NUTRIENT-GROWTH REGULATOR INTERACTION IN SNAKEGOURD (*Trichosanthes anguina* L.) UNDER DRIP IRRIGATION SYSTEM

By

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DECLARATION

I hereby declare that this thesis entitled *"Nutrient-growth regulator interaction in snakegourd (Trichosanthes anguina L.) under drip irrigation system"* is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled ***"Nutrient-growth regulator interaction in snakegourd (Trichosanthes anguina L.) under drip irrigation system"*** is a record of research work done independently by Smt.Elizabeth K. Syriac 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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Abbreviations used in this thesis

%	.....	per cent
@	.....	at the rate of
cbr	.....	centibar
CGR	.....	crop growth rate
CPE	.....	cumulative pan evaporation
cv	.....	cultivar
^0C	.....	degree celsius
DAS	.....	days after sowing
E pan	.....	pan evaporation
ET	.....	evapotranspiration
ET crop	.....	crop evapotranspiration
ETm	.....	maximum evapo-transpiration
ETo	.....	reference crop evapotranspiration
Fig.	.....	figure
FYM	.....	farm yard manure
g	.....	gram
h	.....	hour

ha	.....	hectare
ha cm	.....	hectare centimetre
ha m	.....	hectare metre
IW	.....	irrigation water
kg	.....	kilogram
Kp	.....	pan co-efficient
kPa	.....	kilo pascal
l	.....	litre
LAD	.....	leaf area duration
LAI	.....	leaf area index
LLDPE	.....	linear low density poly ethylene
m	.....	metre
m^3	.....	cubic metre
mg	.....	milligram
mm	.....	millimetre
N	.....	nitrogen
ppm	.....	parts per million
PVC	.....	poly venyl chloride
SCU	.....	seasonal consumptive use
t	.....	tonnes
TSS	.....	total soluble solids
WUE	.....	water use efficiency

INTRODUCTION

INTRODUCTION

India is the second largest producer of vegetables in the world next only to China. The country produces 12 per cent of the world output of vegetables from about 4.5 million ha of arable land (Chadha and Ramphal, 1993). The production, however, does not match with the requirement, the base per capita availability of vegetables being only 130 g day^{-1} as against the requirement of 280 g day^{-1} (Singh, 1990). We have, therefore, to go a long way to achieve self-sufficiency in vegetable production.

The vegetable crops not only provide nutritional security, but also produce more biomass as compared to cereals. If production potentials of these crops are tapped fully, it would help to solve the food problem of the country besides reducing the level of malnutrition and undernutrition among the people.

Kerala, with its unique, warm, tropical climate provides an ideal setting for the cultivation of about 12 major and 23 minor vegetables. The total area under vegetables in Kerala is 15,250 ha and 30 per cent of the area occupied by vegetables come under cucurbits. Snakegourd occupies a prime place among the vegetables cultivated in the State and is a very common component in the diet of the people of South India. The edible portion of snakegourd is 98 per cent and only its seeds are rejected. It is a good source of carbohydrates, minerals, proteins, fibres and vitamins to make the food wholesome and healthy. The medicinal value of snakegourd is well recognised. Inspite of its economic importance as a common vegetable, only very little attempt has so far been made to realise the production potential of the crop.

Since there is little scope for bringing more area under vegetables due to paucity of land, the increase in its production must come from increased productivity of the land already under cultivation. The use of commercial fertilizers is perhaps the most important single factor in bringing about this increase.

From time immemorial man has been exploiting the soil nutrient reserve for crop production thereby causing their widespread deficiency, particularly nitrogen, which is one of the key elements determining the yield of many crops, especially, vegetables. The effect of mineral nitrogen on the growth of vegetables is fast and spectacular and its application is on the increase. An intensive agriculture accentuates the drain on the limited terrestrial supply of this critical element. In vegetables, where succulence is essentially desirable, large quantities of nitrogen have to be applied than what are normally required (Shanmughavelu, 1989). Earlier studies on snakegourd indicated linear response to nitrogen beyond 90 kg ha^{-1} (Haris, 1989). It is, therefore, essential to find out the optimum dose for realising the maximum fruit yield.

The major problem experienced in the commercial cultivation of cucurbits is their increased flower fall, production of a large number of male flowers, wide sex ratio and reduced fruitset which ultimately reduce the yield per unit area.

The role of plant growth substances in altering sex expression in cucurbits is well known and some of the growth regulators are being used commercially. While reviewing the effect of growth regulators on the sex expression of cucurbits, Krishnamoorthy (1981) pointed out that ethephon was most effective in increasing the number of female flowers and inducing earliness. In snakegourd, production of large number of male flowers and wider sex ratio are serious problems affecting productivity. Utilisation of hormonal mechanism is an identified area of research for augmenting snakegourd production which needs investigation (Peter, 1985).

The cucurbitaceous vegetables are irrigated crops. Irrigation scheduling is of particular importance to these crops because of their short vegetative growth phase and continuous flowering and fruiting habit in the reproductive phase. Moisture stress leads to poor growth and low fruit yield. Very often, these crops are over-irrigated, which impairs productivity and quality of fruits. To quote Hillel, 1982, "In irrigation, just enough is the best". The concept holds good for all the vegetable crops. It clearly spells out that only measured quantity of water should be applied at a rate calibrated to meet the continuous requirement of the crop, not less and not certainly more. This type of irrigation scheduling is possible only under drip/trickle irrigation.

Drip irrigation by its very definition is the application of small and pre-determined amount of water near the root zone of plants at frequent intervals through emitting devices through a net work of PVC mains, filtration unit, control valves, PVC submains and LLDPE laterals. The system applies water to keep the soil moisture within the desired range of plant growth.

Realising the scope of drip irrigation, area under drip irrigation grew rapidly in other parts of the world in the late seventies (Bucks *et al.*, 1982). Among vegetables where drip irrigation is followed, in the order of importance are tomatoes, green pepper, egg plant, cucurbits, lettuce, greenpeas, asparagus and artichoke (Halevy *et al.*, 1973).

The concept of trickle irrigation has been tested on an experimental basis in different parts of the country (Sivanappan, 1985). This microirrigation technique is mostly practised in our country, with perennial or widespread crops and in areas where water is a scarce commodity. The high initial installation cost of the system is the major constraint for its wider adoption. But, with yield increases upto 60 per cent in most of the vegetables, the initial installation cost can be got back in one year (Menzel and Obe, 1990 and Gala, 1992).

Drip irrigation has the greatest potential for the efficient use of water and fertilizers, the two major inputs in agriculture. In drip irrigation, better response to applied fertilizers is obtained by applying it in the wetted area of the root zone. However, this may bring changes in soil properties like pH which needs investigation.

Most of the published work on drip irrigation deals elaborately with its design and maintenance aspects. In management aspect, efficiency of drip irrigation is evaluated with other irrigation systems. Only a few references are available on the influence of frequency of drip irrigation for vegetables. In modern agriculture, it is difficult to increase productivity of a crop without the proper knowledge of optimum dose of fertilizer and water for a given set of conditions (Biswas and Prasad, 1990).

Realising the need to optimise the use of three important inputs in vegetable production - nitrogen, growth regulators and irrigation - the investigation was planned with the following objectives:

i) to find out the effect of varying levels of nitrogen and ethephon on the productivity of snakegourd under different drip irrigation frequencies.

ii) to study the effect of the treatments on the size, quality and shelf life of the produce.

iii) to assess the influence of N and drip irrigation frequency on the physico-chemical properties of soil.

iv) to arrive at an economically viable production system involving a suitable combination of nitrogen, ethephon and drip irrigation frequency.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Snakegourd is one of the most important cucurbitaceous summer vegetables grown in South India. It is a nutrient exhaustive crop and responds well to applied nutrients, particularly nitrogen.

The effect of nitrogen on growth and development of plants is fast and spectacular. In plants, nitrogen is largely used in the synthesis of proteins and carbohydrate utilization, but structurally it is also a part of the chlorophyll molecule. Application of nitrogen is very important and its adequate supply improves the growth and yield of crops.

Growth regulating chemicals are becoming important owing to their ability to manipulate the endogenous hormonal make up of plants for better growth and development. The residual effect of these chemicals not only modifies the sex behaviour but also the vegetative growth and yield. Snakegourd, a monoecious cucurbitaceous vegetable crop, shows excellent variable effect to the aforementioned chemicals under varying agroclimatic conditions. Among the plant growth regulators, ethephon has shown promise for increasing yields of various cucurbits through sex expression changes (Shanmughavelu and Thamburaj, 1973; Baker and Bradley, 1976; Verma and Choudhury, 1980).

Snakegourd, being a deep rooted vegetable, prefers a well drained soil. However, it requires considerable quantity of moisture at the stage of maximum growth as well as at the time of fruit development and maturity. But information on various water management aspects of this crop is very meagre. From the point of view of water scarcity usually being experienced in Kerala especially during summer months when snakegourd is extensively grown, there is an urgent need to study the yield performance under drip irrigation.

The available literature on the effect of nitrogen, ethephon and drip irrigation on vegetable crops is reviewed in this chapter.

2.1. Nitrogen

Cucurbitaceous vegetables have a very short growing season, often 12-14 weeks. Within this short span of time, they produce large quantities of biomass. Hence, the demand for nutrients is more and the highest need generally is for nitrogen and the soil must be able to supply this inadequate quantities quickly enough to maintain optimum growth rates. Reviewing the results of National Vegetable Research Station experiments, Greenwood *et al.* (1974) indicated that the average recovery of N by vegetables was only 37 per cent.

2.1.1. Effect of N on growth and yield

Hall (1949) demonstrated that increased N supply reduced the male to female flower ratio in small gherkin (*Cucumis sativus* L.) from 6:1 to 4.6:1. Enhanced female flower production with increased N supply has been observed in cucurbits by a number of workers (Brantley and Warren 1958, 1960 a, 1960 b; Pustgarvi, 1961; Tayal *et al.*, 1965; Rekhi *et al.*, 1968; Parikh and Chandra, 1970; Jassal *et al.*, 1972; Verma, 1975 and Singh *et al.*, 1995).

Nylund (1954) reported that N application increased the yield and table quality of muskmelon (*Cucumis melo* L.). Similar findings were reported by Brantley and Warren (1961); Jassal *et al.* (1970, 1972); Randhawa *et al.* (1981) and Srinivas and Doijode, (1984). Nicklow (1966) and Kmiecik (1976) obtained higher yields in in cucumber (*Cucumis sativus* L.) with N upto 120 kg ha^{-1}, but yield increases at N rates above this level were not significant.

Parikh and Chandra (1970) reported that N rates higher than 80 kg ha^{-1} delayed the appearance of first female flowers in cucumber cv. Longgreen.

Low levels of N reduced the plant height but increased the root weight in squashmelon (*Citrullus vulgaris*) as reported by Mardanove *et. al.* (1971). Mc Collum and Miller (1971) studied the response of pickling cucumber to N and found that the maximum fruit yield (25.9 t ha^{-1}) was at 91 kg N ha^{-1}.

Pew and Gardner (1972) reported that N deficiency delayed the appearance of flower buds and markedly reduced the vegetative growth of cantalopes. According to Sharma and Shukla (1972) the economic optimum dose of N for pumpkin (*Cucurbita moschata* Duch ex Poir.) for summer and rainy seasons were 103 and 96 kg ha^{-1}, respectively. Yield of summer squash (*Cucurbita pepo*) was increased by 15 per cent by enhancing N levels from 0 to 150 kg ha^{-1} owing to an increase in fruit number and mean fruit weight (Venturi and Piazza, 1973). Dubey and Pandey (1973) noticed that N at 80 kg ha^{-1} increased the yield to the extent of 85 per cent in pointedgourd (*Trichasanthes dioica Roxb.*). Pandey and Singh (1973) found that applied N at 50 or 100 kg ha^{-1} increased pistillate and staminate flowers, fruits as well as yield without affecting the female to male flower ratio in bottlegourd (*Lagenaria siceraria* Standl.).

According to Bradley *et al.* (1975), the optimum level of N for cucumber was 68 kg ha^{-1}. Ivanov and Surlekov (1975) observed that for a cucumber crop receiving a basal dose of 30 t FYM ha^{-1}, application of N at the rate of 100 and 70 kg ha^{-1} raised the yield by 28.1 and 25.6 per cent respectively, compared with the untreated controls. Jagoda and Kaniszewski (1975) noted that the optimum fertilizer rate was 600 kg ha^{-1} for both the irrigated and unirrigated cucumber crops. Krynska (1975) observed a 7 per cent increase in cucumber yield with N at the rate of 600 kg ha^{-1} compared to 300 kg ha^{-1} whereas 900 kg ha^{-1} gave only a marginal increase over 600 kg ha^{-1}.

Borna (1976) studied the response of cucumber to fertilizer rates ranging from 200 to 2000 kg ha^{-1} and furrow irrigation at 2 or 3 levels and concluded that irrigation increased the effectiveness of mineral fertilizers even at high rates. Fertilization, irrigation and their interactions had greater effect on marketable yield than on total yield.

Patil and Bhosale (1976) reported that application of 75 kg N ha^{-1} increased the yield of fruits in watermelon by 36 per cent over the lower dose of 37.5 kg N ha^{-1}.

Doss *et al.* (1977) conducted studies to determine the response of cucumber to low, intermediate and high irrigation and 56 or 122 kg ha^{-1} of N and concluded that N increased the yields proportionately with the rate of application. Katyal (1977) recommended a manurial schedule of 35-45 t ha^{-1} of FYM before sowing and 10 kg N ha^{-1} at the time of final land preparation and 8-12 kg N ha^{-1} as top dressing in the form of ammonium sulphate in two splits for cucumber. Katyal (1977) also recommended the application of 50 t ha^{-1} of FYM as a basal dose and a top dressing of ammonium sulphate at the rate of 100 kg ha^{-1} soon after flowering in bittergourd (*Momordica charantia L.*).

Mahakal *et al.* (1977) suggested 75 kg ha^{-1} as the optimum dose of N for tinda (*Citrullus vulgaris* var. fistulosus) grown in a medium heavy soil.

Ottoson (1977) recorded yield response to cucumber upto 210 ppm N in a pot culture experiment. From trials with field grown cucumber, top grade fruits were obtained by Yakubitskaya *et al.* (1977) from plots receiving FYM at 90 t ha^{-1}, and N at 90 kg ha^{-1}, or FYM at 60 t ha^{-1} and N at 135 kg ha^{-1}.

Based on laboratory experiments on cucumber, Adams (1978) concluded that yield increased as the N content of the nutrient solution was raised from 50 to 300 ppm while the other nutrients were not limiting. Under conditions of N deficiency, over 50 per cent of the potential yield was lost. These workers also found that good quality fruits and yield were associated with 4.5 to 5.0 per cent N in the leaf. Hartmann and Waldhor (1978) proved that, in cucumber, top dressing with N at the rate of 5 g m^{-2} $week^{-1}$ starting from four weeks after planting until three weeks before harvest, gave higher yield than with 2.5 or 7.5 g m^{-2}. It was also noted that increasing the water supply from 300 mm m^{-2} to 670 mm m^{-2} enhanced the N utilization by 30 per cent. Within a plant, 70 per cent of the N was in the fruit and 30 per cent in the foliage and stem.

El-Beheidi *et al.* (1978) stated that fairly high rate of N at 60 kg ha^{-1} was needed for satisfactory growth, female flower production and seed yield in cucumber. El-Aidy and Moustafa (1978) observed that more number of leaves, better branching, higher number of female flowers and the maximum yield of fruits were obtained in cucumber when NPK ratio in the applied fertilizer was 1:1:2. Bhosale *et al.* (1978) obtained the highest yield of 26 t ha^{-1} in watermelon with 100 kg N ha^{-1} whereas on chernozem soils, Talmach (1977) recorded the highest yield in cucumber with compost at 25 t ha^{-1} and N at 90 kg ha^{-1}. William (1978) found significant yield increase in cucumber with supplementary N upto 280 kg ha^{-1} over an initial field dressing of 30 t of poultry manure and 4 t of lime ha^{-1}.

In cucumber, Bradley *et al.* (1979) obtained the highest returns with 300 kg N ha^{-1}. Brinen and Locascio (1979) recorded a fruit yield of 66.1 t ha^{-1} in watermelon with N applied at the rate of 1680 kg mixed fertilizer ha^{-1}. Feigin *et al.* (1979) obtained good yields of 8.7 - 12.0 t ha^{-1} from cucumber fertilized with N at the rate of 60 or 120 kg ha^{-1} as compared to control (2.5 t ha^{-1}). Will (1979) reported 8 to 10 per cent increase in fruit yield and improved fruit quality in cucumber with slow release N fertilizers. He also opined that for optimum utilization of N fertilizers, adequate irrigation should be provided.

Based on a three-year trial with pickling cucumbers, O'Sullivan (1980) concluded that eventhough irrigation and N had no significant effect on yield, lower rates of both had deleterious effect on quality of fruits. Fruit colour was affected by irrigation and N. The N content in tissues decreased with increasing depth and frequency of irrigation indicating an increased demand for N when cucumbers are profusely irrigated.

In pumpkin, Rajendran (1981) observed a significant increase in leaf area index at 30 and 60 days after sowing (DAS) and higher total dry matter contents at 60 DAS and at harvest with increasing levels of N. He further noted that the response to N was quadratic and the economic level was 71 kg ha^{-1}.

Studies conducted by Singh *et al.* (1982) on tinda (*Citrallus vulgaris,* Schard) on a sandyloam soil with four levels of N (0, 40, 80 and 120 kg N ha^{-1}) showed that female flowers per plant and diameter and weight of ripe fruits increased significantly with each incremental dose of N.

Singh et al. (1983) obtained the maximum length of vine, number of fruits and diameter of fruits in roundmelon (*Praecitrullus fistulosus* Pang.) with 75 kg N ha^{-1}. The optimum level of N for oriental pickling melon (*Cucumis melo L.*), according to Hassan *et al.* (1984) worked out to be 96.6 kg ha^{-1}. They also reported increases in fruit yield up to 180 kg N ha^{-1}. Alan (1984) obtained the maximum fruit yield in cucumber by supplying 300 ppm of N in a pot culture study. Raychaudury *et al.* (1984) found reduced vine growth, size of leaves and number of flowers in roundgourd due to N deficiency. Based on a study on water management and nutritional requirement of bittergourd at Chalakkudy, Kerala, Thomas (1984) reported that the crop responded up to 60 kg N ha^{-1}. The effect of N on fruit yield (9.35 t ha^{-1}) and yield components viz., number of fruits per plant, mean length of fruit and mean weight of fruit was significant at 60 kg N ha^{-1} as compared to the lower level of 30 kg ha^{-1}.

Mangal *et al.* (1985) recorded double the number of fruits per plant in roundmelon at 40 kg N ha^{-1} when compared to 0 kg N ha^{-1}, but there was no significant difference between 40 and 80 kg N ha^{-1}. In field experiments with muskmelon, Bhella (1986) compared different levels of N (0, 67 or 100 kg ha^{-1}) applied pre-plant and/or 0, 50 or 100 ppm applied as fertigation. Significant increase in stem growth, soil nitrate nitrogen, petiole nitrate nitrogen and early and total yields were generally attained with increasing pre-plant N rates. Fertigation response was reduced in regimes that received 67 or 100 kg pre plant N ha^{-1}. A significant curvilinear relationship was established between soil saturation extract nitrate nitrogen and petiole nitrate nitrogen.

According to Das *et al.* (1987), the growth and yield of pointedgourd (*Trichosanthes dioica*) increased with increase in N rates, the maximum average early yield (4.59 t ha^{-1}) and total yield (13.88 t ha^{-1}) being at 90 kg N ha^{-1}. Hegde (1987) observed significant increases in dry matter (54 %), fruit yield (32 %) and mineral uptake (51 %) in watermelon when N rates increased from 60 to 120 kg ha^{-1}. The yield of rockmelon was the highest (25.4 t ha^{-1}) when N and K were applied at the rate of 240 kg each ha^{-1} (Pryor and Kelly, 1987). Weichmann (1987) reported that in parthenocarpic pickling cucumbers, yield increased from 322 to 400 t ha^{-1} as the fertilizer dose was increased from 100 to 450 kg N ha^{-1} although the portion of out sized fruits also increased. The higher fertilizer doses increased the proportion of fruits that was picked in the first four harvests. Maurya (1987) found the largest number of female flowers, the highest yield and the best fruit quality of cucumber at 80 kg ha^{-1} N. Valenzuela *et al.* (1987) observed that 100 kg N ha^{-1} was adequate for high yield of cucumber and leaf N content increased with increasing rate of N application. John *et al.* (1988) noticed that the yield of pumpkin increased with N application up to 202 kg ha^{-1} under irrigation and that the yield response was limited to 60 kg ha^{-1} under dry conditions.

Al-Mukbtar *et al.* (1988) obtained the highest fruit yield in summer squash (*Cucurbita pepo* L.) with 500 kg ha^{-1} of 18:18:5 NPK mixture. Cerda and Martinez (1988) observed that addition of N enhanced the development of root and shoot dry weights in cucumber. Hegde (1988 a) found that increasing N fertilization from 60 to 180 kg ha^{-1} increased dry matter accumulation and distribution through higher LAI, LAD and CGR and contributed a larger proportion of the dry matter to fruits resulting in higher yield in watermelon. Swaider *et al.* (1988) estimated the fertilizer N requirements for 90 and 100 per cent of marketable yield of pumpkin at 44 and 158 kg N ha^{-1} for dryland and 125 and 225 kg N ha^{-1} for irrigated pumpkins, respectively. However, the applied fertilizer rates of 202 and 269 kg N ha^{-1} delayed harvest by 9 days on irrigated sand and by 6 days on dryland loam compared with lower N rates.

Das *et al.* (1987) and Singh (1989) found 90 kg N ha^{-1} as the optimum dose for pointedgourd. Manuca (1989) reported that increase in growth of cucumber was observed with increased N levels upto 150 kg ha^{-1}. Hanna and Adams (1989) obtained a significant yield increase in cucumber due to high dose of N (680-907 kg ha^{-1}). Ravikrishnan (1989) obtained a linear response to applied N in bittergourd upto 90 kg ha^{-1}. A study conducted at the College of Agriculture, Vellayani revealed that cucumber responded to N up to 100 kg ha^{-1} and length of vine, number of leaves $plant^{-1}$, LAI, total dry matter production, number of fruits $plant^{-1}$, mean weight and girth of fruits, sex ratio, fruit setting percentage and yield were favourably influenced by it (Subba Rao, 1989). Nitrogen at 90 kg ha-^{1} applied to cucumber enhanced the production of leaves and female flowers as reported by Stoliarov and Fanina (1989). According to Spirescu (1989), 150 kg N ha^{-1} produced the maximum leaf photosynthates and the highest fruit yield (42.4 t ha^{-1}) in watermelon.

In snakegourd, Haris (1989) observed a linear response to applied N upto 90 kg ha^{-1}. Subba Rao (1989) found that application of 100 kg N ha^{-1} in cucumber showed marked increases in the length of vine, number of leaves per plant, LAI, total dry matter production, number of fruits per plant, mean length, girth and weight of fruits, fruit setting percentage, sex ratio and fruit yield.

In sand culture experiments, Al-Sahaf and Al-Khafagi (1990) recorded more number of fruits plant^{-1} (13.52) and early yield of 435.51 g plant^{-1} by the application of N at 300 per cent in cucumber. Csermi *et al.* (1990) reported that irrigation and N application had greater beneficial effects on fruit and seed yield of cucumber. Kadyrkhodzhaev (1990) obtained higher yields of cucumber with 69 kg N ha^{-1}.

In muskmelon, Kim *et al.* (1991) obtained the best top growth with the lowest rate of N. Fruit yield and sugar content were normal but fruit quality tended to be higher at lower rate and the highest rate reduced fruit size and weight. Suresh and Pappiah (1991) reported that 80 kg N ha^{-1} with 200 ppm of maleic hydrazide spray produced more female flowers and yield of fruits in bittergourd. Samdyan *et al.* (1992) recorded the highest vine length with 75 kg N ha^{-1} plus gibberellic acid at 100 ppm, while early and total marketable fruit yields were the highest with 50 kg N and cycocel at 200 ppm in bittergourd. Zornoza *et al.* (1992) obtained the maximum growth in cucumber plant when the nutrient solution was rich in N.

The maximum yield of pointedgourd was recorded at 120 kg N ha^{-1} by Yadav *et al.* (1993). Yingjaval and Markmoon (1993) found that application of N (200%) increased the vegetative growth and marketable fruit yield in cucumber.

Application of N at 112 kg ha^{-1} through drip irrigation was found to register the highest total yield of 15.5 t ha^{-1} in pumpkin (Swaider *et al.*, 1994).

Um *et al.* (1995) found that N at 400 kg ha^{-1} produced good yield in cucumber and the number of clubbed and blemished fruits increased in the absence of applied N.

From the foregoing review, it is concluded that cucurbitaceous vegetables respond well to applied N. The beneficial influence of N results from an increase in vegetative growth, number of pistillate flowers, number of fruits and dimensions of fruits. The magnitude of yield response, however, depends, to a large extent, on soil type.

2.1.2. Quality of fruits

Brantley and Warren (1960 a) observed that levels of N (0, 113 and 281 kg ha^{-1}) had no effect on per cent soluble solids in watermelon. Similar results were reported earlier in watermelon by Kimbrough (1930). In solution culture studies by Cernavskaja and Nieiporovie (1963), it was observed that N and protein content of pumpkin fruit increased in response to incremental doses of N. This increase in protein, however, lowered the carbohydrate content of fruits.

Gnanakumari and Satyanarayana (1971) obtained the highest vitamin A and C contents in brinjal (*Solanum melongena* L.) with 280 kg each of N, P and K ha^{-1}. In tomato (*Lycopersicon esculentum* Mill.) adequate supply of N enhanced the fruit quality, fruit size, keeping quality, colour and taste. Acidity was increased by excess N (Sharma, 1971). According to Sharma (1971) and Sharma and Mann (1973), tomato plants with higher doses of N had lower density of fruits with more extractable juice, acidity, total soluble solids, ascorbic acid and reducing sugar.

Choudhury and De (1972) observed that N application increased titrable acidity and decreased ascorbic acid content in fruits while addition of phosphorus increased reducing sugar content. Largskii (1971) reported that N rates above 60 kg ha^{-1} inhibited the accumulation of total sugars and ascorbic acid content in cucumber. According to Sagdullaev and Umarove (1975), application of 100 kg N ha^{-1} improved the quality attributes like TSS in melons.

Krynska *et al.* (1976) conducted studies on cucumber with N at 80,160 and 240 kg ha^{-1} and irrigation depths varying between zero and 120 mm. It was observed that fruit yield and vitamin C content increased with increasing N rates but high rates of N had a depressive effect on fruit quality.

Pandita and Bhatnagar (1981) found that the TSS, juice, acidity and ascorbic acid contents were the highest in tomato fruits harvested from plants receiving N and P at 120 and 90 kg ha^{-1}, respectively. Arora *et al.* (1993) also observed that the TSS and acidity of tomato fruits were higher at 120 kg N ha^{-1}.

Mani and Ramanathan (1981) observed a decrease in crude fibre content of bhindi (*Abelmoschus esculentus* (L.) Moench) fruits with increase in N levels. Randhawa *et al.* (1981) noticed that increasing levels of N increased the TSS and vitamin C contents in muskmelon. However, Debuchananne and Taber (1985) observed that soluble solids and fruit size of muskmelon were not influenced by N rates (45, 90, 135 or 180 kg N ha^{-1}).

According to Joseph (1982) incremental doses of N significantly increased the ascorbic acid content of chilli (*Capsicum annuum* L.) fruits. Similar favourable effects of N fertilization on ascorbic acid content of chilli fruits was reported by Dod *et al.* (1983); Thomas and Leong (1984); Amritalingam (1988); Shibhila Mary and Balakrishnan (1990); Demirovska *et al.* (1992); Lata and Singh (1993) and Sherly (1996). The shelf life and marketable fruit yield of summer squash were not influenced by N rates (90 to 135 kg ha^{-1}) and irrigation (Smittle and Threadgill, 1982). Patil and Bhojappa (1984 a and b) found that N fertilization increased total sugars, juice percentage, TSS and acidity but decreased fruit density and dry matter content in tomato.

In tomato, Bhatnagar *et al.* (1985) obtained quality fruits with the application of 120 kg N ha^{-1} and irrigation at 0.8 IW/CPE. These fruits could be stored for 10 to 20 days with good keeping quality at normal and low temperatures. A significant increase in TSS content of muskmelon fruits with an increase in N levels was reported by Prabhakar *et al.* (1985) and Rao and Srinivas (1990).

Manchanda and Singh (1987) noted that vitamin C content in bell pepper (*Capsicum annum* L.) increased significantly with incremental rates of N and it ranged from 55.42 mg 100 g^{-1} fruit at 0 kg N to 97.12 mg 100 g^{-1} fruit at 160 kg N ha^{-1}.

Annanurova *et al.* (1992) obtained the highest sugar content in tomato with the application of 220 kg N ha^{-1}. Avakyan *et al.* (1992) reported that the application of N at 90 kg ha^{-1} increased leaf chlorophyll, protein and soluble sugar contents in tomato. Ashcroft and Jones (1993) found an increase in fruit yield, size of the fruit and TSS with increasing N application rate in tomato.

A significant increase in the size, TSS and flesh thickness of muskmelon due to the application of N, P and K at the rates of 100, 60, 60 kg ha^{-1}, respectively, was reported by Singh *et al.* (1995).

Premalakshmi (1997) obtained a significant increase in the vitamin C content of gherkins with combined application of higher doses of N and K (100 and 150 kg^{-1}, respectively). However, the moisture content of fruits did not show any appreciable variation.

2.1.3. Chemical composition and nutrient uptake

With the increase in the levels of applied N, the uptake of major nutrients by both the fruits and whole plants markedly increased in cucumber (Aleksandrova, 1971 and Subba Rao, 1989); pickling cucumber (Mc Collum and Miller, 1971); muskmelon (Jassal *et al.*, 1972); watermelon (Hegde, 1987) and snakegourd (Haris, 1989).

Based on a trial with varying levels of N (zero to 268 kg ha^{-1}), Cantliffe (1977) concluded that cucumber yielded the maximum number of fruits, when the N content of the foliage was four to five per cent.

Solntseva (1978) reported that cucumber plants grown in fertile soils utilized 75 to 81 per cent of N from the soil and only 19 to 25 per cent from the applied fertilizers. The addition of N fertilizers increased the N uptake from the soil by 53 to 63 per cent compared to the control plants which received no N. The co-efficient of utilization of N fertilizers by cucumber was 24 to 32 per cent.

According to Laske (1979), cucumber planted at a density of 1.2 plants m^{-2} removed 500 kg of N ha^{-1} during growing season. Tserling *et al.* (1979) observed that about 15 kg m^{-2} yields were produced in cucumber, when the soil contained 20 to 30 mg N kg^{-1} of soil at flowering. At that time, the leaf blade contained about five per cent N.

Both early and late sown plants of ridge cucumbers showed a high requirement of N and the role of N in fruit formation was found to be significant (Dorofeyuk, 1980).

Tesi *et al.* (1981) reported that when adequate N was applied, the uptake of N in *Cucurbita pepo* amounted to 170.5 kg ha^{-1} and the N requirement was the highest during the 15 days preceding the first harvest and during the subsequent 15 days.

Based on field experiments conducted at Chalakkudi, Thomas (1984) observed that all the N levels tried (30 and 60 kg ha^{-1}) exerted their significant influence on the content and uptake of N by bittergourd during the early and later stages of growth and that the interaction between N and irrigation significantly influenced the uptake of N at final harvest.

2.1.4. Water use efficiency

Hegde (1988 b) observed that N application in chilli at the rate of 120 kg ha^{-1} increased the WUE by 96 per cent over the control. Palled *et al.* (1988) also reported similar results.

According to Prabhakar and Naik (1993), N at the rate of 180 kg ha^{-1} reoorded the maximum WUE of 12.6 kg ha cm^{-1} in chilli while in the control, it was only 5.64 kg ha cm^{-1}.

The consumptive use of water and Et/Eo values of bittergourd increased progressively with the levels of N (0, 30, 60 and 90 kg ha^{-1}) and irrigation (at 15, 30 and 45 mm CPE at a depth of 40 mm). The WUE of the crop maintained a positive relation with the levels of N and a negative relation with levels of irrigation (Thampatti *et al.*, 1993).

2.1.5. Moisture extraction pattern

Goyal *et al.* (1987) reported that when N was applied at the rate of 15 g plant-^{1}, more than 80 per cent of chilli roots were concentrated in 0-22 cm soil depth. This depth formed the wetting zone of the dripper.

Thampatti *et al.* (1993) observed that the moisture extraction pattern of bittergourd was not influenced by N levels (0, 30, 60 and 90 kg ha^{-1}) and that a major part of the moisture was extracted from the upper layers of soil in all the treatments irrespective of the N levels.

2.1.6. Physico-chemical properties of soil

The fertilizers carrying N have a considerable effect on the soil pH. Verma *et al.* (1982) observed an increase in soil pH due to urea N. On the contrary, a decrease in pH due to fertilizer-N was reported by Minhas and Mehta (1984) and Sudhadevi and Mohanakumaran (1987).

The addition of fertilizer N always seem to have a positive influence on the availability of N in the soil (Muthuvel, 1976; Bajwa and Paul, 1978; Haris 1989 and Sherly, 1996). Muthuvel (1976) and Bajwa and Paul (1978) observed a significant increase in available N status of soil due to fertilizer N addition. In their fertilizer trial on *Costus speciosus* L., Sudhadevi and Mohanakumaran (1987), found an increase in the total N content of soil with an increase in N level. Similarly, Haris (1989) observed an increase of soil available N from 389.82 to 450.80 kg ha^{-1} with the addition of N at varying levels from 50 to 90 kg ha^{-1} to snakegourd.

The available N content and bulk density of the soil remained unaffected by different levels of N (25, 50 and 75 kg ha^{-1}) applied to garlic (Patel *et al.*, 1995). However, the available N content in soil increased progressively with an increase in nutrient level in chilli and the increase was significant between 50 and 75 kg N ha^{-1}. A significant increase in available P status of soil was also noted with higher doses of (75 and 100 kg ha^{-1}) N as compared to the lower dose of 50 kg ha^{-1} (Sherly, 1996).

Applied fertilizer N has varied influence on the availability of P in the soil. An increase in levels of N improved the available P in the soil (Chellamuthu, 1978; Muthuvel and Krishnamoorthy, 1980; Bhaskaran, 1983; Krishnan, 1986; Premalaksmi, 1997). However, Srivastava (1985) observed a decrease in available soil P status due to the inorganic N addition. According to Sharma and Arora (1988), the applied N levels did not have any influence on available P status of soil.

The applied fertilizer N is having varied influence on the available K status of intensively cropped soils. A significant increase in the available K content of soil due to N application was observed by Chellamuthu (1978), Bhaskaran (1983) and Krishnan (1986). On the other hand, Muthuvel (1976); Subbiah *et al.* (1982) and Srivastava (1985) found that the availability of K in the soil decreased with an increase in level of applied inorganic N.

2.2. Ethephon

The role of plant growth regulators in altering sex expression in cucurbits is known from time immemorial and some of the growth regulators like ethephon are even now used commercially to narrow down the sex ratio and to improve fruit set. An attempt is made in this section to review the important works conducted in India and abroad on the effect of ethephon on cucurbits.

2.2.1. Growth and yield

Earlier research results indicated that ethephon treated cucurbits flowered early with a large number of female flowers and produced high yield (Hass, 1969; Lower and Miller, 1969; Miller *et al.*, 1969; Sims and Gledhill, 1969).

Splittstoesser (1970) reported that ethephon induced a greater number of female flowers, shorter internodes and earlier fruit set in pumpkin.

Higher fruit yield with foliar sprays of ethephon at 250 mg l^{-1} has been reported in summersquash (Singh *et al.*, 1975); pumpkin (Shanmughavelu *et al.*, 1973; Das and Swain, 1977; Arora and Partap, 1988) and ridgegourd (*Luffa acutangula* Roxb.) (Arora et al., 1987; Kumar and Rao, 1988).

In snakegourd, ethephon sprays at 50 and 100 ppm recorded significantly more number of pistillate flowers (34.6 and 31.2%, respectively) and fruit yield (43.9 and 23.5%, respectively) over the control of 0 ppm (Shanmughavelu and Thamburaj, 1973).

Sundararajan and Muthukrishnan (1974) pointed out that when ethephon at 100 to 250 ppm was sprayed at weekly intervals from first true leaf stage to flowering, in five sprays, it induced more pistillate flowers and increased the yield of fruits by 24 per cent, as compared to Alar and gibberellic acid in ashgourd (*Benincase hispida* Thunb Logn.). Shanmughavelu *et al.* (1973) conducted a study on the sex-ratio, yield and quality of pumpkin fruits and found that the pistillate flower production was promoted by ethephon at 100 and 200 ppm thereby narrowing the sex ratio (14:1 and 18:1, respectively). They also observed that the yield of fruits increased by 38.9 per cent over control by ethephon 100 ppm and the total sugars increased at 100 and 1000 ppm. The ascorbic acid content was also found to increase to a maximum of 34.8 mg 100 g^{-1} with 100 ppm of ethephon.

Ethephon 150 ppm applied at 2 to 4 leaf stages on wintersquash (*Cucurbita maxima* Duch.) resulted in the production of pistillate flowers in most of the early nodes and greater number of fruits which tended to be smaller in size (Baker and Bradley, 1976).

Verma and Choudhury (1980)observed that in cucumber variety "Poonakhira", application of ethephon at 50 - 200 ppm increased the number of female flowers significantly, producing the largest number of fruits and the highest yield.

In a study conducted at the College of Agriculture, Vellayani, all the levels of ethephon (50, 100 and 200 ppm) increased the number of female flowers, number of fruits, percentage fruitset, fruit yield and weight of fruits in bittergourd (Kerala Agricultural University, 1982). At the Regional Agricultural Research Station, Pilicode, ethephon at 100 ppm was found to be superior to the other levels in terms of fruit production in cucumber (Kerala Agricultural University, 1983). Dubey (1983) reported a three-fold increase in yield over the control in spongegourd (*Luffa cylindrica* Roem.) with ethephon applied at 250 mg l^{-1} sprayed at 2 and 4 leaf stages of growth.

Ethephon 150 ppm at two leaf stage recorded the highest number of pistillate flowers, the lowest sex ratio, higher number of fruits per plant and yield in cucumber (El-Ghamainy *et al.*, 1985). In watermelon, ethephon at 250 ppm sprayed at the two-leaf and four-leaf stages recorded the highest number of female flowers, a significantly lower number of male flowers, the lowest node number at which the first female flower appeared and the narrowest sex ratio (Alikhan *et al.*, 1986).

Verma *et al.* (1986) noticed that spraying ethephon at 100 and 200 ppm at two-leaf stage produced the highest number of fruits with smaller size, ultimately producing a significant yield increase in pumpkin. In ridgegourd, Kumar and Rao (1988) obtained the highest mean number of fruits per vine (36.0) after applying ethephon at 50 ppm at four leaf stage.

Arora *et al.* (1989 a) reported that ethephon at 250 and 100 ppm significantly increased the number of fruits per vine and yield ha^{-1} because of a reduction in sex ratio resulting in more fruits per plant in pumpkin.

In pumpkin var. Arkasuryamukhi, all the growth regulators tried viz., ethephon (125, 250 and 500 ppm), 2, 4-5 tri idobenzoic acid, ie., TIBA (50, 100 and 200 ppm) and gibberellic acid (25, 50 and 100 ppm) increased the moisture content of fruits and reduced ascorbic acid, beta carotene and reducing sugar contents, compared to control. However, total soluble solid (TSS) content and titrable acidity significantly increased with 200 and 500 ppm, respectively (Gawankar *et al.*, 1990).

Devadas and Ramadas (1994) reported a significant yield increase in bittergourd with ethephon at 100 ppm sprayed at four leaf and vining stages of plant growth.

Arora *et al.* (1995) reported that the interaction effect of N at 60 kg ha^{-1} and ethephon at 100 ppm was significant in increasing the vitamin C content and TSS in ridgegourd.

Das and Das (1996) found that ethephon applied at 200 ppm shortened the vine length (274.33 cm), increased the basal diameter (1.33 cm) of vines, induced earliness in branching (26.37 days) and produced the maximum number of branches (7.71) with short internodal length (7.08 cm) and more fruits per vine (5.33) and the highest average yield of fruits (17.65 kg $vine^{-1}$) in pumpkin.

2.2.2. Sex expression

Lower and Miller (1969) observed that ethephon increased femaleness and it did not increase the percentage fruit set on either pollinated or non-pollinated cucumber plants.

Iwahori *et al.* (1970) reported an increase in the number of female flowers and a decrease in the number of male flowers in cucumber due to ethephon application. The female flowers were also produced earlier and on lower nodes.

Robinson *et al.* (1969) pointed out that ethephon inhibited growth and induced femaleness when applied to the foliage of cucumber at 100 ppm concentration.

Ethephon applied as a foliar spray caused an andromonoecious line of cucumber to produce pistillate flowers analogous to those of monoecious. The degree of conversion depended on the concentration of ethephon and the stage of growth at the time of application. In the green house, a concentration of 50 ppm was the best for the induction of pistillate flowers without marked inhibition of growth (Augustine, 1973).

Ethephon has been most effective in cucurbits in inducing early female flowers at lower nodes (generally occupied by male flowers) and suppressing the male flower production for many days (Patil *et al.*, 1982, 1984; Saimbhi, 1984). Good results have been reported with 150-250 mg l^{-1} concentrations in cucumber (Bhandari *et al.*, 1974; Singh and Singh, 1984; El-Ghamainy *et al.*, 1985), pumpkin (Shanmughavelu *et al.*, 1973; Das and Swain, 1977; Verma *et al.*, 1984, 1985; Arora *et al.*, 1988, 1989), summersquash (Singh *et al.*, 1975, Krishnamoorthy and Sandooja, 1981; Arora *et al.*, 1985), spongegourd (Dubey, 1983) and ridgegourd

(Krishnamoorthy *et al.*, 1976; Saimbhi, 1976) and with 500-1000 mg l^{-1} concentrations in muskmelon (Saimbhi and Thakur, 1972; Sulikeri and Bhandari, 1973; Kaushik and Bisaria, 1974) and bottlegourd (Saimbhi and Thakur, 1976; Arora *et al.*, 1985).

Shanmughavelu (1989) reported that pumpkin cv. Arka Suryamukhi treated with ethephon 250 and 500 ppm at five leaf stage hastened the development of pistillate flowers at 10 to 12 nodes. The results indicated the alteration of sex expression of pumpkin towards femaleness. According to Das and Das (1996), 200 ppm ethephon registered the first flower bud appearance at most early nodes (5.27 against 11.03 in control) and also a narrower sex ratio 6.61 as against 14.45 in control in pumpkin.

2.2.3. Quality of fruits

An increase in acidity with ethephon application has been reported by Shanmughavelu *et al.* (1973) in pumpkin. Shanmughavelu and Thamburaj (1973) noticed an increase in ascorbic acid content and a decrease in total and reducing sugar with an increase in ethephon concentration from 50 to 500 ppm in snakegourd.

Soluble solids tended to be higher in wintersquash with ethephon sprayed at 100 ppm (Baker and Bradley, 1976). Ethephon improved fruit quality in bittergourd by increasing vitamin C and iron contents (Kerala Agricultural University, 1982).

Foliar sprays of ethephon at 250 mg $litre^{-1}$ enhanced TSS content in tomato (Arora *et al.*, 1983).

Titrable acidity in watermelon was increased by the application of ethephon at 250 ppm, but TSS was not influenced by it. With regard to sensory quality of watermelon fruits as shown by colour, consistency, flavour and absence of defects, there was no significant variation between ethephon and the control (Alikhan *et al.*, 1986).

It is, thus, clear from the review that ethephon promotes the production of pistillate flowers, narrows down sex ratio and increases fruit yield in cucurbitaceous vegetables. The choice of the correct dose, however, depends on the type of crop and the weather conditions prevailing at the time of application.

2.3. Drip irrigation

2.3.1. The concept of drip irrigation

Water is fast becoming an economically scarce resource in many areas of the world (Gregory, 1984). Microirrigation techniques are, therefore, suggested to improve irrigation efficiency of crops by reducing soil evaporation and drainage losses and by creating and maintaining soil moisture conditions that are favourable for growth (Batchelor *et al.*, 1996). Drip/trickle irrigation is one of the latest innovations for applying water to row planted, widely spaced crops, especially in the water scarce areas. There can be considerable saving in usage of water by adopting this method since water is applied almost precisely and directly in the root zone without wetting the entire area (Bafna *et al.*, 1993 and Ahlwaalia *et al.*, 1993). Drip irrigation offers greater flexibility in scheduling irrigation as per the requirement of the crop in its different growth stages. It is proved beyond doubt that drip irrigation not only increases the yield of most of the agricultural crops but also improves water use efficiency beyond the level attainable in conventional irrigation systems. Drip irrigation has its beginning in the early 1960's and from the review articles published (Black 1976 a and b; Maillard, 1976; Bresler, 1977; Shoji, 1977; Bucks *et al.*, 1982;

Elfving, 1982 and Haynes, 1985), the scope of drip irrigation can be understood. The chief advantages of drip irrigation are substantial water saving, highly uniform water application, elimination of surface flow of water, prevention of soil erosion and easy regulation of water application (Abrol and Dixit, 1972 and Bucks *et al.*, 1974). De Tar *et al.* (1983) considered drip irrigation as a convenient tool for irrigation experiments. The system offers excellent control of moisture levels and does not obstruct field operations.

Drip irrigation has found rapid acceptance in high-valued and/or perennial crops (Hall, 1974; Bresler, 1977; Ben-Asher *et al.*, 1978; Tsipori and Shimshi, 1979; Turner and Evans, 1980). Today, it is used on a wide variety of crops even those that were initially considered unprofitable for management under drip irrigation (Nakayama and Bucks, 1991). Bangal *et al.* (1987) reported that drip irrigation system can be used easily to grow vegetables.

The literature pertaining to different aspects of drip irrigation especially its effect on yield, yield attributes and quality of vegetable crops are reviewed in this section.

2.3.2. Crop characters as influenced by drip irrigation

2.3.2.1. Growth and yield

Goldberg and Shmueli (1970) recorded a 75 per cent increase in the yield of muskmelon, peppers, tomatoes and sweetcorn with trickle irrigation as compared to sprinkler or furrow irrigation.

Bernaar (1971) reported that compared to drip system, 50 per cent more water was applied in the case of furrow irrigation. Further, a significant increase in yield and fruit size was observed under the drip system.

For nearly the same quantity of irrigation water used, yields of onion (*Allium cepa* L.) and ladies finger (*Abelmoschus esculentus* (L.) Moench) were significantly higher under drip irrigation than in basin irrigation (Abrol and Dixit, 1972). Halevy *et al.* (1973) reported that tomatoes, green pepper, cucumber, muskmelon and other melon varieties gave striking response to drip irrigation in terms of higher yields compared to other surface methods at equal or low volume of water. Grimes *et al.* (1976) obtained substantially higher yields of tomatoes from drip irrigated plots over furrow irrigated plots in the clayey soils. Bar-Yosef (1977); Levin *et al.* (1979) and Levin *et al.* (1980) observed that under arid conditions, the whole root system of tomato developed in the trickle irrigated zone since there was little water available beyond that soil volume.

Earl and Jury (1977) found that the crop yield of squash in sandyloam soils was higher in the periphery of the wetted area under weekly trickle irrigation compared to daily irrigation. This study supports the view that weekly trickle or furrow irrigation is preferable to daily trickle irrigation when the crop is sensitive to oxygen.

Padmakumari and Sivanappan (1978) reported that brinjal plants had larger number of branches and higher yields under trickle irrigation which used only 24 cm of water as against 69 cm of water in the conventional system of furrow irrigation. Similar results in bhindi were reported by Sivanappan *et al.* (1974). Restuccie and Abbate (1978) in their studies on methods of irrigation on tomato observed that with equal volume of water, drip irrigation was far more effective than furrow irrigation in respect of yield.

Rudich *et al.* (1978) observed that drip irrigation in the fruit development stage (which continue for about a month with watermelon and $1\frac{1}{2}$ months with muskmelon) resulted in yield increases of 48 per cent and 45 per cent, respectively. Irrigation during fruit development stage did not affect fruit quality ie., TSS and storage life. According to Singh and Singh (1978) drip irrigation increased the yield of longgourd by 45 to 47 per cent, of roundgourd by 21 to 38 per cent and of watermelon by 10 to 22 per cent as compared to sprinkler and furrow irrigation in the hot arid climate of Jodhpur on a coarse sandy soil.

While comparing the growth and yield response of tomatoes under two moisture regimes, Bar-Yosef *et al.* (1980) found that dry fruit yield and vegetative growth were higher under the lower regime (93 per cent of E pan) giving water three times daily. However, fresh fruit yield was the highest under the higher regime (118 % E pan). This indicated that the lower regime was sufficient to support the plant-dry matter, but insufficient to fill up the fruit and maintain water content necessary to increase the fresh yield.

Hanna *et al.* (1985) also found that drip irrigation doubled the early and marketable yield of fresh tomatoes when compared to no irrigation.

Higher fruit yield of tomato under drip irrigation compared to furrow irrigation was reported by Lin *et al.* (1983); Osorio *et al.* (1983) and Vasanthakumar (1984). However, in a study on tomato by Meck *et al.* (1983), daily drip irrigation did not increase fruit yield as compared to the other methods.

Studies conducted at the Regional Agricultural Research Station, Pilicode revealed that in watermelon and bottlegourd, pitcher irrigation was superior to all the other methods tried ie., basin irrigation at IW/CPE 0.50, 0.70 and 0.90 as well as daily pot watering with 3.5 litres water per pit (Kerala Agricultural University, 1983). Beese *et al.* (1982), in their study on chile pepper under trickle irrigation, found linear response to water application rates at 0.8, 1.0, 1.2 and 1.4 times of the control (applied at -25 cbr) in respect of leaf area and dry matter production and yield.

Paunel *et al.* (1984) obtained an average fruit yield of 21.4 t ha^{-1} under drip and 17.6 t ha^{-1} under sprinkler systems of irrigation in melon. According to Bhella and Wilcox (1985), total yield and vegetative growth of muskmelon were the highest under trickle irrigation.

Bhella (1986) obtained significantly higher stem length, diameter, leaf area, mean fruit weight and yield in muskmelon under trickle irrigation compared to no irrigation. However, trickle irrigation decreased the depth of root penetration and also total soluble solids in fruit. According to Bogle and Hartz (1986), drip irrigation improved earliness and increased total and marketable fruit yield in muskmelon, compared to furrow irrigation.

From the experiments conducted with brinjal (Jaime *et al.*, 1987), papaya (Padmakumari and Sivanappan, 1989); *Cucurbita pepo* and autumn cabbage (Rubeiz *et al.*, 1989) it could be concluded that water requirement under trickle irrigation was around 50 per cent of that of the conventional irrigation system of furrow method.

Mannini and Gallina (1987) found no significant variation in green house-grown cucumber fruit yield due to irrigation methods (trickle and perforated hose) and irrigation intervals (3 and 6 days). However, Hanna and Adams (1989) obtained significantly higher early and total yield and longer fruits in cucumber due to drip irrigation. Oweis *et al.* (1988) obtained the maximum yield of tomatoes under trickle irrigation with 600 mm of net irrigation. In capsicum also, increased early and total yields and fruit weight were obtained with trickle irrigation (Call and Courter, 1989). However, Warriner and Henderson (1989) observed that the total yield of rockmelons was not affected by drip and sprinkler methods of irrigation.

El-Shafei (1989) concluded that in a sandy soil, trickle irrigation at the rate of 80 per cent Ep was required to avoid yield loss of tomato and the soil water potential at 15 cm depth should be -10 to -20 kPa.

The results of a field experiment conducted on a sandy loam soil at the California State University, Fresno, revealed that the yield of red tomatoes and total tomatoes increased with an increase in the quantity of water used in trickle irrigation from 35 per cent to 105 per cent of potential evapotranspiration (Sanders *et al.*, 1989). Comparing drip and furrow irrigation for watermelon, Srinivas *et al.* (1989), observed that drip irrigation resulted in 32 to 36 per cent higher yield and 42 to 46 per cent higher WUE compared to furrow irrigation.

Singh *et al.* (1989) found that trickle irrigation at 0.5 IW/ETP resulted in the highest yield of tomato compared to other ratios and surface irrigation method. Smajstrla and Locascio (1990) observed that the total marketable yield of fruits in tomato increased by 50 and 100 per cent due to drip irrigation in 1987 and 1990, respectively, compared to non-irrigated controls.

Haroon (1991) reported that compared to furrow irrigation, trickle irrigation increased the fresh fruit yield of tomato to the extent of 25 to 60 per cent. However, daily trickle irrigation at the rate of 2 l $plant^{-1}$ was more effective than alternate day trickle irrigation producing 10 per cent higher fruit yield. On the contrary, Kadam and Magar (1992) found that alternate day drip irrigation was more effective in respect of number of fruits, fruit weight and fruit volume compared to furrow and sprinkler irrigation treatments.

When drip irrigation was compared with surface irrigation in six different vegetables, water saving and yield were very much higher in all the cases under drip irrigation (Acharya, 1993). Ahlawaalia *et al.* (1993) observed that compared to the conventional irrigation systems, drip system yielded, on an average, 6 and 56 per cent higher and saved upto 57 and 37 per cent irrigation water in tomato and cauliflower, respectively, resulting in tremendous increase in WUE. Drip irrigation resulted in an additional yield of 16 t ha^{-1} in tomato as compared to furrow method (Jadhav *et al.*, 1993). A twelve per cent increase in the commercial fruit weight of tomato under drip irrigation compared to furrow method was reported by Takahi Amma (1994).

With the same quantity of water used in basin irrigation, four times of area under annual moringa (*Moringa oleifera*) could be irrigated through the drip system (4 l day^{-1} $tree^{-1}$) and the yield could be increased by three folds (Rajakrishnamoorthy *et al.*, 1994).

According to Benke (1995), drip irrigation offers the maximum water use efficiency, higher yield, better quality fruits and decent net profit in watermelon. In drip irrigated egg plant (*Solanum melongena* L.), increasing the quantity of irrigation water from 0.4 ETm to 1.0 ETm significantly increased the yield and number of fruits $plant^{-1}$, whereas the fruit size was not influenced by the amount of water applied (Chartzoulakis and Drosos, 1995).

Elkner and Kaniszewski (1995) observed that the total and marketable yield of tomato was increased by 16 and 28 per cent, respectively, by drip irrigation as compared to the control (no irrigation). Also drip irrigation provided clear increase in fruit compression resistance and fruit weight. Based on a field experiment conducted at the instructional farm attached to the College of Agriculture, Vellayani, Lakshmi (1997) reported that the fruit yield of cucumber was the highest(20.63 t ha^{-1}) at the drip irrigation level of 3 l $plant^{-1}$ day^{-1} compared to the other levels (2 and 4 l $plant^{-1}$ day^{-1}). All drip irrigation treatments were superior to the farmer's practice of conventional pot watering.

Sharma *et al.* (1996) reported 28.23 per cent more yield in tinda (*Citrullus fistulosus Stocks.*) under drip irrigation system compared to furrow irrigation. The highest net return (Rs.27,558 ha^{-1}) and the largest benefit-cost ratio were also obtained in drip system.

The above review clearly suggests that annual/seasonal vegetables are particularly responsive to drip irrigation which provides ample moisture in the root zone throughout the growth phases of the crops. The beneficial effects of drip irrigation result from an increase in the number of branches, number of fruits and fruit weight. Further, the system enforces strict economy in the use of irrigation water.

2.3.2.2. Quality of fruits

In trials with direct sown muskmelon, cv. PMR 45, higher yields, larger fruits and early maturity were obtained by irrigating when soil moisture tensions at 25 cm depth reached 50 or 75 kPa compared with 25 kPa and fruits from the drier treatments were higher in soluble solids (Pew and Gardner, 1983).

Bhella (1986) observed a decrease in total soluble solids in watermelon under the drip system of irrigation.

Sanders *et al.* (1989) reported that while the concentration of soluble solids (SSC), total solids (TS) and pH decreased, while colour, fruit size and acidity increased in tomato with an increase in trickle irrigation rate.

Studies conducted by Elkner and Kaniszewski (1995) on a sandy-loam soil in Poland showed that drip irrigation decreased the amount of carbohydrates, pectins, fibre, vitamin C, dry matter content and nitrates in tomato fruits compared to no irrigation. Comparable results regarding the content of dry matter, carbohydrates and vitamin C were obtained by Rudich *et al.* (1977) and Kaniszewski and Elkner (1987).

Kataria and Michael (1990) reported that TSS was higher in drip compared to furrow irrigated tomatoes. However, total acidity was lower in drip plots.

2.3.2.3. Water use efficiency (WUE)

Drip irrigation, when properly managed, generally results in efficient water use while maintaining acceptable crop yields (Davis, 1967; Goldberg and Shmueli, 1970; Mc Namara, 1970; Bernstein and Francois, 1973; Bucks *et al.*, 1974; Grobbelarr and Lourens, 1974 and Schweers and Grimes, 1976).

Locascio and Mayers (1975) found optimum soil moisture tension under trickle irrigation by providing one third as much water as applied by overhead.

The water use efficiencies in terms of harvested yield per unit volume of water applied were 8.1, 5.4 and 11.0 kg ha m^{-1} for longgourd, roundgourd and watermelon, respectively, whereas the WUE of these crops under furrow irrigation were 4.5, 3.9 and 8.7 kg ha m^{-1}, respectively (Singh and Singh, 1978). Sivanappan *et al.* (1978) reported that a chilli crop of 213 days duration used 41.77 cm water in 90 irrigations through the drip system compared to 109.71 cm of water in 22 irrigations by the conventional furrow method and the quantum of water saved by the drip method was 62 per cent.

The WUE for harvested yield of fresh tomato was 10 to 12 kg ha m^{-3} (Doorenbos and Kassam, 1979). Many studies have shown improved WUE for trickle irrigation as compared to conventional irrigation techniques, although carefully controlled conventional irrigation could sometimes produce WUE equal to trickle irrigation (Sammis, 1980).

Elmstrom *et al.* (1982) observed a 40 per cent less water consumption by watermelon plants under drip compared to overhead irrigation in sandy soils. Osorio *et al.* (1983) reported that, in tomato, drip irrigation used only 20 per cent of the water used by furrow irrigation. Higher WUE for drip irrigation compared to other surface irrigation methods was reported by Kumar (1984) in tomato and Ramesh (1986) in green chilli (*Capsicum annuum* L.).

Bogle and Hartz (1986) found that drip irrigation required only 25 to 40 per cent of irrigation water volume needed by furrow irrigation for muskmelon. Bangal *et al.* (1987) reported WUE of tomato as 3.54 and 2.89 t ha cm^{-1} in trickle and furrow irrigation, respectively.

Chartzoulakis and Michelakis (1988) found the WUE of tomato as 47.7 and 27.8 kg m^{-3} under drip and furrow irrigation, respectively. Santos (1988) observed a decrease in WUE in pouring method compared to drip as a result of partial wetting with varying water regimes.

In tomato, trickle irrigation rates of 35 per cent ET, 70 per cent ET and 105 per cent ET did not differ in WUE (249, 211 and 229 kg ha m^{-1}) but were superior to conventional furrow irrigation (116 kg ha m^{-1}) (Sanders *et al.*, 1989).

Foster *et al.* (1989) evaluated the moisture regime and plant growth of four vegetables under drip irrigation and compared then with conventional furrow irrigation. The results showed greater water savings and higher yields under drip system.

The WUE of cucumber was reported to be the highest under drip irrigation (27.7 kg m^{-3}) compared to the furrow irrigation (16.8 kg m^{-3}) by Chartzoulakis and Michelakis (1990). Compared to the other surface irrigation methods, drip irrigation resulted in 40 to 65 per cent saving in water and 35 to 48 per cent increased yields. The field water use and consumptive use efficiencies were also higher for drip irrigation (Reddy *et al.*, 1990). The studies on the effect of drip and conventional methods of irrigation by Tekinel *et al.* (1990) revealed that the WUE was the highest under drip method in tomato, strawberry, citrus and banana.

The saving of water in the drip irrigation compared to conventional methods was 27 per cent for tomato and 60 per cent for sugarcane (C.W.C., 1991). In tomato, increased WUE of 7.9, 8.2 and 7.9 kg m^{-3} were obtained at 4 l day^{-1}, 2 l day^{-1} and 4 l (alternate day) rates of trickle irrigation, respectively, over furrow irrigation (4.4 kg m^{-3}) (Haroon, 1991). Oguzer *et al.* (1991) opined that WUE of capsicum was the highest with daily trickle irrigation.

Satpute *et al.* (1992), based on a field study conducted at Akola reported that WUE achieved under drip and furrow methods of irrigation at 80 per cent E pan were 1.17 t ha cm^{-1} and 0.59 t ha cm^{-1}, respectively in tomato.

The irrigation requirement of hybrid tomato, on an average, was 67 ha cm in surface irrigation and only 32 ha cm in drip (Bafna *et al.*, 1993). The water required under twin-wall drip irrigation (daily application for 71 days) and surface method (13 irrigations) in okra was 29.9 cm and 43.9 cm, respectively, with a saving in irrigation water to the tune of 31.9 per cent in the former (Kadam *et al.*, 1993).

2.3.2.4. Root distribution pattern

Information on the development and activity of root system of vegetable crops as influenced by trickle irrigation is scanty and there are contradictory reports also. Vaadia and Itai (1968) held the view that partial wilting of soil volume might be detrimental to the crop even if the moisture in the active root surface was sufficient for uptake.

Abrol and Dixit (1972) reported that the average depth of root penetration in okra was only 22.1 cm in the case of drip irrigated plots, while it was nearly double in plots receiving surface irrigation when cumulative evaporation amounted to 85 mm.

Tscheschke *et al.* (1974) found uniform tomato root distribution under trickle irrigation in lysimeters except for a zone of saturation at the bottom where rooting was scarce. Plants grown under trickle irrigation where other sources of moisture supply are negligible are observed to have highly active and concentrated root system limited to the wetted zone (Goldberg *et al.*, 1976; Proebsting *et al.*, 1977; Levin *et al.*, 1979, 1980; Bar-Yosef *et al.*, 1980; Bucks *et al.*, 1981 and Howell *et al.*, 1981). Goldberg *et al.* (1976 a) found that root weight of pepper (*Capsicum annuum* L.) at about 30 cm depth and 30 cm away from the drippers was only two per cent of the total weight and 80 per cent of the roots were within the first 20 cm. This is in agreement with the findings of King *et al.* (1979). In contrast, Black (1976 a & b) observed that in non-arid regions where plants received some moisture from external sources, had more extensive root system throughout the soil volume. Similarly, Silberbush *et al.* (1979) found concentration of roots in the periphery of the wetted zone (20-35 cm).

According to Vaadia and Itai (1968) wetting of sub optimal soil volume might be detrimental even if the active root surface was sufficient for uptake. A level of drought sensitivity is induced in trickle irrigated plants and hence even smaller stress created in the root zone can affect markedly the crop performance. In shallow and distinctly layered soil, root system will be limited and hence needs larger wetting volume (Phene and Beale, 1976) compared to uniform profile.

Bar-Yosef *et al.* (1980) in his investigation on the response of tomato to trickle irrigation, concluded that the main factors that contributed to the different response of plants to the trickle irrigation were the root weight and root distribution in the soil during the growth period. In the once-a-day irrigation treatments, the root weight declined at the time of fruit filling, causing a delay in production while in the three-times-a-day irrigation treatments, the decrease was not marked and fruit dry matter production occurred at a higher rate.

Siderius and Ebersen (1986) noted that trickle irrigation produced shallow rooting in citrus with the result that roots became entirely dependant on the system for their supply of water and nutrients. Similar results were recorded in muskmelon by Bhella (1988). Safadi (1987) observed no significant difference between three different drip irrigation schedules on vertical and horizontal root lengths and oven dry root weight of squash. According to Shatawani (1987), the roots of squash are concentrated mainly in the upper 100 cm soil layer.

Studies on root growth and water status of trickle irrigated cucumber and tomato conducted by Randall and Locascio (1988) showed that water application rates of two or eight litres $hour^{-1}$ did not influence root density distribution or plant water status; however, the 8 litres $hour^{-1}$ application rate resulted in higher water content in the top 20 cm of soil than the lower application rates. Goyal *et al.* (1987) reported that more than 80 per cent of the roots was in the 0-22 cm soil depth which corresponded to the wetting zone of the dripper. Fresh root weight and percentage distribution were significantly higher in 0-11 cm soil depth.

Safadi and Battikhi (1988) observed no significant difference between drip irrigations at different soil moisture tensions with regard to vertical and horizontal root growth and oven dry root weights.

The root length densities of tomato determined at three trickle irrigation treatments (trickle irrigation rates of 35% ET, 70% ET and 105% ET) showed a decrease with soil depth. Greater root length density was found in irrigation at 35 per cent ET than at 70 or 105 per cent ET (Sanders *et al.*, 1989). Seventy four per cent of the total root weight of tomato grown under drip irrigation was confined to the top 15 cm of soil layer (Singh *et al.*, 1989).

In their study on the response of cucumber to irrigation systems (furrow, microtubes, drip, porous clay tubes and porous plastic tubes), Chartzoulakis and Michelakis (1990) observed that roots developed mostly in the first 30 cm of the soil and in this layer was found 83.9 per cent of the whole roots with furrows, 80.5 per cent with drippers, 78.1 per cent with clay tubes and 69.5 per cent with porous plastic tubes.

2.3.3. Irrigation frequency

Several workers reported that crop yield responses to trickle irrigation system depended mainly on the depth and frequency of irrigation. Goldberg and

Shmueli (1970) found decreased yields in tomato, cucumber and muskmelon on a sandy desert soil when drip irrigation frequency was less than daily. Freeman *et al.* (1976) recorded increased tomato yields with increasing irrigation frequency on a Hanwoodloam.

Bar-Yosef *et al.* (1980) noted that increasing irrigation frequency from 1-3 irrigations per day on a sandy soil enhanced the tomato fruit dry matter yield. However, increasing the frequency of trickle irrigation decreased the yields of cabbage when the quantity of applied irrigation water was near or less than the consumptive use rate (Bucks *et al.*, 1974).

Shallow rooted onions gave higher yields with daily irrigation than with weekly trickle irrigation (Bucks *et al.*, 1982).

Suh *et al.* (1987) obtained yield of hot pepper, radish and chinese cabbage with increasing frequency of trickle irrigation and plants grown under conditions of soil water deficit were more likely to show symptoms of B deficiency, root cracking (radish) and tip burn (Chinese cabbage).

Oguzer *et al.* (1991) obtained the highest yields in capsicum with daily trickle irrigation.

2.3.4. Moisture distribution pattern under drip irrigation

In drip irrigation, water movement and its distribution in the soil depend upon many parameters such as soil type, rate of infiltration, hydraulic conductivity, rate of emitter discharge, quantity of water applied, soil moisture content, depth of water table and certain climatic factors.

Bresler *et al.* (1971) reported that under an isolated dripper, the vertical component of wetted zone became larger and the horizontal component smaller with a decrease in discharge rate. Bar-Yosef and Sheikholslami (1976) and Mostoghami *et al.* (1982) observed the same trend but with an increase in discharge rate in sandy and heavy (clay) soils.

The studies of Roth (1974) revealed that the maximum horizontal movement of moisture was greater than the maximum vertical movement for volumes of water less than 190 litres.

The moisture distribution in the soil and wetted area under a point source (dripper) is greatly affected by the parameters like application rate and soil type (Sivanappan and Padmakumari, 1979).

Mostoghami *et al.* (1983) studied soil moisture distribution in a cropped soil at different depths and distances from the water source in trickle irrigated tomato. The results indicated a non-uniform water distribution pattern at different sections of the soil profile. Drip irrigation resulted in higher time average soil moisture content in contrast to other surface methods (Kumar, 1984).

Sivanappan *et al.* (1987) studied the water movement pattern for a drip discharge rate of 8 litres $hour^{-1}$ and observed it up to 30 to 40 cm distance in horizontal and vertical directions, respectively. Carmi and Plant (1988) reported that most of the available water supplied by drip irrigation was found at 0-30 cm depth but infiltration depth increased as evaporation rate decreased. Studies conducted by Randall and Locascio (1988) in trickle irrigated cucumber and tomato showed that discharge rate of 8 litres $hour^{-1}$ resulted in higher water content in top 20 cm of soil than the lower application rate of 2 litres $hour^{-1}$.

Kataria and Michael (1990) observed that in drip irrigation, the surface soil layer up to 10 cm depth had the maximum soil moisture content. This coincided with the region having the maximum number of effective roots resulting in a better environment for higher yields. The soil moisture content reduced with depth.

Satpute *et al.* (1992) conducted studies to obtain information on the effect of discharge rate (2, 4 and 6 litres hour^{-1}) and volume (5, 10 and 15 litre) on soil moisture distribution pattern under a dripper on clay and clay-loam soils. The study revealed that with an increase in the discharge rate, the vertical movement of wetting zone reduced and horizontal movement increased in both the types of soil. The moisture distribution was symmetrical in vertical and horizontal direction at 4 l hour^{-1} discharge rate in clay and clayloam soils.

According to Goyal *et al.* (1993), the lateral movement of water varied between 24.4 and 24.2 per cent in 0-30 cm depth, 40 cm away from the dripper.

2.3.5. Redistribution of moisture under drip irrigation

When drip system is not operated continuously, redistribution of moisture takes place once the emitter is shut off. Jensen (1981) pointed out that while water was being added, the wetted region was adjacent to the emitter and after redistribution, it was somewhere below the emitter at a depth depending upon the time that had passed since irrigation was cut off.

The cyclic pattern of moisture change within a profile was proportional to the application frequency. The variations in moisture depended upon the frequency of irrigation, rate of discharge and also the location relative to the source. The time at which the increase occurred was also different within the profile and tended to lag more at points further away from the source (Ben Asher *et al.*, 1978 and Merril *et al.*, 1978).

2.3.6. Soil type and wetting front

The soils varying in their hydraulic characters are found to differ in their wetting fronts. In general, the higher the discharge rate and lower the infiltrability of the soil, the larger is the wetted area. Hence, sandy soils have a deeper and narrower wetting pattern compared to loamy soils which have a wider and a narrower wetting front (Bresler, 1977). The ponded zone becomes larger as the soil becomes less permeable and as the trickle rate increases. These observations find support from Bresler (1977), Bucks *et al.* (1981) and Jensen (1981).

Singh *et al.* (1978) in their studies on moisture distribution pattern in a loamy sand, observed a saturated zone below the emitter and moisture above 60 per cent of the available range up to 20 cm radius from the point source. The water content was below or near wilting point (3-4%) near the wetting front which was 40 cm from the lateral when the discharge rate was 2 l h^{-1} and the volume of water given was 0.6 of pan evaporation. Similar observations were made by Earl and Jury (1977); Jury and Earl (1977); Obbink and Alexander (1977) and Levin *et al.* (1979).

Soil texture, structure and heterogeneity of the profile are identified to play an important role in determining the wetting pattern (Jensen, 1981). Tension gradient decreased as the distance of wetting front increased from point source and thus infiltration decreased. A high discharge rate of 18.45 l h^{-1} caused surface runoff even in sandy soils. However, a discharge rate of even 4 l h^{-1} caused runoff in fine textured soils (Tsipori and Shimshi, 1979).

Surface runoff is affected by dripper discharge, slope, soil texture and composition of soil surface. Sivanappan and Padmakumari (1979) in their studies on the pattern of moisture movement under a drip system observed that horizontal movement (1.2 m to 1.7 m) was greater than vertical movement (1.0 to 1.2 m) for discharge rates ranging from 5 to 30 l h^{-1}. They advocated lower discharge rate for longer duration for better crop response.

Martin and Chesness (1984) studied soil water distribution under a tensiometer - controlled trickle irrigation system and reported that water distribution beneath the emitter was not affected by soil layering. Mc Auliffe (1986) found that shape and size of the wetted profile varied greatly under point source watering. Further, the soil water distribution and storage characteristics had a major bearing on the spread of the wetted profile and the application rate did not significantly affect the wetted profile.

Goyal (1987) noted that the soil moisture distribution under an emitter was onion shaped with a radius of wetted hemisphere of 40 cm and a dripper spacing of 50 cm will allow enough wetted surface to keep the soil near field capacity. According to Reddy (1988), the optimal fraction of the wetted area under drip irrigation for a given environmental condition ranged from 30 to 50 per cent depending on emitter spacing, discharge rate and soil conditions. Shein *et al.* (1988) reported that the location and shape of the wetted profile produced by trickle irrigation is governed by the pre-irrigation moisture tension distribution in the horizontal and vertical directions and the wetted zone is displaced towards the region of lower moisture tension which is due to the higher rate of water flow towards this region and specifically to the higher soil water permeability.

The wetted pattern of sandy loam soil under trickle irrigation showed that the horizontal distance of the wetted zone, the wetted distance in vertical direction and infiltration capacity are a function of time 't' (Kim and Lee, 1989). Amir and Dag (1993) reported that high Instantaneous Application Rates (IAR) increase the uniformity of the wetting pattern and its width and decreases the depth through an emitter.

Contrary to the general inference, Mostoghami *et al.* (1982) observed an increase in discharge rate resulted in increase in vertical component and a decrease in horizontal component with an increase in discharge rate in heavy taxtured soils probably due to higher gravitational potential under greater discharge. These findings are in conformity with those of Bar-Yosef and Sheikholslami (1976) on clay as well as sandy soils.

2.3.7. Physico chemical properties of soil

Based on field experiments conducted in tomato in Taiwan, Lin *et al.* (1983) observed that electrical conductivity of the root-zone soil extracts was lower for drip irrigated than for furrow irrigated plots. In tomato, daily drip irrigation at 4 l plant^{-1} significantly increased the soil pH compared to alternate day drip irrigation at the same rate (Haroon, 1991).

Patel *et al.* (1995) observed that surface and drip methods of irrigation on alternate days at 0.4, 0.6, 0.8 and 1.0 CPE did not differ significantly with respect to available N content and bulk density of soil after harvesting of garlic. Locascio and Smajstrla (1996) reported that the extractable soil N values were not influenced by water quantities from 0.25 to 1.0 pan under drip irrigation system in tomato. However, according to Sherly (1996), the available N content in the soil after harvesting chilli crop, was high in plots irrigated under drip system at 2 l $plant^{-1}$ compared to furrow irrigated plots. But no significant difference was observed between drip irrigation at 1 l $plant^{-1}$ and furrow irrigation.

2.3.8. Nitrogen management under drip irrigation

Studies conducted by Keng *et al.* (1981) in sweet pepper revealed no significant yield difference when N was injected into the drip system and when banded but both the treatments were superior to broadcast, application in a highly weathered, leached and relatively low fertile acid oxisol. Mangal *et al.* (1982) observed that cauliflower (*Brassica oleracea* L.) yield increased from 41.7 t ha^{-1} in the plots receiving the lowest N rate (50 kg ha^{-1}) and the lowest irrigation level (100 mm CPE) to 62.3 t ha^{-1} in the plots receiving the highest N rate (150 kg ha^{-1}) and the highest irrigation level (44 mm CPE). Application of 150 kg N ha^{-1} and irrigation at 80 per cent available soil moisture gave the maximum yield in brinjal (Gupta and Rao, 1984). In muskmelon, Bhella and Wilcox (1985) obtained the highest vegetative growth and total yield with 150 g $litre^{-1}$ of N applied through trickle irrigation.

Fitter and Manger (1985) reported that increasing irrigation efficiency reduced the leaching of nitrate N. Fresh market tomato production was significantly increased by N rates of 130-200 kg ha^{-1} by increasing the number of extra large and large fruits which was due to the reduced leaching of nutrients and soft fruit storage syndrome under trickle irrigation (Karlen *et al.*, 1985). Nitrogen feeding of rockmelon cv. Early Dawn under trickle irrigation by Pryor and Kelly (1987) resulted in higher yields with 1:1 NK ratios than 2:1 ratios ie. 25.4 t ha^{-1} with 240:240 kg NK ha^{-1}.

Haynes (1988) noted that vegetative growth in chilli was the greatest when 75 kg N ha^{-1} was applied by fertigation compared to broadcast application.

Increase in N levels significantly increased the yield, nitrate N content and N uptake of watermelon under drip irrigation (Hegde, 1988a). Tomato responded to trickle irrigation based on 80 per cent of pan evaporation at the N level of 300 kg ha^{-1} (El-Shafei, 1989). Madramootoo and Rigby (1989) reported that trickle irrigated capsicum plants did not show significant response to varying rates of applied N. Hegde (1989) observed that scheduling irrigation when soil matric potential at 15 cm depth reached -65 kPa and applying 168 kg N ha^{-1} resulted in maximum WUE in chilli. Singh *et al.* (1989) reported that for tomato, drip irrigation equal to 0.5 ET required 25 per cent less N than irrigation equal to ET.

Nitrogen at the rate of 38 g m^{2-1} was found sufficient for drip irrigated cucumber and higher rates did not increase yield or had a significant effect on fruit and leaf nutrient contents (Castilla *et al.*, 1990). Csermi *et al.* (1990) reported that under drip irrigation, N application at 120 kg ha^{-1} had a greater beneficial effect on fruit and seed yield of cucumber.

Titulaer and Slangen (1990) suggested that application of N to trickle irrigated lettuce and gherkin in tune with crop growth minimised the leaching losses and reduced the fertilizer costs.

Mullins *et al.* (1992) evaluated the effect of drip irrigation and different rates of NPK on fruit yield and quality of tomato and reported that broadcast application of 450 kg ha^{-1} of 10:10:10 NPK mixture before planting in combination with drip irrigation produced yield equal to those with higher rates of fertilizer partly applied before planting and partly through the irrigation system.

Studying the distribution of nitrate in soil with drip irrigation, Torre and Victoria (1992) found that broadcast application slightly increased the soil nitrate content near the dripper and at the end of two months, the nitrate recovery was 56 per cent.

Buzetti *et al.* (1994) reported that the three rates of N applied to muskmelon grown under drip irrigation did not influence fruit yield, size, average weight and nutritional status.

The experimental results summarised above clearly indicate, with a few exceptions, that the effectiveness of applied N is appreciably improved by drip irrigation due to their synergistic influence on root proliferation, nutrient absorption and growth of vegetable crops.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field investigation was undertaken during 1994-'95 and 1995-'96 to study the response of snakegourd to nitrogen and ethephon as influenced by drip irrigation. The materials used and the methods adopted for the investigation are presented in this chapter.

3.1. Materials

3.1.1. Experimental site

The experiment was conducted in the garden lands of the instructional farm attached to the College of Agriculture, Vellayani, Thiruvananthapuram, Kerala. The farm is situated at $8^0 5'$ north latitude and $76^0 9'$ east longitude at an altitude of 29 m above mean sea level.

3.1.2. Season

Two field experiments were conducted during the summer seasons (December to April) of 1994-'95 and 1995-'96. The first crop was planted on 29-12-'94 and the second crop on 8-12-'95.

3.1.3. Climate

Vellayani experiences a humid tropical climate. The data on various weather parameters recorded during the cropping periods and the previous five-year average are given in Appendix-I. The weather parameters of the cropping periods are also depicted graphically in Figs.1 and 2 and the mean values are presented in Table 1.

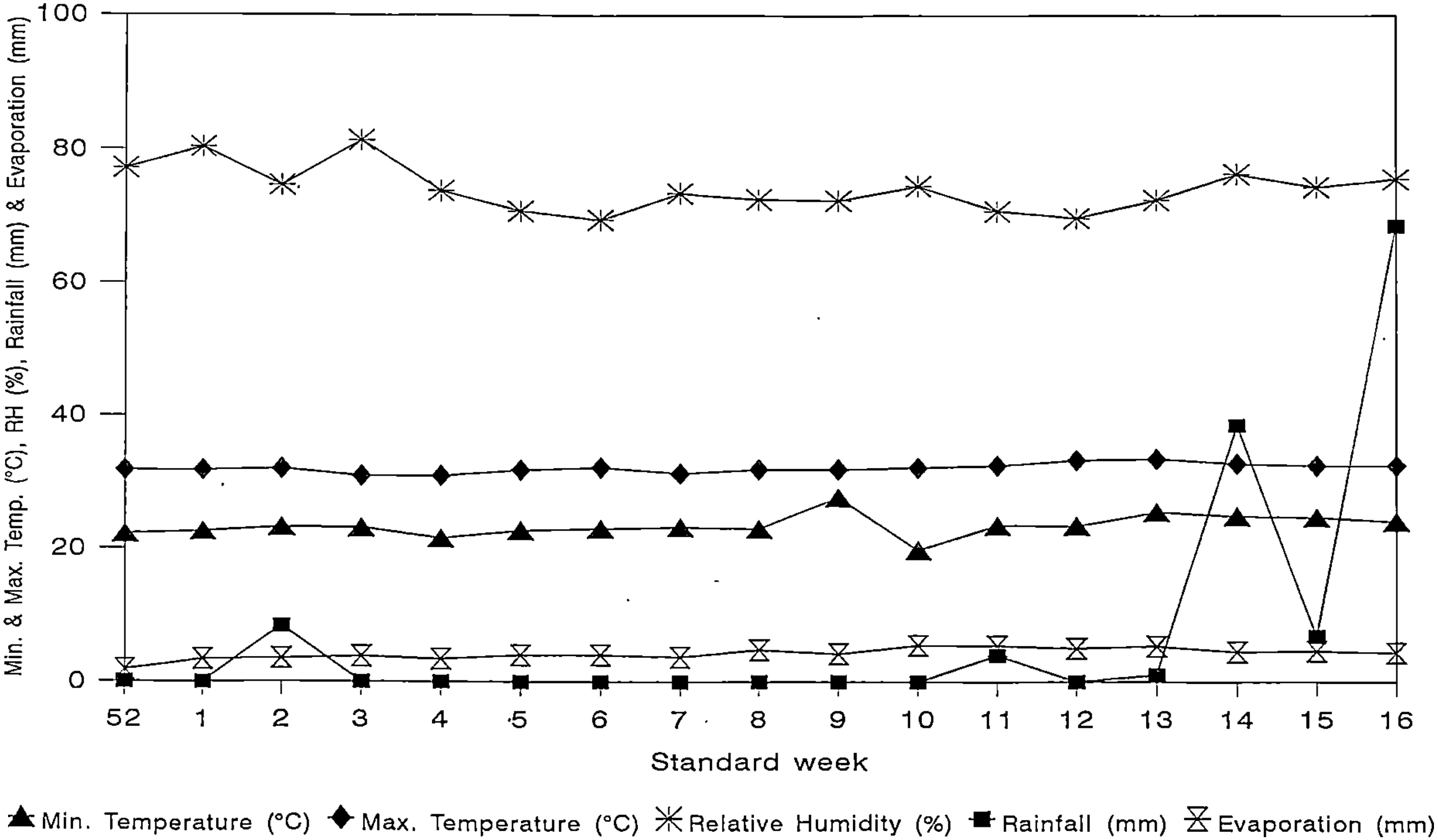


Fig. 1. Weather conditions during the cropping period (1994-95)

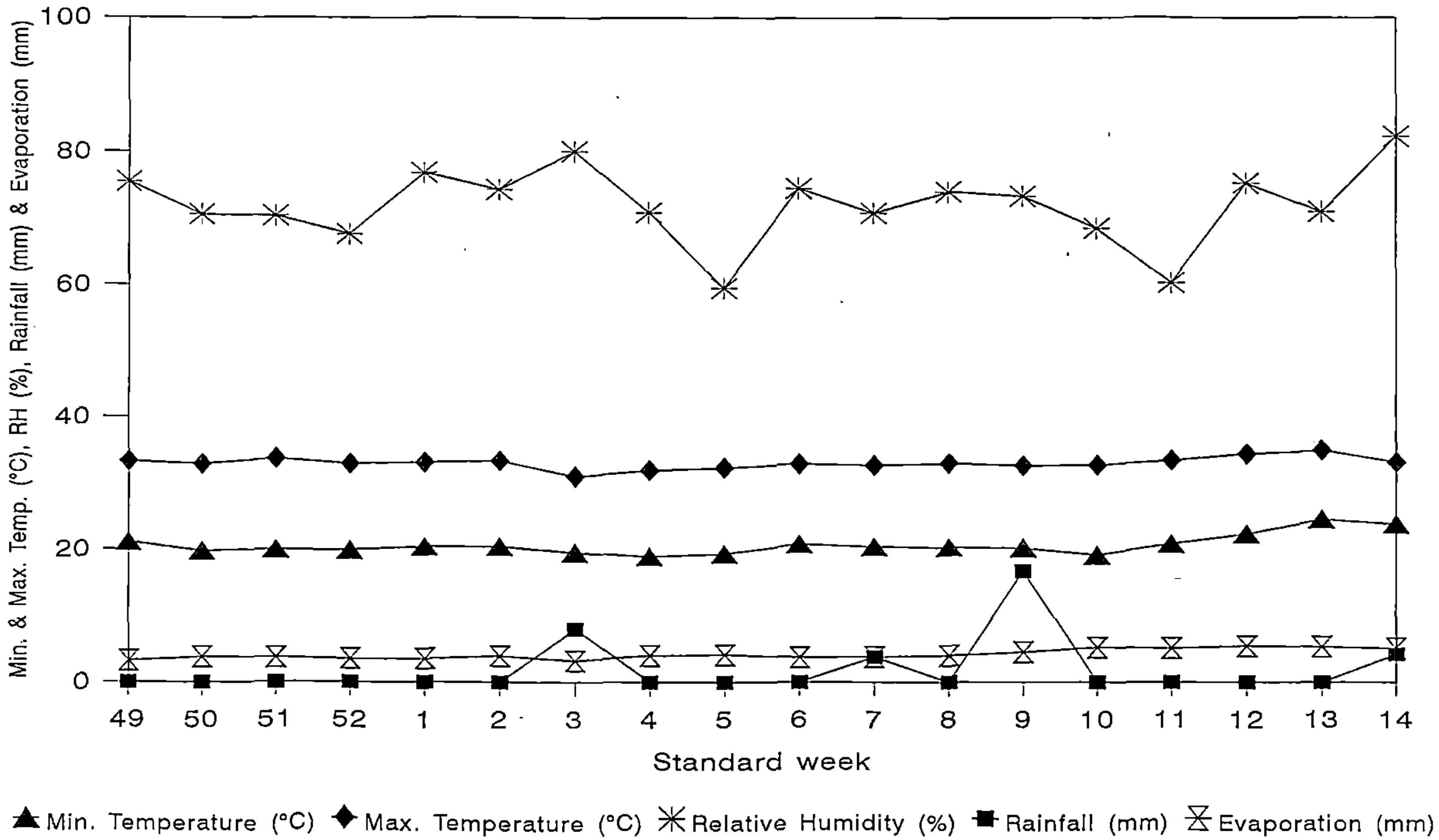


Fig. 2. Weather conditions during the cropping period (1995-96)

Table 1. Mean values of the weather parameters during the cropping period

Parameter	Mean value	
	December, 1994 to April, 1995	December, 1995 to April, 1996
Max. Temp. (^{0}C)	32.1	32.3
Min. Temp. (^{0}C)	23.4	20.6
Relative humidity (%)	74.1	72.0
Daily evaporation (mm)	4.2	4.2
Total rainfall (mm)	127.4	32.7

During the first year (cropping season of 1994-'95), a total of 127.4 mm rainfall was received in five rainy days, of which only 61.0 mm was effective. This was worked out using the balance sheet method (Gupta *et al.*, 1972). During the second year (cropping season of 1995-'96) only 32.7 mm of rainfall was received of which 28.0 mm was effective. The mean weekly minimum and maximum temperature ranged from 19.8°C to 27.7°C and 30.9°C to 33.5°C, respectively during 1994-'95 cropping season. During 1995-'96 cropping season the mean minimum and maximum temperature ranged from 19.1 to 24.5°C and 31.0 to 34.9°C, respectively. The mean weekly relative humidity ranged between 69.5 per cent and 81.4 per cent during the first cropping season and between 59.5 and 80.1 per cent during the second cropping season. In general, the weather conditions were favourable for the satisfactory growth of crops.

3.1.4. Soil

The soil type of the experimental site was laterite (Oxisol) belonging to the family of loamy skeletal kaolinitic isohyperthermic Rhodic Haplustox.

Before starting the lay out of the experiment, composite samples of the soil were drawn from a depth of 0-15 cm and analysed. The physico-chemical properties of the soil and the analytical methods employed are presented in Table 2. The soil was acidic in reaction, low in available nitrogen and potassium and medium in available phosphorus.

3.1.5. Cropping history of the experimental site

The experimental site was under a bulk crop of bittergourd before the field experiment.

Plate 1 General view of the experimental field

Table 2 Physico-chemical properties of the initial soil samples of the experimental site

Sl. No.	Particulars	Mean value		Method
A	Physical properties	1994-'95	1995-'96	
1	Mechanical composition Coarse sand (%) Fine sand (%) Silt (%) Clay (%) Textural class : Sandy clay loam	 16.70 34.30 26.50 22.00	 15.80 33.50 28.00 21.90	Bouyoucos Hydrometer (Bouyoucos, 1962)
2	Bulk density (g cc^{-1})	1.32	1.34	Core sampler (Gupta and Dakshinamoorthy, 1980)
3	Hydraulic conductivity (cm hr^{-1})	14.89	14.61	Jodpur Constant Head Permeameter (Gupta and Dakshinamoorthy, 1980)
4	Water holding capacity (%)	26.0	26.40	Field method (Coleman, 1944)
5	Infiltration rate (cm hr^{-1})	6.0	6.10	Infiltrometer (Coleman, 1944)
B	Chemical properties			
1	pH	5.0	5.10	pH meter with glass electrode (Jackson, 1973)
2	Organic carbon (%)	0.52	0.60	Walkely and Black (Jackson, 1973)
3	Available nitrogen (kg ha^{-1})	278.50	287.60	Alkaline Potassium Permanganate (Subbiah and Asija, 1956)
4	Available P_2O_5 (kg ha^{-1})	40.80	37.60	Bray's calorimetric (Jackson, 1973)
5	Available K_2O (kg ha^{-1})	128.91	114.60	Ammonium acetate (Jackson, 1973)

3.1.6. Crop and variety

The snakegourd variety TA.19, a high yielding fertilizer responsive snakegourd line, recommended for irrigated conditions was used for the experiment. The crop had a duration of about 110 days.

3.1.7. Manures and fertilizers

Urea (45.8 % N), mussoriephos (20.1 % P_2O_5), muriate of potash (60 % K_20) and farm yard manure (0.63, 0.38 and 0.67 % N, P_2O_5, K_2O, respectively) were used for the experiment.

3.1.8. Growth regulator

Pure ethephon (100%) which is chemically 2-chloro ethyl phosphonic acid, was used for the experiment.

3.1.9. Irrigation source

Water from the Vellayani lake was pumped and used for the experiment. The irrigation water was of good quality with normal pH value.

3.2. Methods

3.2.1. Choice of treatments

There were three sets of treatments consisting of 2 irrigation frequencies, 4 doses of nitrogen and 4 levels of ethephon.

3.2.2. Treatment details

A. Nitrogen (kg ha^{-1})

n_1	-	35
n_2	-	70
n_3	-	105
n_4	-	140

Plate 2 General view of the experimental field

B. Ethephon (ppm)

g_1 - 0

g_2 - 50

g_3 - 100

g_4 - 200

C. Drip irrigation frequency (depth 15 mm)

i_1 - 5 mm CPE

i_2 - 10 mm CPE

The treatment combinations are furnished in Table 3.

3.2.3. Experimental design and layout

The experiment was laid out in a 4^2 x 2 asymmetrical confounded factorial design with 2 replications confounding the highest order interaction (NGI) in both the replications. The 32 treatment combinations of each replication were accommodated in two blocks along with two controls in which i_1 and i_2 levels of irrigation were given but without any nitrogen or ethephon. The layout plan of the experiment is depicted in Fig.3.

Design : 4^2 x 2 + 2 asymmetrical confounded factorial, confounding NGI in both the replications.

Treatment combinations	:	32 + 2
No. of treatments per block	:	16 + 2 controls
No. of blocks per replication	:	2
No. of replications	:	2
Total number of plots	:	72
Plot size	:	8 m x 6 m
Spacing	:	2 m x 2 m

Table 3 Treatment combinations

Treatment	Notation		Treatment	Notation	
	(a)	(b)		(a)	(b)
$n_1g_1i_1$	111	T_1	$n_3g_2i_1$	321	T_{19}
$n_1g_1i_2$	112	T_2	$n_3g_2i_2$	322	T_{20}
$n_1g_2i_1$	121	T_3	$n_3g_3i_1$	331	T_{21}
$n_1g_2i_2$	122	T_4	$n_3g_3i_2$	332	T_{22}
$n_1g_3i_1$	131	T_5	$n_3g_4i_1$	341	T_{23}
$n_1g_3i_2$	132	T_6	$n_3g_4i_2$	342	T_{24}
$n_1g_4i_1$	141	T_7	$n_4g_1i_1$	411	T_{25}
$n_1g_4i_2$	142	T_8	$n_4g_1i_2$	412	T_{26}
$n_2g_1i_1$	211	T_9	$n_4g_2i_1$	421	T_{27}
$n_2g_1i_2$	212	T_{10}	$n_4g_2i_2$	422	T_{28}
$n_2g_2i_1$	221	T_{11}	$n_4g_3i_1$	421	T_{29}
$n_2g_2i_2$	222	T_{12}	$n_4g_3i_2$	432	T_{30}
$n_2g_3i_1$	231	T_{13}	$n_4g_4i_1$	441	T_{31}
$n_2g_3i_2$	232	T_{14}	$n_4g_4i_2$	442	T_{32}
$n_2g_4i_1$	241	T_{15}	$n_0g_0i_1$	001	T_{33}
$n_2g_4i_2$	242	T_{16}	n_0g_0i2	002	T_{34}
$n_3g_1i_1$	311	T_{17}	$n_0g_0i_1$	001	T_{35}
$n_3g_1i_2$	312	T_{18}	$n_0g_0i_2$	002	T_{36}

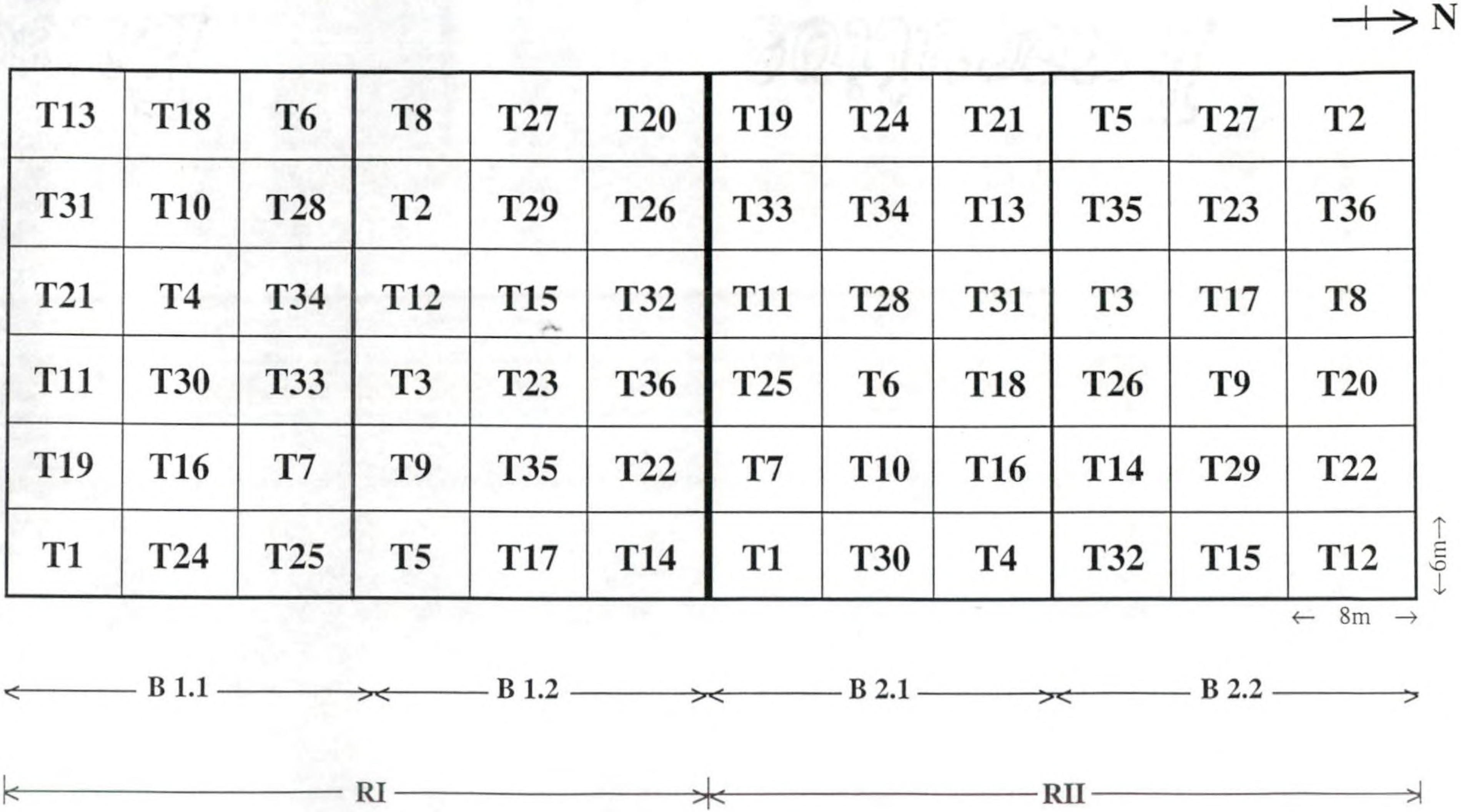


Fig. 3. Lay out plan of the experiment

3.2.4. Field culture

3.2.4.1. Field operation

The experimental fields were dug twice, stubbles removed, clods broken and laid out into blocks and plots. Pits of 60 cm diameter and 45 cm depth were dug in each plot at a spacing of 2 m x 2 m. The pits were half filled with a mixture of top soil and powdered cowdung before planting.

3.2.4.2. Manure and fertilizer application

Farm yard manure was applied at the rate of 25 t ha^{-1} and P_2O_5 and K_2O at the rate of 25 kg each ha^{-1} as basal dressing, as per package of practices recommendations of Kerala Agricultural University (Kerala Agricultural University, 1989). Nitrogen was applied to all the plots except the control plots in the stipulated doses as per treatments in three instalments - 50 per cent as basal dose one day prior to sowing and the rest in two equal split doses at vining (30 DAS) and full bloom (60 DAS) stages.

3.2.4.3. Seeds and sowing

Plumby seeds selected for planting were soaked in water overnight before sowing. Three seeds were planted per pit. At the time of planting, seedlings were also raised in poly bags filled with top soil-cowdung mixture.

3.2.4.4. Spraying ethephon

Ethephon in different concentrations (0, 50, 100 and 200 ppm) as per treatment was sprayed on the foliage of the seedlings, in two applications, coinciding two-leaf (12 DAS) and four-leaf stages (20 DAS). Similarly, simultaneous water sprays were also given to control plots and in plots under `0' ppm treatment. Both the polybag seedlings and the seedlings raised in pits were treated.

3.2.4.5. Irrigation

Pot watering was done daily up to 20 days after sowing (DAS), ie., till the drip system was calibrated and started operating properly.

For scheduling irrigation frequency, the evaporation recorded from USWB Class A Open Pan Evaporimeter installed in the Meteorological Observatory of the Instructional Farm was used. The depth of irrigation was 15 mm which corresponds to 3 litres plant^{-1}. Irrigation was given at 5 mm and 10 mm CPE which coincided, respectively, many a time to daily and alternate day irrigations.

The drip irrigation system already existed in the instructional farm, Vellayani was utilized for the experiment. The drip components were of the sizes 75 mm outer diameter (OD), 63 mm OD and 16 mm OD for the main, submain and laterals, respectively. The pressure ratings at the main, submain and the proximal point in the laterals were 1.5, 0.75 and 0.5 kg cm^{-2}, respectively befitting the design norms for operating the drip system. Stop-cock (calibrating) type emitters were used for regulating discharge and the average emitter discharge was maintained at 1 litre hr^{-1}. The system was operated at the scheduled frequency for 3 hours.

3.2.4.6. Gap filling

The seedlings raised in polybags were kept in different groups to facilitate ethephon spraying at varying concentrations at two-leaf and four-leaf stages and were used for gap filling, wherever necessary.

3.2.4.7. After cultivation

At 15 DAS, plant population was limited and thereafter one plant alone in each pit was maintained. Wooden stakes, 1.5 m long, were fixed in each pit for trailing the plants to the pandal. At 25 DAS, pandals of height 1.8 m were erected

Plate 3 Layout of the drip lateral between two rows of plants

around each plot. Vines were regularly trailed on the pandal very carefully. The plots were kept weed-free for the entire cropping period by manual weeding.

3.2.4.8. Plant protection

To protect the crop from fruitfly attack (*Dacus cucurbitae*) jaggery containing carbofuran (Fn 3 g) was baited in hanging coconut shells set at a spacing of 2 m in the field. Against Downey mildew (caused by *Pseudoperenospora cubensis* Berk & Curt. Rostow.) incidence, 0.3 per cent Mancozeb (Dithane M-45) was sprayed on the plants. In general, the crop was free from serious pests and diseases during the investigation.

3.2.4.9. Harvesting

The crop was harvested at 5 to 6 day-intervals from 56 DAS during the first season and from 61 DAS during the second season. The number of harvests ranged between 8 and 12 during both the seasons.

3.3. Observations recorded

The following observations were recorded from two sample plants in each plot.

3.3.1. Growth and yield components

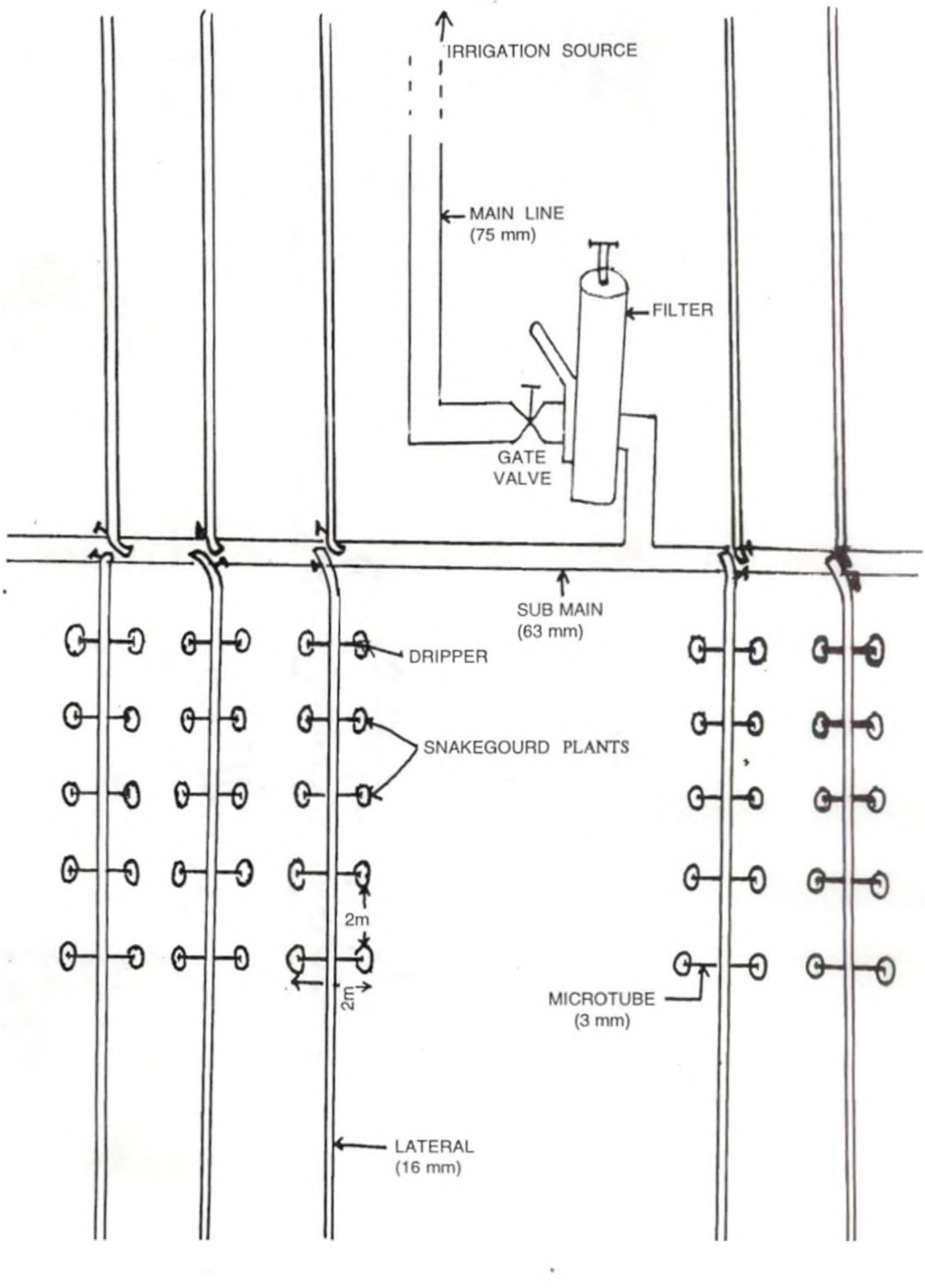
3.3.1.1. Number of leaves plant^{-1}

The total number of leaves from the observational plants was recorded at 50 per cent flowering and the mean number of leaves plant^{-1} worked out.

3.3.1.2. Internodal length

The internodal length was measured at 50 per cent flowering. From the two observational plants, length of ten consecutive internodes were measured leaving the

Plate 4 Water distribution to individual plant through microtube



COMPONENTS OF THE DRIP IRRIGATION SYSTEM first twenty internodes from the base and the mean internodal length was calculated and expressed in cm.

3.3.1.3. Total dry matter production

The weight of fruits from each harvest and that of vines at final harvest were recorded. Samples of fruits at each harvest and vines at final harvest were separately chopped and oven dried to constant weights at 80^0C. The total dry weight of plants was calculated and expressed in g $plant^{-1}$.

3.3.1.4. Days for opening of first male flower

The number of days taken for opening of first male flower was recorded from the observational plants.

3.3.1.5. Days for opening of first female flower

The number of days taken for opening of the first female flower was recorded from the observational plants.

3.3.1.6. Node at which first male flower appeared

The node at which the first male flower appeared was counted from the cotyledonous node in the observational plants.

3.3.1.7. Node at which first female flower appeared

The node at which the first female flower appeared was counted from the cotyledonous node in the observational plants.

3.3.1.8. Crop duration

The total duration of the crop from the date of sowing to the date of final harvest was recorded from the observational plants and expressed in days.

3.3.1.9. Days for first fruit picking

The number of days taken for the first fruit picking in the observational plants was recorded.

3.3.1.10. Number of staminate flowers

The number of staminate flowers in the observational plants were counted from the first flower opening till the flower production ceased.

3.3.1.11. Number of pistillate flowers

The number of pistillate flowers in the observational plants were recorded from the first female flower opening stage till the completion of flowering.

3.3.1.12. Sex ratio

The sex ratio was calculated based on flower count recorded from the observational plants and expressed as the ratio of male to female flowers.

3.3.1.13. Number of fruits per plant

The total number of fruits on the observational plants was recorded and the average worked out.

3.3.1.14. Percentage fruit set

Based on the number of pistillate flowers and fruit number per plant, the percentage fruit set was worked out.

3.3.1.15. Average fruit weight

The weight of a single fruit was obtained as the mean of the weight of ten fruits selected at random from the observational plants and expressed in kg.

3.3.1.16. Average fruit length

Ten fruits from the second and third harvests were randomly selected from the observational plants and length of fruit from the stalk end to the tip was measured and expressed in cm.

3.3.1.17. Average fruit girth

Ten fruits were selected randomly from the second and third harvests of the observational plants and girth at the middle of the fruit was measured and expressed in cm.

3.3.1.18. Yield per hectare

The weight of fruits from the net plot were recorded from each harvest and the total was worked out and expressed in t ha^{-1}.

3.3.1.19. Harvest index (HI)

The harvest index (HI) was worked out from the data on dry matter production by the fruits and vines as follows:

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Fruit yield}}{\text{Fruit yield + vine yield}}$$

3.3.2. Root studies

3.3.2.1. Weight of roots per plant

After final harvest, roots of the observational plants were collected without any damage by excavating the soil, washed and dried to constant weight in a hot air oven at 80^0C and weight expressed in g $plant^{-1}$.

3.3.3. Moisture studies

3.3.3.1. Field water use efficiency

The field water use efficiency was calculated using the following formula (Misra and Ahmed, 1987):

$$\text{Field WUE (kg ha cm}^{-1}) = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Pot water applied upto 20 DAS (cm)} + \text{drip irrigation quantum (cm)} + \text{effective rainfall (cm)}}$$

3.3.3.2. Seasonal consumptive use

The seasonal consumptive use was computed using the modified Penman equation (Doorenbos and Pruitt, 1977).

$$ETo = C\ \{\underbrace{W.Rn}_{\text{radiation term}} + \underbrace{(I - W)\ f(u)\ (ea - ed)}_{\text{aerodynamic term}}\}$$

The values of ETo (potential evapotranspiration) when multiplied by crop-coefficient (kc) gave ET crop which is a measure of the consumptive use by the crop ie., SCU = ETo x kc. The crop coefficient computed for bittergourd ie., 1.35 and 0.9 for the vegetative and reproductive phase, respectively were used (Kerala Agricultural University, 1990).

3.3.4. Soil properties

3.3.4.1. Physical property

At the end of the cropping period and before the experiments, during both the years, core samples were drawn from the top 0-15 cm soil layer and analysed for bulk density as described by Gupta and Dakshinamoorthy (1980).

3.3.4.2. Chemical properties

The composite soil samples collected prior to the field experiments and the soil samples collected from individual plots after the experiments were analysed for organic carbon, available nitrogen, available P_20_5 and available K_20. Soil reaction was also determined.

Organic carbon was estimated by Walkley and Black method (Jackson, 1973). Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray method (Jackson, 1973) and available potassium by neutral normal ammonium acetate method (Jackson, 1973). Soil reaction of 1:2 soil-water suspension was determined using a pH meter with glass electrode (Jackson, 1973).

3.3.5. Plant analysis

3.3.5.1. Nutrient content of fruits

One fruit from each harvest was selected at random from each plot, chopped and dried in a hot air oven at 80^0C till constant weights were obtained. Fruit samples at different harvests from the same plots were bulked and ground to pass through a 0.5 mm mesh in a Willey mill and analysed for total nitrogen by modified microkjeldahl method (Jackson, 1973), total phosphorus by Vanadomolybdo-phosphoric yellow colour method (Jackson, 1973) and total potassium by the flame photometric method.

3.3.5.2. Nutrient content of plants

The whole plant samples were taken at final harvest from each plot. The samples were prepared and analysed for total nitrogen, phophorus and potassium adopting the methods mentioned in section 3.3.5.1.

3.3.5.3. NPK uptake by plant

This was calculated by multiplying the nitrogen, phosphorus and potassium content of the plant or fruits as the case may be, with the total dry weight of the plant or fruits. The uptake values were expressed in kg ha^{-1}.

3.3.6. Qualitative analysis

The fruits collected at the vegetable stage were used for quality analysis. The samples were drawn from each fruit from three portions viz., top, middle and bottom. These samples were used for analysis as detailed below:

3.3.6.1. Moisture

The samples, as mentioned above, were used for determining the moisture content of fruits by gravimetric method and expressed as percentage.

3.3.6.2. Total soluble solids

The total soluble solids was found out using a pocket refractometer and expressed as ^{0} brix.

3.3.6.3. Crude protein

The crude protein content was calculated by multiplying the nitrogen content of the fruits with the factor 6.25 (Simpson *et al.*, 1965).

3.3.6.4. Acidity

The acidity of fruit pulp was estimated as per the method described by A.O.A.C. (1975) and expressed as percentage of citric acid.

3.3.6.5. Total sugar

The total sugar content of the samples was determined as per the method described by A.O.A.C. (1975).

3.3.6.6. Reducing sugars

This was estimated as per the method described by A.O.A.C. (1975).

3.3.6.7. Ascorbic acid

Ascorbic acid content of the fruits was estimated according to the method described by Paul-Gyorgy and Pearson (1967). It is expressed as mg 100 g^{-1} mature fresh fruits.

3.3.6.8. Crude fibre

Crude fibre content was determined by the A.O.A.C. method (1975).

3.3.6.9. Shelf life under ambient conditions

The fruits collected from different treatments were kept under ambient conditions and the days up to which quality was maintained without any deterioration ie., change in colour, shrinkage, microbial growth etc., was recorded.

3.3.6.10. Organoleptic test

The fruit samples were drawn from different treatments, cooked uniformly and subjected to organoleptic evaluation in which colour, appearance, flavour, texture, taste were scored by ten panelists giving 0-5 score values (0 - very poor; 1 - poor; 2 - satisfactory; 3 - good; 4 - very good; 5 - excellent) and overall acceptability was computed. The data were subjected to non parametric analysis using Kruskal - Wallis test since the observations were in ordinal scale (Nageswara Rao, 1983).

3.3.7. Statistical analysis

The experimental data were analysed statistically by applying the technique of analysis of variance as per the layout of the experiments. Also, pooled analysis was conducted for yield.

3.3.8. Economic analysis

The economics of cultivation for the field experiments was worked out considering the total cost of cultivation and the prevailing market price of the produce. The net income and benefit:cost ratio were computed as follows:

Net income (Rs. ha^{-1}) = gross income - total expenditure

Benefit : cost ratio = gross income/total expenditure

RESULTS

RESULTS

Field experiments were conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, during the summer seasons of 1994-'95 and 1995-'96 with the objective of finding out the effect of varying levels of nitrogen (N), ethephon (G) and drip irrigation frequencies (I) on the productivity of snakegourd. The data generated in respect of growth, yield, quality and shelf life of produce and physico-chemical properties of soil were statistically analysed and the results are presented in this chapter.

4.1. Growth characters

4.1.1. Internodal length

4.1.1.1. Effect of N, G and I (Table 4)

A perusal of the mean data presented in Table 4 revealed that internodal length varied significantly due to applied N and drip irrigation during both the years of experimentation. During the first year, the N level n_3 registered the highest value (17.93 cm) and it was on par with n_4 (17.35 cm) and significantly superior to n_1 and n_2 which were on par. Comparing the irrigation frequencies, i_1 had a significantly higher internodal length (17.27 cm) than i_2 (16.56 cm).

During the second year, n_4 recorded the highest value (18.42 cm) but as in the previous year, it was on par with n_3 (18.12 cm) and superior to n_1 and n_2.

Irrigation frequency also showed a similar trend as that of the first year with i_1 registering a significantly higher internodal length (18.23 cm) than i_2 (17.59 cm). The levels of ethephon did not exhibit any substantial influence on this character during both the years of the study.

4.1.1.2. Interaction effect of N, G and I (Table 5)

Among the various interaction effects studied, only the NG interaction was observed to influence the internodal length. As far as the first year's results were concerned, at all the four levels of ethephon either n_3 or n_4, - n_4g_1, n_3g_2, n_3g_3 and n_3g_4 - significantly influenced the internodal length. During the 2nd year, at the lowest level of ethephon ie., g_1, all its combinations with N were significant whereas at g_2, g_3 and g_4, only the combinations of higher levels of N (n_3 and n_4) had marked influence on internodal length.

4.1.2. Number of leaves plant^{-1}

4.1.2.1. Effect of N, G and I (Table 4)

The number of leaves plant^{-1} varied considerably due to the treatments during both the years of the study. In the first year, N, ethephon and drip irrigation frequency influenced the leaf number significantly. Among the four levels of N, n_3 recorded the highest leaf number (83.0) and it was on par with n_4 (82.89). These two levels were significantly superior to n_1 and n_2 which were on par. As far as the effect of ethephon was concerned, g_4 registered the maximum value (83.59) and it was significantly superior to its other levels. Comparing the two irrigation frequencies, i_1 had significantly higher number of leaves (81.92) than i_2 (80.63).

Table 4 Effect of N, G and I on growth characters

Effect	Internodal length (cm)		No. of leaves plant^{-1}		D.M.P. (g plant^{-1})	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	16.17	17.34	78.79	72.26	554.25	485.13
n_2	16.21	17.77	80.42	93.88	706.13	594.38
n_3	17.93	18.12	83.00	78.46	730.19	673.81
n_4	17.35	18.42	82.89	78.73	705.63	625.88
$F_{3, 44}$	**18.27****	**3.25***	**70.79****	**84.23****	**12.32****	**51.87****
g_1	17.22	18.18	78.32	72.92	611.94	436.00
g_2	16.84	17.78	80.69	74.28	696.88	551.50
g_3	16.81	18.01	82.50	76.30	682.25	665.81
g_4	16.78	17.68	83.59	79.83	705.13	725.88
$F_{3, 44}$	**1.04**	**0.77**	**89.49****	**71.65****	**3.41***	**132.97****
C.D. (0.05) N/G	**0.587**	**0.691**	**0.696**	**1.014**	**65.514**	**31.684**
i_1	17.27	18.23	81.92	76.87	693.78	590.88
i_2	16.56	17.59	80.63	74.79	654.31	598.72
$F_{1, 44}$	**12.37****	**4.84***	**28.07****	**34.08****	**2.95**	**0.50**
C.D. (0.05)	**0.416**	**0.522**	**0.492**	**0.717**	--	--
Control 1	15.89	16.68	66.80	67.55	492.75	404.50
Control 2	15.65	16.15	63.33	65.90	418.50	380.75

* Significant at 0.05 level
** Significant at 0.01 level

During the second year, among the N levels, n_4 recorded the highest leaf number (78.73) which was on par with that of n_3 (78.46) and superior to those of n_1 and n_2. As regards ethephon levels, g_4 was significantly superior to the other levels, recording the highest number of leaves $plant^{-1}$ (79.83). With respect to drip irrigation treatments, i_1 with a leaf number of 76.87 $plant^{-1}$ was significantly superior to i_2 (74.79).

4.1.2.2. Interaction effect of N, G and I (Table 5)

Only the NG interaction significantly influenced the leaf number during both the years of experimentation. In the first year, none of the combinations of n_1 with G was significant on leaf number whereas the combinations n_2 and n_4, with g_4 were significantly superior in their influence. Similarly, at the n_3 level, g_3 and g_4 exerted significant influence on leaf number indicating the favourable interaction of both N and G at their higher levels.

During the second year, n_3g_4 registered the highest leaf number of 85.10 $plant^{-1}$ which was on par with that of n_4g_4 (83.35) and these two combinations were significantly superior to the others, emphasising once again the favourable effect of combinations of higher levels of N and G on leaf production.

4.1.3. Dry matter production (DMP)

4.1.3.1. Effect of N, G and I (Table 4 and Fig. 4)

The data summarised in Table 4 revealed that N and G significantly influenced DMP during the first year of experimentation. Among the different levels of N, n_3 recorded the highest DMP of 730.19 g $plant^{-1}$ and it was on par with n_4 and

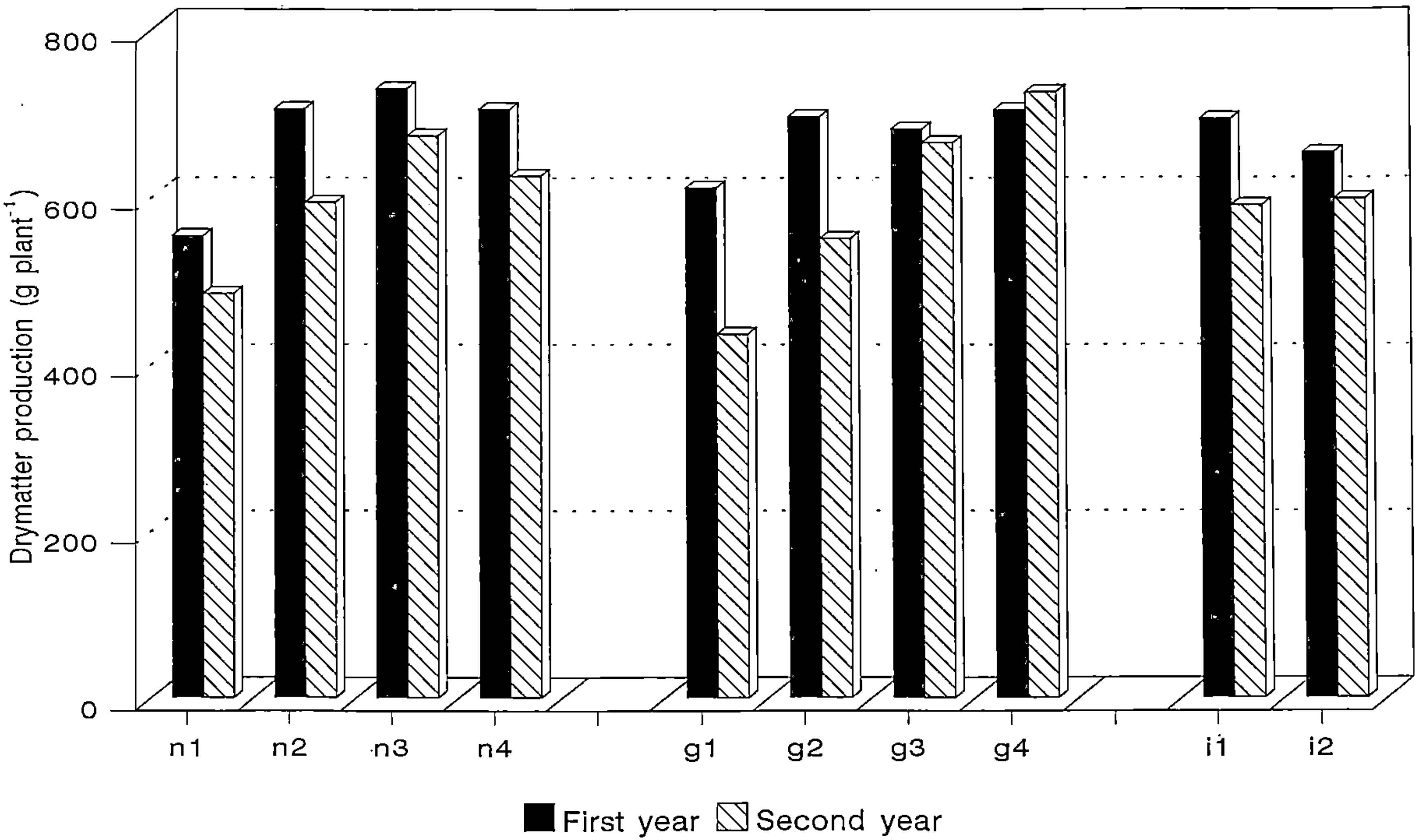


Fig. 4. Effect of N, G and I on drymatter production

Table 5 Interaction effect of N, G and I on growth characters

Effect	Internodal length (cm)		Leaves $plant^{-1}$		D.M.P. (g $plant^{-1}$)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	16.25	18.50	76.83	69.38	464.50	403.75
n_1g_2	16.74	17.55	78.03	71.60	584.00	462.75
n_1g_3	15.89	17.90	80.13	73.30	599.00	516.75
n_1g_4	15.75	14.70	80.18	74.78	569.50	557.25
n_2g_1	16.54	18.20	75.15	72.83	664.25	419.50
n_2g_2	15.93	17.20	79.03	72.75	746.50	582.50
n_2g_3	15.90	17.60	82.93	73.85	700.75	759.50
n_2g_4	16.46	18.13	84.58	76.08	713.00	616.00
n_3g_1	17.36	18.08	79.73	73.53	626.75	473.20
n_3g_2	17.80	18.25	82.48	76.28	688.00	604.75
n_3g_3	18.70	18.35	84.70	78.93	742.25	740.75
n_3g_4	17.85	18.50	85.10	85.10	765.50	876.50
n_4g_1	18.75	17.95	81.58	75.95	692.25	447.50
n_4g_2	16.83	18.13	83.23	76.48	769.00	556.00
n_4g_3	16.75	18.20	82.25	79.13	687.00	646.25
n_4g_4	17.08	19.40	84.50	83.35	772.50	853.75
$F_{9,44}$	**2.73***	**4.74***	**9.74****	**5.03****	**0.58**	**12.16****
C.D. (0.05)	**1.177**	**1.476**	**1.392**	**2.028**	**--**	**63.368**

n_1i_1	16.51	17.20	79.54	73.35	577.25	475.13
n_1i_2	15.83	17.48	78.04	71.18	531.25	495.13
n_2i_1	16.86	17.95	80.73	75.18	745.75	602.63
n_2i_2	15.55	17.59	80.11	72.58	666.50	586.13
n_3i_1	17.92	18.80	83.91	79.20	709.25	664.38
n_3i_2	17.94	17.44	82.09	77.71	702.00	683.25
n_4i_1	17.80	18.98	83.50	79.74	742.88	621.38
n_4i_2	16.90	17.86	82.28	77.71	717.50	630.38
$F_{3,44}$	**1.87**	**2.07**	**1.11**	**0.42**	**0.45**	**0.58**
g_1i_1	17.59	18.29	78.78	73.99	634.38	427.75
g_1i_2	16.85	18.08	77.86	71.85	589.50	444.25
g_2i_1	17.06	18.15	81.40	75.33	739.25	558.25
g_2i_2	16.61	17.40	79.98	73.23	654.50	544.75
g_3i_1	17.30	18.43	82.98	77.01	684.00	655.88
g_3i_2	16.32	17.59	82.03	75.59	680.50	675.75
g_4i_1	17.13	18.06	84.53	81.14	717.50	721.63
g_4i_2	16.44	17.30	82.65	78.51	692.75	730.13
$F_{3,44}$	**0.29**	**0.31**	**0.87**	**0.48**	**0.57**	**0.46**

* Significant at 0.05 level
** Significant at 0.01 level

n_2 and significantly superior to n_1 (554.25 g). Comparing different levels of ethephon, g_4 had the highest DMP of 705.13 g which was on par with those of g_3 (682.25) and g_2 (696.88).

In the second year, DMP varied significantly due to N and G levels. The highest DMP of 673.81 g plant^{-1} was recorded by n_3 and it was significantly superior to the other levels. Both n_4 and n_2 were on par and significantly superior to n_1 (485.13 g). As regards G levels, g_4 with a DMP of 725.88 g plant^{-1} ranked first and it was significantly superior to g_3 (665.81), g_2 (551.50) and g_1 (436.00).

There was no significant variation in DMP due to the irrigation frequencies during both the years of experimentation.

4.1.3.2. Interaction effect of N, G and I (Table 5)

The interaction effects were not significant during the first year. In the following year, however, there was significant variation in DMP due to NG interaction. The highest DMP was recorded by n_3g_4 (876.50 g) and it was on par with n_4g_4 (853.75 g). At all the levels of G, DMP increased with an increase in the level of N up to n_3 and thereafter it tended to fall.

4.2. Earliness

4.2.1. Days to first female flower opening

4.2.1.1. Effect of N, G and I (Table 6)

A critical review of the data presented in Table 6 revealed that during the first year, both G and I influenced the number of days taken for the first female flower to open. The minimum number of days of 36.97 was recorded by g_3. The

Table 6 Effect of N, G and I on earliness

Effect	Days to first flower opening				Node at which first flower opened			
	Male		Female		Male		Female	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year(94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	37.19	37.72	38.53	49.29	15.25	14.91	20.00	21.49
n_2	36.64	38.06	39.41	51.11	15.63	15.01	20.19	21.51
n_3	37.03	38.28	39.13	51.01	15.88	15.11	21.88	22.48
n_4	37.50	38.59	40.09	51.15	15.78	15.35	23.88	22.78
$F_{3,44}$	**0.58**	**1.43**	**2.58**	**11.42****	**0.98**	**3.84***	**67.89****	**20.35****
g_1	38.22	36.81	42.31	53.49	16.22	15.76	22.88	23.02
g_2	36.76	37.50	38.72	51.46	15.94	15.04	22.25	22.63
g_3	36.69	38.41	36.97	50.19	15.44	14.83	19.88	21.29
g_4	36.69	39.94	39.16	47.42	14.94	14.74	20.64	20.91
$F_{3,44}$	**2.55**	**19.25****	**30.40****	**91.01****	**4.13***	**23.05****	**37.65****	**42.09****
C.D. (0.05) N/G	–	**0.877**	**1.151**	**0.759**	**0.792**	**0.275**	**0.624**	**0.418**
i_1	37.36	38.42	39.73	51.33	15.92	15.06	21.56	22.08
i_2	36.82	37.91	38.84	49.95	15.34	15.13	21.41	22.04
$F_{1,44}$	**1.31**	**2.81**	**4.87***	**26.91****	**4.32***	**0.50**	**0.51**	**0.07**
C.D. (0.05)	–	–	**0.814**	**0.537**	**0.560**	–	–	–
Control 1	37.00	38.50	42.63	56.68	13.00	13.13	22.13	23.75
Control 2	38.50	37.75	41.88	55.38	13.00	12.35	22.88	23.03

* Significant at 0.05 level

** Significant at 0.01 level

other levels - g_1, g_2 and g_4 - registered significantly higher number of days. Regarding irrigation frequencies, i_2 recorded the minimum duration of 38.84 days compared to i_1 (39.73) days.

During the second year, N, G and I effected significant variations in the number of days taken for the first female flower to open. The minimum duration of 49.29 days was registered by the level n_1. The other levels took significantly more number of days. Among the levels of ethephon, g_4 recorded the lowest number of days of 47.42. The difference between it and the other levels (g_1, g_2 and g_3) was significant. As in the previous year, the irrigation frequency i_2 registered relatively lower number of days (49.95) compared to i_1 (51.33).

4.2.1.2. Interaction effect of N, G and I (Table 7)

The interactions, NG, NI and GI were not significant during the first year. However, during the second year, NG and GI interactions significantly influenced this attribute. At all the levels of N, the number of days taken for the first female flower to open, decreased gradually with an increase in the level of ethephon with combinations of all the levels of N with g4 recording significantly lower number of days. With irrigation also, G showed the same trend. At both the levels of irrigation (i_1 and i_2), the number of days decreased gradually with an increase in G levels. The combinations of i_1 and i_2 with g_4 recorded conspicuously lower durations.

4.2.2. Days to first male flower opening

4.2.2.1. Effect of N, G and I (Table 6)

None of the main effects had significant effect on the number of days

Table 7 Interaction effect of N, G and I on earliness

Effect	Days to first flower opening				Node at which 1st flower opened			
	Male		Female		Male		Female	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year(95-96)
n_1g_1	36.25	37.13	41.75	51.75	16.25	16.28	24.75	23.63
n_1g_2	38.13	36.75	38.38	50.25	16.25	14.98	23.50	23.63
n_1g_3	35.63	38.00	35.75	49.25	14.50	14.50	22.00	20.38
n_1g_4	38.75	39.00	38.25	45.93	13.25	14.45	25.25	20.45
n_2g_1	37.38	36.88	42.50	53.83	15.75	16.00	23.00	23.45
n_2g_2	36.30	37.13	38.75	51.48	16.25	15.00	21.25	23.48
n_2g_3	36.00	38.25	37.50	50.88	15.00	14.55	20.25	22.33
n_2g_4	36.88	40.00	38.88	48.25	14.75	14.45	23.00	20.65
n_3g_1	35.75	36.63	41.75	52.75	15.50	15.73	20.50	22.40
n_3g_2	36.75	38.00	37.75	51.75	16.63	15.05	19.75	21.65
n_3g_3	37.50	38.75	37.00	50.68	14.75	14.88	18.75	21.48
n_3g_4	38.13	39.75	40.00	48.88	15.50	14.33	21.75	21.25
n_4g_1	37.38	36.63	43.25	55.63	16.00	15.63	20.75	22.53
n_4g_2	35.88	38.13	40.00	52.38	15.25	15.60	19.25	21.78
n_4g_3	37.63	38.63	37.63	49.98	16.75	15.20	18.50	22.60
n_4g_4	39.13	41.00	39.50	46.63	16.00	14.90	21.50	21.28
$F_{9,44}$	**1.17**	**0.67**	**0.53**	**3.22****	**2.74***	**6.94****	**0.38**	**3.60****
C.D. (0.05)	--	--	--	**1.518**	**1.585**	**0.551**	--	**0.835**

n_1i_1	37.19	37.31	39.13	50.38	15.50	15.16	23.63	22.70
n_1i_2	37.19	38.13	37.94	48.21	14.88	15.54	24.13	22.85
n_2i_1	37.38	38.25	39.63	51.79	16.00	15.04	22.31	22.36
n_2i_2	35.90	37.88	39.19	50.43	15.25	15.18	21.44	22.59
n_3i_1	36.94	38.31	39.63	51.69	16.25	15.00	20.19	21.41
n_3i_2	37.13	38.25	38.63	50.34	15.63	15.03	20.19	21.61
n_4i_1	37.94	39.81	40.56	51.48	16.56	15.04	20.13	21.85
n_4i_2	37.06	37.38	39.63	50.83	15.00	14.78	19.88	21.13
$F_{3, 44}$	**0.67**	**5.00****	**0.16**	**1.35**	**3.01***	**1.88**	**1.71**	**2.45**
g_1i_1	37.06	37.50	43.25	54.23	14.88	14.70	23.13	23.15
g_1i_2	36.31	36.13	41.38	52.75	15.00	14.78	22.63	22.89
g_2i_1	36.75	37.69	39.38	51.98	15.88	14.89	22.19	22.80
g_2i_2	36.78	37.31	38.06	50.95	15.00	14.78	22.31	22.46
g_3i_1	36.81	38.38	37.06	51.60	16.38	14.94	20.13	21.53
g_3i_2	36.56	38.44	36.88	48.79	15.50	15.15	19.63	21.86
g_4i_1	38.81	40.13	39.25	47.53	16.56	20.81	20.85	21.95
g_4i_2	37.63	39.75	39.06	47.31	15.88	15.81	21.06	20.96
$F_{3, 44}$	**0.32**	**0.98**	**1.09**	**4.17***	**0.74**	**0.49**	**0.84**	**1.18**
C.D. (0.05)	--	**1.240**	--	**1.073**	**1.121**	--	--	--

* Significant at 0.05 level

** Significant at 0.01 level

taken for the first male flower to open during the first year. But in the second year, ethephon influenced this character significantly. With an increase in the dose of ethephon from g_1 to g_4, the number of days increased from 36.81 to 39.94. The level g_4 took significantly more number of days than g_1, g_2 and g_3.

4.2.2.2. Interaction effect of N, G and I (Table 7)

A perusal of the data showed that the interaction effects of NG, NI and GI were not significant during the first year. However, during the following year, NI interaction was significant in its effect on earliness. Eventhough, N levels, n_2, n_3 and n_4 recorded more number of days at i_1 level of irrigation than at i_2, the increase was significant only at n_4.

4.2.3. Node at which the first female flower opened

4.2.3.1. Effect of N, G and I (Table 6)

The first female flower opened relatively early in the N level n_1 (node 20.00 in 1994-'95 and node 21.49 in 1995-'96), but it was on par with n_2 and significantly superior to n_3 and n_4. The latter two levels differed significantly in the first year but they were on par in the second year.

Among the levels of ethephon, during the first year, g_3 was significantly superior to the others in respect of the node number at which the first female flower opened (19.88). The next best level of G was g_4 (20.64). In the second year, g_4 was the earliest to record the opening of the first female flower in node number 20.91 and it was on par with g_3 (21.29) and significantly superior to g_1 and g_2. The irrigation frequencies had no marked influence on this aspect of study during both the years of experimentation. The results clearly indicated that an increase N resulted in an increase in the number of nodes while an increase in G resulted in a reduction in the number of nodes.

4.2.3.2. Interaction effect of N, G and I (Table 7)

The interaction effects due to NG, NI and GI were not significant during the first year. During the second year, NG interaction was significant with n_1g_3 registering the opening of the first female flower at the lowest node number of 20.38. This treatment combination was, however, on par with n_1g_4 and n_2g_4.

4.2.4. Node at which first male flower opened

4.2.4.1. Effect of N, G and I (Table 6)

In the first year, G and I showed significant influence on the particular node at which male flower opened. Among the levels of ethephon, g_4 was par with g_3 and recorded less number of nodes in comparison with g_1 and g_2. Comparing the irrigation treatments, i_2 was earlier (15.34) than i_1 (15.92) to record the opening of the first male flower.

Nitrogen and ethephon levels effected significant variation in the node at which the male flower opened during the second year. Among the N levels, n_1 recorded the lowest node number of 14.91 on par with n_2 (15.11) and superior to n_4 (15.35). The same trend was noticed for ethephon during the second year also with g_4 registering the lowest node number of 14.74 which was on par with g_3 (14.83) and superior to g_2 and g_1.

4.2.4.2. Interaction effect of N, G and I (Table 7)

A critical study of the data indicated that NG and NI interactions varied significantly in their effect on node number during the first year. At all the levels of N, the node number tended to decline when ethephon was applied and its effect was significant at g_3 and g_4 ie., n_1g_3, n_1g_4, n_3g_3 and n_2g_4 produced male flowers at significantly lower node numbers that the other NG combinations. In combination with I also N showed the same trend ie., with increase in N level, the node number increased. All i_2 combinations of N, except n_3i_2 were significantly earlier to all i_1 combinations of N.

During the second year, at all the levels of N ie., n_1, n_2, n_3, and n_4, the node number decreased gradually with an increase in the levels of G from g_1 to g_4. The NG combinations, g_3n_1, g_3n_2, g_3n_3 g_4n_1, g_4n_2 and g_4n_3 were significantly superior to the others.

4.2.5. Days to first fruit picking (Table 8 & 9)

None of the main effects as well as their interactions had significant influence on this parameter during both the years of experimentation.

4.2.6. Total crop duration

4.2.6.1. Effect of N, G and I (Table 8)

Of the main treatments, irrigation frequency (I) only had marked influence on the total crop duration and that too in the second year of experimentation wherein i_1 level of irrigation significantly increased the duration (129.69 days) over i_2 (117.88).

Table 8 Effect of N, G and I on crop duration

Effect	First fruit picking (days)		Total crop duration (days)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	56.31	64.19	113.38	120.19
n_2	56.81	65.69	114.44	120.50
n_3	56.63	68.06	114.19	118.81
n_4	56.31	69.56	114.75	119.63
$F_{3, 44}$	**0.35**	**2.02**	**2.37**	**0.32**
g_1	56.31	66.69	114.19	120.13
g_2	57.13	68.75	114.13	118.75
g_3	56.00	66.00	113.94	119.63
g_4	56.63	66.06	114.50	120.63
$F_{3, 44}$	**1.31**	**0.58**	**0.37**	**0.38**
i_1	56.47	67.19	114.31	121.69
i_2	56.56	66.56	114.06	117.88
$F_{1, 44}$	**0.05**	**0.14**	**0.43**	**8.59****
C.D. (0.05)	--	--	--	**2.62**
Control 1	57.25	69.50	114.50	120.50
Control 2	56.00	61.00	114.50	121.25

** Significant at 0.01 level

Table 9 Interaction effect of N, G and I on crop duration

Effect	First fruit picking (days)		Total crop duration (days)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	56.00	64.00	113.25	118.75
n_1g_2	57.25	66.25	114.25	120.00
n_1g_3	56.00	64.00	111.75	117.50
n_1g_4	56.00	62.50	114.25	124.50
n_2g_1	57.25	64.00	114.25	123.75
n_2g_2	58.00	62.50	114.25	119.00
n_2g_3	56.00	64.00	114.75	120.25
n_2g_4	56.00	72.25	114.50	119.00
n_3g_1	56.00	71.00	114.50	116.50
n_3g_2	56.00	70.00	113.25	114.75
n_3g_3	56.00	65.75	114.50	120.75
n_3g_4	58.50	65.50	114.50	123.25
n_4g_1	56.00	67.75	114.75	121.15
n_4g_2	57.25	76.25	114.75	121.25
n_4g_3	56.00	70.25	114.75	120.00
n_4g_4	56.00	64.00	114.75	115.75
$F_{9,44}$	**1.14**	**1.46**	**0.93**	**1.67**

n_1i_1	56.63	65.88	113.50	121.88
n_1i_2	56.00	62.50	113.25	118.50
n_2i_1	56.00	65.63	114.88	123.00
n_2i_2	57.63	65.75	114.00	118.00
n_3i_1	56.63	69.13	113.88	120.25
n_3i_2	56.63	67.00	114.50	117.38
n_4i_1	56.63	68.13	115.00	121.63
n_4i_2	56.00	71.00	114.50	117.63
$F_{3,44}$	**1.61**	**0.66**	**0.69**	**0.12**
g_1i_1	56.00	67.13	114.13	122.00
g_1i_2	56.63	66.25	114.25	118.25
g_2i_1	57.25	68.13	114.00	120.63
g_2i_2	57.00	69.38	114.25	116.88
g_3i_1	56.00	66.38	114.63	121.75
g_3i_2	56.00	65.63	113.25	117.50
g_4i_1	56.63	57.13	114.50	122.38
g_4i_2	56.63	65.00	114.50	118.30
$F_{3,44}$	**0.20**	**0.17**	**0.98**	**0.01**

4.2.6.2. Interaction effect of N, G and I (Table 9)

There was no significant variation in the total duration of the crop due to NG, NI and GI interactions during both the years.

4.3. Yield attributes and yield

4.3.1. Number of fruits plant^{-1}

4.3.1.1. Effect of N, G and I (Table 10 and Fig. 5)

The number of fruits plant^{-1} showed significant variation due to N and G during the first year. Among the different levels of N, n_3 registered the highest number of fruits (14.29) and it was on par with n_4 (12.81) and significantly superior to n_2 (12.09) and n_1 (11.57). Comparing the different levels of G, g_3 (14.46) was significantly superior to g_4 (12.61), g_2 (12.64) and g_1 (11.06) which were on par. The frequency of irrigation did not have any significant influence on this yield attribute.

A perusal of the data recorded during the second year showed positive effect of N, G and I on number of fruits plant^{-1}. With respect to N levels, n_3, recording a fruit number of 17.16, was significantly superior to the other levels while n_4 and n_2 were on par (15.59 and 15.18 fruits plant^{-1}, respectively) and n_1 registered the lowest fruit number of 14.56 plant^{-1}. Comparing different levels of G, as in the case of the previous year, g_3 (16.97) was significantly superior to the other levels. However, g_4 and g_2 were on par. The frequency of irrigation had favourable influence on fruit number with i_1 registering 16.05, which was significantly higher than that of i_2 (15.19).

Table 10 Effect of N, G and I on number of fruit plant^{-1}, average fruit weight, length and girth of fruits

Effect	No. of fruits plant^{-1}		Average fruit weight (kg)		Length of fruit (cm)		Girth of fruit (cm)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	11.57	14.56	0.81	0.77	68.71	73.15	23.15	20.76
n_2	12.09	15.18	0.88	0.77	68.58	73.61	23.46	21.01
n_3	14.29	17.16	0.98	0.80	70.33	74.68	23.52	21.84
n_4	12.81	15.59	1.02	0.89	70.67	75.11	23.84	21.22
$F_{3,44}$	**3.72***	**12.13****	**6.34****	**3.94***	**0.57**	**0.86**	**0.45**	**5.26****
g_1	11.06	14.41	0.91	0.78	71.29	75.36	23.31	20.72
g_2	12.64	15.16	0.89	0.80	70.87	74.13	22.98	21.14
g_3	14.46	16.97	0.97	0.85	67.58	73.89	24.02	21.32
g_4	12.61	15.95	0.92	0.81	68.54	73.17	23.66	21.65
$F_{3,44}$	**5.11****	**11.92****	**0.95**	**1.04**	**1.59**	**0.85**	**1.14**	**3.63***
C.D. (0.05) N/G	**1.750**	**0.907**	**0.107**	**0.080**	-	-	-	**0.577**
i_1	13.30	16.05	0.95	0.85	71.33	74.26	23.85	21.50
i_2	12.08	15.19	0.84	0.77	67.81	74.01	23.13	20.91
$F_{1,44}$	**3.98**	**7.29****	**4.62***	**9.83****	**6.09***	**0.07**	**2.93**	**8.51****
C.D. (0.05)	-	**0.642**	**0.080**	**0.054**	**2.872**	-	-	**0.408**
Control 1	8.98	9.35	0.64	0.64	60.88	69.18	21.65	20.20
Control 2	8.00	8.55	0.56	0.63	59.90	67.55	20.85	19.88

* Significant at 0.05 level
** Significant at 0.01 level

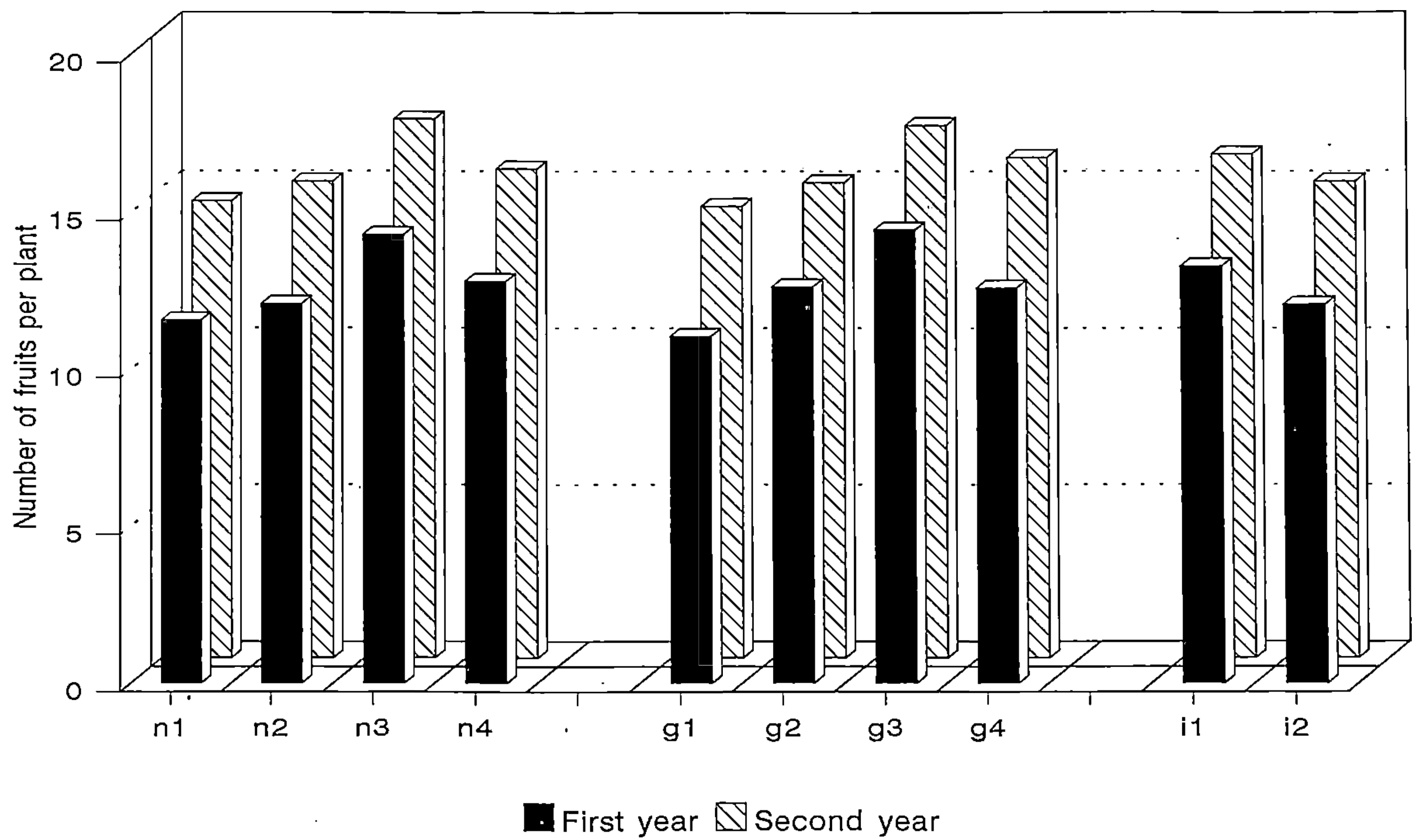


Fig. 5. Effect of N, G and I on number of fruits per plant

4.3.1.2. Interaction effect of N, G and I (Table 11)

Among the various interactions studied, GI interaction alone had a positive influence on fruit number during the first year. At both the levels of irrigation frequency viz., i_1 and i_2, a gradual increase in fruit number was noticed with an increase in the level of ethephon up to g_3. At i_1, all the levels of G had significantly positive effect on fruit number. However, at i_2, favourable influence was noticed for g_3 only, ie., g_3i_2.

None of the interactions showed significant influence on number of fruits plant^{-1} during the second year.

4.3.2. Average fruit weight

4.3.2.1. Effect of N, G and I (Table 10)

Among the different levels of N, n_4 recorded the highest average fruit weight of 1.02 kg and it was on par with n_3 recording a fruit weight of 0.98 kg during the first year. These two levels were significantly superior to n_1 (0.81 kg). Nevertheless, n_1 and n_2 (0.88 kg) were on par. The different levels of G did not influence this yield attribute significantly. Comparing the irrigation frequencies, i_1 registering an average fruit weight of 0.95 kg was significantly superior to i_2 (0.84 kg).

During the second year, n_4 recorded a significantly higher average fruit weight of (0.89 kg) compared to n_1 (0.77 kg), n_2 (0.77 kg) and n_3 (0.80 kg) which were on par. Ethephon levels did not influence average fruit weight significantly.

Table 11 Interaction effect of N, G and I on number of fruits plant^{-1}, average fruit weight, length and girth of fruit

Effect	No.of fruits plant^{-1}		Average fruit weight (kg)		Length of fruit (cm)		Girth of fruit (cm)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	10.15	12.90	0.91	0.70	73.50	70.10	21.88	20.40
n_1g_2	10.60	13.98	0.75	0.71	71.33	72.40	23.95	21.13
n_1g_3	13.63	16.05	0.83	0.82	65.05	74.30	24.18	20.47
n_1g_4	11.90	15.33	0.75	0.86	64.94	75.80	22.60	21.03
n_2g_1	11.15	14.03	0.78	0.80	68.00	77.05	24.00	20.60
n_2g_2	11.90	14.60	0.88	0.81	67.15	73.73	22.23	20.70
n_2g_3	13.20	16.65	1.02	0.83	70.93	70.58	23.50	21.58
n_2g_4	12.10	15.45	0.85	0.79	68.25	73.08	24.13	21.18
n_3g_1	12.53	16.00	0.96	0.80	72.08	77.25	23.63	21.22
n_3g_2	14.28	16.63	0.88	0.92	70.78	73.63	22.15	22.00
n_3g_3	17.10	18.88	1.12	0.94	65.88	75.98	23.97	22.50
n_3g_4	13.28	17.15	0.94	0.83	72.58	71.88	24.33	21.65
n_4g_1	10.43	14.70	0.97	0.78	71.60	77.03	23.75	20.67
n_4g_2	13.78	15.45	1.05	0.76	74.23	76.78	23.60	20.72
n_4g_3	13.90	16.33	0.92	0.80	68.48	74.73	24.43	20.72
n_4g_4	13.15	15.88	1.14	0.76	68.38	71.93	23.58	22.75
$F_{9,44}$	**0.46**	**0.36**	**1.80**	**0.75**	**1.07**	**1.82**	**0.45**	**2.19***
C.D. (0.05)	--	--	--	--	--	--	--	**1.154**

n_1i_1	12.00	15.04	0.82	0.83	70.48	72.45	24.01	21.04
n_1i_2	11.14	14.09	0.81	0.72	66.95	73.85	22.29	20.48
n_2i_1	12.31	15.79	0.89	0.86	69.50	73.90	23.59	21.40
n_2i_2	11.86	14.58	0.87	0.75	67.66	73.31	23.34	20.63
n_3i_1	14.46	17.54	1.00	0.93	72.03	74.60	23.96	22.05
n_3i_2	14.13	16.79	0.95	0.85	68.63	74.76	23.08	21.64
n_4i_1	14.44	15.85	1.10	0.79	73.33	76.10	23.84	21.53
n_4i_2	11.19	15.33	0.94	0.75	68.01	74.13	23.84	20.91
$F_{3,44}$	**1.24**	**0.21**	**0.95**	**0.40**	**0.25**	**0.51**	**1.14**	**0.13**
g_1i_1	12.34	14.86	0.91	0.83	72.90	76.46	23.41	21.11
g_1i_2	9.79	13.95	0.90	0.74	69.69	74.25	23.21	20.34
g_2i_1	14.66	15.19	0.96	0.84	71.43	74.28	22.97	21.44
g_2i_2	10.61	15.14	0.82	0.76	70.31	73.99	22.99	20.84
g_3i_1	14.36	17.64	1.00	0.88	70.81	74.33	24.58	21.51
g_3i_2	14.55	16.31	0.95	0.81	64.35	73.46	23.46	21.13
g_4i_1	11.85	16.53	0.94	0.85	70.19	71.99	24.44	21.95
g_4i_2	13.36	15.38	0.90	0.76	66.90	74.35	22.88	21.35
$F_{3,44}$	**4.25***	**0.79**	**0.62**	**0.03**	**0.60**	**0.95**	**0.80**	**0.15**
C.D. (0.05)	**2.475**	--	--	--	--	--	--	--

* Significant at 0.05 level

With regard to irrigation frequency, i_1, with an average fruit weight of 0.85 kg was significantly superior to i_2 (0.77 kg).

4.3.2.2. Interaction effect of N, G and I (Table 11)

During both the years, none of the interactions were significant in their effect on average fruit weight.

4.3.3. Length of fruit

4.3.3.1. Effect of N, G and I (Table 10)

The frequency of irrigation exerted significant influence on fruit length during the first year with i_1 registering 71.33 cm compared to i_2 (67.81 cm). Nitrogen and G levels had no conspicuous influence on fruit length.

The length of fruit showed no significant variation due to N, G and I during the second year. But with an increase in the level of N from 35 to 140 kg ha^{-1}, there was a gradual increase in fruit length from 73.15 to 75.11 cm. In contrast, ethephon exerted an inverse trend. With an increase in the concentration of ethephon from zero to 200 ppm, a gradual reduction in fruit length was observed from 75.36 cm to 73.17 cm. In the case of irrigation, the difference between the two frequencies was not significant.

4.3.3.2. Interaction effect of N, G and I (Table 11)

During both the years, none of the interaction effects was significant on fruit length.

4.3.4. Girth of fruit

4.3.4.1. Effect of N, G and I (Table 10)

An analysis of the data showed that during the first year, N, G and I did not have any significant influence on fruit girth. However, with an increase in the level of N from n_1 to n_4, there was a gradual increase in fruit girth from 23.15 cm to 23.84 cm. Though non significant, i_1 registered a higher fruit girth of 23.85 cm compared to 23.13 cm by i_2.

In the second year, the n_3 level of N was significantly superior to n_4, n_1 and n_2 recording the maximum fruit girth of 21.84 cm. Among the four levels of ethephon, g_4 recorded the highest fruit girth of 21.65 cm and it was on par with g_3 (21.32 cm) and g_2 (21.14 cm). Irrigation frequency significantly influenced this yield attribute with i_1 recording a fruit girth of 21.50 cm compared to 20.91 cm by i_2.

4.3.4.2. Interaction effect of N, G and I (Table 11)

The interaction effects were not significant on girth of fruits during the first year. However, during the second year, interaction of NG was significant. At the two lower levels of N, viz., n_1 and n_2, the effect of all the four levels of ethephon was on par. On the other hand, at the higher N level n_3, the three upper levels of ethephon - g_4, g_3 and g_2 - were on par and significantly superior to g_1. It was further noticed that at n_4, the highest level of ethephon (g_4) was significantly superior to the other three levels tried.

4.3.5. Number of male flowers plant^{-1}

4.3.5.1. Effect of N, G and I (Table 12)

During the first year, the data on number of male flowers per plant showed no significant variation due to N, ethephon and frequency of drip irrigation. However, in the second year, ethephon application had significant effect on this character with g_4 recording the maximum number of male flowers viz., 1747 plant^{-1}, compared to g_1 (1434), g_2 (1622) and g_3 (1527). The levels g_3 and g_2 were on par. Similarly, g_2 and g_1 were also on par. During the second year, N and I did not influence the number of male flowers plant^{-1}.

4.3.5.2. Interaction effect of N, G and I (Table 13)

During both the years, NI interaction was observed to have significant effect on this character. At all the levels of nitrogen, the number of male flowers plant^{-1} were higher at the level i_1, compared to i_2 level. However, during the second year, along with all i_1 combinations of N, n_2i_2 and n_4i_2 were also significant.

4.3.6. Number of female flowers plant^{-1}

4.3.6.1. Effect of N, G and I (Table 12)

It was observed that during the first year, N and G significantly influenced the number of female flowers plant^{-1}. Among the four levels of N, n_3 recorded the highest number (70.03) which was on par with those of n_4 (62.65) and n_2 (68.02). Comparing different concentrations of ethephon, g_3 recorded the highest number (71.59) and it was on par with g_4 and g_2 and significantly superior to g_1 (58.46).

Table 12 Effect of N, G and I on number of male and female flowers plant^{-1}, sex ratio and fruit setting per cent

Effect	Male flowers plant^{-1}		Female flowers plant^{-1}		Sex ratio		Setting %	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	1859.20	1510.59	60.58	55.71	30.75	27.03	19.45	26.71
n_2	1996.09	1575.07	68.02	58.64	29.31	26.61	17.84	25.66
n_3	1943.94	1608.88	70.03	62.56	27.74	25.56	20.63	28.10
n_4	1715.83	1636.14	62.65	61.23	26.97	26.36	20.46	25.86
$F_{3,44}$	**1.83**	**1.00**	**3.00***	**5.10****	**5.88****	**1.27**	**2.73**	**1.72**
g_1	1764.77	1434.48	58.46	51.78	30.21	27.73	19.31	25.74
g_2	1907.69	1622.28	66.02	58.68	28.63	27.33	19.49	28.01
g_3	1967.02	1527.08	71.59	60.41	27.33	25.29	20.21	28.73
g_4	1875.58	1746.84	64.91	67.27	28.61	25.22	19.37	28.86
$F_{3,44}$	**0.88**	**6.10****	**4.30****	**22.50****	**2.87***	**5.73****	**0.29**	**6.86****
C.D. (0.05) N/G	--	**154.139**	**7.399**	**3.822**	**1.979**	**1.572**	--	**2.413**
i_1	1963.31	1598.57	66.91	60.99	29.28	26.00	20.01	26.75
i_2	1794.22	1566.77	63.58	58.08	28.11	26.78	19.18	26.41
$F_{1,44}$	**3.50**	**0.35**	**1.65**	**4.70***	**2.83**	**1.98**	**1.16**	**0.17**
C.D. (0.05)	--	--	--	**2.703**	--	--	--	--
Control 1	1758.60	1489.08	54.38	48.93	32.35	30.43	16.28	19.10
Control 2	1717.43	1539.13	49.40	46.93	34.76	32.80	16.10	18.75

* Significant at 0.05 level
** Significant at 0.01 level

The number of female flowers plant^{-1} was significantly influenced by N, G and I during the second year. The level n_3 recorded the highest number of 62.56 which was on par with n_4 (61.23) and significantly higher than n_2 (58.64) and n_1 (55.71). Among the four concentrations of ethephon, the level g_4 recorded the highest number of 67.27 which was significantly higher than those of g_3, g_2 and g_1. Comparing the frequency of irrigation, it was observed, that the treatment i_1 (60.99) was significantly superior to i_2 (58.08).

4.3.6.2. Interaction effect of N, G and I (Table 13)

The data revealed that during the first year, NI interaction showed significant effect on this character. At i_1 level of irrigation, the N levels n_2, n_3 and n_4 were on par and superior to n_1. But under i_2, the nitrogen level n_3 was significantly superior to n_4, n_2 and n_1 which were on par.

During the second year, none of the interaction effects was significant on the number of female flowers plant^{-1}.

4.3.7. Sex ratio

4.3.7.1. Effect of N, G and I (Table 12)

The sex ratio was seen significantly influenced by both N and G during the first year. The lowest sex ratio of 26.97 was recorded by n_4 which was on par with n_3 (27.74). These two levels were significantly superior to n_2 and n_1 which recorded sex ratios of 29.31 and 30.75, respectively. Among the different levels of ethephon, g_3 registered the narrowest sex ratio of 27.33 and it was on par with g_4

Table 13 Interaction effect of N, G and I on the number of male and female flowers plant^{-1}, sex ratio and fruit setting per cent

Effect	Male flowers plant^{-1}		Female flowers plant^{-1}		Sex ratio		Setting %	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	1802.63	1457.95	56.33	50.93	32.04	28.54	19.47	25.97
n_1g_2	1715.85	1696.98	57.90	59.60	30.53	28.18	19.33	24.13
n_1g_3	1987.83	1375.18	66.63	52.18	29.42	26.35	20.30	31.15
n_1g_4	1930.50	1512.28	61.45	60.13	31.03	25.08	18.70	25.58
n_2g_1	1930.25	1512.50	62.00	53.28	31.41	28.53	17.90	26.33
n_2g_2	2139.03	1587.38	72.95	56.20	29.33	26.72	16.10	24.65
n_2g_3	1957.80	1573.05	69.60	60.98	28.07	25.73	18.95	27.45
n_2g_4	1957.28	1627.35	67.55	64.10	28.43	25.47	18.42	24.20
n_3g_1	1905.50	1455.08	65.20	53.20	29.32	27.40	19.13	30.03
n_3g_2	1850.60	1561.28	66.63	60.40	27.81	26.40	22.08	27.73
n_3g_3	2278.38	1523.90	84.38	62.80	26.89	24.25	20.45	31.38
n_3g_4	1741.28	1895.25	63.90	73.77	26.93	24.15	20.85	23.28
n_4g_1	1420.70	1312.40	50.30	49.65	28.05	26.43	20.73	29.70
n_4g_2	1925.28	1643.48	66.60	58.50	26.84	28.00	20.48	26.45
n_4g_3	1644.08	1636.20	65.75	65.70	24.96	24.83	21.15	24.93
n_4g_4	1873.25	1952.50	66.75	71.08	28.04	26.20	19.50	22.38
$F_{9,44}$	**1.83**	**1.60**	**1.03**	**2.00**	**0.23**	**0.51**	**0.45**	**1.62**
n_1i_1	1922.33	1589.81	59.01	58.35	30.42	27.18	16.76	26.46

n_1i_2	1796.08	1431.38	53.76	53.06	31.09	26.89	18.60	26.95
n_2i_1	2246.66	1598.21	64.42	61.43	30.62	25.30	20.30	25.89
n_2i_2	1745.51	1551.92	62.78	55.85	28.00	27.93	18.92	25.43
n_3i_1	2188.85	1713.98	73.28	64.63	26.50	25.95	22.69	27.58
n_3i_2	1699.02	1503.77	75.63	60.50	28.98	25.16	18.56	28.63
n_4i_1	2111.48	1733.74	70.94	59.55	29.57	25.59	20.30	27.09
n_4i_2	1320.17	1538.55	62.14	62.91	24.37	27.14	20.63	24.64
$F_{3,44}$	**10.38****	**3.00***	**6.13****	**2.48**	**6.07****	**2.08**	**3.05***	**0.82**
C.D. (0.05)	**364.467**	**217.987**	**10.464**	--	**2.799**	–	**3.116**	--
g_1i_1	1968.71	1478.10	65.05	52.91	30.21	27.89	19.47	28.45
g_1i_2	1560.83	1390.86	51.86	50.65	30.20	27.57	19..14	27.56
g_2i_1	2084.16	1620.90	67.10	60.66	31.01	26.65	22.26	25.34
g_2i_2	1731.21	1623.65	64.94	56.69	26.25	28.00	16.73	26.14
g_3i_1	1892.08	1496.30	71.08	60.96	26.70	24.59	20.26	29.29
g_3i_2	2041.96	1557.86	72.10	59.86	27.97	25.99	20.16	28.16
g_4i_1	1908.29	1798.96	64.43	69.41	29.19	24.89	20.35	23.94
g_4i_2	1842.86	1694.73	65.40	65.13	28.02	25.56	18.39	23.77
$F_{3,44}$	**2.07**	**0.52**	**1.68**	**0.31**	**3.49***	**0.53**	**4.44****	**0.26**
C.D. (0.05)	--	–	--	--	**2.799**	–	**3.116**	--

* Significant at 0.05 level
** Significant at 0.01 level

(28.61) and g_2 (28.63) and significantly superior to g_1 which produced the widest ratio of 30.21. The frequency of irrigation showed no significant effect.

During the second year, eventhough there was a gradual reduction in the sex ratio due to incremental doses of N, the magnitude of reduction was not significant. However, ethephon significantly influenced this yield attribute, with g_4 recording the narrowest sex ratio of 25.22 which was statistically on par with g_3 (25.29) and significantly superior to g_2 (27.33) and g_1 (27.73). As in the previous year, irrigation frequencies did not show any significant influence on sex ratio.

4.3.7.2. Interaction effect of N, G and I (Table 13)

The data indicated that during the first year, NI and GI interactions influenced the sex ratio significantly. At i_1 level of irrigation, the sex ratio narrowed down significantly with an increase in N levels from n_1 to n_3 but at n_4 it again widened. At i_2 level of irrigation, the sex ratio gradually narrowed down with an increase in N levels from n_1 to n_4. But n_4 was significantly superior to the other levels. At i_1 level of irrigation, the sex ratio narrowed down in the case of g_3 and g_4 which were on par and significantly superior to g_1 and g_2. However, at i_2, the ethephon levels g_2, g_3 and g_4 were on par and superior to g_1. In the second year NI, GI and NG interactions showed no significant effect on sex ratio.

4.3.8. Fruit set

4.3.8.1. Effect of N, G and I (Table 12)

The results revealed that during the first year, N, G and I did not have any significant influence on percentage fruitset. However, during the second year, it varied significantly due to ethephon application. The percentage was the highest in g_4 (28.86) and it was on par with g_2 (28.01) and g_3 (28.73) and significantly higher than g_1 (25.74).

4.3.8.2. Interaction effect of N, G and I (Table 13)

The interactions due to NI and GI were significant during the first year. Among different NI interactions, n_1i_1 recorded the lowest percentage of 16.76 which was significantly inferior to n_2i_1, n_3i_1, n_4i_1 and n_4i_2. At i_1 level of irrigation, n_1 was significantly inferior to all other levels of N. However, at i_2, all the levels of N were on par. When the GI interactions were compared, it was found that at all levels of ethephon, i_1 recorded significantly higher fruitset percentage than i_2.

During the second year, NI, GI and NG interactions did not have any significant effect on sex ratio.

4.3.9. Harvest index

4.3.9.1. Effect of N, G and I (Table 14)

The harvest index of the crop varied significantly due to N, G and I during both the years of experimentation. Among the different levels of N, n_2 and n_3 were on par (0.65 each) and superior to n_1 (0.63) and n_4 (0.64). Comparing different levels of ethephon, g_3 (0.66) was significantly superior to g_2 (0.64), g_4 (0.64) and g_1 (0.63). Compared to i_2 (0.64), i_1 registered a significantly higher harvest index (0.65).

During the second year, the highest harvest index of 0.64 was recorded by n_3 which was on par with n_4 (0.63) and superior to n_2 (0.62) and n_1 (0.60).

Table 14 Effect of N, G and I on harvest index and fruit yield

Effect	Harvest index		Fruit yield (t ha^{-1})		
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	Pooled mean
n_1	0.63	0.60	20.99	22.89	21.94
n_2	0.65	0.62	22.99	23.57	23.28
n_3	0.65	0.64	25.36	26.35	25.86
n_4	0.64	0.63	24.68	25.62	25.15
$F_{3, 44}$	**4.15***	**19.63****	**56.64****	**6.32****	**12.39****
g_1	0.63	0.61	22.89	22.55	22.72
g_2	0.64	0.61	23.51	24.21	23.86
g_3	0.66	0.62	24.11	24.82	24.47
g_4	0.64	0.64	23.51	26.77	25.14
$F_{3, 44}$	**9.13****	**8.83****	**3.71***	**7.13****	**4.27****
C.D. (0.05) N/G	**0.008**	**0.011**	**0.741**	**1.863**	**0.710**
i_1	0.65	0.63	24.01	25.95	24.98
i_2	0.64	0.61	23.00	23.25	23.12
$F_{1, 44}$	**11.86****	**28.79****	**14.87****	**16.87****	**13.97****
C.D. (0.05)	**0.008**	**0.008**	**0.524**	**1.317**	**0.497**
Control 1	0.63	0.60	15.15	15.14	15.15
Control 2	0.61	0.58	14.08	14.29	14.19

* Significant at 0.05 level
** Significant at 0.01 level

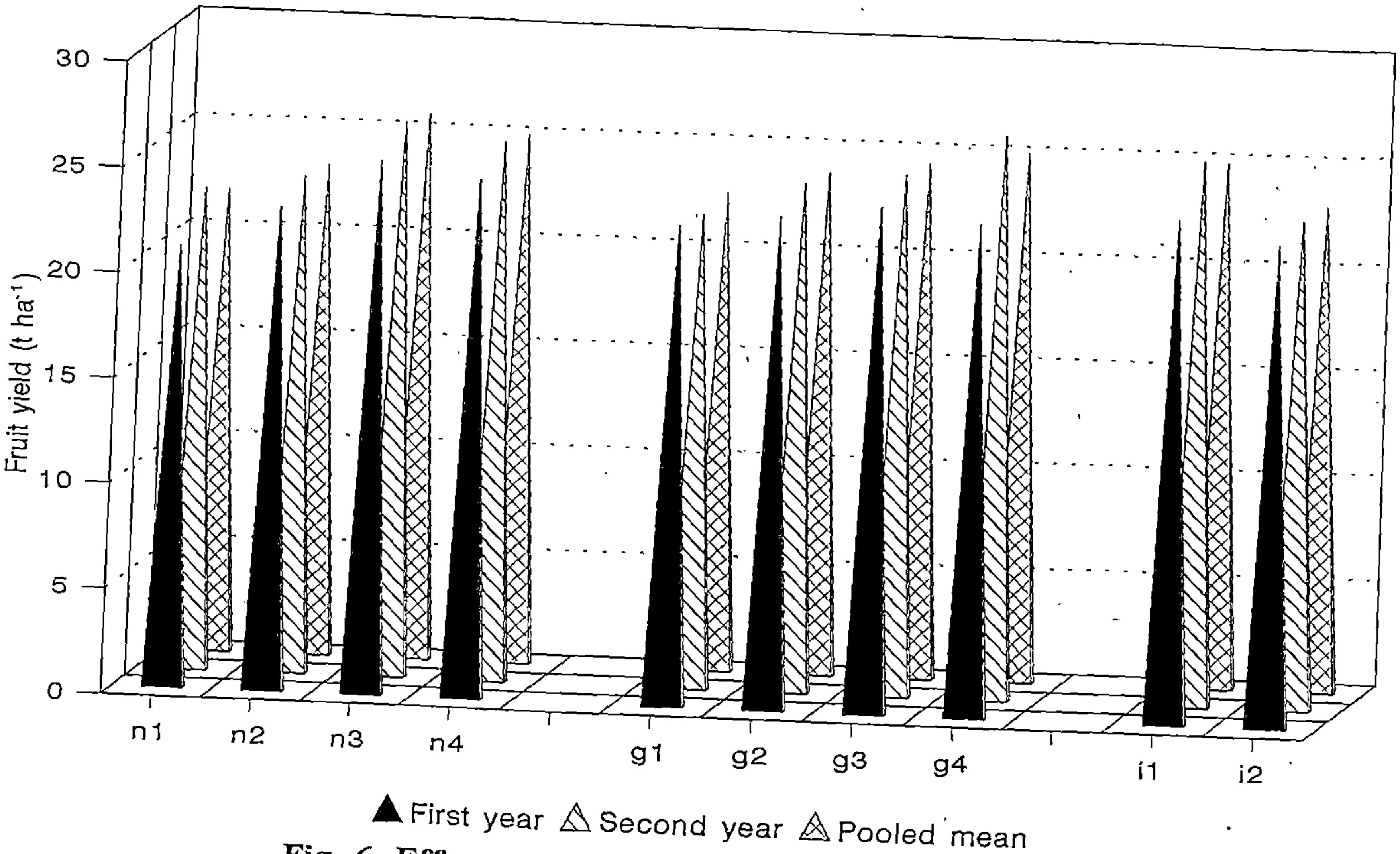


Fig. 6. Effect of N, G and I on fruit yield (t ha^{-1})

Among the levels of ethephon, g_4 (0.64) was significantly superior to g_3 (0.62), g_2 (0.61) and g_1 (0.61). As in the case of the previous year, i_1 recorded a significantly higher harvest index (0.63) than i_2 (0.61).

4.3.9.2. Interaction effect of N, G and I (Table 15)

The effects of NG, NI and GI interactions were of little significance during both the years of the study.

4.3.10. Yield of fruits ha^{-1}

4.3.10.1. Effect of N, G and I (Table 14 and Fig. 6)

A perusal of the data pertaining to the yield recorded in the first year revealed that yield of fruits ha^{-1} was significantly influenced by N, G and I. Among the four doses of nitrogen tried, the level n_3 recorded the highest yield of 25.36 t ha^{-1} which was on par with n_4 registering a fruit yield of 24.68 t ha^{-1} and these two levels were significantly superior to n_2 and n_1. Among the different levels of ethephon, g_3 recorded the highest fruit yield of 24.11 t ha^{-1} which was on par with g_4 and g_2 (23.51 t ha^{-1} each) and superior to g_1 (22.89 t ha^{-1}). The frequency of drip irrigation significantly influenced fruit yield and i_1 recorded an yield of 24.01 t ha^{-1} which was significantly superior to i_2 (23.0 t ha^{-1}).

Significant variation in fruit yield was noticed in the second year also due to N, G and I. Among the N levels, n_3 and n_4 recorded yields of 26.35 and 25.62 t ha^{-1}, respectively which were on par and superior to n_2 and n_1. Comparing different doses of G, g_4 recorded the highest yield of 26.77 t ha^{-1} which was significantly higher

Table 15 Interaction effect of N, G and I on harvest index and fruit yield

Effect	Harvest index		Fruit yield (t ha^{-1})		
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	Pooled mean
n_1g_1	0.64	0.58	20.79	19.63	20.21
n_1g_2	0.64	0.59	20.91	22.74	21.82
n_1g_3	0.65	0.61	21.17	24.56	22.86
n_1g_4	0.63	0.62	21.08	24.62	22.85
n_2g_1	0.64	0.62	22.76	21.38	22.07
n_2g_2	0.65	0.62	22.72	25.14	23.93
n_2g_3	0.66	0.63	23.14	22.25	22.70
n_2g_4	0.65	0.64	23.35	25.52	24.43
n_3g_1	0.64	0.63	24.58	20.75	22.67
n_3g_2	0.65	0.61	25.24	25.55	25.39
n_3g_3	0.68	0.62	26.59	27.48	27.04
n_3g_4	0.65	0.64	25.03	31.64	28.33
n_4g_1	0.62	0.64	23.42	23.44	25.94
n_4g_2	0.64	0.63	25.19	25.24	24.31
n_4g_3	0.65	0.63	25.55	25.34	25.39
n_4g_4	0.63	0.66	24.58	28.47	24.96
$F_{9,44}$	**1.29**	**0.79**	**0.92**	**4.36****	**1.99**
C.D. (0.05)	–	–	–	**3.726**	–

n_1i_1	0.64	0.61	20.84	23.29	22.07
n_1i_2	0.64	0.59	21.13	22.48	21.81
n_2i_1	0.66	0.64	23.34	26.23	24.79
n_2i_2	0.64	0.62	22.64	20.92	21.78
n_3i_1	0.66	0.63	26.54	27.01	26.91
n_3i_2	0.64	0.61	24.19	24.23	24.81
n_4i_1	0.64	0.65	25.30	27.28	26.15
n_4i_2	0.63	0.63	24.06	25.43	24.15
$F_{3,44}$	**1.44**	**0.14**	**4.48****	**2.17**	**1.54**
C.D. (0.05)	--	--	**1.048**	--	--
g_1i_1	0.64	0.63	23.18	23.34	23.26
g_1i_2	0.62	0.60	22.59	21.78	22.18
g_2i_1	0.65	0.62	23.88	25.36	24.62
g_2i_2	0.64	0.61	23.14	23.08	23.11
g_3i_1	0.66	0.63	24.81	26.25	25.53
g_3i_2	0.65	0.61	23.41	23.52	23.47
g_4i_1	0.64	0.65	24.14	28.86	26.50
g_4i_2	0.64	0.63	22.88	24.69	23.79
$F_{3,44}$	**0.31**	**0.85**	**0.57**	**0.71**	**0.52**

** Significant at 0.01 level

than those of the other levels. With regard to frequency of irrigation, i_1 recorded a significantly higher yield of 25.95 t ha^{-1} over i_2 (23.25 t ha^{-1}).

A pooled analysis of the two seasons' data revealed a similar trend as that of individual seasons. The interaction effect of season x major treatments were not, however, significant. Among the N levels, n_4 and n_3 were on par and significantly superior to n_2 and n_1. With respect to ethephon, g_4 was on par with g_3 and significantly superior to g_2 and g_1. As far as frequency of drip irrigation was concerned, i_1 recorded a significantly higher fruit yield than i_2.

4.3.10.2. Interaction effect of N, G and I (Table 15)

The interaction effect of N levels x frequency of irrigation was significant on fruit yield during the first year. At n_1 and n_2 levels, i_1 and i_2 were on par in their effect. However, at the higher N levels of n_3 and n_4, i_1 was significantly superior to i_2. NG and GI interactions showed no significant effect on fruit yield.

During the second year, NG interaction touched the level of significance on fruit yield. Under each level of the growth regulator tested, the response to N was studied. It was found that in the absence of growth regulator, the maximum yield was observed for the level n_4 which was on par with n_3 and n_2 and significantly superior to n_1, while no significant difference was observed among n_3, n_2 and n_1. Differential response could not be observed at various levels of N, when treated in combination with g_2. Under g_3, n_3 recorded significantly higher fruit yield than n_2 while under g_4, the maximum yield was recorded for n_3 which was on par with n_4 whereas no significant difference was noticed between n_1 and n_2. NI and GI interactions did not influence the fruit yield during the second year.

An analysis of the pooled data of both the years revealed that the two planting seasons had no significant effect on any of the interactions studied.

4.3.10.3. Physical optima of N and G

The physical optima for N and G were worked out at i_1 and i_2, separately for the first and second year, fitting the quadratic response surface using the formula,

$$Y = b_0 + b_1N + b_2G + b_{11} N^2 + b_{22} G^2 + b_{12} NG$$

The estimated equations are presented below:

I year

For drip irrigation at 5 mm CPE (i_1)

$$Y = 14.51563 + 0.178160 N + 0.022798 G - 0.000763 N^2 - 0.000100 G^2 + 0.000030 NG$$

(F for regression = 27.15, R^2 = 0.84. The fitted regression explains 84 per cent variation in the yield of snakegourd due to N and G).

The physical optima for N and G were worked out to be 115 kg and 132 ppm ha^{-1}, respectively.

For drip irrigation at 10 mm CPE (i_2)

$$Y = 18.03468 + 0.086845 N + 0.013994 G - 0.000332 N^2 - 0.000067 G^2 + 0.000010 NG$$

(F for regression = 5.72, R^2 = 0.52)

The physical optima for N and G were worked out to be 133 kg and 114 ppm ha^{-1}, respectively.

II year

For drip irrigation at 5 mm CPE (i_1):

$$Y = 16.02625 + 0.1536107\ N + 0.03782943\ G - 0.0006548\ N^2 - 0.0000339\ G^2 - 0.0000475\ NG)$$

(F for regression = 5.520872, R^2 = 0.51)

The physical optimum for N was worked out as 100 kg ha^{-1}. No parabolic trend was observed for G and hence optimum could not be worked out.

For drip irrigation at 10 mm CPE (i_2)

$$Y = 17.50468 + 0.044685\ N + 0.046987\ G + 0.000050301\ N^2 - 0.00003199\ G^2 - 0.0003048\ NG$$

F for regression = 0.9338, R^2 = 0.15)

The physical optima for N and G were worked out to be 115 kg and 183 ppm ha^{-1}, respectively.

The economic optimum dose of N and G were not determinable for the above fitted response surface, with the existing market prices of N, G and snakegourd.

4.4. Root studies

4.4.1. Dry weight of root plant^{-1}

4.4.1.1. Effect of N, G and I (Table 16)

The data on dry weight of roots indicated that N only significantly influenced this attribute during both the years. In the first year, n_3 recorded the

Table 16 Effect of N, G and I on root dry weight and WUE

Effect	Dry weight of root (g plant-[1])		WUE (kg ha cm[-1])	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	9.00	12.06	208.03	242.08
n_2	10.00	13.94	228.36	241.54
n_3	12.06	16.38	249.58	277.14
n_4	10.94	14.38	244.47	266.77
$F_{3,44}$	**3.96***	**4.13***	**35.44****	**4.70****
g_1	10.81	14.19	227.50	237.19
g_2	10.38	14.69	233.53	253.64
g_3	11.13	13.63	236.70	269.06
g_4	9.69	14.25	232.71	277.63
$F_{3,44}$	**0.90**	**0.25**	**1.47**	**4.07***
C D (0.05) N/G	**1.873**	**2.482**	**9.026**	**23.540**
i_1	10.88	14.41	166.84	185.62
i_2	10.13	13.97	298.38	328.14
$F_{1,44}$	**1.30**	**0.25**	**1750.13****	**297.62****
C.D. (0.05)	**–**	**–**	**6.382**	**16.646**
Control 1	8.50	10.75	106.03	110.05
Control 2	6.75	9.00	183.58	201.83

* Significant at 0.05 level
** Significant at 0.01 level

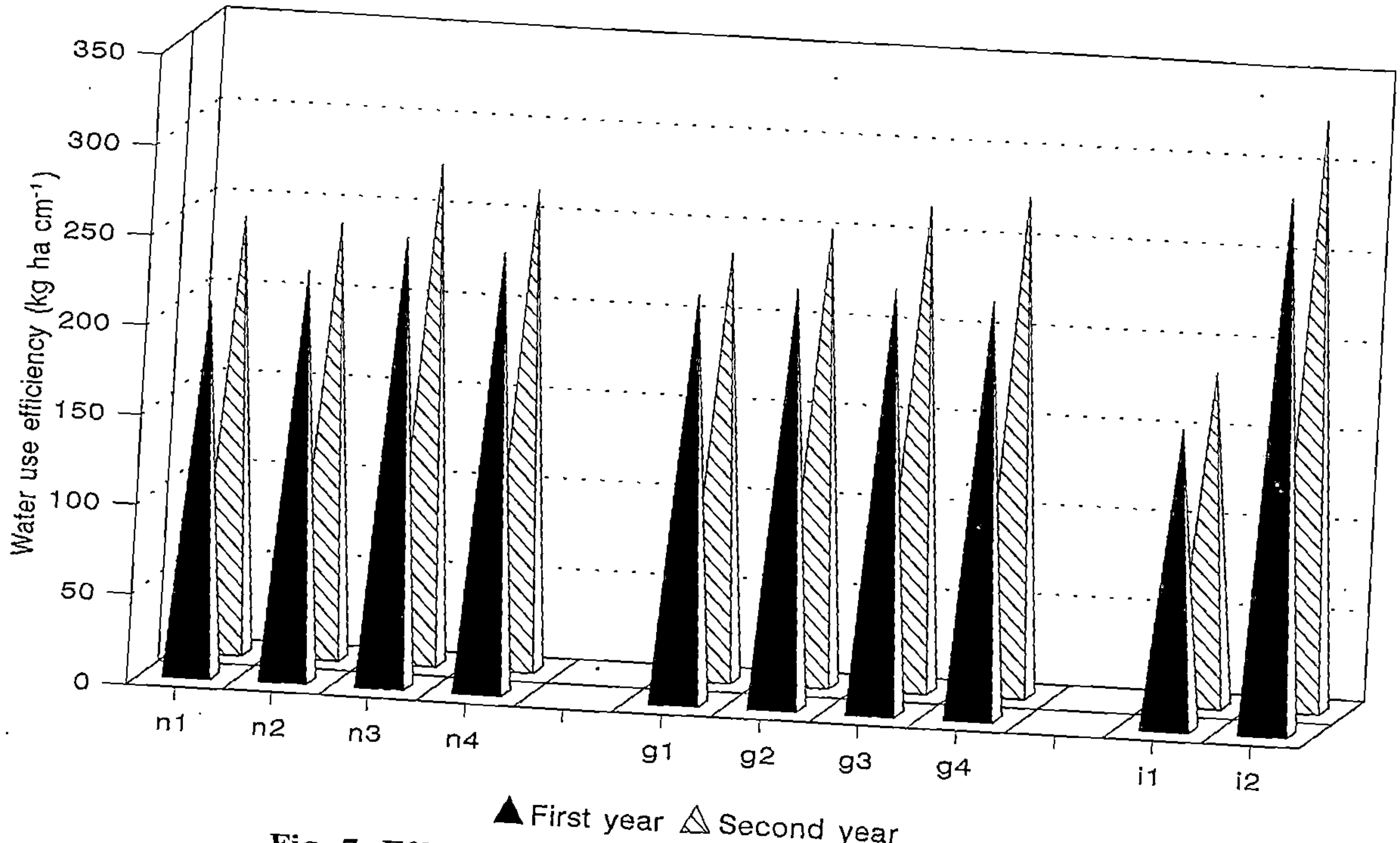


Fig. 7. Effect of N, G and I on water use efficiency

highest dry weight of 12.06 g plant^{-1} which was on par with n_4 (10.94 g) and significantly superior to n_2(10.00 g) and n_1 (9.00 g).

In the second year also, the highest dry weight (16.38 g plant^{-1}) was recorded by n_3 and it was on par with n_4 (14.38 g) and n_2 (13.94 g) and significantly superior to n_1 (12.06 g).

4.4.1.2. Interaction effect of N, G and I (Table 17)

The interaction effects on dry weight of roots due to NG, NI and GI were not significant during both the years.

4.5. Moisture studies

4.5.1. Water use efficiency (WUE)

4.5.1.1. Effect of N, G and I (Table 16 and Fig. 7)

During the first year, WUE varied significantly due to N and I. The highest WUE was recorded by n_3 (249.58 kg ha cm^{-1}) which was on par with n_4 (244.47 kg ha cm^{-1}) and significantly superior to n_2 (228.36) and n_1 (208.03 kg ha cm^{-1}). With respect to irrigation frequency, compared to i_1, the level i_2 recorded a significantly higher WUE of 298.38 kg ha cm^{-1}.

The WUE varied significantly due to N, G and I during the second year. Among the levels of N, n_3 recorded the highest WUE of 277.14 kg ha cm^{-1} which was on par with n_4 (266.77 kg ha cm^{-1}). The levels n_1 and n_2 were on par and they registered significantly lower WUE than n_4. As regards different levels of G, g_4 recorded the highest WUE of 277.63 kg ha cm^{-1} which was on par with g_3 (269.06) and superior to g_2 (253.64) and g_1 (237.19) which were on par. Comparing the

Table 17 Interaction effect of N, G and I on root dry weight and WUE

Effect	Dry weight of root (g plant^{-1})		WUE (kg ha cm^{-1})	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	9.25	11.75	211.6	203.4
n_1g_2	8.75	14.75	207.5	244.8
n_1g_3	9.25	10.00	202.0	262.5
n_1g_4	8.75	11.75	211.2	257.7
n_2g_1	11.00	16.50	224.1	221.1
n_2g_2	9.00	14.50	227.1	259.5
n_2g_3	11.00	11.00	229.3	222.2
n_2g_4	9.00	13.75	233.0	263.5
n_3g_1	12.20	14.75	242.4	212.1
n_3g_2	12.75	16.50	249.2	271.5
n_3g_3	12.75	17.00	262.7	300.6
n_3g_4	10.50	17.25	244.0	324.4
n_4g_1	10.75	13.75	232.0	238.9
n_4g_2	11.00	13.00	250.0	251.1
n_4g_3	11.50	16.50	252.8	265.0
n_4g_4	10.50	14.25	242.7	312.2
$F_{9,44}$	**0.23**	**1.30**	**1.25**	**4.30****
C.D. (0.05)	--	--	--	**47.081**

n_1i_1	9.13	13.00	142.0	166.6
n_1i_2	8.88	11.13	274.1	317.6
n_2i_1	10.88	12.00	163.1	187.7
n_2i_2	9.13	15.88	293.6	295.4
n_3i_1	12.63	14.38	185.5	193.3
n_3i_2	11.50	14.38	313.7	340.4
n_4i_1	10.88	16.50	176.8	195.1
n_4i_2	11.00	16.25	312.1	359.2
$F_{3, 44}$	**0.42**	**1.96**	**0.22**	**2.15**
g_1i_1	11.13	12.88	162.0	166.9
g_1i_2	10.50	15.50	293.0	307.5
g_2i_1	10.50	15.00	166.9	181.3
g_2i_2	10.25	14.38	300.1	326.0
g_3i_1	11.88	15.00	169.7	187.8
g_3i_2	10.38	12.25	303.7	330.4
g_4i_1	10.00	13.00	168.7	206.5
g_4i_2	9.38	15.50	296.7	348.8
$F_{3, 44}$	**0.16**	**2.23**	**0.18**	**0.01**

irrigation frequencies, the WUE (328.14 kg ha cm^{-1}) of i_2 was significantly higher than that of i_1 (185.62).

4.5.1.2. Interaction effect of N, G and I (Table 17)

During the first year, none of the interactions viz., NG, NI and GI was significant. However, during the second year, NG interaction significantly influenced the WUE. The combinations of higher levels of N and G viz., n_3g_4, n_3g_3 and n_4g_4 recorded significantly higher WUE compared to the other NG combinations.

4.5.2. Seasonal consumptive use

The seasonal consumptive use was computed using the modified Penman formula (Doorenbos and Pruitt, 1977) and the values were, 482 mm and 418 mm, respectively, for the first and second years (summer seasons) of experimentation. However, the total water use season^{-1} ie., quantity applied through drip irrigation + quantity used for initial establishment of the crop + effective rainfall, were worked out to be 1431 mm (1170 + 200 + 61) and 771 mm (510 + 200 + 61) during first year and 1398 mm (1170 + 200 + 28) and 708 mm (480 + 200 + 28) during second year for i_1 and i_2, respectively. The total irrigation duration for i_1 and i_2 were 78 and 34 for the first year and 78 and 32 for the second year, respectively. The water saving in per cent were 25 and 67 during first year and 25 and 69 during second year for i_1 and i_2, respectively compared to farmers practice of pot watering at the rate of 4 l plant^{-1}.

4.6. Plant Analysis

4.6.1. Nutrient content of fruits

4.6.1.1. Effect of N, G and I (Table 18)

The data revealed that N content of fruits varied significantly due to applied N, during the first year. The level n_4 recorded the highest N content of fruits (2.66 %) and it was on par with n_3. During the second year, N, G and I significantly influenced the N content of fruits. Among the N levels, n_4 was significantly

Table 18 Effect of N, G and I on nutrient content of fruits

Effect	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	2.33	2.44	0.40	0.42	2.22	1.86
n_2	2.50	2.53	0.43	0.42	2.22	1.89
n_3	2.58	2.58	0.44	0.45	2.24	1.89
n_4	2.66	2.65	0.46	0.45	2.26	1.93
$F_{3, 44}$	**12.31****	**39.74****	**1.73**	**2.90***	**1.26**	**4.69****
g_1	2.48	2.41	0.41	0.44	2.21	1.88
g_2	2.51	2.49	0.42	0.43	2.24	1.86
g_3	2.56	2.66	0.44	0.44	2.24	1.90
g_4	2.52	2.65	0.46	0.45	2.24	1.93
$F_{3, 44}$	**0.72**	**73.77****	**1.44**	**0.47**	**0.82**	**5.87****
C.D. (0.05) N/G	**0.117**	**0.038**	–	**0.030**	–	**0.036**
i_1	2.53	2.53	0.44	0.43	2.24	1.89
i_2	2.51	2.57	0.42	0.45	2.22	1.90
$F_{1, 44}$	**0.22**	**10.58****	**0.99**	**3.29**	**1.14**	**0.14**
C.D. (0.05)	-	**0.029**	-	-	-	-
Control 1	1.90	1.66	0.33	0.34	1.50	2.07
Control 2	1.82	1.77	0.31	0.34	1.40	1.98

* Significant at 0.05 level
** Significant at 0.01 level

superior to the other three levels. As regards G, g_3 recorded the highest fruit N content (2.66%) which was on par with g_4 (2.65%). The irrigation frequency i_2 recorded significantly higher N content (2.57%) than i_1 (2.53%).

None of the main effects exerted significant influence on the P content of fruits during the first year. However, during the second year, N levels significantly influenced it with n_3 and n_4 recording significantly higher values (each 0.45%) compared to n_2 and n_1 (each 0.42%).

The main effects N, G and I did not influence the K content of fruits significantly during the first year. However, during the second year, n_4 topped the N levels registering the highest value of 1.93 per cent although it was on par with n_2 and n_3. Among the different levels of G, g_4 recorded the highest K content of 1.93 per cent, and it was which was on par with g_3.

4.6.1.2. Interaction effect of N, G and I (Table 19)

During the first year, NG and NI interactions did not significantly influence the N content of fruits. However, GI interaction was significant. Except g_1i_1 and g_4i_1 all other combinations of G with i_1 and i_2 recorded significantly higher N content of fruits. The interaction effect of NG was significant during the second year. Among the NG combinations, n_4g_4 and n_3g_4 recorded significantly higher fruit N content than others, emphasising the positive effect of higher levels of N and G, in their combination also.

The NG interaction was found to influence the P content of fruit during both the years. During the first year, at n_1, n_3 and n_4 levels of N, g_2, g_3 and g_4 were

Table 19 Interaction effect of N, G and I on nutrient content of fruits

Effect	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	2.26	2.27	0.35	0.39	2.20	1.79
n_1g_2	2.35	2.39	0.36	0.46	2.20	1.87
n_1g_3	2.35	2.60	0.43	0.42	2.25	1.94
n_1g_4	2.35	2.50	0.46	0.42	2.23	1.97
n_2g_1	2.45	2.45	0.37	0.40	2.19	1.77
n_2g_2	2.46	2.52	0.42	0.41	2.26	1.81
n_2g_3	2.49	2.65	0.42	0.43	2.18	1.84
n_2g_4	2.60	2.48	0.53	0.45	2.23	1.88
n_3g_1	2.60	2.40	0.40	0.39	2.25	1.79
n_3g_2	2.65	2.50	0.42	0.49	2.23	1.82
n_3g_3	2.59	2.64	0.47	0.46	2.24	2.01
n_3g_4	2.50	2.76	0.47	0.47	2.24	2.02
n_4g_1	2.60	2.50	0.39	0.44	2.20	1.75
n_4g_2	2.59	2.54	0.43	0.47	2.26	1.83
n_4g_3	2.82	2.74	0.51	0.45	2.30	2.11
n_4g_4	2.65	2.84	0.50	0.45	1.37	2.09
$F_{9,44}$	**0.87**	**7.39****	**2.48***	**2.32***	**0.80**	**32.83****
C.D. (0.05)	–	**0.082**	**0.102**	**0.060**	--	**0.073**

n_1i_1	2.32	2.47	0.39	0.42	2.22	1.88
n_1i_2	2.33	2.46	0.41	0.42	2.22	1.91
n_2i_1	2.52	2.52	0.44	0.41	2.23	1.91
n_2i_2	2.48	2.53	0.43	0.44	2.20	1.87
n_3i_1	2.54	2.54	0.47	0.44	2.26	1.91
n_3i_2	2.62	2.61	0.41	0.47	2.22	1.95
n_4i_1	2.73	2.62	0.47	0.45	2.26	1.87
n_4i_2	2.60	2.69	0.44	0.46	2.26	1.85
$F_{3,44}$	**1.18**	**0.95**	**0.92**	**0.37**	**0.26**	**2.38**
g_1i_1	2.43	2.40	0.39	0.42	2.22	1.91
g_1i_2	2.52	2.41	0.43	0.45	2.20	1.95
g_2i_1	2.46	2.46	0.43	0.41	2.23	1.87
g_2i_2	2.56	2.51	0.42	0.45	2.25	1.85
g_3i_1	2.52	2.64	0.47	0.46	2.26	1.91
g_3i_2	2.61	2.67	0.40	0.42	2.23	1.89
g_4i_1	2.43	2.60	0.47	0.42	2.26	1.87
g_4i_2	2.62	2.69	0.45	0.47	2.22	1.89
$F_{3,44}$	**3.04***	**1.42**	**1.48**	**2.79**	**0.57**	**2.09**
C.D. (0.05)	**0.165**	-	-	-	-	-

* Significant at 0.05 level
** Significant at 0.01 level

on par and significantly superior to g_1. However, at n_2, g_4 was significantly superior to other levels of G. During the second year also NG interaction significantly influenced the P content of fruits. At n_1 and n_3 levels of N, g_2, g_3 and g_4 were on par and superior to g_1. However, at n_2 and n_4, all the levels of G were on par.

None of the interactions significantly influenced the K content of fruits during the first year. However, during the second year, NG interaction influenced the K content significantly. Among the various combinations of N and G, n_4g_3 and n_4g_4 were on par and superior to others.

4.6.2. Nutrient content of plant parts

4.6.2.1. Effect of N, G and I (Table 20)

During the first year, N content of plant parts varied significantly due to N and G levels. Among the different levels of N, n_3 and n_4 were on par and significantly superior to n_1 and n_2. Among the levels of G, g_2, g_3 and g_4 were on par and g_3 was significantly superior to g_1. In the second year, all the main effects significantly influenced the N content of plant parts, with n_3 registering significantly higher value (2.14%) compared to n_1, n_2 and n_4. Among the levels of G, g_3 and g_4 were on par and superior to g_1 and g_2. Comparing irrigation treatments, i_2 registered significantly higher N content than i_1.

Regarding P content of plant parts, irrigation frequency alone significantly influenced it during the first year and i_1 recorded a significantly higher value (0.34%) than i_2 (0.30%). However, during the second year, N significantly influenced it and n_2, n_3 and n_4 were found to be on par and superior to n_1.

Table 20 Effect of N, G and I on nutrient content of plant parts

Effect	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	1.90	1.85	0.32	0.28	1.30	1.53
n_2	1.95	1.93	0.32	0.32	1.31	1.68
n_3	2.03	2.14	0.32	0.32	1.32	1.68
n_4	2.10	2.06	0.33	0.31	1.38	1.68
$F_{3,44}$	**10.65****	**189.72****	**0.21**	**7.60****	**12.31****	**39.34****
g_1	1.93	1.90	0.32	0.31	1.30	1.63
g_2	1.99	1.94	0.31	0.30	1.32	1.62
g_3	2.07	2.06	0.32	0.31	1.33	1.63
g_4	1.99	2.07	0.34	0.31	1.35	1.69
$F_{3,44}$	**4.23***	**84.19****	**0.77**	**0.20**	**3.36***	**6.39****
C.D. (0.05) N/G	**0.077**	**0.027**	–	**0.022**	**0.030**	**0.034**
i_1	2.00	1.95	0.34	0.31	1.35	1.64
i_2	1.99	2.03	0.30	0.30	1.31	1.65
$F_{1,44}$	**0.21**	**72.06****	**5.47***	**0.63**	**12.74****	**0.48**
C.D. (0.05)	–	**0.019**	**0.032**	--	**0.021**	–
Control 1	1.64	1.42	0.26	0.25	1.23	1.31
Control 2	1.50	1.47	0.22	0.25	1.16	1.31

* Significant at 0.05 level
** Significant at 0.01 level

As far as K content of plant parts was concerned, in the first year, N, G and I significantly influenced it. Comparing levels of N, n_4 was significantly superior to n_1, n_2 and n_3 which were on par. Among the different levels of ethephon, g_2, g_3 and g_4 were on par and superior to g_1. When the irrigation frequencies were compared, i_1 recorded significantly higher K content of plant parts (1.35%) than i_2 (1.31%).

In the second year, N and G influenced the K content of plant parts. The N levels n_2, n_3 and n_4 recorded a K content of 1.68 per cent in plant parts compared to n_1 (1.53%). Among the levels of G, g_4 was significantly superior to g_1, g_2 and g_3.

4.6.2.2. Interaction effect of N, G and I (Table 21)

The interaction effect due to NG and GI significantly influenced the N content of plant parts during the first year. At g_1 and g_2, the higher levels of N viz., n_2, n_3 and n_4 were on par. However, at g_3 and g_4, n_4 was significantly superior to all other levels of N. As far as GI interactions were concerned, at i_1 level of irrigation, g_2 and g_3 were on par and superior to g_1 and g_4. But at i_2, levels g_3 and g_4 were on par and superior to g_1 and g_2.

Comparing different interactions, NG and NI were significant in the second year. At n_1, n_2 and n_4, levels of N, g_3 and g_4 were on par and superior to g_1 and g_2. However, at n_3, g_4 was significantly superior to all other levels of G. Coming to NI interactions, except n_1, at all other levels of N, i_1 was significantly superior to i_2. At n_1, i_1 and i_2 were on par.

Table 21 Interaction effect of N, G and I on the nutrient content of plant parts

Effect	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	1.87	1.81	0.29	0.26	1.26	1.35
n_1g_2	1.92	1.83	0.31	0.26	1.29	1.51
n_1g_3	1.91	1.90	0.34	0.29	1.30	1.65
n_1g_4	1.95	1.88	0.33	0.30	1.43	1.62
n_2g_1	1.90	1.88	0.34	0.27	1.29	1.50
n_2g_2	1.99	1.87	0.30	0.29	1.28	1.71
n_2g_3	2.04	1.97	0.31	0.33	1.30	1.81
n_2g_4	1.89	1.98	0.32	0.38	1.37	1.68
n_3g_1	2.05	1.99	0.33	0.30	1.33	1.50
n_3g_2	2.05	2.08	0.30	0.32	1.37	1.59
n_3g_3	2.02	2.19	0.33	0.31	1.32	1.48
n_3g_4	1.98	2.28	0.35	0.37	1.50	2.16
n_4g_1	1.92	1.93	0.30	0.26	1.26	1.59
n_4g_2	2.09	1.98	0.34	0.34	1.33	1.74
n_4g_3	2.30	2.18	0.32	0.32	1.29	1.65
n_4g_4	2.15	2.15	0.37	0.33	1.29	1.74
$F_{9,44}$	**3.36****	**6.85****	**0.46**	**6.83****	**10.75****	**83.87****
C.D. (0.05)	**0.154**	**0.053**	-	**0.043**	**0.060**	**0.068**

n_1i_1	1.89	1.87	0.31	0.27	1.32	1.50
n_1i_2	1.91	1.84	0.33	0.29	1.32	1.57
n_2i_1	1.98	1.95	0.35	0.34	1.34	1.68
n_2i_2	1.92	1.90	0.28	0.30	1.28	1.68
n_3i_1	2.04	2.20	0.34	0.32	1.41	1.70
n_3i_2	2.01	2.07	0.31	0.32	1.35	1.66
n_4i_1	2.09	2.11	0.36	0.32	1.32	1.68
n_4i_2	2.11	2.01	0.31	0.31	1.28	1.68
$F_{3,44}$	**0.51**	**5.73****	**1.42**	**2.74**	**2.32**	**3.32***
C.D. (0.05)	-	**0.038**	-	-	-	**0.048**
g_1i_1	1.95	1.88	0.35	0.31	1.34	1.70
g_1i_2	1.92	1.93	0.28	0.30	1.32	1.67
g_2i_1	2.06	1.91	0.33	0.30	1.34	1.62
g_2i_2	1.92	1.97	0.29	0.31	1.31	1.62
g_3i_1	2.09	2.00	0.33	0.33	1.31	1.60
g_3i_2	2.05	2.12	0.31	0.30	1.29	1.66
g_4i_1	1.91	2.03	0.35	0.31	1.39	1.63
g_4i_2	2.07	2.11	0.34	0.31	1.31	1.63
$F_{3,44}$	**5.41****	**2.48**	**0.81**	**1.51**	**2.37**	**2.21**
C.D. (0.05)	**0.109**	-	-	-	-	-

* Significant at 0.05 level
** Significant at 0.01 level

In the case of P content of plant parts, during the first year, none of the interactions were significant. However, during the second year, NG interactions significantly influenced it. At n_2 and n_3, the highest level of G ie., g_4 produced significantly higher P content while at n_4, g_2, g_3 and g_4 were on par. At the lowest levels of N ie., n_1 g_3 and g_4 were on par and superior to g_1 and g_2.

Regarding K content of plant parts, interaction effect due to NG was significant in the first year. At n_1, n_2 and n_3, the highest level of G, viz., g_4 recorded significantly higher K content than the lower levels of G, whereas at n_4, g_2, g_3 and g_4 were on par. In the second year, NG and NI interactions were significant. At the lowest level of N, ie., n_1, g_3 and g_4 were on par and superior to g_1 and g_2. At n_2, g_3 was significantly superior to other levels of G. At n_3, g_4 was significantly superior and at n_4, g_2 and g_4 recorded the same value for plant parts and it was significantly higher compared to g_1 and g_3. Coming to NI interactions, both at i_1 and i_2, K content of plant parts was significantly inferior at n_1 compared to that at other levels of N.

4.6.3. Nutrient uptake

4.6.3.1. Effect of N, G and I (Table 22 and Fig. 8)

Nitrogen uptake was significantly influenced by applied N during the first year and n_3 recorded the highest uptake of 44.01 kg ha^{-1} on par with n_4 (40.67 kg ha^{-1}). During the second year, applied N and G significantly influenced it. As in the case of the previous year, n_3 recorded the highest N uptake of 37.99 kg ha^{-1} which was on par with n_4 (36.23 kg ha^{-1}). Among the different levels of G, g_4 recorded a significantly higher uptake value of 41.43 kg ha^{-1} compared to g_1, g_2 and g_3.

Table 22 Effect of N, G and I on nutrient uptake (kg ha $^{-1}$) by the whole plant

Effect	Nitrogen		Phosphorus		Potassium	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	30.44	26.99	5.05	4.43	25.33	21.74
n_2	39.29	31.89	6.52	5.54	31.39	26.39
n_3	44.01	37.99	7.13	6.79	32.78	27.30
n_4	40.67	36.23	7.00	6.15	33.40	29.90
$F_{3, 44}$	**17.51****	**16.81****	**12.81****	**42.03****	**12.73****	**36.20****
g_1	37.49	23.32	6.10	4.18	28.61	19.41
g_2	40.46	30.79	6.33	5.20	32.86	24.19
g_3	36.73	37.68	6.26	6.38	29.91	29.61
g_4	39.72	41.43	7.00	7.14	31.51	32.13
$F_{3, 44}$	**1.64**	**44.90****	**2.23**	**70.91****	**3.22***	**100.91****
C D (0.05) N/G	**3.945**	**3.441**	**0.766**	**0.444**	**2.973**	**1.624**
i_1	39.07	32.98	6.66	5.66	31.20	26.14
i_2	38.13	33.57	6.19	5.79	30.24	26.52
$F_{1, 44}$	**0.46**	**0.24**	**3.15**	**0.62**	**0.85**	**0.45**
Control 1	19.62	17.77	3.12	2.77	18.58	13.43
Control 2	16.83	16.61	2.59	2.65	16.38	13.34

* Significant at 0.05 level
** Significant at 0.01 level

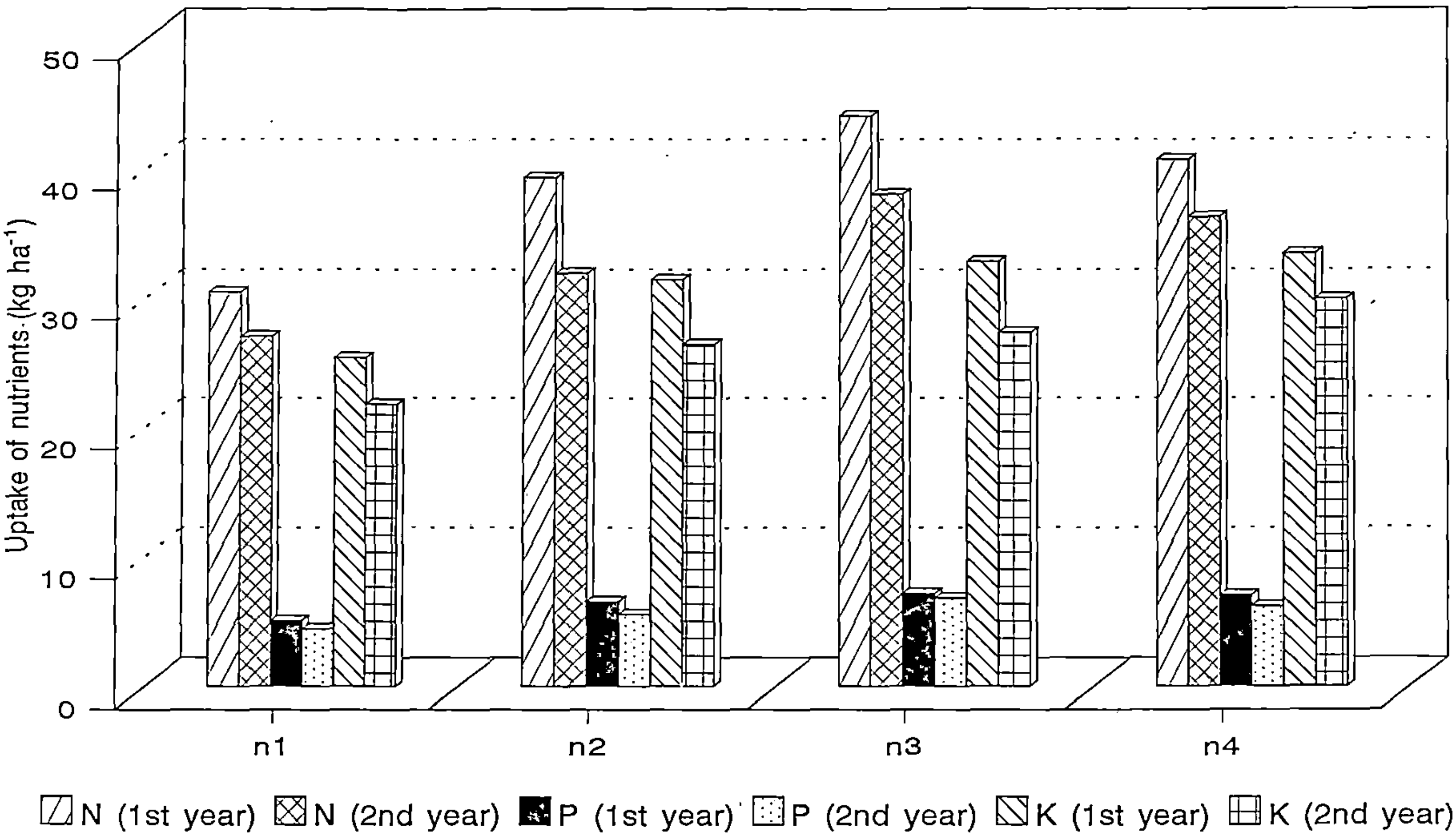


Fig. 8. Effect of N on the uptake of nutrients

The uptake of phosphorus varied significantly due to N application during the first year and n_2, n_3 and n_4 were on par recording uptake values of 6.52, 7.13 and 7.00 kg ha^{-1} respectively compared to n_1 (5.05 kg ha^{-1}). However, during the second year, both N and G significantly influenced the P uptake. Comparing different levels of N, n_3 recorded the highest uptake of 6.79 kg ha^{-1} which was significantly higher than the other levels of N. Among the different levels of G, g_4 recorded the highest uptake of 7.14 kg ha^{-1} which was significantly higher than the lower levels of G. During both the years, irrigation frequency was not significant.

K uptake varied significantly due to N and G during both the years of experimentation. During the first year, n_4 recorded the highest uptake of 33.40 kg ha^{-1}, on par with n_3 (32.78) and n_2 (31.39 kg ha^{-1}). Comparing different levels of G, g_2, g_3 and g_4 were on par and superior to g_1. During the second year, also n_4 recorded the highest uptake of 29.90 kg ha^{-1} and it was significantly superior to n_3, n_2 and n_1. Among the different levels of G, g_4 recorded the highest uptake (32.13 kg ha^{-1}) and it was significantly higher than g_3 (29.61), g_2 (24.19) and g_1 (19.41). Irrigation treatments did not have any significant impact on K uptake during both the years.

4.6.3.2. Interaction effect of N, G and I (Table 23)

The interactions of NG, NI and GI were not significant on the uptake of N and P during the first year. However, K uptake was significantly influenced by NI interactions. For the irrigation treatment i_1, K uptake of n_2, n_3 and n_4 were on par and superior to n_1. However, for i_2, K uptake of n_4 and n_3 were on par and superior to n_1 and n_2. During the second year, NG interactions had a significant impact on N,

Table 23 Interaction effect of N, G and I on nutrient uptake (kg ha $^{-1}$) by the whole plant

Effect	Nitrogen		Phosphorus		Potassium	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	28.74	20.92	4.70	3.55	21.68	17.17
n_1g_2	31.54	25.40	4.76	4.33	26.55	21.37
n_1g_3	29.96	30.25	4.92	4.80	25.83	23.14
n_1g_4	31.51	31.37	5.82	5.04	27.25	25.27
n_2g_1	39.07	22.92	6.00	3.87	28.88	19.09
n_2g_2	43.22	33.12	6.42	5.64	35.00	25.79
n_2g_3	35.59	39.41	6.75	6.58	28.78	33.98
n_2g_4	39.29	32.11	6.91	6.06	32.90	26.72
n_3g_1	25.16	38.50	7.80	4.94	35.45	21.69
n_3g_2	32.02	44.22	6.47	5.55	35.22	25.88
n_3g_3	40.31	46.60	6.18	7.85	29.03	33.21
n_3g_4	54.48	46.73	8.08	8.82	31.40	38.84
n_4g_1	23.80	34.78	5.90	4.36	33.63	19.70
n_4g_2	32.64	42.87	7.68	5.29	34.68	23.72
n_4g_3	40.74	41.37	7.21	6.29	30.80	28.12
n_4g_4	47.75	43.67	7.21	8.64	34.50	37.69
$F_{9, 44}$	**1.31**	**4.48****	**1.50**	**6.34****	**1.16**	**9.82****
C.D. (0.05)	--	**6.882**	–	**0.888**	--	**3.247**

n_1i_1	31.62	26.67	4.92	4.49	25.39	21.71
n_1i_2	29.25	27.30	5.18	4.37	25.26	22.27
n_2i_1	41.30	31.73	6.77	5.65	34.45	26.58
n_2i_2	37.28	32.05	6.27	5.43	28.33	26.21
n_3i_1	39.18	35.96	7.75	6.51	33.61	29.78
n_3i_2	42.17	36.50	6.51	7.07	31.94	30.02
n_4i_1	44.20	37.56	7.20	6.01	33.03	27.00
n_4i_2	43.83	38.42	6.80	6.28	33.78	27.61
$F_{3,44}$	**1.19**	**0.01**	**1.34**	**1.35**	**2.89***	**0.28**
g_1i_1	39.62	22.43	6.14	4.13	30.51	19.06
g_1i_2	35.37	23.96	6.06	4.24	29.30	19.76
g_2i_1	42.82	31.48	6.88	5.04	34.41	24.63
g_2i_2	38.11	30.10	5.78	5.36	31.31	23.75
g_3i_1	34.93	37.00	6.36	6.53	28.11	28.75
g_3i_2	38.54	38.35	6.17	6.23	29.10	30.47
g_4i_1	38.93	41.00	7.27	6.96	31.76	32.13
g_4i_2	40.52	41.85	6.74	7.31	31.26	32.12
$F_{3,44}$	**1.19**	**0.31**	**0.31**	**0.91**	**0.67**	**0.94**
C.D. (0.05)	–	–	–	–	**4.204**	–

* Significant at 0.05 level
** Significant at 0.01 level

P and K uptake by plants. As far as N uptake was concerned, at the lowest level of G viz., g_1 all the levels of N were on par. But at g_2 and g_3, n_2, n_3 and n_4 were on par and superior to n_1. At g_4, n_3 and n_4 were on par and significantly superior to n_1 and n_2.

With respect to P uptake, at the lowest level of N viz., n_1, g_2, g_3 and g_4 were on par and superior to g_1. At n_2, g_3 and g_4 were on par and better than g_1 and g_2. At the higher levels of N viz., n_3 and n_4, g_4 recorded significantly higher P uptake than the other levels of G. Considering K uptake, at the lowest level of N ie., n_1, g_3 and g_4 were on par and superior to g_1 and g_2. At n_2, g_3 was significantly superior to the other levels of G. At n_3 and n_4, g_4 recorded the highest uptake and was significantly superior to the lower levels of G.

4.7. Quality of fruits

The quality of fruits was assessed in terms of moisture (%), TSS (^{0} brix), acidity (%), total sugar (%), reducing sugar (%), ascorbic acid (mg 100 g^{-1}), crude protein (%) and crude fibre (%).

4.7.1. Effect of N, G and I (Tables 24, 25, 26 and 27 and Fig. 9)

A critical review of the data recorded in the first year revealed that the moisture content of fruits was significantly influenced by N, G and I. The level n_4 recorded the highest moisture content of 96.29 per cent and it was on par with n_3 (96.08%) and n_2 (96.20%). The lowest moisture content of 95.51 per cent was recorded by n_1. Comparing different levels of G, g_3 recorded the highest moisture content (96.44%) which was on par with g_4 (96.08%). The levels g_1 and g_2 were on par and recorded significantly lower moisture content than g_3 and g_4. As far as irrigation treatments were concerned, i_1 recorded significantly higher moisture content (96.3%) than i_2 (95.74%).

In the second year, none of the main effects had significant effect on fruit moisture content.

During both the years, the TSS content of fruits was not significantly influenced by N, ethephon and frequency of irrigation.

The data revealed that the acidity of fruits varied significantly due to the irrigation treatments in the first year and i_1 recorded a higher value of 0.13 per cent compared to i_2 (0.12%). However, N and G did not have any significant effect on acidity. During the following year, acidity varied significantly due to N. The highest value of 0.12 per cent was recorded by n_4, n_3 and n_2 and they were significantly superior to n_1 (0.11%).

A perusal of the data showed that total sugars varied significantly due to N application during the second year only. The level n_4 recorded the highest total sugar content of 3.01 per cent on par with n_2 (2.95%). But n_2 was on par with n_3 (2.90%). Depending on the level of G, the total sugar content varied significantly in both the years. In the first year, the highest sugar content was recorded by g_4 (2.74%) which was on par with g_3 (2.54%) and g_2 (2.54%) whereas during the next year, g_3 recorded the highest sugar content of 3.14 per cent on par with g_4 (3.10%).. The total sugar content was influenced by irrigation treatments during the second year only and i_2 (3.0%) was significantly superior to i_1 (2.87%).

Table 24 Effect of N, G and I on the moisture, TSS, acidity, total and reducing sugar content of fruits - I Year (1994-'95)

Effect	Moisture (%)	TSS (^{0}brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)
n_1	95.51	2.46	0.12	2.45	2.09
n_2	96.20	2.54	0.12	2.46	2.09
n_3	96.08	2.76	0.13	2.68	2.19
n_4	96.29	2.70	0.13	2.63	2.27
$F_{3, 44}$	**5.82****	**1.83**	**0.93**	**1.30**	**1.43**
g_1	95.66	2.55	0.11	2.31	2.11
g_2	95.90	2.61	0.12	2.54	2.17
g_3	96.44	2.74	0.14	2.54	2.15
g_4	96.08	2.56	0.13	2.74	2.21
$F_{3, 44}$	**5.04****	**0.69**	**1.92**	**3.21***	**0.39**
C D (0.05) N/G	**0.420**	--	--	**0.292**	--
i_1	96.30	2.57	0.13	2.60	2.16
i_2	95.74	2.66	0.12	2.52	2.16
$F_{1, 44}$	**14.95****	**0.83**	**4.13***	**0.57**	**0.00**
C D (0.05)	**0.297**	--	**0.016**	--	--
Control 1	95.80	2.20	0.08	1.85	1.63
Control 2	94.13	2.55	0.08	1.72	1.52

* Significant at 0.05 level
** Significant at 0.01 level

Table 25 Effect of N, G and I on the ascorbic acid, crude protein and crude fibre content and shelf life of fruits - I Year (1994-'95)

Effect	Ascorbic acid (mg 100 g^{1})	Crude protein (%)	Crude fibre (%)	Shelf life (days)
n_1	10.03	14.59	24.85	14.09
n_2	11.59	15.63	22.41	12.44
n_3	12.11	16.54	21.63	11.84
n_4	10.85	16.68	20.28	11.19
$F_{3,44}$	**1.20**	**24.41****	**1.14**	**26.77****
g_1	8.93	15.49	22.34	12.34
g_2	10.97	16.17	25.19	12.44
g_3	11.71	16.05	19.38	12.50
g_4	12.96	15.74	22.25	12.28
$F_{3,44}$	**4.17***	**2.46**	**1.74**	**0.16**
C D (0.05) N/G	**2.354**	**0.557**	--	**0.691**
i_1	10.79	16.02	21.66	12.39
i_2	11.49	15.70	22.92	12.39
$F_{1,44}$	**0.71**	**2.59**	**0.49**	**0.00**
Control 1	6.90	10.24	15.88	14.38
Control 2	7.20	9.38	16.38	14.13

* Significant at 0.05 level
** Significant at 0.01 level

Table 26 Effect of N, G and I on the moisture, TSS, acidity, total and reducing sugar content of fruits - II Year (1995-'96)

Effect	Moisture (%)	TSS (^{0} brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)
n_1	94.62	2.46	0.11	2.89	1.90
n_2	95.04	2.54	0.12	2.95	1.91
n_3	94.59	2.70	0.12	2.90	1.90
n_4	95.09	2.70	0.12	3.01	1.97
$F_{3, 44}$	**0.82**	**1.25**	**3.93***	**4.73****	**1.58**
g_1	94.82	2.55	0.12	2.60	1.79
g_2	94.76	2.61	0.11	2.90	1.88
g_3	95.02	2.68	0.12	3.14	1.99
g_4	94.73	2.56	0.12	3.10	2.02
$F_{3, 44}$	**0.20**	**0.28**	**1.15**	**86.74****	**12.46****
C D (0.05) N/G	–	–	**0.011**	**0.075**	**0.085**
i_1	94.70	2.54	0.12	2.87	1.86
i_2	94.97	2.66	0.11	3.00	1.97
$F_{3, 44}$	**0.82**	**1.37**	**1.88**	**25.79****	**13.51****
C D (0.05)	–	–	–	**0.053**	**0.060**
Control 1	93.95	2.20	0.09	2.23	1.65
Control 2	93.15	2.55	0.08	2.21	1.65

* Significant at 0.05 level
** Significant at 0.01 level

Table 27 Effect of N, G and I on the ascorbic acid, crude protein and crude fibre content and shelf life of fruits - II Year (1995-'96)

Effect	Ascorbic acid (mg 100 g^{1})	Crude protein (%)	Crude fibre (%)	Shelf life (days)
n_1	5.69	15.24	15.41	13.38
n_2	6.01	15.79	15.02	12.31
n_3	6.21	16.10	14.85	12.13
n_4	6.09	16.59	14.93	11.69
$F_{3, 44}$	**0.95**	**39.99****	**0.09**	**13.66****
g_1	5.76	15.04	15.16	12.28
g_2	5.99	15.54	15.55	12.78
g_3	6.24	16.60	15.50	12.25
g_4	6.03	16.53	13.99	12.19
$F_{3, 44}$	**0.77**	**74.08****	**0.78**	**1.99**
C D (0.05) N/G	--	**0.254**	--	**0.552**
i_1	6.13	16.07	14.95	12.41
i_2	5.88	15.78	15.16	12.34
$F_{1, 44}$	**1.26**	**10.69****	**0.06**	**0.10**
C D (0.05)	--	**0.180**	--	--
Control 1	4.28	10.38	12.90	13.50
Control 2	4.00	11.05	14.00	12.88

** Significant at 0.01 level

None of the main effects had significant effect on the reducing sugar content of fruits in the first year. However, in the second year, it varied significantly due to G and I. The level g_4 recorded the highest value of 2.02 per cent and it was on par with g_3 (1.99%). The irrigation frequency i_2 recorded significantly higher content (1.97%) than i_1 (1.86%).

Regarding ascorbic acid content of fruits, among the main effects, G only influenced it significantly during the first year with g_4 recording the highest content of 12.96 mg 100 g^{-1} which was on par with those of g_3 (11.71) and g_2 (10.97). The same trend was noticed during the second year also, but the magnitude of increase in ascorbic acid content due to the incremental doses of G did not show statistical significance.

The crude protein content of fruits showed significant variation due to N, during the first year and n_4 registered the highest value of 16.68 per cent which was on par with n_3 (16.54%). However, during the second year, N, G and I had significant influence on this attribute. The level n_4 recorded a protein content of 16.59 per cent which was significantly superior to all the other levels of N. Among the different levels of G, g_3 registered the highest protein content of 16.60 per cent which was on par with g_4 (16.53%). Comparing the irrigation treatments, i_1 recorded a significantly higher protein content of 16.07 per cent compared to i_2 (15.78%)

The crude fibre content of fruits showed a decreasing trend with an increase in the level of N. However, the magnitude of decrease was not statistically

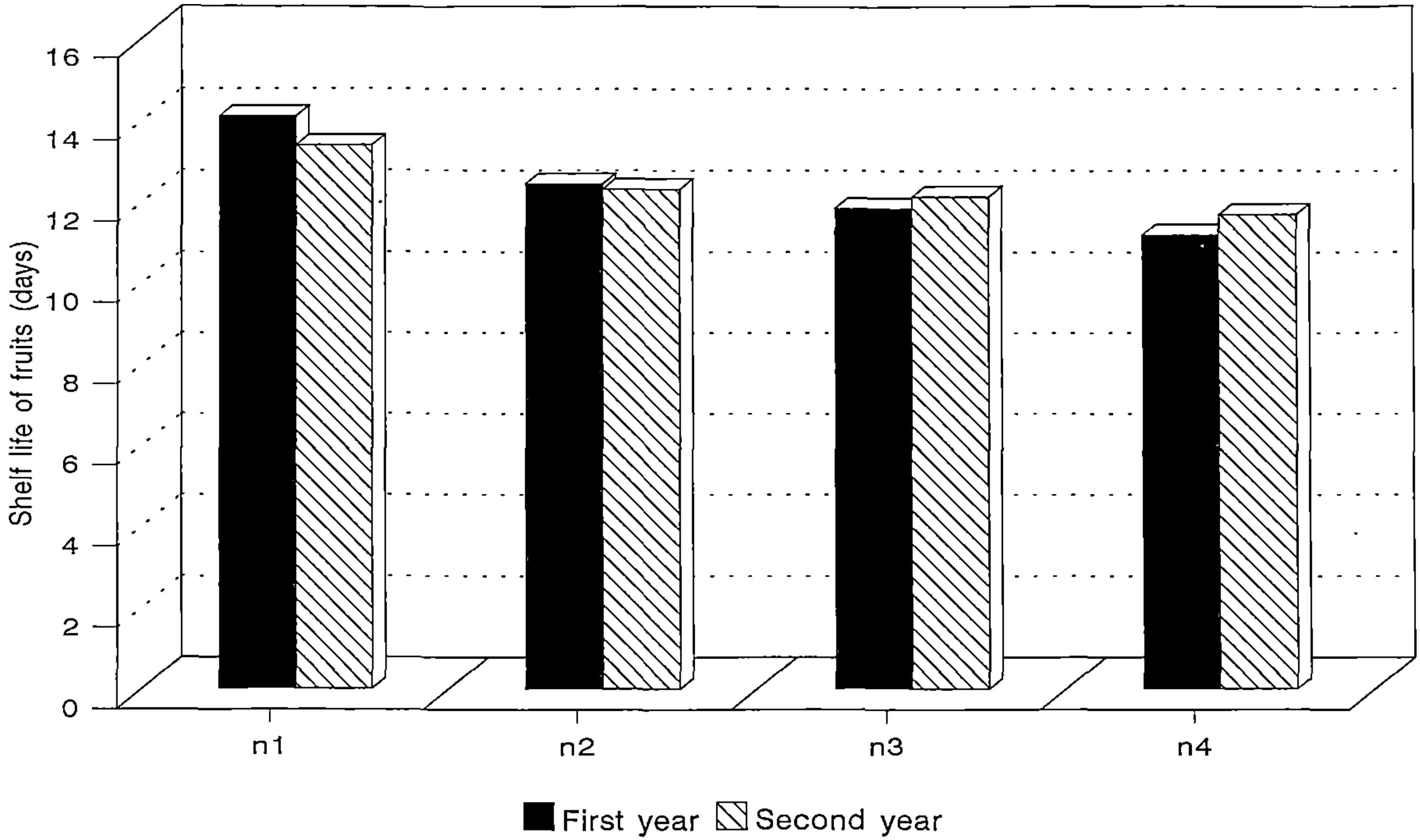


Fig. 9. Effect of N on shelf life of fruits

significant during both the years. G and I also did not significantly influence this attribute during any of the years of experimentation.

The shelf life of fruits was significantly influenced by N during both the years. It showed a decreasing trend with an increase in the level of applied N. Among the different levels of N, n_1 was significantly superior to the other three levels, recording 14.09 and 13.38 days, during the first and second years, respectively.

4.7.2. Interaction effect of N, G and I (Tables 28, 29, 30 and 31)

Moisture content of fruits varied significantly due to NG interaction during the first year and NI interaction during the second year. At the lowest level of N, ie., n_1, g_3 recorded significantly higher moisture content over g_1, g_2 and g_4. At n_2, g_4 was significantly superior to other levels of G. At n_3, g_2, g_3 and g_4 were on par and superior to g_1. At the highest level of N ie., n_4, all the levels of G were on par. Among the NI interactions, n_1i_2 recorded significantly lower moisture content compared to the other combinations.

Eventhough none of the interactions significantly influenced the TSS content of fruits in the second year, it varied significantly due to NG interactions, in the first year. At n_1 and n_2 ie., lower levels of N, there was no significant variation among the various levels of G. However, at n_3, g_2, g_3 and g_4 were on par and superior to g_1. At n_4 ie., highest dose of N, g_3 and g_4 were on par and superior to g_1 and g_2.

Acidity was influenced by NI interactions during the first year. All i_1 combinations of N recorded higher values than i_2 combinations. All i_1 combinations of N were on par; all i_2 combinations of N were also on par. During the second

Table 28 Interaction effect of N, G and I on the moisture, TSS, acidity, total and reducing sugar content of fruits - I Year (1994-'95)

Effect	Moisture (%)	TSS (⁰ brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)
n_1g_1	94.83	2.15	0.10	2.43	2.01
n_1g_2	95.58	2.55	0.10	2.70	1.77
n_1g_3	96.48	2.50	0.16	2.54	1.98
n_1g_4	95.15	2.65	0.11	2.97	2.30
n_2g_1	95.83	2.45	0.11	2.14	2.11
n_2g_2	95.78	2.45	0.14	2.30	2.12
n_2g_3	96.15	2.55	0.09	2.40	2.42
n_2g_4	95.80	2.70	0.14	2.80	2.31
n_3g_1	95.70	2.45	0.11	2.52	2.11
n_3g_2	96.25	2.70	0.13	2.70	2.06
n_3g_3	96.55	2.75	0.15	2.65	2.67
n_3g_4	97.05	3.15	0.14	2.85	2.31
n_4g_1	96.27	2.25	0.13	2.18	1.91
n_4g_2	96.00	2.60	0.11	2.42	2.00
n_4g_3	96.60	2.75	0.15	2.41	2.49
n_4g_4	96.30	3.20	0.13	2.85	2.27
$F_{9, 44}$	**2.44***	**2.13***	**1.87**	**0.84**	**3.75****
C.D. (0.05)	**0.839**	**0.587**	--	--	**0.414**

n_1i_1	95.86	2.33	0.13	2.28	2.05
n_1i_2	95.15	2.60	0.11	2.59	2.12
n_2i_1	96.26	2.58	0.13	2.62	2.20
n_2i_2	96.19	2.50	0.11	2.68	2.19
n_3i_1	96.49	2.68	0.14	2.45	2.32
n_3i_2	95.68	2.85	0.13	2.48	2.21
n_4i_1	96.65	2.70	0.16	2.63	2.06
n_4i_2	95.94	2.70	0.10	2.73	2.13
$F_{3,44}$	**1.50**	**0.60**	**4.10***	**0.60**	**0.36**
g_1i_1	96.15	2.50	0.13	2.30	2.16
g_1i_2	95.18	2.60	0.10	2.32	2.27
g_2i_1	96.04	2.45	0.13	2.53	2.27
g_2i_2	95.76	2.77	0.11	2.46	2.08
g_3i_1	96.59	2.68	0.14	2.62	2.15
g_3i_2	96.30	2.80	0.13	2.54	2.15
g_4i_1	96.44	2.65	0.13	2.94	2.06
g_4i_2	95.71	2.48	0.13	2.75	2.15
$F_{3,44}$	**1.26**	**0.99**	**0.92**	**0.99**	**0.91**
C.D. (0.05)	--	--	**0.032**	--	--

* Significant at 0.05 level
** Significant at 0.01 level

Table 29 Interaction effect of N, G and I on the ascorbic acid, crude protein and crude fibre content and shelf life of fruits - I Year (1994-'95)

Effect	Ascorbic acid (mg 100 g[1])	Crude protein (%)	Crude fibre (%)	Shelf life (days)
n_1g_1	7.98	14.14	23.38	14.25
n_1g_2	11.00	14.69	31.75	14.13
n_1g_3	10.43	14.67	21.65	14.13
n_1g_4	10.70	14.86	22.63	13.88
n_2g_1	8.63	15.33	21.00	12.38
n_2g_2	10.58	15.36	25.88	12.63
n_2g_3	12.70	15.56	20.00	12.75
n_2g_4	14.45	16.27	22.75	12.00
n_3g_1	11.00	16.20	23.63	11.75
n_3g_2	11.85	16.19	22.63	12.00
n_3g_3	13.15	16.55	18.88	11.88
n_3g_4	12.43	17.17	21.38	11.75
n_4g_1	8.13	16.17	21.38	11.00
n_4g_2	10.45	16.24	20.50	11.00
n_4g_3	10.58	16.53	17.00	11.25
n_4g_4	14.25	17.78	22.25	11.50
$F_{9, 44}$	**0.51**	**1.47**	**0.39**	**0.24**

n_1i_1	9.43	14.51	26.01	13.94
n_1i_2	10.63	14.67	23.69	14.25
n_2i_1	11.54	15.76	20.81	12.56
n_2i_2	11.64	15.50	24.00	12.31
n_3i_1	12.06	16.68	21.81	11.94
n_3i_2	12.15	16.40	21.44	11.75
n_4i_1	10.15	17.13	18.00	11.13
n_4i_2	11.55	16.24	22.56	11.25
$F_{3,44}$	**0.18**	**1.24**	**0.78**	**0.30**
g_1i_1	9.75	15.77	23.13	12.19
g_1i_2	8.11	15.21	21.56	12.50
g_2i_1	9.94	15.95	23.44	12.56
g_2i_2	12.00	16.38	26.94	12.31
g_3i_1	10.64	16.36	16.70	12.50
g_3i_2	12.79	15.74	22.06	12.50
g_4i_1	12.85	16.00	23.38	12.31
g_4i_2	13.06	15.47	21.13	12.25
$F_{3,44}$	**1.18**	**1.67**	**1.08**	**0.24**

Table 30 Interaction effect of N, G and I on the moisture, TSS, acidity, total and reducing sugar content of fruits - II Year (1995-'96)

Effect	Moisture (%)	TSS (^{0} brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)
n_1g_1	94.03	2.70	0.11	2.70	1.80
n_1g_2	94.28	2.75	0.10	2.75	1.98
n_1g_3	95.73	2.90	0.10	3.24	2.03
n_1g_4	94.45	2.45	0.11	3.36	2.10
n_2g_1	94.90	2.25	0.12	2.56	1.78
n_2g_2	95.75	2.75	0.12	2.74	1.81
n_2g_3	95.38	2.60	0.14	2.94	1.99
n_2g_4	94.13	3.20	0.10	3.23	2.05
n_3g_1	94.90	2.70	0.11	2.57	1.83
n_3g_2	94.15	2.45	0.12	2.79	1.87
n_3g_3	94.10	2.55	0.11	2.85	1.99
n_3g_4	95.15	2.45	0.15	3.38	1.90
n_4g_1	95.40	2.55	0.11	2.59	1.76
n_4g_2	94.88	2.50	0.13	2.85	1.86
n_4g_3	94.88	2.65	0.13	2.88	1.88
n_4g_4	95.20	2.15	0.12	3.58	2.10
$F_{9,44}$	**1.32**	**1.74**	**4.14****	**31.13****	**1.42**
C.D. (0.05)	--	--	**0.022**	**0.150**	--

n_1i_1	95.43	2.55	0.12	3.00	1.89
n_1i_2	93.81	2.85	0.09	3.02	2.05
n_2i_1	95.46	2.70	0.12	2.87	1.82
n_2i_2	94.61	2.70	0.11	3.04	1.99
n_3i_1	94.52	2.58	0.12	2.85	1.91
n_3i_2	94.65	2.50	0.12	2.95	1.89
n_4i_1	95.00	2.33	0.12	2.76	1.83
n_4i_2	95.17	2.60	0.12	3.01	1.96
$F_{3,44}$	**3.01***	**0.79**	**6.57****	**3.50***	**2.16**
g_1i_1	94.16	2.50	0.10	2.61	1.74
g_1i_2	95.48	2.60	0.11	2.60	1.84
g_2i_1	94.55	2.45	0.12	2.80	1.87
g_2i_2	94.98	2.78	0.11	3.00	1.89
g_3i_1	95.33	2.55	0.13	3.11	1.91
g_3i_2	94.71	2.80	0.12	3.17	2.06
g_4i_1	94.76	2.65	0.12	2.96	1.93
g_4i_2	94.70	2.48	0.12	3.25	2.11
$F_{3,44}$	**1.95**	**1.07**	**2.47**	**6.74****	**1.50**
C.D. (0.05)	**1.182**	–	**0.016**	**0.106**	--

* Significant at 0.05 level
** Significant at 0.01 level

Table 31 Interaction effect of N, G and I on the ascorbic acid, crude protein and crude fibre content and shelf life of fruits - II Year (1995-'96)

Effect	Ascorbic acid (mg 100 g^{-1})	Crude protein (%)	Crude fibre (%)	Shelf life (days)
n_1g_1	5.85	14.17	13.73	13.13
n_1g_2	5.85	14.91	16.90	14.38
n_1g_3	6.35	16.27	18.55	13.13
n_1g_4	6.28	15.63	12.45	12.88
n_2g_1	4.73	15.34	18.05	12.75
n_2g_2	5.38	15.74	13.98	13.13
n_2g_3	4.83	16.55	14.65	11.75
n_2g_4	6.08	15.52	13.40	11.63
n_3g_1	4.83	15.00	13.75	12.25
n_3g_2	5.90	15.64	16.23	11.88
n_3g_3	6.30	16.49	13.55	12.13
n_3g_4	6.08	17.27	15.88	12.25
n_4g_1	5.48	15.63	15.13	11.00
n_4g_2	6.00	15.89	15.10	11.75
n_4g_3	6.83	17.11	15.25	12.00
n_4g_4	7.83	17.72	14.25	12.00
$F_{9, 44}$	**3.78****	**7.44****	**1.51**	**2.13***
C.D. (0.05)	**1.299**	**0.508**	--	**1.104**

n_1i_1	5.74	15.37	15.14	13.13
n_1i_2	5.65	15.12	15.68	13.63
n_2i_1	5.85	15.82	15.03	12.38
n_2i_2	6.18	15.75	15.01	12.25
n_3i_1	6.64	16.32	14.53	12.13
n_3i_2	5.79	15.88	15.18	12.13
n_4i_1	6.30	16.79	15.10	12.00
n_4i_2	5.89	16.38	14.76	11.38
$F_{3, 44}$	**1.19**	**0.94**	**0.08**	**1.42**
g_1i_1	5.18	15.00	15.21	12.44
g_1i_2	5.60	15.08	15.11	12.13
g_2i_1	5.38	15.72	15.23	12.69
g_2i_2	6.34	15.37	15.88	12.88
g_3i_1	6.30	16.52	14.61	12.19
g_3i_2	6.19	16.69	16.39	12.31
g_4i_1	6.68	16.81	14.74	12.31
g_4i_2	5.38	16.25	13.25	12.06
$F_{3, 44}$	**5.44****	**1.40**	**0.69**	**0.43**
C.D. (0.05)	**0.919**	–	–	–

* Significant at 0.05 level
** Significant at 0.01 level

year, NG and NI interactions were significant. Among the various NG interactions, n_3g_4 recorded the highest acidity (0.15%) and n_4g_2, n_4g_3 and n_2g_3 were on par with it. Comparing the NI interactions, n_1i_2 alone recorded significantly lower value for acidity and all other NI combinations were on par.

Regarding total sugar content of fruits, NG, NI and GI interactions were not significant during the first year. However, during the second year, all these interactions were significant. At n_1 level, g_3 and g_4 were on par and superior to g_2 and g_1. At n_2, n_3 and n_4 levels, g_4 was significantly superior to all the other levels. Coming to NI interactions, at n_1 and n_3 levels of N, i_1 and i_2 were on par. However, at n_2 and n_4 levels, i_2 was significantly superior to i_1. Regarding GI interactions, at g_1 and g_3, i_1 and i_2 were on par but at g_2 and g_4, i_2 was significantly superior to i_1.

In the case of reducing sugar content of fruits, none of the interactions were significant during the second year. However, during the first year, NG interactions significantly influenced it. The highest reducing sugar content of 2.67 per cent was recorded by n_3g_3 and it was on par with n_1g_4, n_2g_3, n_2g_4, n_3g_4, n_4g_3 and n_4g_4.

Regarding the ascorbic acid content of fruits, during the first year, the interactions were not significant. But, during the second year, NG and GI interactions influenced it. At the lowest level of N viz., n_1, g_1, g_2, g_3 and g_4 were on par. At n_2 and n_3, g_2, g_3 and g_4 were on par and superior to g_1. At n_4, g_3 and g_4 were on par. Coming to GI interactions, at i_1 level of irrigatioin, g_3 and g_4 were on par and significantly superior to g_1 and g_2 whereas at i_2 level of irrigatioin, g_1, g_2 and g_3 were on par and significantly better than g_4.

Table 32 Sensory qualities of snakegourd as influenced by different treatments - I Year (1994-'95)

Treatment	Appearance	Colour	Flavour	Texture	Taste
T_1	106.3	147.1	155.4	210.3	239.4
T_2	211.6	206.5	212.4	104.4	158.5
T_3	78.3	277.9	188.1	148.3	194.2
T_4	154.1	184.1	203.5	147.4	202.7
T_5	137.7	186.3	204.8	195.5	145.3
T_6	205.6	177.5	166.1	180.8	217.3
T_7	78.3	212.9	170.5	155.3	205.2
T_8	201.6	197.4	202.4	169.0	104.4
T_9	120.4	216.2	166.1	206.4	149.3
T_{10}	190.0	182.7	234.6	169.0	127.5
T_{11}	184.1	242.5	177.6	140.60	169.6
T_{12}	200.4	161.9	202.4	172.2	156.1
T_{13}	150.3	197.6	192.8	166.2	203.5
T_{14}	199.6	139.4	166.1	225.0	145.0
T_{15}	223.4	235.7	170.5	108.3	138.2
T_{16}	204.4	71.3	218.6	219.9	116.4
T_{17}	131.2	147.1	229.6	239.4	172.1

T_{18}	252.4	96.1	148.2	221.0	239.1
T_{19}	266.0	190.4	125.2	210.1	77.3
T_{20}	192.0	177.5	125.2	195.7	194.2
T_{21}	206.7	160.0	170.5	184.6	165.3
T_{22}	230.5	233.1	140.3	258.8	119.7
T_{23}	146.8	233.3	177.6	217.3	178.9
T_{24}	250.2	190.4	232.6	133.7	156.1
T_{25}	171.6	139.4	227.6	148.3	189.9
T_{26}	180.7	177.5	151.0	202.6	180.7
T_{27}	125.8	139.4	214.2	138.4	250.2
T_{28}	193.1	216.2	148.2	181.0	179.1
T_{29}	183.0	123.7	140.3	221.0	23.4
T_{30}	148.4	207.0	177.6	144.6	280.7
T_{31}	291.6	136.1	214.2	97.4	217.3
T_{32}	183.0	200.2	148.2	188.0	225.6
T_{33}	177.1	180.0	191.0	203.6	166.2
T_{34}	172.7	167.2	175.5	195.7	214.2
Kruskel-Wallis $\propto^2$ value	83.52**	68.93**	42.30	55.96**	72.83**
Critical difference	91.22	91.22	--	91.22	91.22

Table 33 Ranking of the treatments based on the sensory qualities and overall acceptance - I Year (1994-'95)

Treatment	Rank values					Overall acceptance	
	Appearance	Colour	Flavour	Texture	Taste	Total	Mean
T_1	32	27	26	8	3	96	19.2
T_2	7	10	8	33	23	81	16.2
T_3	34	1	15	26	13	89	17.8
T_4	24	17	10	27	12	90	18.0
T_5	28	16	9	15	27	95	19.0
T_{16}	9	22	25	18	8	82	16.4
T_7	33	8	21	24	10	96	19.2
T_8	11	13	11	22	33	90	18.0
T_9	31	6	24	10	26	97	19.4
T_{10}	16	18	1	21	30	86	17.2
T_{11}	17	2	17	29	20	85	17.0
T_{12}	12	24	12	20	25	93	18.6
T_{13}	25	12	14	23	11	85	17.0
T_{14}	13	28	23	3	28	95	19.0
T_{15}	6	3	22	32	29	92	18.4
T_{16}	10	34	5	6	32	87	17.4

T_{17}	29	26	3	2	19	79	15.8
T_{18}	3	33	30	5	5	76	15.2
T_{19}	2	15	33	9	34	93	18.6
T_{20}	15	21	32	14	14	96	19.2
T_{21}	8	25	20	17	22	92	18.4
T_{22}	5	5	31	1	31	73	14.6
T_{23}	27	4	16	7	18	72	14.4
T_{24}	4	14	2	31	24	75	15.0
T_{25}	23	30	4	25	15	97	19.4
T_{26}	20	20	27	12	16	95	19.0
T_{27}	30	29	7	30	2	98	19.6
T_{28}	14	7	29	19	17	86	17.2
T_{29}	18	32	31	4	4	89	17.8
T_{30}	26	9	17	28	1	81	16.2
T_{31}	1	31	6	34	7	79	15.8
T_{32}	19	11	28	16	6	80	16.0
T_{33}	21	19	13	11	21	85	17.0
T_{34}	22	23	18	13	9	85	17.0

Table 34 Sensory qualities of snakegourd as influenced by different treatments - II Year (1995-'96)

Treatment	Appearance	Colour	Flavour	Texture	Taste
T_1	187.6	159.4	144.8	256.1	134.8
T_2	130.9	220.3	113.7	231.8	165.1
T_3	161.4	220.3	136.2	176.0	192.4
T_4	108.6	231.4	220.4	188.2	131.8
T_5	141.8	177.8	178.3	161.5	204.6
T_6	164.2	220.3	204.9	188.2	119.6
T_7	172.3	177.8	204.9	173.3	162.1
T_8	112.4	132.6	155.8	214.9	204.6
T_9	157.1	220.3	155.8	161.7	204.6
T_{10}	153.3	177.8	225.0	146.9	162.1
T_{11}	273.1	159.8	162.8	173.6	147.0
T_{12}	179.4	151.0	225.0	190.6	131.8
T_{13}	138.0	162.1	120.7	202.7	232.0
T_{14}	168.5	166.7	247.0	120.2	149.9
T_{15}	179.7	146.4	220.4	188.2	168.5
T_{16}	257.9	177.8	129.2	132.4	204.6
T_{17}	220.8	177.8	220.4	161.5	189.5
T_{18}	194.7	177.8	106.7	200.3	201.7

T_{19}	153.3	231.4	151.8	161.5	232.0
T_{20}	209.9	220.3	151.8	188.2	119.6
T_{21}	242.6	139.5	231.4	134.8	192.4
T_{22}	153.3	182.4	204.9	173.6	204.5
T_{23}	153.3	236.0	105.1	241.6	149.9
T_{24}	262.2	135.3	136.2	120.2	219.8
T_{25}	197.9	151.0	245.4	149.3	162.1
T_{26}	153.3	251.7	136.2	176.0	204.6
T_{27}	273.1	135.3	193.9	128.1	204.6
T_{28}	244.8	166.7	178.3	188.2	162.1
T_{29}	122.8	135.3	212.6	200.3	189.5
T_{30}	179.4	135.3	162.8	188.2	204.6
T_{31}	253.3	166.7	240.5	161.5	165.1
T_{32}	179.4	135.3	220.4	187.0	189.5
T_{33}	138.0	183.4	173.8	202.7	201.7
T_{34}	138.0	225.9	136.2	220.9	194.1
Kruskel-Wallis $\propto^2$ value	84.44**	50.18*	77.48**	41.66	38.85
Critical values	91.22	91.22	91.22	--	--

* Significant at 0.05 level
** Significant at 0.01 level

Table 35 Ranking of the treatments based on the sensory qualities and overall acceptance - II Year (1995-'96)

Treatment	Rank values					Overall acceptance	
	Appe-arance	Colour	Flavour	Texture	Taste	Total	Mean
T_1	11	24	25	1	30	91	18.2
T_2	31	6	32	3	22	94	18.8
T_3	19	7	26	19	15	86	17.2
T_4	34	3	9	12	31	89	17.8
T_5	27	13	16	26	4	86	17.2
T_6	18	8	13	13	34	86	17.2
T_7	16	14	14	22	23	89	17.8
T_8	33	34	21	5	6	99	19.8
T_9	20	10	22	23	7	82	16.4
T_{10}	21	15	6	29	24	95	19.0
T_{11}	1	23	19	21	29	93	18.6
T_{12}	13	25	5	10	32	85	17.0
T_{13}	28	22	31	6	1	88	17.6
T_{14}	17	19	1	33	27	97	19.4
T_{15}	12	27	7	15	20	81	16.2
T_{16}	4	16	30	31	8	89	17.8
T_{17}	7	17	10	25	19	78	15.6

T_{18}	10	18	33	8	12	81	16.2
T_{19}	23	4	23	27	2	79	15.8
T_{20}	8	9	24	17	33	91	18.2
T_{21}	6	28	4	30	16	84	16.8
T_{22}	24	12	12	20	9	77	15.4
T_{23}	25	2	34	2	28	91	18.2
T_{24}	3	29	29	34	3	98	19.6
T_{25}	9	26	2	28	26	91	18.2
T_{26}	22	1	27	18	11	79	15.8
T_{27}	2	30	15	32	10	89	17.8
T_{28}	5	20	17	14	25	81	16.2
T_{29}	32	31	11	9	18	101	20.2
T_{30}	14	32	20	11	5	82	16.4
T_{31}	26	21	3	24	21	95	19.0
T_{32}	15	33	8	16	17	89	17.8
T_{33}	29	11	18	7	13	78	15.6
T_{34}	30	5	28	4	14	81	16.2

The crude protein content of fruits did not vary significantly due to any of the interactions during the first year. But during the second year, it varied significantly due to NG interactions. At the lower levels of N, ie., n_1 and n_2, g_3 recorded significantly higher protein content (16.27 and 16.55%, respectively) than the other levels of G, whereas at the higher levels of N, ie., n_3 and n_4, g_4 recorded protein contents (17.27 and 17.72%, respectively) significantly higher than the other levels of G. During both the years, the crude fibre content was not significantly influenced by any of the interactions.

The shelf life of fruits varied significantly due to NG interactions in the second year with n_1g_2 recording the highest shelf life of 14.38 days and it was significantly superior to the other NG combinations.

A critical review of the data obtained from organoleptic evaluation subjected to non-parametric analysis revealed that there existed considerable variation among the treatments in all the parameters evaluated ie., appearance, colour, flavour, texture and taste (Tables 32 & 34). However, when the treatments were ranked for each parameter and the overall and mean rank values were computed, not much variation could be noticed among the treatments during both the years of experimentation (Tables 33 & 35). Hence, it could be concluded that there was no significant difference in the sensory quality of snakegourd fruits due to the treatments.

4.8. Soil properties

4.8.1. Physical property (Tables 36 and 37)

A perusal of the data recorded on bulk density of the soil revealed that during both the years of experimentation, none of the main effects significantly influenced the bulk density. Similarly, the interactions - NG, NI and GI - also showed no significant effect on the bulk density of the soil during both the years of study.

4.8.2. Chemical properties

4.8.2.1. Effect of N, G and I (Table 38 and 39)

The initial nutrient contents of the experimental,plot, based on the analysis of composite sample, were 278.50 kg ha^{-1} of available N, 40.80 kg ha^{-1} of available phosphorus and 128.91 kg ha^{-1} of available potassium. At the beginning of the second season, the quantum of these nutrients were 287.6 kg ha^{-1} available N, 37.6 kg ha^{-1} available phosphorus and 114.2 kg ha^{-1} available potassium.

The available N content of soil after the harvest of the first year's crop showed that there was considerable increase compared to the pre-treatment value. Among the main effects, N significantly influenced the available N content of the soil with n_4 recording the highest value of 342.86 kg ha^{-1} and it was on par with n_3 with

Table 36 Effect of N, G and I on physical property of soil

Effect	Bulk density (g cc^{-1})	
	I Year (94-95)	II Year (95-96)
n_1	1.34	1.35
n_2	1.35	1.36
n_3	1.34	1.35
n_4	1.35	1.36
$F_{3, 44}$	**0.60**	**0.84**
g_1	1.33	1.35
g_2	1.35	1.36
g_3	1.34	1.36
g_4	1.35	1.36
$F_{3, 44}$	**2.12**	**0.15**
C D (0.05) N/G	–	–
i_1	1.34	1.36
i_2	1.35	1.36
$F_{1, 44}$	**0.17**	**0.60**
Control 1	1.32	1.33
Control 2	1.32	1.33

Table 37 Interaction effect of N, G and I on physical property of soil

Effect	Bulk density (g cc^{-1})	
	I Year (1994-'95)	II Year (1995-'96)
n_1g_1	1.33	1.36
n_1g_2	1.35	1.36
n_1g_3	1.35	1.35
n_1g_4	1.34	1.36
n_2g_1	1.34	1.37
n_2g_2	1.37	1.36
n_2g_3	1.33	1.37
n_2g_4	1.36	1.35
n_3g_1	1.33	1.34
n_3g_2	1.35	1.36
n_3g_3	1.34	1.36
n_3g_4	1.36	1.36
n_4g_1	1.34	1.35
n_4g_2	1.36	1.37
n_4g_3	1.34	1.34
n_4g_4	1.37	1.37
$F_{9,44}$	**0.68**	**1.76**
C.D. (0.05)	--	--

n_1i_1	1.34	1.35
n_1i_2	1.34	1.35
n_2i_1	1.34	1.36
n_2i_2	1.36	1.37
n_3i_1	1.34	1.35
n_3i_2	1.34	1.36
n_4i_1	1.35	1.36
n_4i_2	1.35	1.36
$F_{3, 44}$	**0.35**	**0.33**
g_1i_1	1.33	1.36
g_1i_2	1.34	1.35
g_2i_1	1.36	1.36
g_2i_2	1.35	1.36
g_3i_1	1.34	1.36
g_3i_2	1.34	1.35
g_4i_1	1.35	1.35
g_4i_2	1.36	1.37
$F_{3, 44}$	**0.72**	**1.77**

an available N content of 339.06 kg ha^{-1}. However, the available P and K contents of the soil were not significantly influenced by the main effects.

After the second year's crop also, available N content of the soil varied significantly due to N. The level n_4 recorded the highest value of 357.37 kg ha^{-1} which was significantly higher than those of n_3, n_2 and n_1. The control plots recorded available N content lower than the pre-treatment value. As in the case of the previous year, the main treatments had no marked effect on the available P and K contents.

The organic carbon content of soil was not influenced by N, G and I after both the experiments.

The soil pH varied significantly due to N and I at the end of both the crops. There was a significant reduction in the pH of the soil due to the increase in the level of applied N. The lowest pH (5.13 and 5.07 after the first and second year, respectively) was recorded by n_4 which was on par with n_3 (5.15 and 5.11 after the first and second year, respectively). Irrigation also had similar influence on the soil pH after the crop and i_2 recorded a significantly lower pH of 5.14 and 5.09, respectively, after the first and second year,than i_1 (5.20 and 5.17, respectively after the first and second year).

Table 38 Effect of N, G and I on the available N, P_2O_5 and K_2O content of soil

Effect	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1	326.79	317.75	44.38	41.16	132.88	127.70
n_2	333.70	336.48	44.44	41.26	137.92	127.77
n_3	339.06	350.64	44.94	41.33	147.97	127.06
n_4	342.86	357.37	44.88	41.39	146.72	129.07
$F_{3,44}$	**4.98****	**161.40****	**0.27**	**0.03**	**2.61**	**0.74**
g_1	333.63	338.36	43.55	41.06	147.93	127.87
g_2	336.59	338.83	45.01	41.74	138.48	127.97
g_3	332.54	341.90	44.79	41.95	140.10	127.94
g_4	339.63	343.14	45.29	40.38	139.00	127.82
$F_{3,44}$	**1.04**	**2.81**	**1.82**	**1.38**	**0.98**	**0.01**
C.D.(0.05) N/G	**8.900**	**3.960**	–	–	–	–
i_1	336.72	340.42	44.84	41.06	135.66	128.13
i_2	334.48	340.69	44.48	41.50	137.08	127.67
$F_{1,44}$	**0.51**	**0.03**	**0.40**	**0.53**	**0.69**	**0.23**
Control 1	257.25	265.38	39.03	40.48	139.75	128.33
Control 2	253.28	262.98	37.35	38.98	137.68	125.75

** Significant at 0.01 level

Table 39 Effect of N, G and I on pH and organic carbon content of soil

Effect	pH		Organic carbon (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-'95)	II Year (95-96)
n_1	5.21	5.19	0.63	0.69
n_2	5.19	5.15	0.65	0.69
n_3	5.15	5.11	0.64	0.69
n_4	5.13	5.07	0.64	0.69
$F_{3, 44}$	**6.76****	**9.34****	**1.27**	**0.54**
g_1	5.17	5.14	0.65	0.69
g_2	5.17	5.13	0.65	0.70
g_3	5.17	5.14	0.63	0.68
g_4	5.16	5.13	0.63	0.69
$F_{3, 44}$	**0.11**	**0.15**	**1.45**	**1.21**
C.D. (0.05) N/G	**0.043**	**0.050**	--	--
i_1	5.20	5.17	0.64	0.69
i_2	5.14	5.09	0.64	0.69
$F_{1, 44}$	**14.16****	**18.47****	**0.07**	**0.08**
C.D. (0.05)	**0.030**	**0.035**	-	-
Control 1	5.25	5.18	0.65	0.70
Control 2	5.15	5.05	0.66	0.71

** Significant at 0.01 level

4.8.2.2. Interaction effect of N, G and I (Tables 40 & 41)

After the first year's crop, the available N content of the soil was not influenced by any of the interactions. However, after the second year's crop, NG and NI interactions influenced it. At the lower doses of G viz., g_1, g_2 and g_3 there was significant increase in the available N content due to incremental doses of N from n_1 to n_4. However, at the highest dose of G, ie., g_4, n_4 and n_2 were on par; n_2 and n_3 were also on par and significantly superior to n_1. Regarding NI interactions, both at i_1 and i_2, there was significant increase in the available N content with each incremental dose of N.

None of the interactions significantly influenced the available P content of the soil after the first year. After the second year, NI interactions influenced it significantly. At i_1, the highest level of N viz., n_4 significantly reduced the available P content of the soil and n_1, n_2 and n_3 were on par. But at i_2, the available P increased significantly at the highest dose of N, ie., n_4.

During both the years, NG, NI and GI interactions were not significant in their effect on available K content of the soil.

Among the various interactions, NG significantly influenced the pH of the soil during the first year. The decrease in pH due to incremental doses of N was not significant at g_1 and g_2. However, at g_3, n_4 recorded a significantly lower pH value than n_1, n_2 and n_3. At g_4, n_3 and n_4 were on par and recorded significantly lower pH than n_1 and n_2.

Table 40 Interaction effect of N, G and I on the available N, P_2O_5 and K_2O content of soil

Effect	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	325.78	304.55	42.60	40.00	133.05	131.92
n_1g_2	331.95	315.08	45.00	41.73	130.48	125.55
n_1g_3	314.75	328.20	45.73	40.85	129.00	124.20
n_1g_4	334.68	323.18	44.18	42.05	139.00	129.13
n_2g_1	327.58	325.43	44.30	42.58	135.70	126.00
n_2g_2	333.63	329.60	43.57	42.50	134.50	132.05
n_2g_3	341.2	340.48	43.33	37.88	148.17	128.68
n_2g_4	339.38	350.40	46.55	42.08	133.30	124.35
n_3g_1	347.40	359.40	44.25	39.00	159.70	126.03
n_3g_2	331.60	353.28	45.70	40.65	146.40	122.35
n_3g_3	339.48	343.45	46.10	45.53	147.80	134.00
n_3g_4	337.75	346.43	43.73	40.13	137.98	125.88
n_4g_1	333.78	364.08	43.05	42.68	163.25	127.55
n_4g_2	349.20	357.35	45.78	42.07	142.55	131.93
n_4g_3	334.72	355.48	44.00	43.55	135.43	124.88
n_4g_4	353.73	352.58	46.70	37.28	145.65	131.92
$F_{9,44}$	**1.83**	**12.53****	**1.46**	**1.61**	**0.87**	**1.21**
C.D. (0.05)	-	**4.061**	-	-	-	-

n_1i_1	325.38	315.60	44.83	40.73	134.84	127.01
n_1i_2	328.20	319.90	43.93	41.59	130.93	128.39
n_2i_1	339.63	333.81	44.76	42.10	134.99	128.13
n_2i_2	327.78	339.14	44.11	40.41	140.85	127.41
n_3i_1	340.05	353.89	44.78	41.80	157.33	126.51
n_3i_2	338.06	347.39	45.11	40.85	138.61	127.61
n_4i_1	341.83	358.39	45.00	39.63	155.49	130.88
n_4i_2	343.89	356.35	44.76	43.16	137.95	127.26
$F_{3, 44}$	**1.17**	**4.06***	**0.23**	**3.71***	**1.05**	**1.37**
C.D. (0.05)	-	**5.600**	-	**2.453**	-	-
g_1i_1	329.60	338.82	43.55	41.46	152.39	128.40
g_1i_2	337.66	337.90	43.55	40.66	143.46	127.35
g_2i_1	340.29	339.69	46.95	42.55	139.38	127.76
g_2i_2	332.90	337.96	43.08	40.93	137.59	128.18
g_3i_1	336.74	341.49	45.14	41.04	139.88	128.44
g_3i_2	328.35	342.31	44.44	42.86	140.33	127.44
g_4i_1	340.25	341.69	43.73	39.20	151.00	127.93
g_4i_2	339.01	344.60	46.85	41.56	126.96	127.71
$F_{3, 44}$	**1.47**	**0.55**	**1.39**	**2.61**	**0.60**	**0.12**

* Significant at 0.05 level
** Significant at 0.01 level

Table 41 Interaction effect of N, G and I on pH and organic carbon content of soil

Effect	pH		Organic carbon (%)	
	I Year (94-95)	II Year (95-96)	I Year (94-95)	II Year (95-96)
n_1g_1	5.23	5.20	0.62	0.70
n_1g_2	5.20	5.18	0.64	0.71
n_1g_3	5.25	5.25	0.63	0.66
n_1g_4	5.17	5.15	0.63	0.68
n_2g_1	5.17	5.17	0.69	0.71
n_2g_2	5.20	5.17	0.66	0.69
n_2g_3	5.15	5.15	0.64	0.67
n_2g_4	5.23	5.10	0.63	0.69
n_3g_1	5.15	5.10	0.64	0.68
n_3g_2	5.13	5.10	0.65	0.70
n_3g_3	5.23	5.08	0.63	0.69
n_3g_4	5.10	5.15	0.63	0.71
n_4g_1	5.15	5.05	0.66	0.68
n_4g_2	5.15	5.05	0.64	0.69
n_4g_3	5.05	5.08	0.63	0.71
n_4g_4	5.15	5.10	0.64	0.68
$F_{9,44}$	**2.76***	**1.24**	**0.80**	**1.62**
C.D. (0.05)	**0.085**	-	-	-

n_1i_1	5.24	5.25	0.63	0.69
n_1i_2	5.19	5.14	0.63	0.68
n_2i_1	5.20	5.16	0.66	0.69
n_2i_2	5.18	5.14	0.64	0.69
n_3i_1	5.19	5.16	0.63	0.69
n_3i_2	5.11	5.06	0.65	0.70
n_4i_1	5.16	5.10	0.64	0.69
n_4i_2	5.09	5.04	0.65	0.69
$F_{3,44}$	**0.64**	**1.31**	**1.05**	**0.56**
g_1i_1	5.20	5.18	0.65	0.69
g_1i_2	5.15	5.10	0.66	0.69
g_2i_1	5.17	5.17	0.65	0.70
g_2i_2	5.16	5.08	0.65	0.69
g_3i_1	5.21	5.16	0.64	0.68
g_3i_2	5.13	5.11	0.63	0.69
g_4i_1	5.20	5.16	0.63	0.69
g_4i_2	5.13	5.09	0.64	0.69
$F_{3,44}$	**1.23**	**0.37**	**0.60**	**1.05**

* Significant at 0.05 level

4.9. Economics (Tables 42, 43 and Fig. 10)

The net profit and benefit : cost ratio of various levels of tested inputs were worked out utilizing the pooled yield data (Table 42). The results revealed that among the different levels of N, n_3 fetched the highest net profit of Rs.74,636/- and a benefit : cost ratio of 2.37 followed by n_4 (Rs.70,607/- and 2.28, respectively).

As far as ethephon was concerned, the highest net profit and B:C ratio (Rs.71,194/- and 2.31, respectively) were obtained at g_4. The next best level was g_3 (Rs.67,917/- and 2.25, respectively). The lowest net profit (Rs.59,240/-) and B:C ratio (2.09) were recorded at g_1.

With respect to irrigation, drip irrigation at 5 mm CPE (i_1) registered a higher net profit and B:C ratio (Rs.70,038/- and 2.28, respectively) compared to that at i_2 (Rs.61,615/- and 2.14, respectively).

A perusal of Table 43 revealed that, among the treatment combinations $n_3g_4i_1$ registered the highest net profit (Rs.1,04,271/-) and B:C ratio (3.04) compared to the others. The details pertaining to the cost of cultivation are given in Appendices II and III.

4.10. Statistical Analysis

The experimental data were analysed statistically by applying the technique of analysis of variance as per the layout of the experiment (Cochran and Cox, 1965; Panse and Sukhatme, 1967). Pooled analysis was done for yield. The physical optima were worked out separately for each crop fitting quadratic response function for nitrogen and ethephon, at both the levels of irrigation, using the formula:

$$Y = b_0 + b_1 N + b_2 G + b_{11} N^2 + b_{22} G^2 + b_{12} NG$$ (Das and Giri, 1979).

Table 42 Economics of snakegourd cultivation during the summer season as influenced by N, ethephon and irrigation frequency

A. Nitrogen

Sl. No.	Item	Level of N (kg ha^{-1})			
		n_1 35	n_2 70	n_3 105	n_4 140
1	Cost of cultivation excluding the treatment (Rs. ha^{-1})	53,226	53,226	53,226	53,226
2	Additional cost of the treatment (Rs. ha^{-1})	479	959	1,438	1,917
3	Total seasonal cost of cultivation (Rs. ha^{-1})	53,705	54,185	54,664	55,143
4	Yield of produce (t ha^{-1})	21.94	23.28	25.86	25.15
5	Selling price (Rs. t^{-1})	5,000	5,000	5,000	5,000
6	Income from produce (Rs. ha^{-1})	1,09,700	1,16,400	1,29,300	1,25,750
7	Net profit (Rs. ha^{-1})	55,995	62,215	74,636	70,607
8	B:C ratio	2.04	2.15	2.37	2.28

Cost of 1 kg N : Rs. 5.98

B. Ethephon

Sl. No.	Item	Level of ethephon (ppm)			
		0	50	100	200
1	Cost of cultivation excluding the treatment (Rs. ha^{-1})	53,820	53,820	53,820	53,820
2	Additional cost of the treatment (Rs. ha^{-1})	540	577	613	686
3	Total seasonal cost of cultivation (Rs. ha^{-1})	54,360	54,397	54,433	54,506
4	Yield of produce (t ha^{-1})	22.72	23.86	24.47	25.14
5	Selling price (Rs. t^{-1})	5,000	5,000	5,000	5,000
6	Income from produce (Rs. ha^{-1})	1,13,600	1,19,300	1,22,350	1,25,700
7	Net profit (Rs. ha^{-1})	59,240	64,903	67,917	71,194
8	B:C ratio	2.09	2.19	2.25	2.31

Cost of ethephon 100 ml : Rs. 365.00

C. Irrigation

Sl. No.	Item	Drip irrigation at 5 mm CPE (i_1)	Drip irrigation at 10 mm CPE (i_2)
1	*Fixed cost for irrigation (Rs. ha^{-1})	37,856	37,856
(a)	Life	12 years	12 years
(b)	Depreciation $year^{-1}$ (Rs. ha^{-1})	3,155	3,155
(c)	Repairs and maintenance cost including energy for pumping for one season (Rs. ha^{-1})	1,000	1,000
	Total (b + c) (Rs. ha^{-1})	4,155	4,155
2	Cost of cultivation $season^{-1}$ excluding the treatment (Rs. ha^{-1})	48,952	48,952
3	Additional cost of the treatment (Rs. ha^{-1})	1,755	878
4	Seasonal total cost of cultivation (Rs. ha^{-1})	54,862	53,985
5	Yield of produce (t ha^{-1})	24.98	23.12
6	Selling price (Rs. t^{-1})	5,000	5,000
7	Income from produce (Rs. ha^{-1})	1,24,900	1,15,600
8	Net profit $season^{-1}$ (Rs. ha^{-1})	70,038	61,615
9	B:C ratio	2.28	2.14

* Cost of drip system accessories and instalment	Rs. 30,600
Cost of 1 HP pump	Rs. 3,200
Interest @ 12%	Rs. 4,056
Total	Rs.37,856

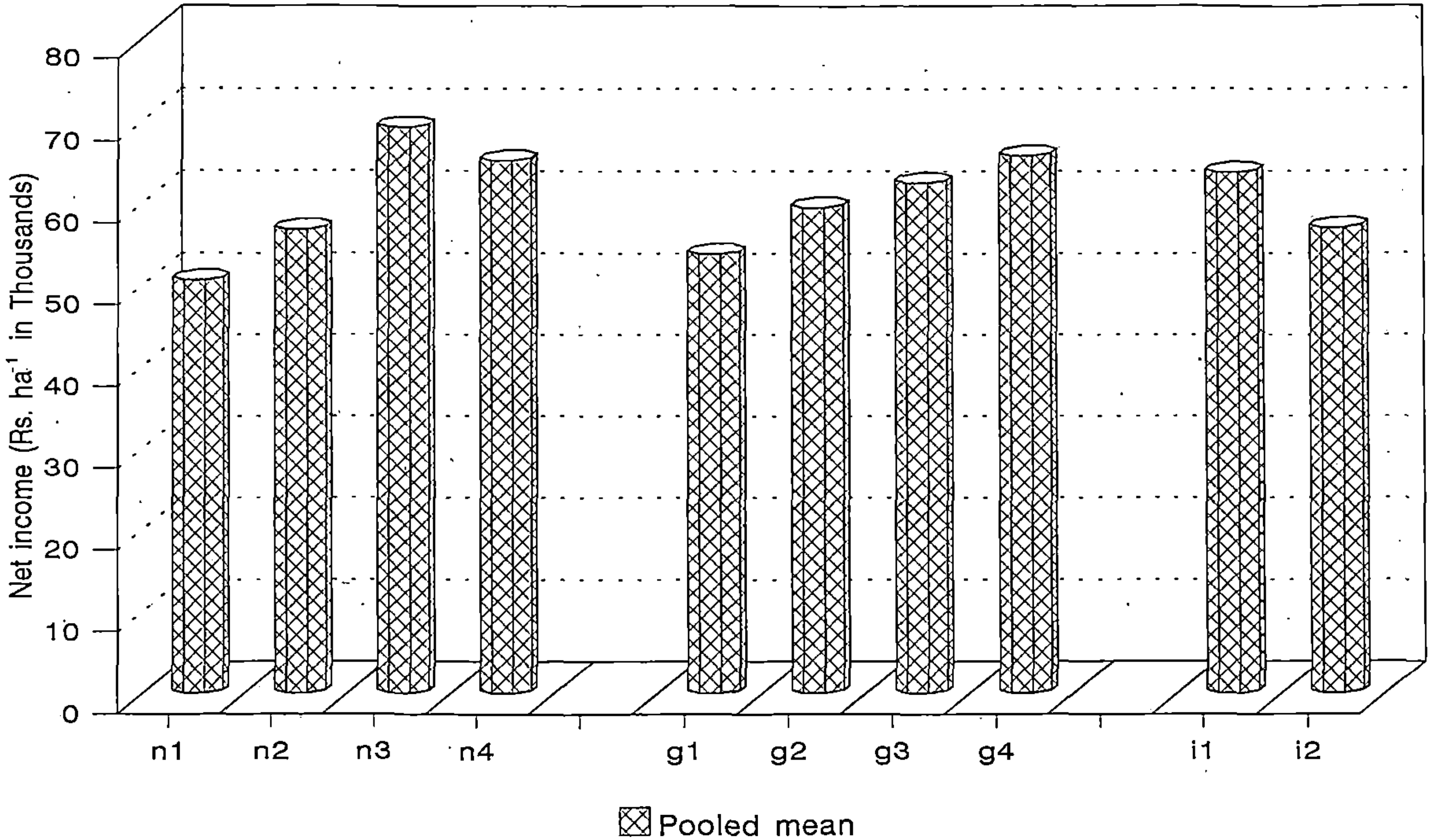


Fig. 10. Effect of N, G and I on net income (Rs.)

Table 43 Economics of snakegourd cultivation during the summer season as influenced by the combination of N, G and I

Treat. combinations	Cost of cultivation excluding the treatments (Rs. ha^{-1})	Addl. cost of the treatment (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Yield of produce (t ha^{-1})	Income from produce (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	B:C ratio
$n_1g_1i_1$	47150	2774	49924	20.32	101600	51676	1.97
$n_1g_1i_2$	,,	1897	49047	20.10	100500	51453	2.05
$n_1g_2i_1$	,,	2811	49961	21.24	106200	56239	2.13
$n_1g_2i_2$	,,	1934	49054	22.05	110250	60566	2.25
$n_1g_3i_1$	,,	2847	49997	23.03	115150	65153	2.30
$n_1g_3i_2$	,,	1970	49120	22.70	113500	64380	2.31
$n_1g_4i_1$	,,	2920	50070	23.33	116650	66580	2.33
$n_1g_4i_2$	,,	2043	49193	22.38	111900	62707	2.27
$n_2g_1i_1$	,,	3254	50404	23.48	117400	66996	2.33
$n_2g_1i_2$	,,	2377	49527	20.66	103300	53733	2.09
$n_2g_2i_1$	,,	3291	50441	25.02	125100	74659	2.48
$n_2g_2i_2$	,,	2414	49564	22.84	114200	64636	2.30
$n_2g_3i_1$	,,	3327	50477	25.07	125350	74873	2.48
$n_2g_3i_2$	,,	2450	49600	20.33	101650	52050	2.53
$n_2g_4i_1$	,,	3400	50550	25.58	127900	77350	2.53
$n_2g_4i_2$	,,	2523	49673	23.28	116400	66727	2.34
$n_3g_1i_1$	,,	3733	50883	24.39	121950	71067	2.40
$n_3g_1i_2$	,,	2856	50006	20.94	104700	54674	2.09

$n_3g_2i_1$	47150	3770	50920	25.88	129400	78480	2.54
$n_3g_2i_2$	,,	2893	50043	24.90	124500	74457	2.49
$n_3g_3i_1$	,,	3806	50956	26.30	131500	80544	2.58
$n_3g_3i_2$	,,	2929	50079	27.78	138900	88821	2.77
$n_3g_4i_1$	,,	3879	51029	31.06	155300	104271	3.04
$n_3g_4i_2$	,,	3002	50152	25.61	128050	77898	2.55
$n_4g_1i_1$	,,	4212	51362	24.85	124250	72888	2.42
$n_4g_1i_2$	,,	3335	50485	27.04	135200	84715	2.67
$n_4g_2i_1$	,,	4249	51339	25.99	129950	78611	2.53
$n_4g_2i_2$	,,	3372	50522	22.64	113200	62678	2.24
$n_4g_3i_1$	,,	4285	51435	27.73	138650	87215	2.70
$n_4g_3i_2$	,,	3408	50558	23.05	115250	64692	2.28
$n_4g_4i_1$	,,	4358	51508	26.05	130250	78742	2.53
$n_4g_4i_2$	,,	3481	50631	23.87	119350	68719	2.36
$n_0g_0i_1$	..	1755	48905	15.28	76400	27495	1.56
$n_0g_0i_2$	,,	878	47028	14.39	71950	23922	1.50
$n_0g_0i_1$	,,	1755	48905	15.25	76250	27345	1.56
$n_0g_0i_2$	,,	878	48028	14.05	70250	22222	1.46

DISCUSSION

DISCUSSION

Field experiments were conducted during the summer seasons of 1994-'95 and 1995-'96 to study the effect of varying levels of nitrogen, ethephon and drip irrigation on snakegourd. A critical analysis of the results of the field experiments revealed that the crop responded differently to the treatments. The factors contributing to the differential response of snakegourd to the treatments are discussed in this chapter.

5.1. Growth characters

Growth, the irreversible gain in dry matter, is the sum total of the vital metabolic processes of cell division and enlargement. The amount of dry matter produced by a crop plant depends upon its photosynthetic efficiency (Arnon, 1975). The effectiveness of photosynthesis, to a great extent is a function of the leaf number. In the present study, there was a considerable increase in internodal length, leaf number and DMP due to N application during both the years of experimentation and the higher doses of N viz., 105 kg ha^{-1} (n_3) and 140 kg ha^{-1} (n_4) were on par and superior to the lower levels. These observations on the positive effect of N on plant growth are in conformity with the findings of Randhawa and Singh (1970) in muskmelon, Haris (1989) in snakegourd, Premalakshmi (1997) in small gherkin and Lakshmi (1997) in cucumber. The increase in dry matter production is the outcome of higher rate of growth and better accumulation of photosynthates owing to enhanced nutrient uptake. Bar-Yosef and Sagev (1982) obtained a significant positive correlation, between DMP and N uptake in tomato. According to Shanmughavelu

(1989), N compounds constitute 40 to 50 per cent of the dry matter of protoplasm and because of this, N is required by crops in large quantities.

Like N, ethephon also significantly influenced the leaf number and dry matter accumulation of the crop and the higher levels, viz., 100 ppm (g_3) and 200 ppm (g_4) were superior to the lower ones, during both the years of the study. Similar favourable effect of ethephon on leaf number and DMP was reported by Arora *et al.* (1991). However, the internodal length was not increased by ethephon, may be due to its antigibberellin action as reported by Verma *et al.* (1986), Arora and Partap (1988) and Arora *et al.* (1991).

Ethylene, the simplest unsaturated hydrocarbon, regulates growth and development to a considerable extent. The mode of action of ethephon is such that in an aqueous system above pH 4.0, it immediately releases ethylene. As the plant cells usually have a pH around 6.0, the chemical breaks down releasing ethylene (Draber, 1977). The primary reaction of ethylene influences the metabolism of plants which cause the different physiological plant responses. Growth promotions due to ethylene is reported by Ku, *et al.*, 1970; Suge *et al.*, 1971; Musgrave *et al.*, 1972; Suge, 1972; Takahashi, 1973; Suge, 1974 and Craker *et al.*, 1978.

It is generally accepted today that certain ethylene induced plant responses are preceded by an ethylene stimulated increase of protein synthesis (Klaus Lurssen, 1984). It is also an established fact that ethylene affects the synthesis of different RNA species (Holm *et al.*, 1970; Hulme, *et al.*, 1971 b; Marei and Romani, 1971). The ethylene action on protein synthesis machinery in general and on the expression of specific gene messages in particular has been confirmed (Christoffersen and Laties, 1982).

The results also revealed that during both the years of experimentation, the drip irrigation frequency, i_1 (5 mm CPE) significantly increased the internodal length, leaf number and DMP over i_2 (10 mm CPE). The higher frequency of irrigation might have led to effective absorption and utilization of nutrients resulting in quick growth. The cucurbits require considerable quantity of moisture, when making their most vigorous growth and upto the time the fruits mature (Whitaker and Davis, 1962). Low irrigation frequency resulting in moisture deficit might manifest many changes in plant anatomy such as decrease in size of cells and intercellular spaces limiting cell division and elongation resulting in overall decrease in plant growth (May and Milthrope, 1962).

According to Kramer (1983) and Dwyer and Stewart (1985), higher stomatal conductance and lesser leaf water potentials are associated with higher DMP rate of frequently irrigated plants, as plant turgidity is important in relation to opening and closing of stomata, expansion of leaves and movement of water and nutrients to various plant parts. The favourable effect of irrigation on DMP at i_1 (5 mm CPE) could thus be due to stimulation of metabolic activities at higher moisture availability. Similar results were reported by Flocker *et al.* (1965), Goldberg and Shmueli (1970), Cummins and Kretchman (1974), Escobar and Gausman (1974), Freeman *et al.* (1976), Bar-Yosef *et al.* (1980), Mathew (1981), Beese *et al.* (1982), Ortega and Kretchman (1982), Thomas (1984), Subba Rao (1989) and Lakshmi (1997) in various cucurbits.

Reduced internodal length, leaf number and DMP under i_2 may be due to moisture stress at different growth stages which could have affected various biochemical processes involved in photosynthesis thus directly affecting growth. Leaf number was also significantly lower at i_2 resulting in reduced photosynthesis. These results showed that plants grown under low frequency deficit irrigation adapt to these conditions through reduced DMP.

The interaction between N and G also significantly influenced internodal length, leaf number and DMP. At all the levels of G, leaf number and DMP increased with an increase in the level of N from n_1 to n_3, showing thereby its favourable effect. However, NI and GI interactions were not significant in their effect on these growth attributes. Reviewing the work done in India on the relationship between irrigation and fertilizer application, Singh and Gandhi (1964) and Singh and Sinha (1977) concluded that WUE and DMP were raised by the applied fertilizer under adequate moisture availability and that response to irrigation was generally improved by increasing the level of fertilizer.

5.2. Earliness

Earliness is an important trait in vegetable crops especially cucurbits. It is indicated by the number of days taken for the opening of flowers and the node at which the flowers are produced. Eventhough earliness is considered as a genetically controlled trait, other factors like environment and cultural practices including plant nutrition, irrigation and application of plant growth substances can play a major role. In the present study, there existed significant variations in the number of days taken for the opening of first female flower due to N levels during the second year. The minimum number of days was registered by applied N at the rate of 35 kg ha^{-1} (n_1). The difference between it and the other levels was significant. Among the major plant nutrients, phosphorus promotes early flowering while higher doses of N and K delay it. The phenomenon of delayed flowering and fruiting due to excessive N supply has been reported by a number of research workers viz., Mc Intyre, (1977), O'Sullivan (1980) in pickling cucumber; Haris (1989) in snakegourd; Bakar (1937), Lingle (1960) and Chinnaswamy (1967) in tomato; Singh *et al.* (1982) in tinda; Karuthamani (1995) in pumpkin; Nirmala (1996) in cucumber and Premalakshmi (1997) in gherkins.

The number of days taken for the opening of male and female flowers varied considerably due to ethephon application also. Its effect was significant on female flower opening during both the years of experimentation and on male flower opening during one of the two years. In all these cases, g_1 (zero ppm) registered the maximum number of days which was significantly higher than those of all the other levels of G viz., g_2, g_3 and g_4, thus indicating the positive effect of ethephon in inducing earliness. This is in agreement with the findings of Mc Murray and Miller (1969); Iwahory *et al.* (1969); Karchi (1970) and Shanmughavelu and Thamburaj (1973). Klaus Lurssen (1984) held the view that ethylene stimulates the early production of female flowers and ethephon which releases ethylene in plant tissue has the same effect.

Irrigation also significantly influenced the days taken for female flower opening and i_2 (10 mm CPE) recorded the minimum number of days compared to i_1 (5 mm CPE) during both the years. It is well known that frequent irrigation enhances vegetative growth as is evident from the higher DMP at i_1 than at i_2. This can be the possible reason for the delay in flowering in i_1 as compared to i_2.

The other attribute contributing to earliness, viz., node at which the first male and female flowers were produced was also significantly influenced by both N and G. As in the case of days taken for flower opening, N exerted a negative influence on this attribute. With an increase in its level, the node number at which the first male and female flowers opened was also enhanced and n_1 and n_2 were found to be on par and superior to n_3 and n_4. Similar results were reported earlier in tinda by Singh *et al.* (1982) and in snakegourd by Haris (1989).

Ethephon showed a significant positive influence on node number and its higher levels viz., g_4 and g_3 produced male and female flowers at significantly lower nodes compared to g_1 and g_2. This observation is in agreement with the results reported by Karchi (1970) in muskmelon and Shanmughavelu and Thamburaj (1973) in snakegourd.

With respect to irrigation, the node number varied significantly for male flowers only and that too for the first year. The same trend as that for the days taken for flower opening was noticed in this case also. The less frequent irrigation treatment (i_2) registered significantly lower node number than i_1.

A critical review of the data indicated the favourable effect of NG, NI and GI interactions on the number of days taken for flower opening. Within each level of N, the days taken for the female flower to open decreased gradually with an increase in the level of G in the second year, thus clearly showing the favourable effect of G in inducing earliness. During the same season, GI interaction also exerted a similar influence. At both the frequencies of irrigation (i_1 and i_2), the number of days taken for flowering decreased gradually with an increase in the level of G. This might be due to the modification of the endogenous hormonal make up of the plant brought about by ethephon (Krishnamoorthy, 1981).

The number of days taken to first fruit picking and total crop duration were not influenced by N and G during both the years. Eventhough irrigation frequencies did not indicate any significant influence on days to first fruit picking, it had a definite effect on total crop duration during the second year. The total duration was significantly lower (117.88 days) in i_2 than in i_1 (121.69 days). This finding is in conformity with that of Kafkafi and Bar-Yosef (1980) in tomato. They observed that low (less frequent) irrigation treatment led to a lower (more negative) matric + osmotic soil water potential as compared to high (frequent) irrigation treatment and the lower water potential caused a relatively smaller canopy and earliness in fruiting.

5.3. Yield attributes and yield

Among the important yield attributes, the number of female flowers plant^{-1}, number of fruits plant^{-1}, fruit setting percentage, sex ratio, mean weight and girth of fruits and harvest index varied considerably due to the application of N. The higher levels of N viz., n_3 (105 kg ha^{-1}) and n_4 (140 kg ha^{-1}) significantly improved all these attributes compared to n_1 (35 kg ha^{-1}) and n_2 (70 kg ha^{-1}). The substantial increase in the number of pistillate flowers, and fruit setting percentage observed at the higher levels of N is attributable to enhanced metabolic activity as a result of translocation of sugar and narrowing down of C:N ratio (Singh *et al.*, 1982). The synthesis of certain bio-regulants also might have influenced the reproductive system of plants by increasing the number of flower buds per vine. Similar results were reported by Brantley and Warren (1958, 1960 a and 1960 b); Parikh and Chandra (1970) and Al-Sahaf and Al Khafagi (1990) in cucumber; Pandey and Singh (1973) in bottlegourd; Bishop *et al.* (1969) and Hanna and Adams (1989) in pickling cucumbers.

According to Agarwala and Sharma (1976), when N is the limiting factor, flowering and fruit setting are adversely affected; flower buds often turn pale and are shed prematurely. The favourable effect of N on fruit setting has been reported in muskmelon by Brantley and Warren (1960 a) and Singh *et al.* (1995).

The sex ratio (M:F) narrowed significantly due to applied N. It is quite logical because the enhancement in the production of female flowers due to N application ultimately results in the narrowing down of the ratio between male and female flowers. Similar favourable effect of N on sex ratio was reported by a number of workers viz., Hall (1949) in small gherkin; Singh *et al.* (1982) in tinda and Haris (1989) in snakegourd. At i_1 level of irrigation where moisture supply was adequate, the number of female flowers increased gradually from n_1 to n_3 but there was significant reduction at n_4 may be because of the withdrawal of auxin by developing fruits. This is supported by Brantley and Warren (1960 b) who increased the number of female flowers in muskmelon with naphthalene ascetic acid. A similar trend was noticed in sex ratio also which is the ratio of male to female flowers.

Translocation of a large quantity of photosynthates to the fruits might have resulted in the higher mean girth and weight of fruits due to higher levels of applied N. Increase in the weight of fruits due to N were reported in pickling cucumber by Manuca (1989); El-Hassan (1991) and Kubo *et al.* (1991); in cucumber by Miller and Ries (1958) and Subba Rao (1989); in muskmelon by Jassal *et al.* (1970); Srinivas and Doijode (1984) and Prabhakar *et al.* (1985); in watermelon by Deswal and Patil (1984); in pumpkin by Rajendran (1981) and Swaider *et al.* (1994) and in pointedgourd by Das *et al.* (1987).

The harvest index showed a substantial improvement due to N application during both the years and just like the other yield attributes, the higher levels of N were significant in this case also. Eventhough there was better partitioning

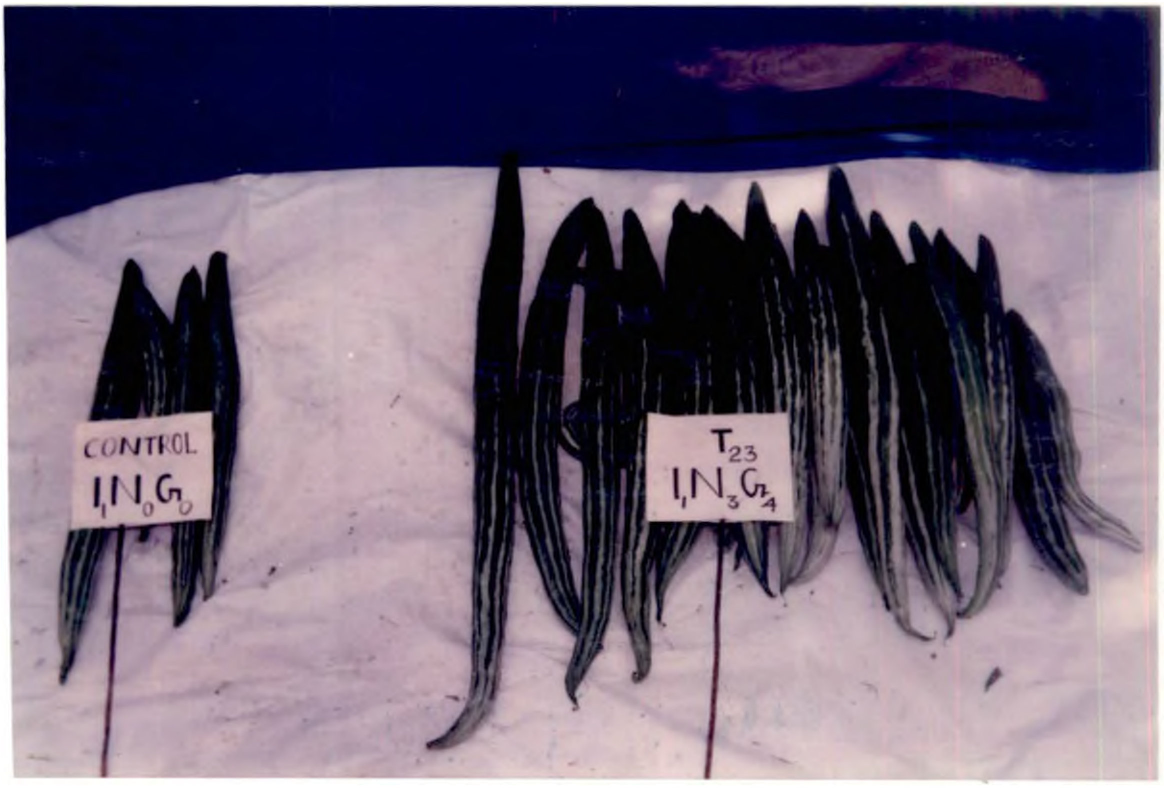


Plate 5 Comparative yield of $n_3g_4i_1$ and $n_0g_0i_1$ from single harvest

of assimilates among the various plant parts, fruits were relatively more efficient in the utilization of assimilates, as evidenced by the harvest index. Whatever may be the quantity of assimilates accumulated due to higher rates of N application, the fruits got the maximum share. Similar findings were reported by Rajendran (1984) in greengram and Premalakshmi (1997) in small gherkin.

The favourable influence of N on yield attributes, in general, could be ascribed to the increased availability and uptake of N for the initiation of floral primordia and production of larger amounts of dry matter.

The yield attributes viz., number of female flowers plant^{-1}, number of fruits plant^{-1}, sex ratio and harvest index varied considerably due to different levels of ethephon during both the years, whereas fruit setting per cent was favourably influenced during the second year only.

The female flower production was consistently high in the ethephon level g_4. Ethephon releases ethylene directly to the plant tissues, producing physiological changes leading to the suppression of male flowers and increased production of female flowers. Three lines of evidences support this: (1) cucurbit plants are known to produce ethylene concentration more in gynoecious plants than in monoecious plants (2) in reduced atmospheric pressure, sex expression in cucurbits changes towards maleness due to the decrease in internal concentration of gases (3) carbondioxide which is a competitive inhibitor of ethylene reduces femaleness (Krishnamoorthy, 1981).

Sex expression is regulated by differences in auxin metabolism or endogenous auxin-gibberellin balance (Heslop Harrison, 1957; Peterson and Anhder, 1960; Bukovac and Witter, 1961 and Atamon *et al.*, 1968). Ethephon is also reported to be an antigibberellin factor (De Wilde, 1971). The positive influence of ethephon on female flower production in cucumber has been reported by a number of workers (Lower and Miller, 1969; Robinson *et al.* 1969; Rudich *et al.*, 1969; Iwahori *et al.*, 1970; Bhandari *et al.*, 1974; Verma and Choudhury, 1980; Singh and Singh, 1984; El-Ghamainy *et al.*, 1985; Verma et al., 1985; Arora *et al.*, 1985, 1988, 1989).

The increase in the production of female flowers due to ethephon application narrowed down the sex ratio leading to the production of a larger number of fruits. Further, ethephon tended to improve fruit setting. The higher levels g_3 and g_4 were on par and superior to the lower levels in narrowing down the sex ratio. This is in conformity with the findings of El-Ghamainy *et al.* (1985); Alikhan *et al.* (1986); Vadigeri and Madalgeri (1989); Ying and Li (1990); Arora *et al.* (1991) and Das and Das (1996).

Irrigation frequency exerted favourable influence on the yield attributes like number of female flowers plant^{-1}, number of fruits plant^{-1}, mean length of fruit, mean fruit weight and girth and harvest index. Between the irrigation frequencies, i_1 was superior to i_2 on most of these attributes. This was but expected due to adequate availability of moisture in the root zone of the crop. Uninterrupted availability favoured rapid absorption of plant nutrients and higher rate of photosynthesis. This agrees with the findings of Kaniszewski and Elkner (1987 and 1990); Swaider *et al.* (1988) and Elkner and Kaniszewski (1995).

At the low irrigation frequency (i_2), moisture stress occurred at different growth stages resulting in slow meristematic activity, reduced rate of photosynthesis and increased abscission of flowers and fruits. This is in conformity with the findings of Czao (1957); Molnar (1965); Kaufman (1972); Kumar (1984); Thomas (1984); Subba Rao (1989) and Haroon (1991). Favourable influence of optimum moisture on yield attributes of cucurbits has been reported by Flocker et al. (1965); Molnar

(1965); Jassal *et al.* (1970); Neil and Zunino (1972); Goyal and Allison (1983); Kumar, (1984); Osorio (1987) and Subba Rao (1989).

In snakegourd fresh fruit is the ultimate product that decides the economics of production. Any management practice that improves the yield of fruit would definitely play a vital role in reducing the cost of production. In the present study also, the various treatments imposed had favourable influence on fruit yield.

A perusal of the yield data indicated significant influence of N, G and I. Among the different levels of N, n_3 and n_4 were on par and they increased the fruit yield significantly over the lower levels ie., n_2 and n_1 during both the years of experimentation. The pooled data also showed a similar trend and the season x treatment interaction was not significant. Hence, from economic point of view, n_3 could be adjudged as the optimum dose of N for snakegourd. In vegetable crops, the response to N is more conspicuous than that of P and K (Bains and Bhardwaj, 1976). Increased availability and uptake of nutrients at higher levels of N might have led to better expression of yield attributes which ultimately resulted in higher yield. According to Russel (1973), with an increase in N supply, the extra protein produced permits the plants to have more surface area available for photosynthesis, resulting in better N use efficiency and enhanced growth. According to Chadha and Lal (1993) higher fruit weight and number are determining factors of yield in snakegourd and this explains the higher yield obtained under higher levels of N, in the present study.

The response of crops to fertilizer application directly depends upon the status of available plant nutrients in the soil and a 'low' rating in the available N status of soil means that crops on such soils should respond very readily to nutrient application (Bains and Bhardwaj, 1976). Bray (1948) and Mc Cants and Black (1957) also held the same view with respect to crop response to fertilizers. In the present study the soil N status was low to medium (278.5 kg ha^{-1}) which explains the better response to applied N.

Considerable variation in fruit yield due to ethephon application was noticed during both the years. The highest yield was recorded by g_3 during the first year and by g_4 during the second year. But, these two levels were on par and significantly superior to g_1 and g_2 during the first year. The pooled data also indicated a similar trend with g_4 recording the highest yield (25.14 t ha^{-1}) on par with g_3 (24.47 t ha^{-1}). This positive effect of g_3 and g_4 on fruit yield may be due to the substantial improvement in yield attributes viz., number of fruits $plant^{-1}$, mean girth of fruits and harvest index due to ethephon. Similar responses were observed in several earlier studies (Shanmughavelu *et al.*, 1973; Shanmughavelu and Thamburaj, 1973; Shanmughavelu *et al.*, 1975; Sundararajan and Muthukrishnan, 1974; Singh *et al.*, 1975; Das and Swain, 1977; Verma and Choudhury, 1980; Dubey, 1983; Verma *et al.* 1986; Arora and Partap, 1988; Arora *et al.*, 1989 a; Gawankar *et al.*, 1990 and Devadas and Ramadas, 1994).

Irrigation treatments also significantly influenced the fruit yield and i_1 was superior to i_2. The superiority of daily drip irrigation over alternate day drip irrigation has been well established (Haroon, 1991). Sharma *et al.* (1996) reported that vine and herbaceous crops required a constant moisture supply for vegetative and reproductive growth and that adequate moisture in the effective root zone by daily drip irrigation resulted in better yield.

Plate 6 Comparative yield of $n_4g_4i_1$ and $n_0g_0i_1$ from single harvest

The better expression of yield attributes viz., fruit number and mean weight and length of fruits at frequent irrigation (i_1) contributed to increased fruit yield This is in agreement with the findings of Rudich *et al.* (1978) who obtained a 48 per cent increase in the yield of watermelon mainly due to the effect of irrigation on fruit size. Significant yield increases due to frequent drip irrigation has been reported by Singh and Singh (1978) in longgourd; Sharma *et al.* (1996) in tinda; Kadam and Magar (1992) and Satpute *et al.* (1992) in tomato and Narayan *et al.* (1994) in sweetpepper.

The interaction between N and I was significant on yield of fruits during the first year by its positive effect on number of female flowers plant^{-1}, sex ratio and fruit setting per cent. At the lower levels of N, viz., n_1 and n_2, the irrigation treatments behaved in a similar way in their effect on yield of fruits. However, at the levels, n_3 and n_4, the irrigation treatment i_1 recorded considerably higher yield over i_2 or at higher nutrient level, the irrigation requirement was also maximum for the better expression of fruit yield. This is in agreement with the findings of Salter (1961) and Sharma (1969)..

A very close relationship exists between the continuous availability of soil moisture and crop response to fertilizer application. If soil moisture becomes a limiting factor during any of the growth stages, addition of fertilizers may adversely affect the yield. The continuous availability of moisture under the irrigation frequency, i_1 in the present study may be the probable reason for the better response of the test crop to N.

According to Bains and Bhardwaj (1976) soil moisture has a tremendous impact on the fertilizer applied. If there is either an excess or deficiency of moisture, the full efficacy of the fertilizer cannot be expected. Cucurbits require considerable amount of moisture coupled with heavy dose of N when making their most vigorous growth and upto the time the fruits become mature, if maximum yields are to be obtained (Whitaker and Davis, 1962 and Subba Rao, 1989).

The physical optima for N worked out by fitting the quadratic response surface for i_1 was 115 kg ha^{-1} and 100 kg ha^{-1} during the first and second year, respectively. Both these doses are around the n_3 level (105 kg N ha^{-1}) and hence, n_3 could be adjudged as the best suited N level for the crop at i_1 which was the significantly superior irrigation treatment. The higher physical optima for N at i_2 (133 and 115 kg ha^{-1} during the first and second year, respectively) could be due to reduced uptake and need for more N. The low fertility status of the soil of the experimental site also explains the reason for the observed response to applied N.

Increased transpiration under high evaporative demand coupled with favourable moisture conditions in the soil will increase the rate of uptake of nutrients as a result of mass transfer of ions through the transpiration stream (Ghildyal, 1971). In the present study, the test crop was raised during the summer months (December to April) when the evaporative demand of the atmosphere was very high and continuous availability of moisture in the vicinity of roots by frequent irrigation along with adequate quantity of N might have resulted in better growth and yield. Similar findings on the positive interaction between N and irrigation have been reported by Goyal *et al.* (1988) and Hartz *et al.* (1993) in chilli.

In crops, where there is a high degree of correlation between the vegetative growth and the yield of commercial product, there is a strong interaction between N and irrigation, otherwise the interaction is often absent and the two factors work independently. This may probably be the reason for the better NI interaction observed in the present study.

Physical optima of N and ethephon

The physical optima of N and G were worked out separately for i_1 and i_2. During the second year, the optimum requirement of N was found to be considerably low compared to the first year. The obvious increase in the available N status of the soil after the first crop could be the possible reason for this lower requirement of N during the second year.

The first year's yield data showed that the optimum quantity of N for obtaining maximum yield at i_1 level of irrigation was 115 kg ha^{-1} as against 133 kg ha^{-1} at i_2. During the second year these values were 100 and 115 kg ha^{-1}, respectively. In the case of ethephon, during the first year the physical optima were 132 and 114 ppm, respectively, for i_1 and i_2. Vigorous plant growth as indicated by the enhanced leaf number and dry matter production in i_1 might have resulted in higher requirement of ethephon for producing the maximum yield. During the second year, since no parabolic trend was observed for G, optimum could not be worked out for i_1, however, for i_2 it was 183 ppm.

5.4. Root studies

During both the years, the dry weight of roots showed significant variation due to N application. The higher levels of N ie., n_3 and n_4 were found to be superior to the lower levels in this regard. Under irrigated conditions, fertilizers greatly help to increase the crop yields through their favourable effects on root mass and root distribution (Wilkinson, 1962). According to Dakshinamurthi and Ghildyal (1976), the root system of crops fertilized with N is nearly four times that of crops not receiving N and the roots of fertilized plants below the 15 cm soil depth weighed twice as much as those of the plants grown on the unfertilized soil.

Comparing different irrigation treatments, the dry weight of root was more in i_1 than in i_2 although the magnitude of variation was not statistically significant. According to Abrol and Dixit (1972), the amount of roots increased with the wetness of the soil. It is a well established fact that root growth of crops decreases as soil moisture tension increases (Klepper *et al.*, 1973; Zabara, 1977; Babaloa and Fawasi, 1980; Salam and Wahid , 1993).

The interaction effects were not significant on dry weight of roots.

5.5. Moisture characteristics

Nitrogen and irrigation treatments significantly influenced the water use efficiency (WUE) in both the seasons. Comparing different levels of nitrogen, n_3 and n_4 were on par in their effect on WUE and significantly superior to n_1 and n_2. The increase in WUE was associated with higher fruit yield. Mecs (1986) suggested that increased nutrient supply decreased evapotranspiration co-efficient and water consumption co-efficient resulting in higher WUE. This result confirms the findings of Thomas (1984); Subba Rao (1989); Thampatti *et a*l. (1993) and Lakshmi (1997) in cucurbits and Hegde (1988 b); Palled *et al.* (1988); Prabhakar and Naik (1993) and Sherly (1996) in chillies.

Growth regulator influenced the WUE during the second year only and g_3 and g_4 were found to be on par and superior to g_1 and g_2. This favourable effect of g_3 and g_4 might be due to their positive influence on yield of fruits which in turn increased the WUE.

Irrigation treatments also had a substantial effect on the WUE during both the seasons with i_2 (irrigation at 10 mm CPE) registering a significantly higher value than i_1 (irrigation at 5 mm CPE). This is but natural since ET increased with the water supply as in i_1 and fruit yield did not increase commensurate with it. Under low frequency irrigation as in i_2 the crop economised its water use by regulating its stomatal openings resulting in low ET (Slatyer, 1967 and Larson, 1975). Higher seasonal consumptive use values for more frequent irrigation was reported by Konishi (1974); Loomis and Crandall (1977); Henkel (1978); Prasad and Singh (1979), Sharma and Parashar (1979); Thomas (1984) Subba Rao (1989) and Thampatti *et al.* (1993). This increase in WUE at lower irrigation regime is in agreement with the findings of Lin *et al.* (1983); Kumar (1984); Fischer and Nel (1990); Haroon (1991); Pawar *et al.* (1993) and Benke, (1995). Similarly, this decrease in WUE with increased expense of water under frequent/higher level of drip irrigation is in conformity with the results reported by Rajakrishnamoorthy *et al.* (1994); Lakshmi, (1997) and Selvaraj *et al.* (1997).

The NG interactions significantly influenced the WUE during the second year. Combinations of higher levels of N and G viz., n_4g_4, n_4g_3 and n_3g_4 recorded significantly higher WUE than the other combinations. The higher yield of fruits recorded at higher levels of N and G at the same quantity of applied irrigation water definitely had a say in this. The interaction between N and I on WUE was not found to be significant. Similar results were reported earlier by Sherly (1996) in chilli.

The total quantity of water used during the cropping period also showed a substantially higher value for i_1 compared to i_2 during both the years. The weather conditions to which the crop was exposed being the same, the effective rainfall received was the same for both the irrigation treatments; also the same quantity of water was used for the initial establishment of the crop. Hence, this difference in total quantity of water used was due to the variation in the irrigation frequency through its indirect effect on the consumptive use of the crop. This increased water use under i_1 has resulted in the reduced WUE for the treatment, eventhough yield of fruits showed significant enhancement due to frequent irrigations.

5.6. Content and uptake of major nutrients

The nitrogen content of fruits as well as plant parts varied considerably due to N, G and I. Obviously there was no dilution effect in treatments recording higher dry weight which might be due to the enhanced mineral uptake. The favourable effect of N in enhancing the content of N in plants is in conformity with the results reported by Tayal *et al.* (1965); Novotorova and Pavlova (1986); Subha Rao (1989); Karuthamani (1995); Nirmala (1996); Premalakshmi (1997) and Lakshmi (1997) in cucurbits.

There was significant increase in the N content of fruits and plant parts and a significant decrease in the P and K content of plant parts at less frequent irrigations as compared to frequent irrigations. According to Michael (1978), when the growth of plant is limited due to moisture stress, N tends to accumulate within the plant. The K content is relatively low as the rate of entry of K decreases to a greater degree than does the rate of utilisation in slower growing plants. Though not significant always, the phosphorus and potassium content also increased due to nitrogen, ethephon and irrigation treatments. The treatment interactions also favourably influenced the plant nutrient content.

The uptake of major nutrients in the present study showed significant variations due to treatments. The uptake of all the major nutrients - N, P and K - increased significantly due to N application during both the years. The various reasons attributed by Tisdale and Nelson (1975) on the favourable effect of N on P uptake are: (i) enhanced root growth and foraging capacity for P (ii) better top growth thus increasing the need for P and (iii) salt effects of N compounds on P solubility and (iv) residual acidity thus increasing P availability. Agarwala and Sharma (1976) opined that the uptake of nutrients depend to a large extent on the degree of development of root system. According to Tanaka *et al.* (1964), the nutrient uptake is controlled by factors like nutrient availability in the soil, the nutrient absorption power of roots and the rate of increase in dry matter. In the present study, the higher levels of N enhanced the total dry matter production and the dry weight of roots which might have resulted in better nutrient uptake. Similar favourable effect of applied N on the uptake of N, P and K in cucurbits was reported earlier by Subha Rao (1989); Adams (1994); Karuthamani (1995); Nirmala (1996); Premalakshmi (1997) and Lakshmi (1997).

Though not significant always, ethephon and irrigation treatments also exerted a positive influence on the uptake of major nutrients. The favourable effect of ethephon on DMP might have helped in the better uptake. Eventhough not significant, frequent irrigation also improved the dry weight of root and DMP resulting in higher uptake of nutrients. Agarwala and Sharma (1976) pointed out that irrigation influenced the response to fertilizers by increasing the availability or uptake of nutrients contained in a fertilizer. Tisdale and Nelson (1975) also opined that soil moisture level has a pronounced effect on the uptake of plant nutrients and as a general rule, there is an increase in the uptake of nutrients as soil moisture tension decreases.

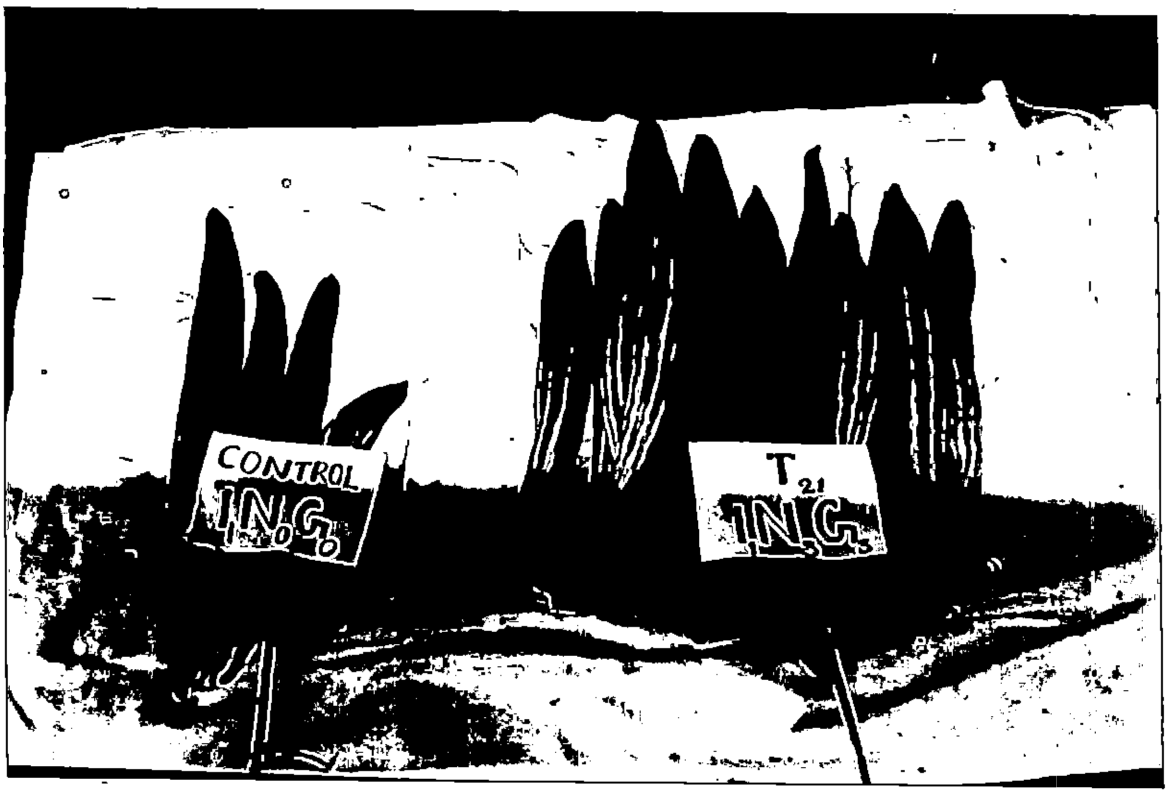


Plate 7 Comparative yield of $n_3g_3i_1$ and $n_0g_0i_1$ from single harvest

5.7. Quality of fruits

The effect of the treatments on the moisture content of fruits was not consistent over the seasons. This quality attribute was influenced significantly in the first year only. The higher levels of N, G and I enhanced the moisture content considerably.

Nitrogen and ethephon did not cause any substantial change in the TSS of fruits. These results agree with those of Kimbrough (1930) and Debuchananne and Taber (1985). The irrigation frequency exerted a negative effect on this quality attribute, which is in agreement with the findings of Moore *et al.* (1958); Vittus *et al.* (1962); Rudich *et al.* (1977); Stevens and Rudich (1978) and Chartzoulakis and Drosos (1995).

Acidity of fruits was positively influenced by N during the second year and this agrees with the findings of Sharma (1971); Choudhury and De (1972); Sharma and Mann (1973); Arora *et al.* (1993) and Patil and Bhojappa (1984 a). The positive effect of irrigation on acidity of fruits was reported earlier (Sanders *et al.*, 1989) in tomato.

The total and reducing sugar content showed a significant enhancement due to N and ethephon, but it decreased substantially due to irrigation during the second year. The favourable effect of N in improving sugar content of fruits was reported earlier by Sharma and Mann (1973); Patil and Bhojappa (1984 b); Avakyan *et al.* (1992) and Annanurova *et al.* (1992). The favourable effect of ethephon on total and reducing sugar content was reported by Shanmughavelu *et al.* (1975) and Gawankar *et al.* (1990) in pumpkin. A decrease in carbohydrate content of tomato fruits by increased irrigation rates was observed by Rudich *et al.* (1977); Kaniszewski and Elkner (1987) and Elkner and Kaniszewski (1995).

Ethephon exerted a significant positive effect on the ascorbic acid content of fruits during both the years. This is in agreement with the findings of Shanmughavelu and Thamburaj (1973) in snakegourd. Though not significant, N also enhanced the ascorbic acid content of fruits which is in accordance with the findings of Krynska *et al.* (1976) and Das *et al.* (1987) in cucurbits; Sharma and Mann (1973); Pandita and Bhatnagar (1981) in tomato; Randhawa *et al.* (1981) in muskmelon; Dod *et al.* (1983); Thomas and Leong (1984); Amritalingam (1988); Shibhila Mary and Balakrishnan (1990); Demirovska *et al.* (1992); Lata and Singh (1993) and Sherly (1996) in chilli.

A significant improvement in the crude protein content of fruits was observed due to N, ethephon and irrigation. The favourable effect of these treatments on N content of fruits, in turn might have resulted in increased protein synthesis in fruits.

Eventhough the magnitude was not significant, the crude fibre content of fruits decreased due to N and irrigation. Similar effect of N on crude fibre content of fruits was reported by Mani and Ramanathan (1981) in bhindi and that of irrigation was reported in tomato by Elkner and Kaniszewski (1995).

Application of N was found to lower the shelf life of fruits significantly and n_1 was significantly superior to the other levels of N in this regard. Lakshmi (1997) also obtained similar results in cucumber. Ethephon and irrigation did not have any significant effect on this quality attribute. Rudich *et al.* (1978) also reported that the shelf life of watermelon was unaffected by irrigation.

Among the various interactions, NG significantly improved the moisture, TSS and reducing sugar content during the first year. The combinations of higher levels of N and G were found to influence the moisture content significantly. In the case of TSS, the highest value was recorded by n_4g_4 and it was on par with n_4g_3, n_3g_4, n_2g_4 and n_1g_4 showing the favourable effect of higher levels of G on this quality parameter, in combination with N. In the case of reducing sugar also G showed its positive influence, with all the combinations of g_4 and g_3 with N except g_3n_1 significantly improving the quality parameter compared to other NG combinations.

During the second year, acidity, total sugar, ascorbic acid, crude protein content and shelf life varied considerably due to NG interactions. Combinations of higher levels of N and G were found to influence these quality attributes positively showing the favourable effect of N and G. Arora *et al.* (1995) also reported beneficial effects of NG interactions on TSS and ascorbic acid content in ridgegourd. Sensory quality of fruits was not significantly influenced by the treatments as evident from the results of non-parametric analysis of the data of organoleptic evaluation. Similar effect of N on the sensory quality of gherkins was reported by Premalakshmi (1997) and of ethephon on snakegourd by Alikhan *et al.* (1986). Singh (1990) has rightly pointed out that there is a wrong notion in the minds of certain people that abundant use of chemical fertilizers in vegetable production affects the quality of vegetables adversely and such vegetables do not possess good taste; however, for high productivity and good quality of vegetables, use of chemical fertilizers is essential.

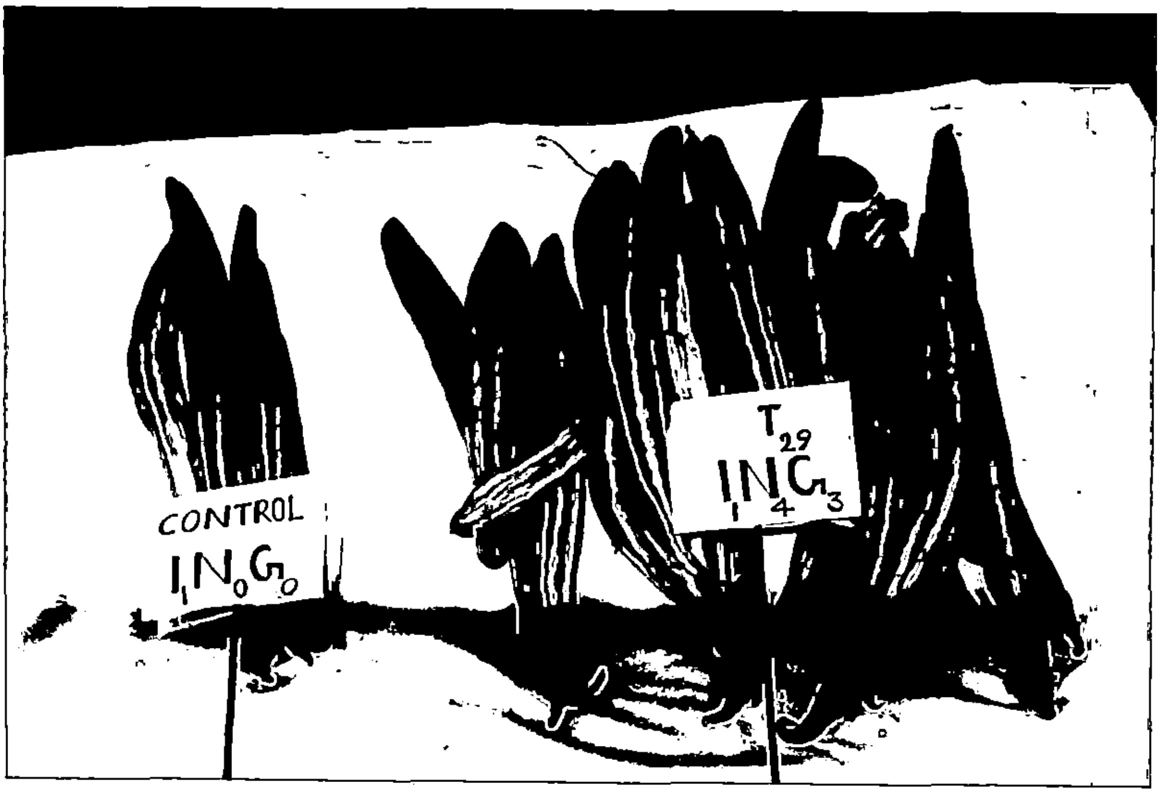


Plate 8 Comparative yield of $n_4g_3i_1$ and $n_0g_0i_1$ from single harvest

5.8. Physico-chemical properties of soil

The bulk density of the soil remained unaffected by N, ethephon and irrigation. Similar effect of N and irrigation on bulk density was reported by Patel *et al.* (1995). This could be due to the very short duration of the snakegourd crop ie., less than four months.

The pH of the soil also showed significant variation due to N application during both the years. There was considerable reduction in the pH of the soil due to the application of incremental doses of N. The higher levels of N viz., n_3 and n_4 reduced the pH significantly compared to n_1 and n_2. It is well established that P and K fertilizers have generally little influence on soil acidity, whereas the carriers of N have a considerable effect on the pH of the soil (Bains and Bhardwaj, 1976). Similar findings on the effect of N in reducing soil pH was reported by Minhas and Mehta (1984); Sudhadevi and Mohanakumaran (1987) and Haroon (1991). However, in the present study, the reduction in pH did not exert any significant influence on nutrient uptake as evident from the higher nutrient uptake and yield. According to Aslander (1952) very often, it is the lack of plant nutrients and not the unfavourable soil reaction which makes the soil unproductive.

As far as irrigation frequency was concerned, drip irrigation at 5 mm CPE increased the pH of the soil significantly compared to irrigation at 10 mm CPE. This is in agreement with the findings of Haroon (1991) in tomato who obtained a negative correlation between pH and EC and the higher EC recorded in plots irrigated through the drip system on alternate days was attributed to the increased irrigation interval leading to greater evapotranspiration resulting in the accumulation of salts in the wetted area. The soil samples for analysis were drawn from just below the emitter and the higher pH recorded at this point could be due to the movement of salts towards wetting front under trickle irrigation (Singh *et al.*, 1978).

The organic carbon content of the soil did not vary significantly due to the treatments during both the years. However, the content of organic matter was found to be at a higher level in the treated plots compared to the control where irrigation alone was given. It could possibly be due to higher production of root biomass, leaf fall etc. Jenny and Raychaudhuri (1960) opined that fertilization with artificial N compounds with additional nutrients would enhance the yield and stimulate the root system in the soil thereby augmenting the soil humus. Compared to the pre-treatment values, the post-treatment soil recorded higher organic carbon content, may be due to the addition of farm yard manure @ 25 t ha^{-1} in all the plots, irrespective of the treatments, during both the seasons.

The available N status of the soil after the crop, was found to be substantially higher than the pre-treatment values during both the seasons and it varied significantly due to N levels. The higher levels of N, viz., n_3 and n_4 registered significantly higher available N content than the lower levels, n_1 and n_2. The enhanced available N status at higher levels of applied N might be due to its residual effect over a uniform dose of farm yard manure. Lesser leaching losses of applied N under drip system of irrigation also might have contributed to the increased N status of the soil. Similar findings were reported by Goldberg *et al.* (1971) and Bar-Yosef and Sheikholslami (1976).

The significant increase in post-experiment soil N status by the addition of higher doses of N is in agreement with the reports of Muthuvel (1976), Bajwa and Paul (1978), Thomas (1984), Sudhadevi and Mohanakumaran (1987), Haris (1989), Sherly (1996), Premalakshmi (1997) and Lakshmi (1997). Farm yard manure has considerable positive influence on the release and availability of N (Venkatesa Rao, 1985 and Thangavel, 1985) which explains the higher post-experiment N status of control plots compared to the pre-treatment values. The available N content was not influenced by the irrigation frequency. Similar results have been reported by Locascio and Smajstrla (1996).

The available phosphorus and potassium contents of the soil were not significantly influenced by the treatments. This is in agreement with the findings of Sharma and Arora (1988).

The available N, P and K contents of the soil did not show any significant variation due to interactions after the first year. However, after the end of the second year, the available N content exhibited significant variation due to NG and NI interactions and available P due to NI interactions. The improvement in the available N content of soil due to higher levels of N, in combination with lower doses of G could be explained on the basis of the reduced DMP and yield and hence less uptake and utilization of this nutrient at the lower doses of G. A critical analysis of the data on NI interactions showed the favourable effect of incremental doses of N in enhancing the available N content of soil at both the frequencies of irrigation. Thus, the favourable effect of higher levels of N in enhancing the available N content of the soil might have contributed to this effect of NI. An entirely different observation was made on the effect of NI interactions on available P content of soil. In frequently irrigated plots, the available P content of soil was significantly reduced by the highest level of N whereas in less frequently irrigated plots, it was increased. Better DMP, yield and nutrient uptake at i_1 compared to i_2 must be the probable reason that could be attributed to this effect.

5.9. Economics of treatments

The net profit as well as the benefit:cost ratio improved progressively with increasing levels of applied N upto n_3 and thereafter it declined. The highest net profit (Rs.74,636) and benefit:cost ratio (2.37) were registered by n_3 followed by n_4 (Rs.70,607/- and 2.28, respectively). As shown earlier, the highest yield of fruits was also registered in n_3 which was on par with n_4. Since both these levels were on par, n_3 was adjudged as the best treatment. The economic analysis also confirmed the significance of n_3 over the other levels of N.

In the case of ethephon also, the net profit increased progressively from Rs.59,240 ha^{-1} to Rs.71,194 ha^{-1} and benefit:cost ratio from 2.09 to 2.31 as its level was raised from 0 to 200 ppm. Eventhough the magnitude of yield increase at the highest level of ethephon (200 ppm) over its next lower dose (100 ppm) was only marginal, the increase in the net profit and benefit:cost ratio was substantial, the cost involved in the treatment application being negligible. Therefore, from the economic point of view, g_4 could be considered as the best treatment.

As far as irrigation was concerned, i_1 (5 mm CPE) realised more net returns (Rs.70,038) and benefit:cost ratio (2.28) even with its higher cost of cultivation as compared to i_2 (10 mm CPE). Based on the above analysis, a treatment combination of $n_3g_4i_1$ could be advocated for commercial cultivation of snakegourd. Data furnished in Table 43, on the economics of treatment combinations also confirm this conclusion.

SUMMARY

SUMMARY

Field experiments were conducted during 1994-'95 and 1995-'96 at the Instructional Farm, College of Agriculture, Vellayani to standardise the optimum dose of nitrogen, ethephon and drip irrigation frequency for snakegourd.

The experiments were laid out in a 4^2 x 2 + 2 asymmetrical confounded factorial design with 2 replications. The treatments consisted of combinations of four levels of nitrogen (35, 70, 105 and 140 kg N ha^{-1}), four levels of ethephon (0, 50, 100 and 200 ppm) and two drip irrigation frequencies (5 mm CPE and at 10 mm CPE) with two controls (drip irrigation at 5 mm CPE and at 10 mm CPE without nitrogen and ethephon) in each block. The highest order interaction NGI was confounded in both the replications and each replication included two blocks. The depth of irrigation was 15 mm. The experiments were conducted during the summer seasons (December to April) of 1994-'95 and 1995-'96.

Growth characters, earliness, yield attributes, yield, water use efficiency, root dry weight, nutrient content in fruits and plant parts, nutrient uptake, quality of fruits and the economics of the treatments were studied and the results interpreted. The inference and conclusions drawn from the results of the experiments are summarised below:

1. The highest length of internode, number of leaves plant^{-1} and dry matter production were observed at the nitrogen level of 105 kg ha^{-1} (n_3).

2. The highest fruit number was recorded at 105 kg N ha^{-1} compared to the other levels of N.

3. The average fruit weight was the highest at 140 kg N ha^{-1}(n_4), however, it was on par with that obtained at 105 kg N ha^{-1} and hence 105 kg N could be adjudged as the optimum dose with respect to this yield attribute.

4. Fruit length was not influenced by nitrogen and girth of fruit was the highest at N @ 105 kg ha^{-1}. The harvest index also improved significantly by the higher levels of N.

5. The earliness attributes viz., days to first female flower opening and node at which first female flower opened were significantly influenced by the N levels. The minimum number of days for flower opening and the lowest node number were recorded at the lowest level of N viz., 35 kg ha^{-1} (n_1).

6. The crop duration was not influenced by nitrogen levels.

7. Significantly higher fruit yield were recorded at 105 and 140 kg N ha^{-1} (which were on par) compared to the lower levels of N viz., 35 and 70 kg ha^{-1} (n_2). The physical optima for N at i_1 were worked out as 115 and 100 kg ha^{-1} during the first and second year, respectively.

8. The dry matter yield of roots was the highest at 105 kg N ha^{-1} but it was on par with that registered at 140 kg N ha^{-1}.

9. The water use efficiency was also influenced by nitrogen levels and the highest value was recorded by 105 kg N ha^{-1} on par with 140 kg N ha^{-1}.

10. The N, P_2O_5 and K_2O content of fruits and plant parts were also significantly more at higher levels of N ie., 105 and 140 kg N ha^{-1} compared to the lower levels. Nutrient uptake also followed a similar trend.

11. The quality of fruits was also favourably influenced by N levels. Nitrogen improved the moisture content, total sugar, reducing sugar, ascorbic acid and crude protein content. The crude fibre content and shelf life decreased by higher levels of nitrogen. The shelf life was the highest at 35 kg N ha^{-1}.

12. Organoleptic evaluation indicated that there was no significant variation in the sensory quality of snakegourd fruits due to the treatments.

13. The post experiment soil nutrient status showed that there was significant increase in the available N content of the soil due to applied N with 140 kg N ha^{-1} recording the highest value.

14. There was significant reduction in the pH of the soil due to higher levels of N, ie., 140 and 105 kg ha^{-1}.

15. There was not much variation in the bulk density and organic carbon content of the soil due to N application.

16. The highest net profit (Rs.74,636/-) and benefit cost ratio (2.37) were registered by 105 kg N ha^{-1} compared to the other levels of N.

17. As far as the ethephon levels were concerned, the highest leaf number and dry matter production were reported at 200 ppm (g_4) which was significantly superior to all other levels tested. However, the internodal length was unaffected by ethephon treatments during both the years.

18. The earliness attributes viz., days to first female flower opening and node at which first male and female flower opened also varied significantly with ethephon. The higher levels were significantly superior to the lower levels tested in this regard.

19. The crop duration was not influenced by ethephon levels.

20. The mean weight and length of fruit were not significantly influenced by ethephon. But there was significant increase in the number of fruits plant^{-1} and girth of fruits due to higher levels of ethephon.

21. The number of female flowers plant^{-1} was higher for 100 and 200 ppm ethephon which were on par and significantly superior to 50 and zero ppm. The sex ratio and percentage fruitset also followed a similar trend.

22. The pooled data showed that the highest fruit yield (25.14 t ha^{-1}) was recorded at 200 ppm ethephon which was on par with 100 ppm ethephon (24.47 t ha^{-1}) and significantly higher than the lower levels of ethephon. NG and NI interactions also favourably influenced the fruit yield.

23. As far as the harvest index is concerned the highest value was recorded by 100 and 200 ppm.

24. There was no significant variation in the dry weight of roots due to ethephon.

25. The highest water use efficiency was registered at 100 ppm ethephon; however it was on par with that recorded at 200 ppm.

26. Nitrogen and potassium content of plant parts differed significantly due to ethephon and the higher levels improved it substantially compared to the lower levels. But there was no significant variation in the phosphorus content of plant parts due to ethephon.

27. The higher levels of ethephon ie., 200 and 100 ppm registered significantly higher N and potassium content of fruits compared to the lower levels (50 and zero ppm). The phosphorus content of fruits was not influenced significantly by ethephon.

28. The uptake of nitrogen, phosphorus and potassium were the highest for 200 ppm ethephon during both the years of experimentation.

29. The quality of fruits in terms of moisture, total sugars, reducing sugars, ascorbic acid and protein content improved considerably due to ethephon application. However, the TSS, acidity, crude fibre, shelf life as well as sensory quality of fruits were not significantly influenced by ethephon during both the years of the study.

30. None of the physical and chemical properties of soil were influenced by ethephon during both the years of experimentation.

31. The economic analysis showed that the highest net profit (Rs.71,194/-) and B:C ratio (2.31) were recorded by 200 ppm ethephon followed by 100 ppm (Rs.67,917/- and 2.25, respectively).

32. Comparing the irrigation treatments, the growth attributes viz., leaf number and internodal length were significantly higher in i_1 (irrigation at 5 mm CPE) than in i_2 (irrigation at 10 mm CPE). However, dry matter production was not significantly influenced by the irrigation treatments.

33. Among the various earliness attributes, days to first female production was significantly influenced by irrigation treatments and i_1 registered significantly more number of days than i_2.

34. The total crop duration also varied significantly due to irrigation treatments and it was significantly higher for frequent irrigation (i_1) compared to less frequent irrigatioin (i_2).

35. During the second year, i_1 recorded significantly higher number of fruits plant^{-1} (16.05) than i_2 (15.19). With respect to mean fruit weight and fruit girth also, i_1 was significantly superior to i_2.

36. Irrigation treatments influenced the fruit length significantly during the first year only; i_1 recorded significantly higher value than i_2.

37. The number of male flowers plant^{-1} was not influenced by the irrigation treatments during both the years. However, during the second year, the number of female flowers plant^{-1} differed significantly due to it and i_1 was significantly superior to i_2.

38. The sex ratio and fruit setting percentage were not influenced by the irrigation treatments during both the years of experimentation.

39. During both the years of study, the harvest index values were higher for i_1, compared to i_2.

40. The pooled data revealed that yield of fruits was significantly higher in i_1 (24.98 t ha^{-1}) compared to i_2 (23.12 t ha^{-1}). A similar result was obtained during individual years also.

41. The irrigation treatments did not exert any significant effect on the dry weight of roots during both the years of the study.

42. Water use efficiency varied significantly by the irrigation treatments and during both the years, i_2 registered significantly higher WUE than i_1. The total seasonal consumptive use was lower for i_2 compared to i_1 during both the years of the study.

43. Comparing the irrigation treatments, the nitrogen content of fruits and plant parts were significantly higher in i_2 than in i_1. However, the phosphorus and potassium content of plant parts followed a reverse trend.

44. The uptake of nitrogen, phosphorus and potassium were not influenced by the irrigation treatments.

45. The quality attributes of fruits viz., TSS, total sugars, reducing sugars, ascorbic acid, crude fibre, shelf life and sensory quality were not significantly influenced by the irrigation treatments. However, moisture, acidity and crude protein were significantly higher in i_1 than in i_2.

46. The physical properties of soil were not influenced significantly by the irrigation treatments.

47. The available nitrogen, phosphorus and potassium and organic carbon content of the soil were not influenced by the frequency of irrigation.

48. With respect to soil pH, i_2 recorded a significantly lower value than i_1.

49. As far as the economics of the irrigation treatments were concerned, i_1 registered a higher net profit and B:C ratio (Rs. 70,038/- and 2.28, respectively) compared to i_2 (Rs. 61,615/- and 2.14).

Conclusion

Snakegourd exhibited remarkable fruit yield response to fertilizer nitrogen, ethephon and drip irrigation frequency. The suitable levels of these inputs for realising the maximum fruit yield and net income were 105 kg N ha^{-1}, 200 ppm ethephon and drip irrigation at 5 mm CPE. A package of these three inputs could be advocated to the vegetable growers for the commercial cultivation of snakegourd.

Future line of work

Based on the results of the present investigation, we could arrive at a suitable combination of N, ethephon and drip irrigation frequency for snakegourd. The results also revealed the favourable effect of frequent drip irrigation on the productivity of snakegourd compared to less frequent irrigation. However, the moisture distribution pattern and wetting front under different frequencies of irrigation may be tested. Also the depth of irrigation for the crop needs standardisation. Similarly, the scope of fertigation may be investigated with a view to improve the efficiency of fertilizer application and irrigation thus reducing the cost of cultivation.

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* Original not seen

APPENDICES

APPENDIX I

Climatic parameters during the cropping periods and the previous five years

Standard week	Period		Temperature (^0C)						Relative Humidity (%)			Rainfall (mm)			Evaporation (mm)		
			Maximum			Minimum			Five year mean	94-95	95-96	Five year mean	94-95	95-96	Five year mean	94-95	95-96
	From	To	Five year mean	94-95	95-96	Five year mean	94-95	95-96									
49	Dec.3rd	Dec.9th	30.9	--	33.3	22.4	--	21.1	77.2	--	75.5	31.1	0	0	3.0	--	3.2
50	Dec.10th	Dec.16th	30.7	--	32.9	22.1	--	19.8	76.2	--	70.6	0.0	0	0	3.2	--	3.8
51	Dec.17th	Dec.23rd	30.5	--	33.7	22.5	--	20.0	74.4	--	70.4	7.3	0	0	2.9	--	3.7
52	Dec.24th	Dec.31st	30.7	31.8	32.9	21.4	22.2	19.9	75.6	77.2	67.6	3.5	0	0	3.3	1.8	3.5
1	Jan.1st	Jan.7th	30.6	31.8	33.1	22.0	22.6	20.4	76.1	80.4	76.8	11.8	0	0	3.4	3.4	3.5
2	Jan.8th	Jan.14th	30.6	32.0	33.3	21.6	23.2	20.4	77.2	74.7	74.3	0.1	8.4	0	3.5	3.5	3.9

3	Jan.15th	Jan.21st	30.9	30.9	31.0	21.5	23.1	19.5	76.8	81.4	80.1	1.6	0	8.0	3.3	3.8	3.2
4	Jan.22nd	Jan.28th	30.7	30.9	31.9	21.0	21.5	18.9	78.0	73.8	70.9	0.0	0	0	3.7	3.4	4.0
5	Jan.29th	Feb.4th	31.0	31.8	32.3	21.2	22.7	19.3	73.8	70.8	59.5	4.0	0	0	4.0	4.0	4.1
6	Feb.5th	Feb.11th	31.1	32.2	32.9	21.6	23.0	20.8	74.8	69.5	74.5	10.0	0	0	4.0	4.0	3.7
7	Feb.12th	Feb.18th	31.2	31.3	32.7	22.1	23.2	20.4	72.9	73.5	70.8	0.0	0	3.8	4.3	3.7	3.8
8	Feb.19th	Feb.25th	31.5	31.9	33.0	22.7	23.0	20.3	72.5	72.6	74.0	0.9	0	0	4.6	4.8	4.0
9	Feb.26th	Mar.4th	31.7	31.9	32.6	22.5	27.7	20.2	74.3	72.4	73.3	6.4	0	16.7	4.8	4.2	4.5
10	Mar.5th	Mar.11th	32.2	32.2	32.7	22.2	19.8	19.1	78.8	74.6	68.5	0.0	0	0	5.0	5.5	5.2
11	Mar.12th	Mar.18th	32.4	32.5	33.4	23.3	23.5	20.8	76.4	70.8	60.3	4.0	4.0	0	5.1	5.4	5.1
12	Mar.19th	Mar.25th	32.3	33.3	34.4	23.7	23.4	22.3	77.8	69.8	75.3	7.5	0	0	5.1	5.0	5.4
13	Mar.26th	Apr.1st	32.8	33.5	34.9	24.7	25.5	24.5	81.0	72.5	71.0	5.6	1.0	0	5.1	5.3	5.3
14	Apr.2nd	Apr.8th	32.5	32.8	33.1	24.7	24.9	23.8	82.3	76.4	82.3	7.7	38.6	4.2	4.7	4.5	5.1
15	Apr. 9th	Apr.15th	32.7	32.5	32.6	24.9	24.7	--	82.4	74.5	--	12.3	6.8	--	5.3	4.6	--
16	Apr. 16th	Apr.22nd	33.0	32.5	32.0	25.4	24.1	--	81.2	75.6	--	2.1	68.6	--	5.0	4.4	--

APPENDIX II

Cost of cultivation of snakegourd (Rs. ha^{-1}) (Mean of two seasons)

	Particulars	Labour			Amount (Rs.)
		Men	Women	Total	
1	Land preparation and layout				
	a) Digging the area	50	--	50	3,375.00
	b) Removal of stubbles	--	10	10	675.00
	c) Taking pits	54	--	54	3,645.00
	d) Sowing seeds, application of BHC etc.	10	--	10	675.00
	e) Mulching with dry leaves	--	10	10	675.00
2	Irrigation and intercultivation				
	a) Pot watering up to 20 DAS	80	--	80	5,400.00
	b) Staking	10	--	10	675.00
	c) First weeding and intercultivation	20	5	25	1,687.50
	d) Second weeding and intercultivation	20	5	25	1,687.50
3	Manuring				
	a) Transporting and application of FYM	20	6	26	1,755.00
	b) Transportation and application of P and K twice	15	--	15	1,012.50
4	Pandal preparation				
	a) Fixing standards	10	--	10	675.00
	b) Tying G.I. wire	5	--	5	337.50
	c) Fixing staywire	3	--	3	202.50
	d) Tying ropes	20	--	20	1,350.00
5	Plant Protection				
	a) Application of plant protection chemicals	10	--	10	675.00
6	Harvesting				
	a) Harvesting fruits and transporting	80	--	80	5,400
	Total	407	36	443	29,902.50

B. Cost of Inputs

Particulars	Quantity	Amount (Rs.)
a) Farm Yard Manure	25 t	7,500.00
b) Seeds	1.500 kg @ Rs.500/-	750.00
c) Phosphorus	25 kg	203.00
d) Potash	25 kg	208.00
e) Coconut leafmid rib for staking	2,500 (Rs.15/- for 100)	375.00
f) Poles for pandal	250 @ Rs.15/-	3,750.00
g) G.I. Wire	20 kg @ Rs.25/-	500.00
h) Coir	13 bundles @ Rs.200/-	2,600.00
i) P.P.Chemicals	--	1,361.00
Total cost of cultivation excluding the treatments		47,150.00

Wage rate 1994-'95	Rs. 65.00
1995-'96	Rs. 70.00
Cost of 1 kg N	Rs. 5.98
Cost of 1 kg P_2O_5	Rs. 8.13
Cost of 1 kg K_2O	Rs. 8.33
Cost of FYM per ton	Rs.300.00

APPENDIX III

Additional cost of the treatments (Mean of two seasons)

Effect	Quantity (ha^{-1})	Cost (Rs. ha^{-1})	Application cost		Total cost (Rs. ha^{-1})
			Labour (ha^{-1})	Amount (Rs. ha^{-1})	
A. Nitrogen					
n_1	35 kg	209.00	4	270.00	479.00
n_2	70 kg	419.00	8	540.00	959.00
n_3	105 kg	628.00	12	810.00	1438.00
n_4	140 kg	837.00	16	1080.00	1917.00
	Mean				1,198.00
B. Ethephon					
g_1	0 ppm	–	8	540.00	540.00
g_2	50 ppm	37.00	8	540.00	577.00
g_3	100 ppm	73.00	8	540.00	613.00
g_4	200 ppm	146.00	8	540.00	686.00
	Mean				604.00
C Drip irrigation		Fixed cost for the system			
i_1 (at 5 mm CPE)		4,155.00	26	1,755.00	5,910.00
i_2 (at 10 mm CPE)		4,155.00	13	878.00	5,033.00
	Mean				5,471.50

APPENDIX IV

Interaction effect of factors on growth characters

Treatment combination	Internodal length(cm)		No.of leaves plant^{-1}		DMP (g plant^{-1})	
	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	17.32	18.29	77.60	71.05	498.50	398.50
$n_1g_1i_2$	15.18	18.75	76.05	67.70	430.50	409.00
$n_1g_2i_1$	16.58	18.15	79.25	71.80	585.50	479.00
$n_1g_2i_2$	17.00	18.35	76.80	71.40	582.50	446.50
$n_1g_3i_1$	16.23	18.45	80.15	74.00	616.50	494.00
$n_1g_3i_2$	15.55	17.35	80.10	72.60	581.50	539.50
$n_1g_4i_1$	15.90	13.95	81.15	76.55	608.50	529.00
$n_1g_4i_2$	15.60	15.45	79.20	73.00	530.50	585.50
$n_2g_1i_1$	17.29	18.60	75.10	73.50	673.50	431.00
$n_2g_1i_2$	15.79	17.80	75.20	72.15	655.00	408.00
$n_2g_2i_1$	16.51	17.20	79.40	74.50	863.00	585.50
$n_2g_2i_2$	15.35	17.15	78.65	71.00	630.00	579.50
$n_2g_3i_1$	16.33	17.45	82.85	75.00	719.50	773.50
$n_2g_3i_2$	15.48	17.70	83.00	72.70	682.00	745.50
$n_2g_4i_1$	17.33	18.55	85.55	77.70	727.00	620.50
$n_2g_4i_2$	15.59	17.70	83.60	74.45	699.00	611.50
$n_3g_1i_1$	16.98	18.05	80.25	74.85	748.50	433.50
$n_3g_1i_2$	17.75	18.10	79.20	72.20	636.00	513.00

$n_3g_2i_1$	18.00	18.25	83.25	77.30	819.00	603.50
$n_3g_2i_2$	17.60	16.85	81.70	75.25	719.00	606.00
$n_3g_3i_1$	19.20	19.25	85.90	78.95	624.50	732.50
$n_3g_3i_2$	18.20	17.45	83.50	78.90	749.50	749.00
$n_3g_4i_1$	17.50	19.65	86.25	85.70	779.50	888.00
$n_3g_4i_2$	18.20	17.35	83.95	84.50	765.50	865.00
$n_4g_1i_1$	18.80	18.25	82.15	76.55	617.00	448.00
$n_4g_1i_2$	18.70	17.65	81.00	75.35	636.50	447.00
$n_4g_2i_1$	17.15	19.00	83.70	77.70	689.50	565.00
$n_4g_2i_2$	16.50	17.25	82.75	75.25	686.50	547.00
$n_4g_3i_1$	17.45	18.55	83.00	80.10	775.50	623.50
$n_4g_3i_2$	16.05	17.85	81.50	78.15	709.00	669.00
$n_4g_4i_1$	17.80	20.10	85.15	84.60	755.00	849.00
$n_4g_4i_2$	16.35	18.70	83.85	82.10	776.00	858.50
$n_0g_0i_1$	15.75	16.90	66.40	67.90	439.50	419.50
$n_0g_0i_2$	15.69	16.30	63.70	65.80	390.00	390.50
$n_0g_0i_1$	16.03	16.50	67.20	67.30	546.00	389.50
$n_0g_0i_2$	15.61	16.10	63.00	66.00	447.00	371.00

APPENDIX V

Interaction effect of factors on earliness

Treatment combination	Days to first flower opening				Node at which first flower opened			
	Male		Female		Male		Female	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	35.00	36.75	42.50	52.90	14.50	15.20	21.00	22.85
$n_1g_1i_2$	37.50	37.50	41.00	50.60	17.00	14.90	20.50	22.20
$n_1g_2i_1$	38.25	36.50	39.50	50.75	15.50	14.40	19.00	22.00
$n_1g_2i_2$	38.00	37.00	37.25	49.75	15.00	14.60	19.50	21.55
$n_1g_3i_1$	36.50	37.75	36.50	51.75	14.50	14.80	18.50	20.80
$n_1g_3i_2$	34.75	38.25	35.00	46.75	14.50	14.05	18.50	19.95
$n_1g_4i_1$	39.00	38.25	38.00	46.10	15.00	15.70	22.00	21.75
$n_1g_4i_2$	38.50	39.75	38.50	45.75	16.00	15.55	21.00	20.80
$n_2g_1i_1$	39.25	37.25	44.00	54.20	17.00	15.40	20.50	22.50
$n_2g_1i_2$	35.50	36.50	41.00	53.40	15.50	16.05	20.50	22.45
$n_2g_2i_1$	37.00	36.75	38.50	52.15	17.50	15.05	19.50	22.25
$n_2g_2i_2$	35.60	37.50	39.00	50.80	16.00	14.70	20.00	21.05
$n_2g_3i_1$	36.50	38.25	36.75	52.00	17.00	15.10	19.00	20.95
$n_2g_3i_2$	35.50	38.25	38.25	49.75	15.50	14.90	18.50	22.00
$n_2g_4i_1$	36.75	40.75	39.25	48.75	12.50	14.45	21.75	19.95
$n_2g_4i_2$	37.00	39.25	38.50	47.75	14.00	14.45	21.75	20.95
$n_3g_1i_1$	35.00	37.00	42.50	53.75	17.00	16.05	23.50	22.50
$n_3g_1i_2$	36.50	36.25	41.00	51.75	15.50	15.95	22.50	22.45

$n_3g_2i_1$	36.25	38.50	39.00	52.75	14.50	15.10	21.00	22.25
$n_3g_2i_2$	37.25	37.50	36.50	50.75	14.50	14.90	21.50	21.05
$n_3g_3i_1$	37.50	38.00	36.00	52.50	15.50	15.05	21.00	20.95
$n_3g_3i_2$	37.50	39.50	38.00	48.85	15.00	14.70	19.50	22.00
$n_3g_4i_1$	39.00	39.75	41.00	47.75	14.50	15.40	23.75	19.95
$n_3g_4i_2$	37.25	39.75	39.00	50.00	17.00	16.05	22.25	20.95
$n_4g_1i_1$	39.00	39.00	44.00	56.00	15.00	15.70	23.75	22.85
$n_4g_1i_2$	35.75	34.25	42.50	55.25	14.50	15.55	25.75	22.20
$n_4g_2i_1$	35.50	39.00	40.50	52.25	17.00	14.60	23.75	22.00
$n_4g_2i_2$	36.25	37.25	39.50	52.50	15.00	14.05	23.25	21.55
$n_4g_3i_1$	36.75	39.50	39.00	50.15	16.50	14.40	22.00	20.80
$n_4g_3i_2$	38.50	37.75	36.25	49.80	15.00	14.60	22.00	19.95
$n_4g_4i_1$	40.50	41.75	38.75	47.50	17.75	15.20	25.00	21.75
$n_4g_4i_2$	37.75	40.25	40.25	45.75	15.50	14.90	25.50	20.80
$n_0g_0i_1$	35.50	37.50	41.50	57.25	13.00	12.70	22.75	22.15
$n_0g_0i_2$	40.50	37.75	40.50	55.50	13.00	12.25	24.25	23.80
$n_0g_0i_1$	38.50	39.50	43.75	56.10	13.00	13.55	21.50	22.95
$n_0g_0i_2$	36.50	37.75	43.25	55.25	13.00	12.45	21.50	23.45

APPENDIX VI

Interaction effect of factors on yield attributes

Treatment combination	No.of fruits plant^{-1} I Year	No.of fruits plant^{-1} II Year	Average fruit weight (kg) I Year	Average fruit weight (kg) II Year	Length of fruit (cm) I Year	Length of fruit (cm) II Year	Girth of fruit (cm) I Year	Girth of fruit (cm) II Year
$n_1g_1i_1$	9.40	13.65	0.96	0.78	74.55	68.80	22.95	20.80
$n_1g_1i_2$	10.90	12.15	0.88	0.63	72.45	71.60	20.80	20.00
$n_1g_2i_1$	12.30	14.40	0.78	0.73	72.25	71.25	24.20	21.40
$n_1g_2i_2$	8.90	13.55	0.72	0.70	70.40	73.55	23.70	20.85
$n_1g_3i_1$	13.50	16.40	0.82	0.85	68.10	77.00	25.45	21.05
$n_1g_3i_2$	13.75	15.70	0.84	0.79	62.00	71.60	22.90	19.90
$n_1g_4i_1$	12.80	15.70	0.71	0.95	67.00	72.95	23.45	20.90
$n_1g_4i_2$	11.00	14.95	0.79	0.77	62.95	78.65	21.75	21.15
$n_2g_1i_1$	14.15	14.70	0.76	0.77	71.95	77.45	23.75	21.15
$n_2g_1i_2$	8.15	13.35	0.81	0.78	64.05	76.65	24.25	20.05
$n_2g_2i_1$	11.90	14.70	0.91	0.80	66.70	74.30	22.45	21.25
$n_2g_2i_2$	11.90	14.50	0.84	0.72	67.60	73.15	22.00	20.15
$n_2g_3i_1$	13.40	17.70	1.05	0.82	71.10	70.45	23.10	21.70
$n_2g_3i_2$	13.00	15.60	1.00	0.79	70.75	70.70	23.90	21.45
$n_2g_4i_1$	9.80	16.05	0.83	0.78	68.25	73.40	25.05	21.50
$n_2g_4i_2$	14.40	14.85	0.86	0.73	68.25	72.75	23.20	20.85
$n_3g_1i_1$	14.75	16.05	0.95	0.80	72.75	79.35	24.50	21.90
$n_3g_1i_2$	10.30	15.95	0.97	0.79	71.40	75.15	22.75	20.50

$n_3g_2i_1$	15.90	16.60	1.01	0.92	70.05	76.55	22.30	21.75
$n_3g_2i_2$	12.65	16.65	0.76	0.69	71.50	70.70	22.00	22.25
$n_3g_3i_1$	16.55	19.20	1.10	0.88	69.75	72.80	24.35	22.40
$n_3g_3i_2$	17.65	18.55	1.15	0.78	62.00	79.15	23.60	22.60
$n_3g_4i_1$	10.65	18.30	0.96	0.84	75.55	69.70	24.70	22.15
$n_3g_4i_2$	15.90	16.00	0.93	0.74	69.60	74.05	23.95	21.15
$n_4g_1i_1$	11.05	15.05	0.97	0.97	72.35	80.45	22.95	20.60
$n_4g_1i_2$	9.80	14.35	0.97	0.74	70.85	73.60	25.05	20.75
$n_4g_2i_1$	18.50	15.00	1.14	0.91	76.70	75.00	22.90	21.35
$n_4g_2i_2$	9.00	15.85	0.96	0.93	71.75	78.55	24.25	20.10
$n_4g_3i_1$	14.00	17.25	1.03	0.99	74.30	77.05	25.40	20.90
$n_4g_3i_2$	13.80	15.40	0.82	0.90	62.65	72.40	23.45	20.55
$n_4g_4i_1$	14.15	16.05	1.27	0.84	69.95	71.90	24.55	23.25
$n_4g_4i_2$	12.15	15.70	1.01	0.82	66.80	71.95	22.60	22.25
$n_0g_0i_1$	8.90	9.05	0.63	0.62	60.70	68.30	21.50	20.00
$n_0g_0i_2$	8.15	8.15	0.55	0.60	60.40	66.70	21.00	19.85
$n_0g_0i_1$	9.05	9.65	0.66	0.66	61.10	70.05	21.80	20.40
$n_0g_0i_2$	7.85	8.95	0.55	0.66	59.40	68.40	20.70	19.90

APPENDIX VII

Interaction effect of factors on yield attributes

Treatment combinations	Male flowers plant[1]		Female flowers plant[-1]		Sex ratio		Setting %	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	1925.55	1610.10	60.50	56.10	31.51	28.51	16.30	24.85
$n_1g_1i_2$	1675.70	1305.80	52.15	45.75	32.57	28.56	22.65	27.10
$n_1g_2i_1$	1695.30	1673.65	49.40	60.50	34.22	27.35	24.70	24.80
$n_1g_2i_2$	1736.40	1720.30	66.40	58.70	26.84	29.00	13.95	23.45
$n_1g_3i_1$	1835.95	1445.55	64.75	53.65	28.12	26.95	20.80	31.35
$n_1g_3i_2$	2139.70	1304.80	68.50	50.70	30.72	25.75	19.80	30.95
$n_1g_4i_1$	1723.50	1629.95	61.40	63.15	27.83	25.90	19.40	24.85
$n_1g_4i_2$	2137.50	1394.60	61.50	57.10	34.22	24.25	18.00	26.30
$n_2g_1i_1$	2377.10	1479.80	77.65	56.25	30.65	26.30	18.20	26.20
$n_2g_1i_2$	1483.40	1545.20	46.35	50.30	32.18	30.70	17.60	26.45
$n_2g_2i_1$	2112.75	1556.55	72.35	62.10	29.11	25.05	16.20	23.60
$n_2g_2i_2$	2165.30	1618.20	73.55	50.30	29.55	28.40	16.00	25.70
$n_2g_3i_1$	1995.50	1451.70	69.70	60.80	28.63	23.75	19.20	29.40
$n_2g_3i_2$	1920.10	1694.40	69.50	61.15	27.50	27.70	18.70	25.50
$n_2g_4i_1$	2501.30	1719.65	73.40	66.55	34.11	26.05	13.45	24.35
$n_2g_4i_2$	1413.25	1535.05	61.70	61.65	22.76	24.90	23.40	24.05
$n_3g_1i_1$	1944.15	1508.15	68.00	51.10	28.68	29.50	21.65	31.40
$n_3g_1i_2$	1866.85	1402.00	62.40	55.45	29.97	25.35	16.60	28.65

$n_3g_2i_1$	1629.65	1773.90	58.45	64.60	27.86	27.55	27.15	25.75
$n_3g_2i_2$	2071.55	1348.65	74.80	56.20	27.77	25.25	17.00	29.70
$n_3g_3i_1$	1937.30	1545.80	80.85	66.15	23.96	23.30	20.80	29.15
$n_3g_3i_2$	2619.45	1502.00	87.90	59.45	29.82	25.70	20.10	33.60
$n_3g_4i_1$	1285.00	2028.05	50.40	76.65	25.49	23.45	21.15	24.00
$n_3g_4i_2$	2197.55	1762.45	77.40	70.90	28.38	24.85	20.55	22.55
$n_4g_1i_1$	1624.05	1314.35	54.05	48.20	30.02	27.20	20.40	31.35
$n_4g_1i_2$	1217.35	1310.45	46.55	51.10	26.08	25.65	21.05	28.05
$n_4g_2i_1$	2898.90	1479.50	88.20	55.40	32.80	26.65	21.00	27.25
$n_4g_2i_2$	1951.60	1807.45	45.00	61.55	20.83	29.35	19.95	25.70
$n_4g_3i_1$	1799.55	1542.15	69.00	63.25	26.08	24.35	20.25	27.25
$n_4g_3i_2$	1488.60	1730.25	62.50	68.15	23.83	25.30	22.05	22.60
$n_4g_4i_1$	2123.50	1818.20	72.50	71.30	29.33	24.15	19.55	22.55
$n_4g_4i_2$	1623.15	2086.80	61.00	70.85	26.75	28.25	19.45	22.20
$n_0g_0i_1$	1713.45	1445.40	53.15	48.25	32.27	29.95	16.25	18.75
$n_0g_0i_2$	1685.10	1477.00	49.40	46.25	34.07	31.95	16.50	18.65
$n_0g_0i_1$	1803.75	1532.75	55.60	49.60	32.43	30.90	16.30	19.45
$n_0g_0i_2$	1749.75	1601.25	49.40	47.60	35.46	33.65	15.70	18.85

APPENDIX VIII

Interaction effect of factors on fruit yield, dry weight of roots and WUE

Treatment combinations	Fruit yield ($t\ ha^{-1}$)			Dry weight of root (g)		WUE ($kg\ ha\ cm^{-1}$)	
	I Year	II Year	Pooled mean	I Year	II Year	I Year	II Year
$n_1g_1i_1$	19.46	21.19	20.32	8.50	13.00	135.95	151.60
$n_1g_1i_2$	22.13	18.06	20.10	10.00	10.50	286.95	255.10
$n_1g_2i_1$	21.28	21.92	21.60	10.00	16.00	148.65	156.75
$n_1g_2i_2$	20.54	23.56	22.05	7.50	13.50	266.40	332.85
$n_1g_3i_1$	21.84	24.22	23.03	9.00	10.00	138.00	173.20
$n_1g_3i_2$	20.50	24.90	22.70	9.50	10.00	265.95	351.70
$n_1g_4i_1$	20.81	25.84	23.33	9.00	13.00	145.45	184.80
$n_1g_4i_2$	21.35	23.41	22.38	8.50	10.50	276.90	330.60
$n_2g_1i_1$	23.75	23.22	23.48	13.50	13.00	165.95	166.10
$n_2g_1i_2$	21.77	19.55	20.66	8.50	20.00	282.30	276.15
$n_2g_2i_1$	22.59	27.44	25.02	7.50	12.50	157.85	196.30
$n_2g_2i_2$	22.84	22.84	22.84	10.50	16.50	296.25	322.60
$n_2g_3i_1$	23.69	26.44	25.07	12.00	11.50	165.55	189.15
$n_2g_3i_2$	22.59	18.06	20.33	10.00	10.50	293.00	255.15
$n_2g_4i_1$	23.34	27.83	25.58	10.50	11.00	163.10	199.05
$n_2g_4i_2$	23.35	23.22	23.28	7.50	16.50	302.85	327.85
$n_3g_1i_1$	25.56	23.22	24.39	14.00	13.00	178.70	166.05
$n_3g_1i_2$	23.60	18.28	20.94	10.50	16.50	306.10	258.20

$n_3g_2i_1$	26.14	25.63	25.88	13.00	18.50	182.70	183.30
$n_3g_2i_2$	24.34	25.47	24.90	12.50	14.50	315.70	359.65
$n_3g_3i_1$	27.47	25.13	26.30	13.00	18.50	191.90	179.75
$n_3g_3i_2$	25.72	29.84	27.78	12.50	15.50	333.55	421.45
$n_3g_4i_1$	26.97	35.14	31.06	10.50	16.00	188.50	251.35
$n_3g_4i_2$	23.09	28.13	25.61	10.50	18.50	299.50	397.35
$n_4g_1i_1$	23.97	25.73	24.85	8.50	12.50	167.50	184.00
$n_4g_1i_2$	22.87	31.22	27.04	13.00	15.00	296.55	440.30
$n_4g_2i_1$	25.53	26.44	25.99	11.50	13.00	178.45	189.00
$n_4g_2i_2$	24.84	20.44	22.64	10.50	13.00	322.20	288.70
$n_4g_3i_1$	26.25	29.22	27.73	13.50	20.00	183.45	208.95
$n_4g_3i_2$	24.84	21.26	23.05	9.50	13.00	322.20	293.15
$n_4g_4i_1$	25.44	26.65	26.05	10.00	12.00	177.80	190.65
$n_4g_4i_2$	23.72	24.03	23.87	11.00	16.50	307.60	339.35
$n_0g_0i_1$	15.35	15.21	15.28	9.50	11.00	107.70	108.75
$n_0g_0i_2$	14.40	14.38	14.39	8.00	9.50	186.80	203.10
$n_0g_0i_1$	14.94	15.57	15.25	7.50	10.50	104.40	111.35
$n_0g_0i_2$	13.90	14.20	14.05	5.50	8.50	180.40	200.55

APPENDIX IX

Interaction effect of factors on nutrient content of fruits

Treatment combination	Nutrient content of fruits					
	N (%)		P_2O_5 (%)		K_2O (%)	
	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	2.20	2.26	0.39	0.34	2.20	1.86
$n_1g_1i_2$	2.33	2.28	0.46	0.50	2.21	2.03
$n_1g_2i_1$	2.39	2.39	0.37	0.46	2.21	1.78
$n_1g_2i_2$	2.30	2.39	0.34	0.45	2.19	1.74
$n_1g_3i_1$	2.39	2.59	0.33	0.48	2.24	1.89
$n_1g_3i_2$	2.30	2.62	0.39	0.36	2.26	1.79
$n_1g_4i_1$	2.30	2.45	0.46	0.40	2.25	1.85
$n_1g_4i_2$	2.40	2.55	0.46	0.39	2.21	1.96
$n_2g_1i_1$	2.40	2.45	0.46	0.40	2.19	2.11
$n_2g_1i_2$	2.44	2.46	0.38	0.39	2.19	2.10
$n_2g_2i_1$	2.50	2.50	0.37	0.38	2.22	1.85
$n_2g_2i_2$	2.42	2.54	0.37	0.43	2.30	1.77
$n_2g_3i_1$	2.53	2.68	0.45	0.40	2.21	1.87
$n_2g_3i_2$	2.45	2.62	0.40	0.46	2.16	1.89
$n_2g_4i_1$	2.59	2.46	0.49	0.45	2.30	1.80
$n_2g_4i_2$	2.62	2.51	0.56	0.46	2.17	1.74
$n_3g_1i_1$	2.56	2.41	0.36	0.50	2.30	1.74
$n_3g_1i_2$	2.64	2.40	0.40	0.48	2.25	1.82

$n_3g_2i_1$	2.67	2.47	0.50	0.38	2.24	2.05
$n_3g_2i_2$	2.63	2.54	0.44	0.39	2.23	2.05
$n_3g_3i_1$	2.64	2.59	0.57	0.48	2.22	1.95
$n_3g_3i_2$	2.54	2.68	0.37	0.44	2.26	2.01
$n_3g_4i_1$	2.31	2.70	0.45	0.39	2.28	1.73
$n_3g_4i_2$	2.69	2.83	0.39	0.56	2.20	1.74
$n_4g_1i_1$	2.87	2.49	0.35	0.45	2.21	1.95
$n_4g_1i_2$	2.33	2.51	0.43	0.43	2.19	1.91
$n_4g_2i_1$	2.69	2.47	0.50	0.42	2.25	1.84
$n_4g_2i_2$	2.49	2.60	0.52	0.52	2.26	1.86
$n_4g_3i_1$	2.86	2.71	0.54	0.46	2.37	1.97
$n_4g_3i_2$	2.78	2.77	0.46	0.44	2.24	1.91
$n_4g_4i_1$	2.51	2.80	0.50	0.46	2.21	2.13
$n_4g_4i_2$	2.78	2.87	0.37	0.48	2.33	2.13
$n_0g_0i_1$	1.89	1.68	0.30	0.34	2.07	1.50
$n_0g_0i_2$	1.86	1.76	0.36	0.33	2.00	1.39
$n_0g_0i_1$	1.92	1.64	0.33	0.34	2.07	1.50
$n_0g_0i_2$	1.78	1.78	0.32	0.35	1.97	1.41

APPENDIX X

Interaction effect of factors on nutrient content of plant parts

Treat-ment combi-nation	Nutrient content of plant parts					
	N (%)		P_20_5 (%)		K_20 (%)	
	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	1.87	1.79	0.32	0.23	1.24	1.33
$n_1g_1i_2$	1.97	1.83	0.26	0.29	1.28	1.36
$n_1g_2i_1$	1.78	1.81	0.26	0.24	1.27	1.47
$n_1g_2i_2$	1.87	1.86	0.36	0.28	1.32	1.56
$n_1g_3i_1$	2.03	1.88	0.37	0.31	1.32	1.61
$n_1g_3i_2$	1.79	1.93	0.31	0.26	1.27	1.69
$n_1g_4i_1$	1.90	1.88	0.30	0.29	1.43	1.59
$n_1g_4i_2$	2.01	1.88	0.37	0.32	1.44	1.66
$n_2g_1i_1$	1.91	1.86	0.34	0.36	1.29	1.53
$n_2g_1i_2$	1.88	1.90	0.34	0.30	1.30	1.48
$n_2g_2i_1$	2.07	1.85	0.36	0.39	1.31	1.73
$n_2g_2i_2$	1.91	1.90	0.24	0.37	1.26	1.70
$n_2g_3i_1$	2.05	1.94	0.35	0.31	1.33	1.76
$n_2g_3i_2$	2.04	2.01	0.27	0.23	1.27	1.87
$n_2g_4i_1$	1.91	1.96	0.36	0.30	1.44	1.69
$n_2g_4i_2$	1.87	2.01	0.27	0.29	1.30	1.66
$n_3g_1i_1$	2.20	1.96	0.39	0.29	1.54	2.16
$n_3g_1i_2$	1.90	2.03	0.26	0.31	1.46	2.16

$n_3g_2i_1$	2.07	2.01	0.35	0.32	1.39	1.60
$n_3g_2i_2$	2.03	2.16	0.25	0.31	1.36	1.58
$n_3g_3i_1$	1.97	2.09	0.31	0.38	1.29	1.49
$n_3g_3i_2$	2.08	2.30	0.35	0.36	1.36	1.47
$n_3g_4i_1$	1.94	2.23	0.33	0.31	1.41	1.55
$n_3g_4i_2$	2.03	2.33	0.37	0.32	1.25	1.44
$n_4g_1i_1$	1.83	1.91	0.36	0.36	1.30	1.78
$n_4g_1i_2$	1.91	1.96	0.25	0.33	1.27	1.69
$n_4g_2i_1$	2.30	1.98	1.30	0.24	1.39	1.67
$n_4g_2i_2$	1.88	1.99	0.31	0.29	1.31	1.64
$n_4g_3i_1$	2.33	2.11	0.31	0.32	1.31	1.56
$n_4g_3i_2$	2.28	2.25	0.33	0.33	1.28	1.62
$n_4g_4i_1$	1.91	2.06	0.41	0.35	1.28	1.70
$n_4g_4i_2$	2.39	2.24	0.34	0.31	1.25	1.72
$n_0g_0i_1$	1.61	1.44	0.25	0.23	1.20	1.31
$n_0g_0i_2$	1.49	1.48	0.22	0.26	1.20	1.33
$n_0g_0i_1$	1.68	1.39	0.26	0.27	1.26	1.31
$n_0g_0i_2$	1.51	1.45	0.22	0.25	1.12	1.29

APPENDIX XI

Interaction effect of factors on the uptake of nutrients

Treatment combinations	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})	
	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	31.58	20.72	4.59	3.48	25.25	16.65
$n_1g_1i_2$	25.90	21.13	4.82	3.64	26.40	17.71
$n_1g_2i_1$	32.09	26.67	4.77	4.45	26.65	21.92
$n_1g_2i_2$	31.01	24.14	4.75	4.205	26.45	20.81
$n_1g_3i_1$	29.65	29.31	4.41	5.28	20.55	22.53
$n_1g_3i_2$	30.27	31.19	5.42	4.33	22.80	23.75
$n_1g_4i_1$	33.17	29.98	5.92	4.75	29.10	23.75
$n_1g_4i_2$	29.85	32.76	5.73	5.33	25.40	26.79
$n_2g_1i_1$	40.87	23.31	5.12	4.03	30.00	19.72
$n_2g_1i_2$	37.27	22.52	6.89	3.71	27.55	18.46
$n_2g_2i_1$	49.24	33.12	7.71	5.50	39.70	26.38
$n_2g_2i_2$	37.20	33.13	5.13	5.79	30.30	25.21
$n_2g_3i_1$	34.17	39.90	7.63	6.78	34.15	32.93
$n_2g_3i_2$	37.01	38.83	5.86	6.38	23.60	35.03
$n_2g_4i_1$	40.93	30.49	6.63	6.29	33.95	27.29
$n_2g_4i_2$	37.65	33.73	7.19	5.83	31.85	26.14
$n_3g_1i_1$	43.31	24.88	8.25	4.53	28.40	19.72
$n_3g_1i_2$	33.70	25.43	7.36	5.34	29.65	19.67

$n_3g_2i_1$	47.30	33.25	7.84	5.47	35.35	24.16
$n_3g_2i_2$	41.15	30.78	5.11	5.63	35.10	23.28
$n_3g_3i_1$	40.88	38.41	6.76	7.84	34.85	27.21
$n_3g_3i_2$	52.32	42.22	5.60	7.85	36.05	29.03
$n_3g_4i_1$	45.31	53.72	8.18	8.19	29.15	36.93
$n_3g_4i_2$	48.14	55.25	7.97	9.44	33.65	38.45
$n_4g_1i_1$	42.72	20.82	6.61	4.47	28.80	20.17
$n_4g_1i_2$	44.62	26.79	5.19	4.26	32.80	23.21
$n_4g_2i_1$	42.66	32.90	7.22	4.75	35.95	26.04
$n_4g_2i_2$	43.09	32.38	8.14	5.83	33.40	25.71
$n_4g_3i_1$	35.02	40.31	6.63	6.21	32.50	32.35
$n_4g_3i_2$	34.54	41.18	7.80	6.38	34.75	34.06
$n_4g_4i_1$	36.31	49.82	8.35	8.63	34.85	40.57
$n_4g_4i_2$	46.44	45.68	6.07	8.65	34.15	37.11
$n_0g_0i_1$	19.34	17.76	3.27	2.83	18.80	14.71
$n_0g_0i_2$	16.42	16.42	2.64	2.75	15.90	14.23
$n_0g_0i_1$	19.89	17.78	2.98	2.71	18.40	12.14
$n_0g_0i_2$	17.25	16.80	2.55	2.56	16.90	12.46

APPENDIX XII

Interaction effect of factors on the quality of fruits - I Year

Treatment combinations	Moisture (%)	TSS (^{0}brix)	Acidity (%)	Total sugars (%)	Reducing sugar (%)	Ascorbic acid (mg 100 g^{-1})	Crude protein(%)	Crude fibre (%)	Shelf life (days)
$n_1g_1i_1$	95.50	2.20	0.10	2.61	2.01	9.10	13.75	23.75	14.00
$n_1g_1i_2$	94.15	2.90	0.10	2.26	2.45	6.85	14.54	23.00	14.50
$n_1g_2i_1$	95.65	2.40	0.07	3.05	1.71	9.10	14.38	35.00	14.75
$n_1g_2i_2$	95.50	2.60	0.13	2.35	1.83	12.90	15.01	28.50	13.50
$n_1g_3i_1$	96.65	2.40	0.15	2.50	2.30	8.45	14.94	19.05	13.00
$n_1g_3i_2$	96.30	2.90	0.17	2.59	2.24	12.40	14.41	24.25	15.25
$n_1g_4i_1$	95.65	2.30	0.10	2.34	2.05	11.05	14.97	26.25	14.00
$n_1g_4i_2$	94.65	2.00	0.12	1.94	1.97	10.35	14.75	19.00	13.75
$n_2g_1i_1$	95.90	3.20	0.12	2.85	2.09	10.40	15.40	19.50	12.75
$n_2g_1i_2$	95.70	2.20	0.10	2.85	1.95	6.85	15.25	22.50	12.00
$n_2g_2i_1$	95.70	2.40	0.17	2.17	2.22	11.05	16.19	21.00	12.25
$n_2g_2i_2$	95.85	2.50	0.10	2.65	2.40	10.10	16.34	30.75	13.00
$n_2g_3i_1$	96.00	2.40	0.12	2.43	1.90	11.05	15.84	16.25	13.50
$n_2g_3i_2$	96.30	2.70	0.07	2.40	2.00	14.35	15.28	23.75	12.00
$n_2g_4i_1$	97.20	2.30	0.14	2.34	1.95	13.65	15.59	26.50	11.75
$n_2g_4i_2$	96.90	2.60	0.15	2.03	2.16	15.25	15.13	19.00	12.25
$n_3g_1i_1$	96.45	2.40	0.14	2.82	2.03	11.05	16.00	24.75	11.75
$n_3g_1i_2$	95.00	3.00	0.09	2.60	2.20	10.95	16.51	22.50	11.75

$n_3g_2i_1$	96.80	2.30	0.16	2.70	2.38	10.50	17.56	23.25	12.00
$n_3g_1i_2$	95.70	3.20	0.10	2.61	1.87	13.20	16.78	22.00	12.00
$n_3g_3i_1$	96.70	3.40	0.13	3.15	2.38	11.70	16.49	18.00	12.25
$n_3g_3i_2$	96.40	2.90	0.16	2.56	2.47	14.60	15.88	19.75	11.50
$n_3g_4i_1$	96.00	2.60	0.12	2.26	2.01	15.00	16.65	21.25	11.75
$n_3g_4i_2$	95.60	2.30	0.16	2.77	2.22	9.85	16.44	21.50	11.75
$n_4g_1i_1$	96.70	2.20	0.16	3.40	1.98	8.45	17.91	24.50	10.25
$n_4g_1i_2$	95.85	2.30	0.10	2.46	2.01	7.80	14.56	18.25	11.75
$n_4g_2i_1$	96.00	2.70	0.16	2.20	2.76	9.10	15.66	14.50	11.25
$n_4g_2i_2$	96.00	2.80	0.10	3.40	2.21	11.80	17.41	26.50	10.75
$n_4g_3i_1$	97.00	2.50	0.18	2.42	1.94	11.35	18.16	13.50	11.25
$n_4g_3i_2$	96.20	2.70	0.12	2.31	2.89	9.80	17.40	20.50	11.25
$n_4g_4i_1$	96.90	3.40	0.16	2.26	2.70	11.70	16.79	19.50	11.75
$n_4g_4i_2$	95.70	3.00	0.10	2.53	1.76	16.80	15.57	25.00	11.25
$n_0g_0i_1$	95.70	2.20	0.07	1.88	1.65	7.65	10.02	16.50	14.75
$n_0g_0i_2$	93.90	2.60	0.09	1.70	1.49	7.95	9.32	14.75	13.75
$n_0g_0i_1$	96.00	2.20	0.09	1.83	1.61	6.15	10.47	15.25	14.00
$n_0g_0i_2$	94.40	2.50	0.07	1.75	1.55	6.45	9.44	18.00	14.50

APPENDIX XIII

Interaction effect of factors on the quality of fruits - II Year

Treatment combinations	Moisture (%)	TSS (⁰ brix)	Acidity (%)	Total sugars (%)	Reducing sugar (%)	Ascorbic acid (mg 100 g⁻¹)	Crude protein (%)	Crude fibre (%)	Shelf life (days)
$n_1g_1i_1$	92.55	2.20	0.12	2.49	1.57	4.05	14.25	12.40	12.75
$n_1g_1i_2$	95.50	2.90	0.11	2.69	1.95	7.65	14.09	15.05	13.50
$n_1g_2i_1$	93.25	2.40	0.12	2.80	1.83	6.30	14.91	19.70	14.25
$n_1g_2i_2$	95.30	2.60	0.08	2.90	1.89	5.40	14.91	14.10	14.50
$n_1g_3i_1$	95.75	2.40	0.11	2.83	1.89	6.30	16.35	17.35	12.75
$n_1g_3i_2$	95.70	2.90	0.09	2.93	1.87	6.40	16.19	19.75	13.50
$n_1g_4i_1$	93.70	2.30	0.14	2.94	2.05	6.30	15.97	11.10	12.75
$n_1g_4i_2$	95.20	2.00	0.09	3.52	2.15	3.15	15.29	13.80	13.00
$n_2g_1i_1$	94.20	3.20	0.11	2.50	1.70	5.85	15.40	19.40	13.50
$n_2g_1i_2$	95.55	2.00	0.10	2.59	1.87	6.70	15.29	16.70	12.00
$n_2g_2i_1$	96.25	2.40	0.11	2.67	1.80	6.30	15.84	12.70	13.00
$n_2g_2i_2$	95.25	2.50	0.13	2.80	1.83	4.45	15.63	15.25	13.25
$n_2g_3i_1$	95.45	2.40	0.12	2.78	1.90	5.40	16.35	14.15	11.50
$n_2g_3i_2$	95.30	2.70	0.15	3.09	2.07	7.25	16.75	15.15	12.00
$n_2g_4i_1$	95.90	2.30	0.08	3.48	1.89	5.85	15.69	13.85	11.50
$n_2g_4i_2$	92.35	2.60	0.12	3.68	2.21	6.30	15.35	12.95	11.75
$n_3g_1i_1$	94.40	2.20	0.12	2.53	1.88	5.85	14.90	13.90	12.00
$n_3g_1i_2$	95.50	2.30	0.10	2.62	1.75	3.85	15.04	13.60	12.50

$n_3g_2i_1$	94.20	2.70	0.13	2.69	1.90	5.85	15.88	13.80	11.75
$n_3g_1i_2$	94.10	2.80	0.11	2.89	1.85	5.95	15.41	18.65	12.00
$n_3g_3i_1$	94.80	2.50	0.11	3.46	1.95	6.75	16.75	11.90	12.00
$n_3g_3i_2$	93.40	2.70	0.12	3.30	2.03	5.85	16.22	15.20	12.25
$n_3g_4i_1$	94.70	3.40	0.13	2.72	1.90	8.10	17.69	18.50	12.75
$n_3g_4i_2$	95.60	3.00	0.17	2.99	1.91	7.55	16.84	13.25	11.75
$n_4g_1i_1$	95.45	2.40	0.13	2.80	1.81	4.95	15.69	15.15	11.50
$n_4g_1i_2$	95.35	3.00	0.12	2.51	1.79	7.20	15.57	15.10	10.50
$n_4g_2i_1$	94.50	2.30	0.10	3.05	1.98	7.05	16.25	14.70	11.75
$n_4g_2i_2$	95.25	3.20	0.12	3.42	1.98	6.60	15.54	15.50	11.75
$n_4g_3i_1$	95.30	2.90	0.13	3.38	1.98	6.75	17.31	15.05	12.50
$n_4g_3i_2$	94.45	2.90	0.13	3.34	2.28	5.25	16.90	15.45	11.50
$n_4g_4i_1$	94.75	3.60	0.13	2.69	1.88	6.45	17.90	15.50	12.25
$n_4g_4i_2$	95.65	3.00	0.12	2.81	2.17	4.50	17.54	13.00	11.75
$n_0g_0i_1$	93.60	2.20	0.09	2.26	1.64	4.00	10.51	13.20	13.75
$n_0g_0i_2$	93.10	2.60	0.08	2.22	1.60	3.85	11.00	14.50	13.00
$n_0g_0i_1$	94.35	2.20	0.08	2.21	1.67	4.55	10.25	12.70	13.25
$n_0g_0i_2$	93.25	2.50	0.08	2.19	1.70	4.15	11.10	13.60	12.75

APPENDIX XIV

Interaction effect of factors on the physico-chemical properties of soil

Treatment combinations	Bulk density (g cc^{-1})		Water holding capacity (%)		pH		Organic carbon (%)	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	1.32	1.37	29.26	26.78	5.25	5.25	0.62	0.71
$n_1g_1i_2$	1.35	1.35	29.16	27.68	5.20	5.15	0.62	0.69
$n_1g_2i_1$	1.36	1.33	28.56	28.60	5.20	5.25	0.65	0.70
$n_1g_2i_2$	1.33	1.36	27.09	26.06	5.20	5.10	0.63	0.72
$n_1g_3i_1$	1.35	1.36	26.28	26.80	5.30	5.30	0.63	0.67
$n_1g_3i_2$	1.35	1.35	26.58	28.61	5.20	5.20	0.64	0.66
$n_1g_4i_1$	1.35	1.36	25.90	26.94	5.20	5.20	0.60	0.69
$n_1g_4i_2$	1.34	1.36	25.30	28.79	5.15	5.10	0.64	0.68
$n_2g_1i_1$	1.35	1.37	26.25	27.78	5.15	5.20	0.70	0.72
$n_2g_1i_2$	1.34	1.38	26.00	27.68	5.20	5.15	0.66	0.70
$n_2g_2i_1$	1.37	1.36	25.98	27.86	5.20	5.20	0.65	0.70
$n_2g_2i_2$	1.37	1.36	26.67	28.78	5.20	5.15	0.66	0.69
$n_2g_3i_1$	1.32	1.37	26.00	27.86	5.20	5.15	0.66	0.66
$n_2g_3i_2$	1.35	1.38	26.09	25.67	5.10	5.15	0.62	0.68
$n_2g_4i_1$	1.35	1.33	27.12	26.69	5.25	5.10	0.63	0.68
$n_2g_4i_2$	1.37	1.37	26.01	27.48	5.20	5.10	0.63	0.69
$n_3g_1i_1$	1.33	1.34	25.03	30.68	5.20	5.20	0.64	0.68
$n_3g_1i_2$	1.33	1.34	26.21	29.15	5.10	5.05	0.65	0.69

$n_3g_2i_1$	1.35	1.36	27.93	27.96	5.15	5.15	0.65	0.70
$n_3g_2i_2$	1.35	1.36	28.83	27.67	5.10	5.05	0.66	0.69
$n_3g_3i_1$	1.34	1.36	27.87	26.75	5.25	5.10	0.64	0.68
$n_3g_3i_2$	1.35	1.36	27.90	28.38	5.20	5.05	0.63	0.69
$n_3g_4i_1$	1.36	1.36	26.86	28.85	5.15	5.20	0.62	0.70
$n_3g_4i_2$	1.36	1.37	25.22	27.85	5.05	5.10	0.65	0.70
$n_4g_1i_1$	1.34	1.35	28.00	30.09	5.20	5.05	0.63	0.68
$n_4g_1i_2$	1.34	1.36	29.01	29.16	5.10	5.05	0.70	0.68
$n_4g_2i_1$	1.37	1.36	29.90	26.89	5.10	5.10	0.64	0.70
$n_4g_2i_2$	1.35	1.36	29.00	26.45	5.15	5.00	0.64	0.68
$n_4g_3i_1$	1.35	1.35	26.96	30.54	5.10	5.10	0.65	0.70
$n_4g_3i_2$	1.33	1.34	28.38	29.11	5.00	5.05	0.62	0.73
$n_4g_4i_1$	1.35	1.35	29.00	29.80	5.20	5.15	0.63	0.68
$n_4g_4i_2$	1.38	1.39	28.06	28.97	5.10	5.05	0.66	0.69
$n_0g_0i_1$	1.31	1.33	28.05	27.87	5.25	5.15	0.65	0.72
$n_0g_0i_2$	1.32	1.33	26.91	26.95	5.20	5.05	0.65	0.69
$n_0g_0i_1$	1.32	1.34	27.33	28.16	5.25	5.20	0.65	0.68
$n_0g_0i_2$	1.32	1.33	27.13	27.70	5.10	5.05	0.67	0.73

APPENDIX XV

Interaction effect of factors on the nutrient status of soil

Treatment combinations	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	I Year	II Year	I Year	II Year	I Year	II Year
$n_1g_1i_1$	315.85	314.95	44.30	40.30	120.50	135.05
$n_1g_1i_2$	335.70	300.15	40.90	39.70	145.60	128.80
$n_1g_2i_1$	334.55	311.15	45.05	40.80	130.25	120.10
$n_1g_2i_2$	329.35	315.00	44.95	42.65	130.70	131.00
$n_1g_3i_1$	319.05	324.60	47.50	40.55	138.90	121.30
$n_1g_3i_2$	310.45	329.80	43.95	41.15	119.10	127.10
$n_1g_4i_1$	332.05	315.70	42.45	41.25	149.70	131.60
$n_1g_4i_2$	337.30	330.65	45.90	42.85	128.30	126.65
$n_2g_1i_1$	320.50	323.35	44.55	41.65	133.20	123.65
$n_2g_1i_2$	334.65	327.50	44.05	43.50	138.20	128.35
$n_2g_2i_1$	342.70	327.65	45.85	44.80	125.10	133.75
$n_2g_2i_2$	319.55	331.55	41.30	40.20	143.90	130.35
$n_2g_3i_1$	346.15	337.45	43.00	38.95	137.70	132.00
$n_2g_3i_2$	331.30	343.20	43.65	36.80	158.65	125.35
$n_2g_4i_1$	330.15	346.80	45.65	43.00	143.95	123.10
$n_2g_4i_2$	340.60	354.00	47.45	41.15	122.65	125.60
$n_3g_1i_1$	355.90	360.90	44.15	38.55	173.70	124.10
$n_3g_1i_2$	338.65	357.90	44.35	39.45	145.70	127.95

$n_3g_2i_1$	319.00	358.20	48.15	43.80	147.10	121.20
$n_3g_2i_2$	344.20	348.35	43.25	37.50	145.70	123.50
$n_3g_3i_1$	346.45	345.60	44.90	44.25	156.15	137.65
$n_3g_3i_2$	332.50	341.30	47.30	46.80	139.45	130.35
$n_3g_4i_1$	338.60	350.85	41.90	40.60	152.35	123.10
$n_3g_4i_2$	336.90	342.00	45.55	39.65	123.60	128.65
$n_4g_1i_1$	325.90	364.10	41.20	45.35	182.15	130.80
$n_4g_1i_2$	341.65	364.05	44.90	40.00	144.35	124.30
$n_4g_2i_1$	359.90	359.75	48.70	40.80	155.05	136.00
$n_4g_2i_2$	338.50	354.95	42.80	43.35	130.05	127.85
$n_4g_3i_1$	330.50	356.30	45.15	40.40	126.75	122.80
$n_4g_3i_2$	339.15	354.65	42.85	46.70	144.10	126.95
$n_4g_4i_1$	351.20	353.40	44.90	31.95	158.00	133.90
$n_4g_4i_2$	356.25	351.75	48.50	42.60	133.30	129.95
$n_0g_0i_1$	250.46	259.26	39.00	40.00	139.50	125.55
$n_0g_0i_2$	248.70	260.14	36.92	37.90	136.4.5	122.80
$n_0g_0i_1$	264.04	271.50	39.06	38.05	140.00	131.10
$n_0g_0i_2$	257.86	265.82	37.78	36.80	138.91	128.70

NUTRIENT-GROWTH REGULATOR INTERACTION

IN SNAKEGOURD (*Trichosanthes anguina* L.)

UNDER DRIP IRRIGATION SYSTEM

By

ELIZABETH K. SYRIAC

ABSTRACT OF THESIS
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ABSTRACT

Two field experiments were conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, to study the effect of varying levels of nitrogen (n), ethephon (g) and drip irrigation frequency (i) on the productivity of snakegourd. The influence of the treatments on the size, quality and shelf life of the produce and also on the physico-chemical properties of soil was investigated. The trials were conducted during the summer seasons (December to April) of 1994-'95 and 1995-'96.

The experiments were laid out in 4^2x2+2 asymmetrical confounded factorial design with two replications and each replication included two blocks. Combinations of four levels each of N (35, 70, 105 and 140 kg ha^{-1}), ethephon (0, 50, 100 and 200 ppm) and two frequencies of drip irrigation (5 mm CPE and 10 mm CPE) constituted the treatments along with two controls ($n_0g_0i_1$ and $n_0g_0i_2$) in each block. The highest order interaction NGI was confounded in both the replications.

Results of the field experiments revealed that during both the years of experimentation, nitrogen, ethephon and irrigation frequency exerted significant positive influence on the fruit yield of snakegourd. During both the years, the higher

levels of nitrogen (105 and 140 kg N ha^{-1}) were found to be significantly superior to the lower levels (70 and 35 kg N ha^{-1}). Pooled analysis of the yield data also revealed a similar trend. Growth characters like internodal length, number of leaves $plant^{-1}$ and dry matter production showed significant enhancement due to N application. The positive significant effect of N was manifested in the yield attributes viz., number of fruits $plant^{-1}$ and average fruit weight. Significant increase in the WUE of the crop due to N application was also observed. The content and uptake of major nutrients also increased substantially due to applied N. Nitrogen improved the quality of fruits, significantly, in terms of crude protein, total sugars, reducing sugars and ascorbic acid content.. However, the shelf life was adversely affected by it. The highest net profit and B:C ratio were recorded by 105 kg N ha^{-1} (Rs. 74,636/- and 2.37, respectively) compared to the other levels of N. Considerable improvement in the physico-chemical properties of soil due to applied N was also noticed.

The results of the field experiments also indicated significant yield increase in snakegourd due to ethephon application. The higher levels of ethephon ie., 100 and 200 ppm, were found to be significantly superior to the lower levels in this regard. Growth and yield attributes as well as quality of fruits were favourably influenced by ethephon. Through its indirect positive effect on fruit yield, the higher levels of ethephon improved the WUE of the crop significantly over its lower levels. The economic analysis also revealed the positive effect of ethephon on the net profit and B:C ratio and the highest values were registered by 200 ppm ethephon (Rs. 71,194/- and 2.31, respectively).

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With respect to irrigation frequency, i_1 (irrigation at 5 mm CPE) registered significantly higher fruit yield compared to i_2 (irrigation at 10 mm CPE). Growth characters and also the quality of fruits exhibited a similar trend. More frequent irrigation treatment (i_1) exerted its positive significant effect on yield attributes viz., number of fruits plant^{-1} and mean weight and girth of fruits. The physical optima for N at i_1 were worked out to be 100 and 115 kg ha^{-1} during the first and second year, respectively. Economic analysis also revealed the favourable effect of frequent drip irrigation, with i_1 registering substantially higher net profit and B:C ratio (Rs. 70,038/- and 2.28, respectively) compared to i_2 (Rs. 61,615/- and 2.14, respectively).

A perusal of the data on fruit yield and economics of the treatment combinations elicited the favourable effect of $n_3g_4i_1$ which registered the highest fruit yield, net profit and B.C ratio (31.06 t ha^{-1}, Rs. 1,04,271/- and 3.04, respectively) and hence this combination could be adjudged as the best one for snakegourd cultivation.