EFFECT OF ORGANIC, INORGANIC FERTILIZER AND THEIR COMBINATION ON PHYSICO-CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL CROPPED UNDER CLUSTERED CHILLI (*Capsicum annuum.* L.)

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled "Effect of organic, inorganic fertilizer and their combination on physico-chemical and biological properties of soil cropped under clustered chilli (*Capsicum annuum* L)" 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 the thesis entitled "Effect of organic, inorganic fertilizer and their combination on physico-chemical and biological properties of soil cropped under clustered chilli (*Capsicum annuum* L)" is a record of research work done independently by Miss.Meena Nair under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Chilli (Capsicum annuum L.) is extensively grown as a cash crop, throughout India. It is grown for its fruits used both green and ripe (dried form) and is specially favoured for its pungency, spicy taste, besides the appealing colour it adds to the food. The pungent forms of chilli are more widely cultivated in India compared to the non-pungent types. It is grown over an area of 8.26 lakh ha with an annual production of 5.48 lakh tonnes (Sankaranarayana and Krishnamurthy, 1987). Out of this, seventy per cent of area lies in four states - Andra Pradesh (1.48 lakh ha), Karnataka (1.43 lakh ha), Maharashtra (1.40 lakh ha) and Tamil Nadu (0.62 lakh ha). India is the largest exporter of chilli in the world, exporting nearly 2.5-3% of her production (Muthukrishnan et al., 1986).

Chilli, being a major condiment, earning an attractive export value in foreign markets, the emphasis now lies on higher production per unit area per unit time in our country. This can be achieved both by bringing more area under chilli and by producing more from unit area. This calls for improved varieties and better

production technology. Improvement in yield in the existing cultivars can be brought about by careful use of manures and fertilizers. Application of manures and fertilizers has come to remain as an indispensable and integral part of modern crop production. The quantum of fertilizers applied to the soil has greatly increased, thanks to the advent of HYV of higher fertilizer response.

KAU Cluster (Capsicum annuum Var. fasciculatum), an erect and clustered-fruited line, is reported adaptable (Thomas and Peter, 1986), high yielding and resistant to bacterial wilt (Goth et al., 1983) under the warm - humid - tropic conditions of Kerala. The main need is to standardise the manurial and fertilizer package of practices in this crop.

It is noted that frequent and heavier application of manures and fertilizers is bound to critically tell upon the physico-chemical and biological properties of soil, which in turn decide the fertility status of soils. As such it has become necessary to keep a close watch on the effect of continuous application of fertilizers, if the productivity of the soil has to be safeguarded.

World wide interest in vesicular-arbuscular mycorrhiza is increasing at a phenomenal rate. VAM is of particular interest because of the large number of agricultural crops on which it occurs. In cultivated soils VAM fungi are affected by various agricultural and horticultural practices, particularly fertilizer additions, pesticide applications and crop rotations. Changes in soil fertility due to amendments with mineral fertilizers or organic matter can markedly affect the activity of the soil mycorrhizal population in terms of the amount of root infection and number of resting spores produced. So far no work has been conducted to study the effect of organic and inorganic fertilizers and their combination on physico-chemical and biological properties of soil cropped under clustered chilli.

It is in the light of the above facts that the present investigation was undertaken with the following objectives:

1. To find out the effect(s) of organic and inorganic fertilizers and their combination on crop productivity.
2. To study the effect(s) of organic and inorganic fertilizers and their combination on the physical,

chemical and biological properties of soil.

3. To work out economics of organic and inorganic fertilizers and their combination in clustered chilli.

Review of Literature

REVIEW OF LITERATURE

Chilli is an important spice commonly used in Indian dietry. A number of chilli varieties are recently evolved, KAU Cluster being one among them. Though chilli responds to application of major nutrients like N, P and K, systematic investigations have not been carried out to work out the optimum dosage of nutrients needed and on the combined application of organic and inorganic fertilizers on yield of chilli. The present review relates to the effect(s) of different levels of organic and inorganic fertilizers and their combination on the physico-chemical and biological properties of soil cropped under clustered chilli.

Effect(s) of organic and inorganic fertilizers and their combination on crop productivity:

a) Growth components:

Almost all the works in chilli crop showed that application of nitrogen was beneficial in increasing the general growth and vigour of the plant. Singh and Nettles (1961-62) observed a linear increase in height and yield by increasing N application from 56.75 to 170 kg/ha.

Significant increase in shoot yields and total dry matter were obtained from the application of nitrogen in chillies (James et al., 1967). Mehrotra et al. (1968) observed significant reduction in branching in chilli due to nitrogen deficiency. The influence of nitrogen on the vegetative growth in respect of branching and plant height are well recognised (Mohammed Kunju, 1970). Lal et al. (1971) observed that with increase in the levels of nitrogen both plant height and number of branches increased. Increased branching with nitrogen application at 250 kg/ha was reported by Gill et al. (1974). Stroechienim and Cebber (1979) found that moderate rates of nitrogen application (100-150 kg/ha) as ammonium nitrate produced the most desirable plant growth characteristics and the highest yields. Ramachandran and Subbiah (1981) reported that in Capsicum cultivar MDU-1, the number of shoots increased with rising N rates, while Sundstrom et al. (1984) found that plant height increased with an increase in N from 0 to 112 kg/ha.

Osaki and Hortenstine (1963) and James et al. (1967) observed that phosphorus application increased plant height end number of branches. Branching was significantly

impaired in chilli by phosphorus deficiency (Mehrotra et al., 1968). Mohammed Kunju (1970) noted that phosphorus at 40 or 60 kg/ha increased the height, number of branches and dry matter production/plant. Gill et al. (1974) reported that both N and P increased the number of branches and fruits/plant.

Significant increase in plant height due to potassium application was reported by Osaki et al. (1957). Mehrotra et al. (1968) noted that branching in chilli was significantly impaired by deficiency of potash, there being less number of branches/plant in potash deficient plants. Contrary to the above point, Mohammed Kunju (1970) observed that there was no significant difference in plant height, branching and dry matter/plant due to different levels of potassium in chillies. Everett and Subramanya (1984) reported that plant height was the only parameter that was significantly influenced by the N K rates in the Capsicum Cv. Early Calwonder and the IFAS breeding line No.811. Growth parameters such as plant height, number of branches, number of leaves and leaf area were higher in the highest fertilizer level of 225 : 112.5 : 112.5 kg NPK/ha in Capsicum annuum Var.

grossum (Nagarajaswamy and Nalawadi, 1982). Doikova et al. (1984) noted that increasing application rates of NPK with or without 50 t FYM/ha to the Cv. Kurtovska Kapiya 1619, increased vegetative growth and fruit production.

b) Earliness, yield and quality attributes:

Joachim and Paul (1938) observed that FYM at 7.5 t/ha alone or in combination with artificial fertilizers had beneficial effects on chilli. Barbieri (1949) obtained higher yields by application of NPK fertilizers to chilli, than the application of cattle manures alone at Compania (Italy). Murthy and Murthy (1955) reported that application of 27 kg N was effective with a basal dressing of FYM and in the absence of basal dressing 18 kg N was optimum for increasing the yields.

In general, N, P and K were all necessary to achieve good yields in chilli which were further improved by the application of organic manures on soils low in organic content (Ballatore, 1966). Vicek and Polach (1969) reported that for good pepper yields high rates of both organic and mineral fertilizers were needed.

Surlikov and Metev (1975) found that mineral fertilizers sometimes produced higher yields than FYM. Mineral fertilizers may be most effective when applied in combination with FYM 20-25 t/ha. Feigen et al. (1978) reported that yields were greatly influenced by nitrogen application and a total yield of 57 t/ha was obtained in plots manured with 90 t/ha FYM + 90 kg ammonium sulphate. Approximately the same yields were obtained when 270 kg ammonium sulphate was used without organic manure. In three years trials with Capsicum cultivar Jubilantka, three rates of NPK (60, 120 and 180 kg N; 14, 28 and 42 kg P and 42, 84 and 126 kg K/ha) were more effective when applied with 40 t/ha FYM than without FYM (Cerna, 1980).

Cerna (1980) also reported that the application of N and K in the absence of FYM retarded formation of vegetative organs and subsequently reproductive organs. Subbiah (1982) working on the effect of the combined application of organic and inorganic fertilizers on yield and nutrient uptake of MDU-1 Chilli reported that the highest yield (3.38 t/ha) was from plants receiving FYM + the highest N rate but no P and K. The control (FYM only)

yield was 1.8 t/ha. FYM favourably affected vegetative mass, dry weight, plant height, photosynthetic potential and consequently yields. Capsicum yields were the highest with 313, 214 and 538 kg of N, P_2O_5 and K_2O and lowest with organic fertilizers alone (Tropea et al., 1982). Fertilizer experiments with Capsicum Cv. Jubilantka revealed that the average yield with FYM was 40.55 t/ha and without FYM 29.6 t/ha (Valsikova and Ivanic, 1982). Doikova et al. (1986) reported that the highest application rate (N : P_2O_5 : K_2O at 360 kg/ha each) with or without FYM produced the highest yield in chilli Cv. Kartovska Kapiya 1619.

Ivanic (1957) observed that nitrogen delayed flowering and prolonged the growing season in chillies. Gill et al. (1974) found that nitrogen dose alone increased the mean number of days required for first flowering from 47.17 to 51.70 days. Mohammed Kunju (1970) reported that there was no significant difference in number of days required for the first flower opening, due to any of the treatments, in a trial with three levels each of nitrogen, phosphorus and potassium. Khan et al. (1977) noted that nitrogen application made little difference in reducing the flowering time in chillies.

Joachim and Paul (1938) recorded high yields by application of nitrogenous fertilizers in Ceylon. Among the two levels of N (20 lb and 40 lb) the higher level doubled the yield. Increased yields with increased application of N were reported by Huitema (1941), Muhr and James (1942), Barbiery (1949), Mehta and Shekhawat (1967), Mohammed Kunju and George (1969), Selvaraj and Subramanian (1973), Tanaka et al. (1974) and Thenabadu et al. (1974). In Italy, however the higher application of N was not effective (Barbiery, 1949). He observed that the fertilized chilli plants ripe earlier than control. Osaki and Hamilton (1954) showed increased yields with increased application of N. Osaki and Osaki (1955) and Osaki and Ray (1957) recorded that increase in level of N from 136.25-272.5 kg/ha showed a corresponding significant increase in yield but at 409 kg/ha, the yield was reduced. Singh and Nettles (1961-62) reported that increasing the rate of N application from 113.6-227.25 kg/ha did not significantly increase plant height, but it did reduce the total marketable yield of peppers.

Maynard (1962) indicated increased fruit set by application of nitrogen. Mohammed Kunju (1970) also observed increased fruit set by application of nitrogen at 75 kg/ha over a rate of 25 kg/ha. Jenkins and Horn (1963) found that nitrogen at 545.5 kg/ha was associated with disease resistance but at the same time there was a significant reduction in the yield of marketable fruits. Fertilizer investigations in chilli by Relwani (1963) revealed that N at 91 kg/ha and P at 91 kg/ha gave significantly higher yield than 45.45 kg of N and P/ha and was significantly better than no N and P. Arora et al. (1965) summarising the results of manurial trials conducted at IARI on chilli reported that there was a progressive increase in the yield of chillies due to nitrogen fertilization. Application of 60 kg nitrogen/ha gave significantly more yield over control, though difference between 60 kg and 120 kg nitrogen/ha was not significant. Gill et al. (1974) observed that fruits/ plant was significantly influenced by varying levels of nitrogen. Covarelli (1976) recorded good response of chilli to nitrogen application; nitrogen increased pods/ plant and 100 pod weight. Increased yields with increased

application of N fertilizers were reported by Gunewardena and Pereira (1975), Sagiv and Kafkafi (1976), Locascio and Fiskell (1977), Ramachandran and Subbiah (1981), Srinivas and Prabhakar (1982), Srinivas (1983), Sundstrom (1984), Singh et al. (1986) and Wiedinfeld (1986). However Spasov et al. (1977) reported that higher fertilizer rates especially N at 600 or 800 kg/ha reduced yields compered with the control.

Khan and Suryanarayana (1977) summarising the results of the manurial experiments on chillies reported that pod number, pod length, girth and yields were the highest with 120 kg nitrogen/ha. Mohammed Kunju (1970) also reported that nitrogen (75 kg/ha) produced the maximum pods/plant and 100 pod weight, but there were no significant differences in pod length or girth of pods at any of the three levels of nitrogen tried. Similar results have also been reported by Murthy and Murthy (1955). They also found that addition of nitrogen in any form or at any level had considerably increased the yield of chilli. The pod weight and pods/plant were also increased by nitrogen application where as length and girth of pods did not vary much due to the treatment. Valsikova (1983)

reported that balanced fertilization did not reduce crop quality of Cv. Jubilantka and that higher application rates could be safely used for economic yields. However Narasappa et al. (1985) reported that the yield of green fruits of Cv. Sindhur, rose with the N rate to a maximum (17.07 t/ha) at 150 kg N/ha and then declined to 15.74 at 250 kg N/ha. Nurzynski (1987) found that increasing N rates increased fruit dry rot symptoms in spite of increased leaf Ca content in Cv. Danube.

Mohammed Kunju (1970) observed that phosphorus application showed a slight earliness in flowering at levels of 40 or 60 kg P_2O_5/ha. Gill et al. (1974) noted that phosphorus application decreased the mean days required for flowering from 47.17 to 42.67 days with 187.5 kg P_2O_5/ha. Covarelli (1976) also observed that phosphorus increased the number of earliest fruits in chillies. Khan and Suryanarayana (1977) reported that number of days to flower was reduced by phosphorus from 60 days to 45-53 days.

Mohammed Kunju (1970) observed that phosphorus application upto 40 kg P_2O_5/ha significantly increased

fruit setting. Maximum number of pods/plant was observed at 60 kg P_2O_5/ha. He also noted that phosphorus did not affect significantly other yield contributing factors such as pod length, pod girth and 100 pod weight; but phosphorus at 40 and 60 kg P_2O_5/ha produced significantly higher yields. Gill *et al.* (1974) noted that P_2O_5 alone increased the mean number of pods/plant and total yield. In experiments with chillies, Covarelli (1976) reported that phosphorus increased number of pods/plant and 100 pod weight. Khan and Suryanarayana (1977) also reported to have got the highest number of pods/plant, length and girth of pods and total yield by application of 90 kg P_2O_5/ha.

Mehrotra *et al.* (1968) found that deficiencies of potash, adversely affected production of flowers and fruits in chillies. Similarly Pimpini (1967) observed that response to added potash was much lower in an area with high soil content of available potassium and application of 160 kg potash/ha increased yield and promoted earliness in chillies.

Mohammed Kunju (1970) observed that application of different levels of potash gave no significant difference

in setting percentage, pods/plant, girth and length of pods and earliness, but potash at 40 and 60 kg/ha increased the weight of 100 pods significantly over 20 kg/ha, while 40 and 60 kg/ha were at par. Covarelli (1976) noted that potash had no obvious effect on earliness and fruits/plant. Contrary to the above findings Khan and Suryanarayana (1977) reported that pods/plant, pod length, girth and yields were the highest with 45 kg K_2O/ha. Subbiah et al. (1982) noted that potash had significant effect on increasing yield of chillies.

Dhulappanavar (1965) noted that though chilli gave good response to nitrogen, application of P_2O_5 gave small increase in yield and advocated the application of phosphoric acid and potash to maintain soil fertility and to obtain more yields in more favourable season. Paunel (1966) found that the highest yield of sweet peppers (35.76 t/ha) was obtained with 150 kg N, 200 kg P_2O_5 and 120 kg K_2O/ha. Pimpini (1967) observed that potash in combination with phosphorus increased fruits/plant and average fruit weight. Pot culture experiments by Ivanic and Pecanko (1969) revealed that all eleven NPK treatments applied increased dry pepper fruit yields compared to the

control and the best results obtained with high rates of all three nutrients namely 3.156 g N, 1.416 g P_2O_5 and 3.673 g K_2O/pot containing 25 kg soil. Contrary to this report, Sanchezcorde (1970) found that the highest rates of both N and K depressed growth of Capsicum plants in sand culture. Mohammed Kunju (1970) summarising the results of manurial trial on chillies found that nitrogen in combination with phosphorus increased the height, pods/plant and setting percentage.

Lal and Pundrik (1971) observed that the highest yield was obtained in response to N (80 kg), P_2O_5 (90 kg) and K_2O (50 kg) and all interactions had positive effects on yield. In a manurial trial on chilli, Bangash and Shaikh (1972) reported that an yield increase of 109% over control was obtained by a balanced fertilization ie, 100 kg/ha each of N, P_2O_5 and K_2O. Similarly Berenyi (1973) also observed that combined application of nitrogen, phosphoric acid and potash gave higher yields. Phosphorus and potash alone increased yields, but the two together were still more effective. Gill et al. (1974) recorded good response of chilli to balanced fertilization. Nitrogen and phosphorus interactional effects were significant in

promoting earliness, pods/plant and branches/plant. On heavy clay chernozem N, P_2O_5 and K_2O at 120 : 120 : 120 kg/ha increased Capsicum yield by 54% compared with non-fertilized control and the yield increase was mainly due to greater fruit set as reported by Ludilov and Ludilova (1975). Nagarajaswamy and Nalawadi (1982) reported that the yield attributing characters such as fruits/plant and average weight of fruits/plant in chillies were the highest at the highest NPK rates. Subbiah (1982) showed that nitrogen in combination with potash tended to produce more yield in chillies. Markovic (1984) found that the highest NPK rates gave the greatest average yields of good quality fresh (18.2 t/ha) and dry (3.2 t/ha) fruits with the Cv. NS-2. Zayed et al. (1985) reported that NPK at the higher rates increased plant height, plant dry weight, fruit number and total yield but had no appreciable effect on fruit chemical composition. The highest yield was obtained with the highest NPK rates plus morphactin treatment. Joseph and Pillai (1985) also reported that higher yields of dry fruits under rainfed conditions were obtained at the highest NPK level, under irrigated conditions, at medium N and higher PK levels.

Effect of organic and inorganic fertilizers and their combination on the physico-chemical and biological properties of soil

a) Physical properties:

Russell (1960) observed an increased available moisture percentage in manured plots than the fertilised plots, the effect being more pronounced in light soils. The above trend was also noted by Mandal and Pain (1965), Ramaswamy (1966), Biswas et al. (1971) and Muthuvel (1973). The findings of Havanagi and Mann (1970) did not agree with the above observation. Rendhawa (1971) reviewing the work on soil water research in India, observed that water holding capacity of soils was improved by application of organic manures and Biswas et al. (1970) showed that retention of water was at a much lower tension than in case of chemical fertilizers, supplying N alone. Phosphorus markedly improved the water holding capacity (Biswas et al., 1964). A combination of NPK fertilizers with cattle manure could exert very favourable influence on WHC of the soil as reported by Manickam and Venkataraman (1972 a & b). Cattle manure treatment increased the WHC

of the soil as reported by Ramaswami *et al.* (1979) and Prasad and Singh (1980).

It is observed that changes in bulk density are related to cropping system, rate of organic matter decomposition, manuring and fertilization practices (Biswas *et al.*, 1970, 1971; Biswas and Khosla, 1971; Gattani *et al.*, 1976). Decrease in bulk density as a result of long term fertilization was reported by Young *et al.* (1960), Russell (1960), Biswas *et al.* (1964), Biswas and Khosla (1971) and Muthuvel (1973). Sharma (1964) observed an increase in bulk density due to application of superphosphate. Havanagi and Mann (1970) and Tanchandrophongs and Davidson (1970) also stated that bulk density decreased due to the cumulative effect of manurial treatments. A significantly negative relationship of bulk density and organic matter content of soil was reported by Biswas *et al.* (1970) but in majority of the experiments the magnitude of difference in bulk density due to cropping and manuring has been rather small and quite often not significant. Mathers and Stewart (1984) also found a decrease in the bulk density of clay loam soil due to manuring.

The continuous addition of bulky organic manures in improving the soil structure has been well documented as judged from the water stability of the aggregates greater than 0.25 mm (Strickling, 1950; Kibe and Basu, 1952; Heinonen, 1956; Biswas and Ali, 1967; Biswas et al., 1970; 1971 and Gattani et al., 1976). A combination of FYM and phosphatic fertilizers were very effective in building up the soil structure according to Das et al. (1966), Kanwar and Prihar (1962 b) and Biswas et al. (1963, 1969). Kemper and Koch (1966) observed that the aggregate stability was influenced by clay only in cultivated soils. According to Singh et al. (1968) long term application of organic and inorganic sources of nitrogen favoured the formation of large sized water stable aggregates. Biswas et al. (1964) and Muthuvel (1973) observed that continuous application of balanced doses of chemical fertilizers had no deleterious influence on the structural status of soil. Pichot (1972) obtained an inverse relationship between the size and stability of aggregates. According to him, aggregate stability was not influenced by N. Lunher (1971) also stated that FYM aided the formation of most stable aggregates. Manickam and Venkataraman (1972) could not observe a marked effect on the aggregate size by application of NPK and cattle manure.

b) Chemical properties:

In several rotational experiments conducted on different soil types, the organic carbon level of the plough layer got appreciably enhanced because of regular incorporation of bulky organic manures, mainly as FYM whereas the cumulative effect of long term use of inorganic fertilizers was relatively small as reported by Basu and Kiba (1946), Rao and Krishnan (1963), Singh et al. (1968), Ghosh and Kanzaria (1964), Biswas et al. (1977), Prasad et al. (1971), Sahu and Nayak (1971) and Shinde and Ghosh (1971). A favourable effect of both organic and balanced doses of chemical fertilizers in building up of organic matter content were brought out by the studies carried out by Acharya and Rajagopalan (1956), Biswas et al. (1977) and Raychaudhuri (1967). Russell (1960) and Young et al. (1960) found that the organic matter content of the soil declined in all the manured plots and the decline was more rapid in control plots. Kanwar and Prihar (1962 a) noticed increased organic carbon content by application of either FYM or ammonium phosphate. According to Russell (1960), addition of FYM to arable lands either increased the organic matter level or

decreased the rate of loss. Patel et al. (1963) and Sharma (1964) noticed the significant effects of phosphatic fertilizers in increasing the organic matter content. Singh et al. (1968) did not find any variation in the organic carbon content of the soil due to application of FYM and ammonium sulphate treatments. Mandal and Pain (1965) observed an increase in organic matter content due to long term manuring. Spratt and Mc Curdy (1966) concluded that fertilizer treatments were ineffective in raising the level of organic matter. Bandyopadhya et al. (1969), Biswas et al. (1969, 1971), Bache and Heathcote (1969), Ramaswami (1966), Havanagi and Mann (1970), Tanchandrophongs and Davidson (1970), Sahu and Nayak (1971), Kuduk (1978), Sivasangaranathan and Pain (1982) and Sharma et al. (1984) have allreported that the organic matter content of soil increased due to long continuous application of organic manures.

The influence of organic matter in increasing the total nitrogen content of soil was observed in several studies pertaining to long term field experiments in the country (Acharya and Rajagopalan, 1956; Kanwar and Prihar, 1962 a; Chaudhry and Vachhani, 1965; Mandal and Pain, 1965;

Sengupta, 1965 and Shinde and Ghosh, 1971. Earlier, Raju (1952) reported a two fold rise over control in total nitrogen content of soil receiving cattle manure and Mariakulandai and Thyagarajan (1959) indicated a general improvement in soil fertility status as well. Kanwar and Prihar (1962 a) observed an increase in nitrogen content due to FYM and ammonium phosphate application. Gasser (1962) observed a high N content in soils receiving FYM. Singh and Sharma (1968) observed no differences in the total N level due to fertilizer application. Bache and Heathcote (1969), Bandyopadya et al. (1969) and Lenz (1970) also showed the superiority of organic manures over inorganic manures in increasing total N content. Shinde and Ghosh (1971) observed an increase in N in soil due to P application.

Sinha (1957) reported that N and P combinations maintained the available nitrogen status of soil as high as did by organic manures such as FYM, green manure and oil cake. Mandal and Pain (1965) indicated that continued use of organic manures, compost and cowdung increased the available nitrogen when compared with control and ammonium sulphate alone. Rao and Badigar (1971), in their studies

on the effect of application of high levels of nitrogen over a period of years observed that there was no significant difference in the available nitrogen content of the soils. In the permanent manurial plots at Coimbatore, the available nitrogen content under organic manure treatments were higher than those under inorganic fertilizer treatments. This increase in the available nitrogen content under organic manure treatments, when the total nitrogen content remained the same might have been a result of increased microbial activity leading to greater mineralisation (Muthuvel, 1973). According to observations made by Mathan et al. (1978) FYM along with NPK significantly improved the organic carbon and total nitrogen but its influence on available nitrogen was relatively small.

Continued application of phosphatic fertilisers generally resulted in the build up of soil P (Russell, 1960; Young et al., 1960; Kanwar and Prihar, 1962 a; and Kowald et al., 1982). Havanagi and Mann (1970) reported that the combination of organic and phosphatic fertilizers had the most significant effect. Lenz (1970) observed that fertilizer treatment did not have any effect on

soil P content. Sahu and Nayak (1971) and Shinde and Ghosh (1971) also reported that the combination of organic matter and phosphatic fertilizer had the most significant effect. Krishnamoorthy and Ravi Kumar (1973) from Coimbatore reported a general increase in total P content of the soil in plots receiving P, NPK, PK, NP and cattle manure treatments.

One of the several findings of much significance that emanated from several long term experiments in different parts of the country is the marked decline in available Phosphorus level in the plough layer as a result of continued application of nitrogenous fertilizers (Kanwar and Prihar, 1960 a; Prasad et al., 1971 and Sahu and Nayak, 1971). This decrease was found much more rapid and sharp when higher doses of fertilizer nitrogen were applied to high yielding crop varieties and the soils were light-textured (Biswas et al., 1977). Generally, addition of organic manures in adequate amounts increased the available P content to a variable extent over the initial level (Kanwar and Prihar, 1962 a). A combination of bulky organic matter and FYM and phosphatic fertilizers had the best effect in increasing the phosphate availability

(Patel et al., 1963; Ray Chaudhuri, 1967 and Havanagi and Mann, 1970).

Raju (1952) observed that continued application of FYM, increased the total K in soil. According to Sahu and Nayak (1971), chemical fertilizers applied continuously for many years resulted in a rise in the content of total K in soil. However Lenz (1970) found reduction in the total K due to application of NPK. Shinde and Ghosh (1971) did not find any differences in the soil K due to mineral fertilizers. Krishnamoorthy and Ravikumar (1973) reported a marked increase in total K in the soil with cattle manure and fertilizer treatment.

Organic manures quite often improved the available K status of the soil (Raju, 1952; Ray Chaudhuri, 1967). According to the observations made by Kanwar and Prihar (1962 a) this was possibly due to the progressive incorporation of K through FYM itself and greater capacity of organic colloids to hold the nutrient at the exchange surface. As could be expected, continued application of potassic fertilizers promoted the build up of available K level in the plough layer of soil

(Sahu and Nayak, 1971; Muthuvel, 1973), but the overall effect even after several years appeared somewhat small possibly due to crop removal, fixation and leaching losses (Ghosh and Biswas, 1978).

The soil reaction (pH) is influenced to variable extent by the prolonged use of manures and fertilizers. A chemical fertilizer like ammonium sulphate added year after year could be expected to decrease the soil pH (Agarwal, 1965; Mandal and Pain, 1965; Prasad et al., 1971). In a few situations FYM dressing was associated with a fall in pH of the soil (Kanwar and Prihar, 1962 a). In certain cases the soil pH was not influenced by fertilizer treatments (Spratt and Mc Curdy, 1966; Singh and Sharma, 1968).

Slight decrease in Cation Exchange Capacity due to long term fertilizer treatments was noted by Young et al. (1960). Russell (1960) and Djokoto and Stephens (1961) observed increase in the exchange capacity of soils due to phosphatic fertilization. Soundararajan (1962) attributed the interaction between manures and fertilizers for the increased CEC of soils in the New Permanent

Manurial Experiment in Coimbatore. Bache and Heathcote (1969), Bandyopadhya et al. (1969) and Sahu and Nayak (1971) obtained a close relationship between the organic carbon content and CEC. The results of quite a few long term studies indicated a favourable effect of FYM and compost on raising CEC of the soil (Mandal and Pain, 1965, Bandyopadhya et al., 1969 and Sahu and Nayak, 1971. No noticeable influence of long term use of chemical fertilizers in different combinations on the CEC of surface soils was observed by Randhawa (1971) and Shinde and Ghosh (1972).

c) Biological properties:

Endomycorrhiza known to mankind for over 100 years, probably existed in our planet some 300 million years ago. In 1885, a typical VA - mycorrhizal association was first reported by Treub in sugarcane. Since 1896, a number of reports were published with regard to the occurrence of VA - mycorrhiza in plants like pigeon pea (Jones, 1924), grapes, citrus and tomato (Gerdemann, 1968), coconut (Lilly, 1975), cowpea, capsicum, soybean (Godse et al. 1976), potato (Thomazeni, 1979), etc. Similar incidence of

VA - mycorrhiza in a wide variety of commonly cultivated crops in Kerala were reported by Potty (1978) in tuber crops such as cassava, sweet potato and coleus. Girija and Nair (1985) reported occurrence of VA - mycorrhiza in chillies. Phillips and Hayman (1970) developed a proper staining technique for VA - mycorrhiza using 0.05% trypan blue in lactophenol after clearing the roots initially in 10% KOH at 90°C for one hour.

The importance of mycorrhiza in the absorption of phosphorus and other nutrients was first reported by Mosse (1957). Gray and Gerdemann (1967), Bowen and Mosse (1969) also found that endomycorrhizal association in many plants greatly increased the uptake of P and Zn from a nutrient solution. Gray and Gerdemann (1969) reported that the presence of an extensive mycelial network of VA mycorrhizal fungi on the infected root enabled the host plant to absorb more phosphorus from larger volume of soil. In an attempt to find out the actual mechanism of increased phosphorus uptake by mycorrhizal plants, Sanders and Tinker (1971) found that the increased surface area due to mycelial network was primarily responsible for the enhanced uptake of P.

Changes in the soil fertility due to amendments with mineral fertilizers or organic matter can markedly affect the activity of the soil mycorrhizal population in terms of the amount of root infection and number of resting spores produced. There is some evidence that organic matter added to the soil leads to better mycorrhizal development (Hayman, 1982). High levels of P tended to reduce infection, while low levels stimulated it. NPK fertilizers, slightly reduced spore numbers without effecting infection (Saif, 1986). Sanders (1975) determined that P application reduced the intensity and rate of spread of the mycorrhizal colonization, reduced the weight of external mycelium associated with each centimeter of colonized root and depressed the supply of P to the host via the mycorrhizae. Although high levels of phosphorus and nitrogen in soil and artificial media inhibited or reduced root colonization (Mosse and Phillips, 1971 and Hayman, 1975) and subsequent spore formation (Kruckelmann, 1975), it was the nutritional status of the plant, not the soil fertility, which determined the degree of colonization and spore formation. Nitrogen fertilization has also been shown to affect mycorrhizal formation negatively. Hayman (1970) found application of NH_4NO_3 to

heavy clay loam soil significantly reduced growth and spore formation of VAM endophytes. Similar results were observed in light sandy soils. The extent to which mycorrhizal colonization was depressed depended on the N : P ratio rather than phosphate concentration alone.

Contrary to the above findings, it was found that the germination of VAM fungal spores does not appear to be greatly influenced by soil fertility. Koske (1901) observed no difference in germination of Gigaspora gigantia spores regardless of phosphorus concentrations. Similarly, Daniels and Trappe (1980) observed that additions of nitrogen or potassium did not appreciably stimulate or inhibit germination and although certain levels of phosphorus amendment gave a statistically significant increase in germination, this stimulation was probably not biologically significant.

From the above review it is seen that chilli responds differently to different levels of organic and inorganic fertilizers and their combination. Their influence on the physico-chemical and biological properties of soils also vary. However meagre information is

available about the effect of different levels of organic and inorganic fertilizers and their combination on crop productivity as well as on the physico-chemical and biological properties of soils cropped under clustered chilli.

Materials and Methods

MATERIALS AND METHODS

The present studies were made to find out effects of organic and inorganic fertilizers and their combinations on physico-chemical and biological properties of soil cropped under clustered chilli, variety KAU Cluster (*Capsicum annuum* var. *fasciculatum*)

Experimental site:

The experimental site is at the Instructional Farm, College of Horticulture, Vellanikkara, Trichur. This research farm is located at an altitude of 23 m above mean sea level and is situated at 10° 32' N latitude and 76° 16' E longitude. This region enjoys a typical warm humid tropical climate.

Season and weather conditions:

The experiments were conducted during three seasons. March to July 1987, August to December 1987 and January to April 1988. The meteorological data during the period of experimentations are furnished in Appendix-I.

Soil characteristics:

A portion of the experimental site was dug to a depth of 120 cm and to a width of 90 cm, to study soil profile (Plate 1). The soil is a well drained sandy clay loam with pH 5.1.

Chilli Var. KAU Cluster

KAU Cluster (Capsicum annuum var. fasciculatum) was used for the experiment. This is an erect and clustered fruited line resistant to bacterial wilt (Goth et al., 1983) and Collar rot (Phytophthora capscici) (Peter et al., 1984). The seeds of this variety were collected from the Vegetable Seed Production Centre of the Department of Olericulture, College of Horticulture, Vellanikkara.

Manures and fertilizers:

Urea (46% N), Mussorie phosphate (22% P_2O_5) and Muriate of potash (60% K_2O) were used as sources of nitrogen phosphorus and potash respectively. Farm yard manure was the organic source used. Chemical analysis of the organic and inorganic fertilizers showed the following composition.

Plate 1. Soil profile of the experimental site

Plate 2. Basic fertility of the experimental site - Bhindi Var. Pusa Sawani

PLATE 1

PLATE 2

Materials	Percentage of nutrients		
	N	P_2O_5	K_2O
Urea	46.0	-	
Mussorie Phos	-	22	-
Muriate of Potash	-	-	60
Farm yard manure	0.4	0.3	0.2

Experimental technique:

The entire experimental site was made homogenous by planting a nutrient depleting crop - Bhindi Var. Pusa Sawani (Plate 2). Sowing of Pusa Sawani was undertaken prior to the actual experimentation, from December 1986 to February 1987. The whole area was made weed free, ploughed and levelled. Bunds were taken on all four sides. Seeds were sown in furrows at a spacing of 30 cm x 15 cm. No manures and fertilizers were applied. Regular irrigation and weeding were given. The chilli crops were raised after the harvest of the bhindi crop.

Design and layout:

The experimental design adopted was Randomised Block Design with four replications. There were five rows of ten plants each in such a way that each plot accomodated 50 plants. The spacing adopted was 60 cm x 45 cm. The layout of the experiment is given in Fig.1.

Treatments:

The experiment consisted of eight treatments as detailed below:

a) Levels of Farm Yard Manure:

15 t/ha

20 t/ha

30 t/ha

b) Levels of Nitrogen:

75.00 kg N/ha

125.00 kg N/ha

175.00 kg N/ha

c) Level of Phosphorus:

40.00 kg P_2O_5/ha

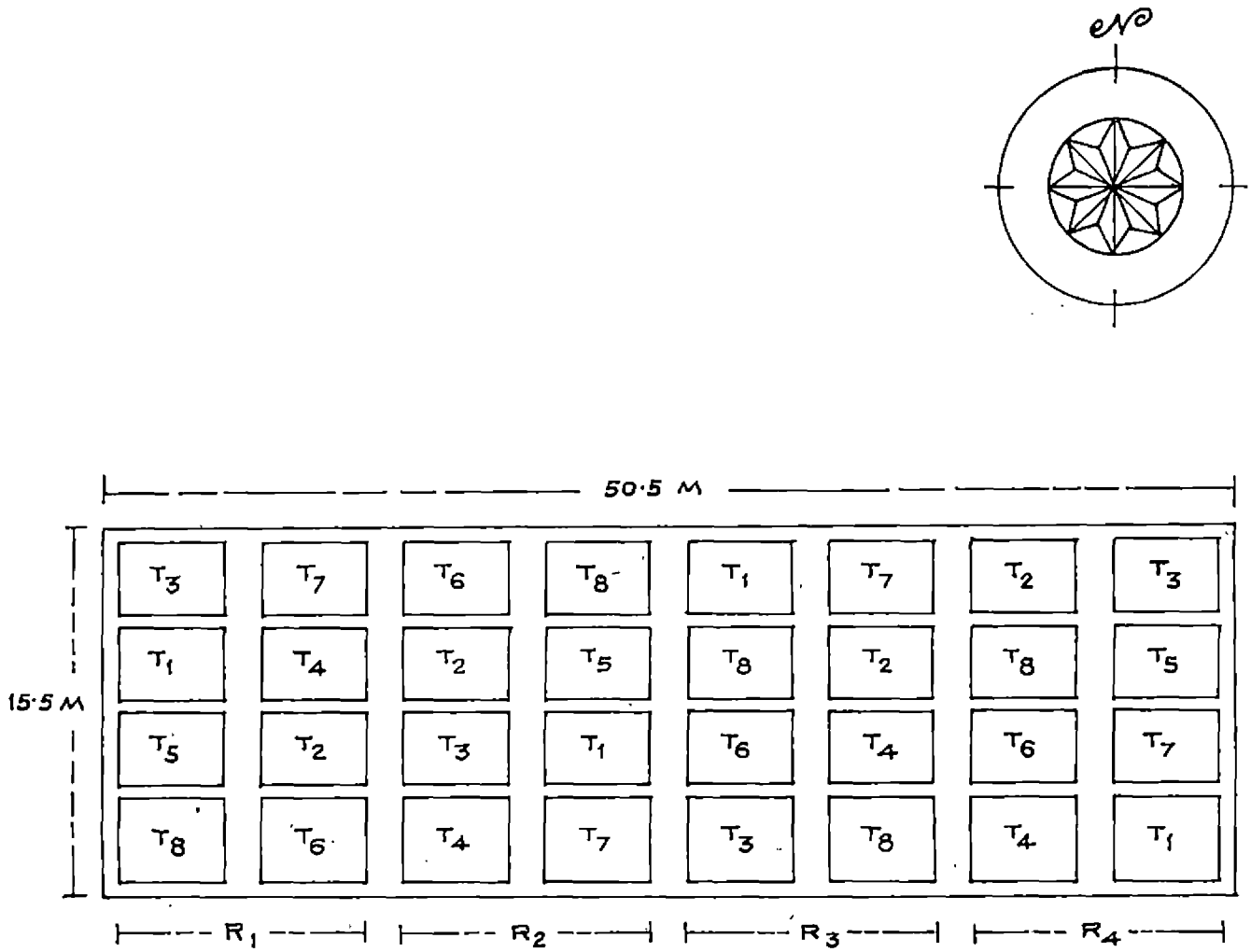

FIG.1. LAY OUT PLAN OF THE EXPERIMENTAL SITE.

d) Level of Potassium:

25.00 kg K_2O/ha

e) The treatments are as follows:

Organic fertilizers alone:

T_1 - 30 t FYM/ha

Inorganic fertilizers alone:

T_2 - 75 : 40 : 25 kg/ha of N, P_2O_5, K_2O.

T_3 - 125 : 40 : 25 kg/ha of N, P_2O_5, K_2O.

T_4 - 175 : 40 : 25 kg/ha of N, P_2O_5, K_2O.

Organic and inorganic fertilizers together:

T_5 - 15 t of FYM/ha + 75:40:25 kg/ha of N, P_2O_5, K_2O.

T_6 - 15 t of FYM/ha + 125:40:25 kg/ha of N, P_2O_5, K_2O.

T_7 - 15 t of FYM/ha + 175:40:25 kg/ha of N, P_2O_5, K_2O.

Control

T_8 - 20 t of FYM/ha + 75:40:25 kg/ha of N, P_2O_5, K_2O.

(Package of Practices Recommendations, KAU, 1986)

Size of plots:

Gross plot size	:	6.3 m x 3.9 m
Net area of a plot	:	13.38 m^2
Spacing	:	60 cm x 45 cm
Number of plants in gross plot	:	50

Number of plants in net plot : 24

Replications : 4

Nursery:

Five hundred grams of seeds were sown in well prepared raised nursery beds. Beds were 1 m wide, 3 m long and 15 cm high. A basal dressing of powdered cattle manure at the rate of 1 kg/m^2 was applied to the nursery bed. Furadan 3 G (0.5 kg ai/ha) was also applied to ward off attack of ants and termites. Nursery beds were irrigated daily.

The nursery for the first crop was raised on 9th February 1987, for the second crop on 22nd July 1987 and for the third crop on December 4th, 1987. The seedlings were ready for transplanting in about 35-40 days.

Field culture:

The experimental area was ploughed and harrowed so as to obtain a fine tilth. Plots of size 6.3 m x 3.9 m were laid out. Ridges and furrows were then taken in such a way that each plot contained five furrows set 60 cm apart. Seedlings were transplanted in the furrows at a

spacing of 45 cm. Shades were also provided for the seedlings for a period of 4-5 days.

Manuring:

The manures and fertilizers were applied as per the schedule of treatments. The time schedule for application was according to the Package of Practices recommendations (KAU-1986). The entire dose of farm yard manure and phosphorus and half the dose of nitrogen and half of potassium were given as basal dressing at the time of land preparation, 1/4 nitrogen and the remaining half of potassium was applied 20 to 25 days after transplanting and the remaining quantity of nitrogen was applied one month after the second application. In case of the treatments receiving organic manures alone, half the quantity of farm yard manure was given as basal dressing and the remaining half applied 20-25 days after transplanting. Raking of the soil was done after each application and irrigation was also given.

After cultivation and Plant Protection:

Daily irrigation was given for a week after transplanting to enable the early establishment of the

seedlings. The first crop did not require further irrigation due to onset of monsoons. The second and third crops were given daily irrigation for a week after transplanting and later irrigated on alternate days to ensure sufficient moisture in the soil. Four hand weedings were given for each crop.

Regular prophylactic sprayings with Nuvacron (0.05%) were given to the crops. Furadan 3 G (0.5 kg ai/ha) was also applied to control the attack of ants and termites. There was however no serious attack of pest or diseases.

Harvesting:

The fruits were harvested at the green mature stage. Four to five pickings were taken. Fruits on the border plants were allowed to ripen for seed purpose.

Observations Recorded:

A. Bhindi : Pusa Sawani

1. Plant height

This observation was taken from 100 plants at random at the time of final harvest. Plant height was measured from the base to the growing tip of the plants.

2. Fruit yield

Yields of the above 100 plants chosen at random were recorded.

3. Pod weight

Average weight of five pods were taken from 20 samples.

4. Pod length

Length of 100 pods were measured.

5. Seeds/pod

The number of seeds/pod of 100 pods were recorded.

B. Chilli : KAU Cluster

a) Growth components:

(i) Plant height at first harvest

This observation was taken from five plants at random in each treatment after eliminating the border rows. The plant height was measured from the base to the growing tip of the plant.

(ii) Branches/plant

The total number of branches/plant at the time of first harvest was recorded from the above five plants selected at random in each treatment.

b) Earliness, Yield and Quality attributes:

(i) Index to Earliness : This was calculated from the formula

$$IE = \frac{a_1 + a_2 + a_3 + \ldots\ldots\ldots\ldots\ldots + a_n}{c_1 + c_2 + c_3 + \ldots\ldots\ldots\ldots\ldots + c_n}$$

where ai = Yield of treated plants on the i^{th} day

ci = Yield of control plants on the i^{th} day

(ii) Fruit length:

Twenty fruits/treatment selected at random were measured and their average length calculated.

(iii) Fruit yield/plot:

The weight of fruits/plot was found out after each harvest and the total fruit yield/plot was then calculated after the final harvest.

(iv) Number and weight of unmarketable fruits 10 days of storage after harvest of green chilli was also found out after each harvest for each treatment.

C) Biomass observations:

The fresh weight of the weeds/plot was recorded after each hand weeding.

Analysis of soils:

Composite soil samples from 0-15 cm depth were taken before the commencement of the experiment, prior to sowing of bhindi. Soil samples were also taken from each plot prior to planting of chilli as well as after the harvest of the crops. The soil samples were then air dried, powdered and passed through a 2 mm sieve. The sieved samples were used for analysis.

Physical properties:

a) Mechanical analysis

Mechanical analysis of the original soil was carried out by the Hydrometer method (Piper, 1942).

b) Physical constants

Apparent density, maximum water holding capacity and absolute specific gravity of original soil and after treatment were determined using the Keen-Raczkowski box (Keen and Raczowski, 1921).

c) Aggregate analysis

The unsieved composite samples were used for the determination of water stable aggregates. The Yoders sieving apparatus was utilised for this (Yoder, 1936).

Chemical Properties:

a) Organic carbon

Walkley and Black method (Jackson, 1958) was used for the determination of total organic carbon content of soil.

b) Total nitrogen

The semi micro-Kjeldahl method (Jackson, 1958) was adopted for the determination of total N content of the soil.

c) Total Phosphorus

Total phosphorus content of soil was determined by Vanadophosphoric yellow colour method using the perchloric nitric acid (1 : 2) extracts (Jackson, 1958 and Hesse, 1971).

d) Total Potassium

Total potassium content of the soil was determined in flame photometer using the perchloric - nitric acid (1 : 2) extracts (Jackson, 1958 and Hesse, 1971).

e) Available Nitrogen

The alkaline permanganate method was used for determining the available nitrogen content of soil (Subbiah and Asija, 1956).

f) Available Phosphorus

Available phosphorus content of the soil was determined using Bray-I extractant and molybdophosphoric acid method in hydrochloric acid system (Jackson, 1958)

g) Available Potassium

Available potassium content of soil was determined

flame photometrically, using the neutral normal ammonium acetate extract (Jackson, 1958).

h) Cation Exchange Capacity:

CEC was determined by displacing the cations using sodium acetate solution. The excess Na ions and moisture was then removed by washing with ethanol and was then treated with IN ammonium acetate to release Na ions from the exchange complex. The Na ions in the extract were then determined photometrically (Jackson, 1958).

i) pH

The soil pH was determined in a 1 : 2.5 soil water suspension using a pH meter.

j) Electrical conductivity

EC was determined by a conductivity bridge using a soil water suspension of 1 : 2.5.

Biological Properties:

a) VA mycorrhizal population

The VA mycorrhizal population was observed during transplanting on 30th day and at final harvest stage. The

method of Phillips and Hayman (1970) was used for observing the VA mycorrhizal infection in the root samples. One hundred root bits of approximately 1 cm length were examined, segment-wise, for this purpose. The root bits were initially washed in tap water and softened by simmering in 10% KOH at 90°C for 1 hour. After cooling, the excess of alkali was removed by repeated rinsing in tap water and then acidified with 2% HCl before staining with 0.05% trypan blue in lactophenol at 90°C for three minutes. The excess stain from the root tissue was removed by clearing overnight in fresh lactophenol. Ten root bits were examined at a time for the typical VA mycorrhizal infection under a light microscope.

Each root bit was divided into four equal segments for recording the presence or absence of VA mycorrhiza and based on this, different grades from 0-4 were given depending on the extent of mycorrhizal infection. The average value thus obtained for 100 root bits examined was taken as the mycorrhizal index.

Statistical analysis:

The data recorded were statistically analysed. The 'F' test was carried out by analysis of variance technique

(Panse and Sukhatme, 1978). Significant results were compared after finding out the critical difference.

Economics:

The yield data were transformed into monetary values based on current market price of green chillies. Cost of inputs were separately worked out for each treatment. The income after deducting the additional cost was found out. The returns due to the application of each treatment was then worked out.

Changes, if any in the physico-chemical and biological properties of soil, due to sequential chilli cropping were later observed and examined.

Results

RESULTS

The present investigation was undertaken to study the effect(s) of organic and inorganic fertilizers and their combinations on physico-chemical and biological properties of soil cropped under clustered chilli (Capsicum annuum Var. fasciculatum). The experimental results are presented under the following heads.

A. Performance of the nutrient depleting crop Bhindi Var. Pusa Sawani.
B. Effect of organic and inorganic fertilizers and their combination on crop productivity.
C. Effect of organic and inorganic fertilizers and their combination on physico-chemical and biological properties of soil.
D. Estimation of net returns due to organic and inorganic fertilizers and their combination in clustered chilli.

A. Performance of the nutrient depleting crop Bhindi Var. Pusa Sawani

The coefficient of variation for characters, plant height and fruit yield in 100 plants of Bhindi Var. Pusa Sawani are presented in Table 1.

Table 1. Coefficient of variation for plant height (cm) and fruit yield (g) in 100 plants of Bhindi Var. Pusa Sawani

Characters	Mean	Standard deviation	Standard error	Coefficient of variation
Plant height (cm)	17.22	7.47	0.75	43.36
Fruit yield (g)	15.89	11.23	1.12	70.67

i) Plant height

The coefficient of variation for plant height was 43.36. The frequency distribution curve for plant height is not normal (Table 2, Fig. 2).

ii) Fruit yield

The coefficient of variation for fruit yield was 70.67. The frequency distribution curve for plant height does not follow a normal curve pattern (Table 3, Fig. 3).

iii) Pod weight

Data on the average weight of five pods/sample for 20 samples are presented in Table 4. No significant variation was seen for pod weight among the 20 samples.

Table 2. Frequency distribution for plant height (cm) in Bhindi Var. Pusa Sawani

Class	Class value	Frequency	Frequency x Class value
5-7	6	7	42.0
8-10	9	16	144.0
11-13	12	14	168.0
14-16	15	15	225.0
17-19	18	16	288.0
20-22	21	10	210.0
23-25	24	5	120.0
26-28	27	8	216.0
29-31	30	3	90.0
32-34	33	4	132.0
35-37	36	2	72.0
Total		100	1707.0

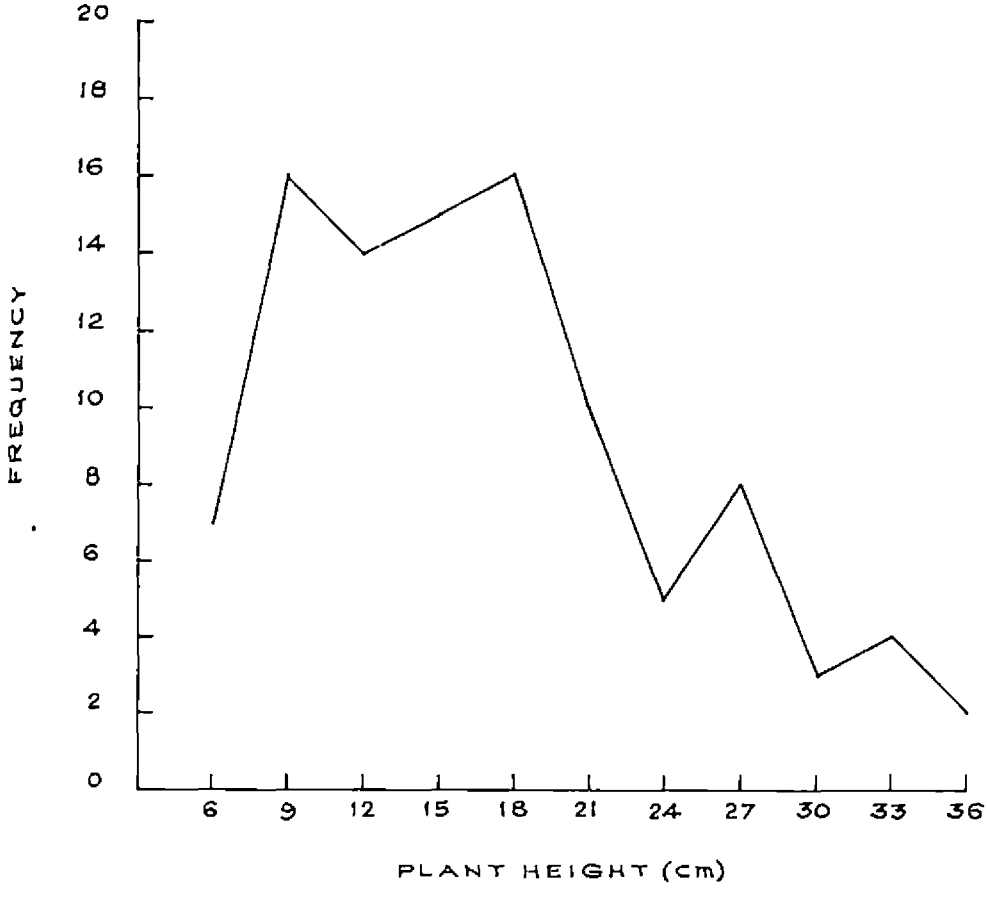

FIG. 2. FREQUENCY DISTRIBUTION FOR PLANT HEIGHT (cm) IN BHINDI VAR. PUSA SAWANI.

Table 3. Frequency distribution for fruit yield (g) in Bhindi Var. Pusa Sawani

Class	Class value	Frequency	Frequency x Class value
3-8	5.5	28	154.0
9-14	11.5	28	322.0
15-20	17.5	22	385.0
21-26	23.5	10	235.0
27-32	29.5	2	59.0
33-38	35.5	3	106.5
39-44	41.5	4	166.0
45-50	47.5	1	47.5
51-56	53.5	1	53.5
57-62	59.5	1	59.5
Total			1588.0

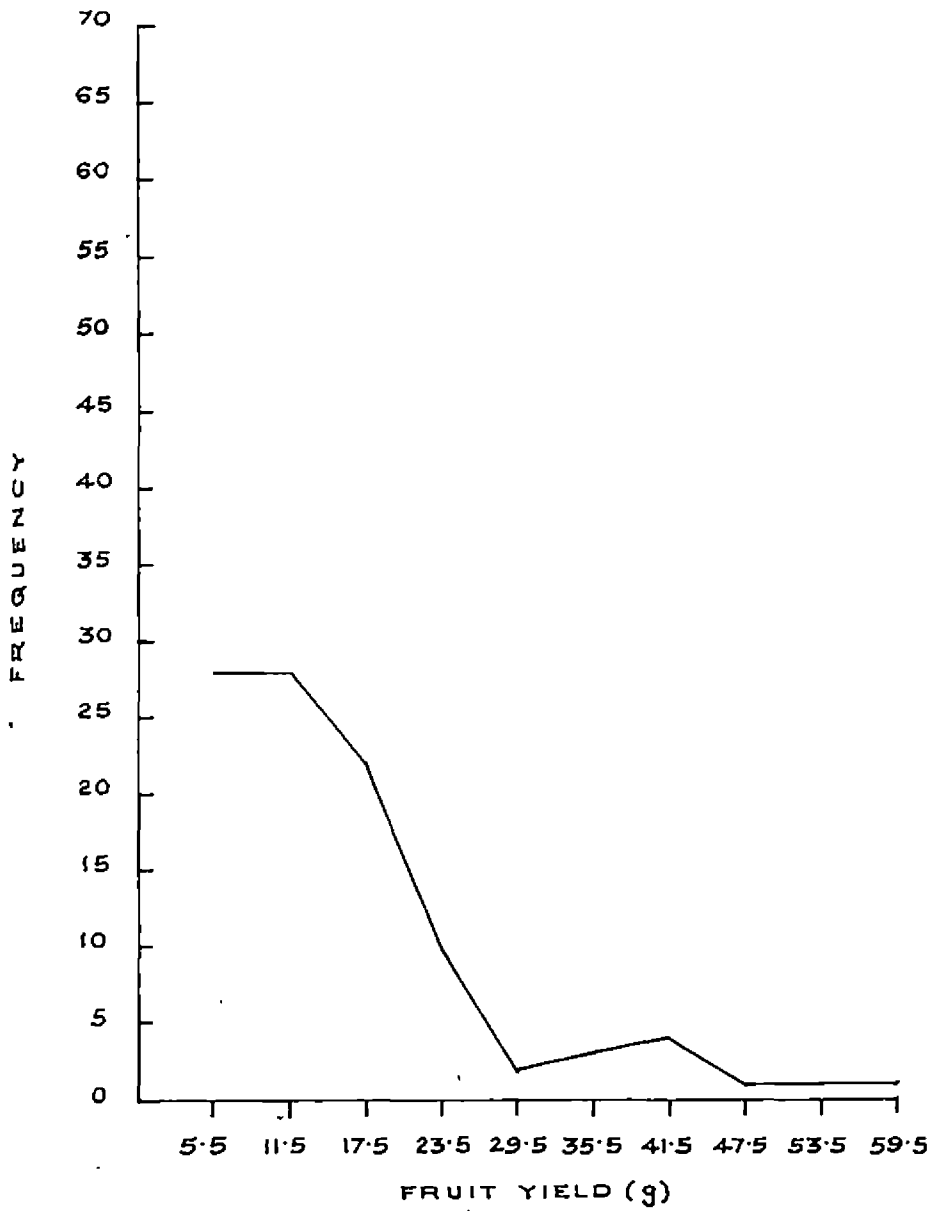

FIG. 3. FREQUENCY DISTRIBUTION FOR FRUIT YIELD (g) IN BHINDI VAR. PUSA SAWANI.

Table 4. Pod weight (g) in Bhindi Var. Pusa Sawani

Sample number	Fruit weight (g) (5 pods/sample)	Sample number	Fruit weight (g) (5 pods/sample)
1	38.30	11	52.85
2	57.25	12	49.60
3	52.25	13	47.75
4	27.50	14	45.45
5	57.40	15	53.35
6	38.30	16	44.25
7	53.80	17	50.95
8	47.50	18	50.30
9	52.80	19	44.20
10	61.70	20	47.90

iv) Pod length

The frequency distribution for pod length is presented in Table 5 and Fig. 4. The 100 pods measured showed great variation in length. The frequency distribution curve obtained is a normal curve.

v) Seeds/pod

The frequency distribution for seeds/pod is given in Table 6 and Fig. 5. A normal curve was obtained. Significant variation was seen.

B. Effect(s) of organic and inorganic fertilizers and their combination on crop productivity

The general analysis of variance (Table 7) indicated that the eight treatments during March-July, 1987 (E_1), August-December, 1987 (E_2) and January-April, 1988 (E_3) were significantly different to create variation for index of earliness, plant height, branches/plant, number of unmarketable fruits ten days of storage after harvest of green chilli, weight of unmarketable fruits, fruit yield/plot and biomass weight. The biomass weight was however

Table 5. Frequency distribution for pod length (cm) in Bhindi Var. Pusa Sawani

Class	Class value	Frequency	Frequency x Class value
8-9	8.5	6	51.0
10-11	10.5	18	189.0
12-13	12.5	21	262.5
14-15	14.5	29	420.5
16-17	16.5	20	330.0
18-19	18.5	3	55.5
20-21	20.5	3	61.5
Total		100	1370.0

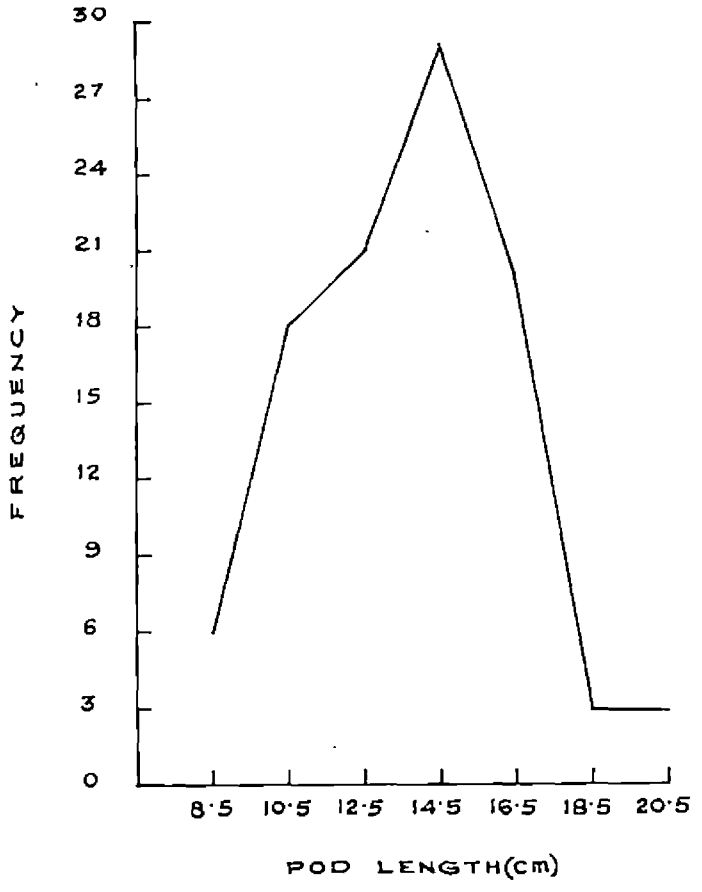

FIG. 4. FREQUENCY DISTRIBUTION FOR POD LENGTH(Cm) IN BHINDI VAR. PUSA SAWANI.

Table 6. Frequency distribution for seeds/pod in Bhindi Var. Pusa Sawani

Class	Class value	Frequency	Frequency x Class value
10-15	12.5	5	62.5
16-21	18.5	11	203.5
22-27	24.5	12	294.0
28-33	30.5	25	762.5
34-39	36.5	14	511.0
40-45	42.5	13	552.5
46-51	48.5	8	388.0
52-57	54.5	6	327.0
58-63	60.5	1	60.5
64-69	66.5	1	66.5
70-75	72.5	4	290.0
Total		100	3518

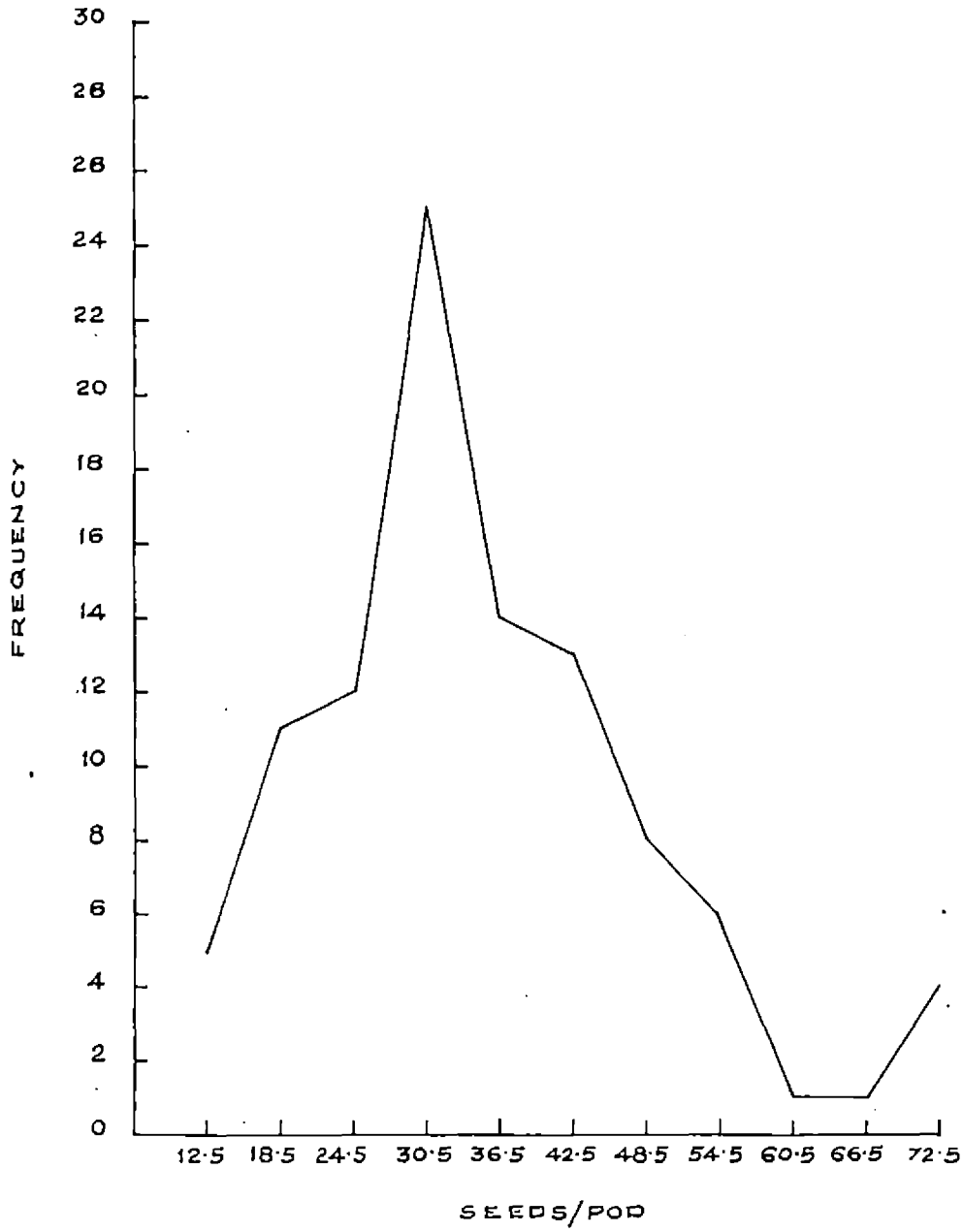

FIG. 5. FREQUENCY DISTRIBUTION FOR SEEDS/POD IN BHINDI VAR. PUSA SAWANI.

Table 7. General analysis of variance

Source of variation		df	M.S.							
			Plant height	Branches/ plant	Index of earliness	Fruit length	Fruit yield per plot	Number of unmarket-able fruits	Weight of unmarket-able fruits	Biomass weight
Blocks	E_1	3	23.900*	14.058	0.894**	0.106*	0.225**	57.281	23.672	15.237
	E_2	3	4.839	0.244	0.103	0.072	0.000	12.865	2.829	15.766
	E_3	3	26.244**	4.090*	1.259*	0.091	0.158**	95.448	45.035	29.239
Treatments	E_1	7(6)+	127.811**	44.308**	0.603**	0.026	0.220**	165.424*	57.088*	81.765**
	E_2	7(6)+	16.515**	1.363**	0.316**	0.045	0.022**	98.138**	25.577**	43.327
	E_3	7(6)+	95.176**	19.117**	1.530**	0.048	0.139**	2257.567**	408.325*	31.794*
Error	E_1	21(18)+	6.791	5.135	0.097	0.023	0.036	52.972	17.811	17.886
	E_2	21(18)+	1.608	0.155	0.035	0.040	0.002	13.650	2.489	22.488
	E_3	21(18)+	5.217	1.173	0.271	0.050	0.026	260.877	141.949	11.359

* p = 0.05
** p = 0.01

\+ degrees of freedom for index of earliness

E_1 = First crop March-July 1987
E_2 = Second crop August-December 1987
E_3 = Third crop January-April 1988

not significantly different during August-December, 1987 (E_2).

a) Growth components

i) Plant height at first harvest

The effect of organic and inorganic fertilizers and their combination on plant height of KAU Cluster is presented in Table 8 and Fig. 6. During March-July, 1987, the treatment T_7 (15 tons FYM/ha + 175:40:25 kg N, P_2O_5, K_2O/ha) recorded the maximum height (37.54 cm) followed by treatment T_6 (15 tons FYM/ha + 125:40:25 kg N, P_2O_5, K_2O/ha) with a height of 34.77 cm and then control T_8 (32.66 cm) (20 tons FYM/ha + 75:40:25 kg N, P_2O_5, K_2O/ha). A reduction in plant height was noticed due to treatments T_1 (30 tons FYM/ha), T_2 (75:40:25 kg N, P_2O_5, K_2O/ha), T_3 (125:40:25 kg N, P_2O_5, K_2O/ha), T_4 (175:40:25 kg N, P_2O_5, K_2O/ha) and T_5 (15 tons FYM/ha + 75:40:25 kg N, P_2O_5, K_2O/ha). Of these, reduction in height caused by T_2, T_3 and T_4 ie, organic fertilizers alone were statistically significant. Percentage increase over control was maximum for T_7 (14.94%) followed by T_6 (6.46%). Decrease in height over control was in the order of T_4 (32.36%), T_3 (26.42%), T_2 (26.21%), T_1 (7.53%) and T_5 (1.47%).

Table 8. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers - Plant height

Treatments	March-July 1987		August-December 1987		January-April 1988	
	Plant height (cm)	Increase or decrease over control (%)	Plant height (cm)	Increase or decrease over control (%)	Plant height (cm)	Increase or decrease over control (%)
T_1	30.20	-7.53	21.50	-11.34	27.56	-11.13
T_2	24.10	-26.21	21.90	-9.69	23.71	-23.54
T_3	24.03	-26.42	22.45	-7.42	22.95	-25.99
T_4	22.09	-32.36	23.10	-4.74	21.71	-29.99
T_5	32.18	-1.47	25.80	+6.39	30.22	-2.55
T_6	34.77	+6.46	24.55	+1.24	31.29	+0.90
T_7	37.54	+14.94	27.40	+12.99	35.62	+14.87
T_8 (Control)	32.66		24.25		31.01	
CD (p = 0.05)	3.83		1.87		3.36	

T_1 = 30 t FYM/ha

T_2 = 75:40:25 kg N, P_2O_5, K_2O/ha

T_3 = 125:40:25 ,,

T_4 = 175:40:25 ,,

T_5 = 15 t FYM/ha + 75:40:25 kg N, P_2O_5, K_2O/ha

T_6 = 15 t FYM/ha +125:40:25 ,,

T_7 = 15 t FYM/ha +175:40:25 ,,

T_8 = (Control) (Package of Practices Recommendation) 20 t FYM/ha + 75:40:25 kg N, P_2O_5, K_2O/ha

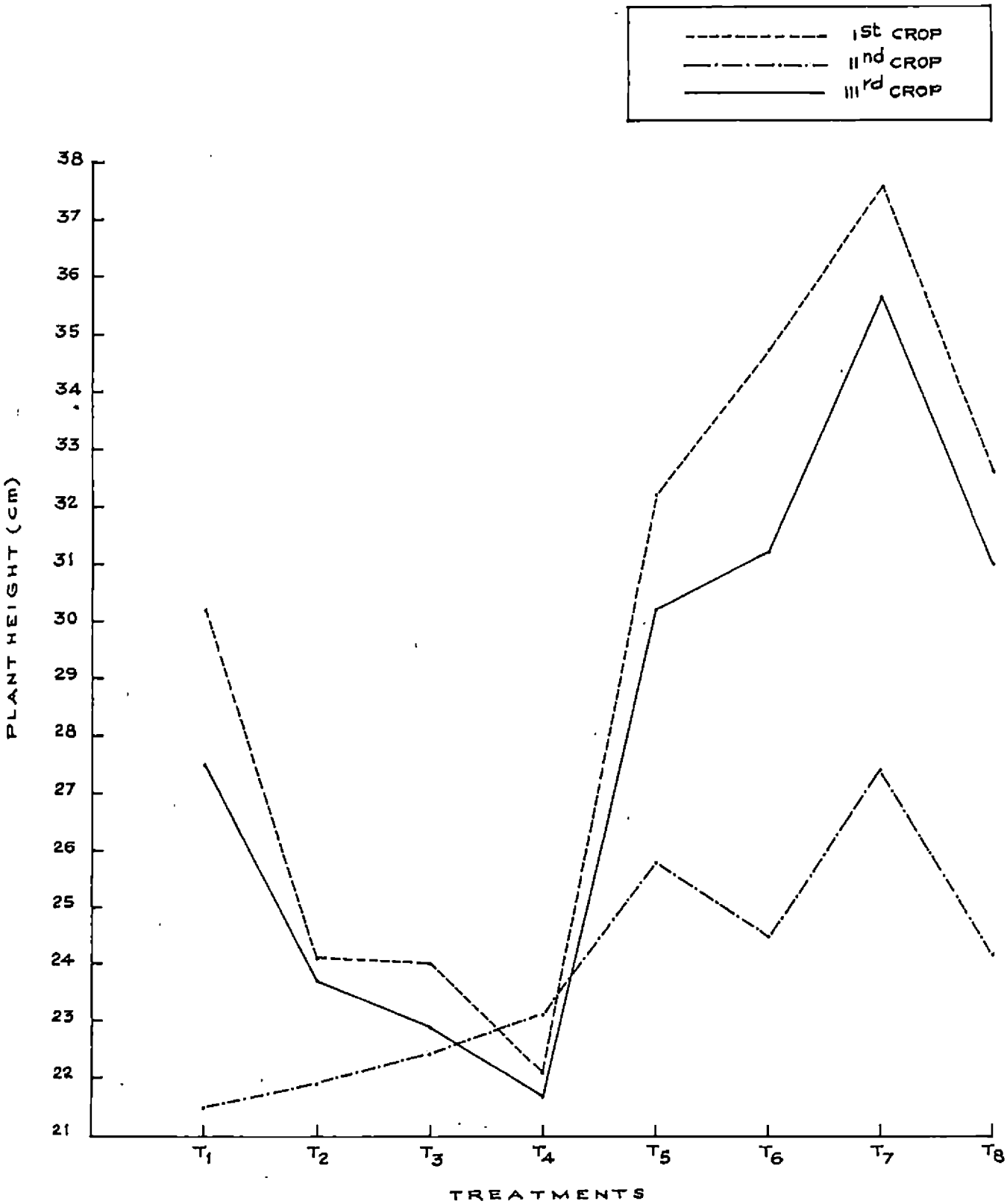

FIG. 6. EFFECT OF DIFFERENT LEVELS OF ORGANIC AND INORGANIC FERTILIZERS AND THEIR COMBINATION ON PLANT HEIGHT(cm) OF CHILLI VAR. KAU CLUSTER.

During August-December, 1987, the maximum height was recorded by treatment T_7 (27.40 cm) followed by T_5 (25.8 cm) and then T_6 (24.55 cm). Of these, the increase in height due to treatment T_7 was only significant. The treatments T_1, T_2, T_3 and T_4 caused a reduction in height when compared to control (T_8). Percentage decrease over control was maximum for T_1 (11.34%) followed by T_2 (9.69%), T_3 (7.42%) and T_4 (4.74%).

During January-April, 1988, the maximum height was again recorded by treatment T_7 (35.62 cm) followed by T_6 (31.29 cm) and then control T_8 (31.01 cm). Once again, the increase in height due to treatment T_7 was only significant. All the other treatments caused a reduction in height when compared to control. The maximum reduction was for T_4 (29.99%) followed by T_3 (25.99%), T_2 (23.54%), T_1 (11.13%) and T_5 (2.55%).

ii) Branches/plant

The maximum number of branches/plant during March-July, 1987, was recorded by the treatment T_7 (15.75) followed by T_6 (11.00) (Table 9 and Fig. 7). But of these, the treatment T_7 was only significant. Percentage increase

Table 9. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers

Branches/plant

Treatments	March-July 1987		August-December 1987		January-April 1988	
	Branches/ plant	Increase or decrease over control (%)	Branches/ plant	Increase or decrease over control (%)	Branches/ plant	Increase or decrease over control (%)
T_1	9.85	-2.47	2.73	-25.82	7.3	-37.87
T_2	6.45	-36.14	3.20	-13.04	8.65	-26.38
T_3	6.10	-39.60	3.00	-18.48	8.65	-26.38
T_4	5.60	-44.55	3.18	-13.59	8.45	-28.09
T_5	9.00	-10.89	3.93	+6.79	10.7	-8.94
T_6	11.00	+8.91	4.03	+9.51	12.35	+5.11
T_7	15.75	+55.94	4.43	+20.38	13.35	+13.62
T_8 (Control)	10.10		3.68		11.75	
CD (p = 0.05)	3.33		0.58		1.59	

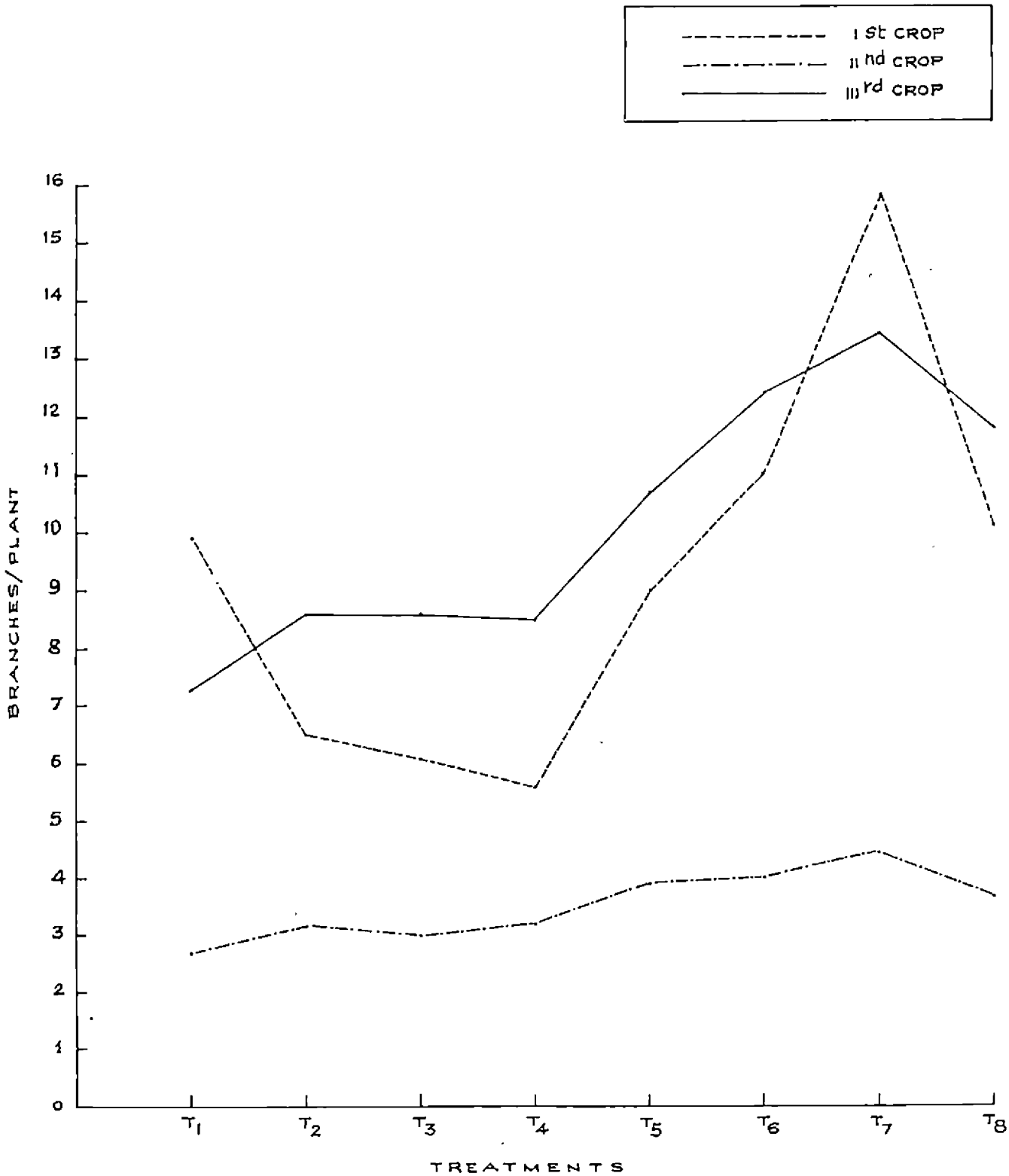

FIG. 7. EFFECT OF DIFFERENT LEVELS OF ORGANIC AND INORGANIC FERTILIZERS AND THER COMBINATION ON THEIR NUMBER OF BRANCHES/PLANT IN CHILLI VAR. KAU CLUSTER.

over control was in the order of 55.94% for T_7 and 8.91% for T_6. All the other treatments recorded a decrease in number of branches/plant when compared to control. The percentage decrease over control was maximum for T_4 (44.55%) followed by T_3 (39.60%) and T_2 (36.14%). The reduction caused by these three treatments were highly significant.

During August-December, 1987 too, the treatment T_7 recorded the highest number of branches/plant (4.43) followed by T_6 (4.03) and T_5 (3.93). All the other treatments recorded a reduction in number of branches/ plant when compared to control and the maximum reduction was in the order of T_1 (25.82%), T_3 (18.48%), T_4 (13.59%) and T_2 (13.04%). The reduction caused by the first two treatments namely T_1 and T_3 were highly significant.

The maximum branches/plant during January-April, 1988, was again recorded by T_7 (13.35) followed by T_6 (12.35) and again only T_7 was significant. All the other treatments recorded a reduction in branches/plant when compared to control. Percentage decrease over control was in the order of T_1 (37.87%), T_4 (28.09%), T_2 and T_3

Plate 3. Organic fertilizers alone - 30 t FYM/ha

Plate 4. Inorganic fertilizers alone - 75:40:25 kg/ha of N, P_2O_5 and K_2O

PLATE 3

PLATE 4

Plate 5. Organic and inorganic fertilizers together - 15 t FYM/ha + 75:40:25 kg/ha of N, P_2O_5 and K_2O

Plate 6. Organic and inorganic fertilizers together - 15 t FYM/ha + 125:40:25 kg/ha of N, P_2O_5 and K_2O

PLATE 5

PLATE 6

Plate 7. Organic and inorganic fertilizers together - 15 t FYM/ha + 175:40:25 kg/ha of N, P_2O_5 and K_2O

Plate 8. Control (Package of Practices Recommendations, KAU, 1986) - 20 t FYM/ha + 75:40:25 kg/ha of N, P_2O_5 and K_2O

PLATE 7

PLATE 8

(26.38%) and T_5 (8.94%). Except treatment T_5 all other treatments differed significantly when compared to control.

b) Earliness, yield and quality attributes

i) Index to earliness

The effect of organic and inorganic fertilizers and their combination on index to earliness in KAU Cluster is presented in Table 10. During March-July, 1987, the treatment T_6 recorded the highest value of 1.34 followed by T_5 (1.31) and T_7 (1.27). The above three treatments were highly significant over the treatments T_2, T_3 and T_4 and although they were superior to treatment T_1, it was not statistically significant.

During August-December, 1987, the treatment T_7 recorded the highest value (1.23) followed by T_6 (0.68). Both these treatments were highly significant over all other treatments except T_5. Treatment T_5 was superior over the treatments T_1, T_2, T_3 and T_4 but was not significantly different.

Table 10. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers

Index to Earliness

Treatments	March-July 1987	August-December 1987	January-April 1988
T_1	0.94	0.49	0.30
T_2	0.55	0.45	0.59
T_3	0.54	0.52	0.57
T_4	0.51	0.56	0.50
T_5	1.31	0.71	0.90
T_6	1.34	0.88	1.75
T_7	1.27	1.23	1.82
CD ($p = 0.05$)	0.46	0.28	0.77

During January-April, 1988, treatments T_7 (1.82) and T_6 (1.75) recorded the highest values and both these were significantly superior over the other treatments.

ii) Fruit length

The treatments did not differ significantly for fruit length during the period of experimentation (Table 11).

iii) Fruit yield/plot

During March-July, 1987, the treatment T_6 gave the highest yield (0.83 kg) followed by T_7 (0.76) and T_5 (0.74 kg) but none of the above treatments were significantly superior over control (0.64 kg) (Table 12 and Fig. 8). A reduction in yield when compared to control was observed for all other treatments. Percentage decrease over control was in the order of T_3 (59.37%), T_4 (56.25%), T_2 (53.13%) and T_1 (25%). Of these, decrease in yield was significant for treatments T_3, T_4 and T_2.

The treatment T_7 (0.32 kg) recorded the highest yield during August-December, 1987, but the increase was not statistically significant over control (0.29 kg).

Table 11. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers

Fruit length

Treatments	March-July (1987)		August-December (1987)		January-April (1988)	
	Fruit length	Increase or decrease over control (%)	Fruit length	Increase or decrease over control (%)	Fruit length	Increase or decrease over control (%)
T_1	3.56	+2.01	3.39	-3.14	2.61	-8.74
T_2	3.56	+2.01	3.62	+3.43	2.96	+3.50
T_3	3.53	+1.15	3.59	+2.57	2.79	-2.45
T_4	3.34	-4.30	3.43	-2.00	2.87	+0.35
T_5	3.59	+2.87	3.62	+3.43	2.91	+1.75
T_6	3.51	+0.57	3.62	+3.43	2.79	-2.45
T_7	3.58	+2.58	3.69	+5.43	2.75	-3.85
T_8 (Control)	3.49		3.50		2.86	
CD (p = 0.05)	0.22		0.29		0.33	

Table 12. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers

Fruit yield/plot (kg)

Treatments	March-July (1987)		August-December(1987)		January-April (1988)	
	Fruit yield/ plot	Increase or decrease over control (%)	Fruit yield/ plot	Increase or decrease over control (%)	Fruit yield/ plot	Increase or decrease over control (%)
T_1	0.48	-25.00	0.14	-51.72	0.16	-65.96
T_2	0.30	-53.13	0.14	-51.72	0.27	-42.55
T_3	0.26	-59.37	0.15	-48.28	0.26	-44.68
T_4	0.28	-56.25	0.17	-41.38	0.24	-48.94
T_5	0.74	+15.63	0.19	-34.48	0.41	-12.77
T_6	0.83	+29.69	0.26	-10.34	0.64	+36.17
T_7	0.76	+18.75	0.32	+10.34	0.65	+38.30
T_8 (Control)	0.64		0.29		0.47	
CD (p = 0.05)	0.28		0.07		0.24	

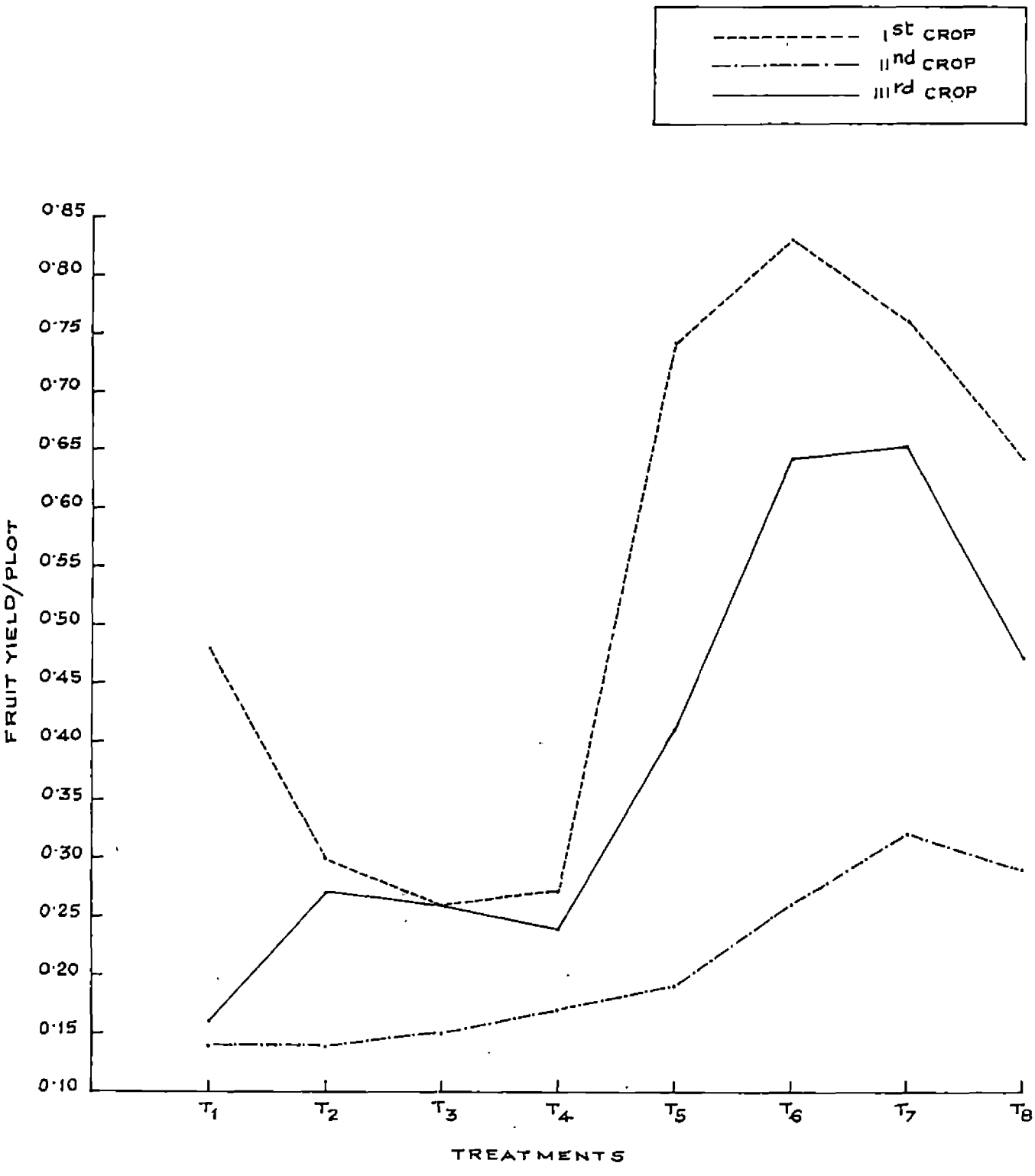

FIG. 8. EFFECT OF DIFFERENT LEVELS OF ORGANIC AND INORGANIC FERTILIZERS AND THEIR COMBINATION ON FRUIT YIELD/PLOT(kg) IN CHILLI VAR. KAU CLUSTER.

All the other treatments recorded lower yields then control. Among them, except the treatment T_6, all the other treatments gave significantly lower yield than control. Percentage decrease over control was maximum for T_1 and T_2 (51.72%) followed by T_3 (43.28%) and then T_4 (41.38%).

During January-April, 1988, the treatment T_7 recorded the highest yield (0.65 kg) followed by T_6 (0.64 kg) but both were not significantly superior over control (0.47 kg). Reduction in yield was recorded by all other treatments when compared to control. Percentage decrease over control was maximum for T_1 (65.96%) followed by T_4 (48.94%) and then T_3 (44.68%) but of these only treatment T_1 was significantly different when compared to control.

iv) Number and weight of unmarketable fruits 10 days of storage after harvest of green chilli

During March-July, 1987, the maximum number of unmarketable fruits (41.75) and weight of unmarketable fruits (20.5 g) was recorded by the treatment T_7 (Table 13).

Table 13. Response of chilli Var. KAU Cluster to different levels of organic and inorganic fertilizers

Number and weight of unmarketable fruits ten days of storage after harvest of green chilli

Treatments	March-July, 1987				August-December, 1987				January-April, 1988			
	1	2	3	4	1	2	3	4	1	2	3	4
T_1	28.50	-28.75	12.85	-31.65	16.25	-37.5	6.83	-42.75	76.75	-35.5	34.08	-35.88
T_2	32.50	-18.75	14.17	-24.63	17.50	-32.69	7.25	-39.23	74.75	-37.18	32.48	-38.89
T_3	25.00	-37.5	10.45	-44.41	16.25	-37.5	7.60	-36.29	87.50	-26.47	39.85	-25.02
T_4	30.75	-23.13	13.95	-25.80	21.00	-19.23	10.25	-14.08	80.00	-32.77	37.08	-30.24
T_5	40.00	0	18.98	+0.96	26.25	+0.96	11.73	-1.68	127.75	+7.35	56.70	+6.68
T_6	40.25	+0.63	19.87	+5.69	27.50	+5.77	12.97	+8.72	124.25	+4.41	54.58	+2.69
T_7	41.75	+4.37	20.50	+9.04	26.50	+1.92	12.43	+4.19	122.75	+3.15	52.35	-1.51
T_8 (Control)	40.00		18.80		26.00		11.93		119.00		53.15	
CD (p=0.05)	10.7		6.21		5.43		2.32		23.76		17.52	

1 - Number of unmarketable fruits
2 - Increase or decrease over control (%)
3 - Weight of unmarketable fruits
4 - Increase or decrease over control (%)

This was followed by treatment T_6 (40.25 and 19.87 g respectively) and T_5 (40 and 18.98 g respectively. However, none of the above treatments were significantly superior over control (40 and 18.80 g respectively). All the other treatments showed reduced values for both number and weight of unmarketable fruits over control. For the number of unmarketable fruits, the treatments T_1 and T_3 showed significant reduction over control whereas for the weight of unmarketable fruits only treatment T_3 was significantly different over control.

The treatment T_6 recorded the maximum number of unmarketable fruits (27.50) and also weight (12.97 g) during August-December, 1987. This was followed by T_7 (26.5 and 12.43 g respectively) and T_5 (26.25 and 11.73 g respectively). None of the above treatments were significantly superior over control (26 and 11.93 g respectively). All other treatments except T_4 showed significant reduction over control for both number and weight of unmarketable fruits.

During January-April, 1988, the treatment T_5 recorded the maximum number (127.75) and weight (56.7 g) of unmarketable fruits followed by T_6 (124.25 and 54.58 g respectively).

But both the treatments were not significantly superior over control. All the other treatments showed reduced values for both characters over control (122.75 and 52.35 g respectively). Although the reduction over control was significant for unmarketable fruits, in case of weight of unmarketable fruits only the treatments T_1 and T_2 showed significant difference.

v) Biomass weight

During March-July, 1987, all the treatments showed increased values for biomass weight over control (Table 14 and Fig. 9). But only treatments T_2 (48.64 kg), T_3 (52.91 kg) and T_4 (51.71 kg) showed significant increase over control (39.57 kg). The other treatments, even though showed an increase over control, were not statistically significant. Percentage increase over control was the greatest for T_3 (33.71%) followed by T_4 (30.68%) and T_2 (22.92%).

During August-December, 1987, all the treatments showed decreased values over control for biomass weight. Only treatments T_4 (17.26 kg) and T_5 (18.35 kg) differed significantly over control (26.24 kg). Percentage

Table 14. Effect of different levels of organic and inorganic fertilizers on biomass production/plot (kg)

Treatments	March-July (1987)		August-December (1987)		January-April (1988)	
	Biomass/ plot (kg)	Increase or decrease over control (%)	Biomass/ plot (kg)	Increase or decreaseover control (%)	Biomass/ plot (kg)	Increase or decrease over control (%)
T_1	45.58	+15.19	23.61	-10.02	25.73	-5.75
T_2	48.64	+22.92	20.11	-23.36	22.19	-18.72
T_3	52.91	+33.71	20.81	-20.69	29.83	+9.27
T_4	51.71	+30.68	17.26	-34.22	25.51	-6.56
T_5	42.86	+8.31	18.35	-30.07	20.70	-24.17
T_6	43.89	+10.92	24.29	-7.43	25.55	-6.41
T_7	45.19	+14.20	25.05	-4.53	25.04	-8.28
T_8 (Control)	39.57		26.24		27.30	
CD ($p = 0.05$)	6.22		6.97		4.96	

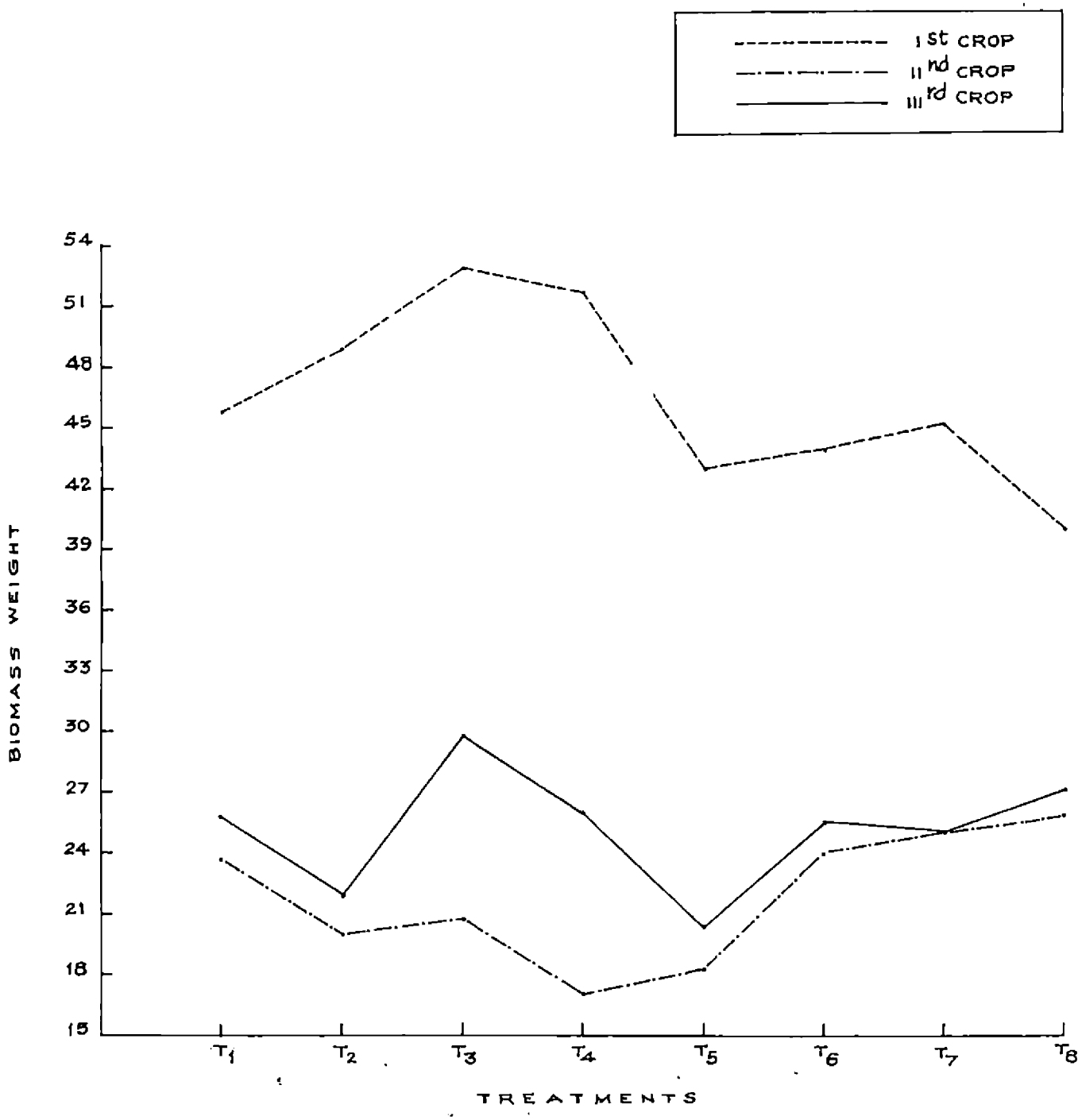

FIG. 9. EFFECT OF DIFFERENT LEVELS OF ORGANIC AND INORGANIC FERTILIZERS AND THEIR COMBINATION ON BIOMASS WEIGHT(Kg).

decrease over control was the greatest for T_4 (34.22%) followed by T_5 (30.07%).

The January-April, 1988, crop showed that only treatment T_3 showed an increase over control but was not statistically significant. All other treatments showed reduced values over control but the reduction was significant only in T_2 (22.19 kg) and T_5 (20.7 kg). Percentage reduction was the greatest for T_5 (24.17%) followed by T_2 (18.72%).

C. Effect of organic and inorganic fertilizers and other combination on the physico-chemical and biological properties of soil

Composite soil samples from 0-15 cm depth were taken before the commencement of the experiment and were used for the determination of physico-chemical properties (Table 15). The data revealed that the soil is medium in organic carbon, available phosphorus and available potassium whereas high in available nitrogen. The pH of the soil comes under the medium range whereas the electrical conductivity of the soil is low.

Table 15. Physical and chemical properties of original soil

15.1. Mechanical composition of soil

Fraction	Percent composition
Sand	67.99
Silt	13.01
Clay	19.00
Textural class : Sandy clay loam	

15.2. Physical constants of soil

Constant	Value
Apparent density (g/cm^3)	1.14
Maximum water holding capacity (%)	41.09
Absolute specific gravity	1.97

15.3. Aggregate size distribution (%)

Sieves used	5 mm	2-5 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	0.25-0.1 mm
	2.08	3.900	6.200	19.200	39.980	1.987

i) Stability index	44.790
ii) Structural coefficient	0.627
iii) Percentage aggregate stability	62.7
iv) Mean weight diameter	0.6564

15.4. Chemical composition of original soil

Description of property	Value
Organic carbon	0.827
Total nitrogen	0.088
Total phosphorus	0.195
Total potassium	0.237
Available nitrogen	0.072
Available phosphorus	0.001
Available potassium	0.006
CEC (meq/100 g)	7.67
pH	5.1
EC (m mhos/cm)	0.13

The general analysis of variance (Table 16) indicates that the eight treatments after the second (E_3) and third crops (E_4) were significantly different for total nitrogen, total potassium, available nitrogen, available phosphorus, available potassium, organic carbon, cation exchange capacity and maximum water holding capacity. After the first crop (E_2), the eight treatments differed significantly only for cation exchange capacity and maximum water holding capacity whereas apparent density was significantly different only before the first crop (E_1) and after the third crop (E_4).

a) Physical properties

i) Mechanical analysis

Data on the mechanical composition of the original soil are presented in Table 15.1. The data revealed that the textural class of the soil is sandy clay loam.

ii) Physical constants

Data on apparent density, maximum water holding capacity (WHC) and absolute specific gravity of the original soil before commencement of the actual experiment are presented in Table 15.2.

Table 16. General analysis of variance

Sources of variation		d.f.	M.S. Apparent density	Maximum W.H.C.	Absolute specific gravity	pH	EC
Blocks	E_1	3	0.001	13.280	0.002	0.030	0.002
	E_2	3	0.000	0.020	0.011	0.061	0.002
	E_3	3	0.002	2.240	0.010	0.442**	0.002*
	E_4	3	0.000	6.54*	0.005	0.112	0.002
Treatments	E_1	7	0.003*	4.015	0.015	0.020	0.000
	E_2	7	0.001	29.194**	0.009	0.031	0.001
	E_3	7	0.001	46.036**	0.007	0.029	0.001
	E_4	7	0.002**	39.621**	0.012	0.072	0.000
Error	E_1	21	0.001	11.769	0.010	0.055	0.001
	E_2	21	0.001	1.564	0.013	0.080	0.001
	E_3	21	0.001	1.910	0.016	0.066	0.000
	E_4	21	0.000	2.360	0.011	0.137	0.001

* p = 0.05 E_1 = Before Crop I E_3 = After Crop II Cont'd.

** p = 0.01 E_2 = After Crop I E_4 = After Crop III

Table 16. Continued

Sources of variation		df	M.S.							
			Organic carbon	Total Nitrogen	Total Phosphorus	Total Potassium	Available Nitrogen	Available Phosphorus	Available Potassium	CEC
Block	E_1	3	0.030	0.000	0.000	0.001	0.000	0.000	0.000	0.062
	E_2	3	0.003	0.000	0.000	0.003	0.000	0.000	0.000	0.142
	E_3	3	0.098	0.001	0.000	0.001	0.001	0.000	0.000	0.116
	E_4	3	0.017	0.000	0.000*	0.006*	0.000	0.000	0.000	0.389
Treatments	E_1	7	0.037	0.000	0.000	0.001	0.000	0.000	0.000	0.094
	E_2	7	0.079	0.001	0.000	0.004	0.001	0.000	0.000	0.819**
	E_3	7	0.269**	0.002**	0.000	0.006*	0.003**	0.001**	0.000**	1.970**
	E_4	7	0.704**	0.006**	0.000	0.010**	0.007**	0.001**	0.000**	1.451**
Error	E_1	21	0.035	0.000	0.000	0.001	0.000	0.000	0.000	0.225
	E_2	21	0.035	0.000	0.000	0.002	0.000	0.000	0.000	0.149
	E_3	21	0.046	0.000	0.000	0.002	0.000	0.000	0.000	0.151
	E_4	21	0.037	0.000	0.000	0.001	0.000	0.000	0.000	0.323

Significant change in apparent density before the first crop was recorded only by plots under treatments T_5 (1.22 g/cm^3) and T_6 (1.19 g/cm^3) (Table 17). All other treatments except T_1 (1.14 g/cm^3) showed greater values than control (1.14 g/cm^3) but were not statistically significant. The highest value was shown by the plot under treatment T_5 (1.22 g/cm^3). After the first crop, soil analysis revealed that even though all the plots under treatments had greater apparent density than control (1.17 g/cm^3) none of them were statistically significant. After the second crop, plots under treatments T_3 (1.11 g/cm^3), T_5 (1.14 g/cm^3) and T_7 (1.12 g/cm^3) showed greater values than control (1.10 g/cm^3) but none were significantly superior. After the third crop, except plots under treatment T_1 (1.04 g/cm^3), all other plots under treatments had greater values than control (1.07 g/cm^3) but only plot under treatment T_4 (1.12 g/cm^3) was significantly different.

There was no significant change in the maximum WHC of the soil before the first crop. The highest value was shown by the plot under treatment T_1 (39.26%) followed by T_4 (39.05%) and then by control T_8 (38.09%) (Table 18). After the first crop, the plots under treatments T_1 (43.38%) and T_7 (40.52%) showed the highest values and

Table 17. Effect of different levels of organic and inorganic fertilizers on physical properties of soil cropped under chilli Var. KAU Cluster

Physical constants (a) Apparent density (g/cm^3)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	1.14	1.19	1.09	1.04
T_2	1.15	1.19	1.10	1.08
T_3	1.16	1.20	1.11	1.10
T_4	1.16	1.20	1.10	1.12
T_5	1.22	1.21	1.14	1.08
T_6	1.19	1.21	1.10	1.08
T_7	1.16	1.21	1.12	1.07
T_8 (Control)	1.14	1.17	1.10	1.07
CD (p = 0.05)	0.05	0.05	0.05	0.03

T_1 = 30 t FYM/ha

T_2 = 75:40:25 kg NPK/ha

T_3 = 125:40:25 kg NPK/ha

T_4 = 175:40:25 kg NPK/ha

T_5 = 15 t FYM/ha + 75:40:25 kg NPK/ha

T_6 = " + 125:40:25 "

T_7 = " + 175:40:25 "

T_8 = 20 t FYM/ha + 75:40:25 NPK/ha (Control)

Table 18. Effect of different levels of organic and inorganic fertilizers on physical properties of soil cropped under chilli Var. KAU Cluster

(b) Maximum Water Holding Capacity (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	39.26	43.38	44.95	47.79
T_2	36.09	35.67	37.59	38.91
T_3	37.78	35.53	35.72	38.68
T_4	39.05	38.82	35.04	38.78
T_5	37.54	36.10	41.00	42.53
T_6	37.66	39.17	40.47	42.25
T_7	37.31	40.52	41.18	43.82
T_8 (Control)	38.09	38.59	42.27	43.08
CD (p =0.05)	5.05	1.84	2.03	2.26

these were statistically significant over control (38.59%). Further the plots under treatments T_2 (35.67%), T_3 (35.53%) and T_5 (36.10%) showed a reduction in the maximum WHC when compared to control and this was statistically significant. After the second crop, it was seen that only the plot under treatment T_1 (44.95%) was significantly superior over control (42.27%). All other plots under treatments except T_6 (40.47%) showed significant reduction in the maximum WHC when compared to control. The same trend was also noticed after the third crop. Plot under treatment T_1 (47.79%) was significantly superior over control (43.08%). Even though the plot under treatment T_7 showed greater WHC (43.82%) than control it was not significant. All other treatments recorded reduced values but only T_2 (38.91%), T_3 (38.68%) and T_4 (38.78%) were significantly different.

With regard to absolute specific gravity, before the first crop, only plot under treatment T_7 (2.19) was significantly superior over control (2.03) (Table 19). Data further revealed that there was no significant change in the absolute specific gravity after the first, second and third crops. Plots under treatments T_4 (2.13), T_5 (2.17) and again T_4 (2.18) recorded the highest values after the first, second and third crops respectively.

Table 19. Effect of different levels of organic and inorganic fertilizers on physical properties of soil cropped under chilli Var. KAU Cluster

(c) Absolute Specific Gravity

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	2.03	2.10	2.15	2.00
T_2	2.02	2.10	2.12	2.11
T_3	2.01	1.99	2.11	2.10
T_4	2.05	2.13	2.07	2.18
T_5	2.08	2.09	2.17	2.06
T_6	2.12	2.04	2.07	2.05
T_7	2.19	2.04	2.07	2.09
T_8 (Control)	2.03	2.10	2.07	2.11
CD ($p = 0.05$)	0.15	0.17	0.19	0.15

iii) Aggregate analysis

Data on the percentage aggregate stability of the original soil before the commencement of the experiment are presented in Table 15.3. There was no significant change in the proportion of water stable aggregates in the soil in any of the treatments (Table 20).

b) Chemical properties

Data on the chemical properties of the original soil before the commencement of the actual experiment are presented in Table 15.4.

i) Organic carbon

There was no significant difference in the organic carbon content of the soil, both before and after the first crop (Table 21). Even though most treatments showed increasing values over control, none were statistically significant. The treatment T_6 had the greatest value (1.17%) followed by T_1 (1.16%) after the first crop. The same trend was noticed after the second and third crops. None of the treatments were statistically superior over control. After the second crop, treatment T_2 (0.86%), T_3 (0.90%) and

Table 20. Aggregate size distribution (%)

Sieves used	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
5 mm	1.972	2.00	2.08	2.00	1.99	2.01	2.08	2.00
2-5 mm	3.932	3.876	3.900	4.032	3.896	4.212	3.901	3.876
2-1 mm	6.082	5.986	6.200	6.187	6.276	6.204	6.31	5.986
1-0.5 mm	19.00	20.00	19.200	19.080	18.287	19.080	19.32	20.00
0.5-0.25 mm	41.712	40.672	39.980	38.876	40.628	38.864	39.98	40.672
0.25-0.1 mm	2.00	2.17	1.987	2.182	2.00	2.234	1.964	2.17
(i) Stability index	44.698	43.620	44.790	44.680	43.280	44.682	43.890	43.620
(ii) Structural coefficient	0.615	0.609	0.627	0.637	0.608	0.641	0.627	0.609
(iii) Percentage aggregate stability	61.50	60.9	62.7	63.7	60.8	63.4	63.1	60.9
(iv) Mean weight diameter	0.6585	0.645	0.6564	0.653	0.644	0.656	0.661	0.645

Table 21. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Organic Carbon (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.88	1.16	1.35	1.56
T_2	0.56	0.81	0.86	0.62
T_3	0.77	0.92	0.90	0.80
T_4	0.80	0.84	0.77	0.93
T_5	0.81	1.06	1.21	1.63
T_6	0.78	1.17	1.37	1.67
T_7	0.71	1.09	1.37	1.52
T_8 (Control)	0.70	1.09	1.36	1.44
CD ($p = 0.05$)	0.27	0.28	0.31	0.28

T_4 (0.77%) showed a significant reduction in the organic carbon content when compared to control (1.36%) and after the third crop too, the treatments T_2 (0.62%), T_3 (0.80%) and T_4 (0.93%) showed significant reduction when compared to control (1.44%).

ii) Total nitrogen

Data on total nitrogen content of the soil (Table 22) before and after the first crop, after the second and third crops, indicated that in all the above cases, none of the treatments were significantly superior over control. While treatment T_2 (0.08%) showed significant reduction in total nitrogen content of the soil, when compared to control (0.11%) after the first crop; treatments T_2 (0.86% and 0.62%), T_3 (0.90% and 0.80%) and T_4 (0.77% and 0.93%) showed significant reduction in the total nitrogen content after the second and the third crops respectively.

iii) Total phosphorus

There was no significant change, due to the various treatments, on the total phosphorus content of the soil before and after the first crop and also after the second and third crops (Table 23).

Table 22. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Total Nitrogen (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.10	0.11	0.13	0.13
T_2	0.08	0.08	0.09	0.08
T_3	0.08	0.09	0.10	0.08
T_4	0.08	0.09	0.08	0.09
T_5	0.09	0.11	0.12	0.17
T_6	0.09	0.12	0.14	0.17
T_7	0.08	0.11	0.14	0.15
T_8 (Control)	0.09	0.11	0.14	0.15
CD ($p = 0.05$)	0.02	0.02	0.03	0.03

Table 23. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Total Phosphorus (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.20	0.19	0.20	0.20
T_2	0.20	0.19	0.20	0.20
T_3	0.20	0.19	0.20	0.20
T_4	0.20	0.19	0.20	0.20
T_5	0.20	0.19	0.20	0.20
T_6	0.20	0.19	0.20	0.20
T_7	0.20	0.19	0.20	0.20
T_8 (Control)	0.19	0.19	0.20	0.20
CD ($p = 0.05$)	0.00	0.00	0.00	0.00

iv) Total potassium

As in the case of total phosphorus, the total potassium content of the soil was not subjected to any major change before the first crop (Table 24). None of the treatments showed any significant increase in total potassium content over control during any of the subsequent crops. However, after the first crop, treatment T_3 (0.29%), after the second crop, treatment T_4 (0.39%) and after the third crop treatments T_2 (0.45%), T_3 (0.47%) and T_4 (0.45%) showed significant reduction in the total potassium content when compared to control (0.38%, 0.49% and 0.55% respectively).

v) Available nitrogen

Data on the available nitrogen content of the soil, both before and after the first crop, indicated that the various treatments did not differ significantly when compared to control (Table 25). None of the treatments showed any significant increase in the available nitrogen content of the soil, over control both after the second and third crop. However, after both the crops, the treatments T_2 (0.08% and 0.05%), T_3 (0.08% and 0.07%) and T_4 (0.07%

Table 24. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Total Potassium (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.23	0.38	0.50	0.55
T_2	0.24	0.33	0.44	0.45
T_3	0.23	0.29	0.44	0.47
T_4	0.26	0.32	0.39	0.45
T_5	0.25	0.36	0.49	0.54
T_6	0.25	0.36	0.36	0.54
T_7	0.26	0.35	0.49	0.57
T_8 (Control)	0.24	0.38	0.49	0.55
CD ($p = 0.05$)	0.05	0.06	0.06	0.05

Table 25. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Available nitrogen (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.08	0.10	0.12	0.14
T_2	0.04	0.07	0.08	0.05
T_3	0.07	0.08	0.08	0.07
T_4	0.07	0.08	0.07	0.08
T_5	0.07	0.10	0.11	0.15
T_6	0.07	0.11	0.13	0.16
T_7	0.06	0.10	0.13	0.14
T_8 (Control)	0.06	0.10	0.13	0.13
CD ($p = 0.05$)	0.03	0.03	0.03	0.03

and 0.08% respectively) recorded significant decrease in the available nitrogen content when compared to control (0.13% after second and third crops).

vi) Available phosphorus

Data on available phosphorus content of the soil, before the first crop and after the first, second and third crops, indicated that the various treatments did not differ significantly over control (Table 26). However treatment T_3 (0.04%) after the first crop, treatments T_2 (0.04%), T_3 (0.04 and 0.03%) and T_4 (0.04 and 0.03%) after the second and third crops respectively showed significant reduction in the available phosphorus content when compared to control (0.06 and 0.07% respectively).

vii) Available potassium

The available potassium content of the soil was not subjected to any major change, due to various treatments, during the period of experimentation (Table 27). None of the treatments showed any significant change over control.

viii) Cation exchange capacity (CEC)

There was no significant change in CEC of the soil before the first crop, in any of the treatments when compared

Table 26. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Available Phosphorus (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.05	0.05	0.06	0.06
T_2	0.04	0.05	0.04	0.04
T_3	0.04	0.04	0.04	0.03
T_4	0.05	0.05	0.04	0.03
T_5	0.05	0.05	0.05	0.06
T_6	0.05	0.05	0.06	0.06
T_7	0.05	0.06	0.06	0.07
T_8 (Control)	0.04	0.06	0.06	0.07
CD ($p = 0.05$)	0.01	0.01	0.01	0.01

Table 27. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Available Potassium (%)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.01	0.01	0.01	0.00
T_2	0.01	0.01	0.01	0.00
T_3	0.01	0.01	0.01	0.00
T_4	0.01	0.01	0.01	0.01
T_5	0.01	0.01	0.01	0.01
T_6	0.01	0.01	0.01	0.01
T_7	0.01	0.01	0.01	0.01
T_8 (Control)	0.01	0.01	0.01	0.01
CD (p = 0.05)	0.00	0.00	0.00	0.00

to control (Table 28). The maximum increase in CEC was recorded by treatments T_4 and T_5 (7.83 meq/100 g). None of the treatments recorded any significant increase in CEC when compared to control during the subsequent crops of chilli. However treatments T_2 (7.39), T_3 (7.29) and T_4 (7.39) after the first crop, T_2 (7.28), T_3 (7.07) and T_4 (7.39) after the second crop, T_2 (7.5), T_3 (7.61) and T_4 (7.5) after the third crop recorded significant decrease in CEC over control (8.37, 8.59 and 8.70 meq/100 g respectively).

ix) pH

Soil pH was not significantly influenced by the various treatments during any of the cropping periods (Table 29). However a slight increase in pH was noticed during the later periods of experimentation when compared to the initial stages.

x) Electrical conductivity

As in the case of soil pH, the EC was also not significantly influenced, due to various treatments, during any of the cropping periods (Table 30).

Table 28. Effect of different levels of organic and inorganic fertilizers on chemical properties of soil cropped under chilli Var. KAU Cluster

Cation Exchange Capacity (meq/100 g)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	7.39	8.26	8.91	8.91
T_2	7.61	7.39	7.28	7.50
T_3	7.50	7.29	7.07	7.61
T_4	7.83	7.39	7.39	7.50
T_5	7.83	7.94	8.26	8.81
T_6	7.72	8.26	8.37	8.37
T_7	7.72	8.15	8.59	8.48
T_8 (Control)	7.72	8.37	8.59	8.70
CD (p = 0.05)	0.70	0.57	0.57	0.84

Table 29. Effect of different levels of organic and inorganic fertilizers on physico-chemical properties of soil cropped under chilli Var. KAU Cluster

pH

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	4.75	5.28	5.23	5.31
T_2	4.85	5.23	5.05	5.21
T_3	4.86	5.40	5.05	4.91
T_4	4.71	5.31	5.03	5.23
T_5	4.74	5.28	5.03	4.98
T_6	4.65	5.46	4.94	5.14
T_7	4.73	5.43	5.13	5.20
T_8 (Control)	4.73	5.43	5.10	5.18
CD ($p = 0.05$)	0.34	0.42	0.38	0.54

Table 30. Effect of different levels of organic and inorganic fertilizers on physico-chemical properties of soil cropped under chilli Var. KAU Cluster

EC (m mhos/cm)

Treatments	Before Crop I	After Crop I	After Crop II	After Crop III
T_1	0.11	0.12	0.08	0.09
T_2	0.09	0.12	0.05	0.07
T_3	0.10	0.10	0.07	0.09
T_4	0.11	0.11	0.06	0.08
T_5	0.11	0.11	0.08	0.09
T_6	0.10	0.15	0.04	0.07
T_7	0.09	0.12	0.05	0.09
T_8 (Control)	0.10	0.09	0.08	0.10
CD ($p = 0.05$)	0.05	0.06	0.03	0.05

C. Biological Properties

i) Influence of different treatments on the natural incidence of vesicular-arbuscular mycorrhiza (VAM) in chillies

The result of the experiment to study the influence of different treatments on the natural incidence of VA mycorrhiza in chilli Var. KAU Cluster is given in Table 31 and Fig. 10. There was no significant difference between treatments in their mean mycorrhizal index. During the first crop, the infection was maximum for the treatment T_1 which had an average index of 0.21. During the second and third crop too, the treatment T_1 had the maximum infection with an average index of 0.27 and 0.28 respectively.

ii) Effect of age of host plant on VA mycorrhizal infection in chilli Var. KAU Cluster.

The infection was maximum on the 30th day with an average index of 0.27, 0.34 and 0.34 for the first, second and third crops respectively, whereas the average index was 0.06, 0.09 and 0.07 respectively at transplanting and 0.12, 0.2 and 0.21 respectively during final harvest (Table 31 and Fig. 10).

Table 31. Influence of different levels of organic and inorganic fertilizers on the natural incidence of VA mycorrhiza in chilli Var. KAU Cluster

Treatments	MYCORRHIZAL INDEX											
	Ist Crop				IInd Crop				IIIrd Crop			
	1	2	3	4	1	2	3	4	1	2	3	4
T_1	0.06	0.36	0.20	0.21	0.09	0.48	0.24	0.27	0.07	0.52	0.26	0.28
T_2	0.06	0.23	0.14	0.14	0.09	0.31	0.20	0.20	0.07	0.34	0.19	0.20
T_3	0.06	0.24	0.12	0.14	0.09	0.28	0.18	0.18	0.07	0.30	0.21	0.19
T_4	0.06	0.21	0.08	0.12	0.09	0.25	0.11	0.15	0.07	0.24	0.13	0.15
T_5	0.06	0.28	0.12	0.15	0.09	0.34	0.21	0.21	0.07	0.36	0.24	0.22
T_6	0.06	0.26	0.09	0.14	0.09	0.38	0.22	0.23	0.07	0.34	0.21	0.21
T_7	0.06	0.24	0.08	0.13	0.09	0.31	0.19	0.20	0.07	0.29	0.19	0.18
T_8 (Control)	0.06	0.30	0.14	0.17	0.09	0.39	0.23	0.24	0.07	0.35	0.26	0.23
Average index	0.06	0.27	0.12		0.09	0.34	0.20		0.07	0.34	0.21	

T_1 = 30 t FYM/ha
T_2 = 75:40:25 kg N, P_2O_5, K_2O/ha
T_3 = 125:40:25 ,,
T_4 = 175:40:25 ,,
T_5 = 15 t FYM/ha + 75:40:25 kg N, P_2O_5, K_2O/ha
T_6 = 15 ,, + 125:40:25 ,,
T_7 = 15 ,, + 175:40:25 ,,
T_8 = 20 ,, + 75:40:25 ,,

1 - At transplanting
2 - 30th day
3 - Final harvest
4 - Average index

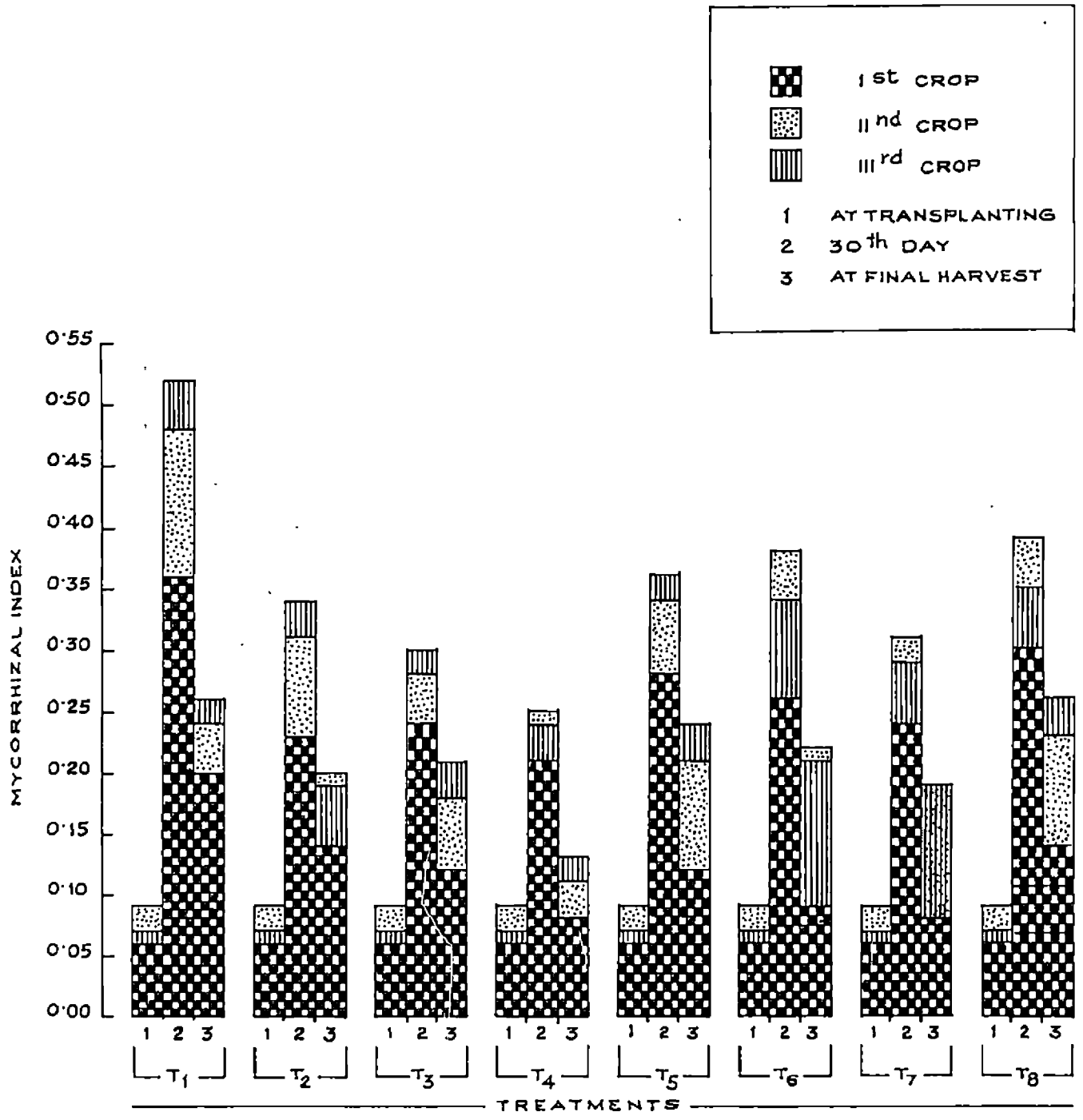

FIG. 10. INFLUENCE OF DIFFERENT LEVELS OF ORGANIC AND INORGANIC FERTILIZERS AND THEIR COMBINATION ON THE NATURAL INCIDENCE OF VAM IN KAU CLUSTER.

Plate 9. Roots of chilli Var. KAU Cluster showing infection of Vesicular-arbuscular mycorrhizal fungi

Plate 10. A
pl

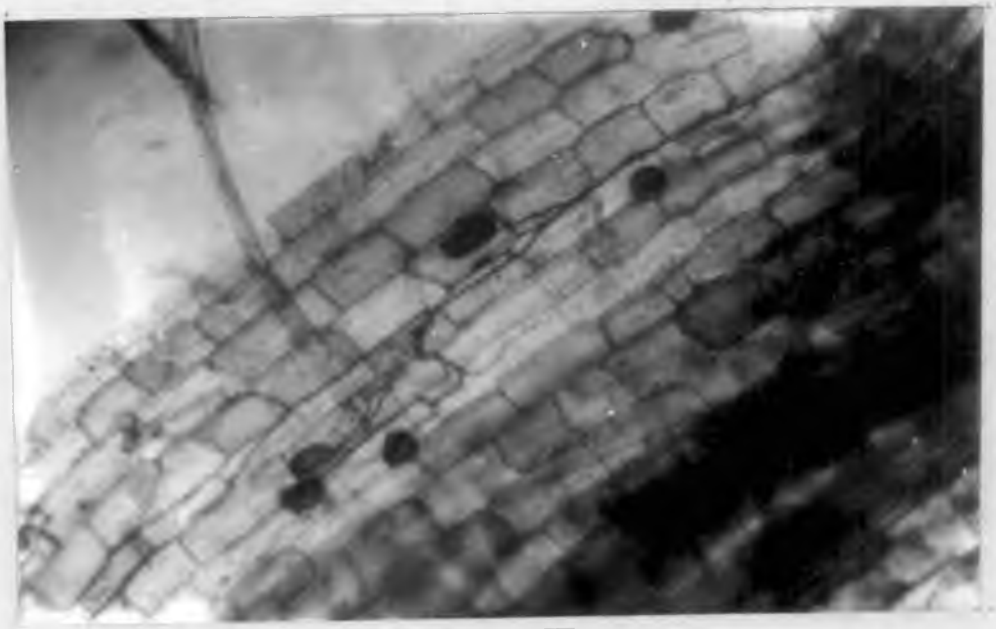

PLATE 9

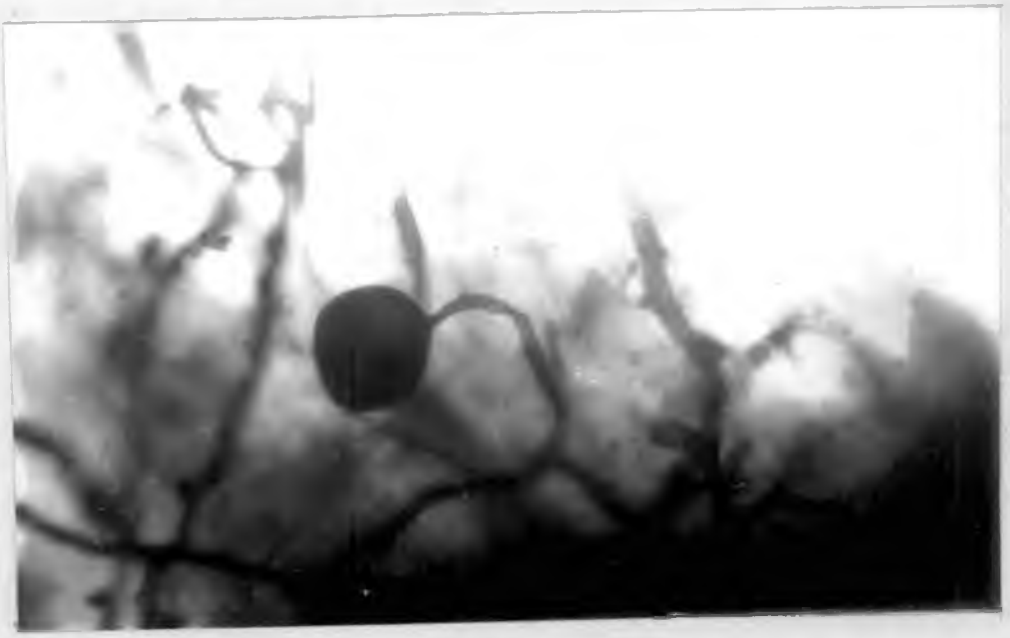

PLATE 10

D. Estimation of net returns due to organic and inorganic fertilizers and their combination in clustered chilli

Economics of application of organic and inorganic fertilizers and their combination on chilli Var. KAU Cluster during March-July, 1987 were worked out (Table 32). Maximum income was obtained from treatment T_6 (Rs.3706.68) followed by T_7 (Rs.3426.48) and T_5 (Rs.3315.54). The net income after deducting the additional cost due to application of manures and fertilizers was maximum for the treatment T_6 (Rs.1284.96) followed by T_5 (Rs.1139.04) and then T_7 (Rs.759.51). Percentage increase over control was maximum for T_6 (611.57%) followed by T_5 (530.77%), T_7 320.59%), T_2 (279.54%) and T_3 (44.43%). Treatments T_1 and T_4 reduced yield considerably. A net loss was observed due to these two treatments.

The economics of application of organic and inorganic fertilizers and their combination during August-December 1987 were also worked out (Table 33). During this season, maximum returns were obtained from treatment T_7 (Rs.1448.16) followed by T_8 ie. control (1308.06) and then T_6 (1163.46). The income after deducting the additional cost due to application of manures and fertilizers was negative for all

Table 32. Economics of application of organic and inorganic fertilizers and their combination on chilli Var. KAU Cluster. March-July, 1987.

Treatments	Mean yield kg/ha	Income	Cost of manures and fertilizers + cost of application (Additional cost)	Income after deducting additional cost	Amount over control	Increase or decrease over control (%)
T_1	361.48	2168.88	3059.00	-890.12	-3566.62	-1975.04
T_2	226.98	1361.88	676.50	685.38	504.8	+279.54
T_3	197.09	1182.54	921.72	260.82	80.24	+44.43
T_4	208.11	1248.66	1166.97	81.69	-98.89	-54.76
T_5	552.59	3315.54	2176.5	1139.04	958.46	+530.77
T_6	617.78	3706.68	2421.72	1284.96	1104.38	+611.57
T_7	571.08	3426.48	2666.97	759.51	578.93	+320.59
T_8 (Control)	476.18	2857.08	2676.50	180.58		

T_1 = 30 t FYM/ha
T_2 = 75:40:25 kg N, P_2O_5, K_2O/ha
T_3 = 125:40:25 kg ,,
T_4 = 175:40:25 kg ,,
T_5 = 15 t FYM + 75:40:25 kg N, P_2O_5, K_2O/ha
T_6 = 15 t FYM + 125:40:25 kg ,,
T_7 = 15 t FYM + 175:40:25 kg ,,
T_8 = 20 t FYM + 75:40:25 kg ,, (Control)

Cost of manures and fertilizers
FYM = Rs.100/ton
Urea = Rs.2.25/kg
Mussorie Phos = Rs.0.90/kg
M.O.P. = Rs.1.70/kg

Table 33. Economics of application of organic and inorganic fertilizers and their combinations on chilli Var. KAU Cluster. August-December, 1987.

Treatments	Mean yield kg/ha	Income	Cost of manures and fertilizers + cost of application (Additional cost)	Income after deducting the additional cost	Amount over control	Increase or decrease over control (%)
T_1	102.19	613.14	3059	-2445.86	-1077.42	-78.73
T_2	102.93	617.58	676.50	-58.92	+1309.52	+95.69
T_3	113.77	682.62	921.72	-239.1	+1129.34	+82.52
T_4	126.66	759.96	1166.97	-407.01	+961.43	+70.26
T_5	144.22	865.32	2176.5	-1311.18	+57.26	+4.18
T_6	193.91	1163.46	2421.72	-1258.26	+110.18	+8.05
T_7	241.36	1448.16	2666.97	-1218.81	+149.63	+10.93
T_8 (Control)	218.01	1308.06	2676.50	-1368.44		

the treatments during this crop. Percentage increase over control was maximum for treatment T_2 followed by T_3 and T_4.

During January-April, 1988, the maximum returns were obtained from treatment T_7 (Rs.2932.20) followed by T_6 (Rs.2853.72) and then control (Rs.2108.34) (Table 34). The income after deducting the additional cost was maximum for T_2 (Rs.518.34) followed by T_6 (Rs.432.00) and T_7 (Rs.265.23). Percentage increase over control was maximum for T_2 (191.23%) followed by T_6 (176.03%) and T_7 (146.68%). Only treatment T_1 recorded a decrease over control.

Table 34. Economics of application of organic and inorganic fertilizers and their combination on chilli Var. KAU Cluster. January-April, 1988.

Treatments	Mean yield kg/ha	Income	Cost of manures and fertilizers + cost of application (Additional cost)	Income after deducting the additional cost	Amount over control	Increase or decrease over control (%)
T_1	120.31	721.86	3059	-2337.14	-1768.98	-311.35
T_2	199.14	1194.84	676.50	518.34	+1086.5	+191.23
T_3	197.46	1184.76	921.72	263.04	+831.2	+146.30
T_4	177.47	1064.82	1166.97	-102.15	+466.01	+82.02
T_5	303.94	1823.64	2176.50	-352.86	+215.3	+37.89
T_6	475.62	2853.72	2421.72	432.00	+1000.16	+176.03
T_7	488.70	2932.20	2666.97	265.23	+833.39	+146.68
T_8 (Control)	351.39	2108.34	2676.50	-568.16		

Discussion

DISCUSSION

The present investigation was carried out to study the effect(s) of organic and inorganic fertilizers and their combinations on physico-chemical and biological properties of soil cropped under chilli Var. KAU Cluster. The data relating to various observations taken were statistically analysed and the results are discussed below:

The study revealed that the effect of nitrogen was significant on plant height and number of branches/plant. Increasing levels of nitrogen enhanced plant height during all the three cropping seasons. The increase in plant height is attributed to the rapid meristematic activity in plants due to nitrogen as reported by Crowther (1935). The significant increase in plant height by higher doses of nitrogen is in confirmity with the findings of Mohammed Kunju (1970), Lal et al. (1971) and Sundstrom et al. (1984). The increase in plant height is attributed to an increased uptake of N which is a constituent of protein and a component of protoplasm. This favourably affected the chlorophyll content of leaves resulting in increased synthesis of carbohydrates. These results agree with the

findings of Osaki et al. (1957) and Maynard (1962). The increase in plant height with increasing doses of NPK with or without FYM agrees with the work of Doikova et al. (1984).

Higher levels of NPK along with FYM produced significantly more number of branches/plant during the three cropping seasons. As stated earlier, nitrogen being a key element of plant growth, its effect on vegetative growth is reflected on number of branches/plant. Similar results of increased branching at higher levels of nitrogen were reported by Lal et al. (1971), Gill et al. (1974) and Nagarajaswamy and Nalawadi (1982).

High rates of both organic and inorganic fertilizers increased fruit yield in all the three crops. This is in confirmity with the findings of Vlcek and Polach (1969). This increase is due to the fact that fruit weight/plant in chillies was the highest at the highest NPK rates (Nagarajaswamy and Nalawadi, 1982). Application of inorganic fertilizers alone decreased fruit yield during the three cropping seasons. Application of NPK in absence of FYM retarded formation of vegetative organs and subsequently reproductive organs (Cerna, 1980). FYM

favourably affected vegetative mass, dry weight, plant height, photosynthetic potential and consequently fruit yields. Yield increased more with FYM than without FYM (Valsikova and Ivanic, 1982). The reason for the increased yield is attributed to the solubilisation effect of plant nutrients by the addition of FYM as evidenced by the increase in uptake of N, P, K, Ca and Mg (Subbiah et al., 1982). The effect(s) of different treatments on fruit length were however not significant during any of the cropping seasons. Similar results were obtained by Murthy and Murthy (1955) and Mohammed Kunju (1970). Increasing rates of nitrogen also resulted in an increase in the number and weight of unmarketable fruits, ten days of storage after harvest of green chillies and this observation is in confirmity with the findings of Singh and Nettles (1961-62) and Jenkins and Horns (1963) who reported a reduction in the total marketable yield of chillies due to increased rate of N application. This is due to the fact that increasing N rates increased fruit decaying in spite of increased leaf Ca content (Nurzynski, 1987).

The effect of nitrogen alone, both in the presence and absence of FYM was worked out. The study revealed

that there was no linear effect due to N alone with or without 15 t of FYM on any of the plant characters like plant height, branches/plant, earliness and quality attributes during the second (August-December, 1987) and third (January-April, 1988) crops. The effects were all non-linear. A linear increase in yield was noted with increasing rates of N in presence of 15 t of FYM during the second crop from August-December, 1987 (Fig. 11 'b'). This is in confirmity with the results of Singh and Nettles (1961-62) who observed a linear increase in yield by increasing N applications from 56.75 to 170 kg/ha. The linear effect of N was also noted for branches/plant in the absence of 15 t of FYM during the first crop (March-July, 1987) (Fig. 11 'a'). The effect of FYM alone, between the treatments T_5 (15 t FYM + 75:40:25 kg N, P_2O_5, K_2O/ha) and T_8 (20 t FYM + 75:40:25 kg N, P_2O_5 and K_2O/ha) for the different characters were also worked out. No linear effect was obtained which revealed that a difference of 5 t/ha of FYM did not have much influence on plant characters in chillies.

The total benefits from manure utilization are not apparent from crop yields during the first or second or

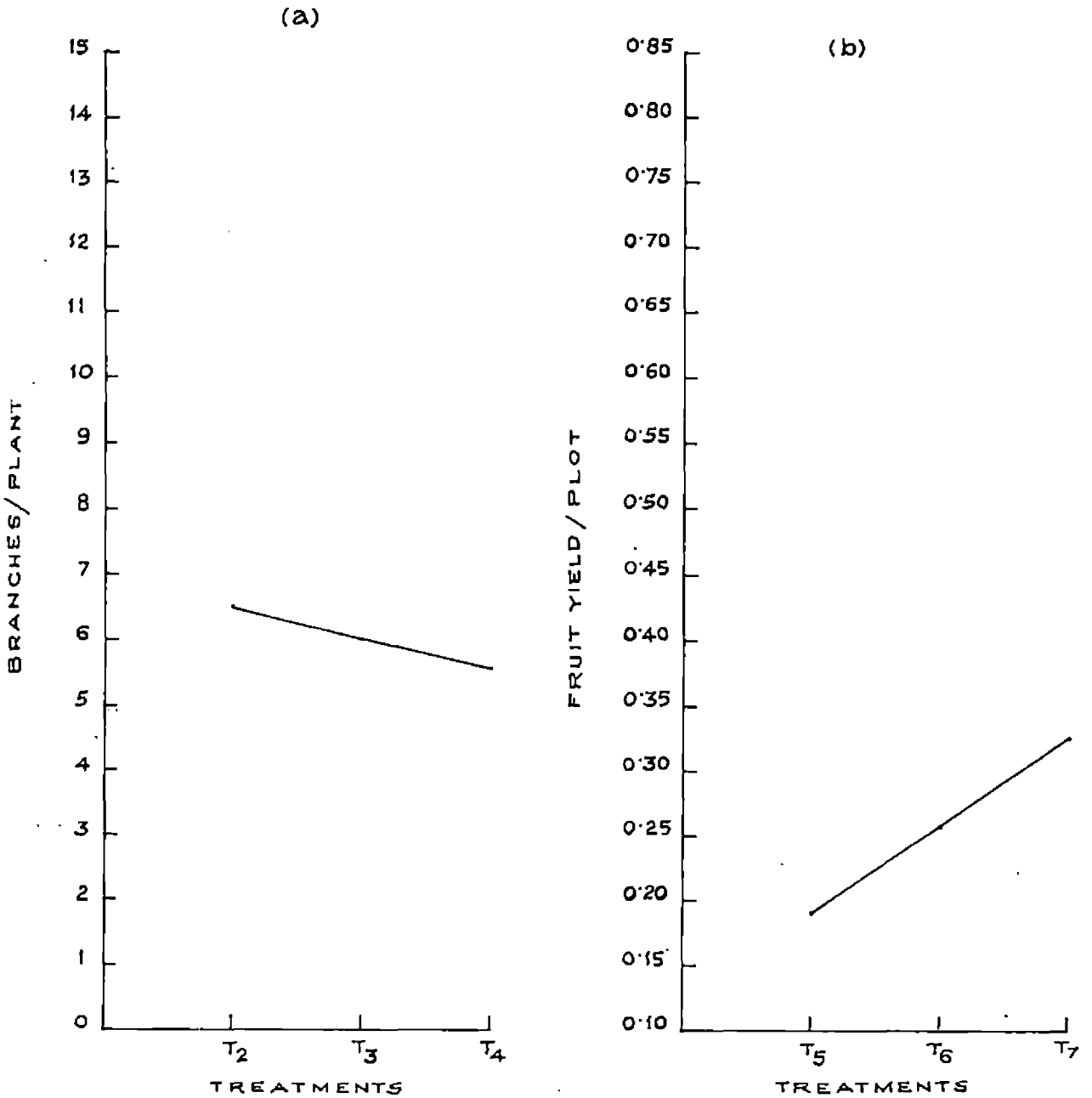

FIG.11. LINEAR EFFECT OF N ON BRANCHES/PLANT (a) AND FRUIT YIELD/PLOT (b).

even third year following the application. Although a portion of the nutrients and organic matter in manure is broken down and released during the first year or second year; some is held in humus like compounds subject to very slow decomposition. Its effect is long standing, not only on future nutrient supplies but also on the physical condition of the soil. The study revealed that the water holding capacity of soils was improved by application of organic manures alone. This agrees with the findings of Randhawa (1971), Ramaswami et al. (1979) and Prasad et al. (1980). A favourable influence on WHC was also noted due to a combination of NPK fertilizers with cattle manure (Manickam and Venkataraman, 1972). The plots receiving inorganic fertilizers alone had reduced available moisture percentage than the manured plots (Russell, 1960).

Aggregates are secondary units of primary soil particles, particularly clays (Singh, 1980). These are formed under natural conditions and mainly influenced by methods of farming, root activity and addition of organic matter (Uriyo, 1979). Structural stability is supported by the stability indices, calculated based on the concept

that a unit weight of large aggregates is more indicative of good structure than an equal weight of small aggregates. Structural coefficient values tending to zero is indicative of poor aggregation and a value close to unity a high degree of aggregation. The present study did not reveal any marked effect on the aggregate size by application of NPK and FYM. This is in accordance with the findings of Manickam and Venkataraman (1972) who could not observe a marked effect on the aggregate size by application of NPK and cattle manure.

When the relative efficiency of organic and inorganic fertilizers on the soil organic matter content was considered it was observed that the organic matter content was higher in manured plots than in fertilizer treated plots. Such increase in organic carbon level due to organic manuring was reported by Rao and Krishnan (1963), Biswas et al. (1967) and Prasad et al. (1971). Spratt and Mc Curdy (1960) observed that fertilizer treatments were ineffective in raising the level of organic matter. Favourable effect of both organic and inorganic fertilizers in building up of organic carbon was also observed. This is in confirmity with the studies carried out by Acharya and Rajagopalan (1950) and Biswas et al. (1967).

Significant reduction in total nitrogen content was seen in plots receiving inorganic fertilizers alone, after the second and third crops, compared to control. This agrees with the findings of Stumpe and Kolbe (1968) who reported that soil nitrogen was decreased by 2 per cent by purely mineral fertlization and was slightly increased by 3 per cent through manuring plus fertilization. The increase in total N in the soil due to application of FYM is in line with the works of Sen and Bonde (1962), Bandyopadya et al. (1969) and Bopiah (1970). The above trend was also noticed in case of total K content in the soils. FYM treated plots recorded a slight increase in total K. This might be due to the fact that on nutrient content basis, addition of K through FYM was more compared to the quantity of K applied through inorganic fertilizers.

FYM application increased the available N content in the soils. This increase in the available N content under organic manure treatments, when the total N content remained the same might have been the result of increased microbial activity leading to greater mineralisation (Muthuvel, 1973). Mineral fertilizers alone decreased the available P content significantly. An increase was seen in FYM applied plots. Application of organic manures

would have produced some organic acids during decomposition which caused the release of P from insoluble P compounds (Mc Intosh et al., 1973). The soil reaction (pH) is influenced to variable extent by prolonged use of manures and fertilizers. In the present study, the soil pH was not influenced by the various treatments. This agrees with Spratt and Mc Curdy (1966) and Singh and Sharma (1968) who observed that soil pH was not influenced by short term fertilizer applications.

The result of the present experiment to study effect(s) of different treatments on VA mycorrhiza in chilli var. KAU Cluster showed that during the three cropping periods, the plot receiving FYM alone had the maximum infection, when compared to plots receiving inorganic fertilizers alone. The addition of organic matter to the soil resulted in better mycorrhizal development was also shown by Hayman (1982). Reduced root colonisation due to high levels of NPK was reported by Mosse and Phillips (1971) and Hayman (1975). The study further revealed that the infection was maximum on the 30th day after transplanting of chillies, when compared to the initial and final stages of crop growth. This pattern was similar to the one

reported earlier by Sutton (1973). According to him, initially a lag phase was observed as the photosynthetic efficiency of the host will be less at this stage, affecting the actual availability of some of the nutrients especially sugars from the host system on which the VAM mainly depends for its growth and infection. Once the lag phase ended, there was an active period of root colonization by VAM which reached a peak around the 30th-45th day of plant growth. This usually corresponded with the peak photosynthetic phase of the host plant. According to Sutton, during the later stages, a reduction in the availability of carbon for initiating fresh infection by VA mycorrhiza is noted and thus a gradual decline in infection is seen. This reduction is due to the greater requirement of carbon by the host for seed formation. It is quite possible that at this stage of plant growth, the host may induce a sort of restriction for new infection by VA mycorrhiza.

The observations and inferences mentioned above lead to the following conclusions. Increasing rates of nitrogen along with FYM had significant effect on plant height and number of branches/plant during all the three cropping seasons. It was seen that while application of high rates

of both organic and inorganic fertilizers increased the fruit yield in all the three crops, application of inorganic fertilizers alone was found to decrease fruit yield. Yield increased more with FYM than without FYM. The study also revealed the relative efficiency of organic and inorganic manures on the various physical and chemical properties of soil. FYM treated plots showed better results when compared to plots receiving no FYM application. The same trend was also noticed for VA mycorrhizal infection. Infection was more in FYM treated plots and also on the 30th day after transplanting when compared to the initial and final stages of crop growth.

Summary

SUMMARY

The present investigations were conducted at the Instructional Farm, College of Horticulture, Vellanikkara during March to July, 1987, August to December, 1987 and January to April, 1988, to study the effect(s) of organic and inorganic fertilizers and their combinations on physico-chemical and biological properties of soil cropped under clustered chilli, variety KAU Cluster. The experiment comprised of eight treatments. (a) Organic fertilizers alone T_1 (30 t FYM/ha) (b) Inorganic fertilizers alone T_2 (75:40:25 kg N, P_2O_5 and K_2O/ha), T_3 (125:40:25), T_4 (175:40:25) (c) Organic and inorganic fertilizers together T_5 (15 t + 75:40:25), T_6 (15 t + 125:40:25), T_7 (15 t + 175:40:25) and control T_8 (20 t + 75:40:25). The experimental design was randomised block design. The findings are summarised below:

1. The performance of the nutrient depleting crop Bhindi Var. Pusa Sawani fluctuated for the various characters. A normal frequency distribution curve was obtained only in case of pod length and seeds/pod.

2. Among the vegetative characters, increasing rates of nitrogen along with FYM increased plant height and

branches/plant during all the three cropping periods. The treatment T_7 (15 t FYM/ha + 175:40:25 kg N, P_2O_5 and K_2O/ha) excelled other treatments during the three crops.

3. All the eight treatments showed significant variation for earliness, fruit yield and also for the number and weight of unmarketable fruits, 10 days of storage after harvest of green chillies. Higher rates of N along with FYM induced earliness, increased fruit yield as well as number and weight of unmarketable fruits, 10 days of storage after harvest of green chillies.

4. The various treatments however had no effect on fruit length during any of the three seasons. The biomass weight also varied during the three cropping periods. Plots receiving inorganic fertilizers recorded a slight increase in biomass weight when compared to control.

5. The treatments did not evince any significant effect on the physical properties of soil such as aggregate stability and physical constants like apparent density and absolute specific gravity. With regard to the maximum water holding capacity only treatment T_1 (30 t FYM/ha) had significant effect on soil during all the three cropping seasons.

6. The eight treatments had no significant effect on any of the chemical properties of soil during the three cropping seasons. None of the treatments were significantly superior to control. The plots receiving inorganic fertilizers alone showed significant reduction in organic carbon, total N and K, available N and P and cation exchange capacity when compared to control. Plots receiving both organic and inorganic fertilizers gave a slightly better result.

7. The various treatments had no significant effect on pH and EC of the soil during the cropping periods.

8. Study on the influence of different treatments on the natural incidence of VAM revealed that there was no significant difference between treatments in their mean mycorrhizal index. The maximum infection was seen in plots receiving FYM alone during the three crops. It was also noted that infection was maximum on 30th day after transplanting.

9. Economics of application of organic and inorganic fertilizers and their combination revealed that maximum income as well as net income after deducting the additional cost of manures and fertilizers were obtained from plots receiving higher doses of N along with FYM.

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* Originals not seen

Appendix

Appendix-I

Weather data during the period of experimentation

Period	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean R.H. (%)	Total rainfall (mm)	Sunshine hours
December, 1986	32.5	23.5	60	10.8	9.3
January, 1987	33.2	22.7	52	0	9.6
February	35.6	22.8	57	0	10.3
March	36.4	22.2	55	0	10.2
April	36.2	25.3	64	130.3	7.97
May	36.1	24.7	66	95.0	8.68
June	30.7	23.7	83	837.7	4.53
July	30.3	23.5	84	336.5	5.67
August	29.6	23.5	87	388.4	3.66
September	31.5	23.9	79	174.0	6.72
October	31.9	23.9	79	280.4	7.66
November	31.6	22.8	77	224.4	8.11
December	31.6	23.3	70	64.6	7.81
January, 1988	32.4	22.0	56	0	9.2
February	35.8	23.1	56	7.8	9.8
March	35.7	24.35	67	37.9	10.1
April	35.06	24.28	70	145.4	8.3
May	33.7	25.4	76	242.6	6.2

EFFECT OF ORGANIC, INORGANIC FERTILIZER AND THEIR COMBINATION ON PHYSICO-CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL CROPPED UNDER CLUSTERED CHILLI (*Capsicum annuum.* L.)

By

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ABSTRACT OF A THESIS

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requirement for the degree of

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ABSTRACT

The present investigations were conducted at the Instructional Farm, College of Horticulture, Vellanikkara during March to July 1987, August to December 1987 and January to April 1988, to study the effect(s) of organic and inorganic fertilizers and their combinations on physico-chemical and biological properties of soil cropped under clustered chilli; variety KAU Cluster. The experiment comprised of eight treatments and was laid out in a randomised block design.

The study revealed that plant height and branches/plant increased with increasing rates of nitrogen along with FYM. The best result was recorded by treatment T_7 (15 t of FYM + 175:40:25 kg N, P_2O_5 and K_2O/ha). Higher rates of nitrogen along with FYM induced earliness and increased fruit yield. The various treatments did not record any significant change in fruit length or biomass weight.

The organic and inorganic fertilizers and their combinations had no significant effect on the physical and chemical properties of soil. Maximum water holding

capacity differed significantly in plots receiving 30 t FYM/ha when compared to control. With regard to chemical properties, the plots receiving inorganic fertilizers alone showed significant reduction in organic carbon, total N and K, available N and P and CEC, when compared to control. The pH and EC of the soil did not show any significant change during the course of experimentation.

Studies on the influence of different treatments on the natural incidence of vesicular-arbuscular mycorrhiza revealed that maximum infection was seen in plots receiving FYM alone. Infection was also maximum on 30th day after transplanting.

Maximum income as well as net income after deducting the additional cost of manures and fertilizers was obtained from plots receiving higher doses of N along with FYM.