WATER MANAGEMENT AND NK NUTRITION OF CUCUMBER (*Cucumis sativus* L.)

By

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THESIS

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1989

DECLARATION

I hereby declare that this thesis entitled "Water management and NK nutrition of cucumber (*Cucumis sativus* L.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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INTRODUCTION

INTRODUCTION

Cucumber (*Cucumis sativus* L.) occupies a prominant position among summer vegetables cultivated in India. The importance of this vegetable emanates not only from its nutritive and medicinal properties but also due to the succulent nature which increases its demand during summer. It ranks high among the group of cucurbitaceous vegetables with regard to nutritive value of fruits particularly proteins, ascorbic acid, phosphorus, potassium and digestable sugars (Choudhary, 1979). The fruit is considered to be a good remedy for indigestion, constipation, dehydration, jaundice and severel stomach ailments. It is also reported to possess cooling, stomachic, appetising, carminative, antipyretic, anthelmintic, laxative and vermifuge properties (Blatter *et al*.1935; Nadkarni, 1954). The fruit is consumed raw, pickled or in cooked form. It forms a major component of salads, sauces and mixed vegetable preparations. In northern parts of the country, during summer, sliced tender cucumber fruits are of high demand for raw eating with powdered spices sprinkled over it. The high moisture content of the fruit helps to quench the thirst during hot summer season. The mature fruit can also be preserved for weeks together by hanging them on threads inside thatched sheds.

On account of these unique qualities this vegetable has become very popular not only in Kerala but all over the country.

In a state like Kerala, where the land resources are limited, utilization of rice fallows for vegetable cultivation has great relevance and wide applicability. Cucumber has been found to be a remunerative vegetable for cultivation in rice fallows during summer season where assured irrigation facilities exist. Therefore emphasis should be given in the direction of evolving technologies useful in increasing the production and net income per unit area by cultivation of this crop.

Water and fertilizer are the two vital and costly inputs in crop production. Among these two, water which influences the availability and uptake of plant nutrients as well as growth and yield of crop is a limiting one during the summer season. The full potential of any cultivar of a crop can be exploited only with judicious application of water and fertilizer. Therefore studies to work out the optimum and economic schedules of irrigation and doses of fertilizers require major attention. Among the three major nutrients, nitrogen and potassium are more important because cucumber is reported to have a low capacity for utilizing phosphorus (Jaszczolt, 1975). No detailed study has been conducted in Kerala on scheduling irrigation to this crop. Investigations on the nutritional aspect is very few. In view of the above, an experiment was undertaken on water management and NK nutrition of cucumber during the summer season of 1984 at tho Agronomic Research Station, Chalakkudy with the following objectives.

1) To study the effect of water management practices and application of N and K fertilizers on the growth and yield of cucumber.

2) To determine the content and uptake of major nutrients (N, P and K) at different stages of growth as influenced by water management practices as well as N and K application.

3) To study tha interaction between irrigation and fertilizers.

4) To work out tho consumptive use, moisture extraction pattern and water use efficiency of cucumber under various treatments.

5) To work out tho economics of different treatments for evolving suitable recommendations.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Studies on the water management and nutritional requirements of vegetables in general has not received as much attention as that of field crops, especially in India. Available literature, however, emphasized the importance of moist regimes and judicious water management (during dry season) and application of optimum dose of manures and fertilizers under normal field conditions. In the ease of cucumber, very little research work has been done on the water management aspect, especially in India. Literature on manurial requirement of this crop is also meagre. Attempts have therefore been made to review the important works conducted in India and abroad on cucurbits, a group of vegetables to which cucumber belongs.

2.1. Effect of irrigation

2.1.1 <u>Growth and yield</u>

Fleming (1936) concluded from the data collected over a three-year period with cucumber and cantaloupe that irrigation water applied weekly at the rate of half inch per irrigation gave the highest total yield with the largest number of quality fruits. His data indicated that regular, small, weekly irrigations gave larger yield than irrigation in large quantities with longer intervals between irrigations.

Mac Gillivray (1951) found that weekly application of water by flooding increased the yield in cucumber as it was found to improve the root growth compared to pot irrigation.

Frohlich (1959) reported that cucumber plant which were given 600-650 litres of water per plant during January and mid-August produced 20 per cent more cucumbers of improved quality than plants given 300 litres of water during the same period. Moreover the crop required about 500 litres of water per plant between April and the end of August. During the intensive growth period the critical zone of the soil for moisture was 15-45 cm below the surface.

Flocker _et al._ (1965) obtained satisfactory yield of melons by irrigating it when the soil moisture tension at 18 inch depth reached 0.3 bars. They observed that the yield increase due to irrigation was mostly by the increase in fruit size and frequent irrigations increased the number of fruits which was in turn associated with increased vine growth and succulance.

Dunkel (1966) based on his studies with sprinkler irrigation in cucumber observed that the highest yield was obtained when the soil moisture did not drop below 70 per cent of field capacity in the upper 10 cm soil and that the water requirement for optimum yield was 600-750 mm per hectare. Root development in fiald grown cucumber was reported to be better following flood irrigation than following sprinkler irrigetion or no irrigation by Bujanovskaja (1970).

Goldberg and Shmueli (1970) observed that in cucumber sprinkler irrigation caused severe laaf scorch and decline, the yield being nil as against an average yield of 4.9 tonnes/1000 m^2 with drip irrigation. Jassal et al. (1970) reported that fruit weight and yield were significantly increased by weekly irrigations as compared to fortnightly ones in musk melon. Varga (1971) not only observed a parebolic relationship between yield and soil moisture content but also reported that the optimum soil moisture content for cucumber was 68-75 per cent of field capacity.

Neil and Zunino (1972) showed that irrigation was economically feasible in melons when it was given upto 80 par cent of maximum evaporation which amounts to 60 per cent of the potential evapotranspiration. Increased irrigation rates produced melons with improved flavour and decreased firmness. However, average irrigation requirement was found to be 2000 m^3/ha. Pestova and Pestova (1973) observed that the best quality musk melons were produced with a stabla soil water content of 55 par cent upto flowering which was increased to 65 per cent for tha period from full bloom to fruit set using soil water deficit approach of scheduling irrigation. Dimitrov (1973) showed thet maintenance of soil moisture at 70 to 80 per cent of field capacity over the entire growing season of water melon crop proved to be the most economic irrigation schedule.

Varga (1973) from the results of a 10 year trial in cucumber concluded that the optimum number of irrigations was 3 to 5 and that the period of 30 to 40 days between flowering and fruit ripening was critical for fruit development when the crop must be supplied with 40 mm water. Moreover, Tomitaka (1974) observed that excessive application of water showed deleterious effects on yield and yield components of cucumber. The highest fruit yield and plant growth were recorded at a medium moisture level of pF 2.0

Escobar and Gausman (1974) from their hydroponic studies on mexican squash (*Cucurbita pepo*) noticed that leaves of plants grown under high stress (2.4 atm) were thicker and smaller containing less water than the plants under low stress (0.4 atm). A similar finding was reported by Cummins and Kretchman (1974) in cucumber from field and greenhouse studies. They noted that leaf area and fruit yield were greatly reduced under high stress compared with low stress. Fruit set was 2 to 3 days earlier in plants under high stress but, the time taken for these fruits to attain 2 inches diameter was 4 to 6 days longer.

From a glasshouse trial with cucumber Dimitrov (1974) recorded the highest yield when the soil moisture was maintained at 70 per cent of field capacity before picking and 90 per cent during the picking period. On a four year average, the yield was 26 per cent higher than that of the control wherein 70 per cent of field capacity was maintained during the entire growing season.

Jagoda and Kaniszewski (1975) reported from an experiment with two cultivars of cucumber that irrigation appreciably improved the yield and fruit quality. The crop was irrigated when the soil water content fell to 58 per cent of field capacity. Similar result was reported by Krynska (1975) based on a study on the effect of irrigation and mineral fertilization on cucumber yield. It was observed that yield increases by 8 to 19 per cent due to irrigation and that irrigation was beneficial only in dry years. In wet years it decreased profitability. However, Pavlov (1976) raported that the highest yield of cucumber was obtained when 70 to 100 l/m^2 water was applied during the plant growing phase in 20 to 32 individual irrigations followed by 480 to 570 l/m^2 during fruiting in 92 to 94 individual irrigations.

Doss *et al*. (1977) conducted studies to determine the response of cucumber to low, intermediate and high irrigation and 56 to 112 kg/ha N. It was observed that intermediate irrigation increased marketable yield and growth but low and high irrigation showed opposite effect.

Katyal (1977) recommended weekly irrigation for cucumber during dry weather. For bittergourd, irrigation was recommended at an interval of 3 to 4 days during summer. Even in rainfed crops irrigation is required during dry spells. The recommended practice in Karnataka is to irrigate the crop once in 4 to 5 days depending on the soil and weather conditions (Anon. 1978).

Loomis and Crandall (1977) observed that the best irrigation schedule for pickling cucumber involved the removal of 48 to 64 per cent of the available water in the upper 90 cm of the soil profile between irrigations.

Singh and Singh (1978) reported highest total yield with daily drip irrigation at 68 per cent of the evaporation from a class A pan in crops like bottle gourd, round gourd and water melon in loamy sand soils of hot arid regions. The yield increase resulted mainly from the increased number of fruits per plant and increased fruit weight.

Pai and Hukeri (1979) based on their experiment to study the water requirement of vegetables concluded that maintenance of soil moisture at or above 75 per cent of availability in the active root zone is essential for good growth of vegetables. They recommended 3 to 4 irrigations per month for summer and 2 irrigations per month for rabi at a place like New Delhi. In Kharif also, irrigation is required whenever there is dry spell for about 12 to 15 days.

Some preliminary studies on scheduling irrigation to bitter gourd in sandy loam soils of the Agronomic Research Station, Chalakkudy, Kerala indicated that 3 cm irrigation at IW/CPE ratio of 0.4 was optimum for the crop in summer rice fallows (Anon, 1980; Anon., 1981). There was no significant difference among the various irrigation treatments with regard to the number of fruits per plant and the mean weight of a single fruit. Similar results were reported from a study on scheduling irrigation in cucumber also at the same time (Anon., 1981).

Another experiment conducted in summer rice fallows at Chalakkudy to evaluate drip irrigation in ash gourd recorded the highest yield at IW/CPE ratio of 1.0 followed by 0.7. However, these two treatments were on par and significantly superior over IW/CPE ratio of 0.4 by 25.4 per cent (Anon, 1982). The levels of irrigation showed an inclination to increase the number of fruits per plant upto 0.7 IW/CPE ratio. The weight of a single fruit increased with increase in the level of irrigation eventhough it was not statistically significant.

Ortega and Kretchman (1982) subjected cucumber to various levels of moisture stress and observed that the rete of growth, length of vines and node number were reduced after one week and inhibited after two weeks of stress. Fruit growth rate, fruit size, girth of fruit and quality were severely reduced in water stressed plants.

Smittle and Threadgill (1982) based on their comparative study in cucumber with two levels of irrigation and four levels of nitrogen found that the highest marketable fruit yield resulted from irrigation at 0.3 bar soil water tension.

In direct sown musk melon, Pew and Gardner (1983) reported higher yields, larger fruits and earlier maturity by irrigating the crop when the soil moisture tension at 25 cm depth reached 50 or 75 K Pa compared with 25 K Pa.

Thomas (1984) based on a field experiment at Agronomic Research Station, Chalakkudy concluded that bittergourd responded well to frequent irrigations and higher levels of fertilizers. Frequent irrigations had significant favourable effect on biometric characters like leaf production, leaf area index and dry matter production. Yield components like mean number of fruits per plant, mean length of fruit and mean weight of fruit were also favourably affected by frequent irrigations. The highest fruit yields of 10.04 t/ha and 8.97 t/ha were produced by farmer's practice of daily pot watering and IW/CPE ratio 1.2 respectively.

From the above review, it is obvious that irrigation profoundly influenced the growth and yield characters of cucurbits in general. However, findings of Mac Gillivray (1951), Bujanovskaja (1970), Goldberg and Shmueli (1970) and Tomitaka (1974) throw light on the facts that cucumber prefers flood irrigation to sprinkling and pot watering not only due to better root development under flooding but also due to the scorching effect of sprinkled water on the leaves of cucumber, both of which had specific significance on plant growth and yield. The general trend is in favour of large quantity of water at optimum intervals according to soil type and other agronomic factors.

2.1.2 Nutrient composition and uptake:

Nutrient uptake and moisture use are closely related. Brown et al. (1960) observed that in many crops the absorption of N, P and K increased linearly in response to increase in soil moisture level from the wilting point to field capacity while Singh (1975) reported that the content of the nutrients in the soil decreased with an increasa in moisture availability due to the increased plant uptake at moist regimes.

Cocucci et al.(1976) from their experiments in squash fruits found a decrease of RNA and protein content in the fruit tissue of water stressed plants and severe reduction in fruit growth as protein synthesis is controlled by water availability.

Thomas (1984) reported that irrigation had profound influence on the content and uptake of major nutrients by bittergourd. The content and uptake of N, P and K was significantly superior in moist regimes than dry regimes. The interaction effect of irrigation and fertilizers also had significant effect on uptake of nitrogen and phosphorus by the crop.

2.1.3 Consumptive use and water use pattern:

Vittum and Flocker (1967) based on their field experiments on various cucurbitacious plants concluded that they require large amounts of water at various growth stages due to the presence of medium or deep root systems.

Borna (1969) showed that irrigation during the entire growing season was more effective than irrigation upto or after fruiting has started. In the melon crop, Neil and Zunino (1972) noted that the water uptake in successive growth stages was 500 m^3/ha between germination and fruit set, 1008 m^3/ha upto fruit enlargement, 882 m^3/ha upto prematurity and 280 m^3/ha upto harvest for a total uptake of 2730 m^3/ha.

Konishi (1974) calculated the total water consumption of a fruit bearing musk melon with a final leaf area of about 11,000 cm^2 as 85 to 90 litres. As the plant grows, the ratio of total water consumption per plant to pan evaportion increased to a maximum at netting stage and then declined with ageing. Another finding was that transpiration was faster in young leaves than in older leaves.

Loomis and Crandall (1977) observed that the best irrigation schedule for pickling cucumbers involved removal of between 48 and 64 per cent of the available soil water in the upper 90 cm of the soil profila by plants between irrigations. The retio of consumptive water use to pan eveporation loss reached a maximum of 1.5 during the aarly harvast saason. Moderate moisture stress had no significant effect on the grade or number of poorly developed fruits. Tha transpiration rate was higher and leaf area smallar for fruiting plants. Fruit production did not significantly affect total water consumption or the seasonal watar use pattern.

Henkel (1978) studied the average additional water requirement of various vegetable crops in normal and dry years and calculeted their respective irrigation periods. For cucurbits, the averege optimum quantity for aach application was 20 mm, rising to 25 mm in July and August. The irrigation cycle was 8 to 10 days in May and 6 to 8 days in June and September. Similarly Kagohashi _et al_. (1978) observed that in musk melon water uptake rose gradually before pollination, increased rapidly efter pollination, remained high for about 15 days and then fell to prepollination levels. However, Pai and Hukeri (1979) reported that water requirement of cucurbits will vary with the soil and the season in which the crops are grown.

Thomas (1984) based on a field experiment in bitter gourd reported that consumptive use was higher in plots receiving frequent irrigation (IW/CPE = 1.2). Field water use efficiency was highest in the IW/CPE ratios 0.4 and 0.8 which received lesser quantity of water.

From the above literature, it is clear that irrigation has a profound influence on consumptive use and water use pattern in cucurbits. The quantity and frequency of irrigation play an important role in the above characters apart from tha type of soil and the cropping season.

2.1.4 Moisture depletion pattern

Based on a review of the pattern of soil moisture extraction by different crops under optimum moisture regimes on sandy loam soils, Gautham and Dasthane (1970) concluded that more than 60 per cent of the total moisture depletion was from aero to 30 cm soil layer in most of the field crops. In a similar field experiment with water melon, Belik and Vaselovski (1975) observed that under irrigated conditions the main root mass was in the 8.5 to 17 cm top soil layer and under unirrigated conditions they were deeper.

Loomis and Crandall (1977) based on a study on the water consumption of cucumber during vegetative and reproductive stages concluded that 60 per cent of tha total amount of water consumed was from tha upper 30 cm of tha soil profile, 30 per cent from the next 30 cm and 10 per cent from the next 30 cm. They opined that as very little watar was extracted from below 90 cm, the effective rooting depth of cucumber can be considered to be 90 cm.

Zabara (1977) noticed that root distribution of cucumber at bearing stage was 64.5 per cent at zaro to 10 cm soil depth, 28.5 par cent at 10 to 20 cm depth and 6.2 per cent at 20 to 30 cm depth under irrigeted conditions. In unirrigated crops the root distribution was 53.7 per cent at zero to 10 cm, 29.0 per cent at 10 to 20 cm and 14.9 per cent at 20 to 30 cm soil depth. The study was conducted in dernopodzolic soil.

Thomas (1984) reported that in bittergourd about 66 to 71 per cent of the total soil moisture depletion was from the top 30 cm soil layer. In comparison with wet regimes, dry regimes depleted more soil moisture from the lower soil layers.

Tha moisture extraction pattern of different crops make it clear that since extraction is greater from surface layers, frequency is more important than depth of irrigation. Higher frequency with lower depth is preferable to a lower frequency and higher depth consistent with application losses.

2.1.5 Soil fertility status:

Mengal and Braunschweig (1972) recommended the application of higher doses of potash to counter balance the negative influence of higher pF on potassium diffusion based on their study on various vegetable crops.

Considerable removal of organic water soluble substances was revealed by Kravtsova and Chuprikova (1975) based on their analysis of percolating water in field cucumber. The process was intensive during the first two months and diminished with plant growth.

Sharma and Yadav (1976) based on field experiments in cucurbits concluded that available phosphorus content of the soil generally increased with increased levels of irrigation, while, Shanmugasundaram *et al.* (1979) concluded that available potassium in the soil was generally low when irrigations were given frequently whereas the same wee markedly high in respect of irrigation at longer intervals. However, Muthuvel and Krishnamoorthy (1980) observed that, in general, available phosphorus content of the soil was affected by variation in soil moisture regimes and the maximum content was noticed in the drier regimes than wetter ones. Influence of soil moisture regimes and their interaction on the available potassium content of the soil was reported to have no influence by Muthuvel and Krishnamoorthy (1981).

A general trend of increasing available K content left behind in the soil with decreasing frequency of irrigation was noticed at Madurai (Anon, 1981 b). Irrigation at IW/CPE 0.9 with 4 cm irrigation left behind the least amount of available K which however was statistically on par with that of IW/CPE 0.75 with 4 cm irrigation. A negative relation was observed between the yield and available K content left behind in the soil decreases indicating that more of available K has been taken up by the crop plant resulting in increased yield and decreased available status in the soil.

Thomas (1984) based on a field experiment in bittergourd concluded that the least frequently irrigated plots showed the maximum build up of available potassium. However, there was no influence on the other two nutrients due to irrigation.

From the above literature, it is obvious that irrigation and soil fertility status are interlinked not only because excessive irrigation can deplete soil of major water soluble nutrients but also because optimum moisture can significantly alter the availability of major nutrients in the soil. These effects in turn will play a major role in plant uptake of nutrients and growth.

2.2 Effect of Fertilizers

2.2.1 Growth and yield:

Miller (1958) observed that in cucumber high yields were associated with soils having abundant soluble N and P. Miller and Ries (1958) showed that plants receiving high N level produced three times as many cucumber fruits than those with low N level. The length to diameter ratio of the fruits was increased by high N.

Dhesi *et al*. (1966) based on their trials in bittergourd with varying levels of NPK concluded that application of N at 56 kg/ha was superior in fruit yield compared to 112 kg/ha. A beneficial response due to P application on fruit yield was noticed during the second year of the trial whereas no such effect could be obtained either with K application or due to the interaction effect of the nutrients.

Importance of Phosphorus nutrition in cucumber was shown by Bishop *et al*. (1969) and they recommended N, P and K doses of 50, 100 and 50 kg/ha respectively.

Padda *et al*. (1969) obtained most profitable yield of musk melon by application of N at 56 kg/ha eventhough the yield was greater when N was used at 112 kg/ha. They did not get any significant yield response to P and K and suggested a dose of 26 kg/ha P_2O_5 and 28 kg/ha K_2O along with nitrogen as a financially sound dose. Tabin and Lukasik (1969) reported that in favourable weather conditions, fertilizer containing NPK at 30:50:120 kg/ha respectively applied before sowing gave the highest yield of commercial and pickling cucumbers.

Jassal et al. (1970) in a fertilizer-cum-irrigation trial observed significant increase in fruit weight and yield by nitrogen application in musk melon. Nitrogen and irrigation interaction was significant in respect of fruit weight. Potassium application increased the yield but phosphorus had no significant effect.

Jagoda et al. (1970) reported that the optimum N rates for unirrigated and irrigated cucumber is 133 and 200 kg/ha respectively. They also obtained high yields under irrigated conditions with FYM at 3 t/ha and N at 66 kg/ha. Roorda Van Eysinga (1970) also observed that in cucumber addition of N and K showed significant yield increase whereas addition of P failed to show any such effect.

Largskii (1971) showed that fertilizers increased the resource of mobile soil nutrients and the yield and quality of cucumber. However, N rates above 60 kg/ha inhibited the accumulation of total sugars and ascorbic acid, whereas P fertilizers at high rates increased the sugars and Vitamin-C content.

Mc Collum and Miller (1971) noticed maximum dry matter production and marketable yield of cucumber at NPK rates of 80 : 42: 80 lb/acre (91:48:91 kg/ha) respectively. Based on a factorial experiment to compare the effect of various combinations of N, P and K on the growth and yield of cucumber, Pettiet (1971) observed that N and P favoured early growth and hastened maturity while lack of K did not inhibit early growth, but K additions were found to be beneficial to growth and cropping. The highest yield was obtained by the annual application of NPK at the rate of 50:80: 80 lb/acre (57:91: 91 kg/ha). Application of N and K at rates above this delayed maturity.

Sharma and Shukla (1972) reported a significant increase in yield of pumpkin in both rainy and summer season by increasing N levels. An increase in the level of phosphorus also resulted in an increase in yield. The suggested rates for economic production were N at 103 kg/ha and P_2O_5 at 106 kg/ha for the summer crop and N at 96 kg/ha and P_2O_5 at 88 kg/ha for the rainy season crop with a constant level of K_2O at 40 kg/ha.

Wilcox (1973) observed optimum growth and yield of musk melon when ammonium nitrate was applied preplant at the rate of 80 to 90 kg/ha.

Pandey __et al__. (1974) studied the response of musk melon to foliar and soil application of nitrogen and found that foliar application of nitrogen as urea at 1.5 per cent in three applications giving a total of 22 kg resulted in the highest number of fruits per plant and yield per hectare as compared with soil application of 50 to 200 kg/ha. Soil applied N at rates above 50 kg/ha was not beneficial to yield.

Bradley _et al_. (1975) compared the effect of plant population and nitrogen levels in cucumber and concluded that optimum N level was 60 lb per acre (68 kg/ha). Ivanov and Surlekov (1975) showed that cucumber crop receiving a basic dose of 30 t FYM per hectare, application of NPK at 100:70:200 and 70 : 120: 200 kg/ha raised yield by 28.1 and 25.6 per cent respectively compared with untreated controls. Jagoda and Kaniszewski (1975) observed that when cucumbers receiving N, P and K at 300, 600 and 900 kg/ha were irrigated when soil water content fell to 58 per cent of field capacity, the optimum fertilizer rate was 600 kg/ha in both irrigated and unirrigated cucumber crops. Krynska (1975) reported that in cucumber N, P and K at 600 kg/ha gave a seven per cent increase compared with 300 kg/ha, but 900 kg/ha dose gave only marginally higher yields than 600 kg/ha. Varma (1975) during a study with a monoecious cucumber line in which effects of N, P and K each at 50, 75 and 100 lb/acre (57, 85 and 114kg/ha) were compared either alone or with various growth hormones reported that yield was enhanced by all fertilizer levels significantly.

Borna (1976) studied the response of cucumber to fertilizer rates ranging from 200 to 2000 kg/ha (N:P:K = 2:2:3) and furrow irrigation at 2 or 3 levels. He concluded that irrigation generally increased the effectiveness of mineral fertilizers even in high rates. Fertilization, irrigation and their interactions had greater affect on marketable yield than on total yield.

Kmiecik (1976) studied the response of cucumber to 40 kg/ha of nitrogen applied once or 80 to 200 kg/ha of N applied in splits before and after sowing. P and K at 110 and 150 kg/ha respectively were applied as basal dressing. A significant yield increase was observed in plots receiving N upto 120 kg/ha but yield increases at rates above that were not significant. Kretschmer and Zengerle (1976) reported that high cucumber yields were obtained from plants to which NPK liquid fertilizers were added through sprinkler irrigation water.

Krynska et al. (1976) conducted studies with NPK at 80: 100: 120, 160:200:240 and 240: 300:360 kg/ha and irrigation rates of zero or 120 mm to cucumber. It was observed that Vitamin C content of fruit rose with increasing NPK rates along with increase in yield of fruits, but high rates had an adverse effect on fruit quality.

Novotorova (1976) observed a positive correlation between leaf P content and productivity in green house cucumber. Critical P level noticed in the third leaf from the apex was 0.30 - 0.35 per cent and higher yields were obtained from soils with 16 mg P_2O_5 per 100 g.

Penny et al (1976 a) reported a markedly poor growth of cucumber in potassium deficient than in full nutrient solution. This was attributed to reduced CO_2 fixation by cotyledons, which form the bulk of the photosynthetic surface at this stage of growth, and to a much lower level of expert of photosynthetic products from the cotyledons. They further pointed out that the magnitude of these effects increased as the seedlings got aged. Penny et al. (1976 b) concluded from another study that cucumber seedlings with leaf like photosynthetic cotyledons had higher growth ratos and requirements for external K supply. They also opined that cucumber seedlings with expanding photosynthetic cotyledons utilized their reserve K during cotyledon development and it was not transported to epicotyl and hence, an external K supply was essential for development of photosynthetic system and the roots.

Cantliffe (1977 a) based on petiole analysis for N reported that optimum yields occurred when leaves contained

4 to 5 per cent total N. Doss et al (1977) conducted studies to determine the response of cucumber to low, intermediate and high irrigation and 56 or 112 kg/ha of N and concluded that N increased yields proportionately with the rate of application.

Katyal (1977a) recommended a manuring schedule of 35-45 t/ha of FYM before sowing, 50 kg of Ammonium sulphate, 100 kg of Superphosphate and 55 kg of Potassium sulphate per hectare at the time of final land preparation, and 40-60 kg/ha of Ammonium sulphate as top dressing in two separate doses - the first when the plants start to 'run' and later when fruiting has started, for successful cucumber crop.

Katyal (1977b) also recommended the application of 50 t/ha FYM as a basal dose and a top dressing of ammonium sulphate at the rates of 100 kg/ha soon after flowering for bittergourd.

Mahakal et al.(1977) reported the optimum dose of NPK as 75:50:100 kg/ha for tinda(Citrullus vulgaris var fistulosus) from trials on a medium heavy soil. Highest fertilizer dose tried (75:100:150 kg/ha) gave only a slight increase in yield. Ottosson (1977) concluded from his trials that cucumber gives the highest yield with N at 150 or 210 ppm and K at 180 ppm. On Chernozem soils, the highest cucumber yields were obtained by Talmach (1977) by applying compost at 25 t/ha and NPK at 19: 60 : 60 kg/ha.

From trials with field grown cucumber, top grade fruits were obtained by Yakubitskaya et al. (1977) from plots receiving FYM at 90 t/ha and NPK at 90: 90: 120 kg/ha or FYM at 60 t/ ha and NPK at 135 : 135: 180 kg/ha. Deficiency of P and K had an adverse effect on fruit chemical composition and processing quality.

Based on laboratory experiments on cucumber, Adams (1978) concluded that there is yield increase as the N content of the nutrient solution increased from 50 to 300 ppm, provided that other nutrients were not limiting. Under conditions of N and K deficiency over 50 per cent of potential yield was found to be reduced. With high K levels Mg deficiency could occur and reduce yield upto 20 per cent. Good yield and fruit quality were associated with the following leaf nutrient levels - 4.5 to 5.0 per cent N, 0.7 to 1.0 per cent P and 2.5 to 3.0 per cent K.

From an evaluation of yield performance of water melon cv. sugar baby Bhosale et al. (1978) obtained highest yield with 75 or 100 kg/ha N, 30 kg/ha P_2O_5 and 75 or 100 kg/ha K_2O. El-Aidy and Moustafa (1978) reported that the best vegetative growth and fruit yield of cucumber was obtained at 1:1:2 ratio of NPK in the applied fertilizers.

El-Beheidi *et al*.(1978 a) studied the response of cucumber to phosphorus and concluded that P fertilization at 22.5 to 37.5 kg/ha stimulated cucumber plant growth, advanced flowering, increased the weight of fruit and yield but had no effect on the number of mature fruits per plant and flower sex ratio.

Hartmann and Waldhor (1978) proved that in cucumber top dressing with 5 g N/m^2 per week starting from four weeks after planting until three weeks before harvest gave higher yield than 2.5 or 7.5 g. It was also noted that increasing the water supply from 300 mm per m^2 to 670 mm per m^2 increased nitrogen utilization by 30 per cent. Within a plant 70 per cent of nitrogen was in the fruit and 30 per cent in foliage and stem.

Oguremi (1978) studied the response of water melon to N at zero to 72 kg/ha in several trials. Increased levels of nitrogen application increased the leaf number and was the highest in plots receiving 72 kg/ha N. Flowering was found to be delayed by a week, with high nitrogen application. Fruit number per unit area and fruit size were highest with N at 48 kg/ha.

Williams (1978) based on a trial with chinese cucumbers reported that the total fruit yield rose markedly with N st 280 kg/ha and K at 78 kg/ha. Bradley *et al*. (1979) after comparing the effect of spacing and fertiliser treatments in cucumber observed that highest returns per hectare was obtained at 300 kg/ha of N.

Feigin *et al*. (1979) compared the effect of N from zero to 180 kg/ha in combination with FYM. Unfertilized controls gave very low yields (2.5 t/ha). Good yields (8.7 to 12.0 t/ha) were obtained from all plots supplied with 60 to 120 kg/ha N with or without organic manure. Further addition of N did not increase the yield significantly in cucumber.

Kruglyakova and Polugar (1979) reported that omission of P from the nutrients applied to cucumber decreased the total yield slightly but had no appreciable effect on the removal of NPK by the plants. Removal of P by the fruits was slightly less when P was not top dressed along with other nutrients. Meanwhile, Sugimaya and Iwata (1979) observed from a pot culture experiment that K application at 1 g per pot increased the fresh weight of cucucmber seedlings and the total fruit yield.

Will (1979) based on a study in cucumber with slow release nitrogen fertilizers reported an increase of 8 to 10 per cent in fruit yield and improved fruit quality. He also opined that for optimum utilization of slow release N fertilizers adequate irrigation should also be provided.

A single application of NPK and Mg was reported to have a more beneficial effect on fruit yield of cucumber than top dressing by Ishkaev and Ibragimov (1980). The optimum proportion of NPK and Mg was 1.0: 0.6: 1.4: 0.4

Based on a three year trial with pickling cucumbers, O'Sullivan(1980) concluded that eventhough irrigation and N rate had no significant effect on yield, decreased rates of both had deleterious effect on fruit quality. Fruit colour was affected by irrigation and nitrogen. Tissue nitrogen decreased with increasing irrigation indicating an increased demand for nitrogen when cucumbers are provided with irrigation.

Randawa (1981) in trials with two cultivars of musk melon reported best results with regard to plant growth, number of fruits per vine, fruit weight per vine and fruit quality from plots receiving an NPK level at 50:37.5:37.5kg/ha.

Rajendran (1981) studied the effect of different doses of NPK on pumpkin. He found that N,P and K alone produced significant difference in the number of days required for female flower production, percentage of fruit set, equitorial parameters of fruit and fruit weight. The effects of main factors N, P and K were found to be significant in the case of LAI at 30 and 60 days after sowing. Total dry matter content at 60th day and at harvest increased with increased levels of N and P. He further noted that the response to nitrogen was quadratic and the economic level was worked out to be 71 kg/ha. However, the response to P was linear. He recommended a fertilizer schedule of 71 kg/ha of N and 50 kg/ha of P_2O_5 as optimum dose. The response to K_2O was not significant in respect of yield as the soil was good in the content of that nutrient.

From a multilocational trial in Kerala to study the effect of graded doses of N, P and K in cucumber with three levels of N (0, 25 and 50 kg/ha), three levels of P_2O_5 (0, 50, 100 kg/ha)and three levels of K_2O (0, 50,100 kg/ha) it was observed that the response to nitrogen was linear even upto 50 kg N/ha, no response to phosphorus even at 100 kg P_2O_5/ha and a linear response to potassium upto 50 kg K_2O/ha which tended to be quadratic at 100 kg K_2O /ha. The results in different locations in different years were inconsistent (Anon, 1982).

Smittle and Threadgill (1982) based on a comparative study with four levels of nitrogen in cucumber and squash reported that the highest marketable fruit yield resulted from application of 22.5 kg/ha nitrogen through irrigation system at 2, 3, 4, 5 and 6 weeks after planting in cucumber.

An experiment conducted in Kerala to find the response of different doses of N, P and K showed that N: P: K at 50 : 25 : 50 kg/ha gave the maximum yield of bittergourd (Anon, 1981). However, this observation was not consistent in the subsequent years (Anon, 1982).

Based on a study on water management and nutritional requirement of bittergourd at Chalakkudy, Kerala, Thomas (1984) reported that the crop responded well to higher levels of fertilizers. Biometric characters like leaf production, leaf area index and dry matter production were significantly influenced by high fertility levels. Yield components like mean number of fruits per plant, mean length of fruit and mean weight of fruit were also favourably affected by high fertility levels. Effect of fertilizers on fruit yield was also significant wherein the highest fertilizer level of 18 t FYM + NPK at 60:30:60 kg/ha produced the maximum fruit yield of 9.35 t/ha.

The above literature show that mineral nutrition has a significant role to play in growth and yield of cucumber, and cucurbits in general. Studies by workers like Jagoda and Kaniszewski (1975), Krynska (1975), Kmiacik (1976) and Feigin *et al*. (1979) to site a few, have showed that cucumber is a crop which shows response to applied fertilizers even upto 600 kg/ha. In general, cucumber responds well to high doses of nitrogen and potassium but response to phosphorus is inconsistent. Interaction between nutrients and irrigation has also been reported by workers like Jagoda et al. (1970), Hartmann and Waldhor (1978) and Will (1979) in cucumber and Thomas (1984) in bittergourd.

2.2.2 Chemical composition and Nutrient uptake:

Tayal et al. (1965) reported that application of nitrogen fertilizers increased nitrogen percentage and the total N absorbed by the plants per unit area in different plant parts. Based on a field experiment on phosphorus nutrition of water melon, Lacascio (1967) observed that there is an increase in tissue phosphorus content and fruit phosphorus content as a result of applied P. Fiskell and Breland (1967) observed that the leaf K content decreased sharply with increasing yield whereas leaf nitrogen content was not significantly affected in cucumber.

Grozdova (1970) determined the N, P and K contents of cucumber leaves during different phases of growth. It was found that cucumber required higher N dose from the time of flower bud formation till the end of growth. The need for P increased during flower bud formation, decreased slightly during flowering and rose again during cropping. Potassium was readily absorbed during early growth, declined during flower bud formation and then rose again.

Ward and Miller (1970) based on their analysis of cucumber fruits for their NPK content showed that very small fruits contained relatively higher percentage of these nutrients. Beyond a certain size the percentage levels are somewhat lower and remained constant for all sizes. Nutrient absorption keeps pace with size eventhough the growth may be erratic. The levels may differ in different parts of the plant but they were uniform for all fruit sizes in each part.

Based on a three year trial with cucumber with varying rates and sources of N, Aleksandrova (1971) noticed that increasing rates of N increased the leaf N content, but there was no constant relationship between N application rates and dry matter accumulation in the leaves.

Mc Collum and Miller (1971) reported that the total uptake of N, P and K by pickling cucumbers was 90, 12 and 145 lb/acre (102, 14, 165 kg/ha) respectively. They estimated the nutrients removed by the harvested fruits as 40,6 and 55 lb/acre(45, 7 and 63 kg/ha) respectively of N, P and K.

Semichev (1971) analysed different parts of cucumber for major nutrients and reported that irrespective of growing conditions, the leaf K content was highest during flowering and declined with plant age, whereas the leaf P content declined with age and rose again after fruiting. The P content of the fruit was higher than that of the other parts. Jassal et al. (1972) reported that the percentage of N and P in the plant tissues were highest after maximum application of the respective nutrient irrespective of irrigation frequency.

Wilcox (1973) determined leaf nitrogen content and related it to yield of cucumber. Optimum leaf nitrogen composition in relation to yield was over 4.5 per cent and the optimum petiole nitrate nitrogen composition was over 15,000 ppm during plant growth and fruit formation respectively.

Jaszczolt (1975) reported that in cucumber P deficiency or excess retarded the early yield and decreased the main yield. He also observed that cucumber had a low capacity for utilising phosphorus.

Based on an experiment with varying rates of nitrogen from zero to 268 kg/ha, Cantliffe (1977 a) observed that optimum yield was noticed when leaves contained 4 to 5 per cent total N. Moreover, nitrogen had a direct influence on the mineral nutrient composition of the leaf tissue at harvest.

Solntseva (1978) reported that cucumber plants grown in fertile soils utilised 75 to 81 per cent of N from the soil and only 19 to 25 per cent from applied fertilizers. The addition of N fertilizers increased plant N uptake from the soil by 53 to 63 per cent compared to the control plants receiving only P and K. Combined application of N fertilizers and FYM increased plant utilization of N fertilizers. The coefficient of utilization of N fertilizers by cucumber was 24 to 32 per cent.

From trials with domestic cucumber, Laske (1979) showed that cucumber planted at the rate of 1.2 plants/m^2 removed equivalent of 500 kg/ha N during the growing season. He noted that when N = 1, the removal of N : P_2O_5 : K_2O was 1.0 : 0.4 : 2.0

Tsarling *et al*. (1979) observed that about 15 kg/m^2 yield was produced in cucumber when the soil contained 20 to 30 mg N, 100 mg P_2O_5 and 400-500 mg K_2O per kg of soil at flowering. At that time the leaf blade contained about 5 per cent N, 1 per cent P_2O_5 and 3 per cent K_2O.

Dorofeyuk (1980) based on field trials with ridge cucumbers concluded that early sown plants showed a high requirement of N and P whereas, in late sown plants the requirement for P diminished but that for N remained high. The role of N in fruit formation was found to be significant.

Tesi et al (1981) reported that when adequate fertilizers were applied the uptake of N, P_2O_5 and K_2O in Cucurbita pepo amounted to 170.5, 71.2 and 394.4 kg/ha respectively. He also observed that nutrient requirements were greatest during the 15 days preceeding the first harvest and during the subsequent 15 days.

Based on a field experiment at Chalakkudy in bittergourd Thomas (1984) reported that all the fertility levels tried had significant influence on the content and uptake of nitrogen and potassium during the early stages, and all the three major nutrients during the later stages. The interaction between fertility levels and irrigation also had significant influence on the uptake of nitrogen and phosphorus at final harvest.

Profound influence on the content and uptake of major nutrients by cucurbits has been made clear by the above literatures. A higher level of plant content of these nutrients during the early stages and adequate supply during the later stages have been shown to be important in high uptake of nutrients which will lead to better fruit yield. Interaction between nutrient levels and moist regimes on uptake of nutrients has also been brought out in some field experiments.

2.2.3 Soil fertility status:

Downes and Lucas (1966) and Bains (1967) noted that soil level of P and K increased linearly with fertiliser application. From glass house experiments it was concluded that available P and K in the soil were affected by the application of the respective fertiliser elements, particularly at higher levels of applied P and K due to the build up of those nutrients in the soil.

Fiskell *et al.*(1970) while experimenting with water melon observed a linear increase of both soil and plant nutrient values at the thinning stage with the percentage of fertilisers added initially, while in trials with cucumber Largskii (1971) indicated that fertilizers increased the reserve of mobile soil nutrients.

Ermorkhin and Naumenko (1975) determined the relationship between cucumber yield and content of available NPK in the soil. They concluded that when the soil NPK content at the time of planting was 15 to 25 mg NO_3-N, 60-70 mg

P_2O_5 and 60 mg K_2O per 100 g soil, application of mineral fertilizers was found to be ineffective. However, at lower levels individual nutrients showed significant effects based on the degree of their deficiency in the soil.

Sharma and Yadav (1976) based on field experiments on various vegetables reported that available phosphorus content of soil generally increased with the addition of P fertilizers.

Mani and Ramanathan (1980) conducted a field experiment to study the effect of N and K fertilizers in vegetable crops on available potassium status of the soil. The available K content of the soil was not influenced by the application of nitrogen. However, the application of K significantly increased the K content of the soil. A progressive reduction in the available K content of the soil was noticed as the crop growth advanced due to crop uptake.

Muthuvel and Krishnamoorthy (1980) noticed that level of applied nitrogen had a significant influence on the available P content of the soil. The lower levels of added nitrogen led to greater available P content of the soil and the maximum phosphorus was under no nitrogen treatment.

Mathew (1981) noted a significant increase in the available potassium content of the soil with the increase in the level of applied potash. Application of 75 kg/ha K_2O recorded the highest available potassium content in the soil during the field experiment. However, the available phosphorus content in the soil did not increase with increased phosphorus application.

Thomas (1984) based on a field experiment on bittergourd at Chalakkudy reported that available N and K status was considerably improved by their fertilisers applied at higher levels.

Effect of applied fertilisers on influencing the status of the respective nutrients in the soil has been clearly brought out by the above literature. It is important to note that soil content of N and K show a tendency to increase with the increase in the level of application of fertilizers containing those nutrients.

2.3 Effect of irrigation and nutrients on sex expression:

Czao (1957) reported that adequate P fertilization and high soil moisture content increased female flower development in cucumber with a proportionate increase in absorption of nitrogen.

Molnar (1965) noticed advanced flowering and increased number of female flowers after frequent irrigations in melon. He also observed a higher water requirement at the beginning of fruit growth and a reduction in fruit drop in irrigated crops.

Rekhi *et al.* (1968) reported an alternation in the ratio of perfect to staminate flowers in musk melon by the application of N at 120 or 180 kg/ha. The ratio was changed to 1 :20.6 and 1:16.6 respectively from 1:41.5 in control plants. However, soil application of P or K did not register any effect on sex expression.

Parikh and Chandra (1969) found that maximum and minimum number of female and male flowers respectively were produced when nitrogen was applied at 80 kg/ha eventhough the trial dosage varied from zero to 120 kg/ha of nitrogen. They also noted that higher N rates delayed the appearance of the first female flower.

Jassal *et al.* (1972) showed that the number of flowers per plant increased with increase in the rate of N application in musk melon. The maximum number of female flowers (7.32 per cent) was produced at 165 kg/ha and 55 kg/ha of N and P respectively.

Pandey and Singh (1973) found that nitrogen at 50 or 100 kg/ha increased pistillate and staminate flowers, fruits as well as yield in bottlegourd where as sex ratio was unaffected.

Pandey et al. (1974) observed that, in musk melon, thera was no effect on sex expression by either folier application or soil application of nitrogen.

Varme (1975) during e study with monoecious cucumber lina in which effects of N, P and K, each at 50, 75 and 100 lb/acre (57, 85 and 114 kg/ha) were compared eithar alone or with various growth harmones reported that the ratio of female to male flowers was greatly increased by the highest fertilizer level and by lower fertilizer levels plus ethrel.

Cantliffe (1977 b) observed a slight increase of pistillate flowers per plant upto a N dose of 134 kg/ha in pickling cucumber grown for once over harvest, when applied as pre-plant.

El-Beheidi et al. (1978 b) reported that a fairly high rate of N (60 kg/ha) was needed for satisfactory growth, female flower production, fruit yield and quality in cucumber.

Rajendran (1981) based on his studies with different doses of NPK on pumpkin reported that N, P and K in combination produced significant difference in the number of days required for female flower production, fruit set and fruit weight.

The above literatures show that sex expression in most of the cucurbits are influenced by nutrients and moisture regimes. However, uniformity of response is lacking due to the adoption of different criteria and methods for expressing sex ratio in relative numerical terms by workers in different crops.

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation on water management and NK nutrition of cucumber was undertaken during summer season of 1984 as a statistically laid out field experiment. The materials used and methods adopted in the study are briefly described below.

3.1 General

3.1.1 Experimental site:

The experiment was laid out in the rice fields of the Agronomic Research Station, Chalakkudy, Trichur district under the Kerala Agricultural University. The station is situated at 10^{0} 20' N latitude and 76^{0} 20' E longitude and at an altitude of 3.25 m above mean sea level.

3.1.2 Soil

The soil of the experimental site was loamy sand in texture with the bulk density ranging from 1.45 to 1.55 g/cm^3. The soil was slightly acidic with pH ranging from 5.5 to 6.0 It was low in organic carbon, available nitrogen and available potassium but medium in available phosphorus. The important physical and chemical properties of the soil are presented in Table 1.

Table 1. Soil characteristics of the experimental area

A. Physical properties

1. Mechanical composition :

Coarse sand	(%)	- 61.2
Fine sand	(%)	- 16.4
Silt	(%)	- 7.9
Clay	(%)	- 12.8
Textural class		- Loamy sand

2. Infiltration rate - 7.2 cm per hour

3. Important soil physical constants

Constant	Depth of soil layer (cm)			
	0-15	15-30	30-60	60-90
Field capacity (%)	11.0	10.3	10.5	10.5
Moisture percentage at 15 bar	3.8	3.6	3.5	3.5
Bulk density (g/cm^3)	1.45	1.55	1.50	1.47

B. Chemical properties:

1. Organic carbon	(%)	- 0.45
2. Available Nitrogen	(kg/ha)	- 82.50
3. Available P	(kg/ha)	- 14.00
4. Available K	(kg/ha)	- 24.00
5. Soil reaction	(pH)	- 5.5
6. Electrical conductivity (m mhos/cm)		- 0.36

3.1.3 Season

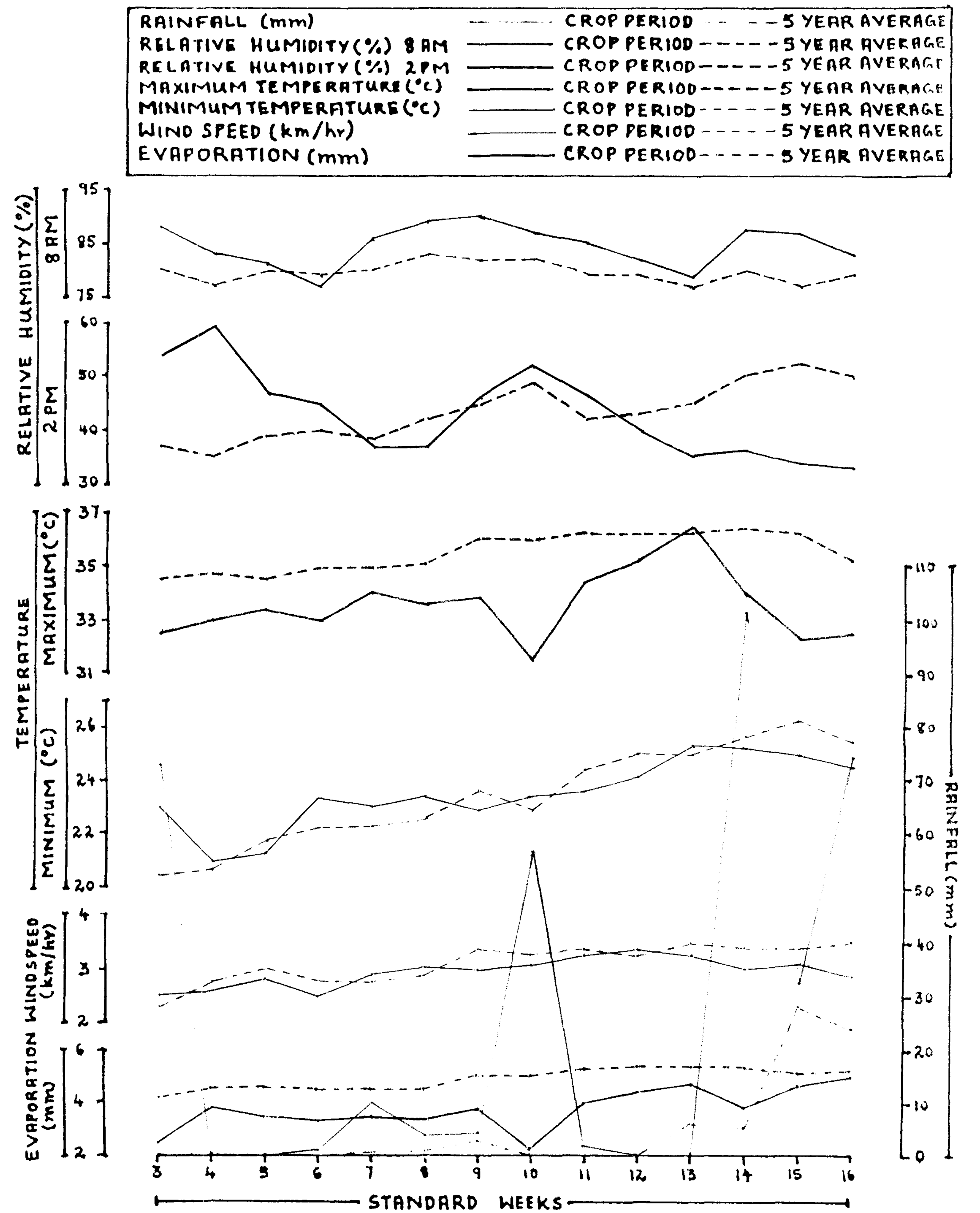
The experiment was conducted during the summer season of 1984 (January to April) as this is the regular growing season of vegetables in rice fallows in the State.

3.1.4 Weather Parameters:

The weekly averages of temperature, evaporation, wind speed, relative humidity and the weekly totals of rainfall during the crop period and their averages for the previous five years collected from the Observatory attached to the farm are presented in Figure 1 and Annexure I. Variation in weather parameters during the crop season compared to the average of the previous five years have also been worked out.

Weather parameters such as temperature, windspeed and relative humidity were normal when compared to that of the previous five years. The weekly averages of maximum temperature ranged between 31.5°C and 36.3°C and the minimum temperature between 20.9°C and 25.3°C. Their respective variations from the average of previous five years ranged between -4.4 to + 0.1°C and -1.3 to + 2.6°C. The variation in relative humidity during the crop season ranged from -2.4 per cent to + 10.0 per cent at 8.00 AM and -17.8 per cent to + 23.9 per cent at 2.00 PM. The variation in mean windspeed ranged from -0.6 to + 0.2 km/hr.

FIG: 1. WEATHER DATA DURING CROPPERIOD AND AVERAGE FOR LAST FIVE YEARS.



However, parameters like rainfall and pan evaporation showed fluctuations from the average of the previous five years due to the occurrence of summer showers during the first week of March as well as April. The variation in rainfall ranged between -2.67 mm and -0.13 mm. The rate of evaporation was found to be medium during the first month, low during the second half of the second month and high during the first half of the second month and during the whole of the third month of the cropping season.

3.1.5 Ground water fluctuations in the experimental area:

Depth to ground water was measured with the help of two piezometers established in the experimental plot and the average values for February, March and April 1984 were 178, 182 and 168 cm respectively. There was a steady decrease in the depth to groundwater during February from 190 to 161cm and it increased from 164 to 190 cm during the rest of the cropping season.

3.1.6 Cropping history of the field and crop rotation followed:

The experimental site was under bulk crop of paddy during the first and second crop seasons of 1983-84. The crop rotation followed was Rice-Rice-Cucumber.

3.1.7 Cultivar used

The cultivar CS-26, a pure line selection from one of the local varieties of South Kerala having long broad fruits and light green colour with a mosaic of white patches all over the fruit, and a duration of 90 days, was used for the study.

3.1.8 Source of seed material

The seeds for the experiment were obtained from the Instructional Farm, College of Agriculture, Vellayani where the selection of this cultivar was done.

3.1.9 Manures and Fertilizers

Cattle manure analysing 42 per cent moisture, 0.55 per cent total N, 0.33 per cent total P_2O_5 and 0.44 per cent total K_2O was given as basal dressing at the rate of 20 t/ha. Urea (46 per cent N) super phosphate (16 per cent P_2O_5) and Muriate of Potash (60 per cent K_2O) were used as the sources of nitrogen, phosphorus and potassium respectively. Phosphorus was given at the rate of 25 kg/ha P_2O_5 as a common dose to all the plots while N and K were applied as per treatments. The cattle manure and fertilizers were applied on the prepared seed beds (20 cm wide and 6 m long) and incorporated with soil.

3.1.10 Source of irrigation water

Canal water from Chalakkudy project and water from the well in the farm were used for irrigation. The method of irrigation was check basin except for the cultivator's practice which received pot watering.

3.2 Experimental methods

3.2.1 Design and Lay out:

The experiment was laid out as a factorial experiment in split plot design. The layout plan of the experiment is given in Figure 2.

3.2.2 Treatments:

The treatments included in the study were the nine combinations of three levels each of nitrogen and potassium in the main plots and four levels of irrigation in the sub plots which are detailed below:

Treatments:

Main plot - Nine combinations of 3 levels each of N and K

Nitrogen - 3 levels - n_0 - 0 kg/ha (control)

n_1 - 50 kg/ha

n_2 - 100 kg/ha

Potassium - 3 levels - k_0 - 0 kg/ha (control)

k_1 - 50 kg/ha

k_2 - 100 kg/ha

Sub plot - 4 levels of irrigation.

i_1 - Cultivator's practice - daily pot watering at the rate of 4 l/plant

i_2 - Irrigation at CPE - 25 mm (5 cm depth)

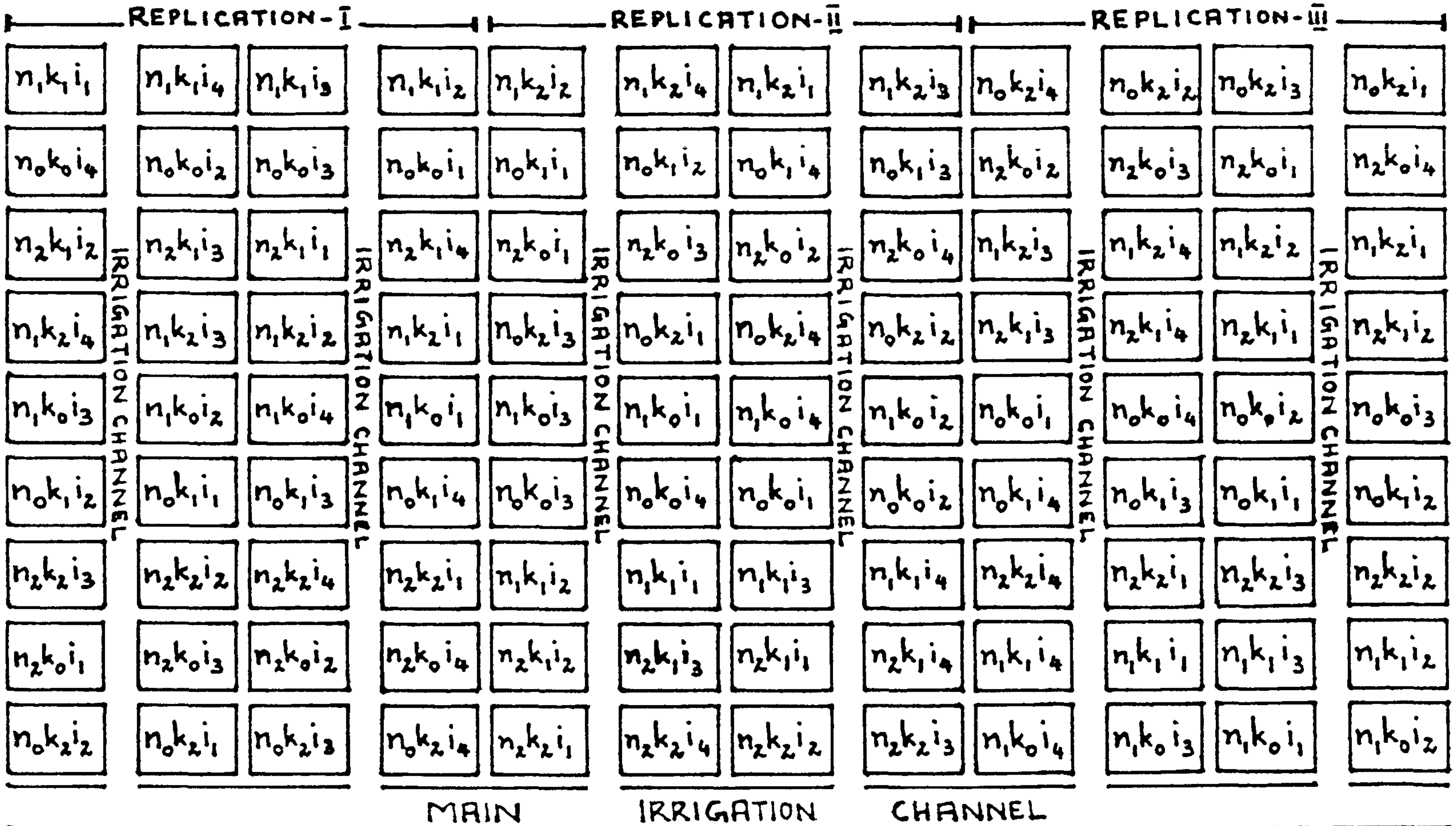
i_3 - Irrigation at CPE - 50 mm (" ")

i_4 - Irrigation at CPE - 75 mm (" ")

The irrigation schedules, i_2, i_3 and i_4 were based on cumulative pan evaporation (CPE) values. The treatment i_1 was standardised after a survey of the local farmer's practice of irrigating cucumber.

Number of treatment combinations	= 36
Number of replications	= 3
Total number of plots	= 108
Gross plot size	= 6.0 x 2.5 m
Net plot size	= 4.5 x 2.5 m
Spacing	= 2.5 x 0.3 m
Wetted area of each plot	= 6.0 x 0.6 m
Number of plants per plot - Gross	= 20 plants
Net	= 15 plants
Border rows	= 5 plants

FIG. 2. LAYOUT PLAN.



3X3X4 FACTORIAL EXPERIMENT IN SPLIT PLOT DESIGN WITH THREE REPLICATIONS.

TREATMENTS

MAIN PLOT: NINE COMBINATIONS OF THREE LEVELS EACH OF NITROGEN AND POTASSIUM.

n_0 = CONTROL
n_1 = 50 kg/ha
n_2 = 100 kg/ha

k_0 = CONTROL
k_1 = 50 kg/ha
k_2 = 100 kg/ha

SUBPLOT: FOUR LEVELS OF IRRIGATION

i_1 = DAILY POT WATERING
i_2 = IRRIGATION AT 25 mm CPE
i_3 = IRRIGATION AT 50 mm CPE
i_4 = IRRIGATION AT 75 mm CPE

Out of the gross number of 20 plants per plot, three plants on the side adjecent to the main irrigation channel and two plants on the other side adjecent to the buffer strip were left as border plants. The remaining 15 plants were observation plants. Five plants in the middle of the plot were marked out for taking biometric observations. Details of an individual plot are given in Figure 3.

3.3 Field culture

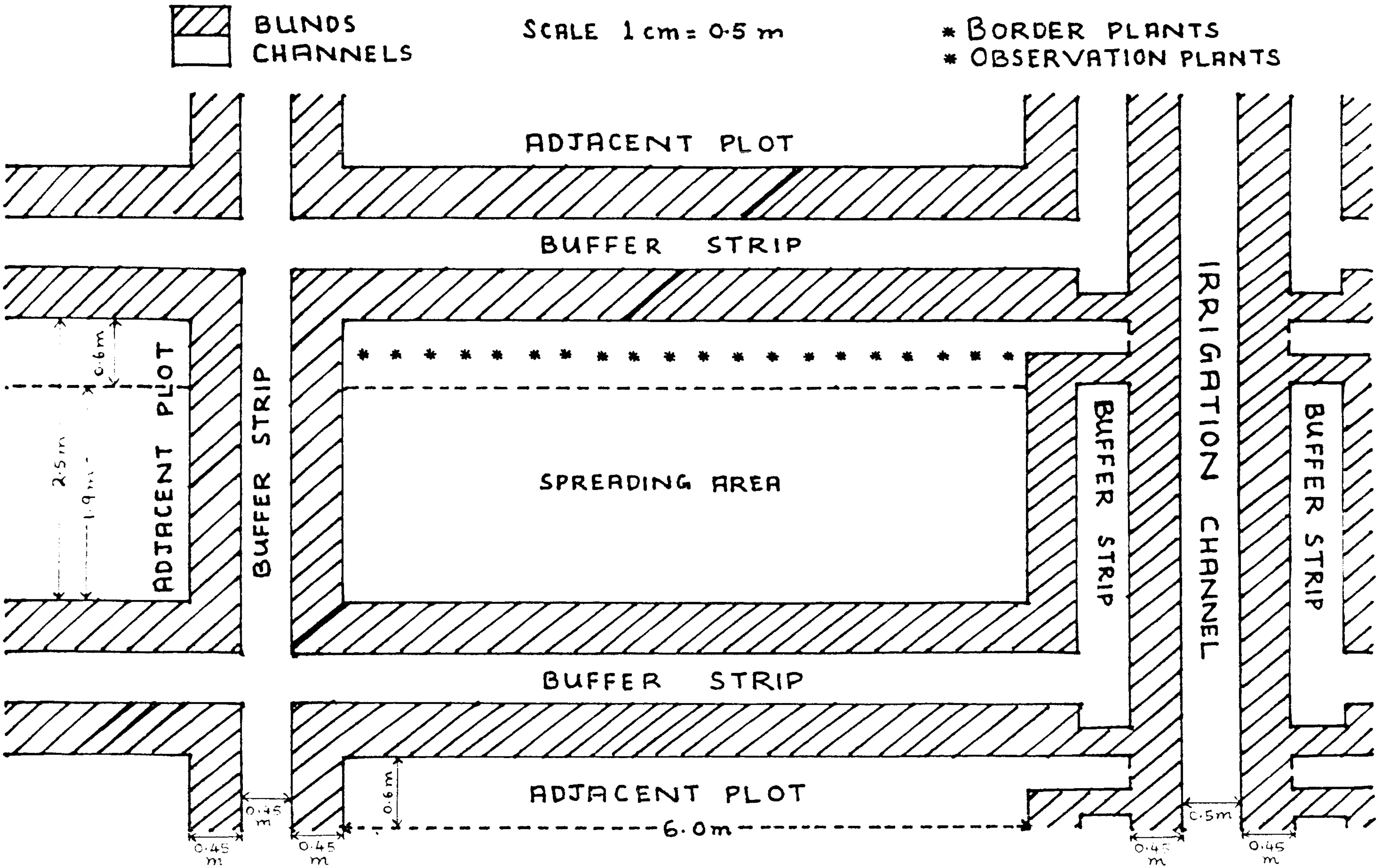
3.3.1 Land preparation and layout:

The experimental areas was ploughed twice with a power tiller and levelled. The field was then laid out into 12 blocks, each with nine plots. The allotment of treatments to various plots was done as per design. Buffer area with 45 cm width was left all around the experimental plots to prevent the seepage of moisture from one plot to another and or from tha irrigation channels to the plots. Irrigation channels were also provided with buffer strips on either side.

3.3.2 Seeds and sowing:

The seeds were soaked in water overnight to ensure good germination. Two seeds were dibbled in each hole side by side, the distance between the holes being 30 cm. The seedlings were thinned to one per hole 10 days after sowing. When

Fig.3. Details of an individual plot.



the plants started to 'run' the vines were individually trained over the spreading area on plated coconut leaves.

3.3.3 <u>Manures and Fertilizers</u>:

Cattle manure at the rate of 20 t/ha was applied uniformly to all the plots as basal dose and mixed well with the top soil. A uniform dose of phosphorus at the rate of 25 kg P_2O_5/ha was also given as basal dose in addition to the cattle manure. Fifty per cent of the differential doses of nitrogen and potassium were applied as basal in accordance with the treatments and the remaining fifty per cent was top dressed on the thirtieth day after sowing.

3.3.4 <u>Irrigation</u>

One pre-sowing irrigation by pot-watering at the rate of 8 l per plot was given uniformly to all the plots just before sowing on 21.1.1984 and this was continued daily till the 15th day of sowing (5.2.1984). On the 16th day (6.2.1984) the differential irrigations as per treatments were started. The depth of irrigation was 50 mm which works out to 180 l of water per plot. The quantity of water to be irrigated was calculated for the wetted area of the basins in each plot (6.0 m length and 0.6 m width).

Table 2. Details of Irrigations given

Serial number of irrigation	i_1	i_2	i_3	i_4
1	Daily	# 6.2.84	# 6.2.84	# 6.2.84
2		17.2.84	25.2.84	3.3.84
3		25.2.84	17.3.84	28.3.84
4		3.3.84	28.3.84	14.4.84
5		17.3.84	9.4.84	-
6		22.3.84	-	-
7		28.3.84	-	-
8		2.4.84	-	-
9		9.4.84	-	-
10		14.4.84	-	-
Total number of irrigations	75	10	5	4
Quantity of irrigation water applied (mm)	* 1667	500	250	200
Pre-treatment irrigation (mm)	* 36	* 36	* 36	* 36
Total quantity of water applied(mm)	1703	536	286	236
Rainfall contribution(mm)	-	33	56	51

Common irrigation

* Equivalent water delta

For those plots receiving daily irrigation as per cultivator's practice, pot watering was given at the rate of 80 l per plot (ie. 4 l/plant) throughout the growing season.

For treatments i_2, i_3 and i_4, 50 mm depth of irrigation was applied as and when the cumulative pan evaporation values reached 25, 50 and 75 mm respectively. After measuring with a circular orifice plate, 180 litres of water was let into each plot. The details of irrigation given and the total quantity of water applied along with relevant details are presented in Table 2.

3.3.5 <u>After cultivation</u>

The crop received two hand weedings followed by two hoeings on the 15th and 30th day after sowing. On the 20th day of sowing plated coconut leaves were spread on the ground in each plot to facilitate smooth running of the vines over the spreading area.

3.3.6. <u>Plant protection</u>

During the cropping period prophylactic plant protection measures were taken against pests diseases according to the general recommendations in the Package of practices (Anon 1982)

3.3.7 Harvesting:

The first harvest of the crop was done on the 60th day of sowing (ie. 20.3.1984). Subsequent harvests were carried out on the 75 th day (ie. 5.4.84) and 90th day of sowing (ie. 20.4.84). The maturity of the fruit for vegetable purpose was judged by visual observation of the fruit size and colour.

3.4. Biometric observations

3.4.1. Length of vine:

The length of vine was recorded on five randomly selected plants at three growth stages, viz. 30th, 60th and 90th day of sowing. The length of the longest vine was measured from the base to the growing tip of the vine and the mean length of vine per plant worked out.

3.4.2. Number of leaves per plant:

The total number of leaves from the randomly selected five plants were recorded on the 30th, 60th and 90th day of sowing and the mean number of leaves per plant was worked out.

3.4.3 Leaf Area Index (LAI)

The LAI was calculated using the punch method in the sample plants used for the estimation of dry matter production on the 30th, 60th and 90th day. The dry weight of the punches of known surface area was related with tho dry weight of the total leaves and the leaf area of individual plant calculated. The leaf area per plant was divided by the land area occupied by the plant and expressed as LAI.

3.4.4 Dry matter production per hectare:

Dry matter production was recorded during three growth stages, viz. 30th, 60th and 90th day of sowing. One plant per plot was randomly selected for that purpose at each stage, cut close to the ground and oven dried at 80 $\pm$ 5°C to a constant weight. The dry weight of fruits and vines recorded separately were added together to obtain the total dry matter production, and then converted into per hectare value.

3.4.5 Number of fruits harvested per plot:

The number of fruits harvested from all the plants in each plot, except the border plants was counted and the average worked out for each plot.

3.4.6 Length of fruits:

The length of all the fruits harvested from each observational plant was recorded in centimeters and the mean length worked out.

3.4.7. Girth of fruit:

The girth at the centre of each fruit harvested from the observational plants was recorded and the mean girth of the fruit calculated.

3.4.8 Weight of fruit:

The weight of all the fruits harvested from the observational plants was recorded in kilograms and the mean weight worked out.

3.4.9 Fruit setting percentage:

The total number of female flowers produced by the five randomly selected observational plants and the total number of fruits harvested from those plants were recorded and the fruit setting percentage worked out.

3.4.10. Sex ratio:

Random count of the total number of male flowers produced in any one of the five observational plants in each plot was related to the total number of female flowers produced by that plant and the sex ratio calculated and expressed as number of female flower per hundred male flowers.

3.4.11 Fruit yield per hectare:

Weight of individual fruits from the various harvests of each plot was totalled at the end of the cropping period and the average yield in kg per hectare worked out.

3.5 Moisture Studies

3.5.1. Field water use efficiency:

Field water use efficiency was calculated by dividing the economic crop yield by the total amount of watar used in the fiald (WR) and expressed in kg per hectare millimeter.

Field water use efficiency (EU) = Y/WR.

3.5.2. Consumptive Use:

Consumptive use was worked out from the data on soil moisture deplation as suggested by Dastane (1972). Soil samples ware collected from zero to 15, 15 to 30, 30 to 60 and 60 to 90 cm depth using a soil augur before tha experiment, before and 24 hours after each irrigation and at final harvest. Thermogravimetric method of soil moisture determination was adopted. Mean daily consumptive use was obtained by dividing total consumptive use by the total number of days.

3.5.3. Moisture depletion pattern:

Tha average relative soil moisture depletion from each soil layer in the root zone (upto 90 cm) was worked out for each irrigation interval. The potential evapotranspiration values for the 24 hours after each irrigation extrapolated from the Class A pan evaporation data were added to the depletion in the respective layer and the total loss of each layer determined and expressed as percentage.

3.6 Analytical procedures

3.6.1 <u>Soil Analysis</u>

3.6.1.1 <u>Physical properties</u>

a) Particle size distribution:

Mechanical analysis of the soil was carried out by the Robinson's International Pipette method, after oxidation of organic matter with six per cent hydrogen peroxide as described by Peiper (1950). Soil was classified into textural groups using I.S.S.S. System.

b) Infiltration rate:

A double cylinder infiltrometer was used for determining the infiltration rate as described by Micheal (1978).

c) Bulk density:

Bulk density was determined in situ by collecting the soil samples using a core sampler (Bodman, 1952).

d) Field capacity:

Field capacity was determined by field method as suggested by Colman (1944).

e) Moisture percentage at 15 bar:

Moisture percentage of the soil at an applied pressure of 15 bar in a pressure membrane apparatus with sausage casing membrane, was noted and taken as an index of the permanent wilting (Richards 1947).

3.6.1.2 <u>Chemical properties</u>

a) Organic carbon:

Organic carbon was estimated by Walkley and Black's rapid titration method (Jackson 1958).

b) Available nitrogen:

The available nitrogen content of the soil was determined by the alkaline permanganate method, described by Subbiah and Asija (1956).

c) Available phosphorus:

Available phosphorus in the soil was extracted in Bray No. 1 dilute acid fluride solution (0.03 N NH_4F and 0.025 N HCI) (Bray and Kurtz, 1945) and colorimetric determination of phosphorus in the extract by the chlorostannous reduced molybdophosphoric blue colour method in hydrochloric acid system(Jackson 1958).

d) Available potassium

The available potassium content of the soil was determined with neutral normal ammonium acetate extract, reading in an EEL flame photometer (Jackson, 1958).

e) Soil reaction:

The pH of the soil water suspension (1:2.5 ratio) was determined using a Perkin Elmer pH meter with glass and calomel electrodes (Jackson, 1958).

f) Electrical conductivity:

Electrical conductivity of an 1: 2 soil water extract was determined using a solu bridge (Jackson 1958).

3.6.2 Plant Analysis

Samples collected for dry matter production studies were oven dried to a constant weight, ground in a Willey Mill and sieved through 60 mesh sieve and used for chemical analysis. The NPK content was determined of the stem and leaves on the 30th, 60th and 90th day after sowing and that of fruits also on the 60th and 90th day.

3.6.2.1 Nitrogen content of plant parts

The content of nitrogen in different plant samples was determined by using Microkjeldahl method (Jackson 1958).

3.6.2.2. Phosphorus content of plant parts

The phosphorus content of the samples was determined using triple acid extract (Jackson 1958). A Klett-Summerson photoelectric colorimeter was used for reading the colour intensity developed by Vanadomolybdo phosphoric yellow colour method in nitric acid system.

3.6.2.3 Potassium content of plant parts

The potassium content of samples was determined with triple acid extract, reading in an EEL flame photometer (Jackson, 1958).

3.6.3 Nitrogen, phosphorus and potassium uptake

The nitrogen uptake by the individual plant samples in kg per hectare at three stages of growth (30th, 60th and 90th day) was obtained on the basis of the nitrogen content in the plant samples and the dry matter produced per hectare at the respective stages.

The nitrogen content was multiplied by the respective dry matter yield per hectare and the total uptake of nitrogen by the crop was determined.

The same procedure was adopted to work out the phosphorus and potassium uptake.

3.6.4 Statistical analysis

Data relating to each character was analysed by applying the analysis of variance technique and significance tested by 'F' test (Snedecor and Cochran, 1967). The yield data was correlated with biometric observations, yield components, dry matter production and uptake of major nutrients and the significance of the correlation coefficient was tested.

RESULTS

RESULTS

The results of the field experiment conducted to evaluate the response of cucumber to different water management practices and levels of nitrogen and potassium on growth, yield, water use and content and uptake of major nutrients are presented in the following pages after analysing the data statistically. The mean values are presented in Tables 3 to 13.

4.1. Growth characters

4.1.1 Length of vine (Table 3, Fig.4)

The data on mean length of vine recorded on the 30th, 60th and 90th day after sowing indicated that vine length was significantly influenced by levels of irrigation, nitrogen and potassium during all the three stages.

Among the levels of irrigation, the treatment i_2 (25 mm CPE) was significantly superior to the others, during all the three stages. The treatment i_1 (daily pot watering) was superior to i_3 and i_4 of which i_3(50 mm CPE) was superior to i_4(75 mm CPE).

The increase in vine length due to each increment in the level of nitrogen application was positive and significant upto n_2 (100 kg/ha), during all the three stages.

Table 3. Length of vine and Number of leaves per plant as affected by levels of irrigation, nitrogen and potassium.

Treatments	Length of vine(cm)			Number of leaves per plant		
	30th day	60th day	90th day	30th day	60th day	90th day
Irrigation levels.						
i_1	159.20	190.00	206.88	73.58	109.72	96.77
i_2	164.89	196.76	215.26	75.08	111.79	97.64
i_3	151.24	183.95	197.67	68.56	102.63	89.49
i_4	131.48	159.51	175.24	50.23	75.94	66.74
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	5.591	6.442	8.051	3.642	5.329	6.405
Nitrogen levels						
n_0	131.67	159.97	169.91	52.12	81.23	71.63
n_1	154.77	187.33	204.11	70.72	103.95	90.21
n_2	168.67	200.36	222.21	77.74	114.87	101.15
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	8.757	7.404	8.501	4.221	6.607	8.974
Potassium levels						
k_0	129.61	158.60	172.98	50.26	88.91	75.78
k_1	157.68	189.79	205.25	71.73	101.34	86.88
k_2	167.83	199.27	218.05	78.59	109.81	100.33
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	8.757	7.404	8.501	4.221	6.607	8.974
Main plot X sub plot interaction (NK X I)						
F test	NS	NS	NS	NS	NS	NS
SEm $\pm$	8.362	8.148	12.702	5.447	8.987	12.568

Successive increase in the level of potassium upto K_2 level (100 kg/ha) also significantly increased the vine length during the three stages of observation.

Interaction between the main plot and sub plot treatments failed to show any significant influence on vine length.

4.1.2 Number of leaves per plant: (Table3, Fig.4)

The data recorded on the 30th, 60th and 90th day after sowing showed that the number of leaves produced per plant was significantly influenced by the levels of irrigation, nitrogen and potassium at all the three stages.

Maximum number of leaves during all the stages was produced by i_2 which was on par with daily pot watering(i_1). However, both these levels were significantly superior to i_3 and i_4, while i_3 was in turn superior to i_4.

The successive increases in the level of nitrogen application showed significant increase in leaf number upto n_2 level at all the three stages.

The increase in leaf number due to potassium application at k_2 over k_1 and k_0 and that k_1 over k_o was significant during all the three stages.

Leaf number was not significantly influenced by the interaction between main plot and sub plot treatments.

4.1.3 Leaf Area Index: (Table 4(a), Fig.4)

Significant influence on leaf area index due to the levals of irrigation, nitrogen and potassium was observed from the data recorded on the 30th, 60th and 90th day.

Eventhough the irrigation treatment i_2 produced the highest LAI, it was on par with i_1 during all the stages, but tha increase in LAI by these two treatments over i_3 and i_4 and that of i_3 over i_4 was significant.

Successive increments in nitrogen application increased the LAI significantly upto n_2 level during all tha three stages.

The increase in LAI due to application of potaesium at k_2 level over k_1 and k_0 and that of k_1 over k_0 was significant during all tha stages.

No significant influence was noticed on LAI dua to the interaction between main plot and sub plot treatments.

Table 4(a). Leaf Area Index and Dry matter production as affected by levels of irrigation, nitrogen and potassium.

Treatment levels	Leaf Area Index			Dry matter production(kg/ha)		
	30th day	60th day	90th day	30th day	60th day	90th day
Irrigation						
i_1	0.55	1.28	0.97	400.10	1987.18	3311.97
i_2	0.56	1.30	0.99	406.66	2037.12	3395.19
i_3	0.48	1.16	0.91	363.91	1599.16	2665.26
i_4	0.41	1.03	0.80	307.05	1464.55	2440.90
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	0.051	0.098	0.059	29.943	161.151	265.252
Nitrogen						
n_0	0.35	1.07	0.80	303.54	1561.77	2602.95
n_1	0.55	1.20	0.92	381.01	1798.07	2996.77
n_2	0.60	1.30	1.03	416.74	1956.14	3260.58
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	0.042	0.085	0.048	27.158	145.567	242.262
Potassium						
k_0	0.42	1.09	0.72	316.80	1594.19	2656.98
k_1	0.51	1.19	0.99	357.83	1784.84	2974.98
k_2	0.57	1.29	1.05	407.67	1936.82	3228.03
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	0.042	0.085	0.048	27.158	145.567	242.262
Main plot x Sub plot interaction (NK x I)						
F test	NS	NS	NS	NS	Sig.	Sig.
SEm ±	0.067	0.118	0.081	34.771	-	-
CD(0.05)	-	-	-	-	267.754	446.256

4.1.4 Dry matter production: (Table 4(a) and 4(b), Fig.5)

The data recorded on the 30th, 60th and 90th day after sowing showed that total dry matter production was significantly influenced by the levels of irrigation, nitrogen and potassium during all the stages.

Among the irrigation levels, eventhough the treatment i_2 produced the highest dry matter, it was on par with daily pot watering (i_1) during all the three stages. However, the increase in dry matter production due to these two treatments, over the levels i_3 and i_4 (both of which were on par, except on the 30th day) was also significant.

Significant increase in dry matter production was observed during all the three stages by increasing the nitrogen application upto n_2 level.

Each successive increment in the level of potassium upto k_2 level also significantly increased the dry matter production at all the stages.

On the 60th and 90th day, the interaction between the NK combinations of the main plot and irrigation levels of the sub plot significantly influenced the dry matter production. During both the stages response in dry matter

Table 4(b). Dry matter production (kg/ha) as affected by interaction between main plot and sub plot treatments on the 60th and 90th day.

Main plot combinations	60th day					90th day				
	Sub plot treatments					Sub plot treatments				
	i_1	i_2	i_3	i_4	Mean	i_1	i_2	i_3	i_4	Mean
n_0k_0	1604.84	1434.49	1480.67	1405.48	1481.37	2674.74	2390.81	2367.79	2342.47	2468.95
n_0k_1	1598.69	1688.16	1539.71	1524.39	1587.74	2664.48	2813.60	2566.18	2540.65	2646.23
n_0k_2	1697.71	1730.60	1507.83	1546.71	1616.21	2799.51	2884.33	2513.05	2577.85	2693.68
n_1k_0	1622.97	1655.86	1589.75	1275.23	1535.95	2704.95	2759.77	2649.58	2125.39	2559.92
n_1k_1	2286.59	2221.37	1567.68	1304.88	1845.12	3810.93	3702.29	2612.80	2174.81	3075.20
n_1k_2	2221.10	2327.14	1918.01	1586.41	2013.17	3701.84	3878.56	3196.69	2644.02	3355.28
n_2k_0	2104.03	2159.40	1507.00	1290.55	1765.25	3506.72	3599.00	2511.67	2150.92	2942.08
n_2k_1	2233.67	2149.69	1662.79	1642.28	1922.11	3722.79	3582.81	2771.32	2737.14	3203.51
n_2k_2	2533.06	2967.32	1619.02	1604.93	2181.08	4221.77	4945.54	2698.36	2674.89	3635.14
Mean	1987.18	2037.12	1599.16	1464.54		3311.97	3395.19	2665.26	2440.90	

CD(0.05) NK x I = 267.754 CD(0.05) NK x I = 446.256

production at the highest level of nutrients was significantly higher at higher frequencies of irrigation (i_1 and i_2) when compared to drier regimes (i_3 and i_4). Thus the highest values were recorded by the combination of n_2k_2 in the main plot with i_2 and i_1 levels of irrigation in the sub plot.

4.2 Yield components and yield

4.2.1 Number of fruits per plot (Table 5, Fig.6)

Levels of irrigation, nitrogen and potassium exerted marked influence on the number of fruits per plot.

Among the water management practices, i_2 produced the highest number of fruits (65.92) and it was statistically on par with daily pot watering (63.43). But the increase in fruit number due to these two levels was significantly superior to i_3 and i_4, among which i_3 was superior to i_4.

Application of nitrogen at n_2 level (64.45) showed significant increase in the number of fruits over n_1(57.07) and no nitrogen (50.35) and, the increase by n_1 over n_0 was also significant.

Number of fruits produced by k_2(60.28) and k_1(58.90) were on par and significantly superior to k_0(52.70).

Table 5. Number of fruits per plot, mean length and girth of fruits as affected by levels of irrigation, nitrogen and potassium.

Treatments	Number of fruits per plot	Mean length of fruits (cm)	Mean girth of fruits (cm)
Irrigation levels			
i_1	63.43	34.59	3.38
i_2	65.92	35.18	3.36
i_3	52.77	32.17	3.31
i_4	47.03	31.26	3.17
F test	Sig.	Sig.	NS
SEm $\pm$	-	-	0.097
CD(0.05)	4.950	1.448	-
Nitrogen levels			
n_0	50.35	30.55	3.07
n_1	57.07	34.56	3.38
n_2	64.45	34.80	3.45
F test	Sig.	Sig.	Sig.
CD(0.05)	6.125	1.974	0.165
Potassium levels			
k_0	52.70	31.68	3.14
k_1	58.90	34.01	3.33
k_2	60.28	34.22	3.43
F test	Sig.	Sig.	Sig.
CD(0.05)	6.125	1.974	0.165
Main plot x sub plot interaction (NK x I)			
F test	NS	NS	NS
SEm $\pm$	7.399	2.165	0.261

Interaction between the main plot and sub plot treatments had no significant effect on fruit number.

4.2.2 Mean length of fruits (Table 5, Fig.6)

The data on the mean length of fruits showed significant influence due to irrigation, nitrogen and potassium.

The irrigation treatments i_2(35.18 cm) and i_1(34.59 cm) were statistically comparable and significantly superior to i_3 (32.17 cm) and i_4(31.26 cm) which were on par.

The highest fruit length was recorded by the n_2 level (34.80 cm) which was on par with n_1 (34.56 cm) and both were superior to no nitrogen (30.55 cm).

The fruit length due to k_2(34.22 cm) and k_1(34.01 cm) were on par and significantly superior to k_0(31.68 cm).

Fruit length was not significantly influenced by the interaction between main plot and sub plot treatments.

4.2.3 Mean girth of fruits (Tablo 5, Fig.6)

Data on girth of fruits showed significant influence by levels of nitrogen and potassium only.

Eventhough the irrigation levels had no significant effect on fruit girth, the values tended to be higher at higher irrigation frequencies (i_1 and i_2).

The fruit girth due to the levels n_2(3.45 cm) and n_1(3.38 cm) was on par and superior to the control(3.07cm).

The effect due to k_2(3.43 cm) and k_1(3.33 cm) on fruit girth did not vary significantly. However, these two levels were significantly superior to no potassium (3.14 cm).

Interaction between main plot and sub plot treatments failed to show any significant effect on this character.

4.2.4 Mean weight of fruits (Table 6, Fig.7)

Only the levels of nitrogen showed significant influence on mean weight of fruits.

Irrigation at higher frequencies (i_1 and i_2) produced heavier fruits eventhough its effect was not significant.

Fruit weight due to tho levels n_2(0.68 kg) and n_1 (0.67 kg) were comparable and significantly superior to no nitrogen (0.54 kg).

Eventhough potassium had no significant effect, the fruit weight tended to be higher at higher levels of application.

No significant influence was noticed on weight of fruits due to the interaction between main plot with sub plot treatments.

Table 6. Mean weight of fruits, Fruit setting percentage and sex ratio as affected by levels of irrigation, nitrogen and potassium.

Treatments	Mean weight of fruits (kg)	Fruit setting percentage	Sex ratio
Irrigation levels			
i_1	0.64	68.46	17.41
i_2	0.65	68.68	18.32
i_3	0.61	64.35	18.74
i_4	0.60	60.61	18.84
F test	NS	Sig.	Sig.
SEm ±	0.063	-	-
CD(0.05)	-	1.743	0.064
Nitrogen levels			
n_0	0.54	63.11	18.54
n_1	0.67	65.84	18.38
n_2	0.68	67.62	18.12
F test	Sig.	Sig.	Sig.
CD(0.05)	0.116	1.229	0.060
Potassium levels			
k_0	0.60	64.04	18.91
k_1	0.64	65.63	18.28
k_2	0.65	66.90	17.79
F test	NS	Sig.	Sig.
SEm ±	0.058	-	-
CD(0.05)	-	1.229	0.060
Main plot X sub plot interaction (NK x I)			
F test	NS	NS	NS
SEm ±	0.139	2.066	0.089

4.2.5 Fruit setting percentage :(Table 6, Fig.7)

The data on fruit setting percentage showed significant influence of irrigation, nitrogen and potassium.

Fruit setting percentage due to the levels i_2(68.68) and i_1(68.46) were on par and significantly superior to i_3 and i_4. The increase due to i_3 over i_4 was significant.

The treatment n_2(67.62) produced significantly higher setting percentage compared to the two lower levels of which n_1(65.84) was superior to n_0 (63.11).

Setting percentage increased significantly with successive increase in the application of potassium upto the k_2 level (66.90).

Interaction between the main plot and sub plot treatments had no significant effect on this yield attribute.

4.2.6 Sex ratio (Table 6, Fig.7)

The sex ratio, expressed as the number of female flowers per hundred male flowers was significantly influenced by irrigation, nitrogen and potassium.

Among the irrigation levels, i_4(18.84) was significantly superior to the other three levels. The effect due to i_3(18.74) over i_2 and i_1 and that due to i_2(18.32) ovor i_1(17.41) was also significant.

Increase in sex ratio due to no nitrogen (18.54) over n_1 and n_2 and that of n_1(18.38) over n_2(18.12) was also significant.

In the case of potassium, sex ratio due to control (18.91) was significantly superior to the two higher levels of which k_1(18.28) was superior to k_2(17.79).

No marked influence was shown on sex ratio by the interaction between main plot and sub plot treatments.

4.2.7 Fruit yield per hectare (Table 7(a) and 7(b), Fig.8)

The fruit yield was markedly influenced by levels of irrigation, nitrogen and potassium.

Among the water management practices, the daily pot watering (i_1) and 25 mm CPE(i_2) treatments were on par and recorded the fruit yields of 26230.80 kg and 26880.90 kg per hectare respectively. These two treatments were significantly superior to i_3(21108.85 kg) and i_4(19331.97 kg) which were on par.

The increase in fruit yield with each successive increase in the level of nitrogen was positive and significant upto the n_2 level. The yields obtained with n_2, n_1 and n_0 levels were 25821.10 kg, 23734.02 kg and 20615.36 kg respectively. The rate of increase in fruit yield at n_2

Table 7(a). Fruit yield and Field water use efficiency as affected by levels of irrigation, nitrogen and potassium.

Treatments	Fruit yield kg per hectare	Field water use efficiency kg per ha-mm
Irrigation levels		
i_1 (1703 mm)	26230.80	15.40
i_2 (536 mm)	26889.90	50.17
i_3 (286 mm)	21108.85	73.81
i_4 (236 mm)	19331.97	81.92
F test	Sig.	Sig.
CD(0.05)	2259.196	8.365
Nitrogen levels		
n_0 (control)	20615.36	63.76
n_1 (50kg/ha)	23734.62	75.04
n_2 (100 kg/ha)	25821.10	82.50
F test	Sig.	Sig.
CD(0.05)	1921.483	6.113
Potassium levels		
k_0 (control)	21534.28	66.10
k_1 (50 kg/ha)	24061.82	76.41
k_2 (100 kg/ha)	24565.99	79.24
F test	Sig.	Sig.
CD(0.05)	1921.483	6.113
Main plot X sub plot interaction (NK x I)		
F test	Sig.	NS
SEm ±	-	10.404
CD(0.05)	3977.591	-

Table 7(b) Fruit yield (kg/ha) as affected by interaction between main plot and sub plot treatments

Main plot combinations	Sub plot treatments				
	i_1	i_2	i_3	i_4	Mean
n_ok_o	21683.94	19435.21	20044.85	19052.36	20054.08
n_ok_1	21602.62	22783.67	20824.16	20621.91	21458.08
n_0k_2	21172.06	21843.85	18903.34	19416.53	20333.94
n_1k_0	21923.20	22357.39	21484.63	17333.07	20774.58
n_1k_1	30682.49	29822.10	21193.34	17724.45	24855.58
n_1k_2	28318.50	29718.18	24317.75	19940.58	25573.76
n_2k_0	28273.17	28904.05	20392.37	17535.25	23801.22
n_2k_1	29984.44	28875.80	22448.80	22178.13	25871.78
n_2k_2	32436.37	38168.65	20371.00	20185.11	27790.28
Mean	26230.80	26889.90	21108.85	19331.97	

CD(0.05) NK x I = 3977.591

and n_1 levels were 25 and 15 per cent respectively over no nitrogen application.

Among the potassium levels, fruit yield due to k_2(24565.99 kg) and k_1(24061.82 kg) were on par and significantly superior to k_0(21534.28 kg). It was seen that tne increase in yield at k_2 and k_1 levels were 14 and 12 per cent respectively over no potassium.

Effect of the interaction between the fertilizer combinations of the main plot with irrigation treatments of the sub plot was significant on fruit yield. Increase in fruit yield at the highest level of nutrients (n_2k_2) was significant at higher frequencies of irrigation (i_1 and i_2) as compared to lesser frequencies (i_3 and i_4). The maximum fruit yields were recorded by the combination n_2k_2 of the main plot with i_2 and i_1 levels of irrigation in the sub plot.

4.3 Moisture studies

4.3.1 Field water use efficiency: (Table 7(a), Fig.8)

The data of field water use efficiency, calculated as kilogram fruits per hectare millimeter of water used, showed that levels of irrigation, nitrogen and potassium had positive and significant influence.

Among the water management practices, the treatments which received irrigation at longer intervals viz. i_4 (81.92 kg) and i_3(73.81 kg) were on par and significantly superior to the more frequently irrigated treatments i_2 and i_1. The effect due to i_2(50.17 kg) as compared with daily irrigation (15.40 kg) was also significant.

Progressive increments in the level of applied nitrogen showed significant increase upto n_2 level. The water use efficiency at n_0, n_1 and n_2 levels were 63.76, 75.04 and 82.05 kg/ ha-mm respectively.

Among the levels of potassium, water use efficiency due to k_2 (79.24 kg) and k_1(76.41 kg) were on par and significantly superior to k_0(66.10 kg).

No significant influence was observed due to the interaction between main plot and sub plot treatments.

4.3.2 Consumptive use (Fig.9(a))

Differential irrigation treatments were started in early February (16th day after sowing). Average daily consumptive use and total consumptive use during the crop period along with Et/Eo values and evaportion data are presented in Table 8.

Total consumptive use and Et/Eo values were maximum in i_2 (454 mm and 1.46) followed by i_3(327 mm and 1.05)

Table 8. Consumptive use, pan evaporation and soil moisture depletion pattern during the growth period of cucumber

Irrigation treatment	Total quantity of water applied (mm)	Total consumptive use (mm)	Average consumptive use (mm/day)	Total CPE during crop period (90 days) (mm)	Average pan evaporation (mm/day)	$\frac{E_t}{E_o}$	Soil moisture depletion pattern: Depth (cm)	Soil moisture depletion pattern: Depletion (%)
25 mm CPE (i_2)	536	434	5.04	310.86	3.42	1.46	0-15	32.6
							15-30	27.5
							30-60	26.0
							60-90	13.9
50 mm CPE (i_3)	286	327	3.63	310.86	3.42	1.05	0-15	32.7
							15-30	28.4
							30-60	24.2
							60-90	14.7
75 mm CPE (i_4)	236	287	3.19	310.86	3.42	0.92	0-15	33.1
							15-30	27.9
							30-60	24.0
							60-90	15.0

and i_4(287 mm and 0.92) respectively. In the cultivator's practice of daily pot watering (i_1) consumptive use determination from soil moisture data was not feasible and hence not calculated.

4.3.3 Soil moisture depletion pattern (Table 8)

The average relative soil moisture depletion from four different soil layers in the root zone (upto 90 cm depth) was worked out for each drying cycle following irrigation and the relevant data are diagramatically present in Fig. 9(b). The figures show that the top 15 cm soil layer accounted for 32 to 33 per cent of the total moisture depleted. The total moisture depletion from the top 30 cm layer accounted for as much as 60 per cent of the total water use, while the next 30 cm accounted for only 24 to 26 per cent. Depletion was as low as 13 to 15 per cent in the last 30 cm layer. Thus, moisture depletion decreased rapidly with depth. In comparison with wet regimes, dry regimes extracted slightly more soil moisture from the lowest soil layer.

4.4. Content of major nutrients in plants

4.4.1 Nitrogen (Table 9(a)).

The data of the percentage of nitrogen in plants recorded on the 30th, 60th and 90th day after sowing showed that nitrogen levels had significant influence while potassium and irrigation levels had no influence.

Among tha nitrogen levels, n_2 and n_1 were on par and significantly superior to no nitrogen at all the stages.

Interaction between the main plot and sub plot treatments also had no influence at any of the three stages.

4.4.2 Phosphorus (Table 10)

Phosphorus content of plants was not significantly influenced by water management practices, nitrogen and potassium as well as the interaction between main plot and sub plot treatments. However, a trend of increasing phosphorus content was noted at zero levels of nitrogen and potassium as well as drier moisture regimes.

4.4.3 Potassium (Table 11(a))

The data on potassium content showed that neither nitrogen nor the water management practices had any significant effect during any of the growth stages. However, the different levels of potassium exerted marked influence during all the three stages.

Among potassium levels, the treatments k_2 and k_1 were on par and significantly superior to k_0.

No significant influence was observed at any of tha stagee due to the interaction between main plot and sub plot treatments.

4.5 Uptake of major nutrients by plants

4.5.1 Nitrogen (Table 9(a) and 9(b), Fig.10)

The data on nitrogen uptake by plants recorded on the 30th, 60th and 90th day after sowing showed significant influence by water management practices, nitrogen and potassium during all the three stages.

The nitrogen uptake due to the irrigation levels i_1 and i_2 were on par and significantly superior to the other two levels, of which i_3 was superior to i_4, during all the three stages.

Each successive addition of nitrogen significantly increased the nitrogen uptake upto the n_2 level during all the stages.

Among the various potassium levels, the increase in nitrogen uptake by k_2 over the two lower levels and that of k_1 and k_0 were significant.

Table 9(a) Content and uptake of nitrogen as affected by levels of irrigation, nitrogen and potassium.

Treatments	Content (%)			Uptake (kg/ha)		
	30th day	60th day	90th day	30th day	60th day	90th day
Irrigation levels						
i_1	2.49	1.94	1.98	9.98	38.65	65.51
i_2	2.57	1.95	1.98	10.47	39.75	67.37
i_3	2.33	1.91	1.95	8.47	30.63	51.91
i_4	2.16	1.90	1.94	6.64	27.89	47.27
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm±	0.164	0.172	0.169	-	-	-
CD(0.05)	-	-	-	0.551	2.737	4.639
Nitrogen levels						
n_0	2.20	1.51	1.54	6.69	23.61	40.01
n_1	2.50	2.02	2.05	9.54	36.33	61.58
n_2	2.51	2.19	2.22	10.44	42.76	72.48
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD (0.05)	0.253	0.239	0.244	0.693	3.483	5.904
Potassium levels						
k_0	2.44	1.91	1.95	7.75	30.54	51.77
k_1	2.49	1.92	1.95	8.94	34.26	58.07
k_2	2.45	1.96	1.99	9.98	37.89	64.22
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm ±	0.136	0.119	0.121	-	-	-
CD(0.05)	-	-	-	0.693	3.483	5.904
Main plot x sub plot interaction (NK x I)						
F test	NS	NS	NS	NS	Sig.	Sig.
SEm ±	0.198	0.187	0.191	0.734	-	-
CD(0.05)	-	-	-	-	5.998	8.946

Table 9(b). Uptake of nitrogen (kg/ha) as affected by interaction between main plot and sub plot treatments on the 60th and 90th day.

Main plot combinations	60th day					90th day				
	Sub plot treatments					Sub plot treatments				
	i_1	i_2	i_3	i_4	Mean	i_1	i_2	i_3	i_4	Mean
n_ok_o	24.25	21.68	22.37	21.24	22.39	41.10	36.74	37.92	36.00	37.95
n_ok_1	24.15	25.51	23.26	23.03	23.99	40.94	43.23	39.43	39.04	40.66
n_ok_2	25.38	26.15	22.79	23.37	24.42	43.02	44.32	38.62	39.61	41.39
n_1k_o	32.80	33.47	32.13	25.77	31.04	55.59	56.72	54.45	43.68	52.61
n_1k_1	46.21	44.89	31.68	26.37	37.26	78.32	76.08	53.69	44.69	63.19
n_1k_2	44.89	47.03	38.76	32.06	40.68	76.08	79.71	65.70	54.34	68.95
n_2k_o	46.00	47.21	32.95	28.21	38.59	77.96	80.01	55.84	47.82	65.41
n_2k_1	48.83	46.99	36.35	35.90	42.02	82.76	79.65	61.61	60.85	71.22
n_2k_2	55.38	64.87	35.39	35.09	47.68	93.86	109.95	59.99	59.47	80.81
Mean	38.65	39.75	30.63	27.89		65.51	67.37	51.91	47.27	

CD(0.05) NK x I = 5.998 CD(0.05) NK x I = 8.946

Except on the 30th day, the interaction between the NK combinations of the main plot and irrigation levels of the sub plot significantly influenced nitrogen uptake. The uptake of nitrogen at the highest level of nutrients showed significant increase at higher frequencies of irrigation (i_1 and i_2) compared to dry regimes. Thus the highest uptake was recorded by the combination of n_2k_2 of the main plot with i_2 and i_1 levels of irrigation in the sub plot.

4.5.2 Phosphorus (Table 10, Fig.10)

The phosphorus uptake by plants recorded on the 30th, 60th and 90th day after sowing showed that irrigation, nitrogen and potassium levels exerted significant influences during all the three stages.

Among the irrigation levels, the treatment i_2 was superior to the other three levels on the 30th day, but was on par with i_1 on the 60th and 90th day. During all the three stages i_1 was superior to i_3 and i_4. However, i_3 was superior to i_4 only on the 30th day and they were on par during the 60th and 90th day.

The increase in phosphorus uptake due to progressive increase in the levels of nitrogen was significant upto n_2 level during all the three stages.

Table 10. Content and uptake of phosphorus as affected by levels of irrigation, Nitrogen and potassium.

Treatment levels	Content (%)			Uptake (kg/ha)		
	30th day	60th day	90th day	30th day	60th day	90th day
Irrigation						
i_1	0.71	0.31	0.35	2.86	6.12	11.63
i_2	0.75	0.31	0.35	3.04	6.30	11.97
i_3	0.68	0.32	0.38	2.48	5.32	10.11
i_4	0.66	0.35	0.40	2.04	5.29	10.05
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm $\pm$	0.855	0.061	0.069	-	-	-
CD(0.05)	-	-	-	0.152	0.516	0.989
Nitrogen						
n_0	0.69	0.33	0.38	2.12	5.21	9.90
n_1	0.70	0.32	0.37	2.66	5.73	10.89
n_2	0.73	0.32	0.37	3.04	6.33	12.03
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm $\pm$	0.063	0.055	0.052	-	-	-
CD(0.05)	-	-	-	0.137	0.438	0.868
Potassium						
k_0	0.75	0.32	0.37	2.40	5.19	9.86
k_1	0.73	0.33	0.36	2.61	5.86	11.01
k_2	0.69	0.33	0.36	2.81	6.32	12.13
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm $\pm$	0.063	0.055	0.052	-	-	-
CD(0.05)	-	-	-	0.137	0.438	0.868
Main plot x Sub plot interaction (NK x I)						
F test	NS	NS	NS	NS	NS	NS
SEm $\pm$	0.113	0.107	0.109	0.193	0.674	1.285

Phosphorus uptake increased significantly due to the increase in level of applied potassium also upto k_2 level during all the stages.

Interaction between main plot and sub plot treatments had no influence on phosphorus uptake.

4.5.3 Potassium (Table 11(a) and 11(b), Fig.10)

Significant influence on potassium uptake was shown by levels of irrigation, nitrogen and potassium during all the three growth stages.

Among the water management practices, the treatments i_2 and i_1, were on par and significantly superior to i_3 and i_4. However, i_3 was superior to i_4 only on the 30th day.

Successive increments in the level of nitrogen application significantly increased the potassium uptake upto n_2 level during all the three stages.

The increase in potassium uptake by increasing the levels of applied potassium was positive and significant upto k_2 level at all stages.

Effect of interaction between the main plot and sub plot treatments was significant only on the 60th and 90th day. Response to the highest levels of nutrients was more pronounced and significant at wetter regimes (i_1 and i_2) as compared with drier regimes (i_3 and i_4). The highest uptake

Table 11(a). Content and uptake of potassium as affected by levels of irrigation, Nitrogen and potassium.

Treatment levels	Content (%)			Uptake (kg/ha)		
	30th day	60th day	90th day	30th day	60th day	90th day
Irrigation						
i_1	2.14	2.45	2.33	8.56	48.61	77.16
i_2	2.25	2.46	2.35	9.16	50.17	79.63
i_3	2.09	2.43	2.31	7.60	38.86	61.68
i_4	2.01	2.42	2.31	6.18	35.63	56.55
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm ±	0.193	0.204	0.196	-	-	-
CD(0.05)	-	-	-	0.817	4.679	7.428
Nitrogen						
n_0	2.25	2.43	2.31	6.86	37.97	60.27
n_1	2.09	2.42	2.31	7.95	43.62	69.24
n_2	2.12	2.47	2.35	8.81	48.26	76.76
F test	NS	NS	NS	Sig.	Sig.	Sig.
SEm ±	0.149	0.153	0.142	-	-	-
CD(0.05)	-	-	-	0.786	4.186	6.645
Potassium						
k_0	1.81	2.03	1.94	5.73	32.43	51.47
k_1	2.34	2.55	2.43	8.38	45.47	72.17
k_2	2.35	2.68	2.56	9.52	52.06	82.63
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CD(0.05)	0.278	0.289	0.282	0.786	4.186	6.645
Main plot x Sub plot interaction (NK x I)						
F test	NS	NS	NS	NS	Sig.	Sig.
SEm ±	0.299	0.318	0.306	0.884	-	-
CD(0.05)	-	-	-	-	6.192	10.765

Table 11(b) Uptake of potassium (kg/ha) as affected by interaction between main plot and sub plot treatments on the 60th and 90th day.

Main plot combinations	60th day					90th day				
	Sub plot treatments					Sub plot treatments				
	i_1	i_2	i_3	i_4	Mean	i_1	i_2	i_3	i_4	Mean
n_ok_o	32.63	29.18	30.11	28.59	30.13	51.80	46.32	47.80	45.38	47.83
n_ok_1	40.72	42.99	39.21	38.82	40.43	64.64	68.25	62.25	61.63	64.19
n_ok_2	45.14	46.51	40.52	41.56	43.43	71.66	73.83	64.32	65.98	68.95
n_1k_o	32.99	33.67	32.32	25.92	31.24	52.38	53.45	51.31	41.16	49.58
n_1k_1	58.24	56.58	39.93	33.23	47.00	92.45	89.81	63.38	52.75	74.60
n_1k_2	59.69	62.53	51.54	42.63	54.10	94.75	99.27	81.82	67.68	85.88
n_2k_o	42.77	43.90	30.64	26.24	35.89	67.91	69.70	48.64	41.66	56.98
n_2k_1	56.89	54.75	42.35	41.83	48.95	90.31	86.92	67.23	66.40	77.71
n_2k_2	68.07	79.74	43.51	43.13	58.61	108.06	126.58	69.07	68.47	93.04
Mean	48.61	50.17	38.86	35.63		77.16	79.63	61.68	56.55	

CD(0.05) NK x I = 6.192

CD(0.05) NK x I = 10.765

was observed by the combination of n_2k_2 of the main plot with i_2 and i_1 levels of irrigation in the sub plot.

4.6 Soil fertility status:

4.6.1 Available nitrogen content (Table 12)

Available nitrogen content of the soil was markedly influenced by nitrogen application alone. The nitrogen levels n_2 and n_1 were on par and significantly superior to no nitrogen application.

Eventhough water management practices had failed to show significant influence on available nitrogen content, it tended to be higher in drier regimes.

Interaction between main plot and sub plot treatments had no appreciable effect on this soil character.

4.6.2 Available phosphorus content (Table 12)

Available phosphorus content did not vary significantly due to the levels of irrigation, nitrogen and potassium as well as interaction between main plot and sub plot treatments.

4.6.3 Available potassium content (Table 12)

Only the levels of applied potassium showed significant influence on available potassium content of the soil. The levels k_2 and k_1 were on par and significantly superior to no potassium application.

Table 12. Available status of major nutrients in the soil as affected by levels irrigation, nitrogen and potassium.

Treatments	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Irrigation levels			
i_1	83.05	12.88	71.54
i_2	83.62	12.29	71.74
i_3	84.41	12.06	72.98
i_4	84.62	11.97	73.06
F test	NS	NS	NS
SEm $\pm$	2.018	0.598	2.152
Nitrogen levels			
n_0	77.27	12.22	71.83
n_1	85.63	12.30	72.33
n_2	89.00	12.38	72.80
F test	Sig.	NS	NS
SEm $\pm$	-	0.423	2.068
CD(0.05)	3.962	-	-
Potassium levels			
k_0	83.51	12.27	68.48
k_1	84.09	12.29	74.02
k_2	84.40	12.34	74.46
F test	NS	NS	Sig.
SEm $\pm$	1.996	0.423	-
CD(0.05)	-	-	4.082
Main plot x Sub plot interaction (NK x I)			
F test	NS	NS	NS
SEm $\pm$	4.005	0.721	5.164

An increasing trend of soil potassium content in drier regimes was noticed eventhough it had not reached the level of significance.

This character also was not influenced by the interaction between main plot and sub plot treatments.

4.7 Correlation studies:

The data on fruit yield was tested for correlation with growth characters, yield components and uptake of major nutrients and the correlation coefficients are presented in Table 13.

Yield had positive correlation with growth characters such as length of vine, number of leaves, Leaf Area Index and dry mattar production on the 90th day.

Yield components such as averags length, girth and weight of fruit, number of fruits and fruit setting percentage had positive correlation with yield. However, sex ratio, expressed as number of female flowers per hundred male flowers, showed a negative correlation with yield.

Positive correlation with yield was also shown by total plant uptake of nitrogen, phosphorus and potassium recorded on the 90th day.

Table 13. Correlation Studies

Character correlated with yield	Correlation coefficient
A. Growth characters	
1. Length of vine	+ 0.68*
2. Number of leaves	+ 0.73*
3. Leaf Area Index	+ 0.71*
4. Dry matter production (90th day)	+ 0.82*
B. Yield components	
1. Average length of fruits	+ 0.75*
2. Average girth of fruits	+ 0.61*
3. Average weight of fruits	+ 0.27*
4. Number of fruits harvested	+ 0.70*
5. Fruit setting percentage	+ 0.51*
6. Sex ratio	- 0.67*
C. Uptake of major nutrients	
1. Nitrogen - 90th day	+ 0.72*
2. Phosphorus- 90th day	+ 0.33*
3. Potassium - 90th day	+ 0.69*

* Significant at 5 per cent level

DISCUSSION

DISCUSSION

The results of an experiment carried out in a loamy sand soil of the Agronomic Research Station, Chalakkudy to study the influence of different water management practices and levels of nitrogen and potassium on cucumber raised in summer rice fallows, presented in the preceeding chapter, are discussed below.

5.1 Growth parameters:

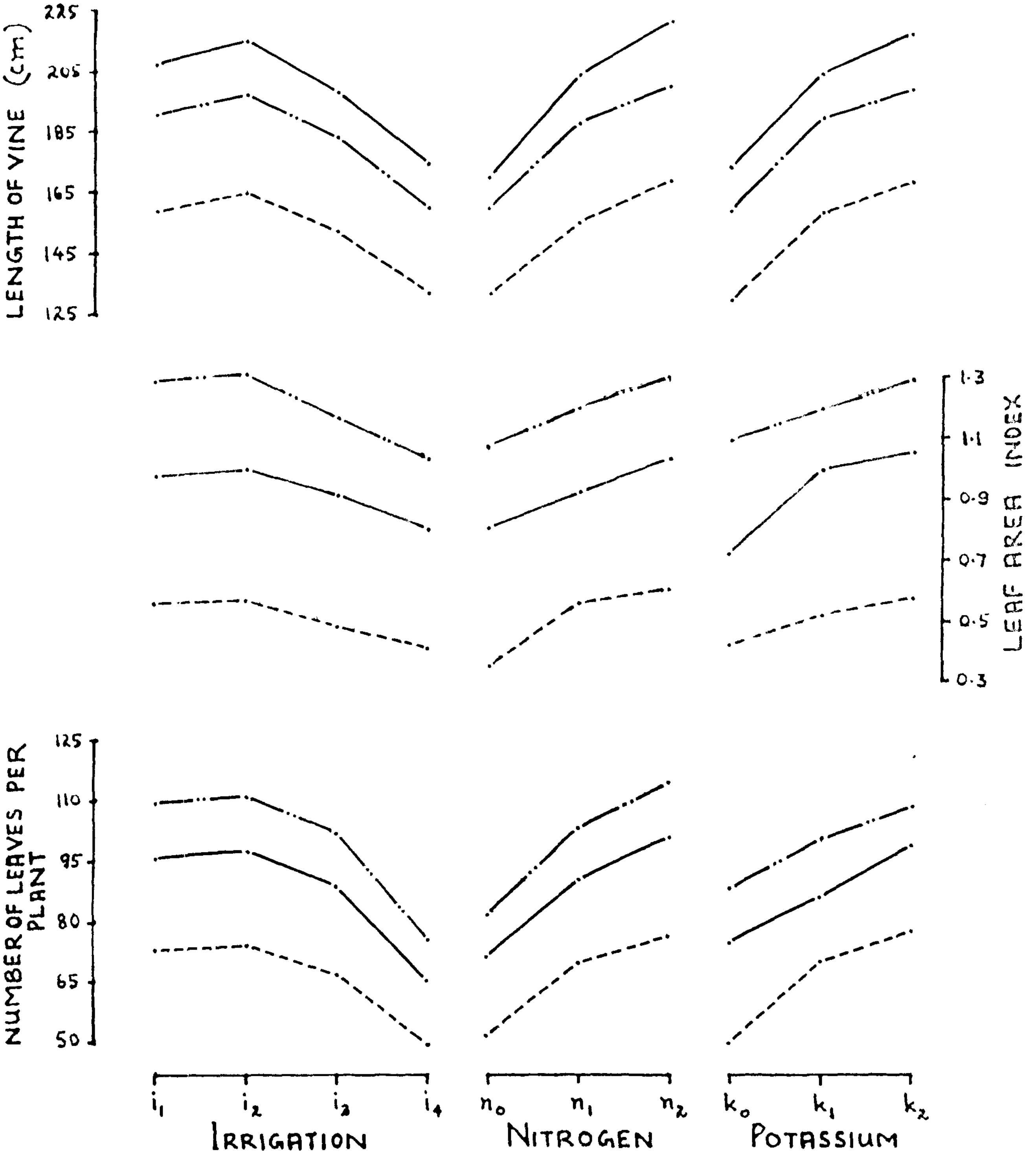
The growth parameters viz., length of vine, number of leaves, Leaf Area Index and dry matter production were recorded on the 30th, 60th and 90th day after sowing. The analysis of the data showed significant influence of water management treatments and fertility levels on all the growth parameters mentioned above at all the three stages of observation (Tables 3, 4(a), 4(b)).

Growth, the irreversible gain in dry matter, is the sum total of the vital metabolic process of cell division and cell enlargement. Water deficit and water stress adversely affect both these processes, of which cell enlargement is more affected (Begg and Turner, 1976; Cocueci *et al*. 1976). In general, growth is suspended during moisture stress and resumed upon its elimination (Arnon, 1975). The poor growth recorded by plants under stress would be attributed to the effect of water stress on the above mentioned two vital processes of growth. The favourable influence of higher levels of irrigation noticed within a period of 15 days after the application of the differential treatments could thus be explained as the stimulation of metabolic activities due to higher moisture availability. Similar results were reported by Flocker *et al* (1965), Cummins and Kretchman (1974), Escobar and Gausman (1974), Mathew (1981), Ortega and Kretchman (1982) and Thomas (1984) in various crops.

The results showed that among the water management treatments, the higher levels of irrigation viz., irrigation at 25 mm CPE and daily pot watering, had significantly increased the length of vines, number of leaves, leaf area index and dry matter accumulation. Cucurbits require considerable amount of moisture when making their most vigorous growth and upto the timethe fruits are mature (Whitaker and Davis, 1962). In general, irrigation at 25 mm CPE showed a trend of increasing growth than daily pot watering. The slightly reduced growth observed in the daily irrigated treatments could be attributed to the possible increase in leaching loss of nutrients beyond the rootzone leading to a reduction in the uptake of nutrients as noticed in the present study (Tables 9,10,11). Similar results

FIG. 4. NUMBER OF LEAVES, LENGTH OF VINE AND LEAF AREA INDEX AS AFFECTED BY LEVELS OF IRRIGATION, NITROGEN AND POTASSIUM.

NUMBER OF LEAVES	------ 30 DAS	—··— 60 DAS	—— 90 DAS
LENGTH OF VINES	------ 30 DAS	—··— 60 DAS	—— 90 DAS
LEAF AREA INDEX	------ 30 DAS	—··— 60 DAS	—— 90 DAS

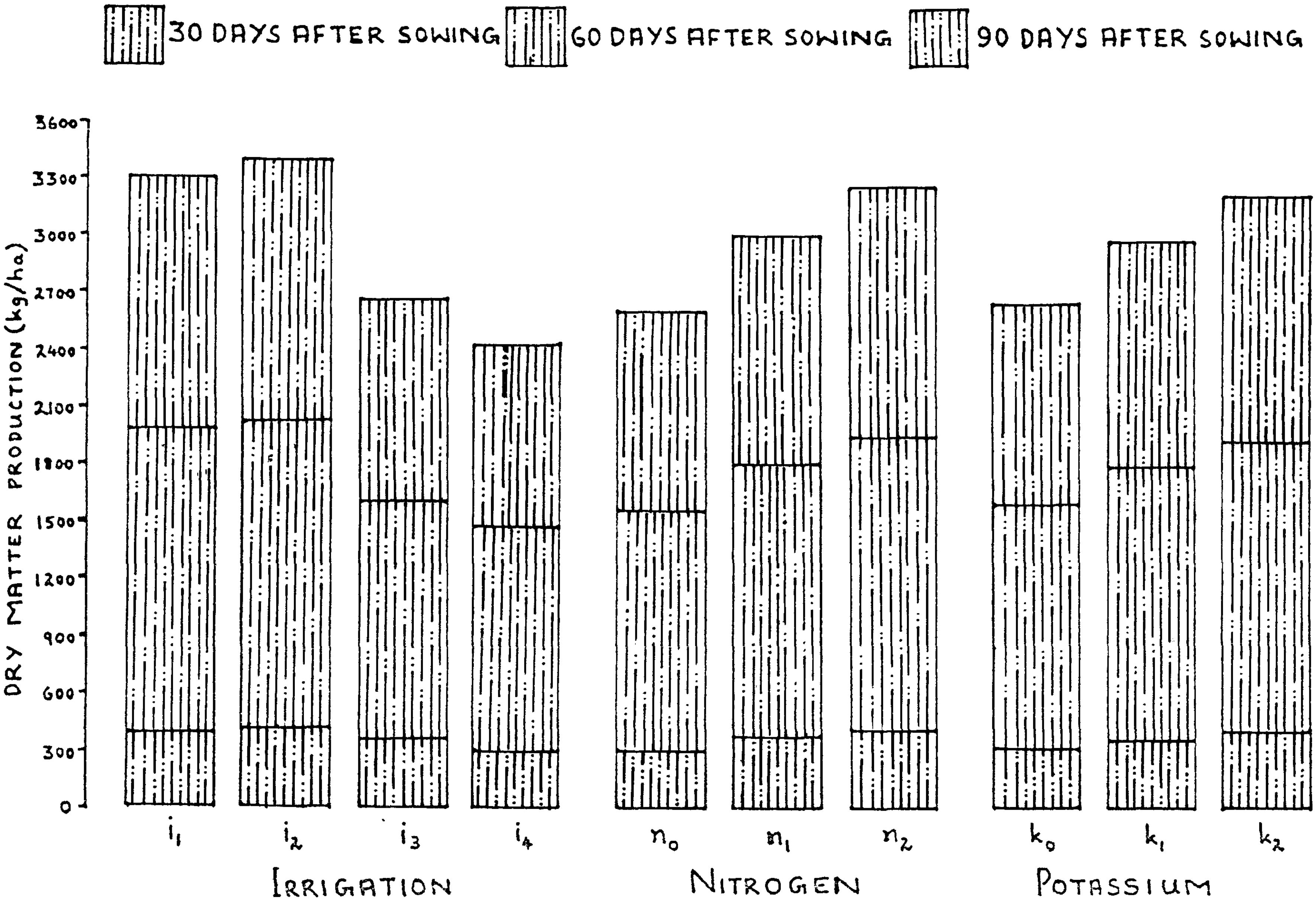


were earlier reported by Tomitaka (1974) and Does et al (1977). Further, plant growth and root development in field grown cucumber has been reported to be better following weekly flood irrigation than pot watering by Mac Gillivray (1951).

The treatments to which 5 cm water was applied only when the CPE values reached 50 mm (i_3) and 75 mm (i_4) might have resulted in stress conditions. The effect of the stress might have reflected on all the growth parameters. The lower LAI could be attributed to the fewer number of leaves and lesser leaf area. The process of leaf production and expansion are largely dependant on moisture regimes and nutrient supply (Arnon, 1975). A steep decline in LAI was reported by several workers in crops when the leaf water potential was decreased to a few bars. A reduction in leaf area due to moisture stress was reported by Cummins and Kretchman (1974), Escobar and Gausman (1974) and Ortega and Kretchman (1982) in cucumber while in related crops similar results were reported by Arnon (1975), Begg and Turner (1976) and Thomas (1984).

As evident from Table 4(a) and Fig.5 the dry matter production at all the three stages increased with increase in soil wetness. The amount of dry matter production depends

Fig. 5. Dry matter production as affected by levels of irrigation, nitrogen and potassium.



upon the effectiveness of photosynthesis of the crop and further more on plants whose vital activities are functioning effectively (Arnon, 1975). The leaves of a plant are the main organs of photosynthesis and LAI is the best measure of the capacity of a crop for producing dry matter. Hence, the dry matter production which is dependant on the growth parameters like vine length, leaf number and LAI, showed significant increase in wetter regimes. Lower photosynthetic efficiency, which was evident from low LAI in less frequently irrigated plots, might be a major reason for the poor growth and low dry matter production in those treatments. Similar results were earlier reported by Cummins and Kretchman (1974), Ortega and Kretchman (1982) and Thomas (1984) in cucurbits.

Increasing doses of nitrogen and potassium had resulted in significant increase in the number of leaves, length of vines, LAI and dry matter production. The soil of the experimental site could be rated as poor in available nitrogen and potassium and medium in available phosphorus. Significant response to the applied nutrients could be attributed to the low fertility status of the soil. Similar responses were previously reported by Miller (1958), Ermorkhin and Naumenko (1975) and Tserling <u>et al</u> (1979) in cucumber.

The role of nitrogen is important as an essential constituent of chlorophyll, which has got a direct bearing on the rate of photosynthesis, and as a constituent of protein for the promotion of the growth of meristematic tissues (Tisdale and Nelson, 1975). Higher dose of nitrogen increased its availability to the crop which might have resulted in increased vine length, leaf number and leaf area for higher dry matter production. Similar results have been observed by Mc Collum and Miller (1971), Pettiet (1971) in cucumber, Wilcox (1973) in muskmelon, El-Aidy and Moustafa (1978) in cucumber, Oguremi (1978) in water melon, Randawa (1981) in muskmelon, Rajendran (1981) in pumpkin and Thomas (1984) in bittergourd.

Increasing levels of potassium also significantly increased the growth parameters even from the early stages. The role of potassium as an essential element for promotion of growth of meristematic tissues has been well established (Tisdale and Nelson, 1975). Absence or decreased level of potassium resulted in markedly poor growth right from the seedling stage. This can be attributed to reduced CO_2 fixation by the leaf-like photosynthetic cotyledons of the cucumber seedlings which in turn will result in a lower level of export of photosynthatee from the cotyledons to other parts. Adverse effects of potassium deficiency and the necessity for adequate external supply of the nutrient were reported in cucumber by Mc Collum and Miller (1971), Fenny et al (1976), El-Aidy and Moustafa (1978) and Sugimaya and Iwata (1979), in musk melon by Randawa (1981) and in bittergourd by Thomas (1984).

Interaction between nutrients (N and K) with irrigation on dry matter production showed that the response to higher levels of nutrients was more pronounced and significant with frequent irrigation schedules (i_1 and i_2). The results corroborate with the findings of Borna (1976), Hartmann and Waldhor (1978), Mathew (1981) and Thomas (1984) in different crops.

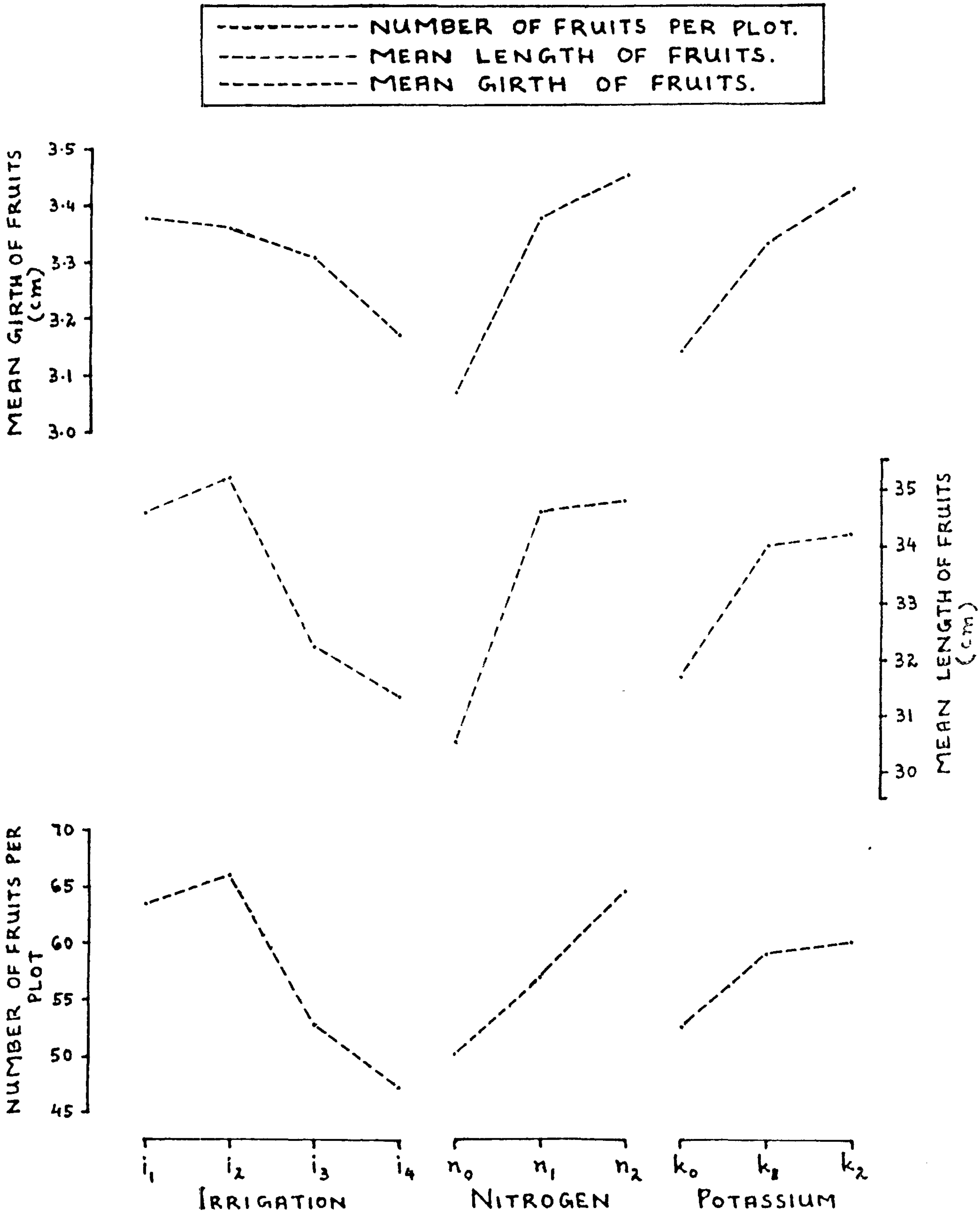
5.2 Yield components

Irrigation treatments significantly influenced the characters contributing to fruit yield namely number of fruits, mean length of fruit, fruit setting percentage and sex ratio (Tables 5 and 6).

Irrigation at 25 mm CPE (i_2) and daily pot watering(i_1) significantly increased the number of fruits per plot, mean length of fruit and fruit setting percentage.

Favourable influence of optimum moisture on yield attributes have been reported by Flocker et al (1965), Molnar (1965), Jassal et al. (1970) and Neil and Zunino (1972)

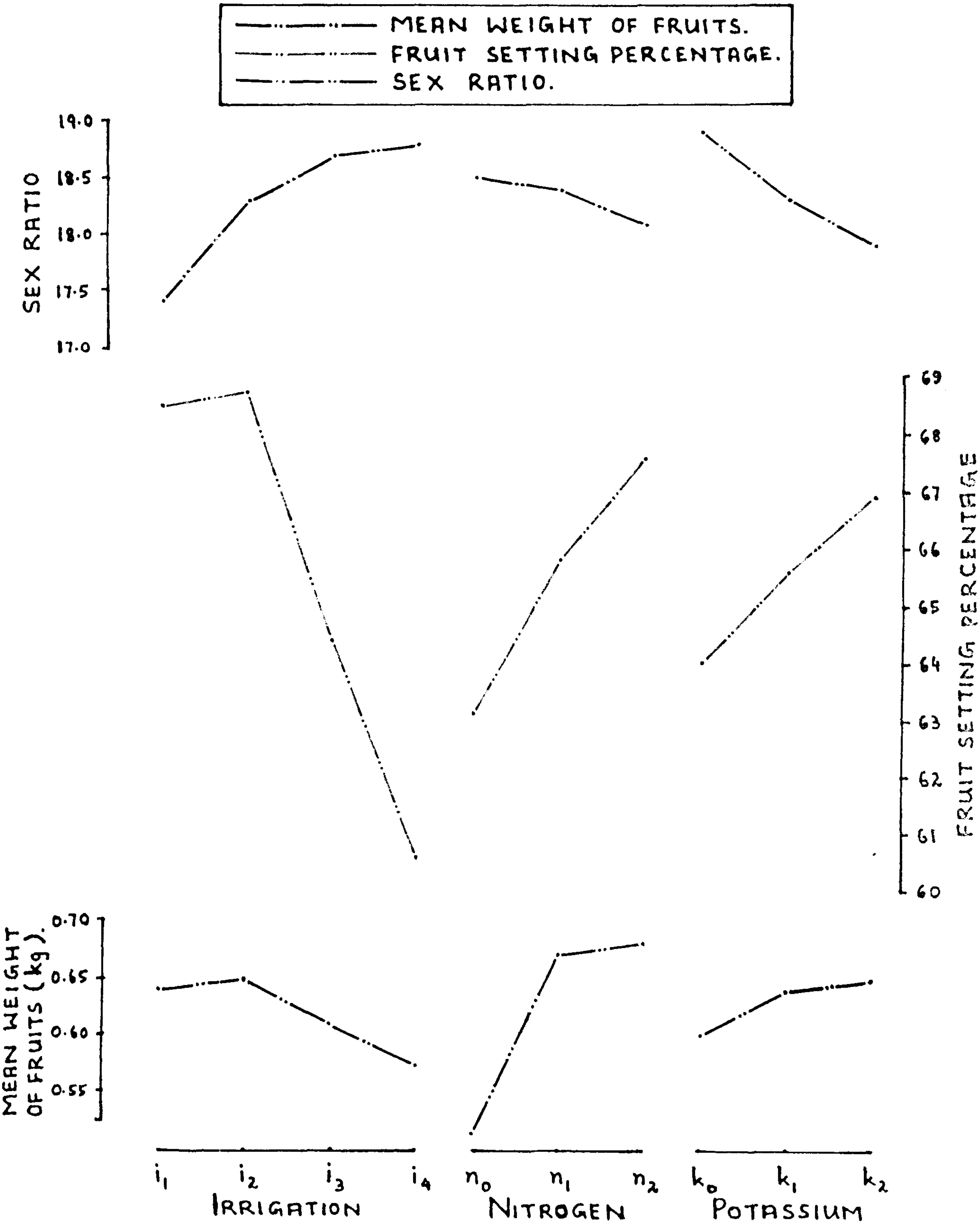
Fig. 6. Number of fruits per plot, Mean length and girth of fruits as affected by levels of irrigation, nitrogen and potassium.



in melons, Singh and Singh (1978) in bottlegourd, round gourd and water melons, Ortega and Kretchman (1982) in cucumber, Pew and Gardner (1983) in muskmelon and Thomas (1984) in bittergourd. Considerable amount of photosynthates are transported into the fruit during the period of fruit development and hence that period is very critical in the reproductive cycle of a plant (Kaufman, 1972; Tisdale and Nelson, 1975). Optimum moisture supply in 25 mm CPE irrigation and pot watering would have increased the availability and supply of plant nutrisnts resulting in better growth and translocation of photosynthates to fruits.

The moisture stress in treatments receiving irrigation at 50 mm CPE (i_3) and 75 mm CPE (i_4) might have affected the metabolism of the plants resulting in retardation of the floral primorida development which in turn was reflected by fewer number of flowers and fruits in those treatments. Besides, it might have adversely affected fruit set probably through the increased abscission of flowers and fruits. All these might have contributed to the decrease in the number of fruits produced under less frequent irrigation schedules (i_3 and i_4). Stress conditions also would have seriously hindered the production and translocation of metabolites to the fruits. Similar results were reported by Czao (1957) in cucumber, Molnar (1965) in melons, Kaufman (1972) in various crops and Thomas (1984) in bittergourd.

Fig. 7. Mean weight of fruits, Fruit setting percentage and Sex ratio as affected by levels of irrigation nitrogen and potassium.



Application of nitrogen and potassium significantly increased the number of fruits, mean length and girth of fruits and fruit setting percentage. However, the mean weight of fruit was significantly influenced only by nitrogen (Tables 5 and 6).

The favourable influence of N and K on yield attributes can be ascribed to the increased availability and uptake of plant nutrients for the initiation of floral primordia and production of larger amounts of dry matter through photosynthesis. The translocation of a larger quantity of photosynthates to the fruits might have resulted in the higher mean length, girth and weight of fruits. Miller and Ries (1958) showed that cucumber plants receiving higher level of nitrogen produced three times as many fruits than those with low nitrogen level, and that the length to diameter ratio of the fruits was increased by high nitrogen. Favourable results of nitrogen application on yield components were reported by Jassal <u>et al</u> (1970) and Pandey <u>et al</u>. (1974) in muskmelon, Oguremi (1978) in water melon, Rajendran (1981) in pumpkin and Thomas (1984) in bittergourd. Agarwala and Sharma (1976) observed that size of fruits was smaller and maturity advanced when nitrogen supply was a limiting factor. Favourable influence of potassium application on yield attributes has been advanced by Rajendran (1981) in pumpkin.

An interesting observation is that the sex ratio followed a reverse trend with the other yield contributing parameters. The ratio of female flowers per hundred male flowers decreased under higher frequencies of irrigation aa well as with increasing levels of nitrogen and potassium. This is because the production of male flowers in proportion to female flowers was less under conditions of moisture stress and lower levels of nutrients. Rekhi *et al* (1968) reported significant variation in sex ratio in musk melon due to nitrogen application.

5.3 Fruit yield

The fruit yield increased with increase in the wetness of soil. The maximum yield was recorded by irrigation at 25 mm CPE (i_2) and it was on par with daily pot watering (i_1) Irrigation at 50 mm CPE (i_3) and 75 mm CPE (i_4) were on par and significantly inferior to wetter regimes. The increase in yield by the frequent irrigation schedules (i_1 and i_2) over irrigation at 50 mm CPE (i_3) ranged from 24 to 27 per cent and that over 75 mm CPE (i_4) ranged from 35 to 39 per cent (Table 7(a), Fig.8).

The importance of photosynthesis as the basic proces to harness sunlight and production of sugars from CO_2 is well established. Leaves act on the main organs for photosynthesis and the effectiveness of dry matter accumulation will therefore depend on their photosynthetic efficiency (Arnon 1975). The production of higher amounts of photosynthates with the aid of a larger leaf area and subsequent translocation of these metabolites to the fruits at a rapid pace due to increased moisture availability under wetter regimes (25 mm CPE and daily pot watering) might have contributed to higher yields. The observed increase in yield with increase in soil wetness can also be attributed to a more or less similar trend noticed in yield attributes like number and length of fruits and setting percentage. This is to be expected since fruit yield is the manifestation of the cumulative effect of these characters.

Higher yields at optimum moisture regimes was reported in cucumber by several workers such as Fleming (1936), Fronlich (1959), Dunkel (1966), Varga (1971), Dimitrov (1974), Jagoda and Kaniszewski (1975), Krynska (1975), Pavlov (1976), and Smittle and Threadgill (1982). Similar results in other cucurbits were reported by Jassal et al (1970), Pestova and Pestova (1973) and Thomas (1984).

The significant reduction in yield in the less frequently irrigated treatments, viz. those at 50 mm CPE (i_3) and 75 mm CPE (i_4) can be ascribed to the adverse effects of stress on the physiology of growth, reproduction and fruit development (Kramer, 1969). Reduction in yield under moisture stress was observed by Varga (1973), Cummins and Kretchman (1974) and Ortega and Kretchman (1982) in cucumber and Thomas (1984) in bittergourd.

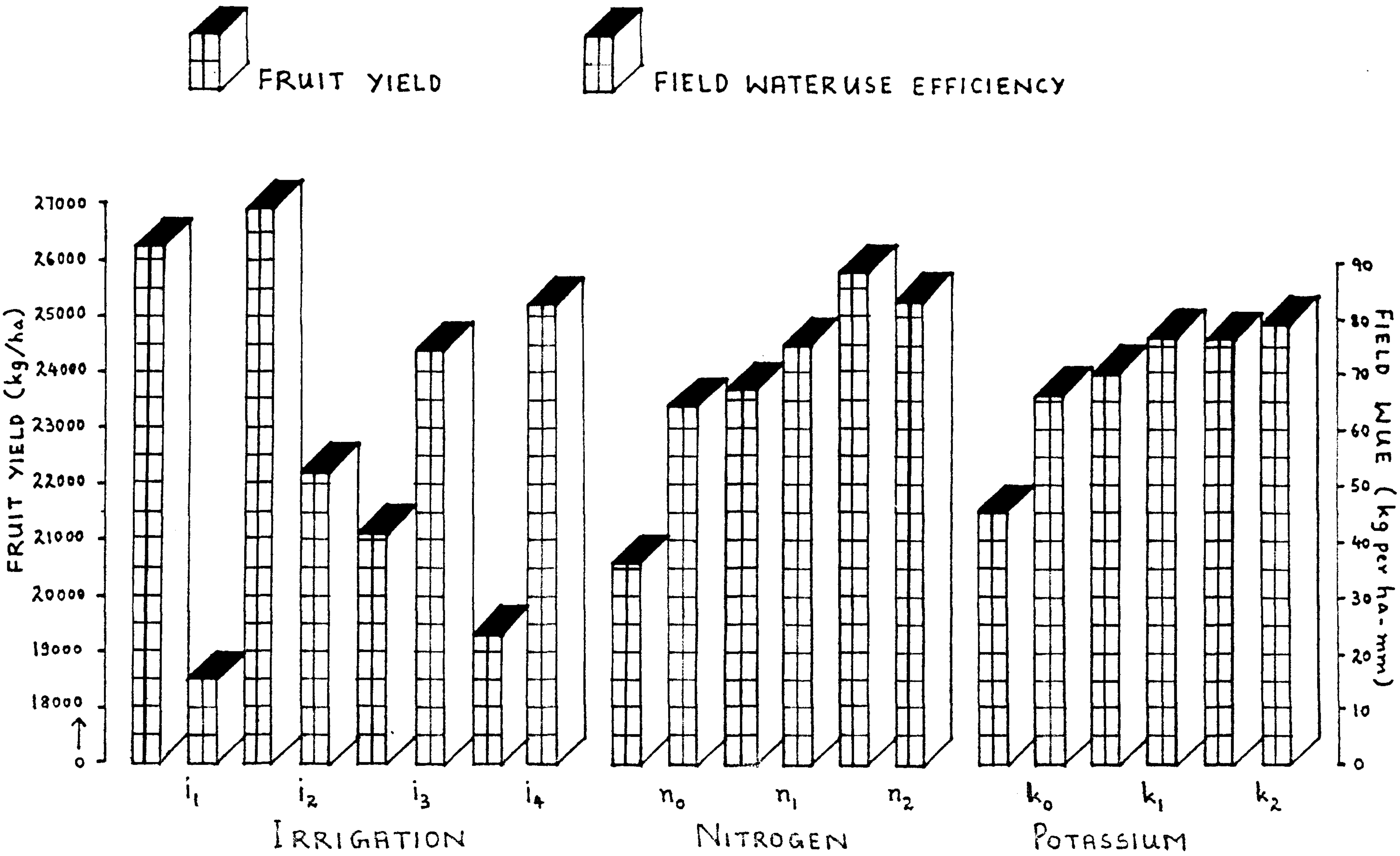
The application of both nitrogen and potassium significantly increased the fruit yield. The percentage increase with 50 and 100 kg/ha of nitrogen over the control was 15 and 25 and the corresponding figures for potassium were 12 and 14 respectively. However, the higher levels of potassium were on par (Table 7(a), Fig.8).

The soil of the experimental field was low in available nitrogen and potassium and hence increased supply of these nutrients to the crop, in general, had lead to the increased uptake of these nutrients (Tables 9(a) and 11(a)). This has resulted in better growth and favourably affected the yield attributing characters resulting in higher yields. The importance of major nutrients on the synthesis of carbohydrates, amino acids, proteins and other metabolic products which contribute to yield has been highlighted by Tisdale and Nelson (1975) and Agarwala and Sharma (1976). Under conditions of nitrogen and potassium deficiency , over 50 per cent reduction of the potential yield was reported in cucumber by Adams (1978).

The favourable effect of nitrogen and potassium on yield of cucumber and other cucurbits have been reported by Dhesi *et al* (1966), Padda *et al* (1969), Jassal *et al* (1970), Jagoda *et al* (1970), Roorda Van Eysinga (1970), Mc Collum and Miller (1971), Sharma and Shukla (1972), Wilcox (1973), Bradley *et al* (1975), Ivanov and Surlekov (1975), Jagoda and Kaniszewski (1975), Krynska (1975), Varma (1975), Miecik (1976), Doss *et al* (1977), Mahakal *et al* (1977), Yakubitskaya (1977), Bhosale *et al* (1978), Williams (1978), Bradley *et al* (1979), Feigin (1977), Ishkaev and Ibragimov (1980), Rajendran (1981) and Thomas (1984).

Interaction between the nutrients and irrigation had significant influence on yield (Table 7(b). Increase in yield due to higher levels of nitrogen and potassium was more pronounced and significant with frequent irrigations (i_1 and i_2). Cucurbits require considerable quantities of moisture coupled with heavy fertilizer application when making their most vigorous growth and upto the time the fruits become mature, if maximum yields are to be realised (Whitaker and Davis, 1962). Existence of optimum soil moisture conditions is a pre-requisite for the plants to be able to absorb and utilize the applied fertilizers from the soil.

FIG. 8. FRUIT YIELD AND FIELD WATER USE EFFICIENCY AS AFFECTED BY LEVELS OF IRRIGATION, NITROGEN AND POTASSIUM.



Increased transpiration under high evaporative demand and favourable moist conditions of the soil increases the rate of uptake of nutrients as a result of mass transfer of ions through the transpirational stream (Ghildyal,1971). In the present study the higher irrigation frequencies would have increased the availability of nutrients at higher doses of fertilizers leading to an increased uptake of major nutrients and higher fruit yield (Table 9(b) and 11(b). Higher demand for nitrogen and potassium under irrigated conditions due to decrease in tissue nutrient levels have been observed by O'Sullivan (1980). The results are in agreement with the findings of Molnar (1965), Borna (1976), Hartman and Waldhor (1978) and Will (1979) in cucurbits.

5.4 Moisture studies:

The results revealed that the field water use efficiency increased with decrease in the level of irrigation and increase in the level of fertilizer application (Table 7(a) Fig.8).

Irrigation at 75 mm CPE showed the highest field water use efficiency which was followed by irrigation at 50 mm CPE but the former treatment was on par with the latter. Both the treatments which received irrigation at higher frequencies, ie. irrigation at 25 mm CPE and daily pot watering, showed poor water use efficiency, the values being the least in the cultivator's practice. Water use efficiency is likely to increase with decrease in soil moisture supply until it reaches the minimum critical level because plants may actively try to economise water loss in the range from inimum critical level to optimum moisture level. However, the total production from a unit area decreases as the available soil moisture falls below the optimum (Singh and Sinha, 1977). Water supplied above the optimum moisture level may be lost in the form of excessive evaporation, excessive transpiration or even as deep percolation.

Low water use efficiency in higher moisture regimes may be attributed to higher values of consumptive use and percolation losses with a comparatively lesser magnitude of difference in fruit yield (Prasad and Singh,1979). These findings are in line with those of Vittum and Flocker (1967), Borna(1969), Loomis and Crandall(1977), Singh and Singh (1979) and Thomas (1984).

Application of both nitrogen and potassium showed significant increase in water use efficiency. Application of 100 kg/ha dose of each nutrient showed the highest water use efficiency, probably due to the increased yield with the same quantity of water applied. This is in agreement with the results obtained by Prasad and Singh (1979), Sharma and Parashar(1979), Pai and Hukeri(1979) and Thomas (1984) in different crops.

FIG. 9(a) CONSUMPTIVE USE AS AFFECTED BY IRRIGATION LEVELS.

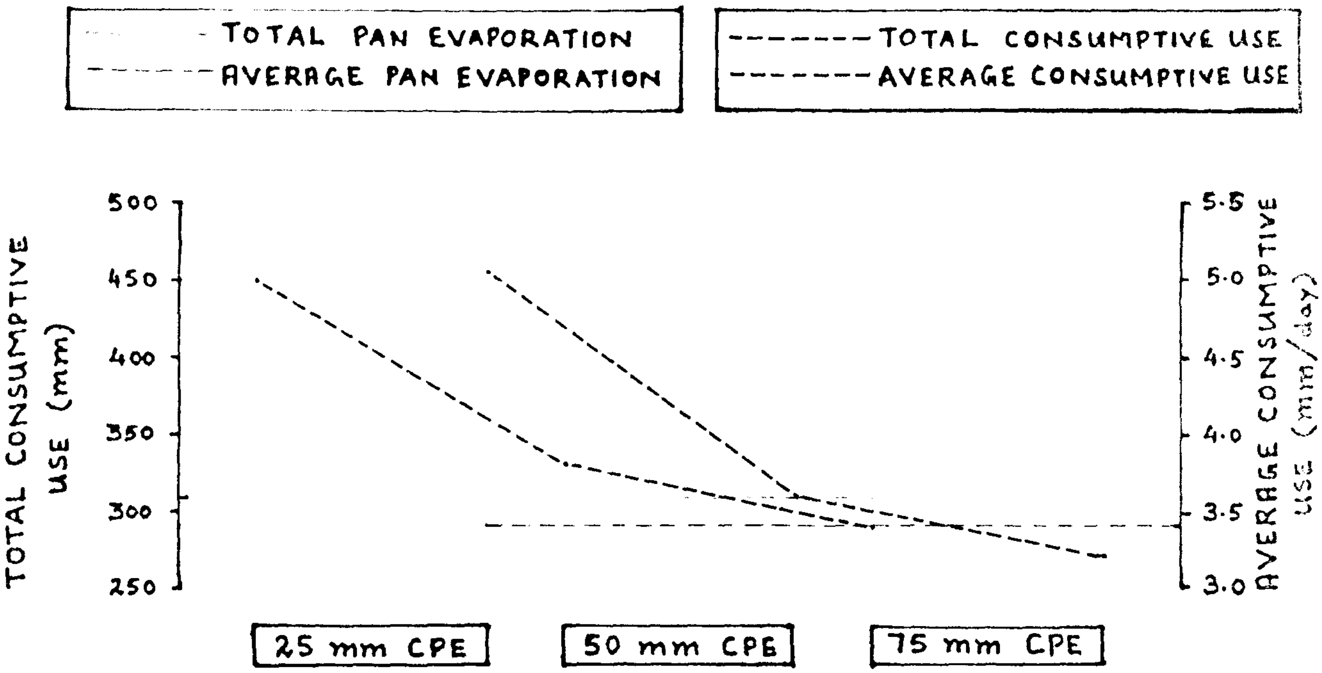
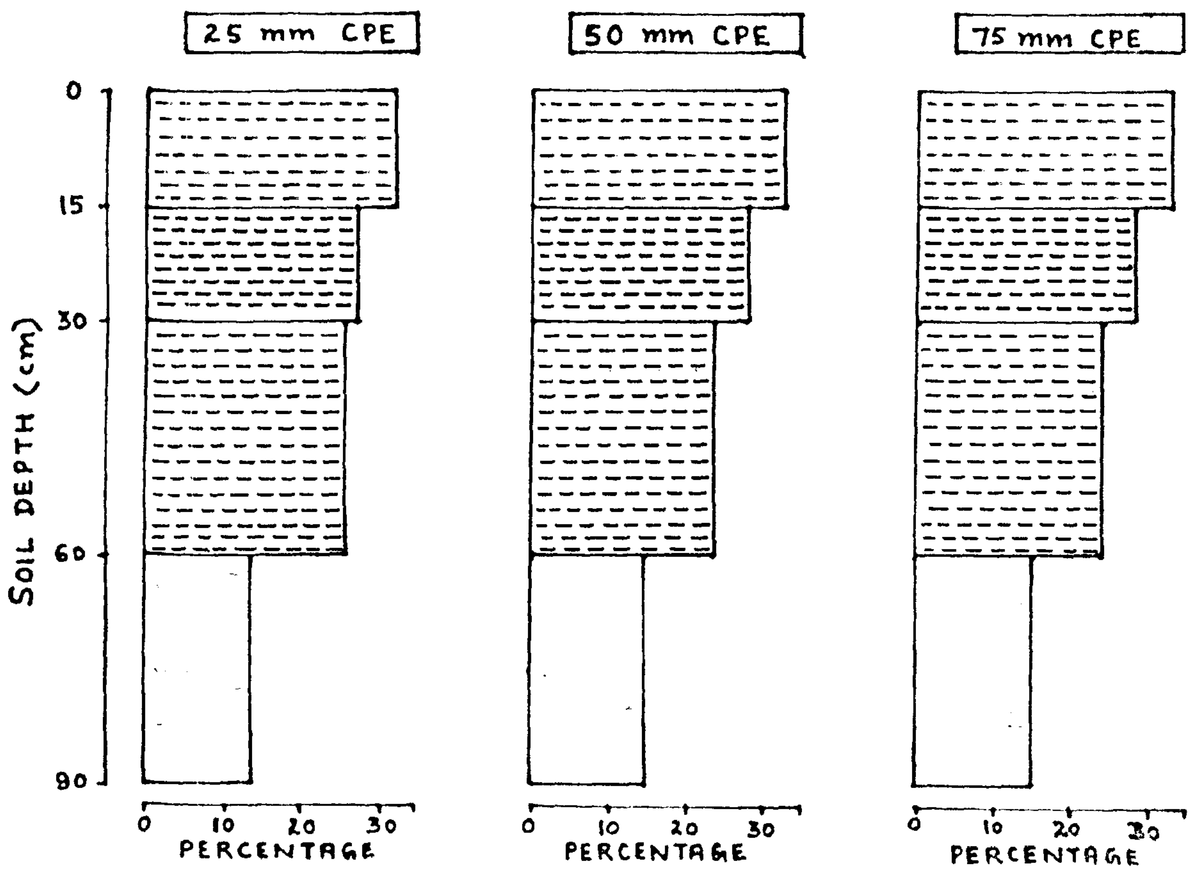


FIG. 9(b). SOIL MOISTURE DEPLETION PATTERN AS AFFECTED BY IRRIGATION LEVELS



The consumptive use increased with increasing frequency of irrigation. The highest value was recorded by irrigation at 25 mm CPE which received ten irrigations during the cropping period of 90 days (Table 8). Frequent moisture supply would have created a condition favourable for an increased rate of transpiration from the plant surface and evaporation from the soil surface. This increase in evapotranspiration would have resulted in a concurrent increase in the consumptive use under high frequency irrigation. Similar observations have been reported earlier by Konishi(1974),Loomis and Crandall(1977), Henkel(1978),Prasad and Singh(1979),Sharma and Parashar (1979) and Thomas (1984).

Maximum depletion of soil moisture was seen from the top 15 cm layer, irrespective of the irrigation frequency and then gradually decreased with the increase in soil depth (Table 8, Fig.9(b)). The high soil moisture depletion from the top 15 cm layer is due to the fact that, besides transpiration from plant surface, losses due to evaporation from the soil surface also occur. The moisture depletion from 15 to 30 cm layer,eventhough lower than the top layer,was higher than the next 30 cm layer below. The top 30 cm layer accounted for as high as 60 per cent of the total depletion. Increased moisture extraction from the upper layer under wetter regimes may be attributed to the better ramification of roots in that layer(Prasad and Singh,1979). The rate of moisture depletion decreased rapidly with increases in soil depth upto 90 cm. It was as low as 15 per cent in the 60 to 90 cm layer. The slight increase noticed in the moisture extraction from the lower layer under drier regimes as compared to wetter regimes may be due to the fact that moisture stress might have induced deeper penetration of roots resulting in increased extraction of soil water from those layers (Plant et al. 1969). The results clearly suggest that the effective rootzone of cucumber is in the top 90 cm soil layer as very little root activity occurs below that depth. These findings corroborates with those of Loomis and Crandall (1977) in cucumber. Importance of root mass and their activity in soil moisture depletion was reported by Gardner (1968). Similar results on soil moisture depletion on cucurbits were earlier reported by Gautham and Dasthane (1970). Belik and Vaselovski (1975), Zabara (1977) and Thomas (1984).

5.5 Content and Uptake of majer nutrients

Irrigation did not influence the content of major nutrients. However, it resulted in significantly higher uptake of major nutrients due to the increased dry matter production (Table 9(a), 10 and 11(a)).

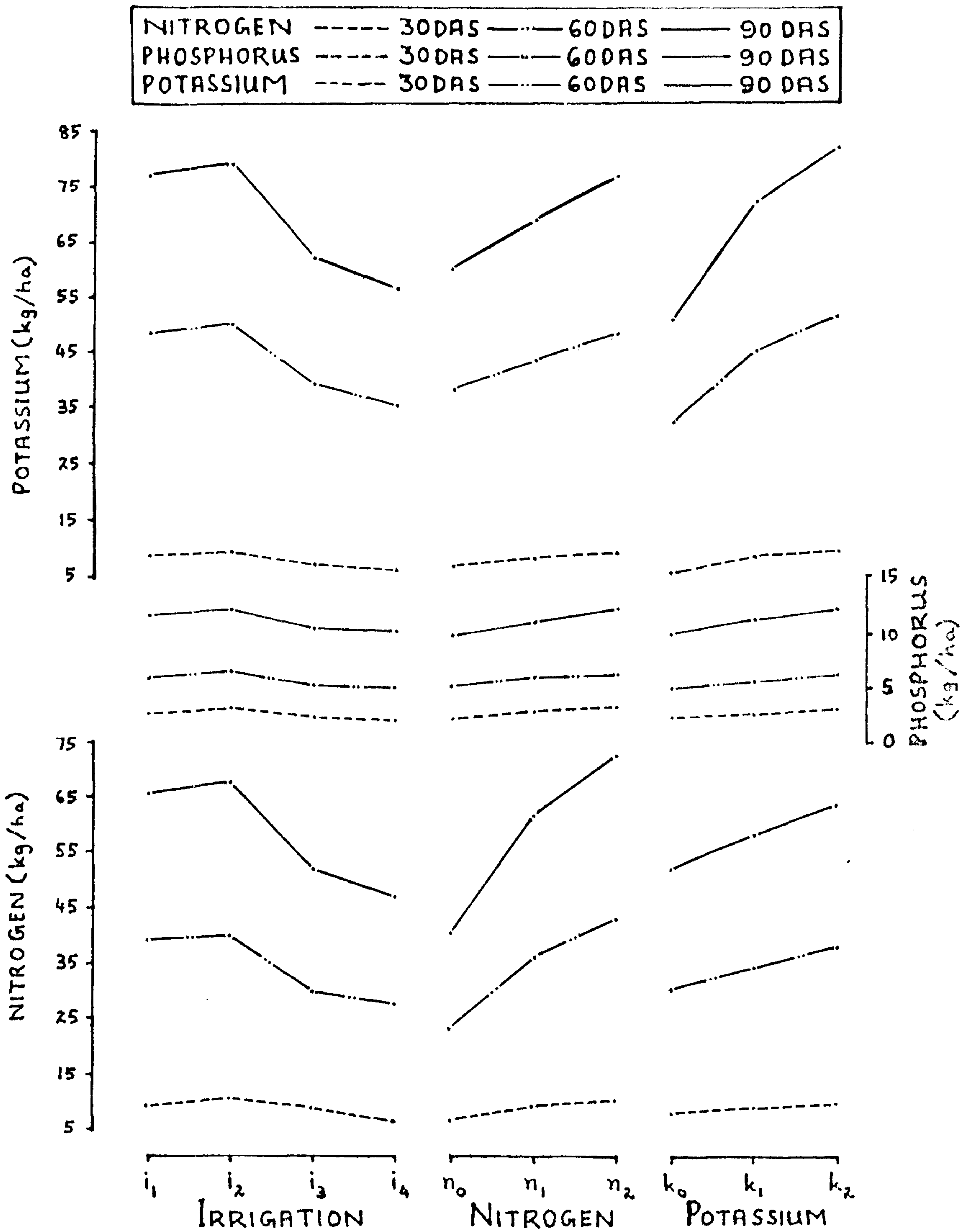
Moisture controls the concentration and availability of various nutrients in the soil. So the availability of water is of great importance to plants to absorb nutrients and for the soil to supply them (Tisdale and Nelson, 1975; Agarwala and Sharma, 1976). Wetter moisture regimes (i_1 and i_2) might have resulted in increased availability of nutrients and root activity leading to higher uptake of nutrients as compared to drier regimes (i_3 and i_4). These results are in agreement with those of Brown et al (1960), Singh (1975), Cocueci et al (1976) and Thomas (1984) in cucurbits. Eventhough the cultivator's practice of daily pot watering ensured sufficient moisture in the root zone, it might have resulted in leaching of some quantity of the soluble nutrients (N and K) beyond the root zone.

Application of nitrogen and potassium at higher levels significantly increased the percentage content of the respective nutrients in plants (Tables 9(a) and 11(a)).

In general, fertilizers increase the reserve of mobiles nutrients in the soil which favours a higher nutrient content in various plant parts (Largskii, 1971). Increase in the plant content of the applied nutrient has been reported by Tayal et al (1965), Lacascio (1967), Grozdova (1970), Jassal et al (1972), Tesi et al (1981) and Thomas (1984) in cucurbits.

The uptake of nitrogen and potassium followed the same trend as that of dry matter production and the nutrient content in plant parts (Table 9(a) and 11(a), Fig.10).

Fig. 10. Uptake of major nutrients as affected by levels of irrigation, nitrogen and potassium.



According to Tanaka et al (1964) the nutrient uptake is controlled by factors like nutrient availability in soil, nutrient absorption power of roots and the rate of increase in dry matter. Increased uptake of nutrients due to fertilizer application can thus be ascribed to direct manurial effects and increased tapping of nutrients from the soil on account of increased vigour and growth of roots. The findings of Thomas (1984) are on similar lines.

The phosphorus uptake was significantly affected by the levels of irrigation as well as nitrogen and potassium. The differential dry matter production recorded in the various irrigation and nutrient levels, without any appreciable variation in the content of phosphorus in the plant parts is the main reason for the significant variation in phosphorus uptake at different stages. Moreover, the available phosphorus content of the soil is reported to increase with increased frequency of irrigation by Sharma and Yadav (1976) resulting in higher plant uptake. Similar variations in the uptake of phosphorus with change in moisture regimes and nutrient status of the soil was reported by Largskii (1971), Muthuvel and Krishnamoorthy (1980) and Thomas (1984).

Interaction between the nutrients and irrigation in the uptake of nitrogen and potassium on the 60th and 90th day (Table 9(b) and 11(b)) also followed a trend similar to that of dry matter production. Increased uptake of nitrogen and potassium due to the application of those nutrients at higher levels could be obtained with frequent irrigations. Requirement of higher doses of nitrogen and potassium under irrigated conditions was reported by Mengal and Braunschweig (1972) and Will (1979) in cucumber. Similar results were reported by Czao (1957), Borna (1976), Hartmann and Waldhor (1978), O'Sullivan (1980) and Thomas (1984) in cucurbits.

5.6 Soil fertility status

The soil chemical properties determined after the final harvest showed a significant increase in available nitrogen and potassium in treatments where the application of the respective nutrients were at higher levels. This may be attributed to the direct effect of the applied fertilizers that was not utilized by the crop. Similar arguments were put forward by Downes and Lucas (1966), Bains (1967), Largskii (1971), Mani and Ramanathan (1980), Mathew (1981) and Thomas (1984) in various crops.

5.7 Correlation studies

The results revealed significant correlation of yield with growth characters, yield components and uptake of major nutrients. Except sex ratio which showed negative correlation, all the characters showed significant positive correlation (Table 13).

Yield is the result of a series of biophysiological processes which starts from sowing and ends with harvest. At each and every step in this process, the effect of various biometric as well as yield attributing factors will contribute to the ultimate yield.

Optimum soil moisture and adequate nutrient supply will result in optimum plant growth. The seedling which emerges out of the seeds contributes to the formation of the frame work on which the photosynthetic units will be located. Thus the length of the vines determine not only the reach and spread of the plant canopy over the ground area but also controls the positioning of the leaves in such a manner that the ultimate aim of harnessing as much solar energy as possible through photosynthesis is achieved effectively. Moreover, in a crop like cucumber with spreading type of vines, the role of longer vines in providing larger number of flowering and fruiting points is a very important factor in deciding the effectiveness of photosynthate accumulation. The canopy strength of any plant decides the efficiency of its photosynthetic machinery. Eventhough, in a succulent crop like cucumber, the photosynthetic vines may contribute a part of the total dry matter production, the major contributors are the leaves.

in the circumstances cited above it is imminent that biometric characters like length of vine, number of leaves and leaf area index have a positive correlation with ultimate fruit yield. Similar findings have been advanced by Flocker *et al*. (1965), Cummins and Kretchman (1974) and Oguremi (1978).

The effect of adequate nutrient supply under optimum moisture regimes naturally leads to a general improvement in plant growth which in turn increases the efficiency of photosynthesis. The increased photosynthate accumulation under favourable conditions leads to a higher quantum of dry matter accumulation in all plant parts, especially so in the fruits, which will invariably contribute to a higher yield. Thus dry matter production may show a positive correlation with yield under conditions which are optimum for plant growth. Similar arguments were advanced earlier by Mc Collum and Miller (1971) and Rajendran (1981) in cucurbits.

Yield components show how effectively the photosynthates produced and translocated by the leaves and vines is accumulated in the fruits. Flowers, which are the initiators of the reproductive phase of plant growth, once fertilized, enter into the pathway of fruit formation by acting as the reservoirs for photosynthates. Hence the fruit setting percentage has great significance in determining the ultimate yield, as reported by Rajendran (1981) in pumpkin. Once the flower sets into the fruit, the equatorial factors of fruit development namely the length and girth of fruit along with the weight of fruits, determine the volumes of accumulation of photosynthates and thue contributes to yield. Similar arguments have been put forth by Miller and Ries (1958), Flocker et al. (1965), Rajendran (1981) and Ortega and Kretchman (1982) in various cucurbits. Apart from these, the number of fruits harvested determines the degress of conversion of photosynthates into harvestable yield through the various phases of the reproductive stage of crop growth and invariably it shows correlation with yield. Findings of Flocker et al (1965), Pandey et al (1974) and Singh and Singh (1978) lents support to this observation.

The only yield component which showed a negative correlation with yield was the sex ratio, expressed as the number of female flowers per hundred male flowers. Eventhough frequent irrigations and higher nutrient application resulted in higher yield, they would have not only delayed the female flower production but also reduced their number when compared to that of male flowers. Thus the stress conditions which increased sex ratio resulted in a negative correlation between sex ratio and yield. Similar observations were reported earlier by Rajendran (1981).

Under conditions of adequate nutrient supply and optimum soil moisture level, the uptake of nutrients by the plants is bound to increase due to the greater availability of nutrients in the soil in an absorbable form (Largakii, 1971; Tisdale and Nelson, 1975). Once the major nutrients are absorbed into the plant, they favourably influence the vital growth processes by becoming a part of the enzyme systems and photosynthetic mechanism. The physiological processes inside the plant steps up their pace with the availability of fresh substrates resulting in increased photosynthate accumulation and dry matter production. Thus increase in uptake of major nutrients triggers a series of physiological process which culminates in higher yield. In these circumstances, uptake of nutrients will have a positive correlation with yield. Mc Collum and Miller (1971) and Rajendran (1981) obtained similar results in cucurbits.

5.8. Economics of irrigation and fertilizer application.

The abstract of the economic analysis of the results is presented in Table 14. Among the irrigation treatments, 5 cm irrigation at 25 mm CPE (i_2) recorded the maximum profit (Rs.10,210) followed by daily pot watering (Rs.5,501), 50 mm CPE

(Rs.5,179) and 75 mm CPE irrigation (Rs.3,552). However, in the case of net return per rupee invested and the benefit:cost ratio, irrigation at 25 mm CPE (Rs.0.61 end 1.61) which ranked first followed by irrigetion at 50 mm CPE (Rs.0.33 and 1.33), daily pot watering (Rs.0.27 and 1.27) and irrigation at 75 mm CPE (Rs.0.23 and 1.23).

Tha results thus revealed thet irrigetion et 25 mm CPE is the most economic schedule for cucumber raised during summer saason in rice fallows. The same treatment which raceivad tan irrigetions, was on par in fruit yield with cultivator's practice of deily pot watering which received 75 irrigations. The latter treatment also reeaivad almost a three-fold increase in the quantity of water applied (Table 7(a)). Hence, the profit, net return and benefit:cost ratio were lower in cultivator's practice due to its higher labour requirement compared to 25 mm CPE irrigation. The treatment where irrigation was given et 50 mm CPE, which ranked third in profit and yield, was second to 25 mm CPE schedula in net return and benefit:cost retio.

Application of nitrogen markedly influenced the economics of production. Eventhough the profit, net return per rupee invested and benefit:cost ratio increased by successive additions of nitrogen, the magnitude of increase was higher between the zero and 50 kg/he levels. The levels

Table 14. Economics of irrigation and fertilizer application.

Treatments	Cost of production excluding the treatment. (Rs.)	Additional cost of the treatment. (Rs.)	Total cost of production. Y (Rs.)	Fruit yield (kg)	Value of yield X (Rs.)	Profit X-Y (Rs.)	Net return per rupee invested X-Y/Y (Rs.)	Benefit : cost ratio
Irrigation levels								
i_1 (1703 mm)	15180	5550	20730	26231	26231	5501	0.27	1.27
i_2 (536 mm)	15180	1500	16680	26890	26890	10210	0.61	1.61
i_3 (286 mm)	15180	750	15930	21109	21109	5179	0.33	1.33
i_4 (236 mm)	15180	600	15780	19332	19332	3552	0.23	1.23
Nitrogen levels								
n_0 (Control)	15520	-	15520	20615	20615	5095	0.33	1.33
n_1 (50 kg/ha)	15520	355	15875	23745	23745	7870	0.50	1.50
n_2 (100 kg/ha)	15520	610	16130	25821	25821	9691	0.60	1.60
Potassium levels								
k_0 (control)	15810	-	15810	21534	21534	5724	0.36	1.36
k_1 (50 kg/ha)	15810	210	16020	24062	24062	8042	0.50	1.50
k_2 (100 kg/ha)	15810	320	16130	24566	24566	8436	0.52	1.52

Price of 1 tonne farm yard manure = Rs.200.00
" 1 kg nitrogen (N) = Rs. 5.10
" 1 kg phosphorus (P_2O_5) = Rs. 5.95
" 1 kg Potassium (K_2O) = Rs. 2.20

Price of 1 kg cucumber = Re . 1.00
Cost of 1 irrigation (furrow) = Rs. 150.00
Cost of 1 pot watering = Rs. 75.00

zero, 50 and 100 kg/ha resulted in profit of Rs.5,095, Rs.7,870 and Rs. 9,691 per hectare, net return of Rs.0.33, Rs.0.50 and Rs.0.60 per rupee invested and benefit: cost ratio of 1.33, 1.50 and 1.60 respectively. The 100 kg/ha level of nitrogen proved to be the most economic one.

Application of potassium also markedly influenced the economics of production. Eventhough the profit, net return per rupee invested and benefit: cost ratio increased due to progressive increase in the level of potassium application, the magnitude of increase was less beyond 50 kg/ha level. The levels zero, 50 and 100 kg/ha resulted in profit of Rs.5,724, Rs.8,024 and Rs.8,436 per hectare, net return of Rs.0.36, Rs.0.50 and Rs.0.52 per rupees invested and benefit: cost ratio of 1.36, 1.50 and 1.52 respectively. The 100 kg/ha level of potassium proved to be the most economic one.

In short, irrigation at CPE value of 25 mm and application of nitrogen and potassium at the rate of 100 kg/ha each were found to be the most economic levels for cucumber raised in summer rice fallows.

SUMMARY

SUMMARY

An experiment was conducted in a loamy sand soil of the Agronomic Research Station, Chalakkudy from January to April 1984 on water management and NK nutrition of cucumber in summer rice fallows. It was laid out as a factorial experiment in split plot design with three replications. The main plot treatments consisted of nine combinations of three levels each of nitrogen and potassium, viz., zero, 50 and 100 kg per hectare. The sub plot treatments consisted of four levels of irrigation viz. cultivator's practice of daily pot watering at the rate of 4 l/plant and irrigation to a depth of 5 cm at cumulative pan evaporation values of 25, 50 and 75 mm. The results of the experiments are summarised below.

1. Irrigation at 25 mm CPE and higher levels of both nitrogen and potassium showed marked increase in the length of vine on the 30th, 60th and 90th day after sowing.

2. The number of leaves per plant was significantly increased by higher frequencies of irrigation and higher levels of both nitrogen and potassium during all the three stages of observation.

3. Pronounced increase in leaf area index was recorded during all the three stages at higher frequencies of irrigation and higher levels of nitrogen and potassium.

4. The total dry matter production per hectare on the 30th, 60th and 90th day increased significantly with increase in the frequency of irrigation as well as level of applied nitrogen and potassium. The effect of interaction between main plot and sub plot treatments (NK x I) was also significant on the 60th and 90th day.

5. The number of fruits harvested per plot rose significantly with increase in the level of irrigation, nitrogen and potassium.

6. Frequent irrigations and higher levels of nitrogen and potassium markedly enhanced the mean length of fruits.

7. There was no influence on mean girth of fruits by irrigation levels. However, fruit girth was markedly enhanced by higher levels of nitrogen and potassium.

8. Application of nitrogen alone significantly increased the mean weight of fruits.

9. Fruit setting percentage showed marked increase at higher levels of irrigation, nitrogen and potassium.

10. Sex ratio, expressed as the number of female flowers per 100 male flowers, was significantly higher when nitrogen and potassium were not applied and irrigation was given at wider intervals.

11. Effect of irrigation, nitrogen and potassium on fruit yield per hectare was positive and significant. The maximum fruit yield of 26230.80 kg and 26880.90 kg were produced by cultivator's practices of daily pot watering and irrigation at 25 mm CPE respectively, and they were statistically on par. The highest nitrogen level of 100 kg/ha produced significantly superior yield of 25821.10 kg/ha. Among the potassium levels, 50 and 100 kg/ha doses were on par (24061.82 kg and 24565.99 kg/ha) and significantly superior to no potassium. Interaction effect of NK combinations in the main plot with irrigation levels of the sub plot also showed pronounced influence on fruit yield.

12. Field water use efficiency was highest in irrigation at 75 mm CPE and 50 mm CPE with fruit yields of 81.92 and 73.81 kg/ha-mm respectively, and they were on par. The highest nitrogen level of 100 kg/ha recorded the maximum water use efficiency of 82.50 kg/ha-mm. Among the potassium level, 50 and 100 kg/ha doses were on par (76.41 and 79.24 kg/ha-mm) and significantly superior to the control.

13. Total consumptive use and Et/Eo values were maximum in irrigation at 25 mm CPE.

14. Soil moisture depletion pattern showed that cucumber extracted as much as 60 per cent of the total moisture from the top 30 cm soil layer. The moisture depletion decreased rapidly with depth. Compared to wet regimes, dry regimes depleted more soil moisture from the lower soil layer.

15. Water management practices and levels of applied potassium had no marked effect on the nitrogen content of plants. However, nitrogen levels significantly increased the percentage of nitrogen in plants at all the three stages.

16. The different levels of irrigation, nitrogen and potassium did not produce any significant effect on the phosphorus content of plants.

17. Water management practices and levels of applied nitrogen failed to show any positive influence on the potassium content of plants. However, potassium levels significantly increased the plant content of potassium during all the three stages.

18. Nitrogen uptake by the crop was significantly increased by higher frequencies of irrigation and higher levels of nitrogen and potassium. The interaction between the main plot and sub plot treatments (NK x I) was also significant on the 60th and 90th day.

19. Uptake of phosphorus by the crop was markedly increased by frequent irrigations and higher nitrogen and potassium levels.

20. Potassium uptake by the crop was significantly increased by higher irrigation frequencies and higher levels of nitrogen and potassium. The interaction between the main plot and sub plot treatments (NK x I) was also significant on the 60th and 90th day.

21. The available nitrogen content of the soil after the experiment showed significant increase at higher levels of nitrogen application. Irrigation and potassium levels had no influence on available nitrogen status of the soil.

22. There was no influence on the available phosphorus content of the soil due to irrigation, nitrogen and potassium.

23. The available potassium content in the soil showed significant increase at higher levels of applied potassium. Irrigation and nitrogen levels had no influence on available potassium status of the soil.

24. Biometric character (length of vine, number of leaves and LAI), dry matter production, yield components (mean length, girth and weight of fruits, number of fruits and fruit setting percentage) and uptake of major nutrients showed significant positive correlation with yield. Only sex ratio showed a negative correlation.

25. Among the water management practices, irrigation at 25 mm CPE recorded the maximum profit of Rs.10,210/ha with the highest net return of Re.0.61/ rupee invested and benefit:cost ratio of 1.61. Among the nutrient levels, 100 kg/ha each of nitrogen and potassium recorded the highest profits of Rs.9,691/- and Rs.8,436 per hectare, net returns of Re.0.60 and Re.0.52 per rupee invested and benefit:cost ratio of 1.60 and 1.52 respectively.

The present study indicated that scheduling irrigation (5 cm depth) when the cumulative pan evaporation values reached 25 mm was the most economic water management practice for cucumber raised in summer rice fallows. This involved irrigation at an approximate intervals of 4 to 6 days after the establishment of the crop. The crop responded well upto 100 kg/ha each of nitrogen and potassium.

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* Original not seen.

APPENDIX

APPENDIX -I

Weather data during the crop period and its variation from the last five years (Weekly average)

Period	Meteorology week	Evaporation (mm)			Rainfall (mm)			Wind speed (km/hr)		
		1984	5 year average.	Variation.	1984	5 year average	Variation	1984	5 year average	Variation
I	3	2.53	4.22	-1.69	72.8	-	+72.80	2.5	2.3	+0.2
	4	3.78	4.58	-0.80	-	-	-	2.6	2.8	-0.2
	5	3.45	4.64	-1.19	-	-	-	2.8	3.0	-0.2
II	6	3.34	4.51	-1.17	1.0	-	+ 1.00	2.5	2.8	-0.3
	7	3.50	4.58	-1.08	9.9	0.12	+ 9.78	2.9	2.8	+0.1
	8	3.41	4.59	-1.18	4.4	0.29	+ 4.11	3.1	2.9	+0.2
	9	3.77	5.16	-1.39	4.2	3.20	+ 1.00	3.0	3.4	-0.4
III	10	2.35	5.02	-2.67	56.6	-	+56.60	3.1	3.3	-0.2
	11	4.00	5.28	-1.28	2.0	-	+ 2.00	3.3	3.4	-0.1
	12	4.41	5.44	-1.03	-	-	-	3.4	3.3	+0.1
	13	4.69	5.35	-0.66	-	5.64	- 5.64	3.3	3.5	-0.2
IV	14	3.92	5.40	-1.48	101.4	5.42	+95.98	3.0	3.4	-0.4
	15	4.73	5.13	-0.40	32.5	28.04	+ 4.46	3.1	3.4	-0.3
	16	4.93	5.06	-0.13	73.7	23.76	+49.94	2.9	3.5	-0.6

(contd..)

APPENDIX-I (contd.)

Period	Meteo-rology week	Temperature (°C)						Relative Humidity (%)					
		Maximum			Minimum			8 AM			2 PM		
		1984	5 year average	Varia-tion	1984	5 year average	Varia-tion	1984	5 year average	Varia-tion	1984	5 year average	Varia-tion.
I	3	32.5	34.5	-2.0	23.0	20.4	+2.6	87.8	79.6	+8.2	54.1	37.0	+17.1
	4	33.0	34.7	-1.7	20.9	20.7	+0.2	83.0	76.5	+6.5	58.8	34.9	+23.9
	5	33.4	34.5	-1.1	21.2	21.7	-0.5	81.3	79.9	+1.4	46.8	39.2	+ 7.6
II	6	33.0	35.0	-2.0	23.4	22.2	+1.2	76.7	79.1	-2.4	45.3	40.1	+ 5.2
	7	34.0	35.0	-1.0	23.0	22.3	+0.7	85.7	79.8	+5.9	37.1	38.1	- 1.0
	8	33.6	35.1	-1.5	23.4	22.5	+0.9	89.0	82.8	+6.2	36.7	42.2	- 5.5
	9	33.9	36.1	-2.2	22.9	23.7	-0.8	90.5	82.1	+8.4	45.6	45.1	+ 0.5
III	10	31.5	35.9	-4.4	23.4	22.9	+0.5	86.8	81.7	+5.1	52.1	49.1	+ 3.0
	11	34.4	36.2	-1.8	23.6	24.4	-0.8	84.6	78.7	+5.9	47.3	41.9	+ 5.4
	12	35.2	36.2	-1.0	24.1	25.0	-0.9	82.1	79.0	+3.1	40.3	43.3	- 3.0
	13	36.3	36.2	+0.1	25.3	25.0	+0.3	79.4	76.9	+2.5	34.7	45.2	-10.5
IV	14	34.0	36.4	-2.4	25.1	25.7	-0.6	88.4	80.2	+8.2	35.7	49.7	-14.0
	15	32.2	36.2	-4.0	24.9	26.2	-1.3	87.3	77.3	+10.0	34.1	51.9	-17.8
	16	32.5	35.2	-2.7	24.5	25.4	-0.9	82.6	78.5	+4.1	32.8	50.1	-17.3

APPENDIX- II

Quality of irrigation water

1.	pH	6.4
2.	EC(micromhos/cm)	40.2
3.	Bicarbonate (meq./litre)	1.0
4.	Chloride (meq./litre)	0.36
5.	Carbonate (meq./litre)	Traces

WATER MANAGEMENT AND NK NUTRITION OF CUCUMBER (*Cucumis sativus* L.)

By

R. SUBBA RAO

ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted at the Agronomic Research Station, Chalakkudy, during the summer season of 1984 (January to April) on water management and NK nutrition of cucumber (*Cucumis sativus* L.). It was laid out as a factorial experiment in split plot design with three replications. The main plot treatments consisted of nine combinations of three levels each of nitrogen and potassium, viz., zero, 50 and 100 kg/ha. The sub plot treatments consisted of four levels of irrigation, viz., cultivator's practice of daily pot watering at the rate of 4 l/plant and irrigation to a depth of 5 cm at cumulative pan evaporation values of 25, 50 and 75 mm.

The study revealed that cucumber responded well to frequent irrigations and higher levels of nitrogen and potassium. Growth characters like length of vine, number of leaves, leaf area index and dry matter production as well as yield components like mean length, girth, weight and number of fruits and fruit setting percentage were favourably influenced by one or more of the above factors. Only sex ratio showed a reverse trend for all the three factors. Fruit yield was also higher in frequently irrigated and well fertilized plots.

Field water use efficiency was higher in the less frequently irrigated treatments and higher levels of nitrogen and potassium. Total consumptive use and Et/Eo values were maximum in 25 mm CPE irrigation treatment. Soil moisture depletion pattern showed that cucumber extracted as much as 60 per cent of the total water used from the top 30 mm soil layer.

The nitrogen and potassium content of plants at all the stages of observation was enhanced by the application of the respective nutrients only. In general, composition of major nutrients in plants was not affected by irrigation. The uptake of major nutrients was higher at higher irrigation frequencies and higher levels of nitrogen and potassium as in the case of dry matter production.

Status of available nitrogen and potassium in the soil after the experiment was enhanced by the application of the respective fertilizers only. In general, irrigation had no influence on content of major nutrients in the soil.

Positive significant correlation with fruit yield was observed with growth characters (length of vine, number of leaves, leaf area index and dry matter production), yield attributing characters (mean length, girth, weight and number of fruits and fruit setting percentage) as well as uptake of major nutrients. Only sex ratio showed a negative correlation with yield.

Irrigation at 25 mm CPE and application of 100 kg/ha each of nitrogen and potassium recorded the maximum profit, net return per rupee invested and benefit: cost ratio.