2000. The first plant crop under Experiment No.I and Experiment No.II were planted on 05-01-1998 and 10-01-1998. While the second plant crops were planted on 04-01-1999 and 06-01-1999. respectively.

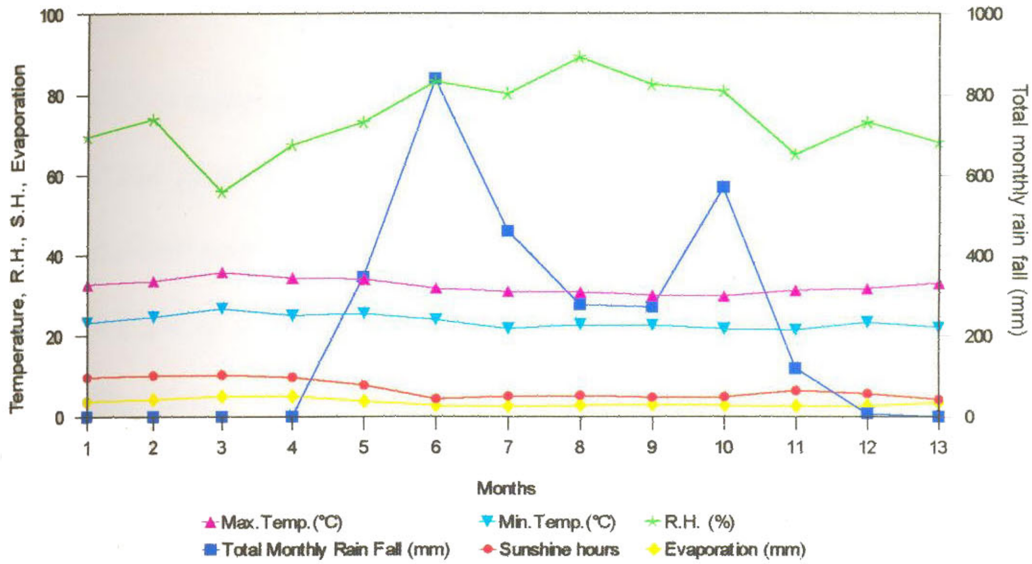


Fig. 1a. Weather parameters during the crop season of 1998-1999

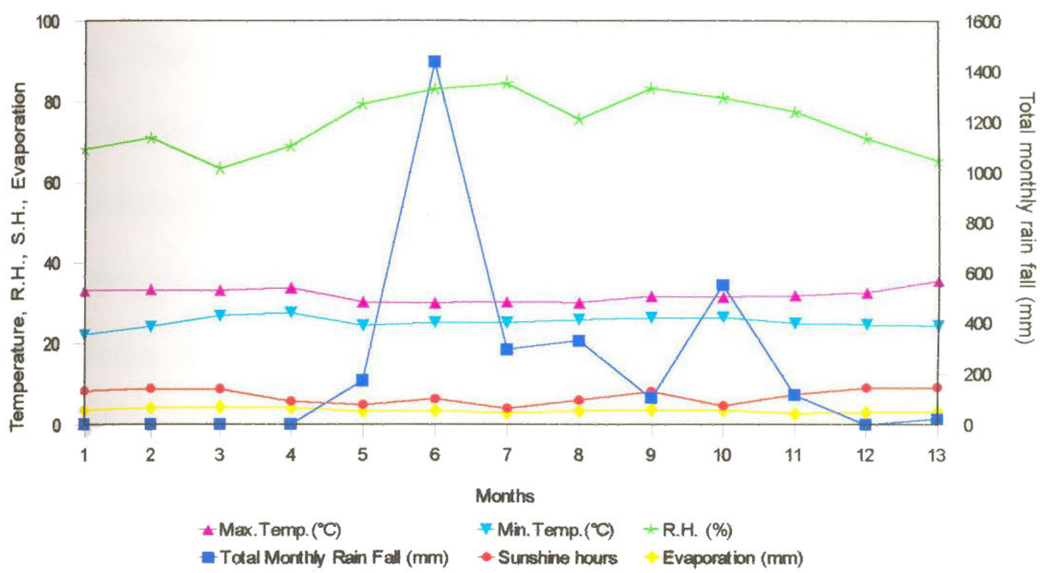


Fig. 1b. Weather parameters during the crop season of 1999-2000

3.1.3. Climate

Thiruvalla enjoys a humid tropical climate with monsoonic inundation during South West and North East monsoon. The weather parameters of the cropping period are depicted graphically in Figs. 1a and 1b and the mean values are presented in Appendix-I and an abstract is given in Table 1.

During first plant crop (1998-'99) a total rainfall of 2893 mm was experienced and in second plant crop of 1999-2000 a total rainfall of 3033 mm was received. But during the formative phase (up to 135 DAP), the crop received a total rainfall of 6.2 mm in first plant crop and 5.1 mm in second plant crop.

The mean of monthly minimum and maximum temperature ranged from 21.7°C to 26.7°C and 29.8°C to 35.8°C, respectively during the first plant crop of 1999-'99. While in the second plant crop of 1999-2000 the mean minimum and maximum temperature ranged from 22.0°C to 27.5°C and 30.0°C to 33.3°C respectively. The average monthly relative humidity ranged between 55.9 to 89.2 per cent during first plant crop and 63.5 to 84.6 per cent in second plant crop. In the case of evaporation and sunshine hours, the average monthly values ranged from 2.7 to 5.1 mm and 4.4 to 10.3 in first plant crop. While in second plant crop it ranged between 2.9 to 4.3 mm and 4.1 to 9.1 respectively. In general agrometeorological conditions were favourable for the growth and development of the crop.

Table 1. Weather parameters during the cropping period

Parameter	Mean value	
	January, 1998 to January, 1999	January, 1999 to January 2000
Max. Temp. (^0C)	32.3	31.8
Min. Temp. (^0C)	23.4	25.2
Relative humidity (%)	74.1	74.8
Daily evaporation (mm)	3.5	3.4
Sunshine hours	7.1	7.0
Total Rainfall (mm)	2893	3033

3.1.4. Soil

Soil of experimental field was riverine alluvium of the order Entisol and sub order Psamments. The texture of the soil was silty clay loam. Before the commencement of the experiment, composite samples of the soil were drawn from a depth of 0 - 30 cm and analysed. The physico-chemical properties of the soil was acidic in reaction, medium in available nitrogen and potassium and low in available phosphorus (Table 2).

3.1.5. Cropping history of the experimental site

The experimental site was grown under a bulk crop of sugarcane prior to the commencement of the present experiments.

3.1.6. Variety

The test variety used for the study was `Madhuri' released from Sugarcane Research Station, Thiruvalla and is a high yielding midlate variety with a yield potential of 120 t ha^{-1}. It was evolved by the hybridization of Co 740 x Co 775. Madhuri moderately resistant to red rot disease and is having a commercial cane sugar (CCS) percentage of 10.85 to 11.5 and sucrose content of 15.08 to 16.5 percentage.

Table 2 Physico-chemical properties of the initial soil samples

Sl. No.	Particulars	Year		Method
		1998-'99	1999-'00	
1	Mechanical composition			
	Sand (per cent)	38.20	37.20	Bouyoucos Hydrometer (Bouyoucos, 1962)
	Silt (per cent)	25.30	26.00	
	Clay (per cent)	35.06	36.20	
2	Bulk density (g cc^{-1})	1.49	1.50	Core sampler (Gupta and Dakshinamoorthy 1980)
3	Particle density (g cc^{-1})	2.63	2.61	
4	Water holding capacity (per cent)	54.86	53.21	
5	Pore space distribution	43.34	42.52	
B	Chemical properties			
1	pH	5.40	5.50	pH meter with glass electrode (Jackson, 1973)
2	Organic carbon (per cent)	0.727	0.712	Walkely and Black (Jackson, 1973)
3	Available N (ppm)	140.00	122.50	Alkaline Potassium Permanganate (Subbiah and Asija, 1956)
4	Available P (ppm)	3.02	2.96	Bray's colorimetric (Jackson, 1973)
5	Available K (ppm)	37.50	38.50	Ammonium acetate (Jackson, 1973)
6	Fe (ppm)	56.66	58.88	Atomic Absorption Spectro-photometer (Jackson, 1973)
	Mn (ppm)	43.33	39.97	
	Cu (ppm)	3.89	3.99	
	Zn (ppm)	1.33	1.22	

3.1.7. Chemical fertilizers

Urea (46.0% N), mussoriephos (20.1% P_2O_5) and muriate of potash (60% K_2O) were used for the experiment.

3.1.8. Industrial by product and crop residues

Press mud was brought from Co-operative Sugar Factory, Chittoor, Palghat (1.1% N, 2.62% P, 1.18% K and 18.4% moisture content) and sugarcane trash (0.44% N, 0.18% P and 0.15% K) was collected from sugarcane field of S.R.S., Tiruvalla at different periods of detrashing and harvesting of crop.

3.1.9. Green manure

Cowpea variety C 152 purchased from National Seeds Corporation was used for intercropping sugarcane as a green manure.

3.1.10. Biofertilizers

Acetobacter diazotrophicus was obtained from main Biocontrol Research Laboratory, Chengalpattu, Tamil Nadu. A commercial preparation of *Azospirillum brasilense* was obtained from National Biofertilizers Development Corporation, Bangalore.

3.1.11. Irrigation source

Water from Manimala river was used for irrigating the crop. The irrigation water was of good quality with a pH value of 6.8 to 7.0.

3.2. Methods

3.2.1. Experimental design and layout

Experiment No. I - Standardization of irrigation management in sugarcane

The experiment was laid out in factorial randomised block design consisting of 8 treatment combinations of four methods of irrigation and two mulching practices with 3 replications (Table 3 a). The lay out plan of the experiment is given in Fig. 2a.

Design - Factorial R.B.D.

Methods of irrigation (4 levels)

I_1 - All Furrow irrigation

I_2 - Alternate furrow irrigation

I_3 - Skip furrow irrigation

I_4 - Farmer's practice

Irrigation was scheduled at fortnightly interval in all, alternate and skip furrow irrigation. While in farmer's practice it was scheduled once in a month. The depth of irrigation was 5 cm.

Mulching (2 levels)

M_0 - No mulch

M_1 - Trash mulching (5 t ha^{-1})

Number of treatment combinations - 8

Total number of plots - 24

Gross plot size - 6 x 5.4 m^2

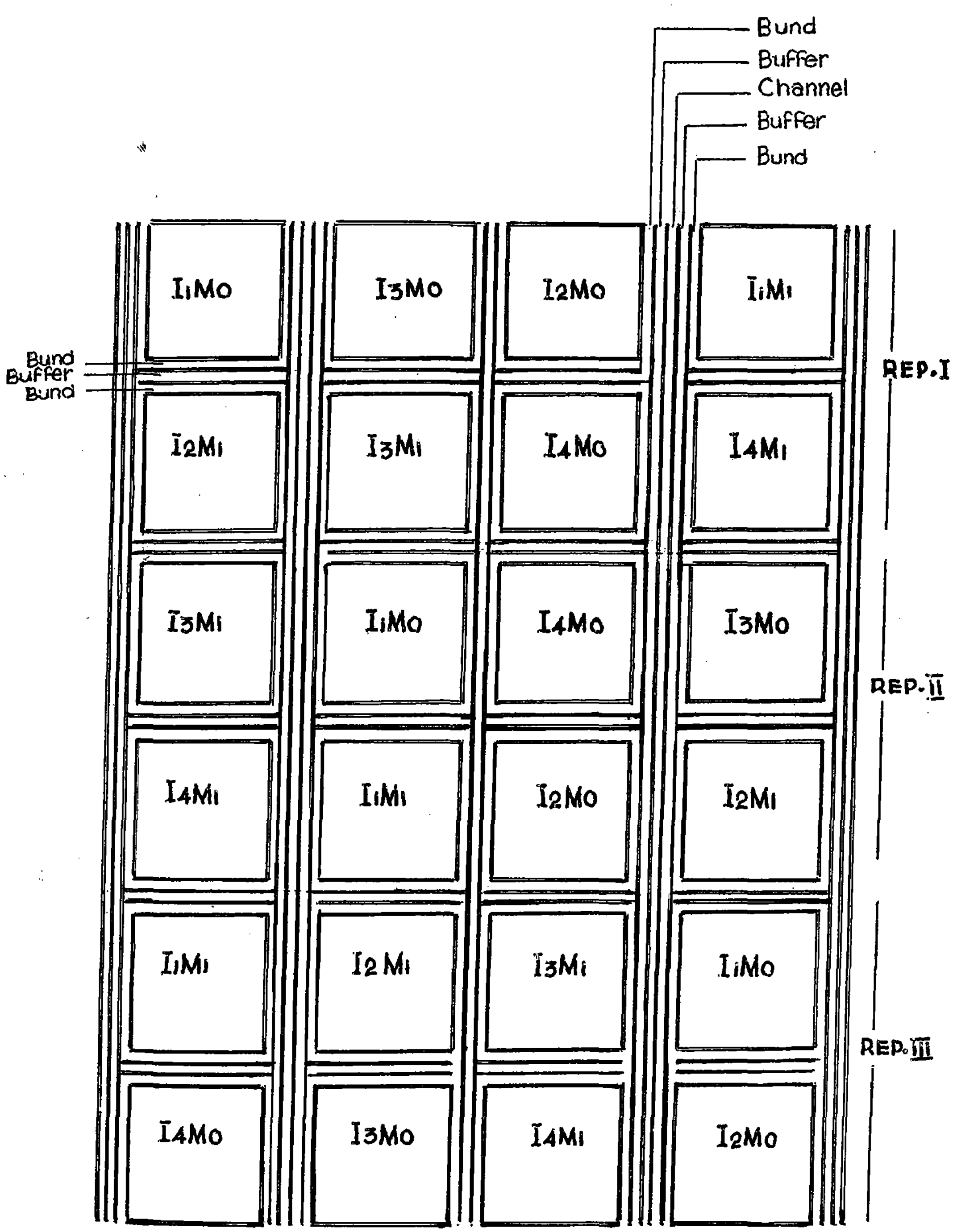
Net plot size - 5.2 x 3.6 m^2

Spacing - 90 cm rows

3.2.2. Experiment No. II : Integrated nutrient management in sugarcane

The experiment was laid out in strip plot design with organic sources in strip I and fertilizer levels in strip II. Six organic sources with 3 fertilizer levels constituting 18 treatment combinations and 4 replications were chosen for the study. The lay out of the plan of the experiment is given in Fig. 2b.

Fig. 2a Layout of the experiment No. I



I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice
M_0 - No mulching
M_1 - Trash mulching

Fig. 2b Layout of the experiment No. II

Rep-I			Rep-II			Rep-III			Rep-IV		
T_6F_1	T_6F_2	T_6F_3	T_3F_2	T_3F_3	T_3F_1	T_1F_3	T_1F_1	T_1F_2	T_4F_2	T_4F_3	T_4F_1
T_1F_1	T_1F_2	T_1F_3	T_2F_2	T_2F_3	T_2F_1	T_5F_3	T_5F_1	T_5F_2	T_2F_2	T_2F_3	T_2F_1
T_3F_1	T_3F_2	T_3F_3	T_5F_2	T_5F_3	T_5F_1	T_6F_3	T_6F_1	T_6F_2	T_6F_2	T_6F_3	T_6F_1
T_5F_1	T_5F_2	T_5F_3	T_4F_2	T_4F_3	T_4F_1	T_4F_3	T_4F_1	T_4F_2	T_5F_2	T_5F_3	T_5F_1
T_2F_1	T_2F_2	T_2F_3	T_1F_2	T_1F_3	T_1F_1	T_2F_3	T_2F_1	T_2F_2	T_3F_2	T_3F_3	T_3F_1
T_4F_1	T_4F_2	T_4F_3	T_6F_2	T_6F_3	T_6F_1	T_3F_3	T_3F_1	T_3F_2	T_1F_2	T_1F_3	T_1F_1

T_1 No organic manure

T_2 Press mud

T_3 Trash

T_4 Green manure

T_5 Acetobacter

T_6 Azospirillium

F_1 50% of the recommended dose of NPK

F_2 75% ,, ,,

F_3 100% ,, ,,

Design - Strip plot

Strip I (Organic sources)

T_1 - Control (No organic matter)

T_2 - Application of press mud (5 t ha^{-1})

T_3 - Application of trash (10 t ha^{-1})

T_4 - Green manuring with intercropped cowpea (variety C 152)

T_5 - Application of *Acetobacter diazotrophicus* (10 kg ha^{-1})

T_6 - Application of *Azospirillum brasilense* (10 kg ha^{-1})

Table 3a Treatment details

Experiment No. I Standardisation of irrigation management in sugarcane

Notations	Treatments
I_1M_0	All furrow irrigation
I_1M_1	All furrow irrigation + Trash mulching
I_2M_0	Alternate furrow irrigation
I_2M_1	Alternate furrow irrigation + Trash mulching
I_3M_0	Skip furrow irrigation
I_3M_1	Skip furrow irrigation + Trash mulching
I_4M_0	Farmer's practice
I_4M_1	Farmer's practice + Trash mulching

Table 3b Treatment details
Experiment No.II Integrated nutrient management in sugarcane

Notations	Treatments
T_1F_1	50% of the recommended dose of NPK without organics
T_1F_2	75% of the recommended dose of NPK without organics
T_1F_3	100% of the recommended dose of NPK without organics
T_2F_1	50% of the recommended dose of NPK + Press mud application at 5 t ha^{-1}
T_2F_2	75% of the recommended dose of NPK + Press mud application at 5 t ha^{-1}
T_2F_3	100% of the recommended dose of NPK + Press mud application at 5 t ha^{-1}
T_3F_1	50% of the recommended dose of NPK + Trash application at 10 t ha^{-1}
T_2F_2	75% of the recommended dose of NPK + Trash application at 10 t ha^{-1}
T_3F_3	100% of the recommended dose of NPK + Trash application at 10 t ha^{-1}
T_4F_1	50% of the recommended dose of NPK + Green manuring with intercropped cowpea
T_4F_2	75% of the recommended dose of NPK + Green manuring with intercropped cowpea
T_4F_3	100% of the recommended dose of NPK + Green manuring with intercropped cowpea
T_5F_1	50% of the recommended dose of NPK + Acetobacter application at 10 kg ha^{-1}
T_5F_2	75% of the recommended dose of NPK + Acetobacter application at 10 kg ha^{-1}
T_5F_3	100% of the recommended dose of NPK + Acetobacter application at 10 kg ha^{-1}
T_6F_1	50% of the recommended dose of NPK + Azospirillum at 10 kg ha^{-1}
T_6F_2	75% of the recommended dose of NPK + Azospirillum at 10 kg ha^{-1}
T_6F_3	100% of the recommended dose of NPK + Azospirillum at 10 kg ha^{-1}

Strip II (Mineral nutrition)

F_1 - 50% of the recommended dose of NPK (82.5 kg N, 41.25 kg P_20_5 and 41.25 K_20 kg ha^{-1})

F_2 - 75% of the recommended dose of NPK (121.75 kg N, 61.87 kg P_20_5 and 61.87 K_20 kg ha^{-1})

F_3 - 100% of the recommended dose of NPK (165 kg N, 82.5 kg P_20_5 and 82.5 K_20 kg ha^{-1})

Number of treatment combinations - 18

Number of replications - 4

Total number of plots - 72

Gross plot size - 6 x 5.4 m^2

Net plot size - 5.2 x 3.6 m^2

Spacing - 90 cm rows

The treatment details of the two experiments are furnished in Tables 3a and 3b.

3.2.3. Field preparation and planting

Field was ploughed deep with cultivator followed by harrowing to bring the soil to fine tilth. After levelling, the field was thrown into ridges and furrows at a distance of 90 cm. The field was laid out into plots as per the technical programmes in both the experiments. To avoid seepage of water from plot to plot a buffer space was provided as shown in Fig. 2a. Sufficient channels were provided for irrigation and drainage in both the experiments.

Three budded setts of the variety Madhuri was chosen for planting in both experiments at 40,000 Nos. ha^{-1}.

In experiment No. I, all cultural practices except irrigation and in experiment No.II, cultural practices other than fertilizer recommendations (K.A.U., 1996) were followed.

3.2.4. Experiment No. I

Irrigation was scheduled at weekly interval till germination phase was completed. Trash was applied in furrows at the rate of 5 t ha^{-1} as per the treatments (30 DAP). During the germination phase a common irrigation was given to the entire crop for uniform germination. Thereafter irrigation was scheduled as per the technical programme. The depth of irrigation for all the treatments was fixed at 5 cm. The experiment was conducted in two plant crops in consecutive years.

3.2.5. Experiment No. II

Experiment No. II was also laid out in 2 consecutive plant crops. In experiment No. II the manurial aspect was tested as per the technical programme. The management practices were followed as per the Package of Practices Recommendations (K.A.U., 1996).

3.2.6. Press mud

Press mud was applied @ of 5 t ha^{-1} at planting.

3.2.7. Trash application

Trash obtained from the sugarcane was collected and applied @ 10 t ha^{-1} along the ridges at planting.

3.2.8. Green manuring

Intercropping of cowpea cv. C152 was taken up along with the planting of sugarcane in the interspaces. It was incorporated at 45 days after planting (DAP)

3.2.9. Acetobacter

Acetobacter diazotrophicus was applied @ of 10 kg ha^{-1}. Before planting 50 per cent of the biofertilizer was treated with setts and the remaining was applied as pocket application at 45 DAP.

3.2.10. Azospirillum

Azospirillum brasiliense was applied as soil inoculation during planting @ 10 kg ha^{-1}.

3.2.11. NPK requirement of sugarcane

The recommended dose of NPK for sugarcane crop in Thiruvalla and Pandalam area is 165 kg N, 82.5 kg P_2O_5 and 82.5 kg K_2O ha^{-1}. Taking this as 100 per cent, 50 and 75 per cent of the recommended dose was worked out.

3.3.1. Harvest

The crop was harvested after 12 months. Matured canes from the net plot area were cut separately, stripped and weighed for final cane yield.

3.3.2. Observations recorded

Within the net plot area 10 canes were selected at random, peg marked and subsequently used for recording the observations.

3.3.3. Growth characters

3.3.3.1. Plant height

Pegs were fixed near the bottom of randomly selected shoots and height measurements were made from the peg level to third visible dew lap leaf of the cane (Dillewijn, 1952). Height measurements were recorded at 120, 240 and 360 DAP. The mean height of the selected canes at each stage was taken as the height of cane and expressed in cm.

3.3.3.2. Number of leaves

Number of fully opened leaves on tagged shoots in each plot was counted at 120, 240 and 360 DAP.

3.3.3.3. Number of nodes

The number of nodes were recorded using 10 randomly selected canes from each plot at 120, 240 and 360 DAP. It is expressed as mean values.

3.3.3.4. Dry matter production (DMP)

Destructive plant samples from 50 cm row were collected at 120 days interval till harvest for computing DMP. The samples were separated into green tops, dried leaves and stem. Their individual fresh weight was recorded.

3.3.3.4.1. Dry matter production by green tops, trash and stem

Sub samples from the separated green top, dried leaves and stem were cut into small bits of 1-2 cm length separately and about 100 g of each was taken and its fresh weight was recorded. The sample was subjected to drying in an electric oven at 80^{0}C to constant dry weight. Then total dry weight of green tops, trash (dried leaves) and stem in each treatment was calculated and expressed in t ha^{-1} basis. Same samples were finely ground and used for chemical analysis.

3.3.3.4.2. Total dry matter production (DMP)

The total dry matter production was obtained by adding up dry matter production of stem with that of green tops and trash and expressed in t ha^{-1}.

3.3.3.5. Germination

Germination count was recorded at 30 DAP and was expressed on percentage of germinated buds to the total number of buds planted.

3.3.3.6. Tiller count

Total number of tillers (main and side tillers) were counted at 90 and 120 DAP and tiller count per hectare was worked out from the tiller number per treatment.

3.3.3.7. Shoot count

Shoot population per plot was counted at 180 DAP and shoot population per hectare was worked out.

3.3.3.8. Cane formed shoots

Total number of cane formed shoots were counted at 240 DAP per treatment and it was worked out on per hectare basis.

3.3.4. Growth analysis

3.3.4.1. Leaf area

The length and breadth of each leaf were measured and leaf area was computed by the following formula and expressed as cm^2 per cane.

$$\text{Leaf area per sample} = \sum_{i=1}^{n} (L \times B) \; K$$

Where L is the length of i^{th} leaf

B is the breadth of i^{th} leaf

n is the total number of leaves per sample

K is a constant factor obtained by dividing the actual area by calculated area (0.682).

3.3.4.2. Leaf area index (LAI)

Leaf area index was worked out at formative phase (120 DAP), grand growth phase (240 DAP) and maturity phase (360 DAP) using the following formula

$$LAI = \frac{\text{Total leaf area } (cm^2)}{\text{Unit land area } (cm^2)}$$

3.3.4.3. Leaf area ratio (LAR)

Leaf area ratio was calculated at formative phase (120 DAP), grand growth phase (240 DAP) and maturity phase (360 DAP) using the formula suggested by Kvet *et al.* (1971) and the values were expressed as $cm^2\ g^{-1}$.

$$LAR\ (cm^2\ g^{-1}) = \frac{\text{Leaf area } (cm^2)}{\text{Total plant dry weight (g)}}$$

3.3.4.4. Specific leaf area (SLA)

Specific leaf area was calculated according to Kvet *et al.* (1971) and expressed as $cm^2\ g^{-1}$.

$$SLA\ (cm^2\ g^{-1}) = \frac{\text{Leaf area } (cm^2)}{\text{Leaf dry weight (g)}}$$

3.3.4.5. Crop growth rate (CGR)

Crop growth rate was arrived from dry weight of the plant using the formula of Watson (1952) and expressed as $g\ m^{2-1}\ d^{-1}$

$$CGR\ (g\ m^{2-1}\ d^{-1}) = \frac{W_2 - W_1}{P\ (T_2 - T_1)}$$

Where W_1 and W_2 are the whole plant weight at first and second sampling respectively. T_1 and T_2 are the time in days at first and second sampling respectively. P is the ground area in m^2.

3.3.4.6. Net assimilation rate (NAR)

Net assimilation rate was calculated from total dry weight and leaf area from different time intervals (Between 120 and 240 DAP and 240 and 360 DAP) using the formula suggested by Watson (1952) and expressed as $mg\ dm^{2-1}\ d^{-1}$.

$$NAR = \frac{(W_2 - W_1)\ (\log_e A_2 - \log_e A_1)}{(t_2 - t_1) \quad (A_2 - A_1)}$$

Where W_1 and W_2 are the weight of whole plant at first and second sampling respectively. A_1 and A_2 are the leaf area at first and second sampling respectively while t_1 and t_2 are the time in days at first and second sampling respectively.

3.3.5. Yield and yield attributes

3.3.5.1. Cane girth

The girth of the cane was measured at the middle of the stalk from already selected canes using Vernier Caliper at 120, 240 and 360 DAP and expressed as mean values in cm.

3.3.5.2. Cane length

After removing the tops of the randomly selected canes, the length in cm was recorded at 360 DAP and expressed as mean values.

3.3.5.3. Single cane weight

Cane weight was recorded at 360 DAP from already selected canes and the mean weight of individual cane was expressed in g per cane.

3.3.5.4. Millable cane count (MCC)

The total number of millable canes were counted at 360 DAP and expressed as '000' ha^{-1}.

3.3.5.5. Cane yield

Cane harvested from the net plot were weighed and yield was expressed in t ha^{-1}.

3.3.5.6. Sugar yield

Sugar yield was calculated from commercial cane sugar per cent and cane yield at harvest as follows and expressed in t ha^{-1}.

$$\text{Sugar yield (t ha}^{-1}) = \frac{\text{CCS}}{100} \times \text{Cane yield (t ha}^{-1})$$

3.3.5.7. Jaggery yield

Jaggery yield was calculated from jaggery recovery per cent and cane yield at harvest as given below and expressed in t ha^{-1}.

$$\text{Jaggery yield (t ha}^{-1}) = \frac{\text{Jaggery recovery x cane yield (t ha}^{-1})}{100}$$

3.3.5.8. Harvest index (H.I.)

The harvest index was calculated based on the commercial cane sugar yield and the total dry matter production as shown below:

$$\text{H.I.} = \frac{\text{CCS yield (t ha}^{-1})}{\text{Total dry matter production (t ha}^{-1})} \times 100$$

3.3.6. Quality attributes

Ten canes from different clumps of each plot were harvested at random. The tops were removed just below the sixth leaf sheath and millable portion of the cane alone were taken for crushing in a vertical cane crusher. Juice samples were drawn from the composite juice sample of the canes taken from each plot and was used for juice analysis.

3.3.6.1. Juice extraction

Extractable cane juice was estimated at harvest using the following formula and expressed as percentage.

$$\text{Juice extraction per cent} = \frac{\text{Weight of juice}}{\text{Weight of millable cane}} \times 100$$

3.3.6.2. SMT Brix (small mill test) and sucrose

From the juice sample, the total solids (Brix per cent) were estimated by using brix hydrometer and sucrose per cent was estimated by Hary's dry lead sub-acetate clarification method (Meade and Chen, 1977).

3.3.6.3. Commercial cane sugar (CCS)

The commercial cane sugar (CCS) per cent was calculated from the Brix and pol per cent using the formula

$$\text{CCS (per cent)} = S - [(B-S) \times 0.4] \times 0.73$$

S = Sucrose per cent
B = Brix per cent

3.3.6.4. Purity coefficient

The purity coefficient of juice was calculated from the total solids (Brix) and sucrose per cent as shown below:

$$\text{Purity coefficient (per cent)} = \frac{\text{Sucrose per cent} \times 100}{\text{Brix per cent}}$$

3.3.6.5. Titrable acidity

Titrable acidity of the sample juice was determined by titrating 0.1 N NaOH against diluted sample juice and expressed as ml of 0.1 N NaOH per 100 ml of juice (Meade and Chen, 1977).

3.3.6.6. Reducing sugar

Reducing sugar in the sample juice pertaining to each treatment was determined by alkaline ferricyanide method (Rao and Asokan, 1974) and expressed as per cent juice basis.

3.3.6.7. Fibre content

Fibre content in randomly selected cane from every treatment was estimated using Rapipol Extractor method as described by Thangavelu and Rao (1982) and expressed as per cent cane basis.

$$\text{Fibre (per cent)} = \frac{\text{Dry weight of fibre (g)}}{\text{Fresh weight of cane (g)}} \times 100$$

3.3.7. Jaggery quality

3.3.7.1. Jaggery recovery

Six canes were selected at random from each treatment. The canes were cut, detrashed and its fresh weight was recorded. The cane was crushed and juice was extracted. Two litres of filtered clear juice from each treatment was measured out and boiled. Jaggery cubes were prepared in the laboratory by neutralizing the boiled cane juice with $NaHCO_3$ followed by pouring the neutralized heated concentrated syrup into cubical mould (Asokan, 1986). The samples obtained from each treatment was weighed and used for quality analysis. The jaggery recovery is expressed as per cent cane.

$$\text{Jaggery recovery (\%)} = \frac{\text{Weight of jaggery cubes}}{\text{Fresh weight of cane crushed}} \times 100$$

3.3.7.2. Moisture content

The moisture content was estimated by drying a known weight of powdered jaggery sample at 80°C for a period of 3 to 4 hours and finding out the loss in weight. It is expressed as per cent.

3.3.7.3. Reducing sugar

The reducing sugars are estimated by titrating the diluted jaggery solution after clarification with 10 ml of Fehling's solution according to Lane-Eynon's colorimetric methods.

3.3.7.4. Brix and sucrose

By using clarified 0.5 N jaggery solutions the total solids (Brix per cent) were determined with Brix hydrometer and expressed in per cent. The sucrose content in jaggery was determined by polarimetry by clarifying a 0.5 N jaggery solution with lead sub-acetate and finding out the polarisation value and expressed in per cent.

3.3.7.5. Purity

The purity coefficient of jaggery was calculated from the total solids (Brix) and sucrose per cent by the formula given below:

$$\text{Purity (\%)} = \frac{\text{Sucrose per cent}}{\text{Brix per cent}} \times 100$$

3.3.8. Plant analysis

3.3.8.1. Uptake of major nutrients

The destructive sampling made for the determination of dry matter production by trash, green tops and stem at 120, 240 and 360 DAP was used for chemical analysis. The trash, green tops and stem obtained were analysed for nitrogen by modified microkjeldhal method (Jackson, 1973), total phosphorus by Vanodomolybdophosphoric Yellow Colour Method (Jackson, 1973) and total potassium, calcium and sodium by the flame photometric method (Jackson, 1973). The uptake was calculated by multiplying the nitrogen, phosphorus and potassium content of the respective plant parts with the dry weight of trash, green top and stem. The uptake values were expressed in kg ha^{-1}.

3.3.8.2. Uptake of micronutrients

The samples collected for working out the DMP by trash, green tops and stem at different stages of observation were used for chemical analysis. The trash green tops and stem collected were analysed for Fe, Mn, Zn and Cu by atomic spectrophotometry (Jackson, 1973). The uptake was computed by multiplying the content of Fe, Mn, Zn and Cu content of the respective plant parts with the dry weights of trash, green tops and stem. The uptake is expressed in kg ha^{-1}.

3.3.9. Soil analysis

3.3.9.1. Soil moisture and soil temperature

Soil moisture was determined by gravimetric method from two depths

0 - 15 cm and 15 - 30 cm prior to each irrigation commencing from 45 DAP to 135 DAP at 15 days interval and was expressed in percentage.

Soil temperature was also recorded at two depths 0 - 15 cm and 15 - 30 cm using soil thermometer during soil moisture determination and expressed in ^{0}C.

3.3.9.2. Physical properties

During both years, pre plant and post harvest soil samples were drawn at a depth of 20 cm from each plot and was analysed for bulk density, particle density and maximum water holding capacity as described by Gupta and Dakshinamoorthy (1980).

3.3.9.3. Chemical properties

The composite soil samples collected prior to field experiments and the soil samples collected from individual plots after the experiment were analysed for organic carbon, available N, available P and available K, Ca and Na content (Jackson, 1973). Soil samples were also analysed for micro nutrients like Fe, Mn, Zn and Cu (Jackson, 1973). The post harvest soil samples collected from every experimental plots were analysed for soil enzymes viz., acid-phosphatase (Tabatabai and Bremner, 1969), cellulase (Panacholi and Rice, 1973) and urease (Tabatabai and Bremner, 1972) and for microbial population viz., bacteric, fungi and actinomycetes (Johnson and Curl, 1972).

3.4. Water use efficiency

Water use efficiency was worked out based on the cane yield ha^{-1} and total depth of irrigation water used during the formative phase and it is expressed as kg ha cm^{-1}. It was computed as shown below:

$$\text{WUE} = \frac{\text{Cane yield (kg ha}^{-1}\text{)}}{\text{Total depth of irrigation water (cm)}}$$

3.5. Economic analysis

The cost of production of all the treatment combinations was worked out on the basis of prevailing input cost and market price of cane (Appendix II, III, IV and V). The benefit cost ratio was computed as shown below:

$$\text{Benefit cost ratio} = \frac{\text{Gross income ha}^{-1}}{\text{Cost of cultivation ha}^{-1}}$$

3.6. Energetics

Energy input through various energy sources like tillage, setts, planting, organic manures, fertilizers, irrigation, weeding and harvesting was calculated by using energy values given in Appendix VI (Pal *et al.*, 1985) and expressed in MJ ha^{-1}. Energy output through economic and biological yields was calculated by using energy values and expressed as MJ ha^{-1}.

$$\text{Energy use efficiency} = \frac{\text{Energy output}}{\text{Energy input}}$$

$$\text{Energy productivity (g MJ}^{-1}\text{)} = \frac{\text{Economic yield}}{\text{Energy input}}$$

3.7. Correlation studies

Simple correlations were worked out between cane yield and yield attributes, growth attributes, nutrient uptake, DMP and also between sugar yield and jaggery yield.

3.8. Statistical analysis

The data generated in the study were statistically analysed following the procedure described by Panse and Sukhatme (1985).

RESULTS

RESULTS

Field investigations were carried out at Sugarcane Research Station, Thiruvalla in Pathanamthitta district, Kerala during the crop season of 1998-'99 (January to January) and 1999-2000 (January to January) with the objective of economising the use of irrigation water in sugarcane through improved surface method of irrigation and to formulate a sustainable production technology by integrating organic, inorganic and biological sources of nutrients for maximum cane yield, juice quality and jaggery recovery. The data generated with respect to growth yield, nutrient uptake, quality, physico-chemical and biological properties of soil were statistically analysed and the results are presented in this chapter.

4.1. Experiment No. I - Standardisation of irrigation management in sugarcane

4.1.1. Growth attributes

4.1.1.1. Plant height (Table 4a and 4b)

The data clearly revealed that the plant height was significantly influenced by methods of irrigation and trash mulching at all stages of growth. However, their interaction effect was significant only at 240 DAP in the first plant crop and at 360 DAP in both the years. The data generated indicated that I_1 registered higher plant height than other treatments. During the first year I_2 was on a par with plant height at 240 and 360 DAP. While in I_3 and I_4 treatments, the plant height was comparatively less during both years of experimentation.

Table 4 a Effect of methods of irrigation and mulching on growth attributes at different stages of growth in first plant crop

Treatment	Plant height (cm) at 120 DAP			Plant height (cm) at 240 DAP			Plant height (cm) at 360 DAP			No. of leaves at 120 DAP			No. of leaves at 240 DAP			No. of leaves at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	142.33	151.67	147.00	272.47	276.60	274.53	285.67	292.53	289.10	9.80	10.13	9.97	9.47	9.93	9.70	8.40	8.73	8.57
I_2	138.00	148.33	143.17	253.47	273.27	263.37	277.13	291.13	284.13	9.33	9.93	9.63	9.33	9.73	9.53	8.20	8.60	8.40
I_3	125.00	134.67	129.83	231.53	252.87	242.20	253.53	273.53	263.53	6.93	7.87	7.40	8.00	8.53	8.27	7.67	7.93	7.80
I_4	129.00	133.33	131.17	242.06	247.67	253.20	255.47	269.73	262.60	7.07	7.40	7.23	8.27	8.47	8.37	7.80	7.93	7.87
Mean	133.58	142.00		249.88	262.60		267.95	281.73		8.28	8.83		8.77	9.17		8.02	8.30	
C.D. (0.05) for (I)			3.11**			11.59**			3.44**			0.03**			0.33**			0.30**
C.D. (0.05) for(M)			2.20**			8.20*			2.44**			0.22**			0.23**			0.21*
C.D. (0.05) for interaction (I x M)			N.S.			16.39*			4.87**			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 4 b **Effect of methods of irrigation and mulching on growth attributes at different stages of growth in second plant crop**

Treatment	Plant height (cm) at 120 DAP			Plant height (cm) at 240 DAP			Plant height (cm) at 360 DAP			No. of leaves at 120 DAP			No. of leaves at 240 DAP			No. of leaves at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	147.87	155.40	151.63	276.07	283.80	279.93	288.93	294.27	291.60	9.73	10.13	9.93	9.13	9.60	9.37	8.47	8.80	8.63
I_2	142.93	153.53	148.23	256.93	280.80	268.87	280.47	293.20	286.83	9.07	9.87	9.47	9.00	9.47	9.23	8.13	8.73	8.43
I_3	127.40	132.73	130.07	241.43	254.93	248.18	258.20	272.67	265.43	7.67	8.07	7.87	8.27	8.67	8.47	7.00	7.93	7.47
I_4	130.27	134.67	132.47	247.00	257.00	252.00	260.60	275.13	283.82	8.07	8.53	8.30	8.33	8.67	8.50	7.33	8.07	7.70
Mean	137.12	144.08		255.36	269.13		272.05	283.82		8.63	9.15		8.68	9.10		7.73	8.38	
C.D. (0.05) for (I)			3.80**			6.32**			2.87**			0.26**			0.32**			0.28**
C.D. (0.05) for (M)			2.69**			4.47*			2.03**			0.18**			0.22**			0.19**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			4.06*			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

The influence of trash mulching on plant height was visible during all the stages of growth in both the years of study. The interaction between methods of irrigation and mulching on plant height was noticed in the later stages of crop growth with maximum height at I_1M_1 and I_2M_1. In general the impact of mulching on plant height was better expressed in lesser irrigated treatments (I_3M_1 and I_4M_1).

4.1.1.2. Number of leaves per cane (Table 4a and 4b)

The data on number of leaves per cane revealed that the methods of irrigation have influenced this character at all stages of growth. However, their interactions did not exert any appreciable influence on leaf production.

Both the years of study the number of leaves produced was higher in I_1 and I_2 at all stages of growth as compared to I_3 and I_4. The effect was very evident in the early stages of crop growth.

The beneficial effect of trash mulching on leaf number was noticed at all stages of growth in both years. Like plant height the benefit of mulching on leaves per cane was better expressed at lesser irrigated treatments.

4.1.1.3. Number of nodes per cane (Table 5a and 5b)

The results revealed that the number of nodes were significantly influenced by methods of irrigation and trash mulching at all stages of growth in both plant crops. But the interaction effect was noticeable only at 360 DAP in second plant crop.

At all stages of growth in both years, irrigation at all furrow method (I_1) recorded the highest number of nodes per cane and was on par with alternate furrow irrigation (I_2). The skip furrow (I_3) and the farmer's methods of irrigation registered lesser number of nodes per cane at all stages of growth. The trash mulch (M_1)

Table 5 a Effect of methods of irrigation and mulching on growth attributes at different stages of growth in first plant crop

Treatment	No. of nodes at 120 DAP			No. of nodes at 240 DAP			No. of nodes at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	7.67	7.87	7.77	24.00	24.60	24.30	28.40	29.93	29.17
I_2	7.27	7.73	7.50	23.40	24.47	23.93	27.60	29.27	28.43
I_3	6.80	7.27	7.03	21.13	23.67	22.40	24.20	27.40	25.80
I_4	6.53	7.33	6.93	22.60	23.27	22.93	25.20	26.73	25.97
Mean	7.07	7.55		22.78	24.00		26.35	28.33	
C.D. (0.05) for (I)			0.45**			0.86**			1.20**
C.D. (0.05) for (M)			0.31**			0.61**			0.85**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S.- Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 5 b Effect of methods of irrigation and mulching on growth attributes at different stages of growth in second plant crop

Treat-ment	No. of nodes at 120 DAP			No. of nodes at 240 DAP			No. of nodes at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	7.73	7.93	7.83	24.67	25.07	24.87	29.00	30.93	29.97
I_2	7.33	7.73	7.53	24.07	24.87	24.47	28.13	30.13	29.13
I_3	6.80	7.13	6.97	21.80	23.53	22.67	22.27	27.67	26.47
I_4	6.87	7.33	7.10	23.00	23.87	23.43	25.60	27.80	26.70
Mean	7.18	7.53		23.38	24.33		27.00	29.13	
C.D. (0.05) for (I)			0.28**			0.74**			0.49**
C.D. (0.05) for (M)			0.19**			0.52**			0.35**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.70*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

exerted an appreciable increase in number of nodes per cane at all stages of growth in both the years. The interaction effect between I and M was noticed only at 360 DAP in the second year. The treatments viz., I_1M_1 and I_2M_1 recorded maximum number of nodes per cane and was superior to the same irrigation treatment without mulch. The treatment I_2M_1 registered a significant increase over I_1M_0. The effect was more pronounced at lesser irrigation with mulch as compared to the unmulched situation.

4.1.1.4. Dry matter production by trash at 120, 240 and 360 DAP (Table 6a and 6b)

The data indicated that the analysis of variance for DMP by trash was significantly affected by methods of irrigation and trash mulching. The interaction was significant only at 240 DAP in first plant crop.

A critical review of the data of the first and second plant crops had shown that all furrow method (I_1) recorded the highest DMP by trash and was significantly superior to other methods of irrigation at all stages of growth. The alternate furrow irrigation (I_2) also showed its superiority in DMP to I_3 and I_4 in both years of study. The skip furrow irrigation (I_3) recorded the lowest value throughout the growth with respect to this character with minor variation only at 120 DAP during the second plant crop.

The impact of mulching was visible at all stages of plant growth with respect to DMP by trash. Although, the interaction effect between I x M was noticeable only during 240 DAP in the second plant crop, a numerical variation of DMP by trash was noticed at I_1M_1 and I_2M_1 throughout the experimentation.

Table 6 a Effect of methods of irrigation and mulching on DMP by trash and green tops at different stages of growth in first plant crop

Treatment	DMP by trash at 120 DAP (t ha^{-1})			DMP by trash at 240 DAP (t ha^{-1})			DMP by trash at 360 DAP (t ha^{-1})			DMP by green tops at 120 DAP (t ha^{-1})			DMP by green tops at 240 DAP (t ha^{-1})			DMP by green tops at 360 DAP (t ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.22	1.32	1.27	5.70	6.44	6.07	5.20	5.74	5.47	7.55	8.04	7.79	5.63	6.33	5.98	3.97	4.49	4.23
I_2	1.11	1.28	1.20	5.25	6.29	5.77	4.86	5.44	5.15	7.10	7.83	7.46	5.42	6.06	5.74	3.71	4.33	4.02
I_3	0.89	1.01	0.95	3.86	4.35	4.11	3.61	3.79	3.70	4.17	5.54	4.86	4.52	4.92	4.72	2.74	3.19	2.97
I_4	0.93	1.01	0.97	4.15	4.43	4.29	3.65	3.99	3.82	4.49	6.01	5.25	4.73	5.13	4.93	2.93	3.32	3.13
Mean	1.04	1.15		4.74	5.38		4.33	4.74		5.83	6.86		5.07	5.61		3.34	3.84	
C.D. (0.05) for (I)			0.06**			0.19**			0.16**			0.34**			0.11**			0.16**
C.D. (0.05) for (M)			0.04**			0.14**			0.11**			0.24**			0.07**			0.11**
C.D. (0.05) for interaction (I x M)			N.S.			0.27**			N.S.			0.49*			0.15*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 6 b Effect of methods of irrigation and mulching on DMP by trash and green tops at different stages of growth in second plant crop

Treatment	DMP by trash at 120 DAP ($t\ ha^{-1}$)			DMP by trash at 240 DAP ($t\ ha^{-1}$)			DMP by trash at 360 DAP ($t\ ha^{-1}$)			DMP by green tops at 120 DAP ($t\ ha^{-1}$)			DMP by green tops at 240 DAP ($t\ ha^{-1}$)			DMP by green tops at 360 DAP ($t\ ha^{-1}$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.42	1.54	1.48	5.89	6.46	6.18	4.73	5.14	4.94	7.59	7.99	7.79	6.47	7.12	6.79	5.18	5.83	5.51
I_2	1.30	1.43	1.37	5.52	6.20	5.86	4.52	4.94	4.73	7.24	7.81	7.52	5.90	6.85	6.38	4.91	5.61	5.26
I_3	0.98	1.19	1.19	4.25	4.91	4.58	3.85	4.08	3.97	5.21	6.59	5.90	4.96	5.42	5.19	3.68	4.49	4.08
I_4	1.11	1.18	1.18	4.46	5.15	4.81	3.91	4.25	4.08	5.76	6.90	6.33	5.27	5.76	5.52	4.35	4.73	4.54
Mean	1.20	1.34	1.34	5.03	5.68		4.26	4.60		6.45	7.32		5.65	6.29		4.53	5.16	
C.D. (0.05) for (I)			0.13**			0.21**			0.18**			0.44**			0.30**			0.32**
C.D. (0.05) for (M)			9.28**			0.15**			0.12**			0.31**			0.21**			0.23**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

4.1.1.5. Dry matter production by green tops at 120, 240 and 360 DAP (Table 6a and 6b)

The data recorded indicated that treatment variation due to methods of irrigation and trash mulching were significant at all stages of growth. However, their interaction effect was significant only at 120 and 240 DAP in the first plant crop.

Among the methods of irrigation, all furrow irrigation (I_1) gave maximum DMP by green tops and was superior to other methods of irrigation. The alternate furrow method of irrigation (I_2) produced the second highest DMP by green tops. The lowest DMP by greentops was found with skip furrow irrigation (I_3). While trash mulching (M_1) registered significantly higher DMP of green tops as compared to unmulched treatment (M_0). The interaction effects showed that only during the first plant crop it was significant at 120 and 240 DAP. The treatment combination of I_1M_1 produced maximum DMP by greentops. However, it was on par with I_2M_1 at 120 DAP and varied significantly at 240 DAP. While I_3M_0 and I_4M_0 recorded comparatively lower values at all stages of growth.

4.1.1.6. Dry matter production by stem at 120, 240 and 360 DAP (Table 7a and 7b)

The data generated revealed that methods of irrigation and trash mulching had exerted significant influence on DMP by stem in both plant crops. But their interaction was significant only at 120 DAP in second plant crop.

The results indicated that all furrow irrigation (I_1) recorded significantly superior values for DMP by stem as compared to other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). Dry matter production by stem was highest with trash mulching (M_1) and it was significantly superior to unmulched treatment (M_0). The interaction was significant at 120 DAP in the second plant crop

Table 7 a Effect of methods of irrigation and mulching on DMP at different stages of growth in first plant crop

Treatment	DMP by stem at 120 DAP (t ha^{-1})			DMP by stem at 240 DAP (t ha^{-1})			DMP by stem at 360 DAP (t ha^{-1})			Total DMP at 120 DAP (t ha^{-1})			Total DMP at 240 DAP (t ha^{-1})			Total DMP at 360 DAP (t ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	9.68	10.36	10.02	38.65	41.17	39.91	42.42	46.36	44.39	18.47	19.74	19.10	49.98	53.95	51.97	51.57	55.65	53.61
I_2	8.55	10.08	9.32	37.15	40.15	38.65	40.88	44.59	42.74	16.77	19.19	17.98	47.82	52.79	50.31	49.43	54.38	51.91
I_3	5.04	6.23	5.63	31.83	35.02	33.42	35.09	38.32	36.71	10.10	12.76	11.43	40.22	44.29	42.26	41.17	45.46	43.32
I_4	5.52	6.65	6.09	33.09	35.84	34.47	35.71	39.02	37.36	10.96	13.65	12.30	41.98	45.46	43.72	42.30	46.30	44.30
Mean	7.20	8.33		35.18	38.04		38.52	42.07		14.07	16.33		45.00	49.13		46.12	50.45	
C.D. (0.05) for (I)			0.57**			1.00**			1.32**			0.89**			1.02**			1.29**
C.D. (0.05) for (M)			0.40**			0.70**			0.93**			0.62**			0.72**			0.91**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 7 b   Effect of methods of irrigation and mulching on DMP at different stages of growth in second plant crop

Treatment	DMP by stem at 120 DAP (t ha^{-1})			DMP by stem at 240 DAP (t ha^{-1})			DMP by stem at 360 DAP (t ha^{-1})			Total DMP at 120 DAP (t ha^{-1})			Total DMP at 240 DAP (t ha^{-1})			Total DMP at 360 DAP (t ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	9.53	10.41	9.97	39.27	42.01	40.64	44.76	46.35	45.56	18.54	19.96	19.25	51.64	55.60	53.62	54.69	58.43	56.56
I_2	7.74	10.20	8.97	37.32	41.32	39.32	40.62	45.65	43.13	16.15	19.45	17.80	48.77	54.38	51.58	50.65	57.34	53.99
I_3	5.31	6.39	5.85	31.82	34.79	33.30	33.53	37.60	35.56	11.54	14.05	12.79	41.05	45.22	43.13	42.40	47.03	44.71
I_4	5.80	7.00	6.40	32.56	35.95	34.26	35.32	38.88	37.10	12.68	15.16	13.92	42.30	46.26	44.28	44.76	48.76	46.76
Mean	7.10	8.50		35.24	38.52		38.56	42.12		14.73	17.15		45.94	50.37		48.13	52.89	
C.D. (0.05) for (I)			0.26**			0.77**			0.87**			0.59**			1.25**			1.09**
C.D. (0.05) for (M)			0.18**			0.54**			0.61**			0.42**			0.88**			0.76**
C.D. (0.05) for interaction (I x M)			0.37**			N.S.			0.23**			0.84*			N.S.			1.54*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

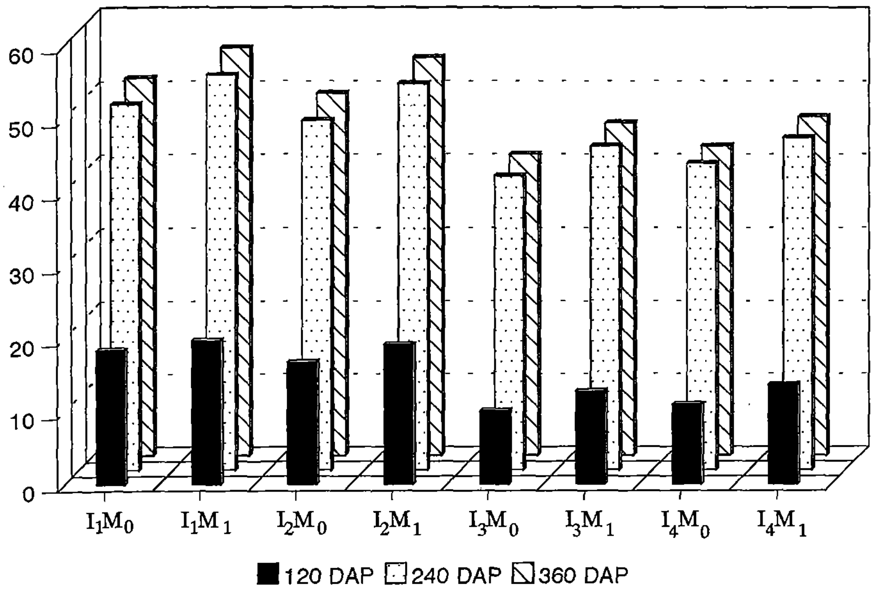


Fig. 3a. Total DMP as influenced by methods of irrigation and trash mulching during first plant crop

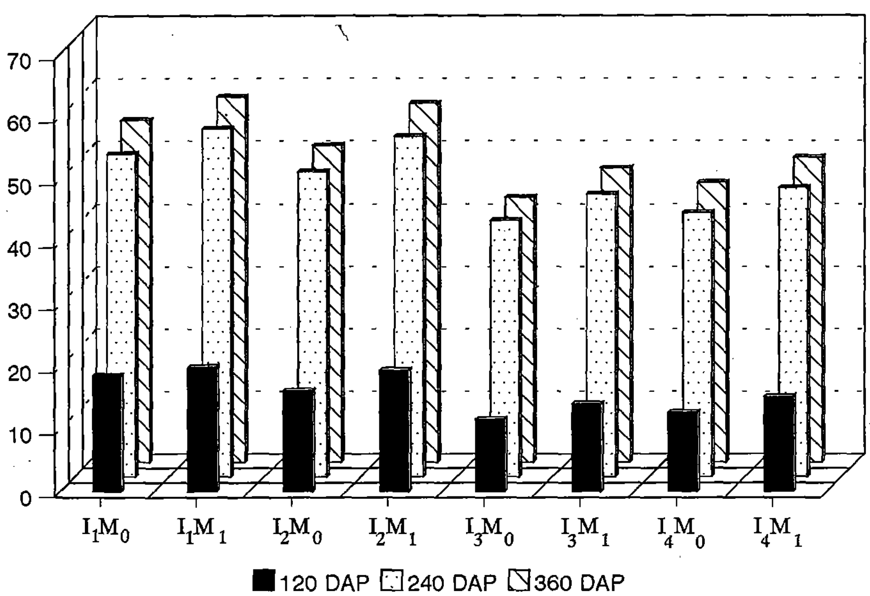


Fig. 3b. Total DMP as influenced by methods of irrigation and trash mulching during second plant crop

and I_1M_1 and I_2M_1 recorded comparatively higher values than other treatment combinations. The lowest DMP by stem was associated with I_3M_0 and I_4M_0.

4.1.1.7. Total dry matter production at 120, 240 and 360 DAP (Table 7a, 7b and Fig. 3a and 3b)

The results revealed that the analysis of variance for total DMP was significantly influenced by methods of irrigation and trash mulching at all stages of growth. But the interaction between I x M was significant only at 120 and 360 DAP in second plant crop alone.

Among the irrigation treatments, all furrow irrigation (I_1) produced highest DMP and was significantly superior to all other methods of irrigation. It was followed by alternate furrow irrigation (I_2) with a remarkable differences with that of farmer's practice (I_4) and skip furrow method of irrigation (I_3). While in mulching M_1 had a profound increase in dry matter over M_0. The interactions between I x M was noticed only during the second plant crop.

4.1.1.8. Germination percentage (Table 8a and 8b)

The data indicated that methods of irrigation, trash mulching or their interaction effects had not influenced the germination of crop in both the years of study.

4.1.1.9. Tiller count at 90 DAP (Table 8a and 8b)

The results have indicated that the tiller count at 90 DAP was significantly influenced by methods of irrigation and trash mulching in both plant crops. However, their interactions were not significant in both years of experimentation.

A critical review of the data revealed that all furrow irrigation (I_1) recorded the highest number of tillers and was superior to alternate furrow (I_2) and farmer's practice of irrigation (I_4). The skip furrow method (I_3) recorded the lowest number of tillers. The trash mulching (M_1) also showed its superiority in tiller production to unmulched treatment (M_0).

4.1.1.10. Shoot count at 120 DAP (Table 8a and 8b)

The data revealed that treatment effects due to methods of irrigation and trash mulching were significant, while interaction was significant only in first plant crop.

The results of the first and second plant crops showed that all furrow irrigation (I_1) had increased the number of shoots and recorded the highest value. It was closely followed by alternate furrow irrigation (I_2). Skip furrow irrigation (I_3) produced the lowest number of shoots. With regard to mulching, M_1 registered maximum number of shoots and was remarkably superior to M_0. Among the treatment combinations I_1M_1 was statistically on par with I_2M_1 and was superior to other treatment combination during the first year of study.

4.1.1.11. Shoot count at 180 DAP (Table 8a and 8b)

The data generated revealed that methods of irrigation and trash mulching had a significant influence on the shoot count. But their interactions were not significant in both plant crops.

The results of first and second plant crops revealed that I_1 recorded maximum number of shoots followed by I_2. In the first year, both I_1 and I_2 were on par. The lowest shoot count was associated with I_3. While in mulching treatments, M_1 produced higher shoot count and was significantly superior to M_0.

4.1.1.12. Cane formed shoots at 240 DAP (Table 8a and 8b)

The data revealed that cane formed shoots were significantly influenced by methods of irrigation and trash mulching. However, their interaction was not significant.

Table 8 a Effect of methods of irrigation and mulching on germination, tillering and shoot count at different stages of growth in first plant crop

Treatment	Germination (%) at 30 DAP			Tiller count ('000) at 90 DAP			Shoot count ('000) at 120 DAP			Shoot count ('000) at 180 DAP			Cane formed shoots ('000) at 240 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	64.22	63.92	64.07	126.29	128.88	127.59	110.24	114.32	112.28	102.84	106.54	104.69	101.23	105.18	103.21
I_2	64.15	63.94	64.04	121.23	127.28	124.26	106.66	112.09	109.38	99.38	104.69	102.03	99.00	103.70	101.35
I_3	63.92	64.11	64.02	113.45	117.65	115.55	98.39	103.08	100.74	91.11	97.52	94.32	90.95	96.04	93.50
I_4	64.22	63.85	64.03	115.80	118.26	117.03	100.49	104.69	102.59	94.32	97.28	95.80	93.60	96.66	95.13
Mean	64.13	63.95		119.19	123.02		103.95	108.55		96.91	101.51		96.20	100.40	
C.D. (0.05) for (I)			N.S.			1.16**			2.27			2.38**			1.78**
C.D. (0.05) for (M)			N.S.			1.16**			1.60			1.69**			1.26**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			3.21			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 8 b Effect of methods of irrigation and mulching on germination, tillering and shoot count at different stages of growth in second plant crop

Treatment	Germination (%) at 30 DAP			Tiller count ('000) at 90 DAP			Shoot count ('000) at 120 DAP			Shoot count ('000) at 180 DAP			Cane formed shoots ('000) at 240 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	63.48	63.40	63.44	126.91	128.64	127.77	105.43	107.77	106.60	102.59	106.54	104.56	100.49	105.30	102.90
I_2	63.55	63.77	63.66	123.58	128.66	125.86	101.35	107.40	104.38	98.51	105.30	101.91	96.78	103.95	100.37
I_3	63.92	63.92	63.92	114.19	117.52	115.86	93.45	99.13	96.29	92.10	95.30	93.70	89.75	92.84	91.29
I_4	63.40	63.77	63.59	114.32	119.13	116.72	94.32	99.38	96.85	93.08	97.15	95.12	90.98	94.93	92.96
Mean	63.59	63.72		119.75	123.39		98.64	103.42		96.57	101.07		94.50	99.26	
C.D. (0.05) for (I)			N.S.			2.18**			1.91**			1.85**			1.86**
C.D. (0.05) for (M)			N.S.			1.54**			1.35**			1.31**			1.31**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

In the first and second plant crops, I_1 registered significantly superior values for cane formed shoots and it was followed by I_2, I_4 and I_3. The lowest cane formed shoots were with I_3. In the case of trash mulching M_1 registered significantly higher values as compared to M_0.

4.1.2. Growth analysis

4.1.2.1. Leaf area index at 120, 240 and 360 DAP (Table 9a and 9b)

The data revealed that treatments varied significantly with methods of irrigation and trash mulching in both plant crops. However, the interactions were significant only at 360 DAP in first and at 120 and 360 DAP in second plant crops. In general, the LAI decreased progressively after 120 DAP and reached the minimum values at the time of harvest.

The results obtained from first and second plant crops revealed that all furrow irrigation (I_1) gave enhanced LAI and recorded significantly superior values at all stages of growth over other treatments. It was closely followed by alternate furrow irrigation (I_2). The lowest value was noticed with skip furrow irrigation (I_3). LAI was reduced significantly in M_0 as compared to M_1. The interaction effect at 360 DAP in first plant crop and at 120 and 360 DAP in second plant crop revealed that I_1M_1 recorded the highest LAI and it was followed by I_2M_1. The LAI was reduced considerably in I_3M_0 and I_4M_0.

4.1.2.2. Leaf area ratio at 120, 240 and 360 DAP (Table 9a and 9b)

The data revealed that the methods of irrigation and trash mulching was significant at all stages of observation. However, the interaction effect was significant only at 360 DAP in first and second plant crops.

Table 9 a Effect of methods of irrigation and mulching on growth indices at different stages of growth in first plant crop

Treatment	Leaf area index at 120 DAP			Leaf area index at 240 DAP			Leaf area index at 360 DAP			Leaf area ratio at 120 DAP ($cm^2 g^{-1}$)			Leaf area ratio at 240 DAP ($cm^2 g^{-1}$)			Leaf area ratio at 360 DAP ($cm^2 g^{-1}$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	5.15	5.76	5.45	3.82	4.34	4.08	1.71	2.02	1.86	28.21	29.35	28.78	7.70	8.09	7.90	3.32	3.63	3.48
I_2	4.70	5.40	5.05	3.62	4.17	3.89	1.47	1.96	1.72	28.15	28.85	28.50	7.58	7.94	7.76	3.00	3.64	3.32
I_3	2.58	3.46	3.02	2.40	2.97	2.68	1.05	1.26	1.15	25.74	27.34	26.54	6.01	6.74	6.37	2.99	2.75	2.87
I_4	2.90	3.76	3.33	2.60	3.09	2.84	1.14	1.31	1.22	26.58	27.77	27.17	6.24	6.82	6.53	2.71	2.85	2.787
Mean	3.83	4.59		3.11	3.64		1.34	1.64		27.17	28.33		6.88	7.40		3.00	3.22	
C.D. (0.05) for (I)			0.27**			0.13**			0.09**			0.93**			0.25**			0.25**
C.D. (0.05) for (M)			0.19**			0.09**			0.07**			0.66**			0.18**			0.18*
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.14*			N.S.			N.S.			0.36*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 9 b Effect of methods of irrigation and mulching on growth indices at different stages of growth in second plant crop

Treatment	Leaf area index at 120 DAP			Leaf area index at 240 DAP			Leaf area index at 360 DAP			Leaf area ratio at 120 DAP ($cm^2 g^{-1}$)			Leaf area ratio at 240 DAP ($cm^2 g^{-1}$)			Leaf area ratio at 360 DAP ($cm^2 g^{-1}$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	4.94	5.51	5.22	3.61	4.28	3.94	1.76	2.11	1.93	26.89	27.37	27.13	7.40	7.86	7.63	3.16	3.54	3.35
I_2	4.31	5.30	4.80	3.44	4.09	3.76	1.49	2.05	1.77	27.77	27.25	27.51	7.27	7.72	7.50	2.87	3.53	3.20
I_3	2.79	3.70	3.25	2.51	2.99	2.75	0.98	1.28	1.13	21.49	23.67	22.58	5.79	6.38	6.08	2.46	2.66	2.56
I_4	3.15	3.94	3.54	2.61	3.12	2.86	1.09	1.35	1.22	21.51	23.75	22.63	6.02	6.46	6.24	2.54	2.71	2.62
Mean	3.80	4.61		3.04	3.62		1.33	1.70		24.41	25.51		6.62	7.10		2.76	3.11	
C.D. (0.05) for (I)			0.14**			0.14**			0.10**			1.39**			0.24**			0.19**
C.D. (0.05) for (M)			0.09**			0.10**			0.07**			0.98*			0.17**			0.13*
C.D. (0.05) for interaction (I x M)			0.19*			N.S.			0.15*			N.S.			N.S.			0.36*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

At all stages of first and second plant crops, all furrow irrigation (I_1) gave the highest LAR. A comparable value was noticed with alternate furrow irrigation (I_2) also. However, skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4) gave lower values for LAR. Like other growth characters, mulching treatment (M_1) gave a positive influence over unmulched treatment (M_0) in LAR at all stages of growth. The interaction effect between I x M was noticed at the harvesting stage with highest values at I_1M_1 and I_2M_1.

4.1.2.3. Specific leaf area ratio at 120, 240 and 360 DAP (Table 10a and 10b)

The data revealed that treatment variation due to methods of irrigation and trash mulching were significant at 120 and 240 DAP in first and at all stages of growth in second plant crop. The interaction effect was significant only at 360 DAP in second plant crop.

The results of the study revealed that all furrow irrigation gave the highest SLA at all stages of growth. Except in the last stage of second plant crop, alternate furrow irrigation (I_2) produced comparable SLA values. Lower SLA values were noticed with farmer's practice (I_4) and skip furrow irrigation (I_3) and they were on par with each other. The mulching treatment (M_1) always showed a higher SLA value over no mulching (M_0). The interaction effect was noticed only at the later part of crop growth in the second plant crop. The treatment combination of I_1M_1 and I_2M_1 recorded higher SLA values over other treatment combinations.

4.1.2.4. Crop growth rate between 120 to 240 DAP and 240 to 360 DAP (Table 10a, 11a, 10b and 11b)

A perusal of the data indicated that CGR was significantly affected by methods of irrigation and trash mulching in first and second plant crops.

Table 10 a Effect of methods of irrigation and mulching on growth indices at different stages of growth in first plant crop

Treatment	SLA at 120 DAP ($cm^2 g^{-1}$)			SLA at 240 DAP ($cm^2 g^{-1}$)			SLA at 360 DAP ($cm^2 g^{-1}$)			Crop growth rate between 120 and 240 DAP ($g m^{2-1} d^{-1}$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	72.55	75.82	74.19	75.80	77.07	76.44	49.85	48.74	49.29	26.15	28.74	27.44
I_2	69.87	74.29	72.08	73.99	76.81	75.40	40.35	49.90	45.12	25.77	28.22	27.00
I_3	65.67	67.55	66.61	58.48	66.36	62.42	44.99	46.27	45.63	24.96	26.19	25.57
I_4	67.63	65.85	66.74	60.67	66.36	63.53	45.47	46.54	46.00	25.65	26.48	26.06
Mean	68.93	70.88		60.23	71.66		45.16	47.86		25.63	27.40	
C.D. (0.05) for (I)			2.53**			3.07**			N.S.			0.62**
C.D. (0.05) for (M)			1.79*			2.17**			N.S.			0.43**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			0.87*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 10 b Effect of methods of irrigation and mulching on growth indices at different stages of growth in second plant crop

Treatment	SLA at 120 DAP ($cm^2\ g^{-1}$)			SLA at 240 DAP ($cm^2\ g^{-1}$)			SLA at 360 DAP ($cm^2\ g^{-1}$)			Crop growth rate between 120 and 240 DAP ($g\ m^{2-1}\ d^{-1}$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	70.44	75.10	72.56	60.52	64.86	62.69	40.66	44.11	42.39	27.42	29.63	28.52
I_2	66.51	73.94	70.22	63.44	64.67	64.05	37.00	43.50	40.25	27.07	28.90	27.98
I_3	58.31	60.00	59.15	55.11	60.25	57.68	33.08	34.71	33.90	24.60	25.68	25.14
I_4	59.14	62.14	60.64	54.18	59.60	56.89	30.85	34.07	32.46	24.46	26.36	25.41
Mean	63.50	67.79		58.31	62.35		35.40	39.10		25.89	27.64	
C.D. (0.05) for (I)			3.43**			3.93**			1.68**			0.88**
C.D. (0.05) for (M)			2.42*			2.78**			1.19**			0.62*
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			2.38*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 11 a Effect of methods of irrigation and mulching on growth indices at different stages of growth in first plant crop

Treat-ment	Crop growth rate between 240 and 360 DAP (g m^{2-1} d^{-1})			Net asimilation rate between 120 and 240 DAP (mg dm^{2-1} d^{-1})			Net assimilation rate between 240 and 360 DAP (mg dm^{2-1} d^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.68	1.25	1.47	27.79	26.76	27.27	5.02	4.93	4.97
I_2	1.30	1.26	1.28	35.05	27.28	31.16	5.32	4.84	5.08
I_3	0.75	0.86	0.81	46.15	37.59	41.87	3.63	4.64	4.14
I_4	0.30	0.57	0.43	39.75	35.74	37.75	3.77	4.08	3.92
Mean	1.01	0.99		37.19	31.84		4.44	4.62	
C.D.(0.05) for (I)			0.72*			5.6**			N.S.
C.D.(0.05) for (M)			N.S.			3.96*			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 11 b Effect of methods of irrigation and mulching on growth indices at different stages of growth in second plant crop

Treat-ment	Crop grown between 240 and 360 DAP (g m^{2-1} d^{-1})			Net asimilation rate between 120 and 240 DAP (mg dm^{2-1} d^{-1})			Net assimilation rate between 240 and 360 DAP (mg dm^{2-1} d^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	2.52	2.17	2.35	29.51	26.96	28.23	5.75	4.88	5.31
I_2	2.11	2.64	2.38	30.74	27.75	29.24	5.67	5.15	5.41
I_3	1.02	1.31	1.16	41.11	33.87	37.49	4.69	4.75	4.72
I_4	2.11	1.41	1.75	35.94	35.62	35.78	6.41	4.59	5.50
Mean	1.94	1.88		34.32	31.05		5.63	4.84	
C.D.(0.05) for (I)			0.57**			2.38**			N.S.
C.D.(0.05) for (M)			N.S.			1.68*			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			3.37*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

The interaction effect was noticed only in first plant crop between 120 and 240 DAP. In general CGR declines after 240 DAP during both the plant crops.

The CGR was positively influenced by methods of irrigation between 120 and 240 DAP and 240 to 360 DAP. The treatments I_1 and I_2 accounted significantly higher CGR values than I_4 and I_3 and were on par with each other. The effect of mulching on CGR was evident only between 120 to 240 DAP and superior values were recorded with M_1. The interaction effect noticed in first plant crop between 120 to 240 DAP revealed that the treatment combinations of I_1M_1 and I_2M_1 had recorded higher values for CGR as compared to other treatment combinations.

4.1.2.5. Net assimilation rate between 120 to 240 DAP and 240 to 360 DAP (Table 11a and 11b)

The data revealed that treatment effects on NAR between 120 to 240 DAP due to method of irrigation and trash mulching were significant in both plant crops. However, the interaction effect was significant only in second plant crop. The results revealed that the impact of treatments on NAR between 240 to 360 DAP was not significant in both plant crops.

The data generated in first and second plant crop showed that skip furrow irrigation (I_3) had registered maximum values for NAR and it was on par with farmer's practice of irrigation. In the case of mulching, M_0 had shown the highest value for NAR and was significantly superior to M_1. The interaction between I x M in the second plant crop revealed that I_3M_0 and I_4M_0 recorded comparatively higher values for NAR between 120 to 240 DAP.

4.1.3. Yield attributes

4.1.3.1. Millable cane count at 360 DAP (Table 12a and 12b)

The data had shown that the treatment variation due to methods of irrigation and trash mulching were significant in both plant crops. However, their interaction effect was not significant.

The results of first and second plant crops revealed that all furrow irrigation (I_1) had a positive influence on number of millable canes and it was significantly superior to other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). The lowest number of millable cane was associated with skip furrow irrigation (I_3). While in mulching, trash application (M_1) registered maximum number of millable canes as compared to unmulched treatment (M_0). Although the interaction was not significant, I_1M_1 and I_2M_1 gave more number of millable canes as compared to other treatment combinations.

4.1.3.2. Cane girth (Table 12a, 12b and Fig. 4a and 4b)

The results revealed that treatment variation due to methods of irrigation and trash mulching were significant at all stages of growth. However, the interaction was significant only at 120 and 240 DAP in first plant crop and at 120 DAP in second plant crop.

Among the irrigation methods tried, all furrow irrigation (I_1) invariably showed its superiority in cane girth at all stages of observation in both years of study. The skip furrow (I_3) and the farmer's methods of irrigation was inferior in attaining cane girth as compared to all (I_1) and alternate furrow irrigation (I_2). Like other growth characters, the beneficial effect of trash mulch (M_1) on cane girth was noticed at all stages of crop growth. The interaction effect between I and M noticed in the earlier part of crop growth was levelled off before the harvest.

Table 12 a Effect of methods of irrigation and mulching on yield attributes in first plant crop

Treat-ment	Millable cane count ('000) at 360 DAP			Cane length (cm) at 360 DAP			Cane girth (cm) at 120 DAP			Cane girth (cm) at 240 DAP			Cane girth (cm) at 360 DAP			Single cane weight (g) at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	97.15	100.49	98.82	249.47	254.07	251.77	8.45	9.02	8.73	9.42	9.49	9.46	9.47	9.56	9.52	1119.25	1147.67	1133.46
I_2	95.06	99.13	97.09	244.20	253.40	248.80	8.33	8.80	8.56	9.24	9.43	9.34	9.31	9.57	9.44	1080.33	1145.00	1112.67
I_3	89.50	92.96	91.23	226.47	238.13	232.30	8.13	8.28	8.20	8.61	9.18	8.89	8.92	9.26	9.09	1015.33	1146.67	1031.00
I_4	90.12	93.21	91.66	228.13	235.20	231.67	8.17	8.17	8.17	8.75	9.11	8.93	9.04	9.22	9.13	1016.58	1032.50	1027.54
Mean	92.96	96.45		237.07	245.20		8.27	8.57		9.00	9.30		9.19	9.40		1057.88	1092.96	
C.D. (0.05) for (I)			1.57**			5.63**			0.09**			0.14**			0.09**			20.88 **
C.D. (0.05) for (M)			1.11**			3.98**			0.06**			0.10**			0.06**			14.76**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.13**			0.20*			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 12 b Effect of methods of irrigation and mulching on yield attributes in second plant crop

Treatment	Millable cane count ('000) at 360 DAP			Cane length (cm) at 360 DAP			Cane girth (cm) at 120 DAP			Cane girth (cm) at 240 DAP			Cane girth (cm) at 360 DAP			Single cane weight (g) at 360 DAP		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	98.14	102.71	100.43	250.57	256.93	253.75	8.50	9.12	8.81	9.43	9.54	9.49	9.56	9.64	9.60	1115.67	1127.00	1121.33
I_2	94.44	101.48	97.96	245.80	255.00	250.40	8.38	9.04	8.71	9.32	9.48	9.40	9.42	9.60	9.51	1104.67	1125.67	1115.17
I_3	88.02	92.47	90.24	229.87	239.93	234.90	8.16	8.23	8.20	8.79	9.10	8.94	9.08	9.28	9.18	1024.33	1052.67	1038.50
I_4	89.13	93.95	91.54	240.33	240.60	240.47	8.24	8.33	8.29	8.81	9.31	9.06	9.14	9.34	9.24	1032.33	1071.00	1051.67
Mean	92.43	97.65		241.64	248.12		8.32	8.68		9.09	9.36		9.30	9.47		1069.25	1094.08	
C.D. (0.05) for (I)			1.57**			5.33**			0.091**			0.221**			0.145**			6.73**
C.D. (0.05) for (M)			1.11**			3.77**			0.065**			0.156**			0.103**			4.76**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.129**			N.S.			N.S.			9.52**

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

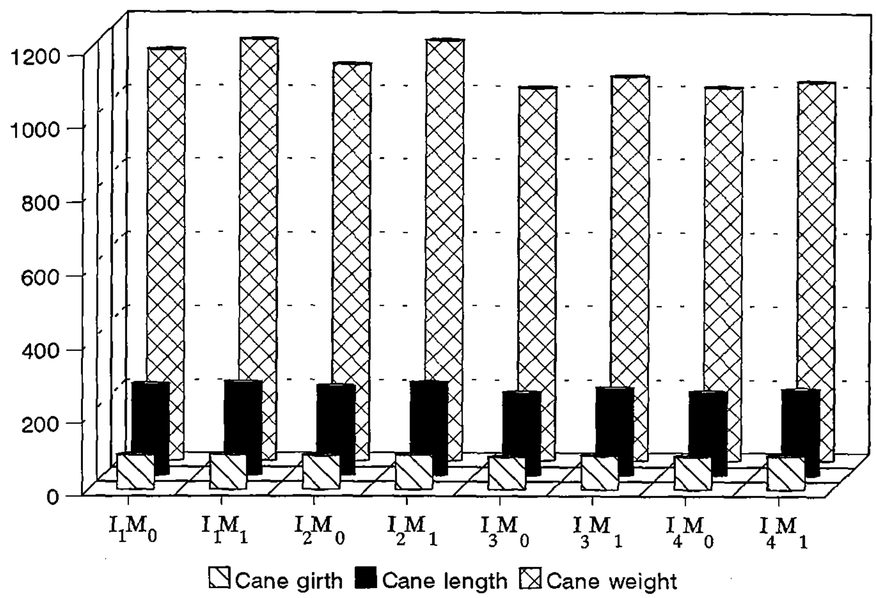


Fig. 4a. Yield attributes as influenced by methods of irrigation and trash mulching during first plant crop

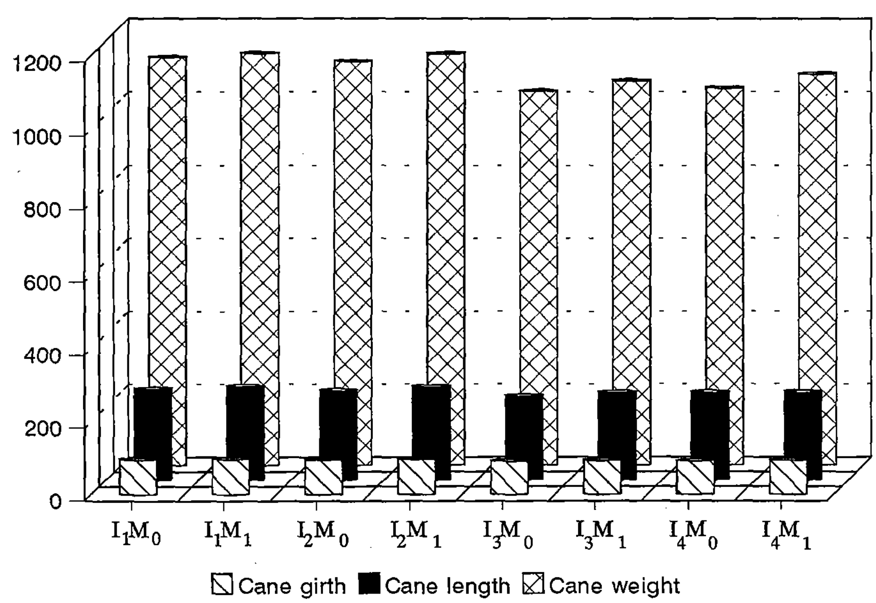


Fig. 4b. Yield attributes as influenced by methods of irrigation and trash mulching in second plant crop

4.1.3.3. Cane length at 360 DAP (Table 12a, 12b and Fig. 4a and 4b)

A critical review of the data revealed that analysis of variance for cane length was appreciably influenced by methods of irrigation and trash mulching in both plant crops.

A perusal of the data showed that all furrow irrigation (I_1) and alternate furrow irrigation (I_2) was on par in cane length and was significantly superior to other methods of irrigation. While skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4) had maintained statistical parity. In the case of trash mulching M_1 recorded taller plants and registered a remarkable difference in cane length over M_0.

4.1.3.4. Single cane weight at 360 DAP (Table 12a, 12b and Fig.4a and 4b)

The data revealed that treatment variation due to methods of irrigation and trash mulching was significant. However, their interaction had exerted significant effects only in second plant crop.

Among the methods of irrigation, all furrow irrigation (I_1) registered maximum single cane weight and was on par with alternate furrow irrigation (I_2). Single cane weight was found lowest with farmer's practice of irrigation (I_4) and skip furrow irrigation (I_3). In the case of trash mulching M_1 recorded greater values as compared to M_0. The interaction effect was noticed only during the second plant crop with heavier canes in I_1M_1 and I_2M_1.

4.1.4. Yield

4.1.4.1. Cane yield (Table 13a, 13b, 14 and Fig.5a and 5b)

The data indicated that cane yield was significantly influenced by methods of irrigation, trash mulching and their interactions in both plant crops.

The results of first and second plant crops revealed that all furrow irrigation (I_1) produced significantly higher cane yield than all other methods of irrigation. It was followed by alternate furrow irrigation (I_2) which again recorded an appreciable variation over skip furrow (I_3) and farmer's practice of irrigation (I_4). In the case of trash mulching, M_1 recorded higher cane yield and was remarkably superior to M_0. The interaction effect between I and M revealed that I_1M_1 and I_2M_1 showed enhanced cane yield over other treatment combinations. It was followed by I_1M_0 which recorded higher cane yield than I_2M_0, I_4M_1 and I_3M_1.

A critical review of the pooled analysis revealed that cane yield was significantly influenced by methods of irrigation, trash mulching and their interactions. There was statistical significance for the cane yield obtained in 1998-'99 and 1999-2000. However, neither the methods of irrigation nor the trash mulching and their interactions over the years were significant.

The results of the pooled analysis had indicated that all furrow irrigation (I_1) remarkably increased the cane yield and it was followed by alternate furrow irrigation (I_2). Skip furrow (I_3) and farmer's practice of irrigation (I_4) recorded lesser cane yield and was on par with each other. Trash mulching (M_1) had increased the cane yield and was significantly superior to unmulched treatments (M_0). The interaction effects revealed that I_1M_1 registered the highest cane yield and was statistically on par with I_2M_1. While I_3M_0 and I_4M_0 recorded significantly lower values for cane yield as compared to other treatment combinations.

4.1.4.2. Sugar yield (Table 13a, 13b and Fig.5a and 5b)

The data generated revealed that treatments varied significantly with trash mulching and methods of irrigation in both plant crops. However, the interaction was noticed in first plant crop alone.

Table 13a Effect of methods of irrigation and mulching on cane, sugar, jaggery yield and harvest index in first plant crop

Treatment	Cane yield (t ha^{-1})			Sugar yield (t ha^{-1})			Jaggery yield (t ha^{-1})			Harvest index (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	101.23	107.40	104.32	12.23	13.17	12.70	10.69	11.48	11.08	23.66	23.63	23.65
I_2	96.54	106.79	101.66	11.24	12.78	12.01	10.12	11.37	10.74	22.66	23.46	23.06
I_3	87.53	91.22	89.37	9.95	10.55	10.25	9.01	9.51	9.26	24.13	23.16	23.65
I_4	89.01	92.71	90.86	10.51	10.55	10.53	9.25	9.67	9.47	24.80	23.66	24.23
Mean	93.58	99.53		10.98	11.76		9.77	10.51		23.81	23.48	
C.D.(0.05) for (I)			1.23**			0.34**			0.12*			0.70*
C.D.(0.05) for (M)			0.87**			0.24**			0.09*			N.S.
C.D. (0.05) for interaction (I x M)			1.74**			0.49**			0.18**			0.49*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 13b Effect of methods of irrigation and mulching on cane, sugar, jaggery yield and harvest index in second plant crop

Treatment	Cane yield (t ha^{-1})			Sugar yield (t ha^{-1})			Jaggery yield (t ha^{-1})			Harvest index (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	103.33	108.76	106.05	11.71	12.94	12.33	10.89	11.50	11.16	21.36	22.10	21.73
I_2	98.14	108.27	103.20	10.82	12.56	11.69	10.20	11.44	10.82	21.03	21.90	21.46
I_3	88.39	92.59	90.49	9.78	10.15	9.97	9.09	9.48	9.29	23.00	21.53	22.46
I_4	90.24	93.95	92.09	9.641	10.44	10.04	9.36	9.72	9.54	21.50	21.40	21.45
Mean	95.03	100.89		10.49	11.52		9.87	10.53		21.72	21.73	
C.D.(0.05) for (I)			2.04**			0.66**			0.26**			N.S.
C.D.(0.05) for (M)			1.44**			0.46**			0.18**			N.S.
C.D. (0.05) for interaction (I x M)			2.88**			N.S.			0.37*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 14 Pooled analysis of cane yield

Treatment	Pooled mean		Mean	Period		Treatment	Period		Treatment	Period	
	M_0	M_1		1998-'99	1999-2000		1998-'99	1999-2000		1998-'99	1999-2000
I_1	102.28	108.08	105.18	96.55	97.95	I_1	104.31	106.04	M_0	93.57	93.02
I_2	97.33	107.82	102.43			I_2	101.66	103.20	M_1	99.53	100.89
I_3	87.95	92.65	90.30			I_3	90.11	90.49			
I_4	89.62	92.58	91.10			I_4	90.12	92.09			
Mean	94.30	100.21									

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

C.D. for I - 1.06**
C.D. for M - 0.78**
C.D. for I x M - 1.56**
C.D. for period - 0.85*
C.D. for I x P - N.S.
C.D. for M x P - N.S.
C.D. for I x M x P - N.S.

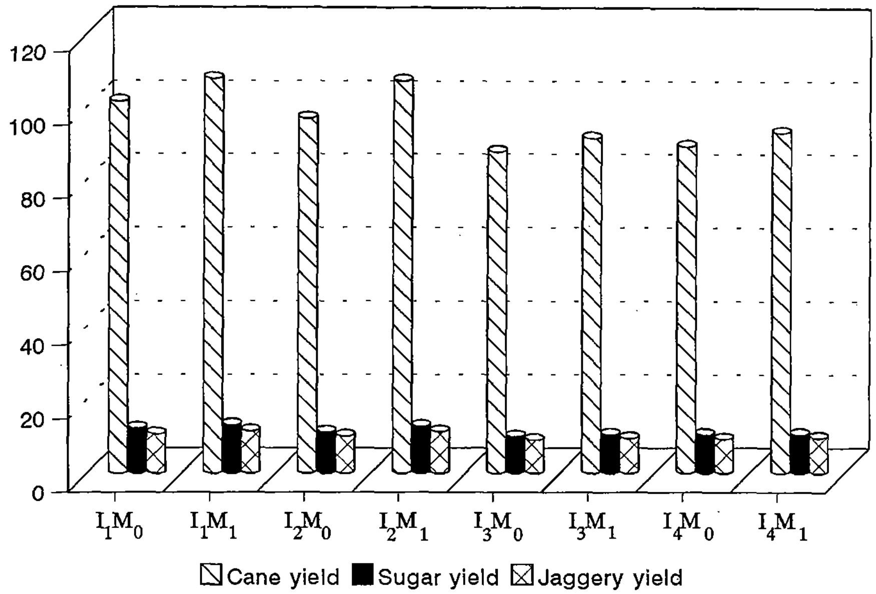


Fig. 5a. Cane, sugar and jaggery yield as influenced by methods of irrigation and trash mulching during first plant crop

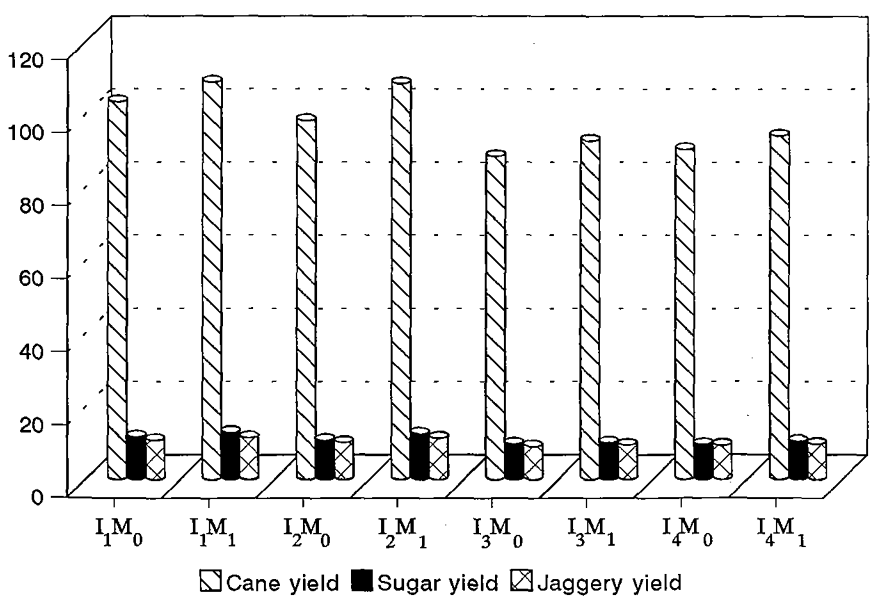


Fig. 5b. Cane, sugar and jaggery yield as influenced by methods of irrigation and trash mulching during second plant crop

A perusal of the data in first and second plant crops showed that all furrow irrigation (I_1) had appreciably increased the sugar yield and was superior to other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). The skip furrow irrigation (I_3) produced the lowest sugar yield. While in the case of trash mulching, M_1 had increased the sugar yield significantly as compared to M_0. The interaction effects exhibited in first plant crop revealed that I_1M_1 registered maximum sugar yield and it was followed by I_2M_1 and I_1M_0.

4.1.4.3. Jaggery yield (Table 13a, 13b and Fig. 5a and 5b)

The results revealed that the treatment variation due to methods of irrigation, trash mulching and their interactions were significant in both plant crops.

A critical review of the data in first and second plant crops showed that all furrow irrigation (I_1) had produced the highest jaggery yield and was significantly superior to all other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). Jaggery production in skip furrow irrigation (I_3) was decreased significantly. In the case of trash mulching (M_1) produced significantly higher jaggery yield as compared to M_0. The interaction revealed that I_1M_1 was on par with I_2M_1. While the jaggery production was reduced significantly in I_3M_0 and I_4M_0.

4.1.4.4. Harvest index (Table 13a and 13b)

The data presented revealed that harvest index was positively influenced by methods of irrigation only. The interaction between methods of irrigation and trash mulching was significant in first plant crop. However, it was not influenced by any of the treatments in second plant crop.

The results have shown that the farmer's practice of irrigation (I_4) had appreciably increased the values of harvest index and it was closely followed by all (I_1) and skip furrow irrigation (I_3). The value of harvest index was reduced in alternate furrow irrigation ((I_2). Among the treatment combinations, I_4M_0 invariably recorded higher harvest index followed by I_3M_0 and I_1M_0.

4.1.5. Juice quality

4.1.5.1. Juice recovery (Table 15a and 15b)

The data revealed that juice recovery was not affected by any of the treatments in both plant crops.

4.1.5.2. SMT brix (Table 15a, 15b and Fig. 6a and 6b)

The data had shown that treatment effects due to methods of irrigation, trash mulching and their interactions were significant only in the first year of experimentation. While in second plant crop SMT brix remained unaffected and it was not influenced by the treatment effects.

The results of the study had shown that alternate furrow method of irrigation (I_2) registered comparable value to that of all furrow irrigation (I_1). The unmulched treatments recorded significantly higher values as compared to mulched treatment combinations.

4.1.5.3. Sucrose content (Table 15a, 15b and Fig.6a and 6b)

The data generated showed that the analysis of variance for sucrose content was significant only due to methods of irrigation in first plant crop. While in second plant crop the treatments failed to exhibit any effect on the sucrose content.

Among the methods of irrigation, all furrow irrigation (I_1) recorded higher content of sucrose and it was comparable with that of alternate furrow irrigation (I_2). Sucrose content in the juice was decreased significantly in skip furrow irrigation.

Table 15a Effect of methods of irrigation and mulching on juice quality in first plant crop

Treatment	Juice recovery (%)			SMT brix (%)			Sucrose content (%)			CCS (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	59.20	59.41	59.30	19.61	18.11	18.86	17.25	17.19	17.22	12.09	12.27	12.18
I_2	59.27	59.49	59.38	19.61	18.94	19.27	17.00	17.13	17.07	11.65	11.97	11.81
I_3	58.92	59.43	59.17	18.11	17.75	17.93	16.46	16.40	16.43	11.38	11.58	11.48
I_4	59.80	59.54	59.67	17.75	18.27	18.01	16.64	16.37	16.50	11.82	11.39	11.61
Mean	59.30	59.47		18.77	18.27		16.84	16.77		11.73	11.80	
C.D. (0.05) for (I)			N.S.			0.46**			0.28**			0.35**
C.D. (0.05) for (M)			N.S.			0.32**			N.S.			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			0.65**			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 15b Effect of methods of irrigation and mulching on juice quality in second plant crop

Treatment	Juice recovery (%)			SMT brix (%)			Sucrose content (%)			CCS (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	60.95	60.66	60.80	18.67	18.14	18.40	16.07	16.54	16.31	11.27	11.90	11.58
I_2	60.24	60.47	60.35	18.57	17.38	17.97	15.91	16.26	16.08	11.03	11.61	11.32
I_3	58.95	59.64	59.29	17.79	17.81	17.80	15.91	15.59	15.75	11.07	10.97	11.02
I_4	59.15	60.10	59.62	18.63	17.87	18.25	15.79	16.10	15.94	10.69	11.12	10.90
Mean	59.82	60.22		18.41	17.80		15.92	16.12		11.01	11.40	
C.D. (0.05) for (I)			N.S.			N.S.			N.S.			N.S.
C.D. (0.05) for (M)			N.S.			N.S.			N.S.			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

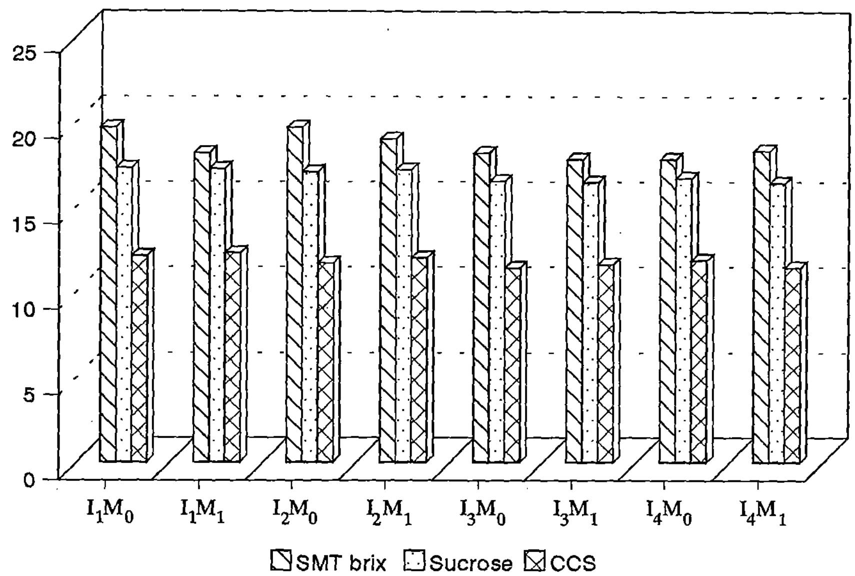


Fig. 6a. Juice quality as influenced by methods of irrigation and trash mulching during first plant crop

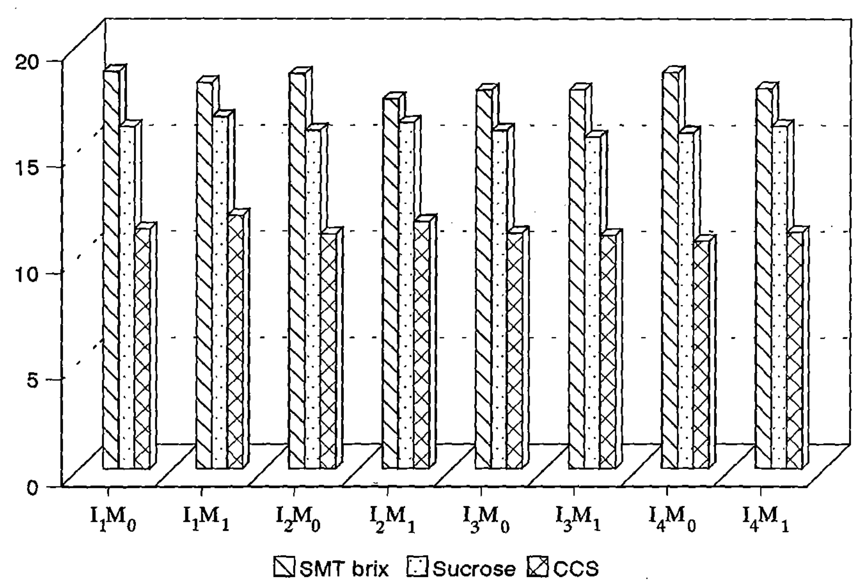


Fig. 6b. Juice quality as influenced by methods of irrigation and trash mulching during second plant crop

4.1.5.4. Commercial cane sugar per cent (Table 15a, 15b and Fig.6a and 6b)

The results revealed that methods of irrigation was significant only during the first year of study. However, in second plant crop, none of the treatments or their interactions had exerted any influence on CCS per cent.

A perusal of the data revealed that all furrow irrigation (I_1) had appreciably increased the CCS per cent and was superior over other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). The CCS per cent was markedly reduced in skip furrow method (I_3).

4.1.5.5. Purity coefficient (Table 16a and 16b)

The results obtained have indicated that treatments varied significantly only due to trash mulching in the first year of experimentation. The interaction between I and M was significant. But in the second year of experimentation, the purity coefficient was not influenced by any of the treatments or their interactions.

The results of the study during the first plant crop revealed that trash mulching (M_1) had remarkably increased the values of purity coefficient and was superior over unmulched treatments (M_0). The interaction effects between I and M revealed that the treatment combinations of I_1M_1 recorded higher values as compared to other treatment combinations.

4.1.5.6. Reducing sugars (Table 16a and 16b)

The data generated indicated that treatments varied significantly due to methods of irrigation and trash mulching in both plant crops. However, their interaction effect was significant only in the second plant crop.

A critical review of the data obtained in first and second plant crop revealed that skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4) had recorded

Table 16a Effect of methods of irrigation and mulching on juice quality in first plant crop

Treatment	Purity coefficient (%)			Reducing sugar (%)			Titrable acidity (ml of 0.1 N NaOH 100 ml^{-1})			Fibre content (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	88.03	94.93	91.48	1.060	0.913	0.987	14.00	13.33	13.66	14.01	13.97	13.99
I_2	86.75	90.49	88.62	1.076	1.033	1.055	14.33	13.66	14.00	15.02	14.88	14.95
I_3	90.92	92.40	91.66	1.453	1.380	1.417	14.66	14.33	14.50	15.07	14.75	14.91
I_4	93.80	89.64	91.72	1.166	1.126	1.147	14.66	14.33	14.50	15.44	14.83	15.13
Mean	89.87	91.86		1.189	1.113		14.41	13.91		14.88	14.61	
C.D. (0.05) for (I)			N.S.			0.090**			N.S.			0.39**
C.D. (0.05) for (M)			1.97*			0.063*			N.S.			0.27*
C.D. (0.05) for interaction (I x M)			3.95**			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 16b Effect of methods of irrigation and mulching on juice quality in second plant crop

Treat-ment	Purity coefficient (%)			Reducing sugar (%)			Titrable acidity (ml of 0.1 N NaOH 100 ml^{-1})			Fibre content (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	86.25	91.47	88.86	1.026	0.916	0.972	14.00	13.33	13.66	15.66	15.62	15.64
I_2	89.05	93.52	91.28	1.133	1.113	1.123	14.33	13.66	14.00	15.84	15.78	15.81
I_3	90.20	88.39	89.30	1.360	1.126	1.243	14.66	14.33	14.50	15.67	15.82	15.74
I_4	85.21	89.64	87.42	1.326	1.163	1.245	14.66	14.33	14.50	15.86	15.88	15.87
Mean	87.68	90.75		1.212	1.080		14.41	13.91		15.76	15.77	
C.D. (0.05) for (I)			N.S.			0.053**			N.S.			N.S.
C.D. (0.05) for (M)			N.S.			0.037**			N.S.			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			0.075**			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

higher content of reducing sugars as compared to the other two methods of irrigation. The unmulched treatment (M_0) had appreciably increased the reducing sugar content as compared to trash mulching (M_1). The interaction effect between I and M in the second plant crop revealed that I_3M_0 had shown the highest value for reducing sugars as compared to other treatment combinations. The lowest values were associated with I_1M_1 and I_2M_1.

4.1.5.7. Titrable acidity (Table 16a and 16b)

The data revealed that titrable acidity was not influenced by either methods of irrigation, trash mulching or their interactions in both plant crops.

4.1.5.8. Fibre content (Table 16a and 16b)

A perusal of the data revealed that the analysis of variance for fibre content was significantly affected by methods of irrigation and trash mulching during the first year of study. While in the second year of study, none of the treatments were significant. The interaction between I and M was not significant in both years of experimentation.

Among the methods of irrigation, alternate furrow irrigation (I_2) had registered invariably higher value for fibre content. The fibre content was reduced in all furrow irrigation (I_1). The unmulched treatment (M_0) had profoundly increased the fibre content as compared to mulched treatment (M_1).

4.1.6. Jaggery quality

4.1.6.1. Jaggery brix (Table 17a and 17b)

The results revealed that the treatment effects due to methods of irrigation, trash mulching and their interactions were not significant in both plant crops.

4.1.6.2. Jaggery sucrose (Table 17a, 17b and Fig. 7a and 7b)

The data revealed that methods of irrigation had exerted significant effect on jaggery sucrose in both years of experimentation. However, the treatment effects due to trash mulching and their interactions were not significant in both plant crops.

The results of the study revealed that all furrow irrigation (I_1) had invariably increased the jaggery sucrose and was comparable with alternate furrow irrigation (I_2). While skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4) recorded comparatively lower values for sucrose content and was statistically on par with each other.

4.1.6.3. Jaggery reducing sugars (Table 17a, 17b and Fig.7a and 7b)

The data had shown that the analysis of variance for reducing sugar was significant with methods of irrigation in both the plant crops. But the treatment variation due to trash mulching and their interactions were significant only in second plant crop.

The results of the first and second plant crops revealed that skip furrow method of irrigation (I_3) had significantly increased the value of reducing sugars as compared to other methods of irrigation. While in all furrow irrigation (I_1), the reducing sugar content was markedly decreased. The unmulched treatment (M_0) had exerted a pronounced effect in increasing the reducing sugars and was superior to trash mulching (M_1) in second plant crop. The interaction effect noticed in the second plant crop revealed that the combination of I_3M_0 and I_4M_0 recorded comparatively higher values than other treatment combinations.

4.1.6.4. Jaggery moisture content (Table 17a and 17b)

A critical review of the data had indicated that jaggery moisture content was

Table 17a Effect of methods of irrigation and mulching on jaggery quality in first plant crop

Treatment	Jaggery Brix (%)			Jaggery sucrose(%)			Jaggery reducing sugar (%)			Jaggery moisture (%)			Jaggery purity (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	79.76	78.48	79.12	72.68	74.71	73.70	6.43	5.76	6.10	5.52	5.67	5.59	91.11	95.16	93.14
I_2	77.23	83.61	80.42	72.79	73.84	73.31	7.60	6.50	7.05	5.78	5.64	5.71	94.24	88.40	91.32
I_3	79.76	77.23	78.49	71.40	71.48	71.44	8.06	7.60	7.83	5.73	5.78	5.75	89.49	92.56	91.02
I_4	78.46	78.46	78.46	70.14	70.14	70.14	7.70	6.63	7.16	5.69	5.61	5.65	90.03	89.36	89.70
Mean	78.67	79.44		71.75	72.54		7.45	6.62		5.68	5.67		91.22	91.37	
C.D. (0.05) for (I)			N.S.			1.67**			0.30**			N.S.			1.96*
C.D. (0.05) for (M)			N.S.			N.S.			0.21**			N.S.			N.S.
C.D. (0.05) for interaction (I x M)			3.07			N.S.			N.S.			N.S.			2.77**

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 17b Effect of methods of irrigation and mulching on jaggery quality in second plant crop

Treatment	Jaggery Brix (%)			Jaggery sucrose (%)			Jaggery reducing sugar (%)			Jaggery moisture (%)			Jaggery purity (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	80.46	79.53	79.99	69.45	71.45	70.45	6.86	6.80	6.83	7.70	7.57	7.63	86.45	89.83	88.14
I_2	79.53	80.84	80.18	68.84	70.74	69.79	8.00	7.33	7.66	7.78	7.61	7.70	86.56	87.49	87.03
I_3	79.53	80.46	79.99	66.25	67.45	66.85	8.76	7.86	8.31	7.86	7.63	7.75	83.22	83.84	83.53
I_4	79.53	79.53	79.53	66.97	68.86	67.91	8.33	7.56	7.95	7.80	7.76	7.78	84.20	86.56	85.38
Mean	79.76	80.09		67.88	69.63		7.99	7.39		7.78	7.64		85.11	86.93	
C.D. (0.05) for (I)			N.S.			2.60*			0.30**			N.S.			N.S.
C.D. (0.05) for (M)			N.S.			N.S.			0.21**			N.S.			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.42*			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

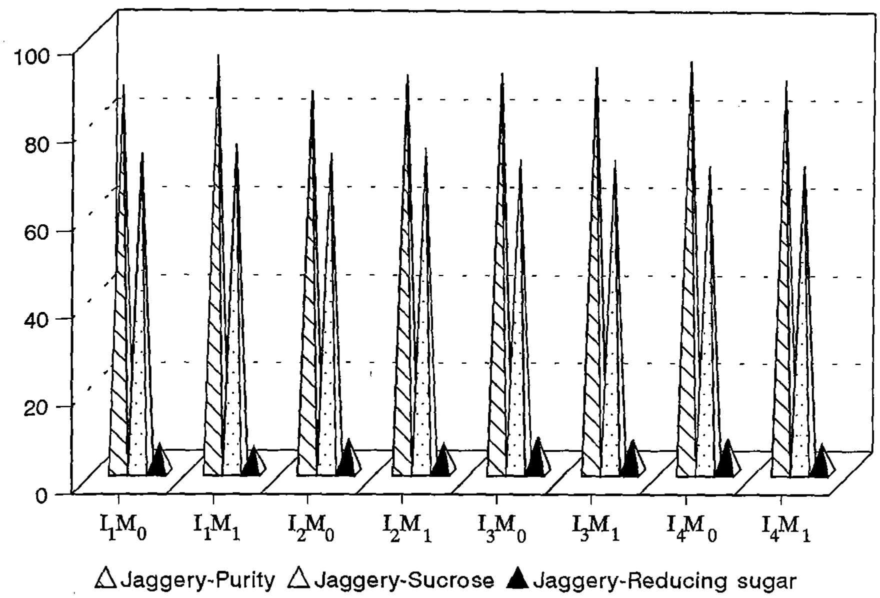


Fig. 7a. Jaggary quality as influenced by methods of irrigation and trash mulching during first plant crop

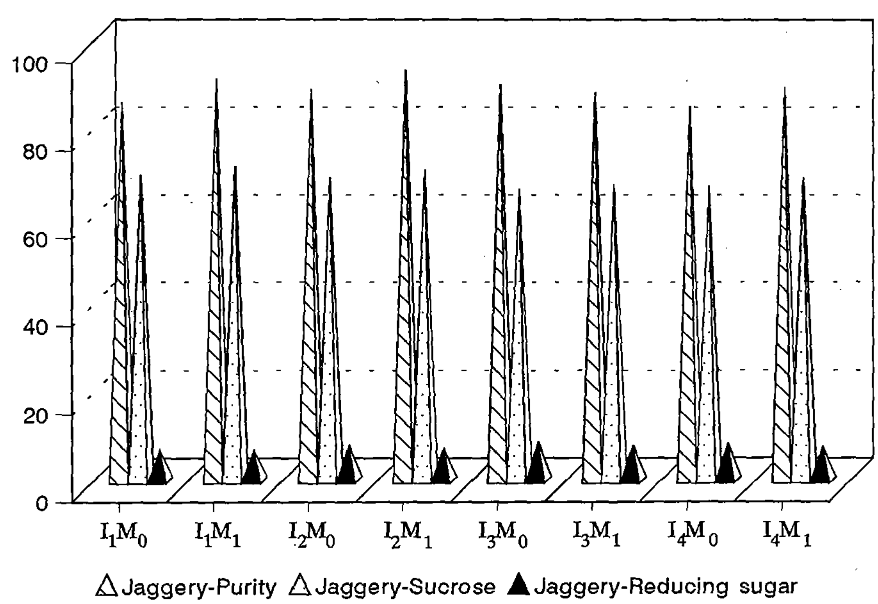


Fig. 7b. Jaggary quality as influenced by methods of irrigation and trash mulching during second plant crop

not influenced by any of the treatments or their interactions in both the years of experimentation.

4.1.6.5. Jaggery purity (Table 17a, 17b and Fig.7a and 7b)

The data revealed that treatment variation due to methods of irrigation and their interactions between methods of irrigation and trash mulching were significant only in first plant crop. While in second plant crop none of the treatments had exerted any effects on jaggery purity.

Among the methods of irrigation tried, all furrow method (I_1) had shown increased value for jaggery purity and was superior over other methods of irrigation. The interaction between I and M had shown that the treatment combination of I_1M_1 and I_2M_0 had invariably increased the jaggery purity.

4.1.7. Nutrient uptake

4.1.7.1. Nitrogen uptake by trash, green tops, stem and total uptake at 120, 240 and 360 DAP (Table 18a, 18b, 19a, 19b and Fig.8a and 8b)

The data generated revealed that the analysis of variance for N uptake by trash, greentops and stem was significantly influenced by methods of irrigation and trash mulching at all stages of growth in both plant crops. However, their interaction was not significant. The data on total N uptake indicated that the treatment variations due to methods of irrigation and trash mulching were significant at all stages of growth in both plant crops with exception to the total N uptake at 240 DAP in first plant crop where the methods of irrigation had only exerted significant effects. The interaction for total N uptake was not significant at any stages of growth.

Table 18 a Effect of methods of irrigation and mulching on N uptake at different stages of growth in first plant crop

Treatment	N uptake by trash at 120 DAP (kg ha^{-1})			N uptake by trash at 240 DAP (kg ha^{-1})			N uptake by trash at 360 DAP (kg ha^{-1})			N uptake by green tops at 120 DAP (kg ha^{-1})			N uptake by green tops at 240 DAP (kg ha^{-1})			N uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	3.64	3.93	3.79	17.01	20.46	18.73	16.51	19.29	17.90	47.98	52.56	50.27	35.71	41.35	38.53	24.32	27.61	25.96
I_2	3.31	3.83	3.57	15.68	20.00	17.84	15.42	18.39	16.91	45.10	51.26	48.18	34.38	40.72	37.55	22.87	26.67	24.77
I_3	2.17	2.38	2.28	10.05	12.18	11.11	10.10	10.60	10.35	24.11	33.13	28.62	24.47	28.47	26.47	14.82	18.41	16.62
I_4	2.26	2.44	2.35	10.85	12.40	11.62	10.21	11.91	11.06	26.01	35.86	30.94	25.61	29.68	27.65	15.86	19.25	17.55
Mean	2.85	3.14		13.40	16.26		13.06	15.05		35.80	43.20		30.04	35.06		19.47	22.98	
C.D. (0.05) for (I)			0.16**			2.07**			1.09**			4.01**			2.39**			1.55**
C.D. (0.05) for (M)			0.11**			1.46**			0.76**			2.83**			1.69**			1.10**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 18 b Effect of methods of irrigation and mulching on N uptake at different stages of growth in second plant crop

Treatment	N uptake by trash at 120 DAP (kg ha^{-1})			N uptake by trash at 240 DAP (kg ha^{-1})			N uptake by trash at 360 DAP (kg ha^{-1})			N uptake by green tops at 120 DAP (kg ha^{-1})			N uptake by green tops at 240 DAP (kg ha^{-1})			N uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	4.46	4.89	4.68	17.56	20.51	19.04	15.90	17.26	16.58	49.45	53.71	51.58	42.29	47.84	45.07	31.89	36.93	34.41
I_2	3.88	4.27	4.07	16.49	19.72	18.11	14.36	16.59	15.48	47.18	52.48	49.83	38.54	46.05	42.30	30.19	35.60	32.90
I_3	2.54	3.08	2.81	11.91	14.10	13.00	11.53	12.15	11.84	29.21	40.62	34.92	27.79	31.41	29.60	30.51	26.78	23.64
I_4	2.87	3.10	2.99	12.48	14.43	13.45	11.66	12.71	12.19	34.42	43.79	39.10	29.51	33.26	31.39	24.32	28.23	26.28
Mean	3.44	3.83		14.61	17.19		13.36	14.68		40.07	47.65		34.53	39.64		26.73	31.88	
C.D. (0.05) for (I)			0.49**			1.92**			1.37**			3.92**			2.44**			1.98**
C.D. (0.05) for (M)			0.35**			1.36**			0.96**			2.77**			1.73**			1.40**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 19a Effect of methods of irrigation and mulching on N uptake different stages of growth in first plant crop

Treatment	N uptake by stem at 120 DAP (kg ha^{-1})			N uptake by stem at 240 DAP (kg ha^{-1})			N uptake by stem at 360 DAP (kg ha^{-1})			Total N uptake 120 DAP (kg ha^{-1})			Total N uptake at 240 DAP (kg ha^{-1})			Total N uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	28.79	30.87	29.83	79.42	92.21	85.82	95.01	109.88	102.44	80.41	87.36	83.88	132.13	154.01	143.07	135.17	157.01	146.09
I_2	25.43	29.99	27.71	76.23	90.60	83.42	91.52	108.17	99.85	73.84	85.07	79.46	126.25	130.22	128.24	129.82	153.13	141.47
I_3	14.10	18.55	16.33	59.58	65.19	62.39	72.08	76.85	74.47	40.38	54.06	47.22	94.11	105.84	99.97	97.04	107.93	102.48
I_4	15.44	19.84	17.64	61.76	67.07	64.42	73.30	87.39	80.35	43.71	58.16	50.94	98.22	109.12	103.67	99.37	118.55	108.96
Mean	20.94	24.81		62.25	78.77		82.98	95.57		59.59	71.16		112.68	124.80		115.35	134.15	
C.D.(0.05) for (I)			2.72**			12.39**			10.34**			5.09**			17.92**			10.33**
C.D. (0.05) for (M)			1.92**			8.76*			7.31**			3.58**			N.S.			7.30**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 19b Effect of methods of irrigation and mulching on N uptake at different stages of growth in second plant crop

Treatment	N uptake by stem at 120 DAP (kg ha^{-1})			N uptake by stem at 240 DAP (kg ha^{-1})			N uptake by stem at 360 DAP (kg ha^{-1})			Total N uptake 120 DAP (kg ha^{-1})			Total N uptake at 240 DAP (kg ha^{-1})			Total N uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	30.32	32.98	31.65	87.97	94.09	91.03	108.52	121.23	114.87	84.23	91.58	87.91	147.82	162.44	155.13	166.31	175.41	170.86
I_2	23.16	32.32	27.74	83.58	92.47	88.03	90.96	118.21	104.58	74.21	89.07	81.64	138.62	158.24	148.43	135.49	171.74	153.61
I_3	15.89	19.04	17.46	59.31	71.52	65.42	76.59	84.22	80.41	47.64	62.72	55.18	99.01	117.03	108.02	108.43	123.15	115.79
I_4	16.24	20.89	18.56	60.57	73.89	67.23	79.11	87.09	83.10	53.53	67.77	60.65	102.73	104.89	103.81	115.10	128.03	121.57
Mean	21.40	26.31		72.86	82.99		88.80	102.69		64.90	77.78		122.04	135.65		131.33	149.58	
C.D. (0.05) for (I)			3.25**			9.89**			11.85**			5.09**			14.80**			11.99**
C.D. (0.05) for (M)			2.30**			6.99**			8.38**			3.60**			10.47*			8.48**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

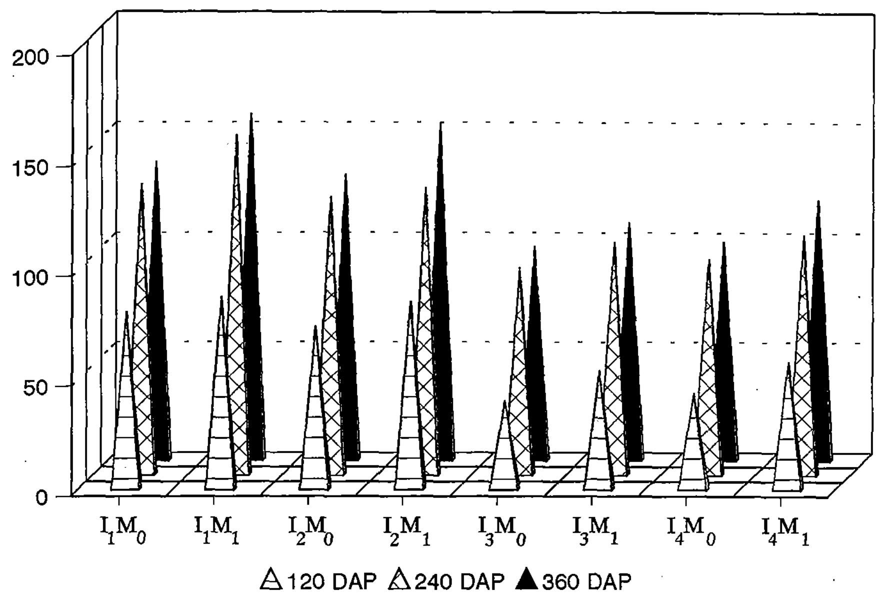


Fig. 8a. Influence of methods of irrigation and trash mulching on N uptake during first plant crop

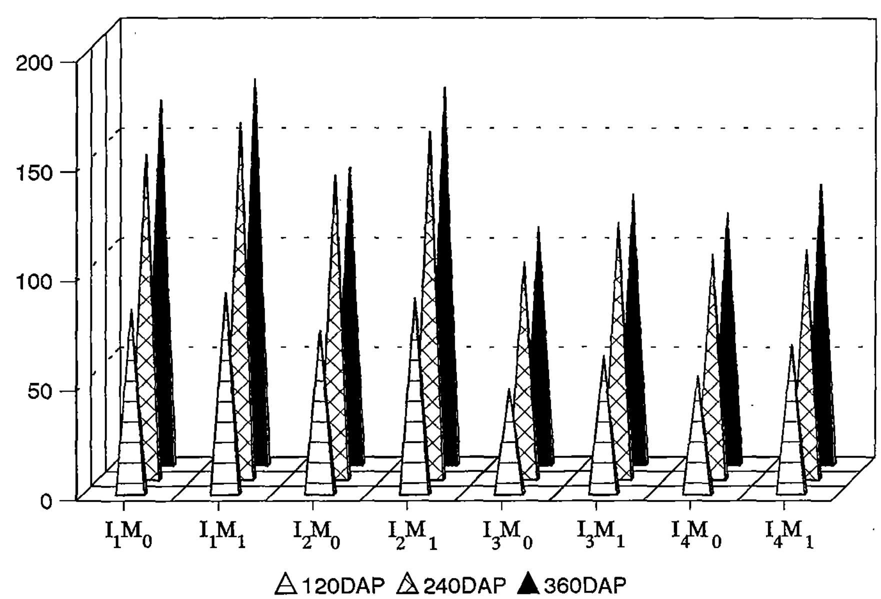


Fig. 8b. Influence of methods of irrigation and trash mulching on N uptake during second plant crop

In both the years of study, the uptake of N by trash, green tops and stem increased significantly with all furrow irrigation (I_1) and was statistically on par with alternate furrow irrigation (I_2) during the advanced stages of growth. The N uptake by trash, green tops and stem was significantly reduced in skip furrow (I_3) and farmer's practice of irrigation (I_4) and were on par with each other. The total N uptake was significantly higher in all furrow (I_1) and alternate furrow irrigation (I_2) which were on par with each other. The other two methods of irrigation recorded lesser uptake of N and were also on par with each other. The impact of mulching was clearly evident at all stages of growth by all plant parts during both the years of study. It was also reflected in the total uptake of N by the crop and was higher in the mulched treatments (M_1) than in unmulched ones (M_0).

4.1.7.2. Phosphorus uptake by trash, green tops, stem and total uptake at 120, 240 and 360 DAP (Table 20a, 20b, 21a, 21b and Fig.9a and 9b)

The total uptake of P and uptake by different plant parts during the three stages of growth summarised revealed that the P uptake was significantly influenced only by methods of irrigation and mulching. The interaction effect was significant only at 240 DAP in first plant crop with P uptake by trash.

The total P uptake was remarkably higher in all furrow irrigation method (I_1) than all other methods tried in both the experiments. The alternate furrow method (I_2) also recorded an appreciable enhancement of P uptake than other two methods tried during both the years of experimentation. The other two methods registered lower uptake of P and were on par with each other except at 120 and 240 DAP in the second year of study.

Table 20a Effect of methods of irrigation and mulching on P uptake at different stages of growth in first plant crop

Treatment	P uptake by trash at 120 DAP (kg ha^{-1})			P uptake by trash at 240 DAP (kg ha^{-1})			P uptake by trash at 360 DAP (kg ha^{-1})			P uptake by green tops at 120 DAP (kg ha^{-1})			P uptake by green tops at 240 DAP (kg ha^{-1})			P uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	3.10	3.21	3.16	9.33	10.99	10.16	8.77	9.94	9.36	17.94	19.62	18.78	16.61	18.83	17.72	9.30	10.6 8	9.99
I_2	2.61	3.12	2.86	8.50	10.73	9.62	7.97	9.16	8.56	16.87	18.96	17.91	15.74	18.03	16.88	8.56	10.2 9	9.43
I_3	2.00	2.25	2.13	6.08	6.65	6.37	5.52	6.05	5.79	9.54	12.91	11.23	11.85	13.42	12.63	6.08	7.14	6.61
I_4	2.12	2.29	2.20	6.45	6.87	6.66	5.66	6.46	6.06	10.84	13.88	12.36	12.59	13.99	13.29	6.50	7.59	7.04
Mean	2.46	2.71		7.59	8.81		6.98	7.90		13.80	16.34		14.20	16.07		7.61	8.92	
C.D. (0.05) for (I)			0.14**			0.48**			0.39**			1.14**			0.41**			0.42**
C.D.(0.05) for (M)			0.10**			0.34**			0.28**			0.80**			0.29**			0.29**
C.D. (0.05) for interaction (I x M)			N.S.			0.69**			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 20b Effect of methods of irrigation and mulching on P uptake at different stages of growth in second plant crop

Treatment	P uptake by trash at 120 DAP (kg ha^{-1})			P uptake by trash at 240 DAP (kg ha^{-1})			P uptake by trash at 360 DAP (kg ha^{-1})			P uptake by green tops at 120 DAP (kg ha^{-1})			P uptake by green tops at 240 DAP (kg ha^{-1})			P uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	3.36	3.78	3.57	9.90	11.33	10.61	8.07	9.00	8.54	18.21	19.49	18.85	18.95	21.36	20.16	12.32	14.11	13.22
I_2	3.08	3.29	3.19	9.06	11.04	10.05	7.61	8.54	8.08	17.18	19.19	18.18	17.14	20.56	18.85	11.54	13.33	12.44
I_3	2.20	2.76	2.48	6.31	7.39	6.85	5.80	6.60	6.20	11.90	15.64	13.77	13.10	14.92	14.01	8.72	10.14	9.43
I_4	2.52	2.78	2.65	6.61	7.76	7.18	6.33	6.87	6.60	14.04	16.39	15.22	13.91	15.85	14.88	9.73	10.90	10.32
Mean	2.79	3.15		7.97	9.38		6.95	7.75		15.33	17.68		15.78	18.17		10.58	12.12	
C.D. (0.05) for (I)			0.31**			0.42**			0.34**			1.10**			0.95**			0.87**
C.D. (0.05) for (M)			0.22**			0.30**			0.24**			0.78**			0.67**			0.62**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 21a Effect of methods of irrigation and mulching on P uptake at different stages of growth in first plant crop

Treatment	P uptake by stem at 120 DAP (kg ha^{-1})			P uptake by stem at 240 DAP (kg ha^{-1})			P uptake by stem at 360 DAP (kg ha^{-1})			Total P uptake 120 DAP (kg ha^{-1})			Total P uptake at 240 DAP (kg ha^{-1})			Total P uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	15.28	17.20	16.24	36.86	41.04	38.95	29.97	35.25	32.61	36.32	40.03	38.18	62.80	70.86	66.83	48.05	55.87	51.96
I_2	11.90	15.70	13.80	35.41	39.54	37.48	27.92	34.65	31.29	31.37	37.77	34.57	59.65	68.30	63.98	44.45	54.10	49.28
I_3	6.94	8.96	7.95	25.39	32.75	29.07	20.24	25.42	22.83	18.47	24.17	21.30	43.32	49.48	46.40	31.84	38.61	35.23
I_4	7.59	9.58	8.58	27.04	30.16	28.60	22.14	25.86	24.00	20.55	25.74	23.15	45.41	51.02	48.22	34.30	39.91	37.11
Mean	10.43	12.86		31.18	35.87		25.07	30.30		26.68	31.92		52.80	59.92		39.66	47.12	
C.D. (0.05) for (I)			1.41**			2.76**			1.63**			2.40**			2.10**			2.18**
C.D. (0.05) for (M)			0.99**			1.95**			1.16**			1.70**			1.49**			1.54**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 21b Effect of methods of irrigation and mulching on P uptake at different stages of growth in second plant crop

Treatment	P uptake by stem at 120 DAP (kg ha^{-1})			P uptake by stem at 240 DAP (kg ha^{-1})			P uptake by stem at 360 DAP (kg ha^{-1})			Total P uptake 120 DAP (kg ha^{-1})			Total P uptake at 240 DAP (kg ha^{-1})			Total P uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	15.44	17.53	16.49	38.36	42.70	40.53	32.67	36.01	34.34	37.01	40.81	38.91	67.21	75.39	71.30	53.06	59.12	56.09
I_2	12.38	17.18	14.78	36.45	42.32	39.38	28.72	36.52	32.62	32.64	39.72	36.18	62.64	73.92	68.28	47.87	58.39	53.13
I_3	8.09	9.20	8.64	24.68	29.20	26.94	21.45	24.70	23.08	21.52	27.60	24.56	44.09	51.52	47.80	35.97	42.42	39.20
I_4	8.12	9.34	9.03	26.71	30.91	28.81	21.19	26.44	23.81	24.68	29.11	26.90	47.23	54.53	50.88	37.26	43.54	40.40
Mean	11.01	13.46		31.55	36.29		26.01	30.92		28.96	34.31		55.29	63.84		43.54	50.87	
C.D. (0.05) for (I)			0.62**			2.06**			1.63**			1.32**			2.22**			1.91**
C.D. (0.05) for (M)			0.44**			1.46**			1.15**			0.93**			1.56**			1.35**
C.D. (0.05) for interaction (I x M)			8.79**			N.S.			2.31*			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

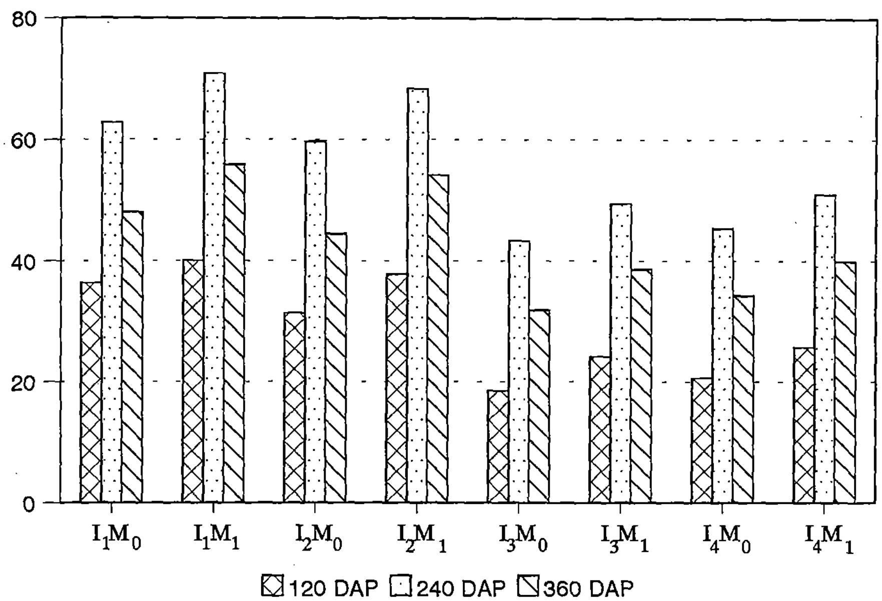


Fig. 9a. Influence of methods of irrigation and trash mulching on P uptake during first plant crop

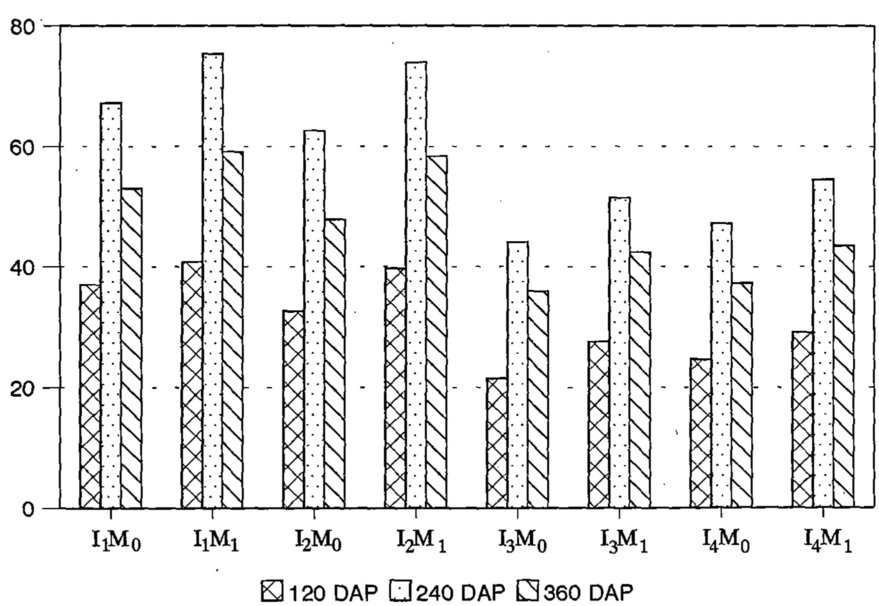


Fig. 9b. Influence of methods of irrigation and trash mulching on P uptake during second plant crop

Among the plant parts viz., trash, green tops and stem, the maximum uptake of P was noticed with all furrow irrigation during all the stages of growth in both the plant crops. The alternate furrow method (I_2) showed a comparable uptake of P by trash at 240 DAP during first plant crop and by the green tops at 120 DAP in the first year of experimentation and at 120 and 360 DAP in second year of study. The P uptake by stem was comparable between these two irrigation methods at 240 and 360 DAP during first year and at 240 DAP in the second year of experimentation. Though, the skip furrow method (I_3) was comparable in P uptake with farmer's practice (I_4), it recorded lower values in P uptake by trash and greentops.

The mulched treatments showed a pronounced effect in the total uptake of P and its uptake by all plant parts at all stages of growth during both the years of study.

4.1.7.3. Potassium uptake by trash, green tops, stem and total uptake at 120, 240 and 360 DAP (Table 22a, 22b, 23a, 23b and Fig. 10a and 10b)

The total uptake of K and uptake by different plant parts at various stages of growth revealed that it was significantly influenced by methods of irrigation and mulching during both years of study. However, the interaction effect between I and M was not observed during both the years of study for total K uptake. While the uptake of K by trash had exerted interaction effect between I and M at all stages in first plant crop alone. Similarly the interaction effect was noticed with K uptake by green tops at 120 and 240 DAP in first plant crop and also with K uptake by stem at 120 DAP in second plant crop.

Table 22a Effect of methods of irrigation and mulching on K uptake at different stages of growth in first plant crop

Treatment	K uptake by trash at 120 DAP (kg ha^{-1})			K uptake by trash at 240 DAP (kg ha^{-1})			K uptake by trash at 360 DAP (kg ha^{-1})			K uptake by green tops at 120 DAP (kg ha^{-1})			K uptake by green tops at 240 DAP (kg ha^{-1})			K uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.54	1.75	1.65	10.65	12.45	11.55	6.76	8.04	7.40	51.82	56.25	54.04	57.76	67.28	62.52	29.83	35.35	32.59
I_2	1.37	1.66	1.51	9.64	12.37	11.01	6.15	7.44	6.80	48.49	54.55	51.52	55.61	59.35	57.48	27.97	34.06	31.02
I_3	1.04	1.11	1.07	5.52	7.10	6.31	3.85	4.28	4.07	26.99	36.94	31.96	42.52	47.00	44.76	19.56	23.47	21.52
I_4	1.05	1.17	1.11	6.09	7.23	6.66	3.89	4.52	4.21	29.21	40.08	34.64	44.77	49.21	46.99	21.58	24.48	23.03
Mean	1.25	1.42		7.98	9.79		5.16	6.07		39.13	46.95		50.17	55.71		24.74	29.34	
C.D. (0.05) for (I)			0.07**			0.50**			0.35**			2.11**			1.73**			1.38**
C.D. (0.05) for (M)			0.04**			0.35**			0.25**			1.49**			1.22**			0.97**
C.D. (0.05) for interaction (I x M)			0.09**			0.71*			0.50*			2.98*			2.45*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 22b Effect of methods of irrigation and mulching on K uptake at different stages of growth in second plant crop

Treatment	K uptake by trash at 120 DAP (kg ha^{-1})			K uptake by trash at 240 DAP (kg ha^{-1})			K uptake by trash at 360 DAP (kg ha^{-1})			K uptake by green tops at 120 DAP (kg ha^{-1})			K uptake by green tops at 240 DAP (kg ha^{-1})			K uptake by green tops at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.84	2.05	1.94	11.38	13.14	12.26	6.31	7.19	6.75	52.61	56.21	54.41	66.84	75.95	71.39	39.56	46.26	42.91
I_2	1.64	1.90	1.77	10.30	12.61	11.46	5.87	6.91	6.39	49.68	54.60	52.14	60.71	72.64	66.68	37.13	43.54	40.33
I_3	1.19	1.38	1.29	6.24	8.17	7.21	4.36	4.75	4.56	34.04	44.09	39.07	47.15	52.23	49.69	26.35	33.35	29.85
I_4	1.29	1.41	1.35	6.68	8.58	7.63	4.30	4.96	4.63	37.62	46.19	41.91	50.24	55.52	52.88	31.44	35.28	33.36
Mean	1.49	1.69		8.65	10.63		5.21	5.95		43.49	50.27		56.24	64.09		33.62	39.61	
C.D. (0.05) for (I)			0.18**			0.50**			0.41**			3.20**			3.06**			2.27**
C.D. (0.05) for (M)			0.12**			0.35**			0.29**			2.26**			2.16**			1.60*
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 23a Effect of methods of irrigation and mulching on K uptake at different stages of growth in first plant crop

Treatment	K uptake by stem at 120 DAP (kg ha^{-1})			K uptake by stem at 240 DAP (kg ha^{-1})			K uptake by stem at 360 DAP (kg ha^{-1})			Total K uptake 120 DAP (kg ha^{-1})			Total K uptake at 240 DAP (kg ha^{-1})			Total K uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	37.46	40.46	38.96	51.56	57.66	54.61	52.32	60.51	56.42	90.82	101.81	96.32	119.97	137.39	128.68	89.01	103.89	96.45
I_2	32.46	39.33	35.90	47.04	55.39	51.22	47.68	59.49	53.59	82.31	95.54	88.93	112.30	127.21	119.75	81.81	100.99	91.40
I_3	17.47	22.84	20.15	29.65	39.69	34.67	32.75	40.87	36.81	45.49	60.88	53.19	77.69	93.83	85.76	56.16	68.62	62.39
I_4	19.48	24.17	21.82	31.97	41.89	36.93	34.53	41.58	38.05	49.73	65.42	57.58	82.83	98.32	90.57	60.10	70.58	65.34
Mean	26.82	31.70		40.06	48.66		41.82	50.61		67.09	80.91		98.20	114.19		71.77	86.02	
C.D. (0.05) for (I)			2.56**			3.54**			3.39**			6.15**			3.94**			4.48**
C.D. (0.05) for (M)			1.81**			2.50**			2.40**			4.35**			2.79**			3.17**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 23b Effect of methods of irrigation and mulching on K uptake at different stages of growth in second plant crop

Treatment	K uptake by stem at 120 DAP (kg ha^{-1})			K uptake by stem at 240 DAP (kg ha^{-1})			K uptake by stem at 360 DAP (kg ha^{-1})			Total K uptake 120 DAP (kg ha^{-1})			Total K uptake at 240 DAP (kg ha^{-1})			Total K uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	37.47	41.64	39.56	53.67	61.61	57.64	56.67	63.36	60.02	91.92	99.89	95.91	131.89	150.69	141.29	102.54	116.81	109.68
I_2	29.67	40.48	35.08	47.26	59.25	53.26	47.61	60.82	54.22	81.00	96.98	89.99	118.28	144.51	131.40	90.61	111.27	100.94
I_3	18.78	23.63	21.20	31.81	40.60	36.20	33.53	41.34	37.44	54.01	69.10	61.56	85.36	100.99	93.18	64.24	79.45	71.85
I_4	20.36	25.66	23.01	32.49	43.14	37.81	36.34	42.76	39.55	59.28	73.27	66.27	89.41	107.24	98.33	72.07	82.96	77.52
Mean	26.57	32.85		41.31	51.15		43.54	52.07		71.55	84.81		106.23	125.86		82.37	97.62	
C.D.(0.05) for (I)			1.13**			3.47**			3.28**			3.67**			5.34**			5.04**
C.D.(0.05) for (M)			0.80**			2.46**			2.32**			2.59**			3.78**			3.56**
C.D. (0.05) for interaction (I x M)			1.60**			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

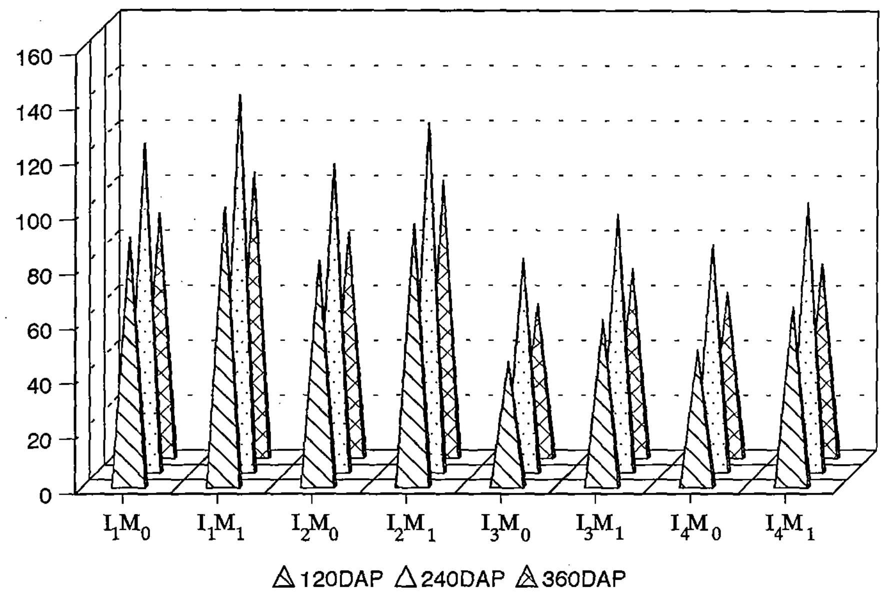


Fig. 10a. Influence of methods of irrigation and trash mulching on K uptake during first plant crop

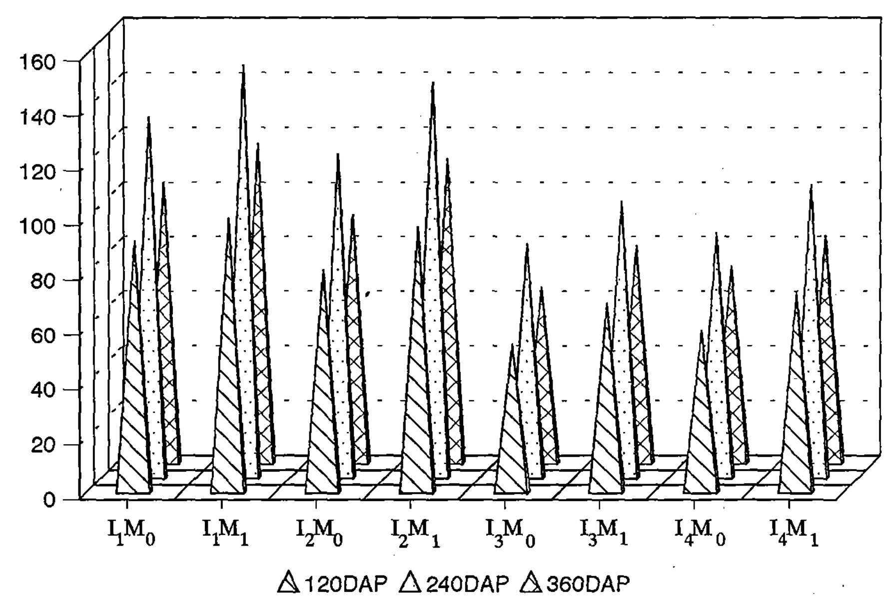


Fig. 10b. Influence of methods of irrigation and trash mulching on K uptake during second plant crop

Among the irrigation methods tried, all furrow irrigation (I_1) invariably showed an enhanced uptake of K by trash, green tops and stem in both years of study. While it was on par with alternate furrow irrigation (I_2) for the K uptake by trash at 360 DAP in first plant crop and at 120 and 360 DAP in second plant crop. Similarly I_1 was statistically on par with I_2 for the K uptake by stem in the later stages of growth during the first plant crop. The total K uptake was appreciably increased in all furrow method of irrigation (I_1) and was significantly superior to other methods of irrigation tried. The alternate furrow method (I_2) also recorded a significant increase in total K uptake, K uptake by trash, greentops and stem over the other two methods of irrigation. The skip method of irrigation (I_3) recorded the lowest total K uptake and uptake of K by different plant parts at all stages of growth in both years of experimentation.

Like N and P, the total K uptake as well as the uptake of K by trash, green tops and stem was also greater and positively influenced by the application of trash mulch over unmulched situation.

The interaction effect revealed that the treatment combination of I_1M_1 and I_2M_1 recorded significantly higher uptake of K by trash, green tops and stem over other treatment combinations.

4.1.7.4. Total Ca uptake at 120, 240 and 360 DAP (Table 24a and 24b)

The data revealed that treatment variation due to methods of irrigation and trash mulching were significant at all stages of growth in both plant crops. But the interaction effect between I and M was significant at 240 and 360 DAP in the first year of study and at 360 DAP in the second year of experimentation.

Table 24a Effect of methods of irrigation and mulching on Ca and Na uptake at different stages of growth in first plant crop

Treatment	Total Ca uptake at 120 DAP (kg ha^{-1})			Total Ca uptake at 240 DAP (kg ha^{-1})			Total Ca uptake at 360 DAP (kg ha^{-1})			Total Na uptake 120 DAP (kg ha^{-1})			Total Na uptake at 240 DAP (kg ha^{-1})			Total Na uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	36.67	46.66	41.66	67.47	81.62	74.54	70.68	83.75	77.22	24.29	27.83	26.06	51.22	62.07	56.65	46.60	60.49	53.54
I_2	31.57	45.16	38.36	63.05	80.61	71.83	66.29	82.13	74.21	21.47	25.95	23.71	47.18	61.96	54.57	45.72	60.36	53.04
I_3	16.72	27.52	22.12	45.68	58.46	52.07	47.90	62.36	55.13	12.40	15.91	14.16	35.37	44.92	40.14	31.29	44.85	38.07
I_4	22.21	30.41	26.31	49.50	60.61	55.05	55.61	62.22	58.91	13.62	16.32	14.97	37.61	48.63	43.12	35.76	47.19	41.47
Mean	26.79	37.43		56.42	70.32		60.12	72.61		17.94	21.50		42.84	54.40		39.84	53.22	
C.D. (0.05) for (I)			2.27**			1.79**			2.25**			1.80**			3.18**			4.07**
C.D. (0.05) for (M)			1.60**			1.26**			1.59**			1.27**			2.25**			2.28**
C.D. (0.05) for interaction (I x M)			N.S.			2.53*			3.18**			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 24b Effect of methods of irrigation and mulching on Ca and Na uptake at different stages of growth in second plant crop

Treatment	Total Ca uptake at 120 DAP (kg ha^{-1})			Total Ca uptake at 240 DAP (kg ha^{-1})			Total Ca uptake at 360 DAP (kg ha^{-1})			Total Na uptake 120 DAP (kg ha^{-1})			Total Na uptake at 240 DAP (kg ha^{-1})			Total Na uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	40.36	49.70	45.03	74.27	89.74	82.00	73.17	86.13	79.65	23.01	27.10	25.05	52.58	65.40	58.99	47.82	60.87	54.34
I_2	35.02	34.73	34.08	67.31	86.44	76.87	66.83	85.01	75.92	19.68	25.56	22.62	44.40	64.74	54.57	43.68	59.09	51.39
I_3	21.66	32.00	26.83	49.58	64.92	57.25	49.08	63.20	56.14	13.59	17.03	15.31	34.12	46.84	40.48	31.46	43.77	37.62
I_4	24.48	34.60	29.54	53.76	67.61	60.69	53.94	65.07	59.50	15.49	19.72	17.60	39.24	48.33	43.78	38.72	45.71	42.21
Mean	30.38	37.76		61.23	77.18		60.75	74.85		17.94	22.35		42.58	56.32		40.42	52.36	
C.D. (0.05) for (I)			5.68**			2.66**			2.10**			1.54**			4.54**			3.70**
C.D. (0.05) for (M)			4.02**			1.88**			1.49**			1.09**			3.21**			2.61**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			2.98*			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

The results of the study revealed that all furrow irrigation (I_1) recorded remarkable increase in the total uptake of Ca at all stages of growth. It was closely followed by alternate furrow irrigation (I_2). Trash mulching registered an enhanced uptake of Ca than unmulched treatment. The interaction effect between I and M was noticed only at the advanced stages of growth in both plant crops. The treatment combination of I_1M_1 and I_2M_1 recorded comparable uptake of Ca. The Ca uptake was lowest in I_3M_0.

4.1.7.5. Total Na uptake at 120, 240 and 360 DAP (Table 24a and 24b)

A critical review of the data revealed that Na uptake was significantly influenced by methods of irrigation and trash mulching during all the stages of growth. However, their interaction effect was not significant. The results of the first and second plant crops revealed that all furrow irrigation (I_1) had appreciably increased the total uptake of Na and it was comparable with alternate furrow method of irrigation at the advanced stages of growth. The uptake of Na was reduced significantly in skip furrow irrigation (I_3). Trash mulching had increased the uptake of Na and was superior over unmulched treatments.

4.1.7.6. Total Fe uptake at 120, 240 and 360 DAP (Table 25a and 25b)

A perusal of the data revealed that methods of irrigation and trash mulching had significantly influenced the total Fe uptake. But their interaction was significant at 120 and 360 DAP in the first plant crop and at 120 DAP in second plant crop.

The results of the first and second year of study showed that all furrow (I_1) and alternate furrow irrigation (I_2) had remarkably increased the uptake of Fe and was superior to other methods of irrigation. The uptake of Fe was reduced markedly in skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4). Trash mulching

Table 25a Effect of methods of irrigation and mulching on Fe and Mn uptake at different stages of growth in first plant crop

Treatment	Total Fe uptake at 120 DAP (kg ha^{-1})			Total Fe uptake at 240 DAP (kg ha^{-1})			Total Fe uptake at 360 DAP (kg ha^{-1})			Total Mn uptake 120 DAP (kg ha^{-1})			Total Mn uptake at 240 DAP (kg ha^{-1})			Total Mn uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	8.98	12.74	10.86	16.75	27.37	22.06	18.16	27.22	22.69	1.31	1.56	1.43	3.19	4.41	3.80	2.20	2.92	2.56
I_2	8.44	12.49	10.46	15.29	26.66	21.03	17.33	27.32	22.33	1.17	1.47	1.32	2.99	4.35	3.67	2.09	2.84	2.46
I_3	4.38	7.17	5.77	9.05	20.86	14.95	8.45	20.08	14.26	0.64	0.95	0.80	2.29	3.07	2.68	1.45	1.98	1.71
I_4	4.85	7.73	6.29	11.01	21.96	16.49	8.95	21.17	15.06	0.73	0.99	0.86	2.42	3.41	2.91	1.59	2.15	1.87
Mean	6.66	10.03		13.02	24.24		13.22	23.95		0.96	1.24		2.72	3.81		1.83	2.47	
C.D. (0.05) for (I)			0.41**			1.14**			1.10**			0.07**			0.12**			0.09**
C.D. (0.05) for (M)			0.29**			0.80**			0.77**			0.05**			0.08**			0.06**
C.D. (0.05) for interaction (I x M)			0.58*			N.S.			1.55**			N.S.			0.17**			0.12*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 25b Effect of methods of irrigation and mulching on Fe and Mn uptake at different stages of growth in second crop

Treatment	Total Fe uptake at 120 DAP (kg ha^{-1})			Total Fe uptake at 240 DAP (kg ha^{-1})			Total Fe uptake at 360 DAP (kg ha^{-1})			Total Mn uptake 120 DAP (kg ha^{-1})			Total Mn uptake at 240 DAP (kg ha^{-1})			Total Mn uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	9.38	13.23	11.30	17.38	28.40	22.89	20.19	28.63	24.41	1.29	1.60	1.45	3.40	4.49	3.94	2.86	3.92	3.39
I_2	8.48	12.55	10.58	16.30	28.06	22.18	18.80	28.73	23.76	1.13	1.52	1.33	3.19	4.40	3.80	2.83	3.71	3.27
I_3	5.04	8.03	6.53	11.02	20.32	15.67	8.82	17.80	13.31	0.71	1.04	0.87	2.22	3.07	2.64	1.73	2.52	2.12
I_4	5.68	8.60	7.14	11.98	22.61	17.29	9.87	18.98	14.42	0.94	1.16	1.05	2.44	3.29	2.86	1.95	2.65	2.30
Mean	7.18	10.60		14.17	24.85		14.42	23.53		1.02	1.33		2.81	3.81		2.34	3.20	
C.D. (0.05) for (I)			0.39**			0.95**			1.08**			0.05**			0.03**			2.34**
C.D. (0.05) for (M)			0.27**			0.67**			0.76**			0.03**			0.02**			0.24**
C.D. (0.05) for interaction (I x M)			0.55*			N.S.			N.S.			0.07*			0.05*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Trash mulching (M_1) had shown remarkably higher values for Fe uptake as compared to unmulched treatments (M_0). The interaction between I and M indicated that I_1M_1 registered higher uptake of Fe and was comparable with I_2M_1. While I_3M_0 and I_4M_0 recorded lower values for the uptake of Fe.

4.1.7.7. Total Mn uptake at 120, 240 and 360 DAP (Table 25a and 25b)

The data generated had shown that the analysis of variance for total Mn uptake with methods of irrigation and trash mulching was significant at all stages of growth in both years of experimentation. The interaction between I and M was significant at 240 and 360 DAP in first plant crop and at 120 and 240 DAP in second plant crop.

The results of the study revealed that all furrow irrigation (I_1) had significantly increased the uptake of Mn and was comparable with alternate furrow irrigation (I_2) during the later stages of growth. While in trash mulching the Mn uptake was highest and it was superior to unmulched treatments. The interaction effect exhibited during early stages of first and second plant crops revealed that treatment combination of I_1M_1 and I_2M_1 recorded higher uptake of Mn as compared to other treatment combinations. The uptake of Mn was reduced considerably in I_3M_0 and I_4M_0.

4.1.7.8. Total Zn uptake at 120, 240 and 360 DAP (Table 26a and 26b)

The data revealed that the treatments varied significantly with the methods of irrigation and trash mulching in both plant crops. But their interaction did not show any significant effects at any stages of growth.

A critical review of the data obtained in first and second plant crops had shown that all furrow irrigation (I_1) recorded significantly higher uptake of Zn as

Table 26a Effect of methods of irrigation and mulching on Zn and Cu uptake at different stages of growth in first plant crop

Treatment	Total Zn uptake at 120 DAP (kg ha^{-1})			Total Zn uptake at 240 DAP (kg ha^{-1})			Total Zn uptake at 360 DAP (kg ha^{-1})			Total Cu uptake 120 DAP (kg ha^{-1})			Total Cu uptake at 240 DAP (kg ha^{-1})			Total Cu uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.588	0.674	0.631	0.858	1.01	0.935	0.529	0.607	0.568	0.475	0.539	0.507	1.12	1.35	1.24	1.56	1.75	1.66
I_2	0.531	0.652	0.592	0.824	0.975	0.900	0.507	0.594	0.551	0.439	0.511	0.476	1.06	1.34	1.20	1.49	1.81	1.65
I_3	0.295	0.404	0.350	0.636	0.775	0.706	0.350	0.447	0.398	0.239	0.328	0.284	0.80	0.95	0.87	1.17	1.30	1.23
I_4	0.328	0.445	0.388	0.675	0.806	0.741	0.373	0.471	0.423	0.268	0.354	0.312	0.86	0.99	0.93	1.21	1.39	1.30
Mean	0.436	0.545		0.749	0.892		0.440	0.530		0.356	0.433		0.96	1.61		1.36	1.56	
C.D. (0.05) for (I)			0.028**			0.019**			0.021**			0.021**			0.03**			0.07**
C.D. (0.05) for (M)			0.020**			0.013**			0.014**			0.015**			0.02**			0.05**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			0.05**			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 26b Effect of methods of irrigation and mulching on Zn and Cu uptake at different stages of growth in second plant crop

Treatment	Total Zn uptake at 120 DAP (kg ha^{-1})			Total Zn uptake at 240 DAP (kg ha^{-1})			Total Zn uptake at 360 DAP (kg ha^{-1})			Total Cu uptake 120 DAP (kg ha^{-1})			Total Cu uptake at 240 DAP (kg ha^{-1})			Total Cu uptake at 360 DAP (kg ha^{-1})		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.577	0.670	0.624	0.891	1.046	0.969	0.564	0.632	0.599	0.506	0.589	0.548	1.35	1.58	1.46	1.62	1.85	1.74
I_2	0.507	0.653	0.580	0.839	1.015	0.927	0.524	0.621	0.573	0.442	0.570	0.507	1.26	1.55	1.40	1.46	1.80	1.63
I_3	0.333	0.446	0.390	0.651	0.791	0.722	0.369	0.479	0.424	0.298	0.376	0.337	0.98	1.13	1.06	1.14	1.32	1.23
I_4	0.370	0.486	0.428	0.685	0.841	0.764	0.406	0.505	0.456	0.335	0.397	0.366	1.04	1.21	1.12	1.23	1.38	1.31
Mean	0.447	0.564		0.767	0.924		0.466	0.560		0.396	0.483		1.16	1.37		1.36	1.59	
C.D. (0.05) for (I)			0.019**			0.022**			0.018**			0.017**			0.04**			0.04**
C.D. (0.05) for (M)			0.013**			0.016**			0.013**			0.012**			0.02**			0.03**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			0.024**			0.05*			0.06**

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

compared to other methods of irrigation. Whereas alternate furrow irrigation (I_2) recorded comparable values during the advanced stages of growth. The uptake of Zn was decreased in skip furrow (I_3) and farmer's practice of irrigation (I_4). Trash mulching (M_1) had shown remarkably higher values as compared to unmulched treatments (M_0).

4.1.7.9. Total Cu uptake at 120, 240 and 360 DAP (Table 26a and 26b)

A perusal of the data revealed that total Cu uptake was significantly influenced by methods of irrigation and trash mulching in both the years of experimentation. The interaction between I and M was significant only at 240 DAP in first and at all stages in second plant crop.

Among the methods of irrigation tried, all furrow irrigation (I_1) registered maximum uptake of Cu and it was closely followed by alternate furrow method (I_2). The uptake was reduced in skip furrow method of irrigation. Trash mulching had increased the uptake of Cu as compared to unmulched treatments. The treatment combination of I_1M_1 and I_2M_1 at 240 DAP in first plant crop and at all stages in second plant crop recorded comparable values for the total uptake of Cu.

4.1.8. Physical properties of soil

4.1.8.1. Soil moisture status (0 - 15 cm) at 45, 60, 75, 90, 105, 120 and 135 DAP (Table 27a, 27b, 28a and 28b)

The data on soil moisture status revealed that it was remarkably influenced by methods of irrigation and trash mulching at all stages of growth except at 60 DAP in second plant crop where the effects of trash mulching was not significant. The results of the first and second plant crops revealed that all furrow irrigation (I_1) had shown an appreciable increase in soil moisture status and was superior over

Table 27a Effect of methods of irrigation and mulching on soil moisture status (0 - 15 cm) at differnt stages of growth in first plant crop

Treatment	45 DAP (%)			60 DAP (%)			75 DAP (%)			90 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	25.05	26.44	25.75	22.44	26.07	25.25	24.83	25.81	25.32	26.01	28.36	27.19
I_2	22.94	24.84	23.89	22.12	24.53	23.33	23.18	24.63	23.91	23.02	25.81	24.41
I_3	22.82	24.92	23.87	17.09	18.31	17.70	16.38	18.03	17.20	15.79	17.72	16.76
I_4	24.53	26.22	25.38	19.11	20.00	19.56	20.39	22.23	21.31	18.88	20.76	19.82
Mean	23.84	25.60		20.69	22.23		21.20	22.67		20.92	23.16	
C.D. (0.05) for (I)			1.32*			0.69**			0.56**			1.05**
C.D. (0.05) for (M)			0.94**			0.49**			0.40**			0.74**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 27b Effect of methods of irrigation and mulching on soil moisture status (0 - 15 cm) at differnt stages of growth in second plant crop

Treatment	45 DAP (%)			60 DAP (%)			75 DAP (%)			90 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	25.25	27.56	26.41	23.83	25.32	24.58	24.15	26.41	25.28	26.68	28.41	27.55
I_2	22.38	24.80	23.59	24.81	23.58	24.20	23.07	24.59	23.83	23.48	26.31	24.90
I_3	23.04	24.68	23.86	17.44	18.24	17.84	15.88	17.50	16.69	15.90	17.06	16.48
I_4	25.40	27.81	26.60	18.78	19.30	19.04	20.46	21.67	21.07	18.14	19.85	18.99
Mean	24.02	26.21		21.22	21.61		20.89	22.54		21.05	22.91	
C.D. (0.05) for (I)			0.90*			2.24**			1.00**			1.18**
C.D. (0.05) for (M)			0.64**			N.S.			0.71**			0.83**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 28a Effect of methods of irrigation and mulching on soil moisture status (0 - 15 cm) at different stages of growth in first plant crop

Treatment	105 DAP (%)			120 DAP (%)			135 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	24.75	26.26	25.51	24.82	25.22	25.02	25.93	29.00	27.47
I_2	22.45	24.53	23.49	21.99	24.08	23.04	22.52	26.32	24.42
I_3	14.67	17.04	15.86	14.41	16.78	15.60	14.21	16.44	15.32
I_4	20.41	21.95	21.18	18.77	19.60	19.19	20.30	22.00	21.15
Mean	20.57	22.44		20.00	21.42		20.74	23.44	
C.D.(0.05) for (I)			0.89**			0.73**			0.84**
C.D.(0.05) for (M)			0.63**			0.51**			0.59**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 28b Effect of methods of irrigation and mulching on soil moisture status (0 - 15 cm) at different stages of growth in second plant crop

Treatment	105 DAP (%)			120 DAP (%)			135 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	25.56	28.37	26.96	27.08	29.46	28.27	27.49	30.78	29.14
I_2	22.98	27.20	25.09	24.01	28.34	27.17	24.79	29.51	27.15
I_3	14.41	16.96	15.69	14.17	16.81	15.49	14.19	16.65	15.42
I_4	20.51	21.64	21.08	19.02	20.35	19.69	21.55	23.68	22.61
Mean	20.87	23.54		21.07	23.74		22.01	25.15	
C.D.(0.05) for (I)			1.20**			1.34**			1.38**
C.D.(0.05) for (M)			0.85**			0.95**			0.98**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

other methods of irrigation. It was closely followed by alternate furrow irrigation (I_2). While the soil moisture status in skip furrow irrigation and farmer's practice of irrigation was decreased significantly. The mulched treatment (M_1) registered higher values for soil moisture status as compared to unmulched treatments.

4.1.8.2. Soil moisture (15 - 30 cm) status at 45, 60, 75, 90, 105, 120 and 135 DAP (Table 29a, 29b, 30a and 30b)

The data had shown that soil moisture status was conspicuously influenced by the methods of irrigation and trash mulching at all stages of growth except at 45 DAP in first plant crop, where the methods of irrigation was not significant. However, their interaction effect was not significant at any stages of growth in both the years of study.

A perusal of the data in first and second plant crops showed that all furrow irrigation (I_1) had appreciably increased the soil moisture status as compared to the other methods of irrigation. The skip furrow irrigation (I_3) was invariably poor in retaining moisture at 15 - 30 cm soil depth. The impact of trash mulching (M_1) was very well evident at 15 - 30 cm depth with remarkably higher moisture retention in the soil.

4.1.8.3. Soil temperature (0-15 cm) at 45, 60, 75, 90, 105, 120 and 135 DAP (Table 31a, 31b, 32a and 32b)

The data recorded revealed that treatment variation due to methods of irrigation and trash mulching was significant at all stages of growth in both the years of study. But the interaction between I and M was significant only at 120 DAP in first plant crop and at 105 and 120 DAP in second plant crop.

Table 29a Effect of methods of irrigation and mulching on soil moisture status (15 - 30 cm) at differnt stages of growth in first plant crop

Treat-ment	45 DAP (%)			60 DAP (%)			75 DAP (%)			90 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	27.51	28.60	28.05	26.22	28.35	27.28	25.51	27.71	26.61	27.95	29.99	28.97
I_2	26.08	28.00	27.04	25.45	26.28	25.87	25.02	25.60	25.31	25.46	27.80	26.63
I_3	26.41	28.38	27.40	17.94	20.44	19.19	17.57	20.07	18.82	17.57	19.20	18.38
I_4	26.93	29.33	28.13	20.81	22.55	21.68	22.74	23.90	23.32	22.07	22.84	22.46
Mean	26.73	28.58		22.61	24.40		22.71	24.32		23.26	24.96	
C.D. (0.05) for (I)			N.S.			0.80**			0.86**			1.19**
C.D. (0.05) for (M)			1.07**			0.57**			0.61**			0.84**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 29b Effect of methods of irrigation and mulching on soil moisture status (15 - 30 cm) at differnt stages of growth in second plant crop

Treatment	45 DAP (%)			60 DAP (%)			75 DAP (%)			90 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	26.16	28.80	27.53	25.44	26.95	26.19	25.76	27.06	26.41	28.22	30.89	29.55
I_2	24.75	25.67	25.21	22.61	25.67	24.14	24.77	26.25	25.51	25.22	28.32	26.77
I_3	23.85	25.66	24.76	17.99	18.37	18.19	16.13	18.74	17.44	16.05	19.01	17.53
I_4	26.30	29.03	27.66	19.34	20.36	19.85	22.28	23.61	22.95	20.18	22.19	21.19
Mean	25.26	27.32		21.35	22.84		22.24	23.92		22.42	25.10	
C.D. (0.05) for (I)			1.06**			0.91**			0.78**			1.03**
C.D. (0.05) for (M)			0.75**			0.65**			0.55**			0.73**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 30a Effect of methods of irrigation and mulching on soil moisture status (15 - 30 cm) at different stages of growth in first plant crop

Treatment	105 DAP (%)			120 DAP (%)			135 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	25.99	27.88	26.93	25.18	26.81	26.00	27.56	30.26	28.91
I_2	24.29	26.25	25.27	22.58	24.95	23.76	24.51	27.51	26.01
I_3	16.83	18.37	17.60	16.47	18.09	17.28	16.28	17.75	17.02
I_4	22.61	22.65	22.63	20.52	21.18	20.85	22.13	24.12	23.13
Mean	22.43	23.79		21.19	22.76		22.62	24.91	
C.D.(0.05) for (I)			0.90**			0.82**			0.81**
C.D.(0.05) for (M)			0.64**			0.58**			0.58**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 30b Effect of methods of irrigation and mulching on soil moisture status (15 - 30 cm) at different stages of growth in second plant crop

Treatment	105 DAP (%)			120 DAP (%)			135 DAP (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	27.33	30.07	28.70	29.11	31.09	30.10	29.62	31.83	30.72
I_2	24.23	28.49	26.36	25.84	29.66	27.75	27.16	30.11	28.64
I_3	15.96	18.71	17.34	15.77	18.54	17.16	15.74	18.46	17.10
I_4	21.49	22.18	21.83	20.18	22.11	21.14	23.88	25.51	24.70
Mean	22.25	24.86		22.73	25.35		24.10	26.47	
C.D.(0.05) for (I)			0.90**			0.95**			0.89**
C.D.(0.05) for (M)			0.63**			0.67**			0.63**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 31a Effect of methods of irrigation and mulching on soil temperature (0 - 15 cm) at differnt stages of growth in first plant crop

Treatment	45 DAP (°C)			60 DAP (°C)			75 DAP (°C)			90 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	34.67	34.17	34.42	34.33	33.17	33.75	33.17	32.33	32.75	36.67	34.83	35.75
I_2	34.83	34.00	34.42	34.33	33.33	33.83	33.33	32.33	32.83	37.00	35.50	36.25
I_3	36.50	35.00	35.75	35.33	34.33	34.83	34.00	33.00	33.50	39.00	36.83	37.92
I_4	35.67	34.50	35.08	34.83	33.67	34.25	34.00	33.50	33.75	37.33	36.17	36.75
Mean	35.42	34.42		34.71	33.63		33.63	32.79		37.50	35.83	
C.D. (0.05) for (I)			0.56**			0.61**			0.71*			0.95**
C.D. (0.05) for (M)			0.40**			0.43**			0.50**			0.67**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 31b Effect of methods of irrigation and mulching on soil temperature (0 - 15 cm) at differnt stages of growth in second plant crop

Treatment	45 DAP (°C)			60 DAP (°C)			75 DAP (°C)			90 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	35.33	33.83	34.58	34.50	32.83	33.67	36.33	34.83	35.58	36.00	34.50	35.25
I_2	35.50	33.83	34.67	34.50	33.00	33.75	36.67	34.83	35.75	36.16	34.16	35.16
I_3	35.83	35.17	35.50	35.50	34.67	35.08	38.50	36.83	37.67	37.16	36.33	36.75
I_4	35.83	35.17	35.50	35.17	34.83	35.00	38.17	36.17	37.17	36.83	36.00	36.41
Mean	35.63	34.50		34.92	33.83		37.42	35.67		36.54	35.25	
C.D. (0.05) for (I)			0.57**			0.48**			0.51**			0.46**
C.D. (0.05) for (M)			0.40**			0.34**			0.36**			0.32**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 32a Effect of methods of irrigation and mulching on soil temperature (0 - 15 cm) at different stages of growth in first plant crop

Treatment	105 DAP (°C)			120 DAP (°C)			135 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	32.33	31.50	31.91	35.83	34.83	35.33	34.50	33.50	34.00
I_2	33.16	31.83	32.50	36.00	35.16	35.58	34.66	33.83	34.25
I_3	34.66	33.83	34.25	39.00	36.50	37.75	35.66	35.00	35.33
I_4	34.16	33.50	33.83	37.66	36.16	36.91	35.33	34.50	34.91
Mean	33.58	32.66		37.12	35.66		35.04	34.20	
C.D.(0.05) for (I)			0.47**			0.53**			0.56**
C.D.(0.05) for (M)			0.33**			0.37**			0.39**
C.D. (0.05) for interaction (I x M)			N.S.			0.75**			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 32b Effect of methods of irrigation and mulching on soil temperature (0 - 15 cm) at different stages of growth in second plant crop

Treatment	105 DAP (°C)			120 DAP (°C)			135 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	34.83	32.66	33.75	37.66	35.33	36.50	35.16	34.16	34.66
I_2	35.16	32.66	33.91	38.00	35.50	36.75	35.50	34.50	35.00
I_3	35.66	35.16	35.41	39.66	38.66	39.16	36.00	35.50	35.75
I_4	35.50	34.83	35.16	39.16	38.33	38.75	35.83	35.16	35.50
Mean	35.29	33.83		38.62	36.95		35.62	34.83	
C.D.(0.05) for (I)			0.53**			0.67**			0.47**
C.D.(0.05) for (M)			0.37**			0.47**			0.33**
C.D. (0.05) for interaction (I x M)			0.75**			0.94*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

The results of the study in first and second plant crops revealed that skip furrow method of irrigation (I_3) had invariably increased the soil temperature. It was closely followed by farmer's practice of irrigation (I_4). The beneficial effects of mulching was observed in M_1 where the soil temperature was drastically decreased at 0 - 15 cm soil depth as compared to unmulched treatment (M_0). The interaction effect observed at 120 DAP in first plant crop and at 105 and 120 DAP in second plant crop indicated that the treatment combinations of I_3M_0 and I_4M_0 recorded higher values for soil temperature as compared to other treatment combinations.

4.1.8.4. Soil temperature (15-30 cm) at 45, 60, 75, 90, 105,120 and 135 DAP (Table 33a, 33b, 34a and 34b)

The data summarised revealed that soil temperature was remarkably influenced by methods of irrigation and trash mulching in both plant crops. But their interaction was significant only at 45, 60 and 90 DAP in second plant crop.

A critical review of the data in first and second plant crops revealed that skip furrow irrigation (I_3) and farmer's practice of irrigation registered higher soil temperature than other two methods of irrigation. While in trash mulching M_1 had decreased the soil temperature as compared to M_0. The interaction effect between I and M at 45, 60 and 90 DAP in second plant crop showed that I_3M_0 and I_4M_0 had appreciably increased the values of soil temperature at 15 - 30 cm soil depth as compared to other treatment combinations. The soil temperature was reduced drastically in I_1M_1 and I_2M_1.

4.1.8.5. Bulk density of soil after the experiment (Table 35a and 35b)

The data revealed that bulk density was significantly influenced by the

Table 33a Effect of methods of irrigation and mulching on soil temperature (15 - 30 cm) at differnt stages of growth in first plant crop

Treatment	45 DAP (°C)			60 DAP (°C)			75 DAP (°C)			90 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	34.00	33.50	33.75	33.50	32.50	33.00	32.66	31.83	32.25	36.00	34.33	35.16
I_2	34.33	33.50	33.91	33.50	32.33	32.91	32.66	31.66	32.16	36.00	34.33	35.16
I_3	35.16	34.33	34.75	34.33	33.16	33.75	33.16	32.50	32.83	37.66	36.00	36.83
I_4	35.16	34.00	34.58	34.00	32.83	33.41	33.00	32.16	32.58	36.33	35.50	35.91
Mean	34.66	33.83		33.83	32.70		32.87	32.04		36.50	35.04	
C.D. (0.05) for (I)			0.49**			0.57*			0.48*			0.86**
C.D. (0.05) for (M)			0.34**			0.40**			0.33**			0.60**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 33b Effect of methods of irrigation and mulching on soil temperature (15 - 30 cm) at differnt stages of growth in second plant crop

Treatment	45 DAP (°C)			60 DAP (°C)			75 DAP (°C)			90 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	34.66	32.83	33.75	34.00	32.00	33.00	34.83	34.00	34.41	35.50	33.66	34.58
I_2	34.66	33.16	33.91	34.16	32.33	33.25	35.83	33.83	34.83	35.33	33.50	34.41
I_3	35.00	34.50	34.75	35.00	34.33	34.66	36.50	35.66	36.08	36.00	35.66	35.83
I_4	35.16	34.66	34.91	34.66	34.16	34.41	36.66	34.83	35.75	36.16	35.16	35.66
Mean	34.87	33.79		34.45	33.20		35.95	34.58		35.75	34.50	
C.D. (0.05) for (I)			0.51**			0.61**			0.71**			0.56**
C.D. (0.05) for (M)			0.36**			0.43**			0.50**			0.41**
C.D. (0.05) for interaction (I x M)			0.72*			0.87*			N.S.			0.83*

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 34a Effect of methods of irrigation and mulching on soil temperature (15- 30 cm) at different stages of growth in first plant crop

Treatment	105 DAP (°C)			120 DAP (°C)			135 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	31.66	30.66	31.16	34.83	33.66	34.25	33.50	32.50	33.00
I_2	32.50	30.66	31.58	35.00	33.83	34.41	33.83	33.00	33.41
I_3	33.66	32.83	33.25	37.50	35.33	36.41	35.16	34.16	34.66
I_4	33.16	32.50	32.83	36.00	34.83	35.41	34.66	33.83	34.25
Mean	32.75	31.66		35.83	34.41		34.29	33.37	
C.D.(0.05) for (I)			0.56**			0.85**			0.60**
C.D.(0.05) for (M)			0.39**			0.60**			0.42**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 34b Effect of methods of irrigation and mulching on soil temperature (15- 30 cm) at different stages of growth in second plant crop

Treatment	105 DAP (°C)			120 DAP (°C)			135 DAP (°C)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	34.16	32.00	33.08	36.66	34.66	35.66	34.66	33.33	34.00
I_2	34.50	32.16	33.33	36.66	34.83	35.75	34.83	33.83	34.33
I_3	35.00	34.50	34.75	38.33	37.50	37.91	35.50	34.83	35.16
I_4	35.00	34.16	34.58	38.00	37.33	37.66	35.16	34.33	34.75
Mean	34.66	33.20		37.41	36.08		35.04	34.08	
C.D.(0.05) for (I)			0.46**			0.60**			0.43**
C.D.(0.05) for (M)			0.32**			0.42**			0.30**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

methods of irrigation, trash mulching and their interactions in first plant crop. But in second plant crop, the effect of trash mulching was significant.

The result of the study in first plant crop revealed that skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4) recorded comparable values for bulk density and were superior to other two methods of irrigation tried. While all furrow irrigation (I_1) and alternate furrow irrigation (I_2) had shown reduced values for bulk density. In trash mulching, M_1 recorded significantly lower values than M_0 in both plant crops. The interaction exhibited in first plant crop revealed that I_2M_0 was statistically on par with I_3M_0, I_4M_0 and I_1M_0.

4.1.8.6. Particle density of soil after the experiment (Table 35a and 35b)

Particle density was not influenced by methods of irrigation, trash mulching and their interactions in both years of experimentation.

4.1.8.7. Porespace distribution of soil after the experiment (Table 35a and 35b)

The data generated revealed that treatment effects due to trash mulching, methods of irrigation and their interactions were significant in first plant crop. However, in second plant crop, methods of irrigation did not exhibit any appreciable influence.

The results of the study revealed that in first plant crop, all furrow irrigation (I_1) recorded higher values for pore space distribution and was comparable with alternate furrow irrigation (I_2). The trash mulching (M_1) recorded significantly superior values than M_0 in both the years of experimentation. The interaction effect between I and M shown that the treatment combination of I_1M_1 and I_2M_1 had remarkably increased the pore space distribution and were statistically on par with each other.

Table 35a Effect of methods of irrigation and mulching on physical properties of soil in first plant crop

Treatment	Bulk density (gcc^{-1})			Particle density (gcc^{-1})			Pore spare distribution (%)			Maximum water holding capacity (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.460	1.426	1.443	2.60	2.62	2.61	43.70	46.02	44.86	56.44	60.32	58.38
I_2	1.466	1.420	1.442	2.62	2.61	2.62	43.22	46.14	44.68	56.29	60.44	58.36
I_3	1.463	1.446	1.445	2.60	2.59	2.60	43.57	44.85	44.21	55.35	59.20	57.28
I_4	1.463	1.443	1.453	2.62	2.63	2.63	43.49	44.90	44.20	55.59	59.95	57.77
Mean	1.463	1.434		2.61	2.60		43.50	45.48		55.92	59.98	
C.D. (0.05) for (I)			0.008**			N.S.			0.48*			0.86*
C.D. (0.05) for (M)			0.006**			N.S.			0.34**			0.61**
C.D. (0.05) for interaction (I x M)			0.011**			N.S.			0.68**			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 35b Effect of methods of irrigation and mulching on physical properties of soil in second plant crop

Treatment	Bulk density (g cc^{-1})			Particle density (g cc^{-1})			Pore space distribution (%)			Maximum water holding capacity (%)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.453	1.420	1.437	2.65	2.63	2.64	44.10	46.41	45.25	58.02	60.63	59.33
I_2	1.460	1.416	1.438	2.62	2.64	2.63	43.62	46.40	45.01	57.75	61.06	59.41
I_3	1.456	1.440	1.448	2.60	2.62	2.62	43.97	45.24	44.61	57.12	59.90	58.51
I_4	1.456	1.436	1.447	2.64	2.61	2.64	43.90	25.29	44.60	57.46	60.26	58.86
Mean	1.457	1.428		2.62	2.63		43.90	45.84		54.26	60.46	
C.D. (0.05) for (I)			N.S.			N.S.			N.S.			N.S.
C.D. (0.05) for (M)			0.007**			N.S.			0.38**			N.S.
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			0.77*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

4.1.8.8. Maximum water holding capacity of soil after the experiment (Table 35a and 35b)

The data indicated that methods of irrigation and trash mulching had significantly influenced the maximum water holding capacity. However, their interactions were not significant. While in second plant crop none of the treatments were significant.

A critical review of the data revealed that all furrow irrigation (I_1) recorded higher value for maximum water holding capacity and was statistically on par with alternate furrow irrigation (I_2) and farmer's practice of irrigation (I_4). While in trash mulching (M_1) registered significantly superior value as compared to unmulched treatments (M_0).

4.1.9. Chemical properties of soil

4.1.9.1. Soil organic carbon after the experiment (Table 36a and 36b)

The data generated revealed that the analysis of variance for soil organic carbon was significantly influenced by methods of irrigation, trash mulching and their interactions in both plant crops.

The data obtained in first and second plant crops indicated that all furrow irrigation (I_1) had invariably increased the organic carbon content in the soil and was statistically on par with alternate furrow irrigation (I_2). While trash mulching (M_1) had registered significantly higher values for organic carbon content as compared to unmulched treatment (M_0). The interaction effect between I and M revealed that the treatment combinations of I_1M_1 and I_2M_1 recorded comparable values and were superior over other treatment combinations.

4.1.9.2. Available Nitrogen in the soil after the experiment (Table 36a and 36b)

A perusal of the data had revealed that available soil N after the experiment was significantly influenced by the methods of irrigation and trash mulching. However, their interaction was not significant in both plant crops.

The data recorded in first and second plant crop revealed that all furrow irrigation (I_1) had appreciably increased the available N content in the soil after the experiment and was closely followed by alternate furrow irrigation (I_2). While in trash mulching (M_1) recorded significantly higher value than M_0 in both years of study.

4.1.9.3. Available Phosphorus in the soil after the experiment (Table 36a and 36b)

The data had shown that treatment effects due to methods of irrigation and trash mulching were significant in both plant crops. But their interaction was not significant.

A critical review of the data in first and second year of study revealed that all furrow irrigation (I_1) and alternate furrow irrigation (I_2) had increased the available P content in the soil after the experiment and was statistically on par with each other. While trash mulching (M_1) had significantly increased the available P content as compared to unmulched treatment (M_0).

4.1.9.4. Available Potassium in the soil after the experiment (Table 36a and 36b)

Data revealed that available K was significantly influenced by methods of irrigation and trash mulching in both plant crops. However, the interaction between I and M was significant only in first plant crop.

Table 36a Effect of methods of irrigation and mulching on chemical properties of soil after the experiment in first plant crop

Treatment	Organic carbon (%)			Available N (ppm)			Available P (ppm)			Available K (ppm)			Available Ca (ppm)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.747	0.820	0.784	163.33	210.00	186.66	3.48	3.74	3.61	46.67	58.33	52.50	143.33	163.33	153.33
I_2	0.744	0.819	0.782	151.66	198.33	175.00	3.43	3.75	3.59	43.33	58.33	50.83	136.66	166.66	151.66
I_3	0.737	0.769	0.754	128.33	175.00	151.66	3.21	3.45	3.33	43.33	45.00	44.17	113.33	143.33	128.33
I_4	0.739	0.762	0.751	140.00	186.66	163.33	3.25	3.48	3.37	45.00	46.67	45.83	120.00	153.33	136.66
Mean	0.742	0.793		145.83	192.50		3.34	3.61		44.58	52.08		128.33	156.66	
C.D. (0.05) for (I)			0.007**			19.66**			0.08**			3.94**			9.01**
C.D. (0.05) for (M)			0.005**			13.55**			0.06**			2.79**			6.37**
C.D. (0.05) for interaction (I x M)			0.009**			N.S.			N.S.			5.57**			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 36b Effect of methods of irrigation and mulching on chemical properties of soil after the experiment in second plant crop

Treatment	Organic carbon (%)			Available N (ppm)			Available P (ppm)			Available K (ppm)			Available Ca (ppm)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.754	0.827	0.791	186.66	221.66	204.16	3.54	3.81	3.68	53.33	60.00	56.66	133.33	156.6	145.00
I_2	0.749	0.827	0.789	175.00	210.00	192.50	3.48	3.85	3.67	48.33	58.33	53.33	123.33	163.33	143.33
I_3	0.739	0.774	0.757	140.00	151.66	145.83	3.25	3.50	3.38	46.67	53.33	50.00	106.66	133.33	120.00
I_4	0.742	0.775	0.759	151.66	186.66	169.16	3.29	3.52	3.41	43.33	55.00	49.16	116.66	143.33	130.00
Mean	0.747	0.801		163.33	192.50		3.39	3.67		47.91	56.66		120.00	149.16	
C.D. (0.05) for (I)			0.007**			19.16**			0.09**			4.49*			7.40**
C.D. (0.05) for (M)			0.005**			13.50**			0.06**			3.17**			5.23**
C.D. (0.05) for interaction (I x M)			0.010**			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

The results of the first and second plant crops revealed that all furrow irrigation (I_1) and alternate furrow method (I_2) had shown higher values for available K content in the soil as compared to other methods of irrigation after the experiment. While trash mulching (M_1) recorded significantly superior values over unmulched treatments (M_0). The interaction effect noticed in first plant crop had shown that I_1M_1 and I_2M_1 recorded significantly higher values than other treatment combinations.

4.1.9.5. Calcium content in the soil after the experiment (Table 36a and 36b)

A perusal of the data revealed that methods of irrigation and trash mulching had significantly influenced the Ca content of the soil after the experiment in both plant crops. However, their interaction did not show any significant effects.

The results of the first and second plant crop revealed that all furrow irrigation (I_1) had shown higher values for the Ca content of the soil after the experiment and was statistically on par with alternate furrow irrigation (I_2). With regard to trash mulching M_1 had given significantly superior values as compared to M_0.

4.1.9.6. Sodium content in the soil after the experiment (Table 37a and 37b)

The data presented revealed that the treatments varied significantly due to methods of irrigation and trash mulching. But their interaction was not significant in both years of experimentation.

The results of first and second plant crops indicated that Na content in the soil after experiment was increased in the case of all furrow irrigation (I_1) and alternate furrow irrigation (I_2). Trash mulching (M_1) had given significantly superior values as compared to unmulched treatments (M_0).

Table 37a Effect of methods of irrigation and mulching on chemical properties of soil after the experiment in first plant crop

Treatment	Na content (ppm)			Fe content (ppm)			Mn content (ppm)			Zn content (ppm)			Cu content (ppm)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	78.33	93.33	85.83	61.84	75.54	68.69	39.62	51.47	45.54	1.51	1.73	1.62	4.91	5.73	5.32
I_2	76.66	95.00	85.83	61.47	74.44	67.95	39.25	51.84	45.54	1.51	1.69	1.60	4.84	5.69	5.27
I_3	61.66	81.66	71.66	54.43	71.82	63.12	38.14	50.36	44.25	1.29	1.62	1.45	4.36	5.33	4.84
I_4	63.33	86.66	75.00	54.80	72.58	63.69	38.51	51.10	44.80	1.33	1.58	1.46	4.44	5.36	4.90
Mean	70.00	89.16		58.13	73.59		38.88	51.19		1.41	1.66		4.64	5.53	
C.D. (0.05) for (I)			3.02**			1.20**			0.86*			0.11**			0.14**
C.D. (0.05) for (M)			2.13**			0.85**			0.61**			0.08**			0.10**
C.D. (0.05) for interaction (I x M)			N.S.			1.70**			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 37b Effect of methods of irrigation and mulching on chemical properties of soil after the experiment in second plant crop

Treatment	Na content (ppm)			Fe content (ppm)			Mn content (ppm)			Zn content (ppm)			Cu content (ppm)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	76.66	95.00	85.83	62.58	83.32	72.95	42.58	53.69	48.13	1.47	1.77	1.62	4.77	5.66	5.21
I_2	78.33	96.66	87.50	60.73	82.95	71.84	42.21	53.32	47.76	1.47	1.66	1.56	4.66	5.62	5.14
I_3	63.33	83.33	73.33	56.28	79.62	67.95	38.51	49.62	44.06	1.25	1.58	1.42	4.29	5.25	4.78
I_4	66.66	88.33	77.50	57.03	80.36	68.69	39.62	50.73	45.18	1.33	1.55	1.44	4.47	5.40	4.94
Mean	71.25	90.83		59.15	81.56		40.73	51.84		1.38	1.64		4.55	5.48	
C.D. (0.05) for (I)			3.91**			1.82**			1.21**			0.08**			0.13**
C.D. (0.05) for (M)			2.76**			1.28**			0.85**			0.06**			0.09**
C.D. (0.05) for interaction (I x M)			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

4.1.9.7. Iron, Manganese, Zinc and Copper content in the soil after the experiment (Table 37a and 37b)

A critical review of the data revealed that the analysis of variance for Fe, Mn, Zn and Cu content in the soil after the experiment was significantly influenced by methods of irrigation and trash mulching. But their interaction was not significant.

The results of the first and second plant crops revealed that all furrow irrigation (I_1) had invariably increased the contents of Fe, Mn, Zn and Cu in the soil after the experiment and it was comparable with alternate furrow irrigation (I_2). While in trash mulching M_1 recorded significantly superior values for soil Fe, Mn, Zn and Cu content after the experiment.

4.1.10. Biological properties of soil

4.1.10.1. Acid phosphatase activity, cellulase activity and urease activity of the soil after the experiment (Table 38a and 38b)

The data indicated that treatment variation due to methods of irrigation, trash mulching and their interactions were significant in both plant crops for acid phosphates activity. While in the case of cellulase and urease activity, the interaction effect was noticed only in the second plant crop.

The results of the first and second plant crops showed that all furrow irrigation (I_1) had appreciably increased the values of acid phosphatase, cellulase and urease activity and was statistically on par with alternate furrow irrigation (I_2). While in trash mulching, M_1 registered significantly higher values than M_0. The interaction effect noticed between I and M with acid phosphatase activity revealed that the treatment combinations of I_1M_1 and I_2M_1 recorded comparatively higher values than other treatment combinations in both plant crops. While the interaction effect observed with cellulase and urease activity in the second plant crop also

Table 38a Effect of methods of irrigation and mulching on soil enzymes and microbial population after the experiment in first plant crop

Treatment	Acid phosphatase (u moles of PNP liberated/hr/g of soil)			Cellulase (u moles of glucose produced/hr/g of soil)			Urease (u moles of NH_3 produced/hr/g of soil)			Bacteria ($x10^7$)			Fungi ($x10^5$)			Actimomycetes ($x10^2$)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.986	1.091	1.039	0.0147	0.0182	0.0164	0.313	0.490	0.402	17.33	21.00	19.16	5.33	8.66	7.00	3.66	5.66	4.66
I_2	0.974	1.088	1.031	0.0147	0.0184	0.0165	0.313	0.493	0.403	17.00	20.33	18.66	5.00	8.33	6.66	4.33	6.00	5.16
I_3	0.774	1.002	0.889	0.0128	0.0165	0.0146	0.246	0.429	0.338	14.66	19.00	16.83	4.33	7.00	5.66	3.00	5.00	4.00
I_4	0.799	1.017	0.908	0.0113	00171	0.0152	0.252	0.440	0.346	16.33	20.33	18.33	5.00	7.33	6.16	3.33	5.33	4.33
Mean	0.884	1.050		0.0138	0.0175		0.281	0.463		16.33	20.16		4.91	7.83		3.58	5.49	
C.D. (0.05) for (I)			0.013**			0.0005**			0.006**			1.41*			0.88*			N.S.
C.D. (0.05) for (M)			0.009**			0.0003**			0.004**			1.00**			0.62**			0.54**
C.D. (0.05) for interaction (I x M)			0.019**			N.S.			N.S.			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 38b Effect of methods of irrigation and mulching on soil enzymes and microbial population after the experiment in second plant crop

Treatment	Acid phosphatase (u moles of PNP liberated/hr/g of soil)			Cellulase (u moles of glucose produced/hr/g of soil)			Urease (u moles of NH_3 produced/hr/g of soil)			Bacteria (x10^7)			Fungi (x10^5)			Actimomycetes (x10^2)		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	0.961	1.047	1.004	0.0149	0.0183	0.0166	0.298	0.484	0.391	15.66	20.33	18.00	6.33	8.33	7.33	4.66	6.66	5.66
I_2	0.956	1.050	1.003	0.0145	0.0183	0.0164	0.296	0.483	0.390	15.33	21.33	18.33	5.66	8.33	7.00	4.33	6.33	5.33
I_3	0.754	1.017	0.886	0.0125	0.0172	0.0148	0.239	0.439	0.339	15.33	20.00	17.66	4.33	6.33	5.33	4.00	6.00	5.00
I_4	0.769	1.022	0.896	0.0129	0.0175	0.0152	0.244	0.446	0.345	15.66	20.00	17.83	5.00	7.00	6.00	3.66	5.66	4.66
Mean	0.861	1.034		0.0137	0.0178		0.270	0.463		15.50	20.41		5.33	7.50		4.16	6.16	
C.D. (0.05) for (I)			0.003**			0.0002**			0.004**			N.S.			0.83**			N.S.
C.D. (0.05) for (M)			0.002**			0.0002**			0.003**			1.15**			0.59**			0.82**
C.D. (0.05) for interaction (I x M)			0004**			0.0004**			0.006**			N.S.			N.S.			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

exhibited similar trend. Among the treatment combinations I_1M_1 and I_2M_1 recorded significantly higher values.

4.1.10.2. Bacterial fungal and actinomycetes population in the soil after the experiment (Table 38a and 38b)

The data revealed that the methods of irrigation and trash mulching had influenced the fungal population in both plant crops and the bacterial population in first plant crop alone. While in second plant crop, trash mulching had only exerted significant influence on bacterial population. In the case of actinomycetes population, the analysis of variance indicated significant difference only with trash mulching in both plant crops.

The data generated in first and second plant crops revealed that all furrow irrigation (I_1) had registered the highest bacterial and fungal population and it was on par with alternate furrow irrigation (I_2). While with trash mulching M_1 had shown maximum bacterial, fungal and actinomycetes population as compared to M_0.

4.1.11. Water use efficiency (Table 39a and 39b)

The data summarised revealed that WUE was markedly influenced by the methods of irrigation, trash mulching and their interactions in both years of study.

The results of the first and second plant crops revealed that alternate furrow irrigation ((I_2) had invariably increased the WUE and was superior to all other methods of irrigation. It was closely followed by farmer's practice of irrigation (I_4). Water use efficiency decreased drastically in treatment with all furrow irrigation (I_1). While trash mulching (M_1) had made perceptible increase in WUE and showed its superiority over unmulched treatments (M_0). The interaction effect also revealed that the treatment combination of I_2M_1 had shown appreciable increase and it was

Table 39a Effect of methods of irrigation and mulching on water use efficiency, economicsand energetics of first plant crop

Treatment	WUE (t ha-cm^{-1})			B:C ratio			Energy productivity (g MJ^{-1})			Energy use efficiency		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.68	1.78	1.73	1.26	1.31	1.28	1457	1509	1483	9.84	10.30	10.07
I_2	2.26	2.50	2.38	1.23	1.33	1.28	1511	1628	1569	10.17	11.26	10.71
I_3	2.05	2.17	2.11	1.11	1.13	1.12	1370	1413	1392	8.87	9.28	9.08
I_4	2.22	2.27	2.24	1.13	1.15	1.14	1344	1343	1343	8.71	8.76	8.74
Mean	2.05	2.18		1.18	1.23		1421	1473		9.40	9.90	
C.D. (0.05) for (I)			0.04**			0.01**			18**			0.26**
C.D. (0.05) for (M)			0.03**			0.01**			13**			0.19**
C.D. (0.05) for interaction (I x M)			0.06**			0.02**			26**			0.38**

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level

Table 39b Effect of methods of irrigation and mulching on water use efficiency, economics and energetics of second plant crop

Treatment	WUE (t ha-cm^{-1})			B:C ratio			Energy productivity (g MJ^{-1})			Energy use efficiency		
	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean	M_0	M_1	Mean
I_1	1.71	1.81	1.76	1.28	1.32	1.30	1520	1555	1537	10.40	10.83	10.61
I_2	2.30	2.54	2.42	1.24	1.34	1.29	1555	1670	1613	10.64	11.47	11.05
I_3	2.07	2.17	2.12	1.12	1.15	1.13	1401	1428	1414	9.28	9.90	9.59
I_4	2.27	2.34	2.30	1.15	1.17	1.16	1385	1405	1395	9.27	9.39	9.33
Mean	2.09	2.21		1.20	1.24		14654	1514		9.90	10.40	
C.D. (0.05) for (I)			0.03**			0.02**			30**			0.26**
C.D. (0.05) for (M)			0.02**			0.01**			21**			0.19**
C.D. (0.05) for interaction (I x M)			0.05**			0.03*			43*			N.S.

Methods of Irrigation

I_1 - All furrow irrigation
I_2 - Alternate furrow irrigation
I_3 - Skip furrow irrigation
I_4 - Farmer's practice

Mulching

M_0 - No trash mulching
M_1 - Trash mulching
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

followed by I_2M_0 and I_4M_1. Whereas I_1M_0 and I_1M_1 had recorded comparatively lower values.

4.1.12. Economics

4.1.12.1. Benefit cost ratio (Table 39 a and 39 b)

The data generated revealed that benefit-cost ratio was significantly influenced by methods of irrigation, trash mulching and their interactions in both years of experimentation.

The results of the study showed that the highest benefit-cost ratio was obtained in all furrow irrigation (I_1) and was on par with alternate furrow irrigation (I_2). Whereas in skip furrow irrigation (I_3) and farmer's practice of irrigation (I_4), the benefit cost ratio was significantly reduced. With trash mulching M_1 had shown greatest benefit-cost ratio than M_0. The interactions exhibited between I and M revealed that the treatment combinations of I_1M_1 and I_2M_1 had shown comparatively higher values for benefit cost ratio and was on par with each other. It was also superior to other treatment combinations.

4.1.13. Energetics

4.1.13.1. Energy productivity and energy use efficiency (Table 39a and 39b)

A critical review of the data revealed that analysis of variance for energy productivity and energy use efficiency was significantly influenced by methods of irrigation, trash mulching and their interactions in both plant crops except that the interaction effect of energy use efficiency was not significant in second plant crop.

The data obtained in first and second plant crops indicated that alternate furrow irrigation (I_2) had shown highest values for energy productivity and energy use efficiency and was superior over other methods of irrigation. While trash mulching (M_1) had remarkably increased the energy productivity and energy use efficiency as compared to unmulched treatments (M_0). The interaction effect between I and M revealed that the treatment combination of I_2M_1 recorded significantly higher values and was superior to all other treatment combinations.

4.1.14. Correlation (Table 40)

Correlation studies between cane yield, growth components like plant height, number of nodes, number of leaves and dry matter production and LAI revealed that all growth characters contributed positively and significantly for the cane yield. The highest positive correlation was associated with DMP followed by LAI.

Correlation worked out between cane yield and yield attributes like MCC, cane girth, cane length and single cane weight had shown that all the yield attributing characters contributed positively and significantly for the cane yield. The highest positive correlation was associated with MCC followed by single cane weight. The lowest positive association was related with cane girth.

The correlation studies carried out between cane yield and nutrient uptake of N, P, K, Ca, Fe, Mn, Zn and Cu also indicated that the nutrient uptake had positively and significantly contributed for the cane yield. Among the correlation worked out, the highest positive correlation was associated with K uptake closely followed by P, Zn and N. The lowest positive contribution for cane yield was noticed with Fe uptake.

Table 40 Correlation matrix of growth, yield attributes, nutrient uptake and cane yield as influenced by methods of irrigation and trash mulching

	MCC	Single cane weight	Cane length	Cane girth	No. of nodes	No. of leaves	Plant height	Cane yield	Total DMP	Total N uptake	Total P uptake	Total Zn uptake	Total Fe uptake	Ca uptake	Cu uptake	Mn uptake	LAI	Sugar field	Jaggery field	
MCC	1.000																			
Single cane weight	0.9387	1.000																		
Cane length	0.9222	0.8947	1.000																	
Cane girth	0.8908	0.8867	0.8700	1.000																
No.of nodes	0.8989	0.8435	0.9436	0.8892	1.000															
No.of leaves	0.8407	0.8399	0.8669	0.7797	0.7360	1.000														
Plant height	0.9253	0.9013	0.9415	0.9323	0.9074	0.8201	1.000													
Cane yield	0.9681	0.9656	0.9217	0.8915	0.8807	0.8767	0.9319	1.000												
DMP	0.9842	0.9542	0.9236	0.9183	0.8912	0.8773	0.9444	0.9763	1.000											
Total N uptake	0.9079	0.9090	0.8412	0.7940	0.7557	0.8310	0.8601	0.9111	0.9270	1.000										
Total P uptake	0.9674	0.9268	0.8921	0.8716	0.8474	0.8926	0.9387	0.9761	0.9764	0.9320	1.000									
Total K uptake	0.9774	0.9563	0.9093	0.9120	0.8756	0.8741	0.9428	0.9815	0.9896	0.9048	0.9798	1.000								
Total Zn uptake	0.9574	0.9192	0.8979	0.9027	0.8697	0.8762	0.9559	0.9519	0.9825	0.9325	0.9805	0.9741	1.000							
Fe uptake	0.8619	0.7752	0.7958	0.8357	0.8319	0.7604	0.8558	0.8321	0.8676	0.8126	0.8737	0.8559	0.9177	1.000						
Ca uptake	0.9679	0.9185	0.9040	0.9021	0.8946	0.8708	0.9394	0.9699	0.9668	0.9068	0.9762	0.9765	0.9665	0.9045	1.0000					
Cu uptake	0.9281	0.9263	0.8918	0.9051	0.8239	0.5714	0.9113	0.9487	0.9535	0.9314	0.9421	0.9491	0.9460	0.8525	0.9467	1.000				
Mn uptake	0.9415	0.8861	0.8549	0.8853	0.8687	0.8274	0.9210	0.9342	0.9479	0.9866	0.9531	0.9535	0.9632	0.9514	0.9738	0.9279	1.000			
LAI	0.9382	0.9598	0.8933	0.8914	0.8381	0.8793	0.9188	0.9715	0.9644	0.9540	0.9599	0.9563	0.9521	0.8337	0.9506	0.9678	0.9318	1.000		
Sugar yield	0.9236	0.9355	0.8930	0.8816	0.8381	0.8769	0.8964	0.9701	0.9513	0.8943	0.9416	0.9494	0.9167	0.7685	0.9289	0.9320	0.8853	0.9582	1.000	
Jaggery yield	0.9581	0.9471	0.9208	0.8778	0.8741	0.8814	0.9277	0.9911	0.9702	0.9228	0.9798	0.9740	0.9541	0.8380	0.9718	0.9567	0.9409	0.9762	0.9680	1.000

The values are significant at 1 per cent

Experiment No. II - Integrated Nutrient Management in Sugarcane

4.2.1. Growth attributes

4.2.1.1. Plant Height at 120, 240 and 360 DAP (Table 41a and 41b)

The data generated revealed that plant height was significantly influenced by organic sources and mineral nutrition at all stages of growth in both plant crops. However, their interaction effects were significant only at 240 and 360 DAP in first and second plant crops.

It was observed that press mud application (T_2) recorded the highest plant height at all stages of growth. It was on par with Azospirillum inoculation (T_6) at 120 and 240 DAP, but was significantly superior at 360 DAP in first plant crop. In second plant crop T_2 recorded higher plant height than T_6 at all stages of growth. The treatments without organic sources (T_1) had consistently recorded the lowest plant height. While with mineral nutrition, N P K application at 100 per cent of the recommended dose (F_3) had produced taller plants as compared to NPK application at 75 per cent (F_2) and 50 per cent (F_1) of the recommended dose. The interaction effects noticed in the later stages of growth revealed that T_2F_3 was statistically superior to all other treatment combinations and it was closely followed by T_2F_2 and T_6F_3.

4.2.1.2. Number of leaves at 120, 240 and 360 DAP (Table 42a and 42b)

A perusal of the data revealed that treatment variation due to organic sources and mineral nutrition were statistically significant during the first and second plant crops. The interaction effect was noticed only at 240 DAP in the first plant crop.

Table 41a Effect of organic sources and mineral nutrition on plant height (cm) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	117.15	121.30	132.50	123.65	229.75	245.75	257.50	244.33	253.50	269.15	280.40	267.68
T_2	152.90	157.50	163.50	157.97	282.75	287.00	291.75	287.17	299.45	308.10	319.35	308.97
T_3	131.25	141.75	146.05	139.68	253.00	259.75	265.00	259.25	275.03	282.15	285.55	280.91
T_4	147.50	150.25	152.70	150.15	271.25	277.00	280.75	276.33	293.25	297.20	299.40	296.62
T_5	146.05	149.35	152.00	149.13	267.50	271.00	274.50	271.00	289.75	295.00	295.90	293.55
T_6	149.60	155.00	156.20	153.60	274.00	283.25	285.50	280.92	297.25	301.75	304.15	301.05
Mean	140.74	145.86	150.49		263.04	270.63	275.83		284.70	292.23	297.46	
C.D.(0.05) for (T)				5.09**				7.55**				6.20**
C.D.(0.05) for (F)				2.75**				2.73**				5.51**
C.D. (0.05) for interaction (T x F)				N.S.				6.22*				6.35**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 41b Effect of organic sources and mineral nutrition on plant height (cm) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	108.90	114.10	121.25	114.75	218.70	233.98	238.25	230.31	242.25	252.80	264.00	253.02
T_2	143.93	148.70	151.40	148.01	274.45	280.00	285.85	280.10	293.60	300.70	310.90	301.73
T_3	122.00	128.05	132.30	127.45	236.30	249.80	257.60	247.90	268.80	273.25	276.90	272.98
T_4	134.45	135.65	143.40	137.83	265.55	268.65	274.50	269.57	284.15	287.00	292.30	287.82
T_5	135.65	138.70	142.30	138.88	261.25	267.45	270.20	266.30	282.10	283.65	287.00	284.25
T_6	141.05	145.45	147.00	144.50	267.60	274.45	278.95	274.00	288.35	295.00	298.75	294.03
Mean	130.99	135.11	139.61		253.98	262.55	267.56		276.54	282.07	288.31	
C.D.(0.05) for (T)				5.32**				3.23**				2.70**
C.D.(0.05) for (F)				3.17**				1.69**				0.98**
C.D. (0.05) for interaction (T x F)				N.S.				3.29**				2.78**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 42a **Effect of organic sources and mineral nutrition on number of leaves at different stages of growth in first plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	8.20	8.70	8.70	8.53	7.30	8.35	9.05	8.23	8.80	9.15	9.60	9.18
T_2	10.05	10.55	10.85	10.48	10.45	10.60	10.80	10.62	11.55	11.15	11.70	11.67
T_3	8.45	8.75	8.75	8.65	9.00	9.10	9.25	9.12	9.55	10.55	10.80	10.30
T_4	9.30	9.60	9.75	9.55	9.25	9.45	9.50	9.40	10.85	10.90	11.20	10.98
T_5	8.80	9.10	9.20	9.03	9.30	9.30	9.45	9.35	10.75	10.90	10.95	10.87
T_6	9.65	10.50	10.65	10.27	9.55	10.10	10.20	9.95	10.90	11.50	11.60	11.33
Mean	9.08	9.53	9.65		9.14	9.48	9.71		10.40	10.79	10.98	
C.D.(0.05) for (T)				0.35**				0.08**				0.40**
C.D.(0.05) for (F)				0.16**				0.09**				0.21**
C.D. (0.05) for interaction (T x F)				N.S.				0.23**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 42b Effect of organic sources and mineral nutrition on number of leaves at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	7.05	7.65	8.30	7.67	7.45	7.55	7.90	7.63	6.15	6.50	7.15	6.60
T_2	9.00	9.30	9.85	9.38	8.90	9.25	9.40	9.18	8.25	8.70	9.00	8.65
T_3	8.20	8.30	8.55	8.35	7.75	8.15	8.25	8.05	6.95	7.50	7.60	7.35
T_4	8.50	8.65	8.90	8.68	8.30	8.40	8.85	8.52	7.50	7.85	8.25	7.87
T_5	8.60	8.65	8.75	8.67	8.15	8.25	8.45	8.28	7.40	7.80	7.95	7.72
T_6	8.90	9.10	9.10	9.03	8.70	8.95	9.05	8.90	8.15	8.30	8.65	8.37
Mean	8.38	8.61	8.91		8.21	8.43	8.65		7.40	7.78	8.10	
C.D.(0,05) for (T)				0.28**				0.19**				0.33**
C.D.(0.05) for (F)				0.19**				0.14**				0.13**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

The results revealed that press mud application (T_2) registered the highest number of leaves and it was closely followed by Azospirillum inoculation (T_6) at all stages of growth. The lowest values for number of leaves was associated with T_1. With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had invariably increased the number of leaves. Whereas F_1 recorded the lowest number of leaves at all stages of growth. The interaction effect at 240 DAP in first plant crop had shown that among the treatment combinations, T_2F_3 had produced significantly more number of leaves.

4.2.1.3. Number of nodes at 120, 240 and 360 DAP (Table 43a and 43b)

The results revealed that treatment effects due to organic sources and mineral nutrition exerted an appreciable increase in the number of nodes in both the plant crops. However, their interaction effect was significant only at the early part of crop growth in first and second plant crops.

It was found that press mud application (T_2) had produced the highest number of nodes and it was remarkably higher than other organic sources at 240 and 360 DAP in first plant crop and at 360 DAP in second plant crop. In the case of mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had consistently produced the highest number of nodes as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interaction effect was significant only at 120 DAP in both plant crops and revealed that T_2F_3 had shown maximum number of nodes.

4.2.1.4. Dry matter production by trash at 120, 240 and 360 DAP (Table 44a and 44b)

The data revealed that analysis of variance for DMP by trash was

Table 43a Effect of organic sources and mineral nutrition on number of nodes at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	5.40	6.55	6.80	6.25	20.75	21.65	23.05	21.82	25.25	26.90	28.15	26.77
T_2	7.95	8.05	8.20	8.07	26.50	27.15	27.10	26.92	30.40	30.85	31.95	31.07
T_3	6.85	7.00	7.65	7.17	23.05	23.80	24.08	23.64	27.50	28.50	28.65	28.22
T_4	7.80	7.85	7.85	7.83	24.20	24.80	25.30	24.77	28.30	29.00	29.50	28.93
T_5	7.50	7.95	7.85	7.77	23.50	24.10	24.50	24.03	28.10	27.95	28.40	28.15
T_6	7.90	8.05	8.10	8.02	24.15	25.45	26.85	25.48	28.95	29.90	30.80	29.88
Mean	7.23	7.58	7.74		23.69	24.49	25.15		28.08	28.85	29.58	
C.D.(0.05) for (T)				0.52**				0.94**				0.68**
C.D.(0.05) for (F)				0.14**				0.34**				0.25**
C.D. (0.05) for interaction (T x F)				0.32**				N.S.				N.S.

Organic sources

- T_1 - Control
- T_2 - Pressmud application
- T_3 - Trash application
- T_4 - Green manuring
- T_5 - Acetobacter inoculation
- T_6 - Azospirillum inoculation

Mineral nutrition

- F_1 - 50% of the recommended dose of NPK
- F_2 - 75% of the recommended dose of NPK
- F_3 - 100% of the recommended dose of NPK
- N.S. - Not significant
- ** - Significant at 1 per cent level

Table 43b Effect of organic sources and mineral nutrition on number of nodes at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	4.80	5.35	6.35	5.50	18.10	19.00	19.50	18.87	24.20	25.10	26.05	25.12
T_2	7.95	8.00	8.00	7.98	23.55	24.20	25.00	24.25	30.00	30.65	31.85	30.83
T_3	6.40	6.55	6.75	6.57	19.85	20.60	21.35	20.60	27.00	27.55	27.90	27.48
T_4	7.30	7.60	7.90	7.60	21.55	22.85	23.25	22.55	28.90	29.15	29.65	29.23
T_5	7.05	7.40	7.20	7.22	21.35	22.00	22.70	22.02	28.60	29.05	28.95	28.87
T_6	7.85	7.90	7.95	7.90	23.00	23.85	24.15	23.67	29.40	29.75	38.30	29.82
Mean	6.89	7.13	7.36		21.23	22.08	22.66		28.02	28.54	29.12	
C.D.(0.05) for (T)				0.20**				0.62**				0.40**
C.D.(0.05) for (F)				0.17**				0.57**				0.24**
C.D. (0.05) for interaction (T x F)				0.53*				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 44a *Effect of organic sources and mineral nutrition on DMP by trash (t ha^{-1}) at different stages of growth in first plant crop*

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.04	1.21	1.30	1.18	4.43	5.31	6.23	5.32	5.58	6.69	7.10	6.46
T_2	1.73	2.29	2.10	2.04	6.97	7.16	7.25	7.13	8.32	8.80	9.20	8.77
T_3	1.47	1.74	1.98	1.73	6.27	6.46	6.33	6.35	7.21	7.48	7.54	7.41
T_4	1.49	1.89	1.93	1.77	6.43	6.62	6.39	6.48	8.20	8.29	8.32	8.27
T_5	2.13	1.75	1.89	1.92	6.21	6.18	6.28	6.22	7.83	7.95	8.04	7.94
T_6	2.29	1.99	2.15	2.14	6.43	6.97	6.71	6.70	8.23	8.44	8.55	8.41
Mean	1.69	1.81	1.89		6.12	6.45	6.53		7.56	7.94	8.12	
C.D.(0.05) for (T)				0.28**				0.41**				0.19**
C.D.(0.05) for (F)				N.S.				0.29*				0.13**
C.D. (0.05) for interaction (T x F)				N.S.				0.71*				0.29**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 44b Effect of organic sources and mineral nutrition on DMP by trash (t ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.99	1.18	1.24	1.14	4.67	5.06	5.44	5.05	4.49	5.91	6.23	5.54
T_2	1.88	2.01	2.13	2.01	6.21	6.42	6.59	6.41	7.80	8.29	8.62	8.23
T_3	1.18	1.36	1.51	1.35	5.47	5.75	5.84	5.69	6.13	6.47	6.54	6.38
T_4	1.78	1.91	1.89	1.86	5.92	6.01	6.08	6.00	6.97	7.08	7.24	7.10
T_5	1.159	1.66	1.69	1.65	5.81	5.90	5.92	5.88	6.68	6.76	6.96	6.80
T_6	1.89	1.95	1.93	1.92	6.01	6.11	6.31	6.14	7.78	8.00	8.17	7.99
Mean	1.55	1.68	1.73		5.68	5.87	6.03		6.64	7.08	7.29	
C.D.(0.05) for (T)				0.11**				0.14**				0.08**
C.D.(0.05) for (F)				0.06**				0.07**				0.05**
C.D. (0.05) for interaction (T x F)				N.S.				0.14**				0.17**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

significantly affected by organic sources, mineral nutrition and their interactions at 240 and 360 DAP in both plant crops. However, in first plant crop at 120 DAP, only the organic sources had exerted significant effects, while in second plant crop organic sources as well as mineral nutrition were significant without any interaction.

The results had shown that DMP by trash was highest with press mud application (T_2) and it was followed by Azospirillum inoculation (T_6). DMP by trash was found lowest in treatments without organic sources (T_1). With mineral nutrition, F_3 registered maximum values as compared to F_2 and F_1. Among the treatment combinations, T_2F_3 had accumulated significantly maximum dry matter in trash at later stages of growth and was followed by T_2F_2 and T_6F_3.

4.2.1.5. Dry matter production by green tops at 120, 240 and 360 DAP (Table 45a and 45b)

The data generated has shown that DMP by green tops was profoundly influenced by organic sources and mineral nutrition without any interaction effects at 240 and 360 DAP in first plant crop. While at 120 DAP the treatment effects due to organic sources was only significant. In second plant crop treatments varied significantly with organic sources, mineral nutrition and their interactions.

The results indicated that press mud application (T_2) had registered an appreciable increase for DMP by green tops at 120 and 240 DAP in first plant crop and at all stages of growth in second plant crop. It was followed by Azospirillum inoculation (T_6) and green manure application (T_4). But at 360 DAP in first plant crop, T_6 had shown maximum DMP by green tops and it was followed by T_2 and T_4. While with mineral nutrition F_3 had recorded maximum DMP by green tops as compared to F_2 and F_1. The interaction effects exhibited in the second plant crop

Table 45a Effect of organic sources and mineral nutrition on DMP by green tops (t ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	6.80	7.30	7.93	7.34	5.57	5.80	6.46	5.94	2.76	3.14	3.27	3.06
T_2	9.84	9.77	10.40	10.01	8.40	8.76	9.25	8.80	4.24	4.42	4.69	4.45
T_3	8.35	8.22	8.71	8.43	6.94	6.74	6.81	6.83	3.58	3.71	3.78	3.69
T_4	7.97	9.30	9.24	8.84	7.13	7.41	7.43	7.32	3.86	3.95	4.25	4.02
T_5	8.57	9.33	9.59	9.16	6.76	6.33	7.18	6.76	3.67	3.86	4.03	3.85
T_6	9.53	9.28	9.40	9.40	7.44	7.64	8.06	7.71	4.49	4.65	4.74	4.63
Mean	8.51	8.87	9.21		7.04	7.11	7.53		3.76	3.96	4.13	
C.D.(0.05) for (T)				0.36**				0.23**				0.11**
C.D.(0.05) for (F)				N.S.				0.21**				0.14**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 45b Effect of organic sources and mineral nutrition on DMP by green tops (t ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	5.99	6.86	7.11	6.65	5.65	5.89	6.24	5.92	2.63	2.73	3.00	2.79
T_2	8.06	8.30	9.03	8.46	7.67	8.26	8.47	8.13	3.75	4.00	4.54	4.09
T_3	6.91	7.16	7.36	7.14	6.08	6.42	6.60	6.37	2.85	3.03	3.13	3.00
T_4	7.51	7.65	7.89	7.68	6.81	7.06	7.43	7.10	3.40	3.47	3.56	3.48
T_5	7.44	7.54	7.69	7.55	6.61	6.71	6.79	6.71	3.20	3.22	3.35	3.26
T_6	7.90	8.00	8.25	8.08	7.29	7.86	8.20	7.78	3.61	3.77	4.10	3.83
Mean	7.30	7.60	7.89		6.68	7.03	7.29		3.24	3.37	3.61	
C.D.(0.05) for (T)				0.27**				0.23**				0.09**
C.D.(0.05) for (F)				0.08**				0.10**				0.06**
C.D. (0.05) for interaction (T x F)				0.28**				0.22**				0.18**

Organic sources
T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition
F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

had revealed that T_2F_3 recorded significantly superior values at 120 DAP and T_3F_3 was on par with T_2F_2 at 240 DAP. While at 360 DAP T_2F_2 recorded significantly higher value as compared to T_6F_3 and T_2F_3. T_1F_1 had produced significantly lowest dry matter accumulation in green tops at all stages of growth.

4.2.1.6. Dry matter production by stem at 120, 240 and 360 DAP (Table 46a and 46b)

The data presented had shown that organic sources, mineral nutrition levels and their interactions exerted remarkable increase on DMP by stem during first plant crop as well as second plant crop. Among the organic sources press mud application (T_2) had produced maximum dry matter in stem and was significantly superior to other organic sources. It was followed by Azospirillum inoculation (T_6) and green manure application (T_4). The treatments without organic sources (T_1) recorded comparatively lower values. With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had produced significantly higher DM in stem as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interaction effects exhibited revealed that T_2F_3 recorded maximum values for DMP by stem and it was followed by T_2F_2, T_6F_3 and T_6F_2. Whereas T_3F_1, T_1F_2 and T_1F_1 had shown comparatively lower values for dry matter accumulation in stem.

4.2.1.7. Total DMP at 120, 240 and 360 DAP (Table 47a, 47b and Fig. 11a, 11b and 12)

The data generated revealed that the analysis of variance for total DMP was significantly influenced by organic sources, mineral nutrition and their interactions in both plant crops at all stages of growth.

Table 46a Effect of organic sources and mineral nutrition on DMP by stem (t ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	3.60	4.30	4.65	4.18	30.48	36.25	39.16	35.29	34.93	38.99	43.11	39.01
T_2	6.09	6.62	7.54	6.75	47.13	48.80	49.85	48.59	50.83	53.44	54.99	53.08
T_3	4.75	5.04	5.15	4.98	38.85	40.64	42.16	40.55	41.47	43.98	45.51	43.65
T_4	5.52	5.71	5.76	5.66	43.47	45.83	46.56	45.29	47.07	48.69	49.51	48.42
T_5	5.18	5.44	5.56	5.39	43.14	44.84	45.45	44.48	46.63	47.17	48.01	47.27
T_6	5.84	6.16	6.78	6.26	45.76	47.19	48.04	46.99	49.07	50.12	51.67	50.29
Mean	5.16	5.54	5.90		41.47	43.92	45.20		45.00	47.06	48.80	
C.D.(0.05) for (T)				0.23**				1.14**				0.81**
C.D.(0.05) for (F)				0.17**				0.61**				0.43**
C.D. (0.05) for interaction (T x F)				0.39**				1.44**				0.87**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 46b Effect of organic sources and mineral nutrition on DMP by stem (t ha^{-1}) on different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	3.38	3.95	4.42	3.92	31.97	35.21	37.62	34.93	38.19	38.58	41.42	38.39
T_2	5.24	5.69	5.99	5.64	43.52	44.93	46.49	44.98	46.95	49.43	50.86	49.08
T_3	4.21	4.48	4.51	4.40	36.77	37.85	38.77	37.80	40.24	42.34	43.07	41.88
T_4	4.62	4.72	4.81	4.71	40.79	42.16	42.79	41.91	43.80	44.96	45.97	44.91
T_5	4.54	4.59	4.63	4.58	39.86	40.76	41.62	40.75	43.13	44.05	44.42	43.87
T_6	4.64	5.17	5.37	4.58	42.54	43.64	44.20	43.46	45.73	47.20	48.19	47.04
Mean	4.44	4.77	4.95	5.06	39.24	40.76	41.92		42.51	44.43	45.65	
C.D.(0.05) for (T)				0.12**				0.27**				0.42**
C.D.(0.05) for (F)				0.11**				0.43**				0.51**
C.D. (0.05) for interaction (T x F)				0.18**				0.60**				0.79**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 47a Effect of organic sources and mineral nutrition on total DMP (t ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	11.43	12.79	14.11	12.78	40.46	47.39	51.85	46.57	43.28	48.86	53.54	48.56
T_2	17.78	18.67	20.24	18.90	62.50	64.79	66.36	64.54	63.39	66.67	68.67	66.24
T_3	14.64	15.38	15.88	15.30	52.05	53.84	55.30	53.73	52.42	55.19	56.86	54.82
T_4	15.86	16.79	17.11	16.59	57.04	59.87	60.40	59.10	59.53	60.93	62.09	60.85
T_5	16.12	16.49	16.99	16.53	56.11	57.58	58.95	57.55	58.25	59.15	60.34	59.25
T_6	16.88	17.56	18.62	17.68	59.72	61.56	62.87	61.38	61.91	63.46	64.97	63.45
Mean	15.45	16.28	17.16		54.65	57.50	59.29		56.46	59.04	61.08	
C.D.(0.05) for (T)				0.33**				1.24**				0.83**
C.D.(0.05) for (F)				0.27**				0.56**				0.50**
C.D. (0.05) for interaction (T x F)				0.68*				1.86**				0.91**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 47b Effect of organic sources and mineral nutrition on total DMP (t ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	10.37	11.70	12.61	11.56	41.87	46.17	49.24	45.76	42.68	47.24	50.57	46.83
T_2	15.19	15.97	17.16	16.11	57.19	59.61	61.54	59.45	58.56	61.76	64.03	61.45
T_3	12.28	12.90	13.39	12.86	48.33	50.07	52.25	49.88	49.34	51.84	53.18	51.45
T_4	13.94	14.29	14.59	14.27	53.51	55.27	56.31	55.03	54.18	55.40	56.77	55.45
T_5	13.55	13.79	14.02	13.78	52.54	53.38	54.42	53.45	52.97	54.16	54.77	53.96
T_6	14.44	15.22	15.49	15.05	55.84	57.50	58.77	57.37	57.15	59.04	60.51	58.90
Mean	13.29	13.98	14.54		51.55	53.67	55.25		52.48	54.91	56.64	
C.D.(0.05) for (T)				0.45**				0.51**				0.44**
C.D.(0.05) for (F)				0.08**				0.50**				0.56**
C.D. (0.05) for interaction (T x F)				0.44**				0.61**				0.88**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

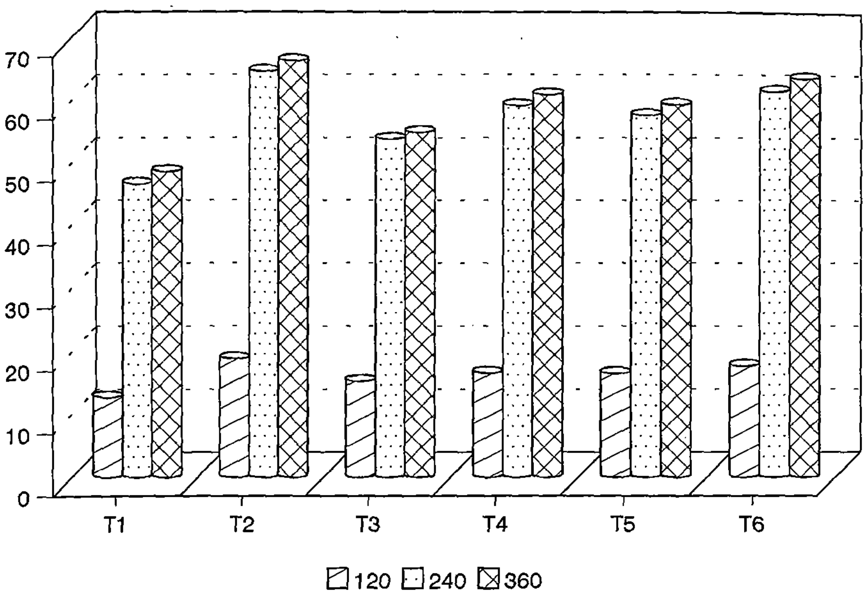


Fig. 11a. Total DMP as influenced by organic sources in first plant crop

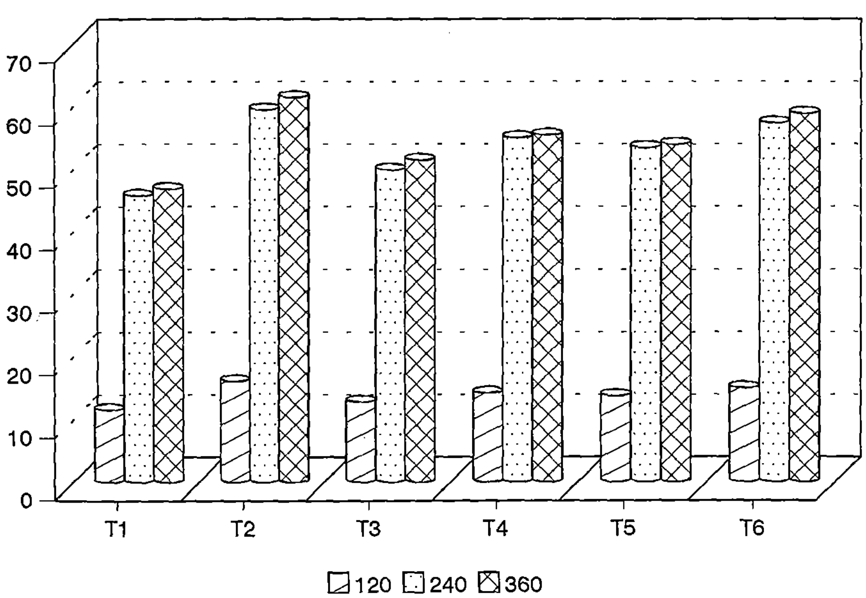


Fig. 11b. Total DMP as influenced by organic sources in second plant crop

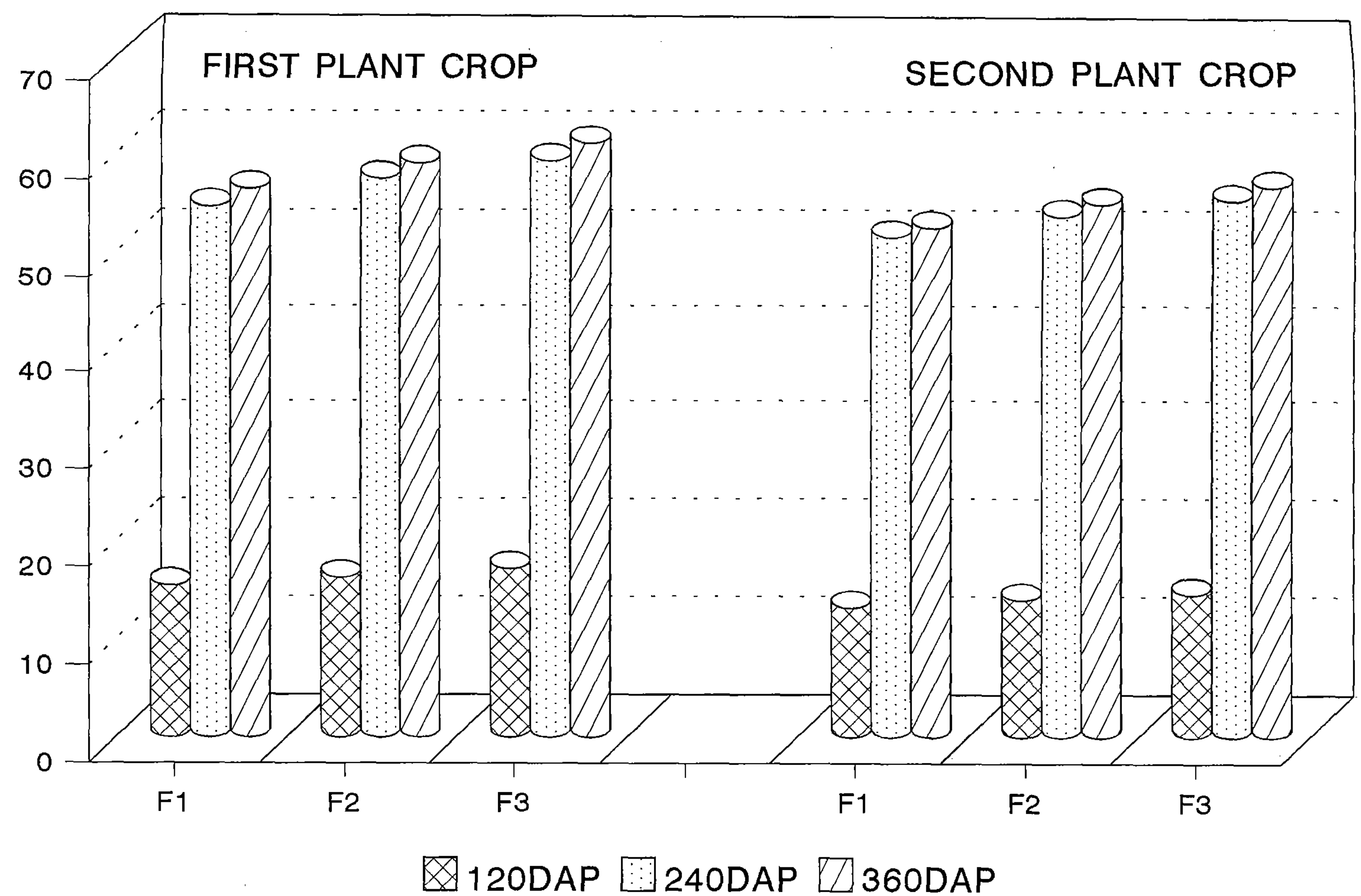


Fig. 12. Total DMP as influenced by mineral nutrition during first and second plant crops

The results indicated that application of press mud (T_2) had produced maximum dry matter and it was significantly superior to all other organic sources. It was closely followed by T_6 and T_4. The lowest DMP was associated with T_1. While with mineral nutrition F_3 registered highest DMP and was significantly superior to F_2 and F_1. The interaction effects revealed that T_2F_3 had recorded maximum values for total dry matter production and it was closely followed by T_2F_2, T_6F_3 and T_6F_2. The treatment combination T_1F_1 had shown lowest value for DMP.

4.2.1.8. Germination (Table 48a and 48b)

The data clearly revealed that treatment variation due to organic sources, mineral nutrition or their interactions had not influenced the germination of the crop in both the years of experimentation.

4.2.1.9. Tiller count at 90 DAP (Table 48a and 48b)

The data had shown that the analysis of variance for tiller count was significantly influenced by organic sources and mineral nutrition in both the plant crops. But the interaction effect due to treatment combination was observed only in first plant crop.

It was noticed that press mud application (T_2) had produced maximum number of tillers and it was immediately followed by Azospirillum inoculation (T_6) and green manure application (T_4). While in mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) registered the highest tiller count than lower rates at F_2 and F_1. The interaction had shown that T_2F_3 was significantly superior to all other treatment combinations in first plant crop.

4.2.1.10. Shoot count at 120 DAP (Table 48a and 48b)

The data revealed that organic sources and mineral nutrition had exerted

Table 48a Effect of organic sources and mineral nutrition on germination, tillering and shoot count at different stages of growth in first plant crop

Treatment	Germination (%) at 30 DAP				Tiller count ('000) at 90 DAP				Shoot count ('000) at 120 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	71.00	71.00	70.66	70.88	127.31	129.00	131.94	129.42	104.72	107.40	111.39	107.83
T_2	70.72	70.33	70.61	70.55	142.22	144.81	146.75	144.59	123.42	126.02	127.89	125.78
T_3	70.66	70.66	70.61	70.64	131.50	132.33	133.52	132.45	110.55	114.16	115.27	113.33
T_4	70.55	70.66	70.77	70.66	137.96	138.79	140.09	138.95	118.05	121.51	122.03	120.53
T_5	70.50	70.50	70.72	70.57	137.59	138.23	139.44	138.42	117.03	118.06	119.17	118.09
T_6	71.11	71.11	71.05	71.09	140.28	142.78	143.79	142.28	120.18	123.05	123.99	122.41
Mean	70.75	70.71	70.74		136.14	137.66	139.26		115.66	118.37	119.96	
C.D.(0.05) for (T)				N.S.				1.46**				2.58**
C.D.(0.05) for (F)				N.S.				0.69**				0.95**
C.D. (0.05) for interaction (T x F)				N.S.				1.64**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 48b Effect of organic sources and mineral nutrition on germination, tillering and shoot count at different stages of growth in second plant crop

Treatment	Germination (%) at 30 DAP				Tiller count ('000) at 90 DAP				Shoot count ('000) at 120 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	67.28	67.72	67.39	67.46	120.83	123.52	124.72	123.02	99.25	100.56	102.04	100.61
T_2	67.61	66.67	67.83	67.37	129.81	131.29	133.24	131.4	106.11	107.41	108.70	107.40
T_3	67.33	67.38	67.33	67.35	126.63	125.83	126.66	125.71	101.48	103.15	103.98	102.87
T_4	67.22	67.33	67.78	67.44	126.94	127.96	128.98	127.96	104.35	104.90	105.83	105.03
T_5	67.88	67.39	67.50	67.59	126.01	126.76	127.49	126.76	103.52	104.26	104.63	104.13
T_6	67.61	67.50	67.61	67.57	128.14	130.28	130.92	129.78	105.09	106.66	107.22	106.32
Mean	67.49	67.33	67.57		126.04	127.61	128.67		103.30	104.49	105.40	
C.D.(0.05) for (T)				N.S.				0.98**				0.65**
C.D.(0.05) for (F)				N.S.				0.59**				0.44**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 49a Effect of organic sources and mineral nutrition on shoot count and cane formed shoots at different stages of growth in first plant crop

Treatment	Shoot count ('000) at 180 DAP				Cane formed shoots ('000) at 240 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	95.91	102.12	106.20	101.41	89.81	94.72	99.35	94.63
T_2	114.07	116.57	117.31	115.98	107.50	109.81	110.83	109.38
T_3	105.74	106.66	108.51	106.97	99.53	99.62	101.11	100.09
T_4	109.53	112.31	112.96	111.60	102.68	105.18	105.74	104.53
T_5	108.79	109.99	110.83	109.87	101.94	102.96	104.69	103.20
T_6	111.94	114.07	116.01	114.01	105.00	107.58	108.24	106.94
Mean	107.66	110.29	111.97		101.08	103.31	104.99	
C.D.(0.05) for (T)				2.52**				2.31**
C.D.(0.05) for (F)				1.03**				0.77**
C.D. (0.05) for interaction (T x F)				1.92**				2.00**

Organic sources

- T_1 - Control
- T_2 - Pressmud application
- T_3 - Trash application
- T_4 - Green manuring
- T_5 - Acetobacter inoculation
- T_6 - Azospirillum inoculation

Mineral nutrition

- F_1 - 50% of the recommended dose of NPK
- F_2 - 75% of the recommended dose of NPK
- F_3 - 100% of the recommended dose of NPK
- N.S. - Not significant
- ** - Significant at 1 per cent level

Table 49 (b) Effect of organic sources and mineral nutrition on shoot count and cane formed shoots at different stages of growth in second plant crop

Treatment	Shoot count ('000) at 180 DAP				Cane formed shoots ('000) at 240 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	96.01	97.31	99.53	97.62	91.20	92.96	94.99	93.05
T_2	104.35	105.46	106.39	105.40	99.25	100.64	102.13	100.67
T_3	98.87	100.74	101.30	100.30	94.16	95.83	96.57	95.52
T_4	101.85	102.96	103.89	102.90	97.12	97.77	98.51	97.80
T_5	101.57	102.22	102.96	102.25	96.38	96.66	97.31	96.78
T_6	103.33	104.63	104.99	104.32	97.86	99.44	100.09	99.13
Mean	101.00	102.22	103.18		96.00	97.22	98.27	
C.D.(0.05) for (T)				0.96**				0.68**
C.D.(0.05) for (F)				0.41**				0.42**
C.D. (0.05) for interaction (T x F)				0.81*				0.60**

Organic sources — Mineral nutrition

T_1 - Control — F_1 - 50% of the recommended dose of NPK
T_2 - Pressmud application — F_2 - 75% of the recommended dose of NPK
T_3 - Trash application — F_3 - 100% of the recommended dose of NPK
T_4 - Green manuring — N.S. - Not significant
T_5 - Acetobacter inoculation — ** - Significant at 1 per cent level
T_6 - Azospirillum inoculation

significant influence on shoot count. But their interactions were not significant in both plant crops.

The results revealed that press mud application (T_2) had recorded the highest shoot count and it was followed by Azospirillum inoculation (T_6) and green manure application (T_4). The lowest shoot count was associated with T_1. With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) registered significantly higher shoot count as compared to F_2 and F_1.

4.2.1.11. Shoot count at 180 and cane formed shoot at 240 DAP (Table 49a and 49b)

The data presented had indicated that shoot count as well as cane formed shoots were profoundly influenced by the treatment effects due to organic sources, mineral nutrition and their interaction effects in both plant crops.

Press mud (T_2) application had shown the highest number of shoots and cane formed shoots in both plant crops. It was closely followed by Azospirillum inoculation (T_6). The shoot count was lowest in treatments without organic sources (T_1). While with mineral nutrition, F_3 had recorded invariably higher values. The interaction effect revealed that T_2F_3 had produced the highest number of shoots and cane formed shoots and it was followed by T_2F_2 and T_6F_3. The treatment combination of T_1F_1 and T_1F_2 had shown lower values at all stages in both plant crops.

4.2.2. Growth analysis

4.2.2.1. Leaf area index (Table 50a and 50b)

The data generated had shown that the analysis of variance for LAI was significantly influenced by organic sources, mineral nutrition and their interactions

Table 50a Effect of organic sources and mineral nutrition on leaf area index at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	3.43	3.87	4.51	3.94	2.09	2.76	3.67	2.84	1.43	1.63	1.94	1.66
T_2	6.36	6.94	7.28	6.86	4.70	5.09	5.27	5.02	2.85	3.04	3.15	3.01
T_3	4.31	4.82	4.88	4.67	3.61	3.62	3.86	3.69	1.89	2.19	2.28	2.12
T_4	5.42	5.90	6.05	5.79	3.96	4.19	4.25	4.13	2.43	2.60	2.72	2.58
T_5	4.99	5.26	5.43	5.23	3.93	3.98	4.15	4.02	2.38	2.45	2.51	2.45
T_6	5.90	6.61	6.82	6.44	4.22	4.66	4.77	4.55	2.63	2.86	2.96	2.82
Mean	5.07	5.57	5.83		3.75	4.05	4.33		2.27	2.46	2.59	
C.D.(0.05) for (T)				0.35**				0.09**				0.10**
C.D.(0.05) for (F)				0.08**				0.08**				0.04**
C.D. (0.05) for interaction (T x F)				0.23**				0.15**				0.12**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 50b **Effect of organic sources and mineral nutrition on leaf area index at different stages of growth in second plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	2.75	3.27	3.95	3.32	2.14	2.60	2.95	2.56	1.07	1.17	1.51	1.25
T_2	4.84	4.71	5.29	4.94	3.72	3.99	4.17	3.96	1.98	2.17	2.31	2.15
T_3	3.81	4.06	4.23	4.03	2.85	3.18	3.16	3.06	1.38	1.54	1.59	1.50
T_4	4.38	4.56	4.75	4.56	3.36	3.44	3.67	3.49	1.66	1.81	1.96	1.81
T_5	4.30	4.37	4.45	4.37	3.17	3.23	3.35	3.25	1.61	1.74	1.81	1.72
T_6	4.71	4.94	4.98	4.87	3.59	3.78	3.86	3.74	1.92	2.03	2.14	2.03
Mean	4.13	4.32	4.61		3.14	3.37	3.52		1.60	1.75	1.89	
C.D.(0.05) for (T)				0.19**				0.12**				0.07**
C.D.(0.05) for (F)				0.11**				0.05**				0.04**
C.D. (0.05) for interaction (T x F)				0.25**				0.12**				0.10**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

in both plant crops. Among the organic sources T_2 recorded maximum values for LAI and it was followed by T_6, T_4 and T_5. While T_1 recorded lower LAI in both the years. In the case of mineral nutrition, F_3 recorded maximum values for LAI and it was significantly superior to F_2 and F_1. Among the interactions, T_2F_3 had exhibited statistical superiority over all other treatment combinations and was closely followed by T_2F_2, T_6F_3 and T_6F_2.

4.2.2.2. Leaf area ratio at 120, 240 and 360 DAP (Table 51a and 51b)

The data generated revealed that organic sources as well as mineral nutrition had exerted remarkable influence on LAR. However, their interaction effect was significant only at 240 DAP in both plant crops.

The results revealed that LAR obtained in T_2 was on par with T_6. Like other growth parameters, LAR was found lowest with T_1 at all stages of growth. In the later stages of growth the treatment effects due to mineral nutrition had revealed that F_3 was significantly superior to F_2 and F_1. Among the treatment combinations, T_2F_3 recorded highest values and it was followed by T_2F_2 and T_6F_3. The lowest values were associated with T_1F_1 and T_1F_2.

4.2.2.3. Specific leaf area at 120, 240 and 360 DAP (Table 52a and 52b)

The data revealed that organic sources had exerted significant effects on SLA at 120 and 360 DAP in first plant crop. During second plant crop, the analysis of variance with organic sources and mineral nutrition were significant at 120 and 360 DAP. However, their interaction was significant only at 360 DAP. But at 240 DAP the treatment effects due to organic sources, mineral nutrition and their interactions were significant in both plant crops.

Table 51a Effect of organic sources and mineral nutrition on leaf area ratio ($cm^2 g^{-1}$) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	30.22	30.45	32.21	30.96	5.22	5.86	7.07	6.05	3.32	3.35	3.65	3.44
T_2	35.89	37.30	36.16	36.45	7.69	7.82	7.97	7.82	4.50	4.59	4.62	4.57
T_3	29.60	31.46	30.89	30.65	6.98	6.99	7.00	6.99	3.64	3.98	4.16	3.93
T_4	34.26	35.20	35.48	34.98	6.98	7.02	7.07	7.02	4.21	4.30	4.41	4.30
T_5	31.08	32.02	32.01	31.70	7.02	6.99	7.06	7.02	4.12	4.19	4.18	4.16
T_6	35.04	37.74	36.66	36.48	7.10	7.60	7.61	7.44	4.27	4.53	4.59	4.46
Mean	32.68	34.03	33.90		6.83	7.05	7.30		4.01	4.16	4.27	
C.D.(0.05) for (T)				2.02**				0.09**				0.16**
C.D.(0.05) for (F)				0.82*				0.11**				0.06**
C.D. (0.05) for interaction (T x F)				N.S.				0.27**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 51b **Effect of organic sources and mineral nutrition on leaf area ratio ($cm^2 g^{-1}$) at different stages of growth in second plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	26.63	28.19	31.45	28.76	5.14	5.81	6.02	5.66	2.51	2.59	3.01	2.70
T_2	31.73	32.13	32.37	32.08	6.48	6.71	6.81	6.66	3.40	3.54	3.6	3.53
T_3	31.08	31.56	31.74	31.46	5.93	6.22	6.26	6.14	2.83	2.99	3.01	2.94
T_4	31.56	31.95	32.71	32.07	6.31	6.25	6.57	6.38	3.08	3.27	3.46	3.27
T_5	31.80	31.80	31.96	31.85	6.08	6.08	6.19	6.12	3.07	3.24	3.32	3.21
T_6	32.56	32.27	32.09	32.31	6.43	6.52	6.57	6.51	3.38	3.45	3.56	3.46
Mean	30.89	31.32	32.05		6.06	6.27	6.40		3.04	3.18	3.33	
C.D.(0.05) for (T)				1.66**				0.20**				0.14
C.D.(0.05) for (F)				0.73*				0.10**				0.07**
C.D. (0.05) for interaction (T x F)				N.S.				0.20**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 52a Effect of organic sources and mineral nutrition on specific leaf area ($cm^2\ g^{-1}$) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	59.04	59.38	65.71	61.38	42.27	52.43	62.84	52.51	77.84	71.58	77.90	75.77
T_2	75.35	79.79	79.04	78.06	62.35	62.37	61.67	62.13	98.40	101.41	98.08	99.30
T_3	62.03	66.60	64.12	64.25	58.98	62.70	64.72	62.13	75.55	83.47	87.80	82.27
T_4	72.52	72.28	73.19	72.66	59.87	60.88	61.86	60.87	86.53	91.04	92.51	90.03
T_5	66.07	66.47	65.81	66.12	63.76	69.10	63.46	65.44	93.28	91.41	89.72	91.47
T_6	74.84	77.91	77.71	76.82	61.95	67.93	64.37	64.75	80.63	83.76	84.71	83.03
Mean	68.31	70.40	70.93		58.20	62.57	63.15		85.37	87.11	88.45	
C.D.(0.05) for (T)				5.01**				2.37**				4.36**
C.D.(0.05) for (F)				N.S.				2.20**				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				4.98**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 52b Effect of organic sources and mineral nutrition on specific leaf area index ($cm^2 g^{-1}$) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	53.00	57.50	63.28	57.92	42.24	49.51	52.49	48.08	50.33	55.63	63.65	56.53
T_2	67.49	69.84	69.58	68.97	53.06	52.91	54.07	53.35	64.51	65.52	62.44	64.15
T_3	62.71	64.35	65.19	64.08	53.04	53.75	53.70	53.50	60.78	64.69	65.04	63.50
T_4	65.29	67.64	68.87	67.26	55.30	54.08	54.81	54.73	61.02	64.89	69.24	65.05
T_5	65.73	65.66	66.21	65.86	52.27	53.39	54.88	53.51	63.77	68.13	68.53	66.81
T_6	67.56	69.10	68.11	68.26	54.40	52.60	51.83	52.94	64.23	63.95	64.36	64.18
Mean	63.63	65.68	66.87		51.72	52.71	53.63		60.77	63.80	65.54	
C.D.(0.05) for (T)				3.76**				1.73**				3.24**
C.D.(0.05) for (F)				1.78*				0.84**				2.07**
C.D. (0.05) for interaction (T x F)				N.S.				2.57**				5.36*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

It was observed that among the organic sources T_2 had shown maximum values for SLA at 120 and 360 DAP in first plant crop and at 120 DAP in second plant crop. While at 240 DAP T_5 was on par with T_4 in first plant crop and at 240 and 360 DAP in second plant crop. With regard to mineral nutrition, F_3 had registered maximum values as compared to F_2 and F_1 in both plant crops. The interaction effect noticed at 240 DAP in first plant crop revealed that T_5F_2 recorded higher values and it was on par with T_6F_2 and T_6F_3. During the second plant crop T_4F_3 had shown the highest value for SLA. Whereas T_1F_1 and T_1F_2 recorded significantly lower values.

4.2.2.4. Crop growth rate between 120 to 240 and 240 to 360 DAP (Table 53a and 53b)

The data given revealed that the analysis of variance for CGR due to organic sources, mineral nutrition and their interactions were significant in both plant crops. However, in the later part, the treatments did not exert any positive influence on CGR.

The results indicated that T_2 had registered higher value for CGR and it was significantly superior to all other organic sources. The crop growth rate was found lowest with T_1. While with mineral nutrition, maximum values for CGR was associated with F_3 and it was significantly superior to F_2 and F_1. The interaction effects revealed that T_2F_3 recorded the highest value for CGR and it was on par with T_2F_2. The lowest crop growth rate was associated with the treatment combination of T_1F_1.

4.2.2.5. Net assimilation rate between 120 to 240 and 240 to 360 DAP (Table 54a and 54b)

The data summarised had revealed that the analysis of variance for NAR

Table 53a **Effect of organic sources and mineral nutrition on crop growth rate in first plant crop**

Treatment	Crop growth rate between 120 and 240 DAP ($g\ m^{2-1}\ d^{-1}$)				Crop growth rate between 240 and 360 DAP ($g\ m^{2-1}\ d^{-1}$)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	24.04	28.68	31.45	28.05	2.33	1.13	1.28	1.58
T_2	37.20	38.30	38.26	37.95	0.67	1.40	1.42	1.16
T_3	30.99	31.78	32.64	31.80	0.24	1.21	0.84	0.76
T_4	34.26	35.85	35.90	35.34	1.95	0.81	1.45	1.40
T_5	33.29	33.80	34.80	33.96	1.55	1.54	1.09	1.39
T_6	35.13	36.54	36.79	36.15	1.80	1.53	1.62	1.65
Mean	32.48	34.16	34.99		1.42	1.27	1.28	
C.D.(0.05) for (T)				1.06**				N.S.
C.D.(0.05) for (F)				0.36**				N.S.
C.D. (0.05) for interaction (T x F)				1.42**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
** - Significant at 1 per cent level

Table 53b Effect of organic sources and mineral nutrition on crop growth rate in second plant crop

Treatment	Crop growth rate between 120 and 240 DAP ($g\ m^{2-1}\ d^{-1}$)				Crop growth rate between 240 and 360 DAP ($g\ m^{2-1}\ d^{-1}$)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	26.10	28.45	30.35	28.30	0.65	1.08	1.19	0.97
T_2	35.23	36.29	36.73	36.08	0.53	1.63	1.82	1.34
T_3	29.88	30.72	31.28	30.63	0.66	1.55	1.88	1.36
T_4	32.74	33.92	34.45	33.70	0.61	0.17	0.61	0.46
T_5	32.14	32.83	33.59	32.85	0.50	0.57	0.18	0.42
T_6	34.53	35.53	36.01	35.36	0.78	0.743	0.14	0.89
Mean	31.77	32.96	33.74		0.62	0.96	1.14	
C.D.(0.05) for (T)				0.43**				N.S.
C.D.(0.05) for (F)				0.38**				N.S.
C.D. (0.05) for interaction (T x F)				0.75**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
** - Significant at 1 per cent level

Table 54a Effect of organic sources and mineral nutrition on Net assimilation rate in first plant crop

Treatment	Net assimilation rate between 120 and 240 DAP (mg dm^{2-1} d^{-1})				Net assimilation rate between 240 and 360 DAP (mg dm^{2-1} d^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	44.12	42.25	36.77	41.05	5.59	6.30	6.62	6.17
T_2	32.88	31.98	31.37	32.08	5.50	6.32	5.81	5.88
T_3	38.22	36.30	36.58	37.03	5.11	5.57	5.47	5.38
T_4	36.09	35.29	37.01	36.13	6.90	5.68	6.19	6.26
T_5	36.62	36.06	35.74	36.14	6.14	6.15	6.33	6.21
T_6	33.93	32.05	31.44	32.47	6.65	6.25	6.07	6.32
Mean	36.98	35.65	34.82		5.98	6.05	6.08	
C.D.(0.05) for (T)				1.24**				4.62**
C.D.(0.05) for (F)				0.72**				N.S.
C.D. (0.05) for interaction (T x F)				2.80**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 54b Effect of organic sources and mineral nutrition on Net assimilation rate in second plant crop

Treatment	Net assimilation rate between 120 and 240 DAP (mg dm^{2-1} d^{-1})				Net assimilation rate between 240 and 360 DAP (mg dm^{2-1} d^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	49.99	45.17	40.88	45.35	4.36	3.31	3.50	3.72
T_2	38.03	36.74	35.04	36.60	2.02	3.45	4.31	3.26
T_3	43.62	39.81	39.36	40.93	2.86	4.32	4.59	3.92
T_4	39.34	39.45	37.99	38.93	2.63	1.36	1.74	1.91
T_5	40.05	40.26	39.82	40.04	2.24	2.10	1.33	1.89
T_6	37.50	37.96	37.72	37.72	1.86	1.92	2.62	2.13
Mean	41.42	39.90	38.47		2.66	2.74	3.01	
C.D.(0.05) for (T)				1.17**				0.84**
C.D.(0.05) for (F)				1.37**				N.S.
C.D. (0.05) for interaction (T x F)				1.79**				1.42*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

between 120 to 240 DAP due to organic sources, mineral nutrition and their interactions were significant in both plant crops. However, in the later stages of growth, the organic sources had only exerted significant effect on NAR between 240-360 DAP in both plant crops. The interaction effect was observed only in the second plant crop.

The results revealed that T_1 had registered remarkably higher values for NAR than all other organic sources during 120 to 240 DAP. While T_2 and T_6 recorded comparatively lower values. In the case of mineral nutrition, F_1 had registered explicitly higher values than F_2 and F_3. The interactions revealed that T_1F_1 recorded the highest NAR and was on par with T_1F_2. Whereas T_2F_3, T_2F_2 and T_6F_3 recorded comparatively lower values.

A critical review of the data on NAR between 240 to 360 DAP has shown that among the organic sources T_6 recorded the highest value and was on par with T_4, T_5, T_1 and T_2 in first plant crop and while in second plant crop, T_3 was on par with T_2 and T_1. Among the interactions, T_3F_3 recorded the highest value and was on par with T_1F_1, T_2F_3, T_2F_2 and T_1F_3.

4.2.3. Yield attributes

4.2.3.1. Cane girth at 120, 240 and 360 DAP (Table 55a, 55b and Fig. 13a, 13b and 14)

The data generated revealed that organic sources and mineral nutrition had exerted significant impact on cane girth in both plant crops. Their interaction was significant at all stages except at 120 DAP in first plant crop.

Among the organic sources, application of press mud (T_2) had recorded maximum cane girth at all stages of growth and was significantly superior to other

Table 55a Effect of organic sources and mineral nutrition on cane girth (cm) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	7.08	7.43	7.48	7.33	8.10	8.37	8.76	8.41	8.40	8.76	8.96	8.71
T_2	8.13	8.28	8.30	8.23	9.51	9.84	10.08	9.81	9.67	9.97	10.33	9.99
T_3	7.33	7.58	7.68	7.53	8.66	8.99	9.12	8.92	8.93	9.12	9.22	9.09
T_4	7.80	7.90	7.98	7.89	9.26	9.37	9.46	9.36	9.43	9.51	9.57	9.50
T_5	7.73	7.73	7.90	7.78	9.09	9.22	9.38	9.23	9.26	9.35	9.50	9.37
T_6	7.95	8.18	8.20	8.11	9.33	9.42	9.64	9.47	9.53	9.70	9.77	9.67
Mean	7.67	7.85	7.92		8.99	9.20	9.40		9.20	9.40	9.56	
C.D.(0.05) for (T)				0.20**				0.14**				0.14**
C.D.(0.05) for (F)				0.12**				0.04**				0.07**
(T x F) interaction				N.S.				0.15**				0.21**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 55b Effect of organic sources and mineral nutrition on cane girth (cm) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	6.41	6.55	7.60	6.85	6.76	6.90	7.89	7.18	6.97	7.37	8.13	7.49
T_2	8.31	8.52	8.65	8.49	8.60	8.69	8.84	8.71	8.64	8.79	9.02	8.81
T_3	7.83	8.18	8.10	8.03	8.30	8.31	8.38	8.33	8.37	8.43	8.48	8.43
T_4	8.15	8.28	8.32	8.25	8.40	8.50	8.57	8.49	8.53	8.61	8.65	8.60
T_5	8.12	8.23	8.29	8.21	8.32	8.42	8.50	8.41	8.50	8.53	8.58	8.54
T_6	8.22	8.43	8.50	8.38	8.46	8.65	8.67	8.59	8.61	8.71	8.73	8.68
Mean	7.84	8.03	8.24		8.14	8.24	8.47		8.27	8.41	8.60	
C.D.(0.05) for (T)				0.24**				0.08**				0.10**
C.D.(0.05) for (F)				0.08**				0.08**				0.10**
C.D. (0.05) for interaction (T x F)				0.33**				0.10**				0.20**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

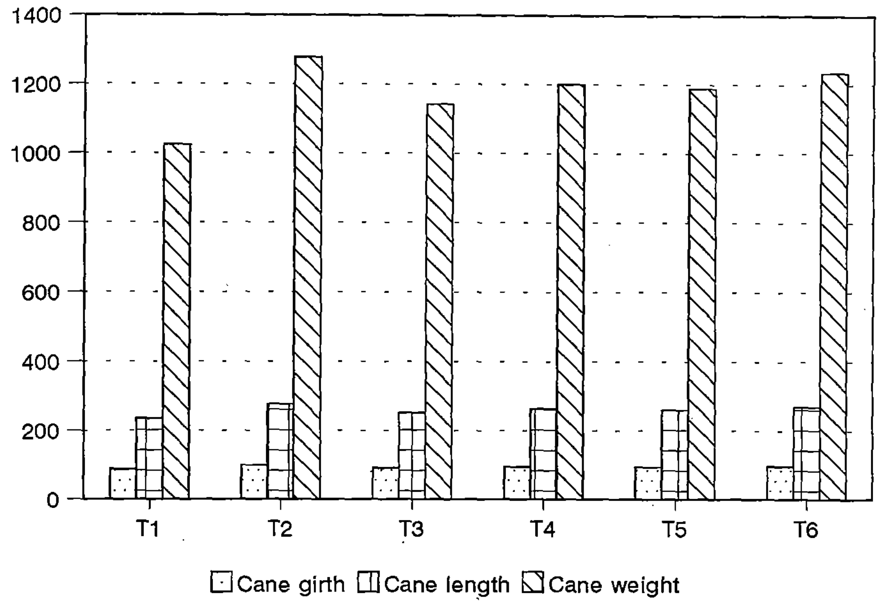


Fig. 13a. Yield attributes as influenced by organic sources during first plant crop

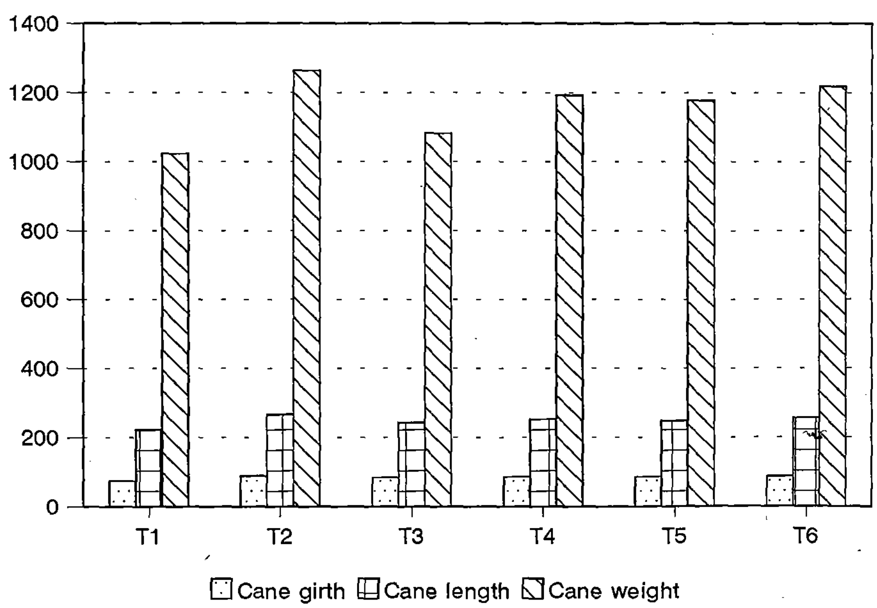


Fig. 13b. Yield attributes as influenced by organic sources during second plant crop

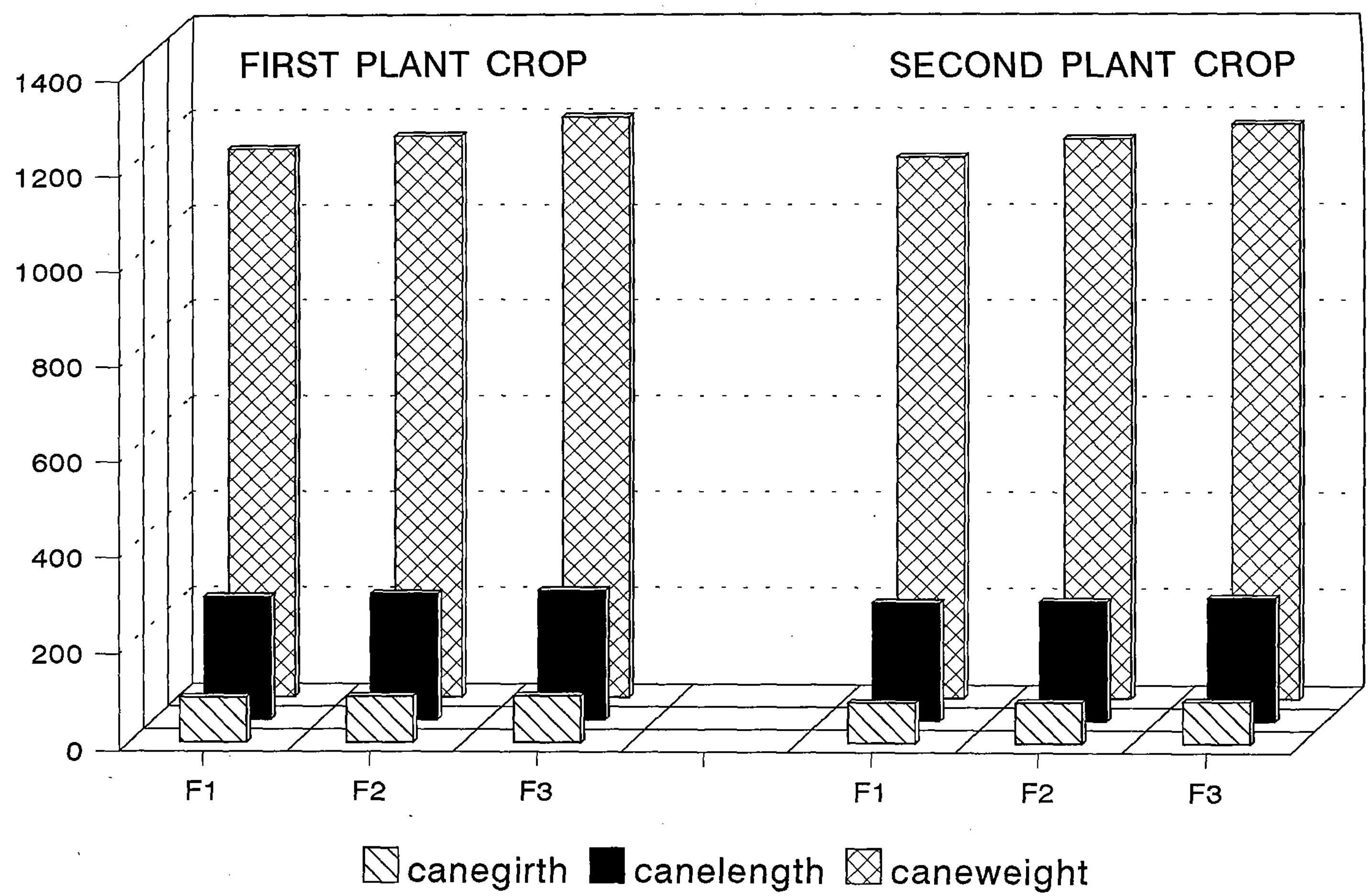


Fig. 14. Yield attributes as influenced by mineral nutrition during first and second plant crop

sources especially at the maturity stage. It was followed by Azospirillum inoculation (T_6) and green manure application (T_4). The lowest values for cane girth was found associated with T_1. While with mineral nutrition, NPK application at 100 per cent of recommended dose (F_3) had recorded maximum cane girth as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). Among the treatment combinations T_2F_3 recorded highest values for cane girth and it was followed by T_2F_2, T_6F_3 and T_6F_2. The combination T_1F_1 had recorded significantly lower values for cane girth in both plant crops.

4.2.3.2. Millable cane count at 360 DAP (Table 56a and 56b)

The data revealed that treatments varied significantly on MCC with organic sources, mineral nutrition and their interactions in both plant crops.

It was observed that press mud application (T_2) had recorded highest MCC and was significantly superior to all other organic sources. It was closely followed by Azospirillum inoculation (T_6) and green manure application (T_4). The MCC was lowest in T_1. With regard to mineral nutrition, MCC was highest with NPK application at 100 per cent of the recommended dose (F_3) and it was significantly superior to F_2 and F_1. Among the treatment combinations T_2F_3 recorded significantly higher MCC and it was followed by T_6F_3 and T_6F_2. While T_1F_1 had registered the lowest MCC.

4.2.3.3. Cane length at 360 DAP (Table 56a, 56b and Fig.13a, 13b and 14)

Cane length was remarkably influenced by organic sources, mineral nutrition and their interactions in both plant crops.

The results obtained revealed that press mud application (T_2) had significantly increased the cane length and was superior to all other organic sources.

Table 56a Effect of organic sources and mineral nutrition on yield attributes in first plant crop

Treatment	Millable cane count ('000) at 360 DAP				Cane length (cm)				Single cane weight (g)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	87.50	90.09	93.42	90.34	219.80	236.60	250.65	235.68	961.17	1003.92	1108.58	1024.56
T_2	99.35	101.67	103.42	101.48	271.70	274.65	286.70	277.68	1240.17	1280.25	1314.17	1278.19
T_3	92.87	94.72	95.46	94.35	246.70	252.58	257.40	252.23	1105.83	1151.34	1169.00	1142.06
T_4	96.66	98.05	98.60	97.77	259.40	264.75	268.80	264.32	1181.00	1207.17	1213.10	1200.42
T_5	96.20	96.48	97.22	96.63	255.45	260.95	266.30	260.90	1175.27	1190.50	1199.08	1188.28
T_6	98.14	99.90	101.20	99.75	267.35	269.95	273.00	270.10	1205.42	1242.67	1254.67	1234.25
Mean	95.12	96.82	98.22		253.40	259.91	267.14		1144.81	1179.31	1209.77	
C.D.(0.05) for (T)				1.23**				5.38**				9.99**
C.D.(0.05) for (F)				0.54**				4.01**				3.26**
C.D. (0.05) for interaction (T x F)				0.82**				5.98**				15.44**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 56b Effect of organic sources and mineral nutrition on yield attributes in second plant crop

Treatment	Millable cane count ('000) at 360 DAP				Cane length (cm)				Single cane weight (g)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	88.98	91.76	93.52	91.42	215.90	221.30	229.65	222.28	979.17	1017.50	1071.67	1022.78
T_2	97.86	99.25	100.55	99.22	255.85	263.70	278.80	266.12	1226.67	1269.17	1295.83	1263.89
T_3	92.59	93.87	94.72	93.73	238.40	242.05	246.10	242.18	1045.83	1085.84	1113.34	1081.67
T_4	95.46	96.47	97.31	96.41	249.55	251.45	255.65	252.22	1168.33	1190.84	1219.17	1192.72
T_5	94.91	95.63	96.29	95.61	248.15	245.05	250.25	247.82	1145.42	1182.50	1205.00	1177.64
T_6	96.94	98.33	98.88	98.05	251.30	254.85	263.40	256.52	1184.17	1225.84	1244.17	1218.06
Mean	94.46	95.88	96.88		243.19	246.40	253.98		1124.93	1161.95	1191.53	
C.D.(0.05) for (T)				0.56**				3.78**				23.90**
C.D.(0.05) for (F)				0.39**				3.83**				8.78**
C.D. (0.05) for interaction (T x F)				0.82**				5.47**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

It was followed by Azospirillum inoculation (T_6) and green manure application (T_4). Whereas treatments without organic sources (T_1) recorded the lowest value. While with mineral nutrition, F_3 gave an appreciable increase in cane length as compared to F_2 and F_1. The interactions revealed that T_2F_3 had registered maximum cane length and it was significantly superior to all other treatment combinations. It was followed by T_2F_2, T_6F_3 and T_2F_1. Whereas T_1F_1 and T_1F_2 had shown statistical parity, but were inferior to all other treatment combinations.

4.2.3.4. Single cane weight at 360 DAP (Table 56a, 56b and Fig.13a, 13b and 14)

The data revealed that the organic sources and mineral nutrition had exerted a profound influence on single cane weight. However, the interaction effect was noticed only in first plant crop.

The treatment effects due to organic sources had indicated that application of press mud (T_2) had recorded the highest single cane weight and it was followed by T_6, T_4 and T_5. While with mineral nutrition, F_3 had produced maximum single cane weight and was significantly superior to F_2 and F_1. The interaction effects indicated that T_2F_3 gave significantly higher single cane weight as compared to other treatment combinations. It was closely followed by T_2F_2, T_6F_3 and T_6F_2.

4.2.4. Yield

4.2.4.1. Cane Yield (Table 57a, 57b, 57c and Fig.15a and 15b)

The data summarised had revealed that organic sources, mineral nutrition and their interactions had exhibited significant effects on cane yield during first and second plant crops.

During first plant crop press mud application (T_2) had produced maximum cane yield (127.56 t ha^{-1}) and it was significantly superior to all other organic sources. It was followed by Azospirillum inoculation (T_6) and was significantly superior to other organic sources viz., green manure application (T_4), Acetobacter inoculation (T_5) and trash application (T_3). The treatment without organic sources (T_1) recorded the lowest cane yield. While with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) registered the highest cane yield and was significantly superior to NPK application at 75 per cent (F_2) and 50 per cent (F_1) of the recommended dose. Among the treatment combinations, maximum cane yield was associated with T_2F_3 (134.17 t ha^{-1}) and it was significantly superior to all other combinations. This combination was followed by T_2F_2 (128.24 t ha^{-1}), T_6F_3 (124.63 t ha^{-1}), T_6F_2 (121.11 t ha^{-1}), T_2F_1 (120.28 t ha^{-1}), T_4F_3 (118.43 t ha^{-1}), T_4F_2 (116.49 t ha^{-1}). The cane yield was drastically reduced in T_1F_1 (82.22). Similarly, T_1F_2 and T_1F_3 also recorded comparatively lesser cane yield.

A critical review of the data revealed that the same trend was continued in second plant crop with press mud application (T_2) producing the highest cane yield. This was followed by Azospirillum inoculation (T_6) and green manure application (T_4). But T_4 was on par with Acetobacter inoculation (T_5) which was again superior to trash application (T_3). All the organic sources recorded highly significant yield improvement over T_1. The mineral nutrition also exhibited a similar trend like the first plant crop with highest yield in F_3 followed by F_2 and F_1. Like the previous year, among the interactions T_2F_3 (127.20 t ha^{-1}) produced maximum cane yield and it was followed by T_2F_2 (121.83 t ha^{-1}), T_6F_3 (118.22 t ha^{-1}), T_6F_2 (115.37 t ha^{-1}), T_2F_1 (115.09 t ha^{-1}). Treatment without organic sources or its combination with NPK levels recorded lower yield as compared to other treatment combinations.

Result of the pooled analysis revealed that the analysis of variance for organic sources, mineral nutrition and their interactions were significant. The treatment effects exhibited similar trend as obtained in the first and second plant crops with regard to organic sources, mineral nutrition and the interaction between organic sources and mineral nutrition.

Cane yield between the years were significant. The organic sources as well as mineral nutrition over the years were significant. The treatment with press mud application (T_2) and Azospirillum inoculation (T_6) had shown positive influence on cane yield over the years. While with mineral nutrition, NPK application at 100 per cent of the recommended dose had appreciably increased the cane yield over the years. The treatment effects over the years were also similar to that of the results obtained during the plant crops of 1998-'99 and 1999-2000. The interaction effect between organic source and mineral nutrition over the years did not exhibit any significant influence on cane yield.

4.2.4.2. Sugar yield (Table 57a, 57b and Fig.15a and 15b)

The data generated had revealed that sugar yield was significantly affected by organic sources and mineral nutrition in both plant crops. But their interaction effect was observed only in the second plant crop.

The results of the first plant crop had shown that press mud application ((T_2) recorded the highest sugar yield and was on par with Azospirillum inoculation (T_6). But T_6 was followed by green manure application (T_4) and Acetobacter inoculation (T_5). The treatments without organic sources recorded lesser value. With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) recorded significantly superior values than NPK application at 75 per cent (F_2) and 50 per cent (F_1) of the recommended dose.

In the second plant crop, press mud application (T_2) recorded maximum sugar yield and it was significantly superior to other organic sources. It was followed by Azospirillum inoculation (T_6), green manure application (T_4) and Acetobacter inoculation (T_5). The treatment without organic sources produced the lowest sugar yield. Among the treatments with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had registered maximum sugar yield and it was significantly superior to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_3). The interaction effects revealed that T_2F_3 (15.26 t ha^{-1}) recorded maximum sugar yield and it was followed by T_2F_2 (14.69 t ha^{-1}) which was on par with T_6F_3 (14.08 t ha^{-1}).

4.2.4.3. Jaggery yield (Table 57a, 57b and Fig.15a and 15b)

The data presented had shown that the analysis of variance for jaggery yield was appreciably influenced by organic sources, mineral nutrition and their interactions in both plant crops.

Among the organic sources, the press mud application (T_2) had consistently recorded highest values for jaggery yield and was superior. It was followed by Azospirillum inoculation (T_6) green manure application (T_4), Acetobacter inoculation (T_5), trash application (T_3). The treatment without organic sources recorded the lowest jaggery yield in both plant crops. The treatments with mineral nutrition revealed that NPK application at 100 per cent of the recommended dose (F_3) had shown increased values for jaggery yield as compared to NPK application at 75 per cent (F_2) and 50 per cent (F_1) of the recommended dose. The interaction effects indicated that T_2F_3 (13.97 t ha^{-1} and 13.64 t ha^{-1}) had recorded maximum jaggery yield and was significantly superior to all other treatment combinations. It was

Table 57a Effect of organic sources and mineral nutrition on cane, sugar and jaggery yield in first plant crop

Treatment	Cane yield (t ha^{-1})				Sugar yield (t ha^{-1})				Jaggery yield (t ha^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	82.22	89.90	100.92	91.02	8.94	9.85	10.88	9.89	7.83	9.02	10.24	9.03
T_2	120.28	128.24	134.17	127.56	13.59	14.25	14.73	14.19	12.49	13.47	13.97	13.31
T_3	97.88	106.48	109.54	104.63	10.95	11.56	12.39	11.63	10.03	11.01	11.33	10.79
T_4	112.13	116.49	118.43	115.68	12.43	12.37	13.95	12.92	11.76	12.04	12.42	12.07
T_5	110.55	113.15	114.99	112.90	11.72	12.33	13.25	12.44	11.35	11.76	11.92	11.68
T_6	115.46	121.11	124.63	120.40	13.40	13.91	14.60	13.97	12.02	12.78	13.21	12.67
Mean	106.42	112.56	117.11		11.84	12.38	13.30		10.911	11.68	12.18	
C.D.(0.05) for (T)				2.09**				0.45**				0.22**
C.D.(0.05) for (F)				0.43**				0.38**				0.10**
C.D. (0.05) for interaction (T x F)				1.87**				N.S.				0.33**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 57b Effect of organic sources and mineral nutrition on cane, sugar and jaggery yield in second plant crop

Treatment	Cane yield (t ha^{-1})				Sugar yield (t ha^{-1})				Jaggery yield (t ha^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	83.74	89.91	96.85	90.16	8.96	10.15	10.73	9.95	8.13	9.03	10.11	9.09
T_2	115.09	121.83	127.20	121.37	13.31	14.69	15.26	14.42	12.14	12.89	13.64	12.89
T_3	94.35	101.66	104.44	100.15	10.07	11.39	11.69	11.05	9.76	10.65	10.87	10.42
T_4	108.79	111.76	113.86	111.47	12.47	13.14	13.18	12.93	11.50	11.83	12.05	11.79
T_5	105.92	109.54	112.22	109.23	12.39	12.32	12.94	12.55	11.13	11.53	11.83	11.50
T_6	112.99	115.37	118.22	115.53	13.61	13.69	14.08	13.80	11.97	12.25	12.56	12.26
Mean	103.48	108.34	112.13		11.80	12.56	12.98		10.77	11.36	11.84	
C.D.(0.05) for (T)				2.49**				0.51**				0.32**
C.D.(0.05) for (F)				0.66**				0.36**				0.12**
C.D. (0.05) for interaction (T x F)				1.93**				0.76*				0.31**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 57 (c) Pooled analysis of cane yield

Treatment	Pooled mean				Organic source x Years			Mineral nutrition x Years		
	F_1	F_2	F_3	Mean	Organic source	1998-'99	1999-2000	Mineral Nutrition	1998-'99	1999-2000
T_1	82.98	89.90	98.88	90.58	T_1	91.02	90.16	F_1	106.42	103.48
T_2	117.68	125.03	130.68	124.46	T_2	127.56	121.37	F_2	112.56	108.34
T_3	96.11	104.07	106.99	102.39	T_3	104.63	100.15	F_3	117.11	112.11
T_4	110.46	114.12	115.94	113.50	T_4	115.68	111.47			
T_5	108.23	111.34	113.60	111.05	T_5	112.90	109.23			
T_6	114.22	118.24	121.42	117.96	T_6	120.40	115.53			
Mean	104.94	110.45	114.58							
C.D.(0.05) for (T)				3.16**	C.D.(0.05) for T x Y	1.68**		C.D. (0.05) for F x Y	1.06*	
C.D.(0.05) for (F)				0.61**						
C.D. (0.05) for interaction (T x F)				2.13**						

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

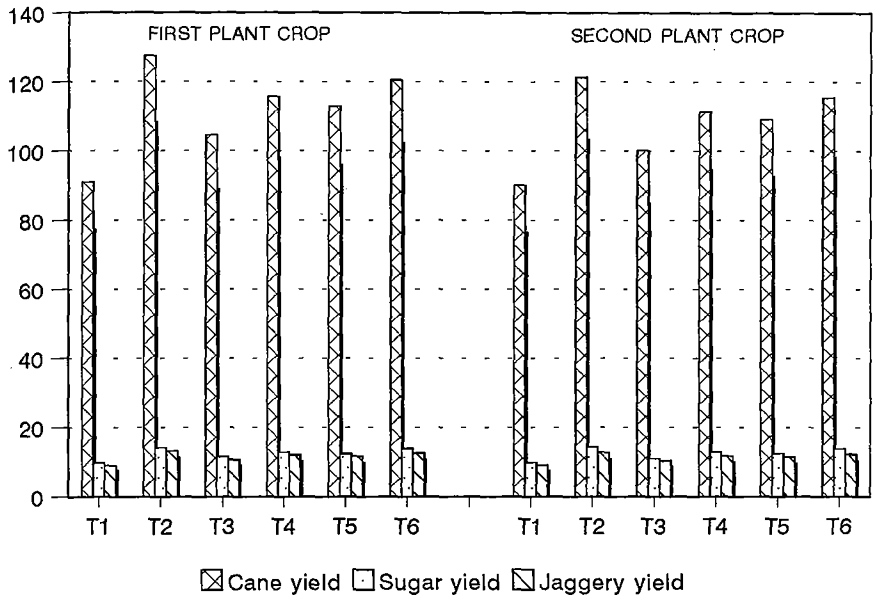


Fig. 15a. Influence of organic sources on cane, sugar and jaggery yield during first and second plant crops

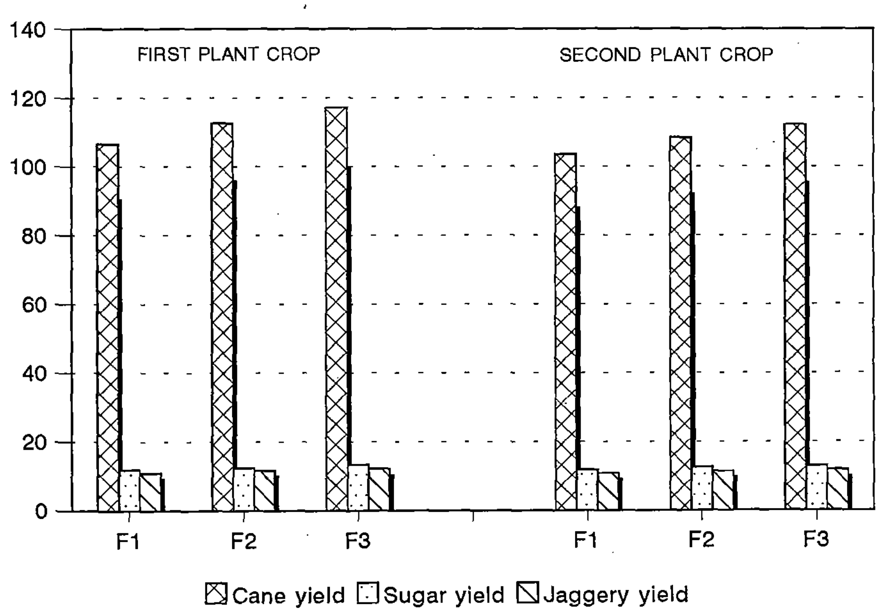


Fig. 15b. Influence of mineral nutrition on cane, sugar and jaggery yield during first and second plant crops

immediately followed by T_2F_2 (13.47 and 12.89 t ha^{-1}) and T_6F_3 (13.21 and 12.56 t ha^{-1}). The jaggery production was consistently reduced in treatment combination with T_1F_1 (7.83 and 8.13 t ha^{-1}), T_1F_2 (9.02 and 9.03 t ha^{-1}) and T_3F_1 (10.03 and 9.76 t ha^{-1}).

4.2.5. Juice quality

4.2.5.1. Juice recovery (Table 58a and 58b)

Juice recovery was significantly influenced by organic sources and mineral nutrition in both plant crops.

Among the organic sources, Azospirillum inoculation (T_6), press mud application (T_2) and green manure application (T_4) recorded higher juice recovery during first plant crop. While in second plant crop T_6 was significantly superior to all other organic sources and was followed by T_2. While with mineral nutrition, F_3 was statistically on par with F_2 but significantly superior to F_1.

4.2.5.2. Sucrose (Table 58a, 58b and Fig.16a, 16b and 17)

The data revealed that it was significantly influenced by organic sources in both plant crops. However, the mineral nutrition and their interactions did not influence the sucrose content.

The results obtained revealed that Azospirillum inoculation (T_6), Acetobacter inoculation (T_5) and press mud application (T_2) with higher sucrose content were on par with each other in the first plant crop. In second plant crop T_2, T_6, T_4 and T_5 were on par with each other.

4.2.5.3. Commercial cane sugar (CCS) per cent (Table 58a, 58b and Fig. 16a, 16b and 17)

The data presented had shown that CCS per cent was neither influenced by organic source nor by mineral nutrition and their interactions during first plant crop.

Table 58a Effect of organic sources and mineral nutrition on juice quality in first plant crop

Treatment	Juice recovery (%)				Sucrose (%)				CCS (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	52.02	53.93	54.82	53.59	15.31	15.22	15.60	15.38	10.88	10.96	10.78	10.87
T_2	55.39	56.09	56.26	55.91	15.78	15.55	15.45	15.59	11.30	11.19	11.10	11.20
T_3	54.85	54.74	55.45	55.01	15.13	15.00	15.14	15.09	10.80	10.86	11.30	10.99
T_4	56.04	55.68	56.32	56.01	15.76	15.50	16.37	15.88	11.09	11.12	11.79	11.33
T_5	54.00	55.91	56.05	55.32	15.42	16.26	15.91	15.86	10.97	11.01	11.46	11.14
T_6	56.21	56.77	56.98	56.65	16.10	16.03	16.30	16.14	11.62	11.60	11.50	11.57
Mean	54.75	55.52	55.96		15.58	15.59	15.79		11.11	11.12	11.32	
C.D.(0.05) for (T)				1.62*				0.61*				N.S.
C.D.(0.05) for (F)				0.86*				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

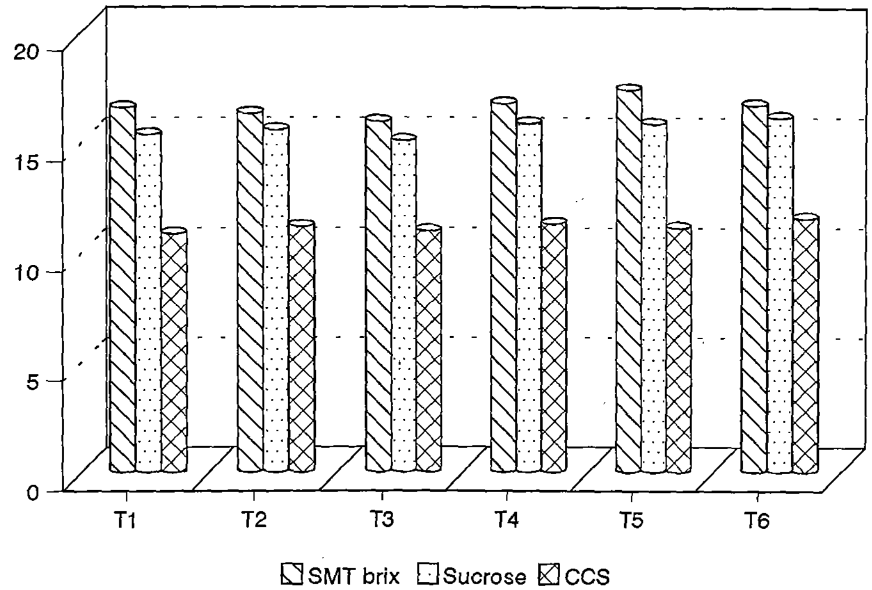


Fig. 16a. Juice quality as influenced by organic sources during first plant crop

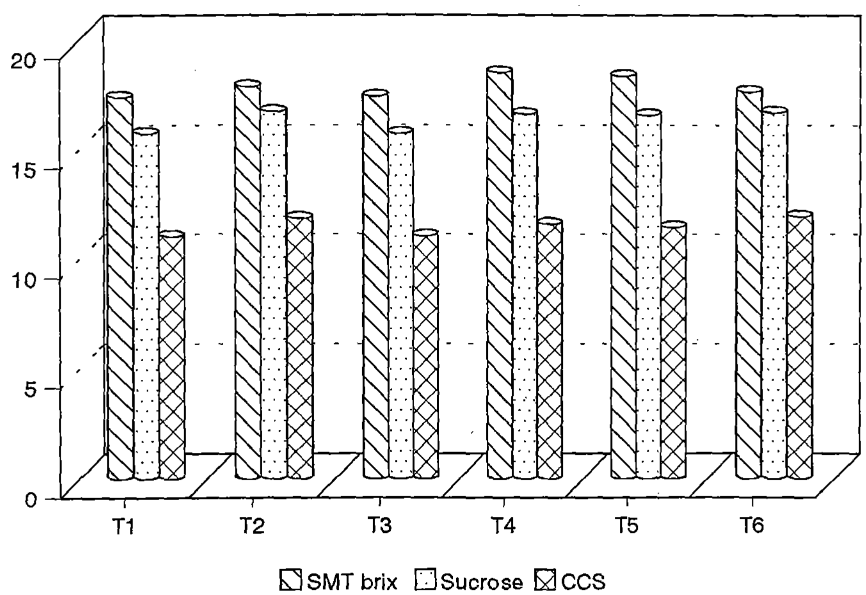


Fig. 16b. Juice quality as influenced by organic sources during second plant crop

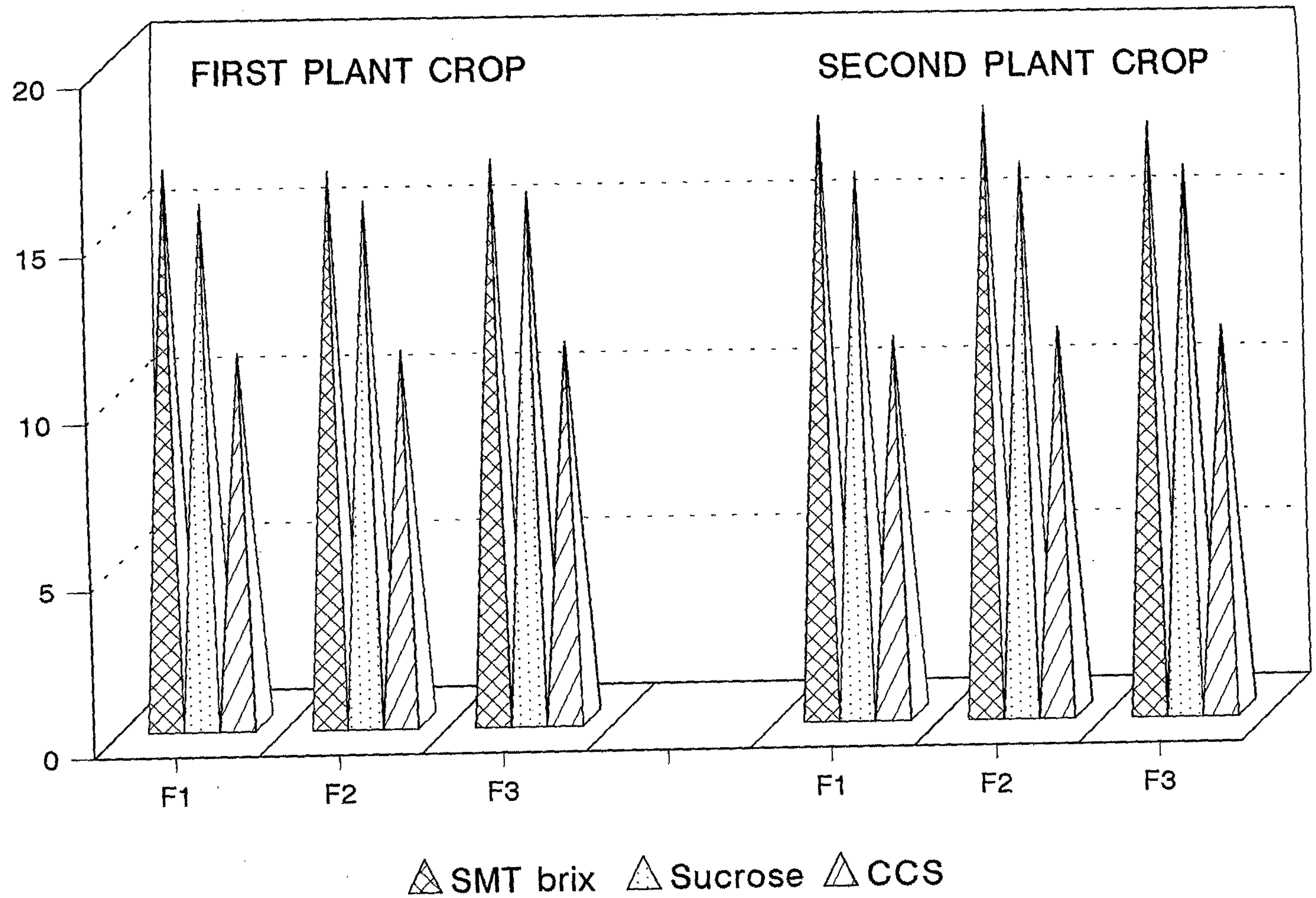


Fig. 17. Juice quality as influenced by mineral nutrition during first and second plant crops

Table 58b Effect of organic sources and mineral nutrition on juice quality in second plant crop

Treatment	Juice recovery (%)				Sucrose (%)				CCS (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	50.73	56.68	57.15	54.85	15.33	16.11	15.80	15.74	10.70	11.30	11.09	11.03
T_2	58.72	58.84	58.71	58.76	16.55	17.21	16.54	16.76	11.56	12.06	12.00	11.87
T_3	57.54	57.81	58.20	57.85	15.66	15.83	15.74	15.74	10.75	11.20	11.20	11.05
T_4	58.32	58.74	58.91	58.66	16.60	16.91	16.39	16.63	11.46	11.75	11.58	11.60
T_5	56.99	57.21	57.24	57.15	16.65	16.32	16.77	16.58	11.59	11.25	11.53	11.46
T_6	58.93	59.84	60.77	59.85	16.87	16.49	16.77	16.71	12.06	11.87	11.92	11.95
Mean	56.87	58.19	58.50		16.23	16.48	16.33		11.35	11.57	11.55	
C.D.(0.05) for (T)				1.06**				0.61**				0.37**
C.D.(0.05) for (F)				0.93*				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

M_1 - Control
M_2 - Pressmud application
M_3 - Trash application
M_4 - Green manuring
M_5 - Acetobacter inoculation
M_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

However, in second plant crop only the organic sources had exhibited a remarkable variation in CCS percentage.

The results revealed that in second plant crop, inoculation of Azospirillum (T_6) and press mud application (T_2) registered higher CCS per cent and it was on par with each other and significantly superior to other organic sources. The lowest CCS per cent was noticed in T_1 and T_3.

4.2.5.4. SMT brix (Table 59a, 59b and Fig.16a, 16b and 17)

The results given indicated that the SMT brix percentage was significantly influenced by organic sources in the first plant crop alone.

Among the organic sources, Acetobacter inoculation (T_5) recorded maximum value for SMT brix and was statistically on par with green manure application (T_4) and Azospirillum inoculation (T_6).

4.2.5.5. Reducing sugar (Table 59a and 59b)

The data generated revealed that treatment effects due to organic sources was only significant only in first plant crop. But in second plant crop, it was significantly influenced by both organic sources as well as mineral nutrition without any interaction effects.

The results obtained had shown that application of trash (T_3) increased the content of reducing sugars in cane juice and it was on par with treatments without organic sources (T_1) and significantly superior to other organic sources in first plant crop. In second plant crop T_1 recorded maximum values and it was on par with (T_3). The lowest values were associated with Azospirillum inoculation (T_6) in both plant crops. With mineral nutrition, NPK application at 50 per cent of the recommended dose (F_1) had shown increased values for reducing sugars as compared

Table 59a Effect of organic sources and mineral nutrition on juice quality in first plant crop

Treatment	SMT brix (%)				Reducing sugar (%)				Titrable acidity (ml of 0.1 NaOH 100 ml^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	16.31	15.79	17.67	16.59	1.10	1.04	0.99	1.04	13.25	12.75	12.75	12.92
T_2	16.67	16.29	16.04	16.33	0.90	0.92	0.90	0.90	9.25	11.25	11.50	10.67
T_3	15.93	15.29	16.67	15.96	1.09	1.08	1.05	1.07	12.50	13.00	11.50	12.33
T_4	17.18	16.18	16.93	16.77	1.07	1.04	0.85	0.99	12.25	12.00	12.00	12.08
T_5	16.93	18.86	16.42	17.40	0.99	0.86	0.95	0.93	10.25	10.75	11.00	10.67
T_6	16.54	16.54	17.04	16.71	0.93	0.90	0.85	0.89	8.75	9.75	9.25	9.25
Mean	16.59	16.49	16.79		1.01	0.97	0.93		11.04	11.58	11.33	
C.D.(0.05) for (T)				0.83*				0.06**				1.01**
C.D.(0.05) for (F)				N.S.				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

M_1 - Control
M_2 - Pressmud application
M_3 - Trash application
M_4 - Green manuring
M_5 - Acetobacter inoculation
M_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 59b Effect of organic sources and mineral nutrition on juice quality in second plant crop

Treatment	SMT brix (%)				Reducing sugar (%)				Titrable acidity (ml of 0.1 NaOH 100 ml^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	16.97	17.93	17.31	17.40	1.07	1.02	0.99	1.02	12.00	13.50	13.75	13.08
T_2	17.84	18.59	17.24	17.89	0.86	0.76	0.86	0.83	10.25	12.00	11.75	11.33
T_3	17.68	17.70	16.943	17.44	1.09	1.01	0.96	1.02	12.50	11.50	12.25	12.08
T_4	18.95	18.92	17.68	18.52	0.89	0.75	0.87	0.84	11.75	11.75	12.25	11.92
T_5	18.20	18.58	18.31	18.36	0.80	0.86	0.79	0.82	10.25	11.75	11.25	11.08
T_6	17.74	17.08	18.17	17.66	0.84	0.83	0.75	0.80	10.00	11.00	10.75	10.58
Mean	17.90	18.13	17.61		0.92	0.87	0.87		11.13	11.92	12.00	
C.D.(0.05) for (T)				N.S.				0.06**				0.92**
C.D.(0.05) for (F)				N.S.				0.04**				0.68*
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 60a **Effect of organic sources and mineral nutrition on juice quality in first plant crop**

Treatment	Purity coefficient (%)				Fibre content (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	94.09	96.57	88.30	92.99	15.80	16.18	15.86	15.94
T_2	94.95	95.68	96.31	95.64	15.57	15.90	15.71	15.72
T_3	95.03	98.09	91.07	94.73	15.63	15.71	15.70	15.68
T_4	92.38	95.83	94.22	94.14	15.49	15.47	15.77	15.58
T_5	91.64	86.35	97.05	91.68	15.36	15.50	15.80	15.55
T_6	97.34	97.17	96.12	96.88	15.58	15.56	15.49	15.54
Mean	94.24	94.95	93.84		15.57	15.72	15.72	
C.D.(0.05) for (T)				N.S.				N.S.
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant

Table 60b Effect of organic sources and mineral nutrition on juice quality in second plant crop

Treatment	Purity coefficient (%)				Fibre content (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	90.34	89.88	91.43	90.55	15.09	15.54	15.15	15.26
T_2	91.55	92.62	96.30	93.49	15.36	15.25	15.24	15.29
T_3	88.72	89.51	93.97	90.73	15.29	15.27	15.29	15.28
T_4	87.77	89.40	92.76	89.98	15.21	15.39	15.51	15.37
T_5	91.46	87.90	91.70	90.35	15.33	15.31	15.68	15.44
T_6	95.27	96.46	92.61	94.78	15.45	15.57	15.58	15.53
Mean	90.85	90.96	93.13		15.29	15.39	15.41	
C.D.(0.05) for (T)				N.S.				N.S.
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
* - Significant at 5 per cent level

to NPK application at 100 per cent (F_3) and 75 per cent of the recommended dose (F_2).

4.2.5.6. Titrable acidity (Table 59a and 59b)

The data presented had shown that titrable acidity was remarkably influenced by organic sources in both plant crops. However, the mineral nutrition was significant only in second plant crop.

The treatment effects due to organic sources revealed that the treatments without organic sources (T_1) had recorded superior values for titrable acidity in both plant crops. The titrable acidity values were lowest with Azospirillum inoculation (T_6). The mineral nutrition was significant only in second plant crop. Application of NPK at 100 per cent of the recommended dose (F_3) showed statistical parity with NPK application at 75 per cent (F_2) but significantly superior to 50 per cent of the recommended dose (F_1).

4.2.5.7. Purity coefficient and fibre content (Table 60a and 60b)

The data revealed that treatment variation due to organic sources and mineral nutrition or their interactions were not significant for purity coefficient and fibre content of the juice in both the years of study.

4.2.6. Jaggery quality

4.2.6.1. Jaggery moisture (Table 61a and 61b)

The results revealed that treatment variation due to organic sources, mineral nutrition and their interactions were not significant in both plant crops.

4.2.6.2. Jaggery sucrose (Table 61a, 61b and Fig.18a, 18b and 19)

The results presented had shown that jaggery sucrose was significantly affected by organic sources in both plant crops. However, the mineral nutrition was not significant. The interaction effect was noticed only in first plant crop.

The data recorded revealed that Azospirillum inoculation (T_6) had increased the values of sucrose content and it was on par with Acetobacter inoculation (T_5) and press mud application (T_2) in first plant crop. Whereas in second plant crop, T_2 was on par with T_6, but significantly superior to other organic sources. The treatments with mineral nutrition had shown that F_3 had recorded numerically higher values as compared to F_2 and F_1 in both plant crops. The interaction effects studied in first plant crop revealed that T_6F_3 recorded highest value for sucrose content, but was on par with T_6F_2, T_6F_1 and T_5F_2. The lowest value was associated with T_1F_1 and T_1F_2.

4.2.6.3. Jaggery Brix (Table 61a and 61b)

The data recorded had revealed that treatment variation due to organic sources was only significant in first plant crop. The interaction effect between organic sources and mineral nutrition were significant in first and second plant crops. Among the organic sources, Acetobacter inoculation (T_5) recorded maximum Brix values and was on par with Azospirillum inoculation (T_6) in first plant crop. While in second plant crop the organic sources had not exerted any significant effects. The interaction effects revealed that T_4F_3 was on par with T_5F_3, T_6F_2 and T_6F_3 in first plant crop. Whereas in second plant crop among the treatment combinations T_1F_2 recorded highest Brix value and was on par with T_2F_3, T_3F_3 and T_3F_1.

4.2.6.4. Jaggery reducing sugars (Table 62a, 62b and Fig.18a, 18b and 19)

The data generated showed that treatment effects due to organic sources, mineral nutrition and their interactions were significant in first plant crop. However, in second plant crop only the organic sources had exerted significant effects on jaggery reducing sugars.

Table 61a ***Effect of organic sources and mineral nutrition on jaggery quality in first plant crop***

Treatment	Jaggery moisture (%)				Jaggery sucrose (%)				Jaggery Brix (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	4.80	4.69	4.91	4.80	61.82	60.78	64.25	62.29	77.23	77.23	78.23	77.56
T_2	4.48	4.80	4.48	4.59	68.13	68.55	68.55	68.41	76.30	77.23	76.30	76.61
T_3	4.77	4.59	4.68	4.68	63.63	64.17	64.19	63.99	80.15	79.50	78.23	79.29
T_4	4.57	4.70	4.73	4.67	66.99	66.65	69.30	67.65	81.07	77.23	84.92	81.07
T_5	4.40	4.88	4.73	4.67	69.36	69.82	66.92	68.70	84.00	84.00	84.00	84.00
T_6	4.25	4.51	4.43	4.39	70.30	70.82	71.23	70.78	84.00	84.00	83.00	83.66
Mean	4.54	4.69	4.66		66.71	66.80	67.41		80.45	79.86	80.78	
C.D.(0.05) for (T)				N.S.				2.85**				2.07**
C.D.(0.05) for (F)				N.S.				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				2.08*				2.38**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 61b Effect of organic sources and mineral nutrition on jaggery quality in second plant crop

Treatment	Jaggery moisture (%)				Jaggery sucrose (%)				Jaggery Brix (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	5.32	5.28	5.11	5.24	64.92	64.03	64.17	64.37	80.15	83.00	80.15	81.11
T_2	5.26	5.30	5.26	5.27	67.59	67.57	67.98	67.71	80.15	78.15	82.07	80.12
T_3	5.39	5.30	5.19	5.29	64.61	66.24	65.57	65.47	81.07	80.15	81.00	80.74
T_4	5.21	5.36	5.12	5.23	66.04	66.61	66.63	66.43	82.07	78.23	78.23	79.51
T_5	5.22	5.23	5.39	5.28	66.07	66.17	66.94	66.39	81.07	77.15	78.15	78.79
T_6	5.21	5.37	5.29	5.29	66.54	68.02	68.07	67.54	81.07	81.07	78.23	80.13
Mean	5.27	5.30	5.23		65.96	66.44	66.56		80.93	79.62	79.64	
C.D.(0.05) for (T)				N.S.				1.24**				N.S.
C.D.(0.05) for (F)				N.S.				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				2.23**

Organic sources

T_1 - Control
T - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 62a Effect of organic sources and mineral nutrition on jaggery quality in first plant crop

Treatment	Jaggery reducing sugar (%)				Jaggery purity (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	9.49	9.07	8.71	9.09	80.05	81.94	82.15	81.38
T_2	7.23	7.02	6.56	6.93	89.40	88.76	89.91	89.36
T_3	8.68	8.36	8.43	8.50	79.61	81.10	82.15	80.95
T_4	7.70	8.19	6.95	7.62	82.70	86.30	81.61	83.53
T_5	6.62	6.61	7.64	6.95	82.62	83.19	79.74	81.85
T_6	6.05	5.62	5.38	5.68	83.78	83.78	85.84	84.47
Mean	7.63	7.48	7.28		83.03	84.18	83.57	
C.D.(0.05) for (T)				0.97**				4.10**
C.D.(0.05) for (F)				0.23*				N.S.
C.D. (0.05) for interaction (T x F)				0.60**				2.84*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 62b Effect of organic sources and mineral nutrition on jaggery quality in second plant crop

Treatment	Jaggery reducing sugar (%)				Jaggery purity (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	8.78	8.69	8.65	8.70	79.54	77.17	80.12	78.95
T_2	7.25	7.32	6.67	7.08	84.36	86.52	82.90	84.59
T_3	9.12	8.28	8.26	8.55	79.69	80.72	80.88	80.43
T_4	8.20	7.82	8.12	8.04	80.78	85.27	85.26	83.77
T_5	8.18	8.14	7.72	8.01	81.65	85.76	84.74	84.05
T_6	7.04	6.56	6.50	6.70	82.06	86.26	87.13	85.15
Mean	8.09	7.80	7.65		81.35	83.62	83.51	
C.D.(0.05) for (T)				0.86**				3.00**
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

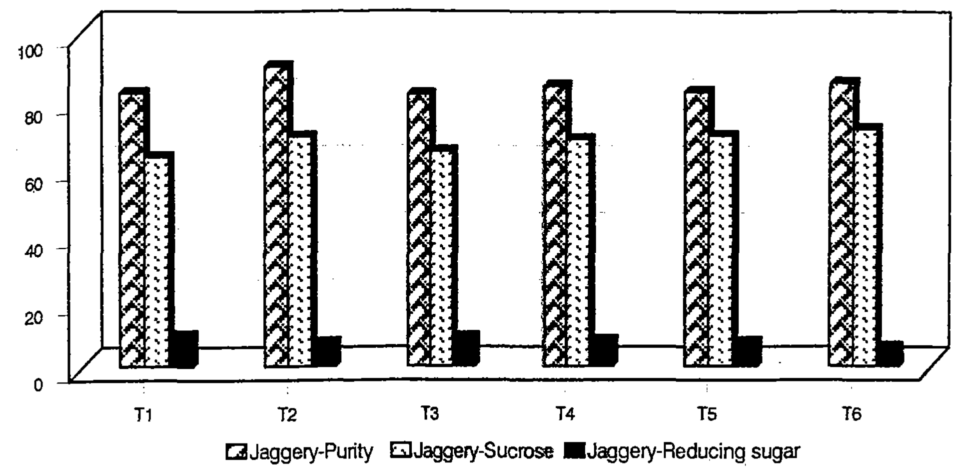


Fig. 18a. Jaggery quality as influenced by organic sources during first plant crop

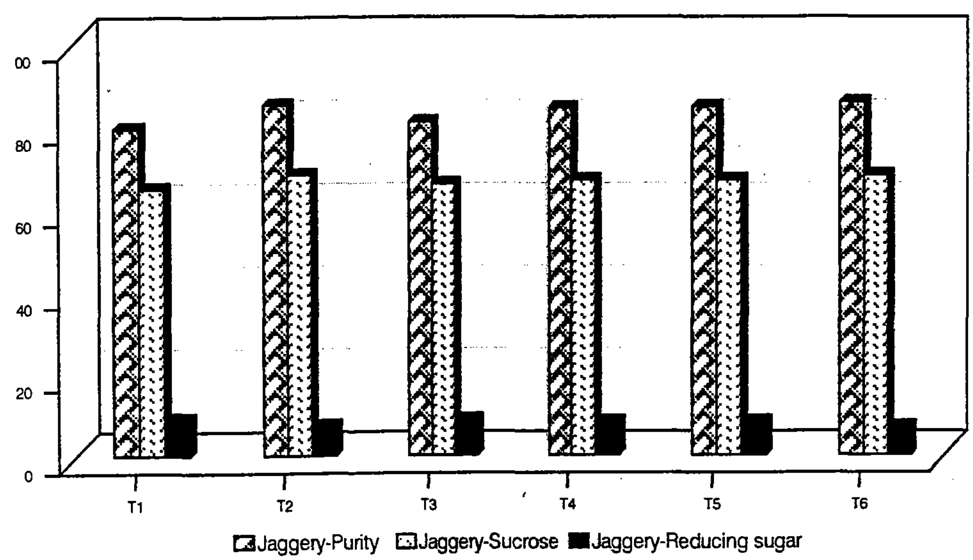


Fig. 18b. Jaggery quality as influenced by organic sources during second plant crop

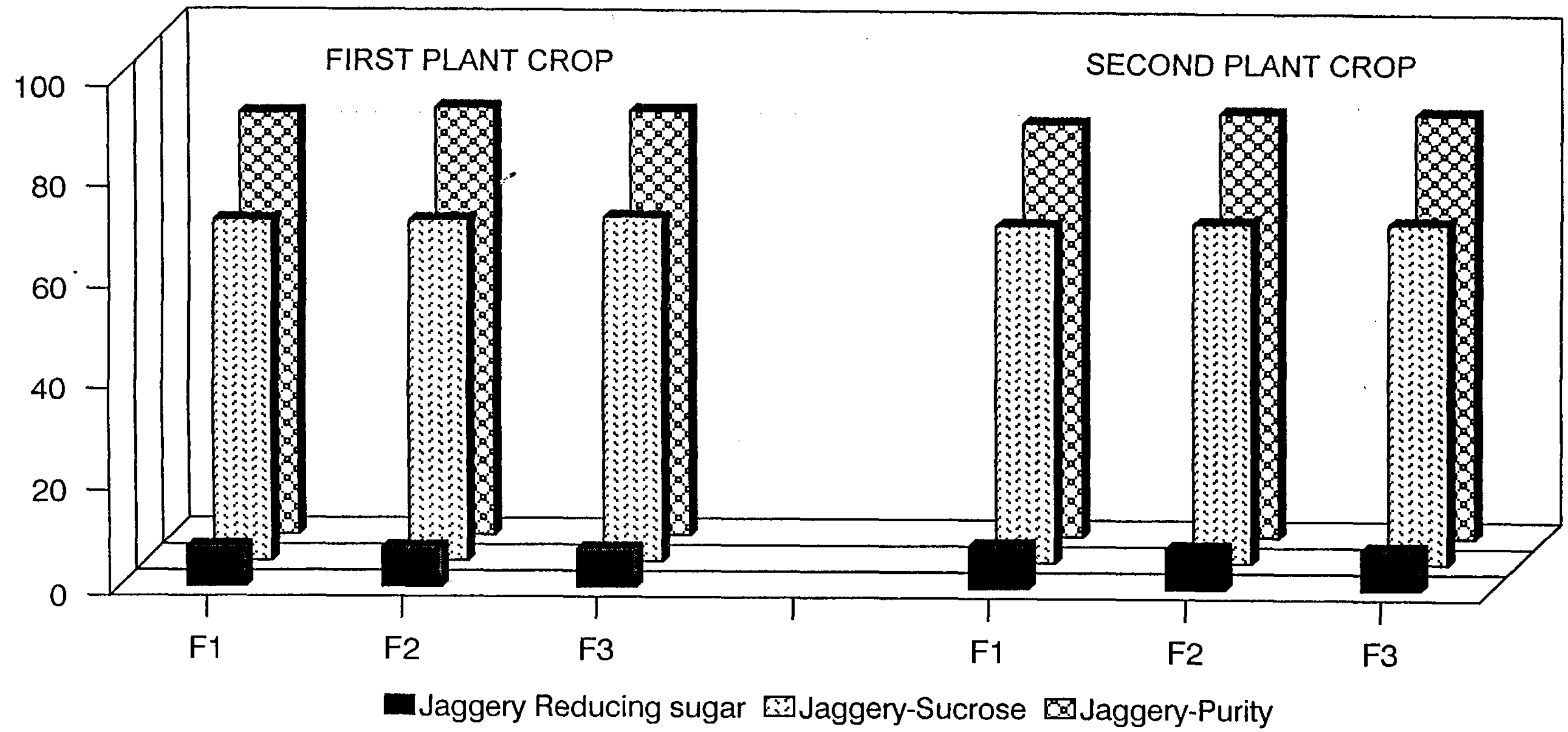


Fig. 19. Jaggery quality as influenced by mineral nutrition in first and second plant crops

The results of the treatments had shown that treatments without organic sources (T_1) increased the content of jaggery reducing sugar and it was on par with trash application (T_3) in both plant crops. Azospirillum inoculation (T_6) had recorded lesser values for jaggery reducing sugars. Among the treatments with mineral nutrition, F_1 was on par with F_2 but was superior to F_3 in first plant crop. The interaction effects exhibited in first plant crop revealed that T_1F_1 recorded maximum value for reducing sugars and was on par with T_1F_3, whereas the jaggery reducing sugar was found lowest with T_6F_3.

4.2.6.5. Jaggery purity (Table 62a and 62b and Fig.18a, 18b and 19)

The data generated showed that jaggery purity was appreciably influenced by organic sources in both plant crops. However, the mineral nutrition was not significant. The interaction effect was significant only in first plant crop.

The results revealed that press mud application (T_2) had recorded maximum value for jaggery purity and was superior to all other organic sources. It was followed by Azospirillum inoculation (T_6). In second plant crop T_6 was on par with T_2 and T_4. The lowest value was found with T_1 in both plant crops. Among the interactions in first plant crop T_2F_3 registered maximum value for jaggery purity and it was followed by T_2F_2 and T_2F_1.

4.2.7. Nutrient uptake

4.2.7.1. Uptake of N, P and K by trash at 120, 240 and 360 DAP (Table 63a, 63b, 64a, 64b, 65a and 65b)

The data recorded revealed that the analysis of variance for the uptake of N, P and K by trash was profoundly influenced by organic sources and mineral nutrition at all stages of growth in both years of experimentation. The interaction effect

Table 63a Effect of organic sources and mineral nutrition on N uptake by trash (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	2.58	3.08	3.81	3.16	12.43	15.59	19.50	15.84	16.44	19.66	22.03	19.38
T_2	5.54	8.36	7.93	7.27	24.42	26.07	26.42	25.63	31.45	35.74	38.62	35.27
T_3	3.67	4.56	5.84	4.69	17.54	18.95	19.53	18.67	22.21	23.00	24.29	23.16
T_4	4.33	6.29	6.11	5.58	20.70	20.50	21.41	20.87	26.42	28.99	30.29	28.56
T_5	6.27	5.18	5.87	5.77	19.88	20.80	21.09	20.59	24.13	26.71	27.02	25.95
T_6	7.51	7.28	7.78	7.52	22.56	24.48	24.53	23.85	28.84	30.66	33.54	31.01
Mean	4.98	5.79	6.22		19.59	21.06	22.08		24.91	27.46	29.30	
C.D.(0.05) for (T)				1.04**				2.34**				1.91**
C.D.(0.05) for (F)				0.84*				1.67*				2.19**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 63b Effect of organic sources and mineral nutrition on N uptake by trash ($kg\ ha^{-1}$) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	2.35	2.98	3.44	2.92	11.74	13.50	15.22	13.48	12.56	15.70	17.43	15.23
T_2	5.77	7.04	7.47	6.76	20.43	21.56	22.08	21.35	27.27	31.33	33.82	30.81
T_3	2.97	3.81	4.01	3.59	13.78	15.27	16.37	15.14	17.15	18.10	21.08	18.78
T_4	4.96	5.62	5.83	5.47	17.41	16.83	18.70	17.64	20.50	22.79	24.34	22.54
T_5	4.45	4.85	4.74	4.68	17.03	18.16	18.24	17.81	20.58	20.82	23.34	21.58
T_6	5.57	6.30	6.45	6.11	19.36	19.66	21.20	20.07	23.99	26.88	28.59	26.49
Mean	4.34	5.10	5.32		16.62	17.49	18.63		20.34	22.60	24.77	
C.D.(0.05) for (T)				0.87**				1.58**				2.77**
C.D.(0.05) for (F)				0.46**				1.19*				0.96**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 64a **Effect of organic sources and mineral nutrition on P uptake by trash (kg ha^{-1}) at different stages of growth in first plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.49	2.34	2.76	2.20	6.32	7.60	9.33	7.75	7.80	9.66	10.87	9.44
T_2	4.89	7.36	6.81	6.35	13.20	14.30	15.08	14.19	17.57	19.45	21.01	19.35
T_3	3.03	3.95	4.58	3.85	8.95	9.76	10.11	9.61	10.65	11.70	11.79	11.38
T_4	4.06	5.14	5.45	4.88	11.11	11.65	11.80	11.52	14.98	15.89	16.97	15.95
T_5	4.98	4.21	4.61	4.60	10.32	10.81	11.28	10.80	14.07	14.95	15.66	14.89
T_6	6.21	5.72	6.43	6.12	11.65	13.57	13.19	12.80	16.56	17.66	18.25	17.49
Mean	4.11	4.79	5.11		10.26	11.28	11.79		13.61	14.89	15.76	
C.D.(0.05) for (T)				0.66**				0.73**				0.59**
C.D.(0.05) for (F)				0.52**				0.53**				0.41**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				0.67**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 64b Effect of organic sources and mineral nutrition on P uptake by trash (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.17	1.45	1.80	1.47	5.97	6.47	7.34	6.60	5.06	6.99	8.26	6.77
T_2	4.07	4.89	5.49	4.82	10.85	11.95	12.84	11.88	14.38	16.13	17.33	15.95
T_3	1.64	2.19	2.45	2.09	6.99	7.94	8.45	7.80	7.45	8.37	8.46	8.09
T_4	3.42	3.96	4.06	3.81	9.16	9.90	9.79	9.62	10.89	11.63	13.02	11.85
T_5	2.66	2.86	2.95	2.82	9.38	9.53	9.64	9.52	10.21	11.00	11.68	10.96
T_6	3.86	4.32	4.33	4.17	9.98	11.03	11.54	10.87	13.54	14.64	15.22	14.46
Mean	2.80	3.28	3.51		8.72	9.48	9.93		10.25	11.46	12.33	
C.D.(0.05) for (T)				0.21**				0.49**				0.32**
C.D.(0.05) for (F)				0.20**				0.18**				0.45**
C.D. (0.05) for interaction (T x F)				0.35*				0.57**				0.62**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 65a Effect of organic sources and mineral nutrition on K uptake by trash (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.11	1.29	1.48	1.30	5.53	7.14	9.66	7.44	5.57	7.03	8.52	7.04
T_2	2.68	3.73	3.78	3.40	14.62	16.29	16.67	15.86	13.73	15.39	16.56	15.23
T_3	1.60	2.12	2.38	2.03	9.55	11.14	11.56	10.75	8.11	8.80	9.22	8.71
T_4	1.94	2.61	2.93	2.49	12.38	13.09	13.09	12.85	10.87	11.81	13.09	11.92
T_5	2.68	2.31	2.59	2.53	11.64	11.89	12.56	12.03	9.78	10.53	12.42	10.91
T_6	3.17	3.13	3.42	3.24	12.84	14.66	14.45	13.98	9.78	10.53	11.65	10.65
Mean	2.20	2.53	2.76		11.09	12.37	13.00		9.64	10.68	11.91	
C.D.(0.05) for (T)				0.40**				1.05**				0.61**
C.D.(0.05) for (F)				0.28**				0.51**				0.34**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				0.68*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 65b Effect of organic sources and mineral nutrition on K uptake by trash (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.08	1.27	1.42	1.25	5.71	6.58	8.15	6.81	4.26	5.92	7.01	5.73
T_2	2.87	3.21	3.67	3.25	12.72	14.28	15.00	14.00	12.47	14.08	15.06	13.87
T_3	1.26	1.56	1.73	1.52	7.92	9.63	10.36	9.30	6.59	7.27	7.68	7.18
T_4	2.17	2.48	2.83	2.49	11.10	11.57	12.00	11.55	8.88	9.91	11.04	9.94
T_5	1.90	2.15	2.28	2.11	10.60	11.21	11.53	11.11	8.01	8.77	9.91	8.90
T_6	2.79	3.13	3.17	3.03	11.70	12.51	13.09	12.44	11.48	12.57	13.48	12.51
Mean	2.01	2.30	2.52		9.96	10.96	11.69		8.61	9.75	10.69	
C.D.(0.05) for (T)				0.23**				0.45**				0.74**
C.D.(0.05) for (F)				0.11**				0.32**				0.37**
C.D. (0.05) for interaction (T x F)				N.S.				0.53**				0.53*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

between T and F was significant for P uptake at 120 and 360 DAP in first plant crop. While with K uptake by trash, the interaction effect was noticed only at 360 DAP in first plant crop and at 240 and 360 DAP in second plant crop. However, the interaction did not show any statistical differences for N uptake.

The results obtained also revealed that the uptake of N and P by trash increased appreciably with Azospirillum inoculation (T_6) and press mud application (T_2) during the early stages of growth. But in the later stages of growth T_2 had shown higher uptake of N and P by trash. While with K uptake, press mud application (T_2) had consistently recorded highest values. The uptake of N, P and K was decreased in treatments without organic sources (T_1). In the case of mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) registered the highest uptake of N, P and K at all stages of growth as compared to other two treatments (F_2 and F_1). The interaction effects exhibited had shown that the treatment combination of T_2F_3 recorded the highest uptake of P and K by trash and it was closely followed by T_2F_2 and T_6F_3. Whereas the uptake of P and K by trash was significantly reduced in T_1F_1 and T_1F_2.

4.2.7.2. Uptake of N, P and K by green tops at 120, 240 and 360 DAP (Table 66a, 66b, 67a, 67b, 68a and 68b)

The data presented had shown that organic sources and mineral nutrition had exerted perceptible influence on the uptake of N, P and K by green tops at all stages of growth in both years of study. However, their interaction was significant with P uptake by green tops at 120 DAP in first plant crop and at 240 and 360 DAP in second plant crop. The interaction effect was also significant with K uptake by green tops at all stages in both plant crops. In general the uptake of N, P and K by green tops was higher up to 240 DAP. Thereafter a steady decline was noticed.

Table 66a Effect of organic sources and mineral nutrition on N uptake by green tops (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	39.04	43.06	51.52	44.54	30.49	32.48	37.85	33.61	15.02	17.53	18.77	17.10
T_2	73.05	75.09	84.41	77.52	55.27	61.34	66.02	60.88	27.87	29.16	31.53	29.52
T_3	50.33	53.06	58.49	53.96	38.74	41.35	42.22	40.77	20.06	21.85	22.74	21.55
T_4	59.76	65.12	67.31	64.06	46.88	48.68	49.94	48.50	24.26	25.41	27.39	25.69
T_5	57.61	65.28	68.43	63.78	42.55	41.67	48.24	44.15	22.58	23.74	25.43	23.92
T_6	60.96	70.73	74.29	68.66	50.02	52.42	56.40	52.95	28.25	30.64	31.16	30.01
Mean	56.79	62.06	67.41		43.99	46.32	50.11		23.01	24.72	26.17	
C.D.(0.05) for (T)				1.71**				3.36**				1.87**
C.D.(0.05) for (F)				3.59**				2.39**				1.31**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 66b Effect of organic sources and mineral nutrition on N uptake by green tops (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	34.40	39.39	41.81	38.53	29.25	31.32	34.93	31.83	14.35	15.33	16.79	15.49
T_2	57.56	62.77	69.62	63.32	49.53	55.44	58.06	54.34	23.61	25.20	29.22	26.01
T_3	39.74	43.14	46.37	43.08	32.30	36.86	38.80	35.98	15.17	17.43	18.36	16.98
T_4	46.25	50.36	54.08	50.23	42.88	44.43	47.82	45.04	19.98	20.88	21.42	20.76
T_5	47.92	49.58	50.56	49.35	39.80	42.26	43.73	41.93	17.90	18.98	21.13	19.34
T_6	54.17	56.60	57.77	56.18	47.02	51.62	55.01	51.22	21.64	22.69	25.32	23.22
Mean	46.67	50.31	53.37		40.13	43.65	46.39		18.78	20.08	22.04	
C.D.(0.05) for (T)				3.39**				4.32**				1.82**
C.D.(0.05) for (F)				1.76**				2.02**				0.67**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 67a Effect of organic sources and mineral nutrition on P uptake by green tops (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	12.65	13.83	16.24	14.24	14.65	15.28	18.19	16.04	6.01	6.95	7.62	6.86
T_2	30.49	32.84	36.61	33.31	27.92	29.76	32.31	29.99	12.36	13.75	14.86	13.65
T_3	16.70	18.61	19.99	18.43	19.07	19.38	20.09	19.51	8.17	8.65	8.93	8.58
T_4	22.05	25.56	27.52	25.04	22.20	23.80	24.13	23.38	9.44	10.51	12.16	10.70
T_5	20.39	24.37	25.87	23.54	20.26	20.34	22.93	21.17	8.85	9.76	10.79	9.80
T_6	24.16	30.47	31.86	28.83	24.01	25.33	27.07	25.47	12.85	13.94	14.43	13.74
Mean	21.07	24.28	26.35		21.35	22.32	24.12		9.61	10.59	11.46	
C.D.(0.05) for (T)				1.24**				0.87**				0.26**
C.D.(0.05) for (F)				0.98**				0.91**				0.41**
C.D. (0.05) for interaction (T x F)				1.59**				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 67b Effect of organic sources and mineral nutrition on P uptake by green tops (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	9.16	10.72	12.18	10.69	13.36	13.99	15.78	14.38	6.12	6.35	7.52	6.66
T_2	22.28	25.19	27.39	24.95	22.98	25.45	26.99	25.14	11.10	12.25	14.34	12.56
T_3	11.49	13.70	14.33	13.17	14.86	16.66	17.46	16.33	7.33	7.72	8.16	7.74
T_4	16.75	18.84	21.25	18.94	19.37	20.56	22.01	20.45	9.44	9.74	10.35	9.84
T_5	15.23	17.17	18.05	16.82	18.04	18.80	19.80	18.88	8.52	9.06	9.59	9.06
T_6	19.70	23.14	24.03	22.29	21.62	23.81	24.97	23.46	10.43	11.24	12.42	11.36
Mean	15.77	18.13	19.54		18.37	19.88	21.17		8.82	9.39	10.40	
C.D.(0.05) for (T)				1.23**				0.73**				0.39**
C.D.(0.05) for (F)				0.49**				0.32**				0.20**
C.D. (0.05) for interaction (T x F)				N.S.				0.86*				0.76**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 68a **Effect of organic sources and mineral nutrition on K uptake by green tops (kg ha^{-1}) at different stages of growth in first plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	36.82	41.95	48.16	42.31	52.23	57.10	66.13	58.48	17.23	20.26	25.46	20.98
T_2	74.80	78.18	85.84	79.61	94.65	100.32	108.22	101.06	34.87	38.86	40.47	38.07
T_3	50.55	53.62	58.81	54.33	70.58	72.25	73.90	72.24	25.22	27.57	27.65	26.81
T_4	62.99	67.91	68.42	66.44	78.01	82.00	82.68	80.95	30.07	31.38	34.70	32.05
T_5	60.39	66.69	70.24	65.77	73.54	69.18	78.98	73.90	28.32	30.57	32.76	30.55
T_6	62.76	76.61	77.68	72.35	80.91	86.17	92.07	86.38	36.56	38.65	39.29	38.17
Mean	58.05	64.16	68.19		74.99	77.83	83.69		28.71	31.22	33.39	
C.D.(0.05) for (T)				2.79**				2.46**				1.71**
C.D.(0.05) for (F)				1.83**				1.75**				1.02**
C.D. (0.05) for interaction (T x F)				4.17*				5.52**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 68b Effect of organic sources and mineral nutrition on K uptake by green tops (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	31.73	39.06	42.80	37.86	52.28	58.12	63.63	58.01	16.15	17.43	20.88	18.16
T_2	59.84	65.56	73.60	66.33	84.52	94.12	97.78	92.14	30.44	34.19	39.11	34.58
T_3	41.47	46.17	49.13	45.59	61.20	68.40	70.97	66.85	19.84	22.60	23.74	22.06
T_4	53.48	55.06	57.77	55.44	74.17	77.64	82.60	78.14	25.90	27.52	28.88	27.43
T_5	52.08	53.12	55.14	53.45	70.42	72.49	74.03	72.31	24.55	25.29	27.15	25.67
T_6	57.65	62.46	64.54	61.55	80.21	87.41	93.50	87.04	29.29	31.12	34.01	31.47
Mean	49.37	53.57	57.16		70.47	76.36	80.42		24.36	26.36	28.96	
C.D.(0.05) for (T)				1.95**				2.26**				0.75**
C.D.(0.05) for (F)				0.52**				1.10**				0.40**
C.D. (0.05) for interaction (T x F)				2.56**				2.58**				1.51**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

The result of first and second plant crops revealed that press mud application (T_2) had invariably increased the uptake of N, P and K by green tops and it was closely followed by Azospirillum inoculation (T_6) and green manuring (T_4). While with mineral nutrition, the highest uptake of N, P and K by green tops was associated with NPK application at 100 per cent of the recommended dose (F_3) followed by 75 (F_2) and 50 per cent (F_1) NPK application.

The interaction effects revealed that T_2F_3 had recorded superior values for P and K uptake by green tops and it was followed by T_2F_2 and T_6F_3. The P and K uptake by green tops was highly reduced in T_1F_1 and T_1F_2.

4.2.7.3. Uptake of N, P and K by stem at 120, 240 and 360 DAP (Table 69a, 69b, 70a, 70b, 71a, and 71b)

A perusal of the data revealed that organic sources and mineral nutrition had produced perceptible effects on the uptake of N, P and K by stem at all stages of growth in both years of experimentation. The interaction effect between organic sources and mineral nutrition was significant for N, P and K uptake by stem at 120 DAP and for P and K uptake at 360 DAP in both plant crops. In general enhanced uptake of NPK by stem was noticed after 120 DAP and continued up to maturity. The rate of uptake of N, P and K by stem was highest between 120 to 240 DAP.

It was noticed that N, P and K uptake by stem was positively influenced by press mud application (T_2) and was closely followed by Azospirillum inoculation (T_6) and green manure application (T_4). The uptake of N, P and K by stem was reduced significantly in treatments without organic sources (T_1). With regard to mineral nutrition, application of NPK at 100 per cent of the recommended dose (F_3) had registered increased values for the uptake of N, P and K by stem as compared

Table 69a Effect of organic sources and mineral nutrition on N uptake by stem (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	10.62	13.25	14.29	12.72	55.69	70.88	77.01	67.86	68.42	81.86	102.42	84.23
T_2	22.21	26.75	33.60	27.52	118.56	129.84	139.58	129.27	142.30	156.97	161.43	153.57
T_3	13.98	16.23	17.32	15.84	76.07	85.47	94.42	85.32	98.69	110.71	114.67	108.02
T_4	18.49	19.99	20.16	19.54	84.94	102.65	110.86	99.48	125.27	129.43	138.61	131.10
T_5	16.71	19.07	18.74	18.17	84.69	94.28	101.52	93.50	117.50	125.40	127.89	123.59
T_6	20.60	22.55	25.65	22.93	108.48	119.03	120.90	116.14	137.40	140.33	144.67	140.80
Mean	17.10	19.64	21.63		88.07	100.36	107.38		114.93	124.12	131.62	
C.D.(0.05) for (T)				2.65**				10.95**				8.27**
C.D.(0.05) for (F)				1.04**				8.86**				4.15**
C.D. (0.05) for interaction (T x F)				3.16*				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 69b Effect of organic sources and mineral nutrition on N uptake by stem (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	8.50	10.50	11.78	10.26	62.56	73.94	84.18	73.56	64.06	81.08	86.83	77.32
T_2	16.87	20.78	24.31	20.65	115.71	125.79	130.17	123.89	124.81	138.18	142.57	135.18
T_3	10.64	12.61	13.27	12.17	77.26	84.79	92.33	84.79	89.80	100.72	102.55	97.69
T_4	13.58	14.54	14.77	14.30	91.30	100.32	101.84	97.82	110.34	113.37	122.10	115.27
T_5	12.72	12.81	13.58	13.03	83.69	91.30	99.00	91.33	102.65	110.99	111.87	108.50
T_6	14.32	16.63	18.02	16.32	107.22	115.99	117.67	113.63	121.66	125.42	128.10	125.06
Mean	12.77	14.64	15.96		89.62	98.69	104.20		102.22	111.63	115.67	
C.D.(0.05) for (T)				2.36**				12.02**				14.63**
C.D.(0.05) for (F)				1.06**				8.77*				10.07*
C.D. (0.05) for interaction (T x F)				2.18*				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 70a Effect of organic sources and mineral nutrition on P uptake by stem (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	4.18	5.36	6.49	5.34	18.75	25.17	29.98	24.63	15.02	17.35	22.85	18.40
T_2	11.05	13.09	15.57	13.24	64.30	72.31	78.00	71.54	44.60	52.50	57.65	51.58
T_3	6.54	7.27	7.78	7.20	27.66	35.63	37.70	33.66	20.56	27.83	28.67	25.68
T_4	8.82	9.66	10.34	9.61	49.93	58.55	62.73	57.07	33.54	38.09	46.02	39.21
T_5	8.11	8.94	9.58	8.88	47.97	53.68	55.99	52.55	33.22	34.43	41.15	36.27
T_6	10.29	11.45	13.31	11.68	59.26	65.94	69.57	64.92	44.06	47.49	49.84	47.13
Mean	8.17	9.30	10.51		44.64	51.88	55.66		31.83	36.28	41.03	
C.D.(0.05) for (T)				0.68**				2.26**				2.35**
C.D.(0.05) for (F)				0.43**				2.45**				0.78**
C.D. (0.05) for interaction (T x F)				0.85**				N.S.				3.33*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 70b Effect of organic sources and mineral nutrition on P uptake by stem (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	3.32	4.13	5.37	4.27	19.56	23.96	28.08	23.87	16.18	19.09	21.95	19.07
T_2	8.44	10.12	11.14	9.90	58.64	65.89	71.14	65.22	39.68	46.81	52.24	46.24
T_3	4.96	5.50	6.28	5.58	26.17	31.98	34.70	30.95	20.60	24.65	26.27	23.84
T_4	6.44	7.06	7.72	7.07	45.40	52.61	58.35	52.12	31.21	34.40	39.80	35.14
T_5	6.20	6.62	6.92	6.58	41.76	46.78	50.56	46.36	29.21	32.92	36.88	33.00
T_6	7.25	8.59	9.35	8.39	53.60	59.49	63.20	58.76	38.92	43.92	45.66	42.83
Mean	6.10	7.00	7.80		40.85	46.78	51.00		29.30	33.63	37.13	
C.D.(0.05) for (T)				0.43**				2.99**				3.11**
C.D.(0.05) for (F)				0.27**				2.14**				1.11**
C.D. (0.05) for interaction (T x F)				0.57**				N.S.				2.76*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 71a Effect of organic sources and mineral nutrition on K uptake by stem (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	10.84	13.92	16.04	13.60	25.98	33.43	43.03	34.15	27.94	33.15	47.39	36.16
T_2	27.09	30.58	36.39	31.35	77.76	86.58	88.49	82.28	71.18	90.72	96.22	80.04
T_3	16.14	18.52	19.82	18.16	41.80	48.69	53.70	48.06	43.57	51.70	54.62	49.96
T_4	22.49	24.11	25.35	23.98	60.90	66.43	74.53	67.28	58.84	64.48	67.73	63.68
T_5	20.72	22.67	23.87	22.42	58.23	63.87	67.01	63.04	60.12	60.13	63.60	61.28
T_6	25.68	27.53	31.16	28.12	70.93	76.87	80.50	76.10	66.28	73.93	80.12	73.44
Mean	20.49	22.89	25.44		55.93	62.64	67.88		54.6	62.35	68.28	
C.D.(0.05) for (T)				0.46**				3.99**				3.50**
C.D.(0.05) for (F)				1.00**				1.50**				1.34**
C.D. (0.05) for interaction (T x F)				1.86**				N.S.				5.33**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 71b Effect of organic sources and mineral nutrition on K uptake by stem ($kg\ ha^{-1}$) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	10.06	12.63	15.02	12.57	26.35	32.61	40.38	33.11	27.26	31.82	42.49	33.85
T_2	22.91	26.01	28.45	25.79	69.64	76.37	81.30	75.77	63.32	79.04	86.47	76.29
T_3	13.99	16.26	17.02	15.76	37.69	42.58	46.53	42.27	40.29	47.64	49.53	45.82
T_4	18.47	19.47	20.78	19.57	55.08	60.07	66.33	60.49	52.55	57.28	60.86	56.89
T_5	17.82	18.58	19.54	18.64	51.84	56.05	59.32	55.74	50.68	53.99	57.71	5413
T_6	20.07	22.98	24.55	22.53	64.87	70.94	74.02	69.95	59.41	64.88	72.27	65.52
Mean	17.22	19.32	20.89		50.91	56.44	61.31		48.92	55.78	61.55	
C.D.(0.05) for (T)				0.75**				3.43**				3.92**
C.D.(0.05) for (F)				0.40**				1.46**				1.83**
C.D. (0.05) for interaction (T x F)				0.85**				N.S.				3.36**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

to NPK application at 75 per cent (F_2) and 50 per cent (F_1). While F_1 had recorded lower values in both plant crops at all stages of growth. The interaction effect observed at 120 and 360 DAP in both plant crops revealed that T_2F_3 had shown the highest uptake and it was followed by T_2F_2, T_6F_3 and T_2F_1. The uptake of N, P and K by stem was highly reduced in treatment combination of T_1F_1 and T_1F_2.

4.2.7.4. Total uptake of N, P and K at 120, 240 and 360 DAP (Table 72a, 72b, 73a, 73b, 74a, 74b and Fig. 20a, 20b, 21a and 21b)

A critical review of the data had indicated that total uptake of N, P and K was explicitly influenced by organic sources and mineral nutrition at all stages of growth in both years of study. The interaction effect was significant for total P uptake at 120 DAP in first plant crops and for total K uptake at 120 and 360 DAP in first plant crop and at all stages in second plant crop. However, the interaction effect was not significant for total N uptake at any of the stages of crop growth.

The treatment effects due to organic sources revealed that press mud application (T_2) had recorded a remarkably higher values for total uptake of N, P and K and it was closely followed by Azospirillum inoculation (T_6) and green manure application (T_4). The total uptake of N, P and K was reduced considerably in treatments without organic sources (T_1). While with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had shown statistical superiority over 75 per cent (F_2) and 50 per cent (F_1) of the NPK dose in both plant crops. Among the treatment combinations T_2F_3 recorded superior values for total uptake of P and K and it was closely followed by T_2F_2, T_6F_3 and T_2F_1. Whereas the total P and K uptake was lowest with T_1F_1 and T_1F_2 at all stages oaf growth in both plant crops.

Table 72a Effect of organic sources and mineral nutrition on total N uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	52.34	59.51	69.62	60.49	98.60	118.96	133.69	117.08	99.88	119.04	143.23	120.72
T_2	100.79	110.20	125.94	112.31	198.24	218.06	232.02	216.10	201.63	221.76	231.58	218.32
T_3	68.10	74.50	81.65	74.75	132.35	145.77	156.05	144.72	140.96	155.56	161.70	152.74
T_4	82.57	86.41	95.55	88.17	152.52	171.83	182.20	168.85	176.09	183.83	196.29	185.40
T_5	80.59	89.53	93.54	87.89	147.12	157.48	170.85	158.48	164.21	175.86	180.41	173.49
T_6	88.94	100.56	107.48	98.99	181.05	195.95	201.84	192.94	194.53	201.62	209.37	201.84
Mean	78.89	86.79	95.63		151.65	168.01	179.44		162.88	176.28	187.10	
C.D.(0.05) for (T)				3.39**				11.16**				8.61**
C.D.(0.05) for (F)				3.49**				9.77**				4.76**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 72b Effect of organic sources and mineral nutrition on total N uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	45.25	52.87	57.03	51.71	102.80	118.75	134.20	118.58	90.97	112.11	120.99	108.02
T_2	80.33	90.59	101.15	90.69	185.66	202.78	210.31	199.58	175.69	194.71	205.60	192.00
T_3	53.35	59.56	63.65	58.85	123.34	136.91	147.49	135.91	122.10	136.24	142.08	133.47
T_4	64.79	75.51	74.68	71.66	151.58	161.49	168.35	160.47	150.82	157.04	167.85	158.57
T_5	65.09	67.23	68.88	67.06	140.52	151.72	160.96	151.07	141.12	150.79	156.30	149.40
T_6	74.06	79.52	82.25	78.61	173.59	187.28	193.88	184.92	167.29	174.99	182.53	174.93
Mean	63.81	70.88	74.60		146.25	159.82	169.88		141.33	154.31	162.56	
C.D.(0.05) for (T)				5.34**				12.14**				15.13**
C.D.(0.05) for (F)				2.08**				9.05**				10.22
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 73a Effect of organic sources and mineral nutrition on total P uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	18.32	21.52	25.49	21.77	39.72	48.05	57.49	48.42	28.82	33.96	41.33	34.70
T_2	46.43	53.29	58.99	52.90	105.42	116.87	125.39	115.89	74.58	80.68	93.51	82.92
T_3	26.14	29.82	32.25	29.40	54.43	64.77	67.90	62.37	39.38	48.18	49.38	45.64
T_4	34.93	40.35	43.30	39.53	83.93	85.67	98.66	89.42	57.96	64.48	75.15	65.86
T_5	33.48	37.37	40.06	36.97	78.56	84.83	90./19	84.53	56.14	59.14	67.60	60.96
T_6	40.57	47.69	51.07	47.44	94.92	104.91	109.68	103.17	73.47	79.09	82.51	78.36
Mean	33.31	38.34	41.86		76.16	84.18	91.55		55.06	60.92	68.25	
C.D.(0.05) for (T)				1.59**				3.55**				2.92**
C.D.(0.05) for (F)				1.12*				4.81**				1.14**
C.D. (0.05) for interaction (T x F)				1.63**				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 73b Effect of organic sources and mineral nutrition on total P uptake ($kg\ ha^{-1}$) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	13.65	16.30	19.33	16.43	38.90	44.42	51.19	44.84	27.37	32.43	37.73	32.51
T_2	34.79	40.20	44.02	39.67	92.46	103.28	110.97	102.24	65.15	75.20	83.91	74.75
T_3	18.09	21.38	23.06	20.84	48.05	56.53	60.11	54.90	35.37	40.74	43.15	39.75
T_4	26.61	29.85	33.02	29.83	73.92	83.07	90.15	82.38	51.54	55.76	63.17	56.82
T_5	24.08	24.96	27.84	25.63	69.18	75.10	79.99	74.76	47.91	52.98	58.15	53.01
T_6	30.81	31.62	37.70	33.38	85.37	94.38	99.71	93.15	62.89	69.80	73.29	68.66
Mean	24.67	27.39	30.83		67.98	76.13	82.02		48.37	54.48	59.89	
C.D.(0.05) for (T)				2.12**				3.14**				3.12**
C.D.(0.05) for (F)				1.15**				2.04**				1.15**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 74a Effect of organic sources and mineral nutrition on total K uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	48.78	57.16	64.85	56.93	83.74	97.62	118.82	100.06	50.74	60.44	81.37	64.18
T_2	104.57	112.49	125.84	114.30	189.82	203.18	213.37	202.12	119.77	144.97	153.25	139.33
T_3	68.27	74.25	81.00	74.51	121.93	132.08	139.16	131.06	76.84	88.06	92.73	85.88
T_4	87.42	94.63	96.70	92.92	151.28	161.51	170.47	161.09	99.78	107.69	115.51	107.66
T_5	83.79	92.27	97.29	91.12	143.42	145.07	158.55	149.01	98.22	101.23	108.77	102.74
T_6	91.60	104.77	112.25	102.87	164.68	177.69	187.02	176.46	112.62	123.09	131.06	122.26
Mean	80.74	89.26	96.32		142.48	152.86	164.56		92.99	104.25	113.78	
C.D.(0.05) for (T)				2.77**				5.22**				4.30**
C.D.(0.05) for (F)				2.25**				3.49**				1.18**
C.D. (0.05) for interaction (T x F)				3.65**				N.S.				6.52**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 74b Effect of organic sources and mineral nutrition on total K uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	42.87	52.96	59.23	51.69	84.35	97.31	112.15	97.93	47.67	55.17	70.50	57.78
T_2	85.62	94.78	105.72	95.37	166.89	184.81	194.09	181.93	106.23	127.35	140.61	124.73
T_3	56.72	63.63	67.87	62.74	106.81	120.60	127.86	118.42	66.88	77.52	80.95	75.12
T_4	74.12	77.15	81.39	77.55	140.34	149.28	160.95	150.19	87.32	94.71	100.77	94.27
T_5	71.80	73.84	76.96	74.20	132.86	139.75	145.16	139.26	83.24	88.06	94.77	88.69
T_6	80.50	88.57	92.26	87.11	156.78	170.86	180.61	169.42	100.14	108.57	119.76	109.49
Mean	68.61	75.15	80.57		131.34	143.77	153.47		81.91	91.90	101.23	
C.D.(0.05) for (T)				2.35**				3.77**				3.81**
C.D.(0.05) for (F)				0.77**				1.66**				1.71**
C.D. (0.05) for interaction (T x F)				2.95**				3.95**				3.81**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

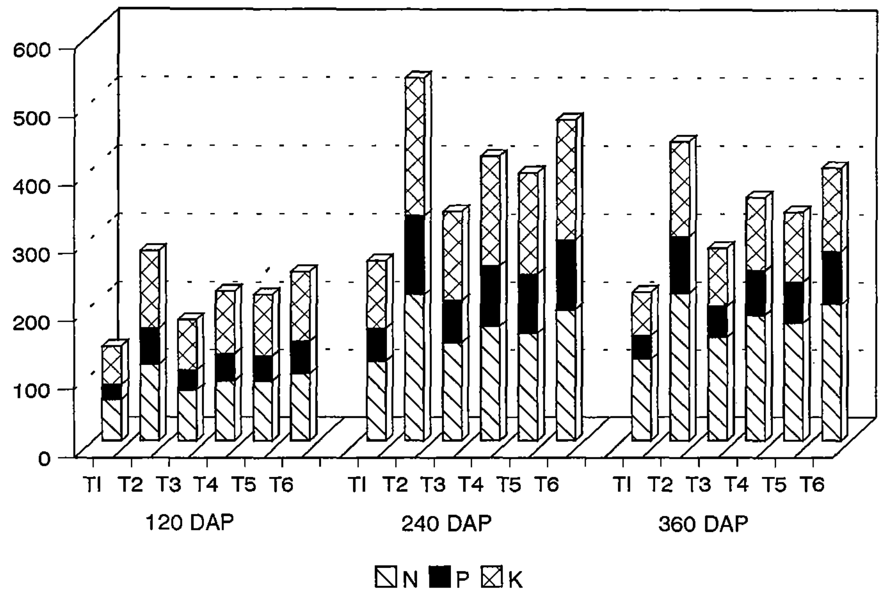


Fig. 20a. Effect of organic sources on the uptake of N, P and K during first plant crop

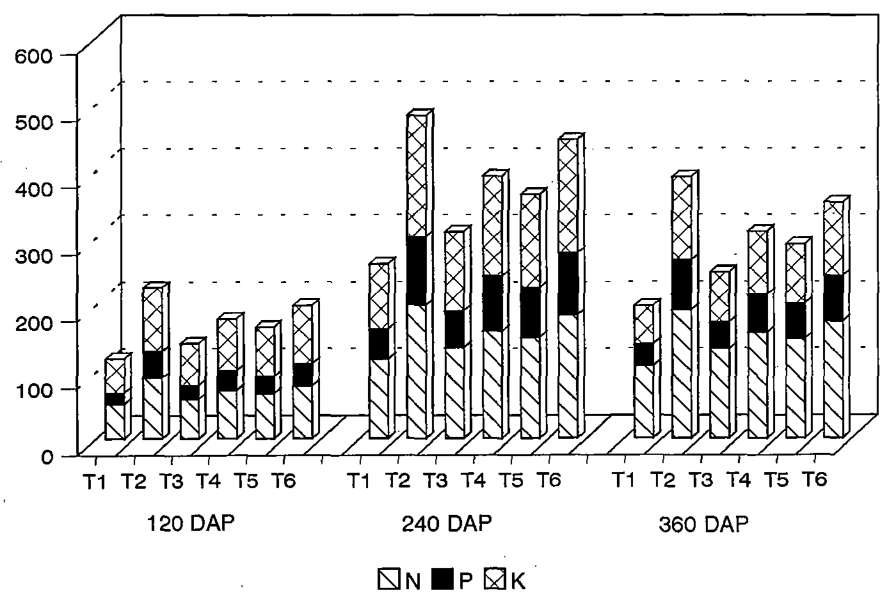


Fig. 20b. Effect of organic sources on the uptake of N, P and K during second plant crop

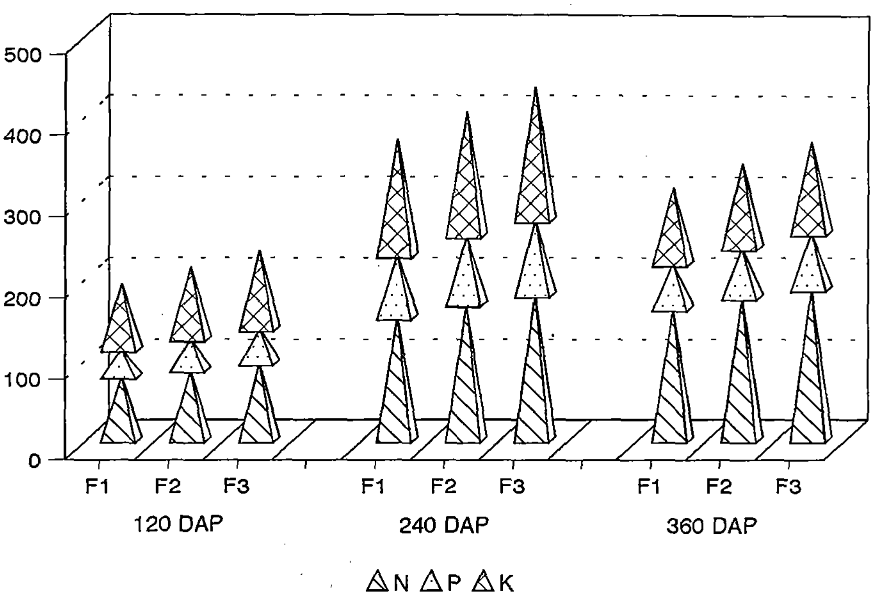


Fig. 21a. Effect of mineral nutrition on the uptake of N, P and K during first plant crop

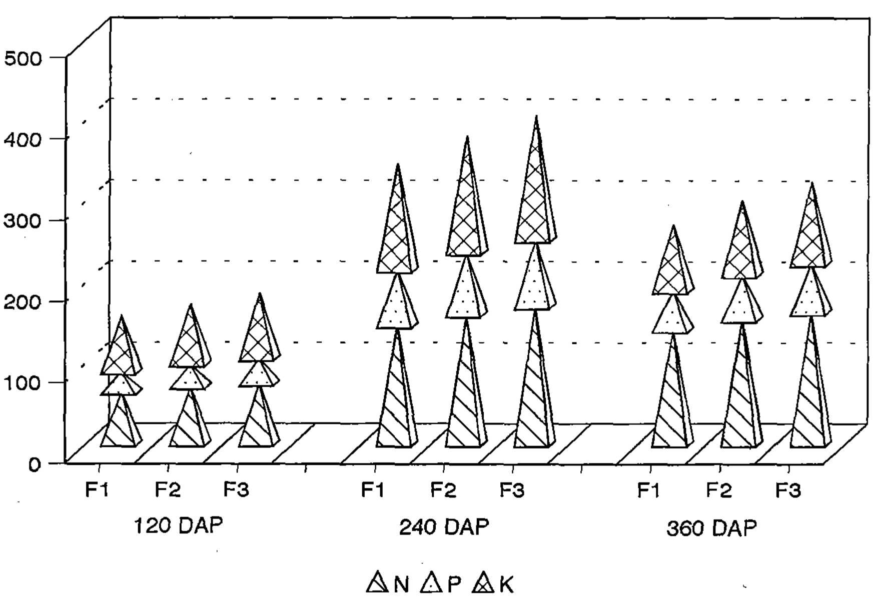


Fig. 21b. Effect of mineral nutrition on the uptake of N, P and K during second plant crop

4.2.7.5. Total Ca uptake at 120, 240 and 360 DAP (Table 75a and 75b)

The data revealed that organic sources mineral nutrition and their interactions had got significant effects on Ca uptake at all stages of growth in both plant crops.

It was observed that press mud application (T_2) had shown significantly higher Ca uptake and was followed by Azospirillum inoculation (T_6) and green manure application (T_4) at 120 and 240 DAP in both plant crops. While at 360 DAP, T_6 was on par with T_2 and superior to all other organic sources. In the case of mineral nutrition, maximum Ca uptake was associated with NPK application at 100 per cent of the recommended dose (F_3) as compared to NPK application at 75 per cent (F_2) and 50 per cent (F_1) of the recommended dose. The interaction effects at 120 and 240 DAP in both plant crops revealed that T_2F_3 recorded superior values for total Ca uptake and it was followed by T_2F_2 and T_6F_3. While the interaction at 360 DAP showed that T_6F_3 was on par with T_2F_3 and was significantly higher than other treatment combinations. But the total Ca uptake was highly reduced in T_1F_1 and T_1F_2 at all stages of growth.

4.2.7.6. Total Fe uptake at 120, 240 and 360 DAP (Table 76a and 76b)

The results revealed that organic sources, mineral nutrition and their interactions had exerted significant effects on total Fe uptake in first and second plant crop. Among the organic sources, Azospirillum inoculation (T_6) had recorded maximum values for total uptake of Fe. It was on par with T_2 at 120 DAP and 240 DAP in first plant crop. However, enhanced Fe uptake was noticed by T_6 at 360 DAP in both the plant crops. The treatments with mineral nutrition had shown that NPK application at 100 per cent of the recommended dose (F_3) had registered maximum uptake of Fe and it was followed by F_2 and F_1. The interaction effects

Table 75a Effect of organic sources and mineral nutrition on total Ca uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	18.71	23.03	26.48	22.74	47.61	53.11	65.16	55.29	52.26	61.03	69.12	60.80
T_2	42.16	48.25	53.50	47.97	117.45	128.33	133.37	126.38	95.94	101.17	105.95	101.02
T_3	34.96	35.23	38.23	36.14	79.47	83.41	86.58	83.16	82.50	87.37	91.74	87.20
T_4	41.16	44.29	44.87	43.44	92.29	99.16	99.94	97.13	78.82	83.07	87.48	83.13
T_5	34.92	37.97	40.92	37.94	80.92	84.00	88.86	84.59	94.09	96.93	102.37	97.79
T_6	41.76	45.95	49.26	45.66	96.15	101.15	104.41	100.57	96.26	101.69	107.77	101.91
Mean	35.61	39.12	42.21		85.65	91.53	96.39		83.31	88.55	94.07	
C.D.(0.05) for (T)				1.51**				2.91**				3.14**
C.D.(0.05) for (F)				1.09**				1.79**				2.39*
C.D. (0.05) for interaction (T x F)				1.88**				4.18**				3.02*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 75b Effect of organic sources and mineral nutrition on total Ca uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	16.21	19.82	21.85	19.29	48.76	53.32	59.46	53.84	48.52	56.13	62.51	55.72
T_2	34.44	38.12	41.85	38.14	99.60	112.21	116.60	109.47	82.34	90.58	98.35	90.42
T_3	28.40	30.44	31.45	30.10	70.14	76.29	79.39	75.27	70.03	77.28	79.77	75.69
T_4	33.65	35.42	36.61	35.23	85.51	91.65	94.38	90.51	68.82	73.25	77.22	73.10
T_5	29.03	30.63	32.12	30.59	76.07	78.30	80.98	78.45	79.50	84.09	87.47	83.68
T_6	34.98	37.65	38.80	37.15	88.01	92.90	97.13	92.68	85.19	90.84	95.87	90.63
Mean	29.45	32.02	33.78		78.01	84.11	87.99		72.40	78.69	83.53	
C.D.(0.05) for (T)				0.85**				2.52**				3.26**
C.D.(0.05) for (F)				0.41**				1.60**				1.58**
C.D. (0.05) for interaction (T x F)				1.06**				2.61**				3.16*

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 76a Effect of organic sources and mineral nutrition on total Fe uptake ($kg\ ha^{-1}$) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	3.02	3.31	3.97	3.43	8.02	18.63	21.67	16.11	13.21	15.29	18.85	15.78
T_2	6.44	7.89	8.39	7.57	26.53	28.30	29.23	28.02	14.84	16.81	23.05	18.23
T_3	5.26	5.83	6.19	5.76	22.42	24.77	27.37	24.85	26.25	27.95	29.29	27.83
T_4	4.61	5.02	5.34	4.99	26.90	28.87	30.13	28.63	19.12	22.77	23.80	21.90
T_5	5.68	5.66	6.42	5.92	22.15	23.87	28.50	24.84	14.10	23.03	29.62	22.25
T_6	6.69	7.67	9.21	7.86	25.53	27.42	35.33	29.42	34.48	32.81	34.73	33.01
Mean	5.28	5.89	6.59		21.92	25.31	28.70		19.83	23.11	26.56	
C.D.(0.05) for (T)				0.43**				1.76**				3.14**
C.D.(0.05) for (F)				0.28**				1.03**				1.28**
C.D. (0.05) for interaction (T x F)				0.62**				1.55**				1.45**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 76b Effect of organic sources and mineral nutrition on total Fe uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	2.64	3.09	3.69	3.14	14.29	18.41	20.01	17.57	12.61	14.67	18.54	15.27
T_2	6.18	6.75	7.42	6.78	24.59	26.24	27.31	26.05	19.15	20.28	21.69	20.37
T_3	4.28	4.94	5.21	4.81	20.06	22.75	24.86	22.56	24.88	26.14	27.33	26.12
T_4	4.26	4.51	4.67	4.48	25.46	26.93	27.85	26.75	19.79	20.68	21.86	20.78
T_5	4.62	4.75	4.89	4.75	20.71	21.52	23.07	21.76	13.00	16.25	17.42	15.56
T_6	5.36	6.12	6.88	6.12	24.24	25.77	27.19	25.73	29.63	31.13	32.89	31.22
Mean	4.56	5.03	5.46		21.56	23.60	25.05		19.84	21.53	23.29	
C.D.(0.05) for (T)				0.44**				1.29**				3.09**
C.D.(0.05) for (F)				0.11**				0.72**				0.81**
C.D. (0.05) for interaction (T x F)				0.25**				1.26**				0.94**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

revealed that T_6F_2 and T_2F_3 recorded higher uptake of Fe during the early stages of growth in both plant crops.

4.2.7.7. Total Mn uptake at 120, 240 and 360 DAP (Table 77a and 77b)

The results indicated that the total Mn uptake was significantly influenced by organic sources, mineral nutrition and their interactions at all stages except at 360 DAP in first plant crop.

The data generated revealed that Azospirillum (T_6) inoculation had recorded maximum values for the uptake of Mn and was superior to all other organic sources. The treatment effects due to mineral nutrition showed that NPK application at 100 per cent of the recommended dose (F_3) had increased the total uptake of Mn and it was significantly superior to F_2 and F_1. The interaction effects exhibited at 120 and 240 DAP in first plant crop and at all stages in second plant crop had revealed that T_6F_3 recorded significantly higher total Mn uptake and it was closely followed by T_6F_2 and T_2F_3. The lowest Mn uptake was associated with T_1F_1 at all stages of growth.

4.2.7.8. Total Zn uptake at 120, 240, and 360 DAP (Table 78a and 78b)

The data generated revealed that the analysis of variance for total Zn uptake was remarkably affected by organic sources, mineral nutrition and their interactions in both plant crops.

The treatment variation due to organic sources revealed that Azospirillum inoculation (T_6) had shown the highest uptake of Zn at 120 and 240 DAP in first plant crop. While at 360 DAP in first plant crop and at all stages in second plant crop, press mud application had registered maximum uptake of Zn. The lowest uptake of Zn was associated with T_1 at all stages of growth. While with mineral

Table 77a Effect of organic sources and mineral nutrition on total Mn uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.81	0.92	1.04	0.93	2.16	2.65	3.12	2.65	1.81	2.08	2.74	2.21
T_2	1.52	1.66	2.21	1.80	4.71	4.97	6.21	5.30	4.04	4.33	4.63	4.34
T_3	1.09	1.75	1.97	1.60	4.82	5.00	5.17	5.00	3.77	4.24	4.44	4.15
T_4	1.18	2.07	2.23	1.83	3.35	3.81	3.87	3.68	3.63	3.91	4.09	3.88
T_5	1.53	1.93	2.42	1.96	3.41	3.54	4.01	3.65	4.97	5.23	5.57	5.26
T_6	2.04	2.24	2.93	2.40	5.78	6.14	6.54	6.15	6.06	6.33	6.78	6.39
Mean	1.36	1.76	2.13		4.04	4.35	4.82		4.05	4.35	4.71	
C.D.(0.05) for (T)				0.06**				0.27**				0.13**
C.D.(0.05) for (F)				0.05**				0.14**				0.15**
C.D. (0.05) for interaction (T x F)				0.12**				0.24**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 77b Effect of organic sources and mineral nutrition on total Mn uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.74	0.87	0.98	0.87	2.19	2.60	3.00	2.60	2.74	3.39	4.27	3.47
T_2	1.33	1.44	1.91	1.56	4.26	4.53	5.41	4.73	5.29	5.65	6.07	5.67
T_3	0.95	1.49	1.79	1.41	4.29	4.53	4.74	4.52	6.11	6.66	6.91	6.56
T_4	1.09	1.75	1.91	1.16	3.33	3.53	3.69	3.52	4.89	5.25	5.51	5.22
T_5	1.28	1.60	1.96	1.62	3.20	3.39	3.71	3.44	5.14	5.79	6.21	5.71
T_6	1.76	1.89	2.42	2.02	5.32	5.60	6.12	5.68	8.21	8.64	9.25	8.70
Mean	1.19	1.51	1.83		3.77	4.03	4.45		5.40	5.90	6.40	
C.D.(0.05) for (T)				0.04**				0.18**				0.50**
C.D.(0.05) for (F)				0.02**				0.06**				0.17**
C.D. (0.05) for interaction (T x F)				0.07**				0.15**				0.19**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 78a Effect of organic sources and mineral nutrition on total Zn uptake (kg ha^{-1}) at different stages of growth in first plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.341	0.431	0.448	0.407	0.664	0.763	0.899	0.775	0.388	0.448	0.499	0.445
T_2	0.633	0.678	0.738	0.683	1.251	1.339	1.407	1.332	0.816	0.907	0.959	0.894
T_3	0.433	0.537	0.573	0.514	1.064	1.154	1.218	1.145	0.530	0.590	0.638	0.586
T_4	0.490	0.586	0.595	0.557	1.102	1.168	1.220	1.163	0.640	0.680	0.718	0.679
T_5	0.486	0.610	0.703	0.600	1.061	1.089	1.150	1.100	0.629	0.652	0.679	0.653
T_6	0.823	1.134	1.233	1.063	1.271	1.403	1.451	1.375	0.739	0.811	0.866	0.805
Mean	0.534	0.663	0.715		1.069	1.153	1.224		0.623	0.681	0.726	
C.D.(0.05) for (T)				0.021**				0.044**				0.032**
C.D.(0.05) for (F)				0.019**				0.020**				0.015**
C.D. (0.05) for interaction (T x F)				0.030**				0.046**				0.017**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 78b Effect of organic sources and mineral nutrition on total Zn uptake (kg ha^{-1}) at different stages of growth in second plant crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.305	0.369	0.411	0.361	0.682	0.744	0.833	0.753	0.367	0.421	0.461	0.416
T_2	0.535	0.578	0.622	0.578	1.197	1.287	1.350	1.278	0.706	0.789	0.834	0.777
T_3	0.403	0.458	0.481	0.447	0.845	0.953	1.012	0.937	0.481	0.503	0.541	0.508
T_4	0.467	0.483	0.505	0.485	1.028	1.075	1.131	1.078	0.588	0.623	0.652	0.621
T_5	0.457	0.470	0.505	0.477	0.988	1.027	1.105	1.023	0.564	0.585	0.606	0.585
T_6	0.495	0.575	0.658	0.576	1.124	1.253	1.314	1.230	0.658	0.727	0.780	0.072
Mean	0.443	0.489	0.530		0.977	1.056	1.116		0.561	0.608	0.646	
C.D.(0.05) for (T)				0.021**				0.023**				0.025**
C.D.(0.05) for (F)				0.010**				0.010**				0.011**
C.D. (0.05) for interaction (T x F)				0.025**				0.019**				0.013**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 79a **Effect of organic sources and mineral nutrition on total Cu uptake (kg ha^{-1}) at different stages of growth in first plant crop**

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.194	0.221	0.246	0.220	0.720	0.860	0.970	0.850	1.250	1.410	1.590	1.420
T_2	0.455	0.491	0.533	0.493	0.990	2.070	2.150	2.070	2.260	2.310	2.400	2.320
T_3	0.433	0.446	0.483	0.454	1.500	1.570	1.660	1.580	1.570	1.810	1.900	1.760
T_4	0.320	0.356	0.374	0.350	1.380	1.470	1.520	1.460	1.760	1.830	1.900	1.830
T_5	0.307	0.310	0.321	0.312	1.600	1.670	1.710	1.660	1.780	1.800	1.880	1.820
T_6	0.265	0.279	0.304	0.283	1.920	2.010	2.090	2.010	1.910	1.970	2.050	1.980
Mean	0.329	0.350	0.377		1.520	1.610	1.680		1.760	1.850	1.950	
C.D.(0.05) for (T)				0.016**				0.042**				0.040**
C.D.(0.05) for (F)				0.008**				0.017**				0.041**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				0.086**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 79b Effect of organic sources and mineral nutrition on total Cu uptake (kg ha^{-1}) at different stages of growth in second plan crop

Treatment	120 DAP				240 DAP				360 DAP			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.192	0.226	0.262	0.227	0.740	0.810	0.910	0.820	1.220	1.380	1.510	1.370
T_2	0.402	0.425	0.462	0.4292	1.790	1.880	1.970	1.880	1.980	2.130	2.240	2.120
T_3	0.333	0.362	0.377	0.357	1.380	1.450	1.520	1.450	1.470	1.660	1.760	1.630
T_4	0.315	0.332	0.349	0.332	1.270	1.360	1.390	1.340	1.610	1.670	1.730	1.670
T_5	0.293	0.303	0.311	0.302	1.460	1.530	1.600	1.530	1.600	1.650	1.690	1.650
T_6	0.280	0.300	0.320	0.300	1.770	1.840	1.920	1.840	1.740	1.820	1.890	1.820
Mean	0.302	0.325	0.346		1.400	1.480	1.550		1.610	1.720	1.800	
C.D.(0.05) for (T)				0.018**				0.054**				0.040**
C.D.(0.05) for (F)				0.008**				0.018**				0.021**
C.D. (0.05) for interaction (T x F)				0.013**				N.S.				0.050**

Organic sources

- T_1 - Control
- T_2 - Pressmud application
- T_3 - Trash application
- T_4 - Green manuring
- T_5 - Acetobacter inoculation
- T_6 - Azospirillum inoculation

Mineral nutrition

- F_1 - 50% of the recommended dose of NPK
- F_2 - 75% of the recommended dose of NPK
- F_3 - 100% of the recommended dose of NPK
- N.S. - Not significant
- ** - Significant at 1 per cent level

nutrition, NPK application at 100 per cent of the recommended dose (F_3) had shown higher uptake of Zn as compared to F_2 and F_1. Among the treatment combinations T_6F_3 recorded highest uptake of Zn and it was superior at 120 and 240 DAP in first plant crop and at 120 DAP in second plant crop. While T_2F_3 had registered maximum total uptake of Zn at 360 DAP in first plant crop and at 240 and 360 DAP in second plant crop. The uptake of Zn was invariably reduced in lower doses of NPK without any organic manure as noticed in T_1F_1 and T_1F_2.

4.2.7.9. Total Cu uptake at 120, 240 and 360 DAP (Table 79a and 79b)

The data presented had shown that treatment variation due to organic sources and mineral nutrition had exerted conspicuous effects at all stages in both plant crops. However, their interaction effect was significant only at 360 DAP in both plant crops. The treatment effects due to organic sources revealed that press mud application (T_2) had shown the highest Cu uptake and it was followed by Azospirillum inoculation (T_6) in the later stages of growth in first plant crop and at all stages in second plant crop. With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had shown its superiority in Cu uptake over F_2 and F_1. The interaction effects revealed that T_2F_3 and T_2F_2 were on par with each other at 360 DAP in first plant crop and was significantly superior to all other treatment combinations at 120 and 360 DAP in second plant crop. The total uptake of Cu was lowest with T_1F_1 at all stages of growth.

4.2.8. Physical properties of soil after the experiment

4.2.8.1. Bulk density of soil after the experiment (Table 80a and 80b)

The data summarised revealed that the bulk density was significantly influenced by the application of organics in both plant crops. However, the mineral nutrition and their interactions were not significant.

Table 80a Effect of organic sources and mineral nutrition on physical properties of soil after the experiment in first plant crop

Treatment	Bulk density (g cc^{-1})				Particle density (g cc^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.495	1.485	1.485	1.488	2.608	2.613	2.605	2.608
T_2	1.430	1.433	1.433	1.432	2.658	2.655	2.660	2.658
T_3	1.425	1.420	1.425	1.423	2.655	2.660	2.655	2.657
T_4	1.435	1.433	1.433	1.433	2.645	2.653	2.655	2.651
T_5	1.480	1.480	1.485	1.482	2.640	2.645	2.633	2.639
T_6	1.473	1.468	1.468	1.469	2.648	2.655	2.638	2.647
Mean	1.456	1.453	1.455		2.642	2.647	2.641	
C.D.(0.05) for (T)				0.009**				N.S.
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 80b Effect of organic sources and mineral nutrition on physical properties of soil after the experiment in second plant crop

Treatment	Bulk density (g cc^{-1})				Particle density (g cc^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.493	1.488	1.488	1.489	2.613	2.615	2.600	2.609
T_2	1.425	1.430	1.428	1.428	2.660	2.658	2.653	2.657
T_3	1.420	1.415	1.428	1.421	2.655	2.663	2.658	2.658
T_4	1.430	1.430	1.428	1.429	2.650	2.655	2.650	2.652
T_5	1.478	1.478	1.480	1.478	2.640	2.643	2.643	2.642
T_6	1.468	1.465	1.463	1.465	2.653	2.658	2.645	2.652
Mean	1.452	1.451	1.452		2.645	2.648	2.641	
C.D.(0.05) for (T)				0.009**				N.S.
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 81a Effect of organic sources and mineral nutrition on physical properties of soil after the experiment in first plant crop

Treatment	Pore space distribution (%)				Maximum water holding capacity (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	42.66	43.15	42.99	42.93	54.27	54.18	54.11	54.18
T_2	46.19	46.05	46.13	46.12	58.92	59.13	59.42	59.15
T_3	46.32	46.61	46.33	46.42	62.01	61.68	61.99	61.89
T_4	45.74	45.99	46.04	45.92	58.72	59.02	58.99	58.91
T_5	43.93	44.04	43.58	43.85	55.29	54.99	55.16	55.15
T_6	44.37	44.72	44.35	44.48	56.86	56.93	57.01	56.93
Mean	44.87	45.09	44.90		57.67	57.65	57.78	
C.D.(0.05) for (T)				0.43**				4.10*
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 81b Effect of organic sources and mineral nutrition on physical properties of soil after the experiment in second plant cro[p]

Treatment	Pore space distribution (%)				Maximum water holding capacity (%)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	42.87	43.11	42.78	42.92	55.23	55.38	55.29	55.30
T_2	46.43	46.19	46.24	46.28	60.01	60.56	60.72	60.43
T_3	46.51	46.85	46.56	46.64	62.74	62.82	62.79	62.78
T_4	46.04	46.14	46.13	46.10	59.40	59.76	59.79	59.65
T_5	44.03	44.08	43.99	44.03	56.21	55.83	56.17	56.07
T_6	44.67	44.96	44.70	44.78	58.53	58.31	58.42	58.42
Mean	45.09	45.22	45.07		58.68	58.77	58.86	
C.D.(0.05) for (T)				0.42**				0.76**
C.D.(0.05) for (F)				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

The data recorded indicated that treatments without organic sources (T_1) had shown maximum values for bulk density in both plant crops. It was followed by Acetobacter inoculation (T_5). The lowest values for bulk density were associated with trash application (T_3) and press mud application (T_2).

4.2.8.2. Particle density of soil after the experiment (Table 80a and 80b)

Particle density of the soil was not influenced either by organic sources, mineral nutrition or by the combination effect of the treatments.

4.2.8.3. Pore space distribution of soil after the experiment (Table 81a and 81b)

The data recorded revealed that trash application (T_3) had significantly increased the pore space distribution and it was statistically on par with press mud application (T_2), but significantly superior to all other organic sources. The treatments without organic source (T_1) had recorded the lowest value for pore space distribution.

4.2.8.4. Maximum water holding capacity of the soil after the experiment (Table 81a and 81b)

Treatments indicated that analysis of variance for maximum water holding capacity was significant with organic sources in both plant crops. However, the mineral nutrition and their interaction effects were not significant.

Among the organic sources, trash application (T_3) recorded maximum values for water holding capacity and it was on par with press mud application (T_2) and green manure application (T_4) in first plant crop. While T_3 was superior to all other organic sources and it was followed by T_2 and T_4 in second plant crop.

4.2.9. Chemical properties of soil after the experiment

4.2.9.1. Organic carbon in the soil after the experiment (Table 82a and 82b)

The data given indicated that analysis of variance for organic carbon was significantly influenced by organic sources and mineral nutrition. But the interaction between organic sources and mineral nutrition was not significant in both plant crops.

The treatment effects due to organic sources had revealed that trash application (T_3) recorded maximum values for organic carbon and was significantly superior to other treatments in both plant crops. It was followed by green manure application (T_4) and press mud application (T_2). The treatments without organics had recorded lower values for organic carbon content in the soil after the experiment. The treatments with mineral nutrition had revealed that NPK application at 100 per cent of the recommended dose (F_3) recorded significantly superior values as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1).

4.2.9.2. Available N in the soil after the experiment (Table 82a and 82b)

The data revealed that organic sources had significantly influenced the available N content in the soil during both plant crops. But the mineral nutrition was not significant in either plant crops.

The treatment effects due to organic sources revealed that trash application (T_3) was on par with press mud application (T_2), but was superior to other organic sources. The available N content in the soil after the experiment was lowest in T_1. The treatments with mineral nutrition did not vary statistically.

4.2.9.3. Available P in the soil after the experiment (Table 82a and 82b)

The data generated indicated that treatment variation due to organic sources, mineral nutrition and their interactions were significant in both plant crops.

Table 82a Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in first plant crop

Treatment	Organic carbon (%)				Available N (ppm)				Available P (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.727	0.729	0.748	0.735	140.00	148.75	157.50	148.75	3.06	3.18	3.31	3.18
T_2	0.814	0.819	0.821	0.818	192.50	201.25	210.00	201.25	3.80	3.86	4.03	3.90
T_3	0.845	0.862	0.872	0.860	201.25	210.00	218.75	210.00	3.71	3.76	3.85	3.77
T_4	0.836	0.842	0.849	0.842	183.75	192.50	201.25	192.50	3.66	3.78	3.83	3.76
T_5	0.763	0.769	0.773	0.768	175.00	183.75	183.75	180.83	3.13	3.18	3.47	3.26
T_6	0.771	0.772	0.776	0.773	183.75	192.50	201.25	192.50	3.43	3.48	3.53	3.48
Mean	0.793	0.799	0.806		179.38	188.13	195.42		3.47	3.54	3.67	
C.D.(0.05) for (T)				0.011**				14.35**				0.09**
C.D.(0.05) for (F)				0.005**				N.S.				0.06**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				0.09**

Organic sources

- T_1 - Control
- T_2 - Pressmud application
- T_3 - Trash application
- T_4 - Green manuring
- T_5 - Acetobacter inoculation
- T_6 - Azospirillum inoculation

Mineral nutrition

- F_1 - 50% of the recommended dose of NPK
- F_2 - 75% of the recommended dose of NPK
- F_3 - 100% of the recommended dose of NPK
- N.S. - Not significant
- ** - Significant at 1 per cent level

Table 82b Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in second plant crop

Treatment	Organic carbon (%)				Available N (ppm)				Available P (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.721	0.723	0.742	0.729	131.25	140.00	148.75	140.00	3.08	3.18	3.32	3.19
T_2	0.806	0.812	0.814	0.810	183.75	192.50	201.25	192.50	3.86	3.91	4.02	3.93
T_3	0.840	0.857	0.862	0.853	192.50	201.25	210.00	201.25	3.75	3.77	3.86	3.79
T_4	0.829	0.836	0.842	0.835	175.00	183.75	192.50	183.75	3.69	3.80	3.83	3.77
T_5	0.756	0.763	0.767	0.762	166.25	175.00	175.00	172.08	3.16	3.19	3.50	3.28
T_6	0.763	0.769	0.769	0.767	175.00	192.50	192.50	186.67	3.47	3.50	3.51	3.49
Mean	0.786	0.793	0.799		170.63	180.83	186.67		3.50	3.56	3.67	
C.D.(0.05) for (M)				0.012**				24.91**				0.06**
C.D.(0.05) for (F)				0.005**				12.01*				0.06**
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				0.09**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

A critical review of the data revealed that press mud application had shown significantly superior values for available P in the soil after the experiment and it was followed by trash application (T_3) and green manure application (T_4). The lowest value for available P in the soil was associated with treatments that had not received organic source (T_1). The treatment effects due to mineral nutrition had shown that NPK application at 100 per cent of the recommended dose (F_3) recorded higher values for available P in the soil after experiment and it was significantly superior to NPK at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1).

Among the interactions, T_2F_3 recorded maximum values for available P in the soil and was significantly superior to all other treatment combinations. It was closely followed by T_2F_2 and T_3F_3 in both plant crops.

4.2.9.4. Available K in the soil after the experiment (Table 83a and 83b)

A perusal of the data had indicated that the treatment effects due to organic sources and mineral nutrition were significant in both plant crops. However, the interaction effect was significant only in first plant crop.

The results indicated that press mud application (T_2) had appreciably increased the availability of K in soil after the experiment and it was superior to all other organic sources. The available K was decreased in treatments without organic sources (T_1). While with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) was on par with NPK application at 75 per cent of the recommended dose (F_2) in first plant crop. But F_3 was superior to F_2 and F_1 in second plant crop. The interaction effects exhibited in first plant crop revealed that T_2F_3 was on par with T_2F_2, followed by T_3F_3 and T_3F_2.

Table 83a Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in first plant crop

Treatment	Available K (ppm)				Ca content (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	41.25	42.50	45.00	42.92	132.50	137.50	145.00	138.33
T_2	57.50	67.50	68.75	64.58	197.50	202.50	225.00	208.33
T_3	45.00	51.25	57.50	51.25	105.00	140.00	152.50	132.50
T_4	46.25	51.25	52.50	50.00	202.50	212.50	217.50	210.83
T_5	43.75	46.25	47.50	45.83	185.00	185.00	185.00	185.00
T_6	43.75	50.00	51.25	48.33	167.50	187.50	190.00	181.67
Mean	46.25	51.46	53.75		165.00	177.50	185.83	
C.D.(0.05) for (T)				4.06**				10.47**
C.D.(0.05) for (F)				2.67**				8.10**
C.D. (0.05) f r int racti n (T x F)				3.94*				12.49**

Organic sources		Mineral nutrition	
T_1 -	Control	F_1 -	50% of the recommended dose of NPK
T_2 -	Pressmud application	F_2 -	75% of the recommended dose of NPK
T_3 -	Trash application	F_3 -	100% of the recommended dose of NPK
T_4 -	Green manuring	N.S. -	Not significant
T_5 -	Acetobacter inoculation	** -	Significant at 1 per cent level
T_6 -	Azospirillum inoculation	* -	Significant at 5 per cent level

Table 83b Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in second plant crop

Treatment	Available K (ppm)				Ca content (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	40.00	41.25	42.50	41.25	127.50	130.00	135.00	130.83
T_2	53.75	63.75	67.50	61.67	182.50	192.50	210.00	195.00
T_3	43.75	48.75	56.25	49.58	102.50	135.00	147.50	128.33
T_4	43.75	48.75	51.25	47.92	195.00	205.00	207.50	202.50
T_5	41.25	43.75	45.00	43.33	185.00	180.00	182.50	182.50
T_6	42.50	47.50	48.75	46.25	165.00	182.50	185.00	177.50
Mean	44.17	48.96	51.88		159.58	170.83	177.92	
C.D.(0.05) for (T)				3.55**				9.02**
C.D.(0.05) for (F)				2.46**				4.59**
C.D. (0.05) for interaction (T x F)				N.S.				10.14**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

4.2.9.5. Ca content in the soil after the experiment (Table 83a and 83b)

The data summarised revealed that treatment variation due to organic sources, mineral nutrition and their interactions were significant in first and second plant crops.

A perusal of the data revealed that T_2 and T_4 were statistically on par for the availability of Ca in the soil after the experiment, but was superior to other organic sources. While with mineral nutrition, NPK application at 100 per cent of the recommended dose had shown significantly superior values as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interaction effects studied revealed that T_2F_3 was on par with T_4F_2 and T_4F_3 in both plant crops. The calcium content in the soil was found lowest with T_1F_1, T_1F_2 and T_1F_3.

4.2.9.6. Fe content in soil after the experiment (Table 84a and 84b)

The data summarised revealed that the analysis of variance for Fe content in the soil was remarkably influenced by organic sources, mineral nutrition and their interactions in both plant crops.

A critical review of the data had revealed that Fe content in the soil was maximum in Acetobacter inoculation (T_5) and was superior to other organic sources. It was followed by Azospirillum inoculation (T_6) and press mud application (T_2). The treatment variation due to mineral nutrition had revealed that NPK application at 100 per cent of the recommended dose recorded significantly higher values and it was followed by NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interaction effects revealed that T_5F_3 recorded maximum values for Fe content in the soil followed by T_5F_2 and T_5F_1.

Table 84a Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in first plant crop

Treatment	Fe content (ppm)				Mn content (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	57.49	58.33	58.88	58.23	44.16	45.00	45.83	45.00
T_2	83.88	89.99	94.99	89.62	52.21	52.49	53.88	52.86
T_3	71.38	83.88	94.15	83.14	49.16	53.04	54.99	52.40
T_4	84.43	94.99	101.66	93.69	45.83	46.11	48.05	46.66
T_5	107.76	108.32	111.10	109.06	45.83	46.60	49.99	47.49
T_6	96.65	99.43	102.77	99.62	47.49	48.60	53.04	49.71
Mean	83.60	89.15	93.92		47.45	48.65	50.96	
C.D.(0.05) for (T)				1.68**				1.44**
C.D.(0.05) for (F)				1.40**				1.06**
C.D. (0.05) for interaction (T x F)				3.07**				1.83**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 84b Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in second plant crop

Treatment	Fe content (ppm)				Mn content (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	59.44	60.55	60.82	60.27	40.27	40.82	41.66	40.92
T_2	91.66	94.15	94.71	93.51	49.99	50.55	51.66	50.73
T_3	82.21	83.60	88.32	84.71	48.33	51.66	52.49	50.82
T_4	93.04	95.26	97.76	95.36	45.55	46.38	46.36	46.10
T_5	104.13	106.93	108.59	106.55	45.80	46.94	47.49	46.74
T_6	93.88	95.54	97.48	95.63	47.22	48.05	49.99	48.42
Mean	87.39	89.34	91.28		46.19	47.40	48.27	
C.D.(0.05) for (T)				1.85**				0.56**
C.D.(0.05) for (F)				0.69**				0.74**
C.D. (0.05) for interaction (T x F)				1.52**				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

4.2.9.7. Mn content in the soil after the experiment (Table 84a and 84b)

The data revealed that treatment variation due to organic sources as well as mineral nutrition were significant in first as well as second plant crops. However, the interaction effect was observed only in first plant crop.

The results indicated that press mud application (T_2) had shown maximum values for Mn content in the soil and was on par with trash application (T_3) in first plant crop. While in second plant crop, T_3 was on par with T_2. The lowest value was associated with treatments without organic sources (T_1). With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) recorded significantly superior values as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). Among the treatment combinations T_3F_3 recorded the highest Mn content in the soil and was on par with T_2F_3 in first plant crop.

4.2.9.8. Zn content in the soil after the experiment (Table 85a and 85b)

The results presented revealed that organic sources, mineral nutrition and their interactions had exerted significant effects on Zn content in the soil during first and second plant crops.

The data generated had shown that press mud application (T_2) had registered the highest values for Mn content in the soil after the experiment. It was followed by trash application (T_3). While in the case of mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) was on par with NPK application at 75 per cent (F_2). The interaction effects revealed that T_3F_3 was on par with T_2F_3, T_3F_2 and T_2F_2.

Table 85a Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in first plant crop

Treatment	Zn content (ppm)				Cu content (ppm)			
	F_1	F_2	F_3	Mean	F	F_2	F_3	Mean
T_1	1.36	1.36	1.41	1.38	3.94	4.05	4.14	4.04
T_2	1.91	1.94	1.99	1.95	4.41	4.50	4.61	4.50
T_3	1.58	1.97	2.02	1.86	5.16	5.88	4.58	5.87
T_4	1.52	1.58	1.61	1.57	4.58	4.47	4.63	4.56
T_5	1.55	1.58	1.66	1.60	5.19	5.44	5.63	5.42
T_6	1.22	1.36	1.39	1.32	4.83	4.96	5.05	4.94
Mean	1.52	1.63	1.68		4.68	4.88	5.11	
C.D.(0.05) for (T)				0.07**				0.12**
C.D.(0.05) for (F)				0.07**				0.18**
C.D. (0.05) for interaction (T x F)				0.12**				0.28**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 85b Effect of organic sources and mineral nutrition on chemical properties of soil after the experiment in second plant crop

Treatment	Zn content (ppm)				Cu content (ppm)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.30	1.30	1.39	1.33	3.99	4.14	4.19	4.11
T_2	1.80	1.88	1.94	1.87	4.72	4.91	4.88	4.83
T_3	1.52	1.91	1.99	1.81	5.42	5.88	6.02	5.77
T_4	1.47	1.52	1.55	1.51	4.52	4.58	4.61	4.57
T_5	1.50	1.52	1.66	1.56	5.08	5.11	5.25	5.14
T_6	1.22	1.33	1.36	1.30	4.56	4.88	5.05	4.83
Mean	1.52	1.58	1.65		4.71	4.92	5.00	
C.D.(0.05) for (T)				0.09**				0.10**
C.D.(0.05) for (F)				0.10*				0.05**
C.D. (0.05) for interaction (T x F)				0.13**				0.13**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Signficicant at 5 per cent level

4.2.9.9. Cu content in the soil after the experiment (Table 85a and 85b)

The data generated revealed that the analysis of variance for Cu content in the soil was significantly influenced by organic sources, mineral nutrition and their interactions in first and second plant crops.

Among the organic sources trash application (T_3) had recorded maximum values for the Cu content in the soil after the experiment. The lowest value was associated with T_1. While in the case of mineral nutrition, F_3 had shown maximum values as compared to F_2 and F_1. The interaction effects revealed that T_3F_3 had shown maximum value for Cu content in soil after the experiment. The Cu content in the soil was reduced in T_1F_1 at both plant crops.

4.2.10. Biological properties of soil after the experiment

4.2.10.1. Acid Phosphatase activity in the soil after the experiment (Table 86a and 86b)

The results revealed that acid phosphatase activity was explicitly influenced by organic sources, mineral nutrition and their interactions in both plant crops.

The data obtained had indicated that acid phosphatase enzyme activity was at increased rate with press mud application (T_2). It was followed by trash application (T_3) and green manure application (T_4). The acid phosphatase activity was comparatively less in treatments without organic sources. Among the treatments with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had shown higher value as compared to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interaction effects revealed that T_2F_3 had recorded the highest acid phosphatase enzyme activity and it was followed by T_2F_2 and T_2F_1.

Table 86a Effect of organic sources and mineral nutrition on soil enzymes after the experiment in first plant crop

Treatment	Acid phosphatase (u moles of PNP produced/hr/g of soil)				Cellulase (u moles of glucose produced/hr/g of soil)				Urease (u moles of NH_3 produced/hr/g of soil)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.811	0.816	0.899	0.842	0.0130	0.0140	0.0147	0.0140	0.217	0.311	0.365	0.297
T_2	1.625	1.632	2.187	1.815	0.0187	0.0188	0.0208	0.0190	0.547	0.554	0.574	0.558
T_3	1.342	1.400	1.440	1.394	0.0270	0.0285	0.0314	0.0290	0.447	0.495	0.516	0.486
T_4	1.379	1.391	1.400	1.390	0.0165	0.0174	0.0185	0.0174	0.465	0.481	0.484	0.477
T_5	1.060	1.109	1.190	1.120	0.0161	0.0168	0.0174	0.0167	0.565	0.571	0.578	0.571
T_6	1.058	1.225	1.231	1.171	0.0163	0.0172	0.0181	0.0172	0.612	0.629	0.643	0.628
Mean	1.212	1.262	1.391		0.0180	0.0190	0.0200		0.475	0.507	0.526	
C.D.(0.05) for (T)				0.014**				0.0008**				0.012**
C.D.(0.05) for (F)				0.015**				0.0006**				0.005**
C.D. (0.05) for interaction (T x F)				0.026**				0.0007**				0.009**

Organie sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 86b Effect of organic sources and mineral nutrition on soil enzymes after the experiment in second plant crop

Treatment	Acid phosphatase (u moles of PNP produced/hr/g of soil)				Cellulase (u moles of glucose produced/hr/g of soil)				Urease (u moles of NH_3 produced/hr/g of soil)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	0.858	0.880	0.891	0.876	0.0131	0.0137	0.0146	0.0140	0.236	0.272	0.314	0.274
T_2	1.385	1.398	1.427	1.404	0.0183	0.0188	0.0206	0.0192	0.522	0.536	0.548	0.535
T_3	1.306	1.371	1.377	1.351	0.0265	0.0280	0.0294	0.0280	0.431	0.480	0.501	0.471
T_4	1.347	1.358	1.363	1.356	0.0160	0.0167	0.0178	0.0170	0.452	0.462	0.473	0.462
T_5	1.020	1.084	1.103	1.069	0.0154	0.0162	0.0171	0.0160	0.551	0.568	0.574	0.564
T_6	1.142	1.180	1.195	1.172	0.0160	0.0168	0.0177	0.0170	0.592	0.618	0.625	0.612
Mean	1.176	1.212	1.226		0.0175	0.0183	0.0200		0.464	0.489	0.506	
C.D.(0.05) for (T)				0.005**				0.0007**				0.005**
C.D.(0.05) for (F)				0.904**				0.0007**				0.004**
C.D. (0.05) for interaction (T x F)				0.010**				0.0006*				0.010**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

4.2.10.2. Urease activity of the soil after the experiment (Table 86a and 86b)

The data given had shown that treatments varied with organic sources, mineral nutrition and their interactions significantly.

The data generated indicated that Azospirillum inoculation (T_6) had shown maximum urease activity in soil and was markedly superior to all other organic sources. It was followed by Acetobacter inoculation (T_5) and press mud application (T_2). With regard to mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had shown increased values and was superior to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interactions revealed that T_6F_3 had recorded the highest urease activity and it was followed by T_6F_2 and T_6F_1.

4.2.10.3. Cellulase activity in the soil after the experiment (Table 86a and 86b)

The data generated revealed that cellulase activity varied with organic sources, mineral nutrition and their interactions in both plant crops.

A critical review of the data in first and second plant crops revealed that activity of cellulase enzyme was remarkably higher in trash application (T_3). It was followed by press mud application (T_2) and green manure application (T_4). The treatments with mineral nutrition had revealed that the cellulase activity was found to be at increased rates with NPK application at 100 per cent of the recommended dose (F_3) and it was significantly superior to NPK application at 75 per cent (F_2) and 50 per cent of the recommended dose (F_1). The interactions exhibited showed that T_3F_3 recorded the highest values for cellulase activity and it was followed by T_3F_2 and T_3F_1.

4.2.10.4. Bacterial population in the soil after the experiment (Table 87a and 87b)

The data presented had revealed that organic sources exerted perceptible influence on bacterial population. However, the mineral nutrition and interactions had not shown any significant effects.

The data generated revealed that Azospirillum inoculation (T_6) had registered highest bacterial population as compared to other organic sources. It was followed by Acetobacter inoculation (T_5) and press mud application (T_2). The bacterial population was found at lowest level in treatments that has not received any organic sources (T_1).

4.2.10.5. Fungal population in the soil after the experiment (Table 87a and 87b)

The data generated had shown that fungal population was significantly affected by organic sources. But the mineral nutrition and the interactions did not show any statistical variation.

The results revealed that maximum values for fungal population was associated with trash application (T_3) and it was significantly superior to other organic sources. Press mud application (T_2) and green manure application (T_4) had recorded comparatively higher population, but was only next to (T_3).

4.2.10.6.Actinomycetes population in the soil after the experiment (Table 87a and 87b)

The data revealed that the analysis of variance for actinomycetes population was conspicuously influenced by organic sources and mineral nutrition. However, their interaction effects were nonsignificant in both plant crops.

A perusal of the data obtained showed that press mud application (T_2) had appreciably increased the population of actinomycetes in the soil after the experiment. While trash application (T_3) and green manure application (T_4) had also

Table 87a Effect of organic sources and mineral nutrition on microbial population after the experiment in first plant crop

Treatment	Bacteria ($x10^7$)				Fungi ($x10^5$)				Actinomycetes (($x10^2$)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	15.50	16.00	16.00	15.83	4.25	4.50	4.75	4.50	2.50	2.75	2.75	2.67
T_2	24.25	24.50	25.00	24.58	8.00	8.25	9.00	8.42	6.75	7.00	7.50	7.08
T_3	20.50	22.00	22.25	21.58	10.25	11.00	11.00	10.75	5.75	6.75	6.75	6.42
T_4	20.75	21.00	21.25	21.00	7.00	7.50	7.50	7.33	6.25	6.25	6.25	6.25
T_5	25.00	25.50	26.00	25.50	5.00	5.25	5.25	5.17	4.75	5.25	5.25	5.08
T_6	26.50	27.00	27.00	26.83	5.50	5.50	5.75	5.58	4.75	5.25	5.50	5.17
Mean	22.08	22.67	22.92		6.67	7.00	7.21		5.13	5.54	5.67	
C.D.(0.05) for (T)				0.90**				0.96**				0.60**
C.D.(0.05) for (F)				N.S.				N.S.				0.38*
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 87b Effect of organic sources and mineral nutrition on microbial population after the experiment in second plant crop

Treatment	Bacteria ($x10^7$)				Fungi ($x10^5$)				Actinomycetes (($x10^2$)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	15.00	16.50	16.00	15.83	4.00	4.50	4.50	4.33	3.25	3.50	3.50	3.42
T_2	23.00	23.00	23.50	23.17	7.75	8.25	8.50	8.17	7.50	7.50	7.75	7.58
T_3	20.00	21.50	21.50	21.00	9.75	10.00	10.50	10.08	6.25	7.00	7.25	6.83
T_4	20.00	20.25	20.75	20.33	7.25	7.75	7.75	7.58	6.25	6.50	6.75	6.50
T_5	25.50	25.50	25.25	25.42	5.50	5.75	6.00	5.75	5.25	5.50	5.75	5.50
T_6	27.00	27.50	27.75	27.42	5.75	6.00	6.25	6.00	5.50	5.75	6.00	5.75
Mean	21.75	22.38	22.46		6.67	7.04	7.25		5.67	5.96	6.17	
C.D.(0.05) for (T)				1.32**				0.74**				0.63**
C.D.(0.05) for (F)				N.S.				N.S.				0.32*
C.D. (0.05) for interaction (T x F)				N.S.				N.S.				N.S.

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level
* - Significant at 5 per cent level

increased actinomycetes population, but stood next to T_2. The results of the mineral nutrition revealed that NPK application at 100 per cent of the recommended dose (F_3) and NPK application at 75 per cent of the recommended dose (F_2) were showing statistical parity but was significantly superior to NPK application at 50 per cent of the recommended dose.

4.2.11. Economics

4.2.11.1. Benefit cost ratio (Table 88a and 88b)

A critical review of the data revealed that benefit cost ratio was perceptibly influenced by organic sources, mineral nutrition and their interactions in both plant crops.

The results revealed that among the organic sources, press mud application (T_2) and Azospirillum inoculation (T_6) had shown statistical parity and recorded superior values. It was followed by green manure application (T_4). The benefit cost ratio was reduced in treatments without organic sources. While with mineral nutrition, NPK application at 100 per cent of the recommended dose (F_3) had increased invariably the benefit cost ratio as compared to NPK application at 75 per cent and 50 per cent of the recommended dose of NPK. The interaction effects between organic sources and mineral nutrition had shown that T_2F_3 recorded significantly higher values for benefit cost ratio and it was followed by T_6F_3, T_2F_2. The benefit cost ratio was reduced in T_1F_1.

4.2.12. Energetics

4.2.12.1. Energy productivity (Table 88a and 88b)

The data generated had shown that it was markedly influenced by organic sources, mineral nutrition in first plant crop. However, the mineral nutrition did not show any perceptible influence in second plant crop.

The results revealed that press mud application (T_2) recorded maximum values for energy productivity and was superior to all other organic sources.

Table 88a Effect of organic sources and mineral nutrition on economic analysis and energetics of first plant crop

Treatment	Benefit:Cost ratio				Energy Productivity (g MJ^{-1})				Energy use efficiency			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.06	1.15	1.28	1.16	1321.04	1384.51	1492.18	1399.24	9.15	9.77	10.37	9.76
T_2	1.45	1.53	1.58	1.52	178..94	1833.04	1847.24	1823.07	12.49	12.75	12.86	12.70
T_3	1.22	1.31	1.33	1.29	1490.87	1558.03	1541.86	1530.25	10.55	10.89	10.70	10.71
T_4	1.39	1.43	1.44	1.42	1708.26	1703/88	1667.16	1693.10	12.01	11.91	11.68	11.86
T_5	1.41	1.42	1.43	1.42	1636.34	1615.64	1581.18	1611.05	11.45	11.27	11.05	11.26
T_6	1.47	1.53	1.55	1.52	1718.10	1729.92	1714.12	1720.71	12.11	12.18	12.02	12.10
Mean	1.33	1.39	1.43		1610.59	1637.50	1640.62		11.29	11.46	11.45	
C.D.(0.05) for (T)				0.02**				30.93**				0.18**
C.D.(0.05) for (F)				0.01**				6.32**				0.04**
C.D. (0.05) for interaction (T x F)				0.02**				28.33**				0.17**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Table 88b Effect of organic sources and mineral nutrition on economic analysis and energetics of second plant crop

Treatment	Benefit:Cost ratio				Energy Productivity (g MJ^{-1})				Energy use efficiency			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
T_1	1.08	1.15	1.23	1.15	1374.91	1413.53	1460.68	1416.38	9.16	9.67	9.98	9.60
T_2	1.39	1.45	1.50	1.44	1746.45	1775.10	1784.10	1768.55	12.22	12.28	12.39	12.30
T_3	1.17	1.25	1.27	1.23	1467.08	1517.14	1498.26	1494.16	10.02	10.32	10.17	10.17
T_4	1.35	1.37	1.38	1.36	1691.82	1667.25	1633.52	1664.20	11.56	11.37	11.13	11.35
T_5	1.35	1.38	1.39	1.37	1604.89	1594.45	1671.81	1590.38	10.91	10.46	10.65	10.67
M_6	1.44	1.45	1.47	1.46	1712.52	1679.85	1642.28	1678.22	11.81	11.66	11.54	11.67
Mean	1.30	1.34	1.37		1599.61	1607.89	1598.44		10.95	10.96	10.98	
C.D.(0.05) for (T)				0.03**				37.74**				0.21**
C.D.(0.05) for (F)				0.01**				N.S.				N.S.
C.D. (0.05) for interaction (T x F)				0.02**				30.62**				0.34**

Organic sources

T_1 - Control
T_2 - Pressmud application
T_3 - Trash application
T_4 - Green manuring
T_5 - Acetobacter inoculation
T_6 - Azospirillum inoculation

Mineral nutrition

F_1 - 50% of the recommended dose of NPK
F_2 - 75% of the recommended dose of NPK
F_3 - 100% of the recommended dose of NPK
N.S. - Not significant
** - Significant at 1 per cent level

Press mud application (T_2) was closely followed by Azospirillum inoculation (T_6) and green manure application (T_4) in both plant crops. The treatments without organic sources (T_1) had recorded the lowest value. The treatment effects due to mineral nutrition had revealed that NPK application at 100 per cent of the recommended dose (F_3) was statistically on par with NPK application at 75 per cent (F_2) but significantly superior to 50 per cent of recommended dose (F_1) in first plant crop. In second plant crop also a similar trend was noticed. The interaction effects revealed that T_2F_3 was on par with T_2F_2. But significantly superior to all other treatment combinations.

4.2.12.2. Energy use efficiency (Table 88a and 88 b)

The data recorded revealed that treatment effects due to organic sources mineral nutrition and their interactions were significant during first plant crop. However, the mineral nutrition did not show any variation in second plant crop.

A critical review of the data revealed that press mud application (T_2) recorded significantly superior values. It was followed by Azospirillum inoculation (T_6) and green manure application (T_4). The treatment without organic sources had recorded the lowest energy use efficiency. With regard to mineral nutrition, NPK application at 100 per cent (F_3) and 75 per cent of the recommended dose (F_2) were statistically on par but was superior to NPK application at 50 per cent of the recommended dose (F_1) in first plant crop. The interactions revealed that T_2F_3 had recorded the highest energy use efficiency and it was on par with T_2F_2 and T_2F_1.

4.2.13. Correlation (Table 89)

Correlation studies between cane yield and growth components like plant height, number of nodes, number of leaves, DMP and LAI revealed that all growth characters contributed positively and significantly to the cane yield. The highest positive correlation was associated with DMP followed by LAI. The lowest contribution was expressed by the number of nodes.

Table 89 Correlation matrix of growth, yield attributes, nutrient uptake and cane yield as influenced by integrated nutrient management

	MCC	DMP	No. of nodes	No. of leaves	plant height	Cane girth	Single cane weight	Cane length	Cane yield	Sugar yield	Jaggery yield	LAI	Mn uptake	Zn uptake	Fe uptake	Ca uptake	Cu uptake	N uptake	P uptake	K uptake
MCC	1.0000																			
DMP	0.9759	1.0000																		
No. of notes	0.8301	0.8619	1.0000																	
No. of leaves	0.8695	0.8974	0.7873	1.0000																
Plant height	0.8873	0.9199	0.8406	1.0000																
Cane girth	0.9073	0.9406	0.8709	0.8463	0.8961	1.0000														
Single cane weight	0.9564	0.9767	0.8659	0.9016	0.9232	0.9217	1.0000													
Cane length	0.8797	0.9199	0.8564	0.8132	0.9470	0.8809	0.9271	1.0000												
Cane yield	0.9793	0.9861	0.8678	0.9032	0.9228	0.9374	0.9863	0.9205	1.0000											
Sugar yield	0.9049	0.9235	0.8199	0.8439	0.8542	0.8799	0.9262	0.8734	0.9329	1.0000										
Jaggery yield	0.9701	0.9839	0.8718	0.9077	0.9303	0.9292	0.9846	0.9846	0.9916	0.9382	1.0000									
LAI	0.9614	0.9743	0.8559	0.9558	0.8938	0.9235	0.9631	0.8926	0.9762	0.9145	0.9719	1.0000								
Mn uptake	0.6922	0.7073	0.5460	0.6883	0.6543	0.6076	0.7249	0.6608	0.6957	0.7121	0.7193	0.7040	1.0000							
Zn uptake	0.9529	0.9614	0.8777	0.8860	0.8802	0.9328	0.9356	0.8872	0.9579	0.9060	0.9807	0.9632	0.6780	1.0000						
Fe uptake	0.3416	0.3502	0.3039	0.3523	0.3225	0.3012	0.3813	0.3849	0.3397	0.4296	0.3759	0.3396	0.7153	0.3358	1.0000					
Ca uptake	0.8690	0.8787	0.7292	0.8365	0.7991	0.8018	0.8949	0.8210	0.8788	0.8417	0.8840	0.8664	0.8807	0.8607	0.5289	1.0000				
Cu uptake	0.9168	0.9298	0.8787	0.8502	0.8504	0.9048	0.9253	0.8603	0.9345	0.8668	0.9202	0.9151	0.5799	0.9458	0.2295	0.8367	1.0000			
N uptake	0.9240	0.9468	0.8440	0.8466	0.9097	0.9006	0.9325	0.9159	0.9397	0.8969	0.9428	0.9347	0.6701	0.9312	0.3416	0.8295	0.8916	1.0000		
P uptake	0.9312	0.9486	0.8452	0.8622	0.8958	0.9194	0.9200	0.8898	0.9415	0.9143	0.9374	0.9530	0.7013	0.9537	0.3617	0.8317	0.8821	0.9250	1.0000	
K uptale	0.9326	0.9467	0.8609	0.8694	0.9024	0.9239	0.9317	0.8992	0.9581	0.8905	0.9508	0.9506	0.6441	0.9503	0.7683	0.8228	0.9063	0.9383	0.9399	1.0000

The values are significant at 1 per cent

Correlation between cane yield and yield attributes like MCC, cane girth, cane length and single came weight had also shown that all the yield attributing characters contributed positively and significantly to the cane yield. The highest positive correlation was associated with single cane weight closely followed by MCC. The lowest positive association was rested with cane length.

The correlation studies carried out between cane yield and nutrient uptake viz., uptake of N, P, K, Ca, Fe, Mn, Zn and Cu also revealed that the nutrient uptake was positively and significantly contributed for the cane yield. Among the nutrient uptake studied the highest was associated with the uptake of K closely followed by the uptake of Zn, P and N. The lowest positive contribution was noticed with the uptake of Fe.

Sugar as well as jaggery yield were also significantly and positively correlated with cane yield.

DISCUSSION

DISCUSSION

The present investigation were undertaken during the crop seasons of 1998-'99 and 1999-2000 with the objective of economising the use of irrigation water through improved surface method of irrigation and to formulate a sustainable production technology by integrating organic and inorganic sources of nutrients for enhancing cane yield, juice quality and jaggery production. The results of the two experiments presented in the previous chapter are discussed separately. Under experiment No. I viz., 'Standardization of irrigation management in sugarcane', the discussion of the results are made in this chapter . While under experiment No.II viz., 'Integrated nutrient management in sugarcane', the results are critically analysed and discussed separately.

Experiment No. I - Standardization of irrigation management in sugarcane

Growth attributes

Plant height recorded at different stages of growth form a key index to assess the vigour of cane. Irrigation through all furrow had significantly increased the plant height. Alternate furrow showed an enhanced plant height than skip furrow and farmer's practice of the region. Trash mulching at 5 t ha^{-1} had produced marked effect on plant height throughout the crop growth. The combination of trash mulching with all furrow irrigation produced taller plants. While the alternate furrow with trash mulching gave taller plants than that of all furrow method of irrigation without trash mulching.

Cane elongation takes place under adequate supply of optimum soil moisture and plant nutrients. The stalk elongation was found to be inversely proportional to the cumulative soil water depletion (Koehler *et al.*, 1982). High soil moisture content provided through all furrow and alternate furrow methods of irrigation might have favoured in attaining higher plant height than skip furrow irrigation where the soil moisture status at the root zone was lesser. The present observations are in line with the findings of Chang *et al.* (1965), Naidu and Reddy (1976) and Singh and Reddy (1980).

The number of leaves emerged and nodes formed showed a remarkable increase with all furrow irrigation. But recorded comparable values with that of alternate furrow irrigation. Trash mulching at 5 t ha^{-1} had an appreciable increase in the number of leaves and nodes. Continuous moisture availability is needed in first two physiological stages prior to full canopy development in sugarcane, since adequate water is required for vigourous vegetative growth to physiological growth stages (Gascho, 1985). The increased height might have also resulted due to the emergence of more number of leaves and number of nodes formed.

Water relations play an important role in tiller production and determines the outcome of millable cane count. All furrow irrigation had provided adequate supply of soil moisture during the early stages of crop growth in the root zone and might have increased the availability of nutrients and its uptake. The increased plant height with more number of leaves and nodes might have produced favourable effects for enhancing tillering, shoot formation and cane formed shoots. Conversely the inadequate supply of soil moisture in skip furrow irrigation and farmer's practice had reduced the tiller production and recorded the lesser values for other growth attributes. Application of trash at the rate of 5 t ha^{-1} might have improved the physical conditions of soil which along with its soil moisture conservation ability might have resulted in increasing the tiller production, shoot formation and ultimately cane formed shoots. The results obtained in the present study are in accordance with the findings of Singh *et al.* (1984), Pandian *et al.* (1989) and Annadurai (1997).

Dry matter production is a good index of cane growth. Irrigation through all furrow had enhanced the DMP by trash, green tops and stem at all stages of growth and it was comparable with irrigation through alternate furrow. The stress condition induced in skip furrow and farmer's practice of irrigation had decreased the DMP. Marked difference in DMP by trash, green tops and stem was noticed with trash mulching as compared to its control. Total dry matter production which is the sum total of DMP by trash, green tops and stem had followed the same trend as mentioned above.

The moisture regime in the soil during the cane growth period determines the functional activities responsible for the accumulation of dry matter (Hargreaves, 1960 and Srinivasan and Mariakulandai, 1969). Soil moisture stress during the early growth phase retarded the growth and reduced the DMP (Singh and Kanwar, 1964 and Singh *et al.*, 1975). Desirable plant water relations maintained during the formative phase and fairly sufficient irrigation water provided through all furrow or alternate furrow irrigation under trash mulching might have increased the CO_2 assimilation rate, effective absorption of plant nutrients and functioning of plant metabolic process besides its role in cell division and cell enlargement. It was also observed that the growth attributes like plant height, leaf emergence and node formation, tiller production, shoot formation and cane formed shoots increased with irrigation provided through all furrow or alternate furrow under trash mulching. The expression of these growth parameters at higher rate might have attributed for the increase in total dry matter production with the above treatments. Similar results were reported by Prasad (1976), Hellmann (1977) and Kingston (1977).

Growth analysis can be used to evaluate the response of cane growth to various treatments. The results revealed that irrigation through all furrow had increased the values of LAI, LAR, SLA and CGR and it was comparable with alternate furrow method. The stress conditions prevailed in skip furrow and farmer's practice had reduced the values of growth indices. Trash application had also shown increased values for growth indices. But net assimilation rate had shown higher values in skip furrow irrigation and in control plots. The combination of trash mulching with either all furrow or alternate furrow method had increased the values of LAI, LAR, SLA and CGR as compared to other treatment combinations.

The increased leaf area associated with all furrow irrigation was due to adequate availability of soil moisture which might have attributed for the crop to absorb higher quantity of nutrients needed for the growth. Similarly, the dry matter produced by green tops and total dry matter production at different growth stages of crop were also found highest with all furrow as well as alternate furrow irrigation under trash mulching. The above factors might have contributed and resulted for giving higher values for LAI, LAR, SLA and CGR. Similar results were reported by Barnes (1964), Gosnell (1968) and Daniel (1984).

The stress conditions prevailed during the formative phase in skip furrow and farmer's practice had recorded lower rate of leaf emergence and reduced the total leaf area per plant and the dry matter production markedly. This might be the reason for getting lower values for LAI, LAR and SLA. The above results are in conformity with the findings of Venkataramana *et al.* (1984), Sundarsingh (1989) and Annadurai (1997).

Skip furrow irrigation and farmer's practice under unmulched condition had increased the net assimilation rate. This was due to the fact that LAI has recorded lower values and the total leaf area per plant compared to total dry matter produced per plant was less partially due to the drying of leaves and reduced rate of leaf production.

Yield attributes

Millable cane count is an important yield component deciding the productivity of cane. Irrigation through all furrow had produced perceptible increase in the number of millable canes and recorded comparable values with alternate furrow method. Trash mulching had conspicuously increased the millable cane. The difference in the production of number of millable canes was probably due to the difference in soil moisture brought out by all furrow, alternate furrow and skip furrow irrigation. The combination of trash mulching either with all furrow or alternate furrow irrigation produced marked increase in millable cane count as compared to all furrow and alternate furrow without trash application. The soil moisture status available in the root zone was adequate under all furrow and alternate furrow irrigation. This might have favoured the root proliferation and penetration covering a very large soil-root volume resulting in the high mobility and uptake of nutrients enhancing the number of millable canes than skip furrow or farmer's practice. The changes in soil moisture would modify the supply of nutrients from soil (Zende, 1988). Singh *et al.* (1986) observed reduction in MCC with reduced levels of irrigation.

Application of trash might have mediated a favourable environment by reducing the soil temperature as evidenced and retaining more amount of soil moisture in the root zone for growth and development of cane which had reflected with the increased number of millable canes. This again indicates that irrigation through alternate furrow under trash mulching was found as beneficial as all furrow method in combination with trash application. This could result in the saving of irrigation water without sacrificing the number of millable canes. The above results are in agreement with the findings of Sundarsingh (1989), Mann and Chakor (1989) and Pandian *et al.* (1992).

Irrigation provided through all furrow method had produced lengthier canes and it was statistically on par with alternate furrow method. Perceptible reduction in cane length was observed with skip furrow irrigation. Trash application had increased the cane length as compared to control. It is brought to the notice that stalk elongation was influenced by the degree of moisture supply to sugarcane crop. Increased cane length recorded under high moisture status might be due to the cumulative increase in cane height at formative and grand growth stages of cane. Cane growth is directly related to water balance in plant tissue. As the plant water potential increases physiological processes like cell enlargement, cell division and photosynthesis are promoted (Yang, 1980). According to Santo and Basshart (1980) the stalk elongation was proportional to the quantity of irrigation water supplemented. Water stress at any stage of growth would reduce stalk height adversely (Naidu *et al.*, 1977 and Parashar *et al.*, 1980). Longer millable cane was harvested by Ridge (1984) and Cockett (1985) under adequate moisture availability. Reduced supply of soil moisture had shortened the cane (Panwar and Patil, 1989).

Application of trash might have increased the nutrient assimilation efficiency which again might have improved the photosynthetic efficiency by modifying the soil conditions ideal for growth and development. The combination of trash mulching with alternate furrow and all furrow irrigation had shown lengthier canes. It was lowest with skip furrow irrigation without mulching. The present findings are in conformity with the studies made by Mann and Chakor (1989) and Kanwar *et al.* (1992).

The radial growth as measured in terms of cane girth had showed that irrigation through all furrow as well as alternate furrow was statistically superior to skip furrow and farmer's practice. Application of trash had increased the cane girth significantly at all stages of growth, as compared to control. Srinivasan (1975) obtained higher cane girth by maintaining the soil moisture around field capacity as compared to lesser moisture status. Acute moisture stress would markedly decrease the thickness of the cane (Schtiya, 1988). The moisture supply provided in all furrow as well as alternate furrow with trash mulching might have increased synthate accumulation due to rapid vegetative growth resulting increased cane girth.

Single cane weight is a function of leaf area, number of nodes and cane length. The increased leaf area, higher number of nodes, lengthier and thicker canes associated with all furrow and alternate furrow irrigation under trash mulching had contributed maximum DMP at formative grand growth and maturity phase due to adequate supply of soil moisture and increased uptake of nutrients. This might have attributed to the increased cane weight. Similar relationships were earlier reported by Mali and Singh (1989) and Singh and Mohan (1994).

Cane, sugar and jaggery yield

It was observed that the effect of moisture supply on the cane yield was perceptible. The cane yield was profoundly increased by all furrow irrigation and produced higher yield than other irrigation management practices. The beneficial effect of all furrow irrigation over alternate furrow was 2.68 per cent. Alternate furrow irrigation also recorded enhanced cane production as compared to other two irrigation management practices. Application of trash at the rate of 5 t^{-1} had also shown remarkable increase in cane yield as compared to unmulched plots and produced an yield increase of 6.26 per cent over the control.

The soil moisture status and desirable plant water relations maintained in all furrow and alternate furrow irrigation had favoured the growth attributes like plant height, number of leaves, nodes, tiller production, DMP and yield attributes like millable cane count, cane girth, cane length and single cane weight. This might have contributed for the increase in cane yield. Singh *et al.* (1987) reported the positive effect of irrigation regime on cane yield. According to Agarwal and Singh (1986) availability of adequate soil moisture influenced the cane yield through cane growth and yield attributes.

Skip furrow irrigation and farmer's practice invariably decreased all the growth and yield parameters which resulted in lower cane yield. Under skip furrow irrigation, the moisture contribution from the irrigated furrow to the permanently unirrigated furrow was much less as evidenced by soil moisture data. Similarly irrigating the crop once in a month (farmer's practice) was also unable to retain adequate soil moisture due to increased interval between irrigation. This might have detracted the growth and yield parameters resulting in lower yield. Similar results were also reported by Manisekaran *et al.* (1988).

Under moisture stress situation the soil mechanical resistance increases and the root growth is reduced. Philips (1966) reported that under unsaturated soil moisture environment, a vapour gap would be formed around the roots by their turgor pressure under water stress. Such a gap if even present would reduce the availability of nutrients to the roots probably due to lesser contact between roots and soil particles causing drastic reduction in the uptake of nutrients and DMP. This might be the major reason for the skip furrow as well as farmer's practice of irrigation to record lower cane yield.

The decomposition and mineralization of the trash applied into the soil might have resulted in the release of plant nutrients. The post harvest status of nutrients in the mulched plots showed an enhancement in the availability of major and minor nutrients. The activity of microbial population was found to be highest with trash mulched plots. This has also increased the soil enzymes like acid phosphatase cellulase and urease thereby increasing the availability of plant nutrients. Trash mulching had also improved the physical properties of soil by promoting infiltration rate, soil porosity and water holding capacity of soil. The improved soil physical conditions along with increased uptake of plant nutrients might have favoured better cane growth and increased rate of photosynthesis resulting in the maximum expression of growth and yield parameters. This trend was well expressed in the cane yield also. The above results are in accordance with the findings of Durai (1996) and Swamy *et al.* (1998).

The combination of trash mulching with all furrow and alternate furrow irrigation had produced comparable cane yield and were statistically superior to other treatment combinations. The combined effect of moisture availability and nutrient uptake have contributed to the increased cane yield (Zende, 1988). Irrigation through all furrows without trash mulching had ranked third and irrigation through alternate furrow alone had ranked fourth with respect to cane yield. This again suggest that it is possible to save irrigation water by alternate furrow methods with trash mulching. Mulching recorded about 10.46 per cent yield increase in alternate furrow irrigation while all furrow, skip furrow and irrigation once in a month, such a benefit of mulching was not visible. It could be presumed that a minimum moisture level available in alternate furrow was necessary for its better conservation through mulching. In higher and lower levels of irrigation, the benefit of mulching was comparatively less.

Skip furrow irrigation had recorded the lowest cane yield and was comparable with farmer's practice. The present results are in agreement with the findings of Mann and Chakor (1989), Pandian *et al.* (1992), Kanwar *et al.* (1992), Thanki *et al.* (1999) and Veeraputhiran *et al.* (1999).

Sugar yield is a product of cane yield and CCS per cent. Higher correlation between sugar yield and cane yield and between CCS per cent and sugar yield was established by Chinnuswamy (1990). As in the case of cane yield, sugar yield was also increased due to irrigation through all furrow method and it was comparable with alternate furrow irrigation. The yield increase was 0.57 and 0.54 per cent over alternate furrow method during first and second plant crop. Trash mulching had also increased the sugar yield. The increased rate of cane growth due to higher uptake of plant nutrients and adequate supply of soil moisture had resulted in attaining increased sugar yield.

The environmental factors viz., dry weather, medium RH and bright sunshine hours prevailed during the maturity and ripening phase are the prerequisite for better sugar accumulation. According to Humbert (1968) a dry, sunny and cool climate influences the maturity and ripening of cane resulting in higher sugar yield. Rao (1985), Srinivasan (1986) and Srinivasan and Naidu (1986) reported that inadequate moisture supply reduced sugar yield which is the result of poor cane growth yield attributes and yield.

The jaggery yield obtained at harvest had revealed that irrigation supplemented through all furrows recorded the highest jaggery production and the values were comparable with irrigating furrows alternately. Application of trash had increased the jaggery yield as compared to control. Jaggery yield is the function of cane yield and jaggery recovery. The reasons for the individual effect and combined effect of treatments as attributed under the cane yield also hold good to the jaggery yield. The combination of trash mulching with all and alternate furrow method had increased the jaggery yield significantly as compared to all furrow and alternate furrow irrigation alone. The jaggery yield was reduced drastically in skip furrow irrigation and farmer's practice under unmulched situation. The favourable growth conditions prevailed in all and alternate furrow irrigation under trash mulching had increased the growth and yield attributing factors. This had promoted the uptake of plant nutrients and thereby enhanced the cane yield. The increased rate of jaggery recovery coupled with higher cane yield had contributed maximum jaggery production.

Juice quality

Juice recovery was not improved by any of the treatment effects and remained unchanged. The quality parameters like SMT Brix, sucrose content, CCS per cent and purity coefficient were influenced in first plant crop. While in second plant crop there was no appreciable variation in juice quality due to treatment effects. This was probably due to the higher rainfall experienced at the maturity phase of the second plant crop.

The sucrose content, SMT Brix and CCS per cent were improved by irrigation supplemented through all furrow and was comparable with alternate furrow irrigation. The mulched plots had shown increased values for sucrose content, CCS per cent and purity coefficient. But the control plots had given higher values for SMT Brix. The combination effect of trash mulching either with all or alternate furrow irrigation had slightly improved the sucrose content, CCS per cent and purity per cent in both plant crops as compared to all and alternate furrow without trash mulching. Skip furrow irrigation as well as farmer's practice without trash mulching had reduced the values of sucrose content, CCS per cent and purity coefficient. However, the SMT Brix values were increased.

The moisture stress conditions prevailed in skip furrow as well as farmers practice might have resulted for increasing the reducing sugars in cane juice significantly. This was due to inadequate supply of soil moisture which triggered the activity of invertase enzyme favouring the inversion of sucrose into fructose and glucose. The above treatments have also recorded comparatively lower values for sucrose content and CCS per cent which might be due to the increased rate of inversion. The mulched plots had decreased the reducing sugar content in cane juice as compared to control plots. Trash mulching had resulted in the conservation of soil moisture and reduction of soil temperature. The above soil conditions might have favoured for the reduced activity of the enzyme and suppressed the inversion of sucrose into reducing sugars. The combination of trash mulching with either all or alternate furrow irrigation had recovered lower values for reducing sugar as compared to all or alternate furrow irrigation without trash mulching.

Irrigation provided through all furrow method had increased jaggery-Brix, jaggery-sucrose, jaggery-purity and was comparable with alternate furrow irrigation. The jaggery reducing sugar increased with skip furrow irrigation and farmer's practice. The combination of trash mulching with either all furrow or alternate furrow had shown numerically higher values for jaggery quality.

Nutrient uptake

Clements (1980) suggested optimum and critical levels of nutrient indices viz., leaf N, sheath P and sheath K to achieve high cane yields. The uptake of N, P, K by trash, green tops and stem were enhanced with irrigation through all furrow and recorded comparable values with alternate furrow method. In the case of skip furrow and farmer's practice, the uptake of N, P, K. by trash, green tops and stem was reduced drastically. Mulching with trash at 5 t ha^{-1} had increased the N, P and K uptake through trash, green tops and stem than that of control plots. The interaction effect between methods of irrigation and trash mulching was observed in certain stages of growth. However, the combination of trash mulching with all and alternate furrow irrigation had recorded higher uptake of NPK by trash green tops and stem as compared to skip furrow irrigation and farmer's practice without trash mulching. The total uptake of N, P and K which is the sum total of the uptake made by trash, green tops and stem also reflected the same trend as mentioned above.

The total uptake of Ca, Na, Fe, Mn, Zn and Cu differed significantly with methods of irrigation and trash mulching. All furrow irrigation had increased the uptake of Ca, Na, Fe, Mn, Zn and Cu and recorded comparable values with alternate furrow irrigation. While with trash mulching, the uptake of above nutrients increased appreciably as compared to plots without mulching. The combination of trash mulching with all furrow or alternate furrow irrigation recorded comparatively higher uptake than all furrow, alternate furrow and skip furrow irrigation without mulching.

Many researchers observed that optimum soil moisture favoured greater absorption of nutrients from the soil and resulted in higher values of nutrient indices (Samuels, *et al.*, 1953, Chowdhary, 1960 and Bhoj, 1962). Adequate and optimum supply of soil moisture through all and alternate furrow irrigation under trash mulching might have increased the concentration of major, secondary and micronutrients in the soil solution which in turn had increased the uptake of nutrients by the plants. Further, under adequate irrigation the growth of the crop would be vigourous and for the better activity of plant cell, nutrients are required in greater extent. This might be the reason for the significant increase in the uptake of major, secondary and micronutrients under high soil moisture status. In addition to this, trash mulch might have undergone biodegradation and mineralization enhancing the availability of soil and applied nutrients at different stages of growth.

The increased rate of DMP in treatments with irrigation through all and alternate furrow under trash mulching had contributed greatly for the increased uptake of nutrients. A large quantity of nutrient was removed by sugarcane because of the larger biomass production (Humbert, 1968). The result of post harvest soil analysis for N, P, K, Ca, Na, Fe, Mn, Zn and Cu indicated that irrigation through all furrow and alternate furrow method under trash mulching had enhanced the availability of above nutrients as a result of better mobility of nutrients with adequate moisture supply and through the release of nutrients by the trash on account of degradation and mineralization. The above results are in agreement with the findings of Sundarsingh (1989) and Parameswaran (1993).

Physico chemical and biological properties of soil after the experiment

The depletion of available soil moisture in all furrow irrigation was relatively less than that under alternate furrow irrigation. The unirrigated furrow in skip furrow irrigation and farmer's practice of irrigating the crop once in a month had lesser available soil moisture than that of irrigated furrows. The soil temperature was also low in all furrow irrigation due to the greater moisture status in the soil. While skip furrow and farmer's practice of irrigation had increased the soil temperature considerably. This was reflected in the cane growth, yield attributes and cane yield recorded under skip furrow and farmer's practice of irrigation as discussed earlier under different sections. The difference in the available soil moisture between all and alternate furrow irrigation was remarkably higher in control than in trash mulched plots. Thus the application of trash at 5 t ha^{-1} was found to contract the stress caused by alternate furrow irrigation. It was clearly observed that in mulched plots soil moisture status was higher than control in both soil depths. The combination of trash mulching with alternate furrow irrigation economises the use of water. Therefore, it could be concluded that application of trash mulch at the rate of 5 t ha^{-1} under alternate furrow method of irrigation could save irrigation water without any loss in cane yield. The results are in line with the findings of Gosnell and Lonsdale (1977), Yadav (1986), Thind (1996) and Swamy *et al.* (1998).

The results of the post harvest properties of the soil indicated that irrigation through all furrow as well as alternate furrow irrigation had improved the physical properties of soil like bulk density, pore space distribution and maximum water holding capacity. The combination of trash mulching with either all or alternate furrow irrigation had shown appreciable improvement in the physical properties of soil after the experiments. This might be due to the enhanced rate of cane growth made under adequate soil moisture conditions which resulted in increased root proliferation and addition of more organic matter. Trash mulching might have also resulted in the progressive build up of soil organic matter. The present findings are in accordance with the inferences made by Clarsen *et al.* (1983), Ramaswami and Sree Ramulu (1983) and Sundarsingh (1989). Besides being an organic matter with its greater influence in creating favourable crumb structure in the soil, it might have favoured high degree of water stable aggregates providing better aeration in the root zone (King *et al.*, 1965).

Irrigation through all furrow method recorded higher values for organic carbon, available N, available P and available K. It has also increased the contents of Ca, Na, Fe, Mn, Zn and Cu in the soil after the experiment. But was comparable with the value obtained in alternate furrow irrigation. The trash application had also increased the availability of above nutrients as compared to control. The increased DMP especially by trash added naturally into the soil due to increased growth observed in all furrow as well as in alternate furrow might be the reason for increasing the soil fertility status. In addition to this, under high soil moisture status with optimum soil temperature, the root activity might have increased and enhanced root proliferation which resulted in the build up of organic matter in soil after the experimentation. The combination of trash mulching either with all or alternate furrow irrigation had improved the soil fertility status in general as compared to other treatment combinations. Application of trash has got marked influence in building up organic status of soil. The organic matter added into the soil and obtained through biomass production when undergoes microbial degradation resulted in the release of plant nutrients and made further additions to the soil pool. The present findings are in agreement with the results of Rajamannar *et al.* (1979), Motiwale *et al.* (1989) and Sundarsingh (1989).

The activity of soil enzymes like acid phosphatase, cellulase and urease increased remarkably in treatments with irrigation through all and alternate furrow irrigation. Similarly trash mulching had also favoured the activity of soil enzymes than the control plots.

Microbial population like bacteria, fungus and actinomycetes in the soil after the experiment had increased due to the combination of trash mulching either with all or alternate furrow irrigation. The increased activity of microbes might have favoured the enhancement of the soil enzyme activity resulting in the availability of more nutrients. This might have also attributed for the increase in the fertility status of soil.

Water use efficiency

Water use efficiency is the function of crop yield and total water use. Water use by a crop is governed by the vegetative cover including the root proliferation, climatic factors and water available for exploitation by the vegetation. Alternate furrow irrigation with trash mulching had remarkably increased the WUE but it was reduced considerably in all furrow irrigation with or without mulching and recorded lower values as compared to all other combinations of methods of irrigation and trash mulching.

In general, WUE was lesser with higher water use. Water use efficiency was higher where the cane yield was maximum with lesser expense of water (Singh and Mohan, 1994 and Gulati *et al.*, 1995). According to Durai *et al.* (1996) irrigation at lesser intervals increased the WUE compared to wider intervals. Pandian *et al.* (1992) and Patel *et al.* (1989) observed that alternate furrow irrigation showed better WUE and water use was reduced almost to one-third. In the present study alternate furrow irrigation with trash mulching recorded higher cane yield in both the years of experimentation and it was comparable with that of all furrow irrigation. This might be the reason for the treatment combination of alternate furrow irrigation with trash mulching to record higher values for WUE. The result revealed that a saving of water to the tune of 41 per cent was possible in alternate furrow with mulching as compared to all furrow irrigation with or without trash mulching. The results are in conformity with the findings of Pandian *et al.* (1992), Thanki *et al.* (1999) and Veeraputhiran *et al.* (1999).

Economics

The benefit cost ratio of all furrow irrigation was comparable with that of alternate furrow irrigation. Trash mulching had increased benefit cost ratio by 4.2 and 3.33 per cent over control in both plant crops. Among the treatment combination, trash mulching with alternate furrow irrigation had shown highest benefit cost ratio and was comparable with trash mulching under all furrow method of irrigation. Hence, it can be inferred that when irrigation is supplemented through alternate furrows under trash mulching, a substantial amount of water could be saved without any financial loss. Hence, the above agronomic practice can be adopted for economising the use of irrigation water and at the same time fetching more returns to the farmers. The skip furrow irrigation without trash cover had reduced benefit cost ratio considerably. It was also noticed that alternate furrow irrigation without trash mulch would cause reductions in financial returns compared to all furrow irrigation. The reduction in benefit cost ratio is estimated to be 2.4 and 3.2 per cent respectively in both plant crops. Hence, under water scarce situations as well as in areas with sufficient irrigation potential, it is recommended to adopt alternate furrow irrigation with trash mulching to cover more area under irrigation than all furrow irrigation with or without mulching.

Energetics

Alternate furrow irrigation had increased the values of energy productivity and energy use efficiency. Trash mulching had also increased the values as compared to control plots. Among the treatment combinations, the combination of alternate furrow irrigation with trash mulching had registered the highest values for both energy use efficiency and energy productivity. This again suggest that cane yield per unit of energy used with respect to inputs and energy in terms of output compared to the energy in terms of input increased by supplementing irrigation through alternate furrow under trash mulching. This could be due to the increased yield, high biomass production and high water use efficiency observed in alternate furrow irrigation under trash mulching as compared to other methods of irrigation. The farmer's practice of irrigation without any trash mulching registered lower values for both energy productivity and energy use efficiency.

Experiment No.2. Integrated Nutrient Management in Sugarcane

Growth attributes

There was an appreciable increase in plant height due to press mud application at 5 t ha^{-1} at all stages of growth and it was comparable with soil inoculation of Azospirillum at 10 kg ha^{-1}. Similarly the mineral nutrition with NPK at 100 per cent of the recommended dose had produced perceptible increase in plant height as compared to mineral nutrition at 75 per cent and 50 per cent of the recommended dose. The combinations of press mud with 100 per cent NPK at recommended dose had increased the plant height markedly and was comparable with press mud along with 75 per cent NPK and integrated use of Azospirillum with mineral nutrients at 100 per cent of the recommended dose. Application of chemical fertilizers at different doses of NPK without organic sources had shown inferior values and the height was reduced considerably.

Application of mineral nutrients in adequate quantities plays a pivotal role in changing the growth rate of cane. It results in the quick release and availability of plant nutrients to the cane. In addition to this the mineralization of press mud results in the slow release of macro and micro nutrients. Press mud besides supplying nutrients in readily available form to plants, also increases the organic carbon and organic matter content of the soil. It also reacts with applied and native reserve of nutrients rendering them available to plants. The above factors might have attributed for the increased height growth observed in press mud application with 100 per cent mineral nutrition. Similar results were reported by Prasad *et al.* (1976), Sinha and Prasad (1977) and Jayamani (1992).

Evidence indicated that the positive effects of Azospirillum inoculation was through altered root growth and subsequent effects on nutrient uptake. The Azospirillum which live on or in the roots release phytohormones which favours plant growth by inducing proliferation of lateral roots. This could be the possible reason for the increased height found with the use of Azospirillum inoculation with 100 per cent NPK application. The results are in accordance with the findings of Venkateswarlu and Rao (1983), Shinde *et al.* (1989) and Joshi and Zende (1998).

Press mud application at 5 t ha^{-1} had increased the rate of leaf production and number of nodes formed. It was comparable with soil inoculation of Azospirillum at 10 kg ha^{-1}. The leaf emergence rate as well as formation of nodes were reduced in control. Mineral nutrition with NPK at 100 per cent had appreciably increased the number of leaves and nodes formed as compared to NPK application at 75 per cent or 50 per cent of the recommended dose. Combined application of press mud with 100 per cent NPK at recommended dose had shown higher values for leaf emergence rate and number of nodes than its lower doses. The increased plant height and enhanced number of tillers might have contributed to a corresponding increase in the number of leaves and nodes. Continuous and steady supply of plant nutrients into the soil solution to match the required absorption pattern through integrated use of press mud with mineral nutrients at 100 per cent might have enabled the cane to meet the required nutrients for physiological processes which in turn would have increased photosynthetic efficiency and CO_2 assimilation, thereby influencing the growth attributes.

The capacity to produce tillers although an inherent behaviour of a variety, it could be altered favourably to certain extent and it is having a positive influence on the final millable cane count. Organic sources as well as mineral nutrition had influenced the tiller production. Application of press mud had enhanced the tiller production shoot formation and cane formed shoots significantly and it was comparable with soil inoculation of Azospirillum. Tiller production, shoot formation and cane formed shoots were reduced drastically in control. Mineral nutrition with NPK at 100 per cent recommended dose had appreciably increased tillering shoot formation and cane formed shoots as compared to NPK application at 75 and 50 per cent of the recommended dose. Integrated use of press mud at 5 t ha^{-1} along with NPK application at 100 per cent had increased the tiller production, shoot count and cane formed shoots remarkably. It was comparable with combined use of press mud with 75 per cent NPK application and conjunctive use of Azospirillum at 10 kg ha^{-1} along with 100 per cent NPK application.

Press mud besides being an excellent source of nutrients, adds organic matter, leads to better plant nutrition and promotes cation exchange capacity. It also include ameliorative effects in acid soil as it has got positive correlation between soil properties and crop yield (Bawaskar, 1982 and Yadav, 1995). The microbial activity in the soil was also improved substantially due to press mud application. Inubushi and Watanabe (1988) considered that microbial biomass is a small but most active pool of bioelements. The above factors might be the reasons for the favourable growth conditions which imparted an increased uptake of plant nutrients in press mud amended plots with chemical fertilizers at 100 per cent NPK and resulted in the higher rate of tiller production. The present findings are in agreement with the results of Rakkiyppan and Saminathan (1999), Bangar *et al.* (2000) and Nagaraju *et al.* (2000).

The amount of dry matter produced by a crop plant depends upon its photosynthetic efficiency (Arnon, 1975). The effectiveness of photosynthesis to a greater extent is a function of leaf number. The rate of increase of DMP was slow during the formative phase, very rapid during grand growth phase and again slow thereafter up to maturity phase. Press mud application at 5 t ha^{-1} had markedly enhanced the DMP by trash, green tops and stem at all stages of growth. It was comparable with Azospirillum inoculation and green manuring through intercropping cowpea. The lowest values for DMP by trash green tops and stem were associated with control. Mineral nutrition with NPK at 100 per cent recommended dose had remarkably increased the DMP by trash, green tops and stem as compared to its 75 per cent or 50 per cent rate. Combined application of press mud at 5 t ha^{-1} with 100 per cent NPK had produced maximum dry matter accumulation in trash, green tops and stem and was comparable with 75 per cent mineral nutrition. Application of chemical fertilizers alone at 100 per cent or its lower rates with trash application at the rate of 10 t ha^{-1} had decreased the individual and total dry matter production.

Growth is the irreversible gain in dry matter and it is the sum total of vital metabolic processes of cell division and cell enlargement. There was remarkable increase in growth attributes like plant height, leaf production rate and number of nodes formed, tiller production, shoot count and cane formed shoots in integrated use of press mud with mineral nutrients at 100 or 75 per cent or with the combined use of Azospirillum inoculation with mineral nutrition at 100 or 75 per cent. The expression of these growth attributes at higher rate might have resulted in the increased DMP by trash, green tops and stem, thereby increasing the total DMP.

Several Scientists (Virendrakumar and Mishra, 1991 and Gupta *et al.*, 1986) have documented the supremacy of press mud in improving the dry matter production in sugarcane. The reason for such an increase in DMP was due to the high content of N, P, K and other nutrients available in the press mud. The use of press mud might have supplied plant nutrients in the forms readily available to plants and would have also reacted with native nutrients in the way that enhanced their availability to crops. The work of Kumaresan *et al.* (1985) was in agreement with the present findings. Apart from this, application of press mud might have improved soil physical conditions resulting in better root proliferation with consequent increase in DMP as quoted by Patil and Shingte (1981). The above results corroborates with the findings of S.B.I., (1998), Sharma *et al.* (1999), Srinivasan and Hari (1999) and Bangar *et al.* (2000). The chemical fertilizers have the capacity to supply only major nutrients unlike organic sources which supply both macro and micronutrients essential for the healthy growth and development of sugarcane. The inadequate supply of nutrients during the initial stages of growth would have depressed the uptake of plant nutrients. This might have reduced the cane growth and lowered the values of all growth characters. It can be the possible reason ascribed for the drastic reduction of DMP in trash, green tops and stem in treatments without any organic sources either at its lower or higher NPK level.

Growth analysis

The growth characteristics studied revealed that application of press mud had positively influenced the growth indices like LAI, LAR, CGR and SLA. Azospirillum inoculation had also shown comparable values with that of press mud application. But the control treatments had shown reduced values. Mineral nutrition with NPK at 100 per cent had increased the values of LAI, LAR, SLA and CGR remarkably as compared to NPK application at 75 per cent and 50 per cent. The interaction exhibited had shown that the combined application of press mud at 5 t ha^{-1} along with NPK at 100 per cent had recorded higher values for the above growth indices and was comparable with press mud application with NPK at 75 per cent and Azospirillum inoculation with NPK at 100 per cent. Application of chemical fertilizers without organic sources had reduced the values considerably.

Increased plant height and enhanced number of tillers observed with the integrated use of chemical fertilizers with either press mud or Azospirillum inoculation might have contributed to a corresponding increase in the number of leaves which in turn increased the LAI. The increased rate of dry matter accumulation in green tops, total DMP and increased leaf area due to increased rate of leaf production might have favoured for an enhancement in the LAR and CGR.

The reduced number of leaves would have decreased the leaf area considerably and the DMP was also reduced. As a result of this the dry matter production in relation to the leaf area might be large. This might have contributed to the increased values for NAR associated with NPK application at 50 per cent or 75 per cent NPK without organic nutrition.

Yield attributes

Millable cane count is the most important yield attributing factor as proved by several path analysis studies (James, 1971, Kairwal and Babu, 1975 and Hapse and Repale, 1999). Millable cane count increased appreciably with press mud application and was comparable to that of Azospirillum inoculation. Mineral nutrition with NPK at 100 per cent had conspicuously increased the number of millable cane as compared to its 75 per cent or 50 per cent rates. It was also noticed that integrated use of press mud with mineral nutrition at 100 per cent NPK had produced the highest number of millable canes and was comparable with press mud application with 75 per cent NPK. Application of NPK alone at 50 per cent or 75 per cent of the recommended dose had reduced the millable cane count drastically.

The final output of sugarcane production mainly depends on the number of millable cane. Wrong-Chong and Martin (1981) reported that early tillering in sugarcane was desirable for maximum cane yield and sucrose content at harvest. Significant role played by N in enhancing the number of millable canes has been highlighted by several workers in the past. The increased rate of tiller production, shoot count and cane formed shoots observed with integrated use of press mud with NPK application at 100 per cent or 75 per cent might have resulted for the enhancement of millable cane. Tillering has got positive relationship with number of millable cane as reported by Asokan (1981) and Rakkiyappan (1987). The improvement made in the physical properties particularly moisture retention permeability and enrichment of plant nutrients in the soil due to press mud application and biomass addition and its degradation in soil might have mediated a favourable environment for the growth and development of cane which might have resulted for increasing the number of millable canes. The present finding is in accordance with the results of Swamy *et al.* (1995), Durai (1997), Sharma *et al.* (1999) and Nagaraju *et al.* (2000).

The number of millable cane is a resultant of the survival of the tillers produced earlier. Combined use of Azospirillum with 100 per cent NPK application had also increased the millable cane count. This could be due to the complementary interaction of biofertilizers with inorganic N. The present results are in conformity with the findings of Kathiresan *et al.* (1993), Joshi and Zende (1998), and Thopate and Jadhav (1999).

In treatments with mineral nutrition at 50 per cent or 75 per cent of the recommended dose of NPK alone had reduced tiller production, shoot count and cane formed shoots due to inadequate supply and low availability of plant nutrients. This might have affected the millable cane production and recorded lower values for millable cane count.

In sugarcane production cane length assumes practical significance as it is directly related to productivity. Application of press mud at 5 t ha^{-1} was found to enhance the cane length appreciably to the highest magnitude and it was followed by Azospirillum inoculation at 10 kg ha^{-1}. Cane length was reduced considerably in control. Mineral nutrition with NPK at 100 per cent had accentuated the cane length remarkably as compared to 75 per cent or 50 per cent of the recommended dose. The interaction effect had shown that combined application of press mud at 5 t ha^{-1} with recommended dose of NPK at 100 per cent had markedly increased the cane length and it was comparable with press mud application along with NPK at 75 per cent and Azospirillum inoculation with 100 per cent recommended dose of NPK. The chemical fertilizer application without any organic sources at different doses of NPK at 50, 75 and 100 per cent had produced shorter canes. The lengthier canes obtained due to integrated use of press mud with recommended dose of NPK might be due to the steady supply of plant nutrients in adequate quantities and increased availability of nutrients in the soil to meet the nutritional requirement of cane. It also brings an additive effect for the recovery of nutrients from the fertilizers and minimises the nutrient loss from the soil which is a common phenomenon in most of the soils. The increased uptake of nutrients might have improved photosynthetic efficiency and this would have increased the CO_2 assimilation efficiency with concomitant increase in growth and dry matter production. The increased cane length recorded under combined use of organic sources with inorganics might be due to the cumulative increase in cane height noticed at formative, grand growth and maturity phase of sugar cane. The present findings corroborates with the studies made by Rakkiyappan and Saminatham (1999) and Bangar *et al.* (2000). Lal and De (1953), Alexander (1975) and Joshi and Zende (1998) correlated sub normal photosynthesis at reduced N levels. This would be the reason for the reduced cane length observed in NPK application at 50 or 75 per cent of the recommended dose without any organic sources.

The final weight of cane depends mostly on cane length, but the contribution made by cane girth could not be ruled out. Cane girth increased conspicuously with the application of press mud at 5 t ha^{-1} and recorded comparable values with that of Azospirillum inoculation at 10 kg ha^{-1} and green manuring through intercropping cowpea. The radial growth of cane was reduced significantly in control at all stages of growth. The mineral nutrition with NPK application at 100 per cent had recorded higher values for cane girth as compared to NPK application at 75 per cent and 50 per cent. The interaction effect showed that combined use of press mud at 5 t ha^{-1} with 100 per cent NPK had increased the cane girth and was comparable with press mud application along with NPK at 75 per cent and Azospirillum inoculation with NPK application at 100 per cent.

The increased cane growth observed with the combined use of press mud with recommended dose of NPK had increased the total DMP as well as the dry matter accumulation in stem. The increased rate of dry matter accumulation in stem might have favoured for the enhancement of radial growth at all stages of growth resulting in maximum cane girth. Integrated use of organics with inorganics would have provided continuous and steady supply of nutrients ensuring balanced nutrition for the growth of crop. The results are in line with the findings of Joshi and Zende (1998) and Rakkiyappan and Saminathan (1999). The nutrients released from NPK application at 75 per cent or 50 per cent was not sufficient enough to meet the nutritional requirement of the cane resulting in reduced cane growth. This would have depressed the uptake of all plant nutrients, decreased the DMP and dry matter accumulation in stem. This might have attributed to the reduced rate of radial growth resulting in the formation of thinner canes.

The weight of single cane at harvest is yet another important yield attributing parameter. There was a conspicuous increase in the weight of single cane due to the application of press mud at 5 t ha^{-1} and was comparable with Azospirillum inoculation. Single cane weight was found lowest in treatments without organic sources. NPK application with 100 per cent of the recommended dose had remarkably increased the cane weight as compared to that of 75 or 50 per cent rates. Integrated use of press mud with NPK at 100 per cent had shown positive influence on single cane weight and the values were comparable with that of press mud application with 75 per cent NPK and Azospirillum inoculation with 100 per cent NPK. This could be due to the favourable condition created by the judicious application of organic sources with inorganic fertilizers, enhancing the availability of native and applied nutrients. It might have exerted positive influence on the fertility status of soil, thereby increasing the cell activities and plant growth. Application of NPK at 100 per cent recommended dose along with organic sources like press mud or Azospirillum inoculation had increased appreciably the height, cane length, cane girth, number of nodes and DMP as discussed earlier. The cumulative effect of all these parameters would have increased the single cane weight. The results are in line with the studies made by Rakkiyappan and Saminathan (1999) and Bangar *et al.* (2000).

Cane yield, Sugar yield and Jaggery yield

There was remarkable increase in cane yield due to press mud application and recorded an increase of 5.51 per cent as compared to soil inoculation of Azospirillum. While it was 9.58 per cent over green manuring through intercropping cowpea. Acetobacter inoculation and trash application had produced comparable cane yields. Cane yield was reduced drastically in control and the decrease was to the tune of 27.22 per cent as compared to press mud application.

In the present study it was observed that application of press mud had increased the organic carbon availability of N, P and K content in the soil after the experiment and also enhanced the availability of Ca, Fe, Mn, Zn and Cu content in the post harvest soil. This again indicate the favourable growth conditions provided due to the application of press mud which might have increased the uptake of all the above nutrients resulting in maximum cane growth and yield. Mineral nutrition with 100 per cent NPK application had enhanced the cane yield by 3.76 per cent over NPK application at 75 per cent and 8.73 per cent compared to NPK application at 50 per cent of recommended dose. Prominent response of sugarcane to fertilization is a proven result in many soil situations. The nutrient demand of the crop during the early growth phase could not be met from the soil alone but warrants an external addition through fertilizers. Sugarcane being a heavy feeder of nutrients, shows response to the graded levels of nutrients which becomes non-linear at higher levels.

In the present investigation, mineral nutrition with NPK at 50 or 75 per cent of the recommended dose was quite inadequate to meet the nutritional requirement of the crop. As a result of this, the positive influence of these applied nutrients on growth attributes as well as yield attributes was reduced and ultimately the cane yield was decreased. However, NPK application at recommended dose exhibited maximum effects on the growth parameters, thereby influenced the cane yield positively. The beneficial role of N in enhancing the cane production was reported by Singh *et al.* (1981), Singh and Singh (1983), Singh *et al.* (1999), Sathyavelu *et al.* (1999) and Hamullah Azim *et al.* (2000). The findings of Singh *et al.* (1991a), Lestari (1993) and Dang *et al.* (1996) could be cited to mark the response of P in sugarcane. While the documentation made by Subramanian *et al.* (1992), Bangar and Sharma (1992) and Yaduvanshi and Singh (1999) highlighted the importance of K nutrition in sugarcane productivity.

The interaction effect between organic sources and mineral nutrition was significant. Integrated use of press mud with 100 per cent of the recommended dose of NPK had increased the cane yield appreciably and the cane yield enhanced to the tune of 4.51 and 11.04 per cent as compared to press mud application with 75 per cent and 50 per cent NPK and 7.62 per cent over Azospirillum inoculation with 100 per cent NPK application. But there was a remarkable decrease in cane yield and it was to the tune of 32.16 per cent when resorted to mineral nutrition with 100 per cent NPK alone as compared to combined application of press mud with 100 per cent NPK.

Studies have also revealed that press mud application at 5 t ha^{-1} along with 75 per cent of the recommended dose of NPK had shown an increase of 2.97 per cent over Azospirillum inoculation with 100 per cent NPK and 7.65 per cent over green manure application with 100 per cent NPK, 10.06 per cent over Acetobacter inoculation with 100 per cent NPK, 16.86 per cent over trash application with NPK at 100 per cent and 26.44 per cent over NPK application at 100 per cent alone.

The combined use of mineral nutrition at 100 per cent along with either green manuring or Acetobacter inoculation had produced comparable cane yields, but lesser than Azospirillum inoculation with 75 per cent NPK and press mud application with 50 per cent NPK. Trash application with 100 per cent NPK had recorded an enhancement in cane yield to the tune of 8.20 per cent over chemical fertilizer application with 100 per cent NPK alone. However, the combinations of NPK with green manuring and NPK with Acetobacter inoculation had increased the cane yield compared with all treatment combination of trash application. The lowest cane yield was associated with chemical fertilizer application alone at 50 per cent of the recommended dose of NPK and the cane yield decreased to the tune of 36.50 per cent as compared to press mud application at 5 t ha^{-1} with 100 per cent NPK.

The yield of a crop variety is considerably affected by the plant characteristics which attribute to the growth of the plant in general and yield of the crop in particular. Quintus (1923) and Singh and Singh (1954) identified the yield components affecting the final yield of sugarcane as number of millable cane per unit area and single cane weight which in turn is determined by the height growth, girth and number of nodes of the cane. Studies on correlation revealed that cane yield per ha was significantly and positively associated with number of millable canes, cane height, cane girth and single cane weight. Path coefficient analysis indicated that tillering, cane height, cane girth, sucrose per cent, CCS per cent were the important components of cane yield (Malavia and Ramani, 1992 and Hapse and Repale, 1999).

Integrated use of press mud with recommended dose of NPK at 100 per cent had favourably influenced all the growth attributes like plant height, leaf production rate and number of nodes formed, tillering, shoot count and cane formed shoots resulting in the increased rate of DMP. The uptake of major and micronutrients were also increased on account of increased rate of DMP and enhanced the absorption of plant nutrients. The above factors might have attributed to the better expression of yield attributes like cane length, cane girth, single cane weight and millable cane count. The increased rate of cane growth coupled with better expression of yield attributes might have contributed for enhancing the cane yield in integrated use of press mud with 100 per cent NPK application. It was comparable with press mud application with recommended dose of NPK at 75 per cent for all the growth characters yield attributes and nutrient uptake. But the magnitude of variation in cane yield was only marginal. Hence, it is possible to save 25 per cent of the recommended dose of NPK when press mud is applied at 5 t ha^{-1}. The above results clearly suggest that in an integrated approach press mud is the best organic source and under such circumstances even 25 per cent reduction in NPK is possible.

Manickam (1993) opined that the use of organic manures in combination with inorganic fertilizers increased crop production without impairing soil health. According to Datta and Gupta (1983) the application of press mud effectively increased soil pH, exchangeable Ca, Mg, available P and lime potential of soil. Press mud application also improves the soil structure, better percolation permeability and aeration (Rakkiyappan, 1982) and Rakkiyappan *et al.* (1986). The results of the post harvest soil also showed that application of press mud along with inorganic fertilizers had improved the physico-chemical properties. The bacterial, fungal and actinomycetes population in the soil was increased. As a result of this, the activity of soil enzymes were also increased. The activity of phosphatase, urease and cellulase in post harvest soil was found comparatively higher with combined application of press mud with inorganic fertilizer at 100 per cent NPK.

Organic sources has got advantages like nutrient conservation, capacity to release nutrients at slower rate, improvement of soil physico-chemical and biological conditions. The above factors discussed might have favoured for the combination of press mud with inorganic fertilizers to show higher relative efficiency in increasing the cane yield. The results are in accordance with the findings of Rakhiyappan and Saminathan (1999), Sharma *et al.* (1999), Rao and Veeranna (1999) and Nagaraju *et al.* (2000).

Evidence indicated that the positive effects of Azospirillum inoculation was through the excretion of biologically fixed nitrogen, production of growth hormones and growth regulators and stimulation of nutrient uptake (Rennie, 1980; Tien *et al.*, 1979 and Lin *et al.*, 1983). It also involves in the proliferation of root system and alters the root growth with increased mineral uptake (Okon, 1982). Srinivasan and

Hari (1999) reported that Azospirillum inoculation in sugarcane had significantly improved the root biomass as compared to control. It was observed that the growth of Azospirillum associated with plant root was stimulated by the presence of inorganic nitrogen (O'Hara *et al.*, 1987). The above factors might have exerted positive effect on nutrient uptake and would have influenced growth as well as yield attributes. The increased cane growth might have resulted for the higher cane yield noticed with integrated use of Azospirillum inoculation with 100 per cent NPK at recommended dose. The present findings corroborates with the results of Thakur and Singh (1996), Joshi and Zende (1998), Kathiresan and Manoharan (1999) and Muthukumaraswamy *et al.* (1999).

According to Yadav *et al.* (1987) the mineralization of trash takes place at a slower rate due to its wider C/N ratio (124:1) and results in the slow and partial release of nutrients. It also contains very little amount of readily available nutrients. This could be the possible reason for the combined use of trash with different doses of NPK to produce lesser cane yields as compared to other combinations of organic sources with inorganic fertilizers.

There is no second opinion that fertilizers contribute a major share for enhancing the productivity of cane. But indiscriminate use of chemical fertilizers cause serious problems to soil health (Gunjal, 1991). Intensive cultivation without the addition of organic sources affects the crop productivity. It is also well realised that substantial quantities of fertilizers applied to the soil are not available to the plants. A sizeable portion is lost by various mechanism operating in the soil. This could be the reason for the treatments with chemical fertilizer application at 100 per cent alone to record lower values for growth attributes and yield parameters.

This would have resulted for the reduced levels of cane production as compared to integrated use of organic sources with inorganic fertilizers. The inadequate supply of plant nutrients and poor physico-chemical and biological conditions prevailed in the treatments with chemical fertilizer application alone at 50 per cent or 75 per cent of the recommended dose of NPK had not promoted the cane growth as it was unable to meet the nutritional demand of the crop. The nutritional imbalance caused might have affected photosynthetic efficiency and total DMP and the cane yield was reduced considerably. The results are in line with the findings of Mathywathany (1998).

The amount of sugar produced per unit area is important in the sense that it represents the economic produce in sugarcane. The difference in sugar yield among the treatments were so striking and highly conspicuous. Sugar yield showed generally a similar trend to various treatments as that of cane yield. There was substantial increase in sugar yield with the application of press mud at 5 t ha^{-1} and recorded comparable values with that of Azospirillum inoculation. Sugar yield decreased to the tune of 9.82 and 6.72 per cent with green manuring and 14.06 and 14.90 per cent with Acetobacter inoculation as compared to press mud application in both plant crops. The sugar yield was decreased drastically in the treatment without any organic manure applied.

Mineral nutrition with NPK at 100 per cent of the recommended dose has increased the sugar yield appreciably as compared to NPK application at 75 per cent and 50 per cent of the recommended dose. Gopal Rao *et al.* (1976) observed that sugar yield increased significantly by the application of both phosphorus and potassium along with N. Since the NPK levels did not significantly alter the juice, sucrose and CCS per cent as observed the increase in sugar yield obtained under mineral nutrition are mainly through increased cane production due to NPK application. The results are in accordance with the findings of Clindagave (1999) and Sathyavelu *et al.* (1999), with N nutrition, Lestari (1993) and Dang *et al.* (1996) with P nutrition and Yaduvanshi and Singh (1999) with N and K nutrition.

Combined application of press mud at 5 t ha^{-1} with 100 per cent NPK had increased the sugar yield markedly and recorded a yield increase of 3.36 and 3.88 per cent over press mud application with 75 per cent NPK. While it was 0.89 and 8.38 per cent as compared to Azospirillum inoculation with 100 per cent NPK application. The combinations of inorganic fertilizers with green manuring and Acetobacter inoculation had produced comparable values for sugar yield. But was inferior to the combinations of press mud and Azospirillum inoculation with inorganic fertilizers. Application of inorganic fertilizers at 100 per cent NPK alone had reduced the sugar yield considerably and it was to the tune of 35.38 and 30.53 per cent compared to press mud application along with 100 per cent NPK. The sugar yield was lowest with the application of chemical fertilizers at 50 per cent and 75 per cent of the recommended dose of NPK without organic sources.

It is a known fact that sugar yield is a function of cane yield and CCS per cent and adequate cane production is a pre-requisite for enough storage and steady transport of metabolites required for sugar production. Continuous and steady supply of nutrients due to the mineralization of organic sources and release of readily available forms of nutrients from the inorganic fertilizers into the soil solution might have provided favourable conditions for the absorption of required nutrients for physiological processes. In the present study it was evident that combined application of press mud with inorganic fertilizers at 100 per cent NPK, 75 per cent NPK and Azospirillum inoculation with 100 per cent NPK improved the absorption of plant nutrients from the soil which in turn increased nutrient uptake. This might have promoted the supply of assimilates from source to sink thereby increasing the yield attributes and sugar yield. The results corroborates with the findings of Swamy *et al.* (1995), S.B.I., (1998), Sharma *et al.* (1999), Kathiresan and Manoharan (1999) and Nagaraju *et al.* (2000).

The results of jaggery yield revealed that like sugar yield there was a perceptible increase in jaggery production due to press mud application at 5 t ha^{-1} and was comparable with Azospirillum inoculation. Similarly, green manuring with cowpea and Acetobacter inoculation had produced comparable values for jaggery yield but lower than press mud application. Jaggery yield was reduced considerably in control. Application of NPK at 100 per cent had increased the jaggery yield appreciably as compared to 75 and 50 per cent NPK application. Since jaggery yield is the function of cane yield and jaggery recovery, the reasons for the individual effect and combined effect of treatments as attributed under the cane yield also hold good to the jaggery yield.

The interaction effect between organic sources and mineral nutrition was significant. The combined use of press mud with 100 per cent recommended dose of NPK had produced the highest jaggery yield and it was comparable with that of press mud application with 75 per cent NPK or Azospirillum inoculation with 100 per cent NPK. The considerable positive response observed with press mud application along with 100 per cent NPK with reference to cane yield is to be recalled at this juncture. This kind of comparative analysis contemplates the nutrient support given by the combination of inorganic fertilizer with press mud and Azospirillum inoculation throughout the growth phase of the cane. The increased plant nutrition would have aided better cane growth leading to increased cane yield and jaggery recovery which might have resulted in enhancing the jaggery production. The present findings are in accordance with the studies made by Chauhan *et al.* (1991), Sushila and Gupta (1992) and Patil and Shingte (1992).

Juice quality

The juice extracted from the cane assumes greater importance as it is significantly and more directly related with the commercial output of sugarcane. The nature and composition of the juice decides the quality of the final product. Attempts are to be strengthened to improve the composition of the juice particularly with more commercial cane sugar content to boost the productivity of sugar.

Azospirillum inoculation had increased the juice recovery, improved the sucrose content, CCS per cent, SMT Brix and purity coefficient and it was comparable with press mud application. The reducing sugar as well as titrable acidity was decreased significantly in the above treatments. Juice recovery as well as quality parameters were affected in control. It had recorded lower values for sucrose content, CCS per cent, SMT Brix and purity coefficient, but increased the values of reducing sugar and titrable acidity.

Azospirillum inoculation results in the production of growth hormones and stimulates the uptake of nutrients (Lin *et al.*, 1983). Biofertilizers may contribute to the synthesis of growth hormones and growth regulators like nicotinic acid, pantothenic acid, pyridoxine, biotin, heteroauxin and gibberellin which accelerate plant growth in addition to fixation of atmospheric N (Mishustin, 1970, Badgire and Bindu, 1976). The phytohormones and other growth regulators liberated in the treatments due to Azospirillum inoculation might have produced favourable conditions in the soil for cane growth and nutrient uptake. This could have influenced the juice quality and resulted in the improvement of quality parameters. Perumal (1999) concluded that sugarcane grown under organic manure had improved the juice quality and obtained higher CCS per cent as compared to cane grown with chemical fertilizer application alone. This might be the possible reason for obtaining improved values for juice quality due to press mud application. The results obtained are in conformity with the findings of Sharma *et al* (1999) and Rakkiyappan and Swaminathan (1999).

Mineral nutrition did not exert any positive influence on juice quality. However, mineral nutrition with 100 per cent NPK had increased the juice recovery and had shown numerically higher values for sucrose content, CCS per cent, SMT Brix and purity coefficient. It was comparable with NPK application at 75 per cent. While mineral nutrition with 50 per cent of the recommended dose of NPK had depressed the quality parameters.

Balanced fertilization is necessary to achieve higher cane yields with good juice quality and higher sugar recovery. Supply of deficient nutrient will improve the quality and tonnage. But disproportionate application of nutrients would lower the quality of cane and tonnage. The contents of NPK in juice are important as far as sucrose content, CCS per cent, SMT Brix and reducing sugars are concerned (Niphande and Ghorpade, 1998). In order to get maximum sugar recovery, juice N, P_2O_5 and K_2O should be below 100, 300 and 1000 ppm, respectively (Perumal, 1989).

It was observed that NPK application at 50 per cent or 75 per cent of the recommended dose without organic sources had decreased the values of all quality parameters. It could be due to the nutritional imbalance created and reduced availability of plant nutrients for luxuriant growth of cane. This might have decreased the uptake of plant nutrients and altered the composition of cane juice. The NPK contents in the juice composition might have attributed for the decreased values of the quality parameters. The present findings corroborates with the results of Sathyavelu *et al.* (1999), Singh *et al.* (1999) and Yaduvanshi and Singh (1999).

Jaggery quality

Quality of jaggery is directly related to the quality of juice. High quality juice having low reducing sugar/sucrose ratio and high purity percentage is considered to be good for jaggery manufacturing (Chauhan *et al.*, 1991). Soil inoculation with Azospirillum had increased the values of jaggery sucrose, jaggery brix and jaggery purity and it was almost comparable with press mud application. But the reducing sugars in the jaggery was decreased considerably due to reduced rate of inversion. The quality parameters of jaggery was depressed in control.

Good quality jaggery is obtained from juice with high sucrose, purity, less reducing sugars and amino acid nitrogen. In the present study it was observed that the juice quality was improved with the application of Azospirillum inoculation and press mud application where the sucrose content, CCS per cent, SMT Brix and purity coefficient were increased, whereas titrable acidity as well as reducing sugar was decreased considerably. The above quality parameters would have attributed for getting jaggery with improved quality in treatments with Azospirillum inoculation and press mud application. The results are in line with the findings of Mishra *et al.* (1965) and Patil and Shingte (1982). The magnitude of variation between treatments due to mineral nutrition on jaggery quality has not reached statistical significance in almost all cases and the results were not consistent. However, mineral nutrition with NPK at 100 per cent had registered numerically higher values for jaggery sucrose, brix and purity per cent as compared to NPK application at 75 or 50 per cent in which there was substantial increase in the content of reducing sugars.

The interaction effect was not consistent. However, the combination of chemical fertilizers either with Azospirillum inoculation or press mud application had shown comparatively higher values for jaggery quality and decreased the levels of reducing sugars as compared to the application of chemical fertilizers alone at different doses.

Mineral nutrition with NPK is important for producing cane with better quality of jaggery. It was reported that higher dose of nitrogenous fertilizers resulted in improving the glucose content, but reduced the sucrose content (Rege *et al.*, 1963 and Misra *et al.*, 1964). Nitrogen application at optimum levels recorded highest sucrose and purity per cent. N application at 200 kg ha^{-1} along with 115 kg each of P_2O_5 and K_2O was found to be beneficial for the preparation of quality jaggery and for increasing the recovery of jaggery (Wandre *et al.*, 1985 and Patil and Shingte, 1982).

In the present investigation, it was observed that mineral nutrition with NPK at 50 or 75 per cent of the recommended dose without organic sources had affected the cane production and depressed the juice quality parameters as it had registered higher values for reducing sugars titrable acidity and lower values for sucrose, CCS per cent and purity coefficient due to inadequate supply of plant nutrients, imbalance in the absorption and uptake of nutrients and its improper assimilation and utilization in the metabolic activities. The plant nutrition below the optimum dose might have resulted for the reduced recovery of jaggery and adverse effects on the quality characters of jaggery.

Nutrient uptake

Sugarcane being a heavy feeder of nutrients may putforth adequate response to the nutrients though not linear at higher levels. Prominent response of sugarcane to fertilizer is a proven result in many soil situations. Even in fertile soils sugarcane responds well to external inputs as the demand of this crop during the early growth phase could not be met from the soil alone. The uptake of N, P and K by trash green tops and stem enhanced appreciably due to press mud application and was comparable with Azospirillum inoculation. The uptake was reduced in trash application and control. While green manuring with cowpea and Acetobacter inoculation had recorded comparable values and had shown enhanced uptake as compared to trash application and control. Mineral nutrition with NPK at increased levels have increased the uptake of N, P and K by trash, green tops and stem. The interaction effect was significant. Integrated use of press mud at 5 t ha^{-1} along with NPK application at 100 per cent had markedly enhanced the uptake values. While press mud application along with 75 per cent NPK had shown comparable values with that of Azospirillum inoculation with 100 per cent NPK.

The total uptake of NPK which is the sum total of the uptake made by trash green tops and stem had followed the same trend as mentioned above.

The total uptake of Ca, Fe, Mn, Zn and Cu increased remarkably with Azospirillum inoculation as well as press mud application at all stages of growth. The uptake values were lowered in control. Green manuring through intercropping cowpea and Acetobacter inoculation had recorded comparable uptake values for Ca, Fe, Mn, Zn and Cu and was greater than trash application. Increasing levels of NPK had appreciably enhanced the total uptake of Ca, Fe, Mn, Zn and Cu. The interaction effect revealed that the conjunctive use of Azospirillum at 10 kg ha^{-1} with NPK application at 100 per cent had recorded increased uptake values and was comparable with press mud application at 5 t ha^{-1} with 100 per cent NPK and press mud application at 75 per cent NPK. Application of NPK at 50 per cent, 75 per cent or 100 per cent of the recommended dose alone had depressed the uptake of Ca, Fe, Mn, Zn and Cu.

The root biomass is a healthier index for vigourous growth of sugarcane plant since it supports the above ground plant parts. Application of press mud improves the physical properties of soil like structure, porosity and water holding capacity resulting in better growth (Parameswaran, 1985). In the present investigation it was observed that application of press mud with different doses of mineral nutrients had improved the physical properties of the post harvest soil. The application of press mud results in the release of major and minor nutrients when it undergoes mineralization. This would have contributed to the increased availability of plant nutrients and addition of organic matter to the soil. There was enhancement in the availability of plant nutrients in the post harvest soil due to the combined use of press mud with mineral nutrients. This has resulted in an increase in fertility status of the soil and provided a better environment for high root development favouring increased absorption of plant nutrients and better nutrient uptake. This would have influenced the growth attributes and resulted in high leaf surface area promoting photosynthetic efficiency and dry matter accumulation at a rapid rate.

Soil organic matter has got the property of attracting and retaining mineral nutrients on its surface in the forms available for uptake of plants (King *et al.*, 1965). The release of absorbed nutrients from the organic matter added to the soil through organic sources might have favoured for the increased absorption of nutrients by the crop resulting in the better growth and higher nutrient uptake. Addition of press mud helped in high N recovery due to the slow release of N, reduced leaching and its gaseous losses. The results are in conformity with the findings of Singh *et al.* (1982), Patil and Kale (1983), Yaduvanshi and Yadav (1991), Jayamani (1992), Jayamani and Devarajan (1995) and Bangar *et al.* (2000).

Azospirillum inoculation causes proliferation in the roots by apparently invading the internal parts and promoting root hair development and branching (Patriquin *et al.*, 1983 and Kapulnik *et al.*, 1983). The altered root growth might have resulted in higher nutrient uptake and improved the water status in the plants. It was also reported that Azospirillum inoculation increased nutrient availability by altering root surface characteristics involved in nutrient uptake (Okon and Kapulnik, 1986 and Okon *et al.*, 1988). Growth promotion due to production of plant growth regulators besides biological N fixation with integrated use of Azospirillum with mineral nutrients might have exerted positive influence on all growth attributes and resulted in the enhanced rate of cane growth and total dry matter production. The above factors were the possible reasons for the perceptible uptake of plant nutrients with the combined use of Azospirillum inoculation along with 100 per cent NPK application at recommended dose. Perceptible variations observed due to the organic sources and levels of NPK on the uptake of plant nutrients could be ascribed to the increased rate of DMP coupled with the enhanced absorption of plant nutrients, since the uptake is merely the multiplication of DMP and concentrations of nutrients in plant. The results are in accordance with the findings of Lin *et al.* (1983).

In spite of the improved performance of high analysis fertilizers, it is now well realised that substantial quantities of fertilizer applied to the soil may not be available to the plants. This might be the reason for the treatments with NPK application at 100 per cent alone to record comparatively lower values for nutrient uptake than integrated use of organics with inorganic fertilizers.

Physical properties of soil

The organic sources have remarkably improved the physical properties of soil consistently as compared to control. Trash application at 10 t ha^{-1} had lowered the values of bulk density, enhanced pore space distribution and maximum water holding capacity and it was statistically on par with press mud application. The variation due to mineral nutrition and its interaction effects were not significant. However, the combination of chemical fertilizers with either trash or press mud application had improved the physical conditions of the soil as compared to the application of chemical fertilizers alone or the combinations of other organics with fertilizers.

Organic sources play a vital role in stabilizing the soil structure and other physical phenomenon occurring in the soil thereby favouring the plant growth. The organic sources on biodegradation, release organic acids which will act as binding agents for soil aggregation. Due to the increase in organic matter and formation of humus, the bulk density was decreased. This would have favourably increased water holding capacity, total soil porosity and infiltration rate as observed in treatments with trash and press mud application due to its bulkiness and subsequent degradation. The inoculation of biofertilizers had enhanced the yield, but improved the physical properties of the soil to lesser extent. The favourable influence of trash application and press mud application on the physical properties of soil has been reported by George (1982) Rakkiyappan (1982), Rakkiyappan *et al.* (1986), Yadav *et al.* (1994) and Sagwal and Kumar (1998).

Chemical properties of soil

Organic sources had exerted considerable influence on the fertility status of the post harvest soil compared to control. This is attributed to the release of major and micronutrients from organic sources incorporated due to steady and slow mineralization process as it is fairly resistant to decomposition but mineralized at slower rate.

The organic carbon and available N status in the soil after the experiment enhanced remarkably with trash application and it was comparable with press mud application and green manuring with cowpea. There was perceptible increase in available P and K status with press mud application. Same trend was observed for exchangeable Ca and was comparable with trash application.

Soil receiving organic sources regularly needs no additional application of secondary and micronutrients (Kumaraswamy, 1990). The micronutrient status of the soil after the experiment was also markedly improved due to organic sources. Inoculation with Azospirillum and Acetobacter had improved only the Fe content. There was appreciable increase in Mn content in the soil after the experiment due to press mud and trash application. Zinc content increased conspicuously with press mud application, while Cu content increased markedly with trash application.

The increasing levels of NPK had enhanced the availability of macro and micro nutrients. Interaction effect was significant with most of the nutrients.

The combined use of chemical fertilizers with trash application had increased the availability of organic carbon available N and micro nutrients like Mn and Zn. While the integrated use of press mud with different doses of chemical fertilizers had enhanced the availability of P, K, Ca, Mn and Zn.

Trash itself contains very little amount of readily available nutrients and it is not easily decomposed by microorganism owing to wider C/N ratio and siliceous nature. The increase in organic carbon content, available N, Mn and Cu content in the soil after the experiment might be probably owing to the humification of cane trash (Sinha *et al.*, 1977) and partial release of 0.42 per cent N, 236.4 ppm Mn and 16.8 ppm Cu present in the trash. The nutrient losses from the soil was minimised. It was also evident from the study that the total uptake of macro and micronutrients was reduced in the treatment combinations of inorganic fertilizers with trash application. The above aspects might have favoured for the increased availability of nutrients in the soil. The present findings are in conformity with the results of Yadav *et al.* (1987), Singh and Yadav (1992) and Yadav (1995).

Press mud contains sizable quantities of macro and micro nutrients besides 20 to 25 per cent of organic carbon. The favourable build up in the availability of NPK exchangeable Ca, Fe, Mn and Zn content could be ascribed to the great manurial potential of press mud and partial release of 1.25 per cent N , 2.5 per cent P, 1.5 per cent K, 11.0 per cent Ca, 898 ppm Mn and 2000 ppm Fe. It was also observed that the application of press mud with mineral nutrients have increased the activity of acid-phosphatase enzyme due to the enhanced microbial activity. The increased activity of acid phosphatase enzyme in the soil might have favoured the bio-conversion of the more resistant phosphate to soluble phosphate thus causing a higher availability. Singh and Yadav (1992) reported that press mud has got great manurial potential to supply nutrients and increase the organic carbon, availability of N, P, K, Zn and Mn in soils. The increase in the availability of nutrients is attributable to its higher addition than crop removal through fertilizers and its release from the mineralization of press mud. In the present investigation, it was evident that integrated application of press mud with different levels of fertilizer nutrients had increased the dry matter production by trash and ultimately the total DMP at various stages of growth.

The trash produced during the early stages of growth would have made additions to the soil which in turn might have resulted in the release of macro and micro nutrients on mineralization. This could be possibly another reason for the enrichment and build up of soil fertility status observed in the soil after the experiment. The results are in conformity with the findings of Juwarkar *et al.* (1993), S.B.I. (1998), Perumal (1999) and Nagaraju *et al.* (2000).

The conjunctive use of either Acetobacter or Azospirillum with different doses of NPK had appreciably enhanced the availability of Fe content in the soil after the experiment. The above biofertilizers besides nitrogen fixation synthesise auxins, vitamins growth, hormones and growth regulators and stimulate the uptake of plant nutrients by increasing its availability. The reason for such an increase in Fe content might be due to the formation of soluble Fe complexes leading to enhanced Fe availability in soil in addition to the chelation properties of organic matter.

The use of chemical fertilizers alone at 50 or 75 per cent of the recommended dose of NPK had shown lower values for the availability of plant nutrients studied in different magnitudes as compared to integrated nutrient management. However, there was enrichment in the soil after the experiment with respect to individual fertility status prior to experimentation. The possible reason could be the addition of crop residues derived from trash, root biomass and water shoots which on degeneration and biodegradation release plant nutrients. It has to be emphasised that roots accumulate considerable amount of plant nutrients and when it is turned back to the soil results in the release of appreciable amounts of nutrients. The present results are in accordance with the findings of Biswas *et al.* (1971), Pannu *et al.* (1985), Kapur (1994), More (1994), Kavitha (1995) and Mathywathany (1998).

Biological properties

Quantitative and qualitative data on soil microflora and soil enzymes provide an useful index of soil fertility. The activity of soil enzymes as well as microbial population increased conspicuously with organic sources. Press mud addition had increased the activity of acid phosphatase enzyme and the population of actinomycetes. It was comparable with trash application and green manuring with cowpea. The urease activity and bacterial population enhanced due to Azospirillum inoculation and it was comparable with Acetobacter inoculation and press mud addition. The activity of cellulase as well as fungal population increased remarkably due to trash and press mud application.

The increasing levels of N, P and K had enhanced the activity of soil enzymes. The interaction between organic sources and mineral nutrition was significant only for soil enzymes. Integrated use of press mud with NPK application at different doses had increased the activity of acid phosphatase. Whereas the combined use of trash with NPK at different doses had increased the cellulase activity. Similarly Azospirillum alongwith different doses of NPK had enhanced the activity of urease in the soil. Chemical fertilizers supplementing NPK alone had depressed the activity of all soil enzymes.

Soil enzymes mostly secreted by microbial organism in the soil are involved in various decomposition and chemical transformation in the soil. Application of organic manures to the soil adds large quantities of organic carbon and other major essential elements to the soil. Soils with high organic matter have higher microbial population too. According to Rajannan and Oblisami (1979) increase in organic carbon leads to proportional increase in microbial population. In the present study it was observed that the integrated use of chemical fertilizers either with press mud or trash application had increased the organic carbon content appreciably and the availability of nutrients in the soil. This might have probably increased the microbial population resulting in the enhanced activity of soil enzymes. The increase in the soil enzyme activities in the above treatments were probably due to the increase in the different groups of enzyme producing micro organism in the soil. The present results are in conformity with the findings of Hasebe *et al.* (1985), Bolton *et al.* (1985), Palaniswami and Sree Ramalu (1994).

Economics

The economics of treatments clearly reveals that the use of organic matter is essential in getting higher returns in sugarcane production. Among the organic sources Azospirillum inoculation and press mud application had given Rs. 1.52 per rupee invested on cultivation in the first plant crop. In the second year also a similar trend continues with Rs. 1.46 and 1.44 per rupee. Among the organic sources, trash application recorded lowest returns. While sugarcane production depending only on chemical fertilizers at its recommended rate showed a lower B:C ratio of 1.15 and 1.16.

The variation in NPK rate also differs in the returns. The highest return of Rs.1.43 and 1.37 per rupee invested was noticed with full dose of NPK in the first and second year of study. The remarkable point in economic analysis is with the interaction effect of organic and inorganic sources. Press mud with full rate of NPK application invariably recorded the highest returns. While at 50 per cent of NPK levels, the Azospirillum registered higher returns indicating its usefulness in sugarcane cultivation with lesser fertilizer application or in high fertility areas. Except trash application all the other organic sources with 50 per cent of recommended NPK gave greater B:C ratio than full NPK rate without any organic matter addition.

The substantial increase made in cane yield due to treatment effects might have resulted in maximum returns thereby enhancing the B:C ratio. In the present study it was evident that integrated use of organic sources along with inorganic fertilizer had favoured the cane growth and yield besides improving physico-chemical and biological properties of soil. This is the way to maintain the sustainability of the crop production without causing deleterious effects to the soil. This method of farming gives an assurance of satisfactory yield besides maintaining soil health and productivity. On the other hand the use of inorganic fertilizer at 100 per cent of the recommended dose of NPK or 75 or 50 per cent without organic sources had resulted lesser returns and the B:C ratio was decreased considerably. In this context it has to be noted that chemical fertilizer have the capacity to supply only one or two plant nutrients whereas the organic manures supplies number of macro and micro nutrients essential for healthy growth and development of sugarcane. For sustainability in sugarcane and sugar production neither chemical fertilizers nor manures alone but their integrated use has been observed to be highly beneficial (Bangar *et al.*, 1994).

Energetics

Efficient use of energy input from nonrenewable source is essential since they are becoming scarcely available. Studies in the efficient use of nonrenewable sources of energy and substitution and supplementation of these sources of energy suitably with renewable sources of energy is essential and crucial for sustaining crop productivity and maximising energy use efficiency (Singh and Ghosh, 1994 and Ghosh, 1996) . In this context integrated nutrient management plays a vital role for the conservation and effective utilization of resources in crop production systems.

Statistical scrutiny of the data revealed that energy use efficiency and energy productivity increased markedly with press mud application and Azospirillum inoculation. Mineral nutrition with increasing doses of NPK had shown marginal increase and the magnitude of variation has not reached statistical significance with energy use efficiency. The interaction between organic sources and mineral nutrients was significant. Integrated use of press mud at 5 t ha^{-1} with 100 per cent NPK at recommended dose had recorded the highest values for energy productivity and energy use efficiency. It was comparable with combined use of Azospirillum with 100 per cent NPK at recommended dose and press mud application with 75 per cent NPK.

The increased energy output through enhanced biomass production and higher energy output through increased economic yield observed with above integration of organic sources with inorganic fertilizer would have resulted for obtaining higher values for energy productivity and energy use efficiency. Pal *et al.* (1985) pointed out that the use of intermediate chemical inputs helped in pushing up the energy use efficiency without causing any reduction in yield.

SUMMARY

SUMMARY

An investigation entitled "Irrigation and integrated nutrient management for sustainable sugarcane production" was undertaken at Sugarcane Research Station, Thiruvalla in Pathanamthitta district of Kerala state for a period of two years during the crop seasons of 1998-1999 and 1999-2000. The study was conducted in two field experiments which included 'Standardisation of irrigation management in sugarcane' as Experiment No. I and 'Integrated nutrient management in sugarcane' as Experiment No.II.

In Experiment No.I surface methods of irrigation was evaluated under mulched and unmulched situations. The experiment was laid out in factorial randomised block design comprising of four surface methods of irrigation with two mulch treatments constituting eight treatment combinations. It was replicated thrice. The surface methods of irrigation included all furrow, alternate furrow and skip furrow and irrigation once in a month (farmer's practice). While 5 tonne ha^{-1} trash was applied as soil mulch in the mulched treatments.

In Experiment No.II studies with the integrated use of organic sources like press mud, trash application, green manuring, Acetobacter and Azospirillum inoculation with 50, 75 and 100 per cent of the recommended dose of N, P and K were carried out. The experiment was laid out in strip plot design with 6 organic sources including a control in strip I and three recommended dose of N, P and K in strip II constituting eighteen treatment combinations with four replications.

Test variety for the study was Madhuri a midlate, high sugared variety moderately resistant to red rot reaction, developed at S.R.S., Thiruvalla.

The salient findings of the two field experiments are summarised below:

Standardisation of irrigation management in sugarcane (Experiment No. I)

(1) All and alternate furrow irrigation had appreciably increased the plant height, number of leaves and nodes per cane and was comparable with each other. The beneficial effect of trash mulching was noticed at all stages of growth on the above growth attributes.

(2) The tillering and cane formed shoots were profoundly influenced by all furrow irrigation followed by alternate furrow irrigation. Trash mulching showed its superiority in tiller production and cane formed shoots than unmulched condition.

(3) The DMP by trash, green tops and stem increased explicitly with all furrow irrigation and it was closely followed by alternate furrow irrigation. The impact of mulching was observed on DMP by different plant parts throughout the growth period.

(4) All furrow irrigation had invariably increased the total DMP at all stages of growth. It was closely followed by alternate furrow irrigation. The positive influence of trash mulching was noticed on total DMP at all stages of growth.

(5) The combination of all furrow irrigation with trash mulching had recorded remarkably higher LAI and LAR. It was closely followed by the combination of alternate furrow irrigation with trash mulching.

(6) All furrow and alternate furrow irrigation had exerted positive influence on SLA as compared to other methods of irrigation. Trash mulching also showed a higher SLA value over unmulched treatment.

(7) All furrow and alternate furrow irrigation had accounted for higher CGR values between 120 to 240 and 240 to 360 DAP. While the effect of trash mulching on CGR was noticed only between 120 to 240 DAP.

(8) Skip furrow irrigation had registered higher values for NAR and it was comparable with farmer's practice of irrigation. The unmulched treatments had shown its superiority in NAR over mulched treatment.

(9) All furrow irrigation had registered maximum cane girth, cane length, single cane weight and MCC. It was comparable with alternate furrow irrigation. Trash mulching recorded greater values as compared to unmulched treatment.

(10) Cane, sugar and jaggery yield increased remarkably with all furrow irrigation and it was followed by alternate furrow irrigation. Skip furrow and farmer's practice of irrigation recorded significantly lesser yield. Trash mulching had invariably increased the cane, sugar and jaggery yield. The combination of all furrow irrigation with trash mulching produced the highest cane, sugar and jaggery yield and it was comparable with the combination of alternate furrow irrigation with trash mulching. The yield of cane, sugar and jaggery was reduced in skip furrow irrigation.

(11) The reducing sugar content in the cane juice increased significantly with skip furrow and farmers practice of irrigation. The unmulched treatment recorded significantly higher content of reducing sugar as compared to trash mulching.

(12) All furrow had invariably increased the jaggery sucrose and decreased the jaggery reducing sugar. It was comparable with alternate furrow irrigation. The unmulched treatment had exerted a pronounced effect in increasing the reducing sugars.

(13) The uptake of N by trash, green tops, stem and the total N uptake increased significantly with all furrow irrigation and was comparable with alternate furrow irrigation. The impact of trash mulching was clearly evident on the total N uptake.

(14) The total plant uptake of P or by different plant parts was significantly higher in all furrow irrigation and it was followed by alternate furrow irrigation. The mulched treatment showed a pronounced effect in the uptake of P.

(15) All furrow irrigation had invariably showed and enhanced total uptake of K and uptake by different plant parts. It was comparable with alternate furrow irrigation in most of the growth stages. Trash mulching had also exerted positive influence on K uptake over unmulched situation.

(16) All furrow irrigation recorded remarkable increase in the total uptake of Ca and Na. Trash mulching registered an enhanced uptake than unmulched treatment.

(17) The total uptake of Fe, Mn, Zn and Cu enhanced appreciably with all furrow irrigation and was comparable with alternate furrow irrigation. Trash mulching had also shown higher values for the total uptake of all the above elements. The combination of all furrow and alternate furrow irrigation with trash mulching was comparable.

(18) The soil moisture status increased with all furrow irrigation at all stages of growth. It was closely followed by alternate furrow irrigation. The impact of trash mulching was very well evident with a significantly higher moisture retention in the soil.

(19) Soil temperature was reduced in all furrow and alternate furrow irrigation at 0 - 15 and 15 - 30 cm depth of soil. Trash mulching had reduced the soil temperature as compared to unmulched treatment.

(20) Trash mulching had improved the physical properties of post harvest soil and registered lowest values for bulk density, increased pore space distribution and maximum WHC.

(21) The fertility status of the post harvest soil increased in all furrow irrigation and it was comparable with alternate furrow irrigation. Trash mulching had shown perceptible increase in organic carbon content, available P, available K, Ca, Na, Fe, Mn, Zn and Cu in the post harvest soil over unmulched treatment.

(22) The activity of soil enzyme like acid phosphatase, cellulase and urease increased with all furrow and alternate furrow irrigation. Trash mulching had also increased the values of above soil enzymes.

(23) Trash mulching had significantly increased the population of fungi, bacteria and actinomycetes in the post harvest soil

(24) Water use efficiency increased invariably with the treatment combination of alternate furrow with trash mulching. It was reduced considerably in all furrow irrigation.

(25) All furrow irrigation with trash mulching had shown higher values for B : C ratio and was comparable with alternate furrow irrigation with trash mulching. The B : C ratio was reduced in farmers practice and was least in skip furrow irrigation.

(26) Alternate furrow irrigation with trash mulching had recorded significantly higher values for energy productivity and energy use efficiency. It was followed by all furrow irrigation with trash mulching.

Integrated nutrient management in sugarcane (Experiment No. II)

(1) The integrated use of press mud at the rate of 5 tonne ha^{-1} along with 100 per cent or 75 per cent of the recommended dose of NPK had appreciably increased the plant height, number of leaves and nodes per cane and was comparable with soil inoculation of Azospirillum at 10 kg ha^{-1} with full dose of NPK.

(2) Tiller production, shoot count and cane formed shoots increased remarkably with the combined use of press mud either with 100 or 75 per cent of the recommended dose of NPK. It was comparable with the conjunctive use of Azospirillum with 100 per cent NPK application.

(3) Total DMP, dry matter accumulation in trash, green tops were positively influenced by press mud application and mineral nutrition at its full dose. The DMP by trash, green tops and stem was reduced at 50 per cent of NPK dose without any organics.

(4) Application of press mud had positively influenced the growth indices like LAI, LAR, SLA and CGR. It was comparable with Azospirillum inoculation. Similarly, mineral nutrition with NPK application at 100 per cent of the recommended dose had increased the values of growth indices as compared to 75 or 50 per cent of the recommended dose.

(5) The yield attributes viz., MCC, cane length, cane girth and single cane weight were perceptibly increased with the combined use of press mud along with 100 per cent of NPK application. Comparable values were noticed either by integrated use of press mud with 75 per cent of NPK dose or with Azospirillum inoculation and 100 per cent NPK application.

(6) Conjunctive use of press mud with full dose of NPK had enhanced the cane yield and recorded a marginal increase of 4.5 per cent as compared to 75 per cent of NPK application and 7.6 per cent over Azospirillum inoculation with full dose of NPK. Without any organics, full dose of NPK registered 32.2 and 26.4 per cent lesser yield as compared to the combined use press mud either with 100 or 75 per cent of the recommended dose of NPK, respectively.

(7) Sugar and jaggery yield also increased with the combined use of press mud 100 per cent NPK application and recorded marginal increase over integrated use of press mud with 75 per cent NPK application and Azospirillum inoculation with full dose of NPK.

(8) Azospirillum inoculation had increased the juice recovery, improved the sucrose content, CCS per cent, SMT Brix and purity coefficient and was comparable with press mud application. The mineral nutrition alone had increased the contents of reducing sugar and titrable acidity and recorded lower values for sucrose content, CCS per cent and SMT Brix.

(9) Soil inoculation with Azospirillum had increased the values of jaggery sucrose, jaggery Brix and jaggery purity. It was almost comparable with press mud application. Mineral nutrition without any organics had shown increased values for reducing sugar in jaggery. While the sucrose, jaggery Brix and purity coefficient of the jaggery were reduced.

(10) The total uptake and uptake of N, P and K by trash, greentops and stem also increased appreciably with the combined use of press mud with 100 per cent NPK application. The results also revealed that there was perceptible increase in the uptake of Ca, Mn, Fe, Zn and Cu with the combination of press mud with 100 per cent of the recommended dose of NPK application. It was statistically on par with the combined use of press mud with mineral nutrition at 75 per cent of the recommended dose of NPK. The results also showed that mineral nutrition with 100, 75 or 50 per cent of the recommended dose of NPK without any organics had depressed the total uptake of N, P, K, Ca, Na, Fe, Mn, Zn and Cu.

(11) Trash application had lowered the values of bulk density and increased pore space distribution and WHC and was comparable with press mud application. In general, the combination of fertilizers either with trash, press mud or green manure had improved the physical condition of the soil as compared to the application of fertilizer nutrients alone.

(12) The organic sources had exerted considerable influence on the fertility status of the post harvest soil. The organic carbon, available N and Mn content in the soil was enhanced by trash application and was comparable with press mud application or green manuring. There was perceptible increase in the availability of P, K, Ca, Mn and Zn in the soil due to press mud or trash application.

(13) The activity of soil enzymes as well as microbial population in the post harvest soil increased with organic sources. Press mud application at 5 t ha^{-1} had increased the activity of acid phosphatase and the population of actinomycetes. The urease activity and bacterial population enhanced due to Azospirillum or Acetobacter inoculation, whereas cellulase activity and fungal population were found to be increased remarkably in the trash and press mud applied treatments.

(14) The economic analysis revealed that press mud with full dose of NPK application recorded the highest returns. But It was comparable with 75 per cent NPK alongwith press mud or full dose of NPK with Azospirillum inoculation.

(15) Press mud application with full dose of NPK had recorded higher values for energy productivity and energy use efficiency.

Future line of research

In the present investigation it was noticed that all furrow or alternate furrow irrigation with trash mulching at the rate of 5 t ha^{-1} produced higher cane yield and recorded maximum economic returns. The results obtained in `Integrated nutrient management' revealed that press mud application at the rate of 5 t ha^{-1} with 100 per cent of the recommended dose of NPK had given the highest cane, sugar and jaggery yield. But it was comparable with the combination of press mud with 75 per cent of the recommended dose of NPK. Mineral nutrition without any organics had reduced the cane yield and economic returns. Taking into consideration of the present findings as a future line of study, it is proposed to take up studies with paired row irrigation, gradual widening of furrows (Broad bed irrigation) and skip furrow without permanently skipping the irrigation. Scheduling of irrigation based on climatological approach through alternate furrow with trash mulching have to be investigated. Scheduling irrigation based on leaf temperature using infrared thermometer can also be undertaken.

Under integrated plant nutrient supply, it is proposed to conduct fundamental studies and field experimentation on appropriate strains, rates and time of inoculation of N_2 fixers, under diverse agroclimatic conditions to ascertain the efficient strains for promoting cane and sugar yields. Intensive research efforts are needed to identify efficient strains of phosphorus solubilizing bacteria for increasing the availability of native as well as applied P through cheaper sources. Effect of various biotic and abiotic factors influencing applied biofertilzers in the soil need to be investigated. There is a need to investigate the combined effect of N_2 fixers like Azospirillum, Azotobacter, Acetobacter, Phosphorus solubilizing bacteria and integration with other organic sources and mineral nutrition so as to develop crop specific comprehensive production technologies for sustainable cane production. The influence of organic sources applied in the plant crop and its residual effects in the first and second ratoon crops have to be explored.

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* Originals not seen

APPENDICES

APPENDIX - I

CLIMATIC PARAMETERS (MONTHLY MEAN) DURING THE CROPPING PERIOD AND THE PREVIOUS FIVE YEARS

Monthly interval	Temperature (°C)						Relative humidity (%)			Total rainfall (mm)			Sunshine hours			Evaporation (mm)		
	Maximum			Minimum			Five years average	'98-'99	'99-'00	Five years average	'98-'99	'99-'00	Five years average	'98-'99	'99-00	Five years average	'98-'99	'99-'00
	Five years average	'98-'99	'99-'00	Five years average	'98-'99	'99-'00												
January	33.1	32.7	33.0	19.2	23.2	22.0	90.2	69.6	68.2	12.26	xx	xx	9.5	9.7	8.3	4.2	3.8	3.5
February	33.2	33.6	33.3	20.9	24.6	24.1	90.8	74.0	71.0	15.3	xx	xx	9.7	10.1	8.9	4.7	4.3	4.1
March	34.0	35.8	33.1	22.2	26.7	26.8	94.0	55.9	63.5	16.6	xx	xx	9.6	10.3	8.8	5.1	5.1	4.3
April	33.5	34.3	33.7	23.4	2.9	27.5	90.8	67.6	69.0	37.5	xx	xx	8.5	9.7	5.7	4.2	5.1	4.1
May	32.9	34.0	30.2	22.6	25.4	24.3	9.2	73.2	79.4	194.1	346.0	172.9	7.4	7.7	4.8	3.7	3.8	3.2
June	30.9	31.8	30.0	21.7	24.0	25.1	95.0	83.3	83.2	471.9	840.0	1437.8	4.8	4.4	6.3	2.9	2.8	3.4
July	30.3	31.0	30.3	22.3	21.7	25.1	95.2	80.3	84.6	559.0	462.0	297.5	3.8	5.1	4.0	2.2	2.7	2.9
August	30.2	30.8	30.5	23.3	22.7	25.8	95.4	89.2	75.7	236.0	276.5	329.7	5.1	5.2	6.0	2.9	2.9	3.4
Septem-ber	30.8	30.0	31.6	23.1	22.6	26.2	93.6	82.5	83.3	283.4	270.2	105.0	6.2	4.7	8.1	3.4	3.0	3.7
October	31.3	29.8	31.4	22.9	21.7	26.4	94.4	80.9	81.0	425.1	571.2	550.9	6.8	4.9	4.6	3.4	2.8	3.5
Novem-ber	31.6	31.3	31.8	21.2	21.5	24.9	94.0	65.3	77.5	199.0	119.7	117.6	6.7	6.5	7.4	2.8	2.7	2.7
Decem-ber	32.6	31.7	32.5	20.7	23.3	24.7	92.0	73.2	70.9	54.7	8.4	xx	8.4	5.7	9.1	3.4	2.7	3.0

APPENDIX - II

Cost of cultivation of sugarcane under experiment No. I (Rs. ha^{-1})

A. Labour cost

	Particulars	Labour		Total	Amount
		Men	Women		
1)	Preparatory cultivation				
(a)	Levelling and removal of stubbles after tracter ploughing	2	20	22	1800
2)	Layout and planting work				
(a)	Preparation of setts	x	20	20	1500
(b)	Loading and distribution	5	x	5	750
(c)	Making ridges, furrows and digging the furrows	30	x	30	4500
(d)	Fertilizer application	x	2	2	150
(e)	Dibbling of setts	x	25	25	1875
3)	Intercultural operations				
(a)	Weeding	x	40	40	3000
(b)	Hoeing twice	60	x	60	9000
(c)	Fertilizer application	x	5	5	375
(d)	Detrashing and interlocking	x	40	40	3000
(e)	Earthing up	24	x	24	3600
4)	Harvesting				
(a)	Cutting	80	x	80	12000
(b)	Cleaning	x	50	50	3750
(c)	Bundling	x	50	50	3750
(d)	Loading	20	x	20	3000
	Total	221	252	473	52050

B. Cost of inputs

Particulars	Quantity	Amount (Rs.)
(a) Hire charges for tractor ploughing twice for a period of 15 hours.	Rs. 200/hour	3000
(b) Setts	40,000 Nos. of 3 budded setts @ Rs.125/1000 Nos.	5000
(c) Chemical fertilizer		
(i) Urea	358 kg @ 4.80/kg	1718
(ii) Mussoriphos	344 kg @ 2.70/kg	929
(iii) Muriate of potash	137 kg @ 4.70/kg	644
Total cost excluding treatments (Labour cost + input cost)		63,341

Wage rate for Men :: Rs. 150.00
Wage rate for women :: Rs. 75.00

APPENDIX - III

Additional cost of treatments

Effect	Quantity	Cost (Rs. ha^{-1})	Application cost		Total cost (Rs. ha^{-1})
			Labour	Amount	
A. Methods of irrigation					
(i) All furrow (I_1)			30	4500	4500
(ii) Alternate furrow (I_2)			20	3000	3000
(iii) Skip furrow (I_3)			20	3000	3000
(iv) Farmer's practice (I_4)			16	2400	2400
B. Mulching					
(i) Trash mulching (M_1)			20	1500	1500

APPENDIX - IV

Cost of cultivation of sugarcane under experiment No. II (Rs. ha^{-1})

A. Labour cost

	Particulars	Labour		Total	Amount
		Men	Women		
1)	Preparatory cultivation				
(a)	Levelling and removal of stubbles after tracter ploughing	2	20	22	1800
2)	Layout and planting work				
(a)	Preparation of setts	x	20	20	1500
(b)	Loading and distribution	5	x	5	750
(c)	Making ridges, furrows and digging the furrows	30	x	30	4500
(d)	Fertilizer application	x	2	2	150
(e)	Dibbling of setts	x	25	25	1875
3)	Intercultural operations				
(a)	Weeding	x	40	40	3000
(b)	Hoeing twice	60	x	60	9000
(c)	Fertilizer application	x	5	5	375
(d)	Detrashing and interlocking	x	40	40	3000
(e)	Earthing up	24	x	24	3600
(f)	Irrigation	25	x	25	3750
4)	Harvesting				
(a)	Cutting	80	x	80	12000
(b)	Cleaning	x	50	50	3750
(c)	Bundling	x	50	50	3750
(d)	Loading	20	x	20	3000
	Total	246	252	498	55800

APPENDIX - V

Additional cost of treatments

Effect	Quantity	Cost (Rs. ha^{-1})	Application cost		Total cost (Rs. ha^{-1})
			Labour	Amount	
A. Organic sources					
(i) Press mud (T_2)	5000 kg	4000	10	1125	5125
(ii) Trash application (T_3)	x	x	35	2625	2625
(iii) Green manuring (T_4)	5 kg	200	35	2625	2825
(iv) Acetobacter inoculation (T_5)	10 kg	500	7	675	1175
(v) Azospirillum inoculation (T_6)	10 kg	400	5	600	1000
B. Mineral nutrition					
(i) NPK at 50% of the recommended dose (F_1)	82.50 : 41.25 : 41.25 kg	1645	x	x	1645
(ii) NPK at 75% of the recommended dose (F_2)	123.75 : 61.87 : 61.87	2469	x	x	2469
(iii) NPK at 100% of the recommended dose (F_3)	165.82 : 82.50 : 82.50	3291	x	x	3291

B. Cost of inputs

Particulars	Quantity	Amount (Rs.)
(a) Hire charges for tractor ploughing twice for a period of 15 hours.	Rs. 200/hour	3000
(b) Setts	40,000 Nos. of 3 budded setts @ Rs.125/1000 Nos.	5000
Total cost excluding treatments (Labour cost + input cost)		63,800

Wage rate for Men	::	Rs. 150.00
Wage rate for women	::	Rs. 75.00
Cost of 1 kg N	::	Rs. 10.41
Cost of 1 kg P_2O_5	::	Rs.11.26
Cost of 1 kg K_2O	::	Rs. 7.80
Cost of 1 kg press mud	::	Rs. 0.80
Cost of 1 kg Acetobacter	::	Rs.50.00
Cost of 1 kg Azospirillum	::	Rs.40.00

APPENDIX - VI

Energy equivalents

	Energy sources	Unit	Equivalent energy (MJ)
A	INPUTS		
(a)	Human labour		
	Adult men	Man-hour	1.96
	Adult women	Women-hour	1.57
(b)	Diesel	1 litre	56.31
(c)	Electricity	1 kwh	11.93
(d)	Seeds (Sugarcane setts)	1 kg	5.30
(e)	N	1 kg	60.60
(f)	P	1 kg	11.1
(g)	K	1 kg	6.7
(h)	Irrigation	1 ha cm	46.02
B	OUTPUTS		
(a)	Sugarcane leaves and green tops	1 kg	16.10
(b)	Cleaned cane	1 kg	5.3

APPENDIX - VII
Water use under different methods of irrigation

Treatment	Water applied per irrigation after the germination phase (1 ha^{-1})	Total nos. of irrigation scheduled during the formative phase	Total depth of irrigation (cm)	Savings of irrigation water (%)
All furrow irrigation	5,00,000	12	60.00	--
Alternate furrow irrigation	2,50,000	12	42.50	41.17
Skip furrow irrigation	2,50,000	12	42.50	41.17
Farmer's practice	5,00,000	8	40.00	50.00

APPENDIX - VIII
Biomass production and NPK contribution by green manuring crop

Treatment	Biomass production (dry basis, kg ha^{-1})	Nutrients contributed		
		N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Green manuring with 50 per cent NPK	1852	40.93	9.63	36.48
Green manuring with 75 per cent NPK	1879	41.52	9.77	37.01
Green manuring with 100 per cent NPK	1888	41.72	9.81	37.11

IRRIGATION AND INTEGRATED NUTRIENT MANAGEMENT FOR SUSTAINABLE SUGARCANE PRODUCTION

BY

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ABSTRACT

Two field experiments were conducted at Sugarcane Research Station, Thiruvalla in Pathanamthitta district of Kerala state to standardise the surface methods of irrigation with and without trash mulching and to study the potential of integrated nutrient management in sugarcane for sustainable cane production. The study was carried out for a period of two years in plant crops during 1998-1999 and 1999-2000. The influence on growth, yield attributes, yield, quality, nutrient uptake and physico-chemical properties and biological properties of the soil were investigated.

In Experiment No. I viz., `Standardisation of irrigation management in sugarcane' the methods of irrigation with and without trash mulching was investigated. The treatment comprised of 4 methods of irrigation viz., all furrow, alternate furrow, skip furrow and irrigation once in a month (farmer's practice) under mulched and unmulched situations.

The results revealed that all furrow irrigation in combination with trash mulching had positively influenced all the growth characters, yield attributes, nutrient uptake and appreciably increased the cane, sugar and jaggery yield. It was comparable with alternate furrow irrigation with trash mulching. While cane growth and sugar production was reduced in skip furrow irrigation with or without trash mulching. Trash mulching also improved physical conditions, fertility status, microbial population and enzymatic reactions in the soil. It had also shown better retention and conservation of soil moisture and reduced the soil temperature as compared to unmulched treatments. Since the combination of trash mulching with all furrow and alternate furrow irrigation had recorded comparable values for cane

yield, B : C ratio, it could be possible to economise the use of irrigation water by following alternate furrow irrigation with trash mulching during the formative phase of sugarcane. It was revealed that a water economy to the tune of 41 per cent was possible in alternate furrow irrigation with trash mulching as compared to all furrow with trash mulching. By mulching alone an increase of 10 per cent in cane yield was observed in alternate furrow irrigation. While in all furrow, skip furrow or irrigation once in a month the beneficial effect of mulching was not visible to such an extent as in the case of alternate furrow irrigation. Alternate furrow irrigation under trash mulching had recorded the highest WUE, energy use efficiency and energy productivity which again suggest the effective and efficient utilisation of resources with better conservation.

In Experiment No. II viz., `Integrated nutrient management in sugarcane', studies with the integrated use of organic sources like press mud, trash, green manuring with cowpea, Acetobacter and Azospirillum inoculation with mineral nutrition at 50, 75 and 100 per cent dose of NPK and mineral nutrition alone were carried out. The results revealed that integrated use of press mud at 5 t ha^{-1} with mineral nutrition at 100 per cent of the recommended dose of NPK had explicitly increased the growth characters, yield attributes and uptake of nutrients producing the highest cane, sugar and jaggery yield. However, it was comparable with the conjunctive use of press mud at 5 t ha^{-1} with 75 per cent of the recommended dose of NPK. Soil inoculation of Azospirillum at 10 kg ha^{-1} with mineral nutrition at 100 per cent or 75 per cent had also produced significant impact on growth, yield attributes, yield and quality of cane. It also increased the B:C ratio as compared to the integrated use of mineral nutrition with green manuring, Acetobacter inoculation or trash application. Application of NPK at 50 per cent of the recommended dose along with Azospirillum inoculation had shown higher B:C ratio as compared to the integration of other organics with 50 per cent of the recommended dose of NPK.

Mineral nutrition without organics even at full dose had produced lesser cane sugar and jaggery yield as compared to the integrated use of press mud, Azospirillum, green manuring or Acetobacter along with mineral nutrition at 50 per cent of the recommended dose of NPK. The conjunctive use of press mud either with 100 or 75 per cent of the recommended dose of NPK had shown comparable values for B:C ratio, energy use efficiency and energy productivity besides improving physico-chemical properties and biological properties of soil. Hence, it is possible to save 25 per cent of the recommended dose of NPK by applying press mud at 5 t ha^{-1}.

It can be concluded from the study that alternate furrow irrigation under trash mulching had resulted in substantial savings in irrigation water during the formative phase without any reduction in yield or quality. While in integrated nutrient management, it was concluded that press mud application at 5 t ha^{-1} along with mineral nutrition at 75 per cent of the recommended dose of NPK had increased the cane yield with a saving of 25 per cent of the recommended dose of NPK. Mineral nutrition alone even at its full dose recorded comparatively lesser cane yield and B:C ratio than all other combinations with organics.