`

YIELD MAXIMIZATION OF ORIENTAL PICKLING MELON (*Cucumis melo* var. *conomon* (L) Makino) BY HIGH DENSITY PLANTING AND NUTRIENT MANAGEMENT

By

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2013

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THESIS

Submitted in partial fulfilment of the

requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR-680 656
KERALA, INDIA

2013

DECLARATION

I, hereby declare that the thesis entitled "YIELD MAXIMIZATION OF ORIENTAL PICKLING MELON (*Cucumis melo* var. *conomon* (L) Makino**) BY HIGH DENSITY PLANTING AND NUTRIENT MANAGEMENT" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.**

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CERTIFICATE

Certified that the thesis entitled **"YIELD MAXIMIZATION OF ORIENTAL PICKLING MELON (*Cucumis melo*** var. *conomon* (L) Makino**) BY HIGH DENSITY PLANTING AND NUTRIENT MANAGEMENT"** is a record of research work done independently by Mr. Rajees P.C. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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We, the undersigned members of the advisory committee of **Mr. Rajees, P.C.,** a candidate for the degree of **Master of Science in Agriculture** with major in Agronomy, agree that the thesis entitled "**Yield maximization of oriental pickling melon (*Cucumis melo* var. *conomon* (L.) Makino) by high density planting and nutrient management**" may be submitted by of **Mr. Rajees, P. C.** in partial fulfilment of the requirement for the degree.

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EXTERNAL EXAMINER

ACKNOWLEDGEMENT

It is with great respect and devotion, I place on record my deep sense of gratitude and indebtedness to my major advisor ***Dr. P.A. Joseph****, Professor, Department of Agronomy, for his sustained and valuable guidance, constructive suggestions, unfailing patience, friendly approach, constant support and encouragement during the conduct of this research work and preparation of the thesis. I gratefully remember his knowledge and wisdom which nurtured this research project in right direction without which fulfillment of this endeavor would not have been possible.*

No words can truly represent my profound gratitude and indebtedness to ***Dr. C.T. Abraham****, Principal Investigator, AICRP on Weed Control, Department of Agronomy, member of my Advisory Committee for his unstinted support and guidance in the conduct of field experiment, constructive criticism, valuable suggestions and critical scrutiny of the manuscript.*

I am deeply indebted to ***Dr. V. Jaikumaran,*** *Professor and Head, ARS, Mannuthy and member of my Advisormy Committee for his unbounded support, valuable suggestions, critical scrutiny of the manuscript and for providing me the facilities for the conduct of field experiment.*

I am extremely delighted to place on record my profound sense of gratitude to ***Mr. S. Krishnan,*** *Associate Professor, Agricultural Statistics, member of my Advisory Committee for his support, critical comments and valuable advice during the preparation of this manuscript.*

I sincerely thank ***Dr. P.S. John, Dr. Mercy George, Dr. C. George Thomas , Dr. K. E. Usha, Dr. Meera V. Menon, Dr. Pameela , Dr. Sindhu P.V., Dr. Latha A. and Dr. Savithri. K.E.*** *from Department of Agronomy for the valuable help and advice rendered during the course of my study.*

I am thankful to ***Dr. P.K. Sushama and Mr.Vishveshvaran S.,*** *Department of Soil Science and Agricultural Chemistry for sincere help during chemical analysis.*

Let me express my sincere thanks to Sri. A.G. Rajendra Babu, Farm Manager, Department of Agronomy and Sri. Nandakumar, Farm Officer, AICRP on Weed Control for their whole hearted co-operation and assistance always accorded me during the course of investigation.

I wish to express my sincere thanks to Mrs. Sreela, Ms.Saritha, Mrs. Valsala, Mrs. Priya and Mrs. Jini for the help and concern.

I am extremely thankfulto labours, Department of Agronomy for their co-operation and support during the conduct of field experiments.

I wholeheartedly thank my friends Mr. Athul B.M, Mr. Varunkumar, Ms. Syama S. Menon, Ms. Savitha Antony and Mrs. Kavitha P.R for their whole hearted Cooperation and timely help.

I am happy to place on record my sincere thanks to my seniors and juniors of Dept. of Agronomy for their innumerable help and support during the course of this study.

The award of Junior Research fellowship of the KAU is thankfully acknowledged.

I am at a loss of words to express my heartleft gratitude to my parents for their constant encouragement and silent prayers throughout the study.

Finally, I bow my head before THE ALMIGHTY whose blessings enabled me to undertake this venture successfully.

Rajees P.C.

Dedicated to those unsung heroes who throughout the history of mankind toiled, laboured and turned the wheels of destiny for millions....
For the Kisans who continued to till the land despite all odds to sustain humanity.....

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Introduction

1. INTRODUCTION

Vegetable growing is one of the most important branches of agriculture. Vegetables provide a good source of income to the growers and play an important part in human nutrition. They are quick growing and provide immediate returns to the growers. Since the yield from vegetables is three to four times more than that of cereals and pulses their cultivation occupies an important place in the agricultural development and economy of the country.

In Kerala, vegetable production is estimated at 5.16 lakh tonnes annually from an area of 43,412 ha (Farm Information Bureau, 2012), whereas the requirement of the state is 27.11 lakh tonnes, as per ICMR norms. Moreover, the yield per hectare is also very low, as compared to that of developed countries. The soil and climatic conditions in Kerala are quite suitable for getting maximum production per unit area. These necessitate extended research efforts to increase the productivity and to improve quality of the vegetable production. As far as Kerala is concerned, the extent of cultivable land is limited and hence vegetable production can be enhanced only through intensive multiple cropping practices. Therefore, vegetable cultivation in summer rice fallow has very good scope and is gaining popularity among the farmers of the state.

Cucurbits are the largest group of summer vegetable crops. They belong to the family Cucurbitaceae and are good sources of carbohydrates, vitamin-A, vitamin-C and minerals (Yawalker, 1980). Growing of cucurbitaceous vegetables in summer rice fallow is a common practice in Kerala. In India, it is eaten as raw with salt and pepper, or as salad with onion and tomato or else as cooked vegetable. The role of these vegetables in our diet needs no emphasis as it is regarded as protective food well equipped to combat malnutrition.

Oriental pickling melon (*Cucumis melo* var. *conomon*), popularly known as *kani vellari,* is grown for its golden yellow coloured matured fruits. In Kerala it is mainly cultivated in the rice fallows during summer months. The recommended spacing of the crop is 2.0 x 1.5 m which accommodates 10,000 plants per ha. Studies revealed that even long duration and vigorously growing varieties of oriental pickling melon occupy only about 50 percent of the land area used for its cultivation. Studies also revealed that fruit yield of oriental pickling melon variety 'saubhagya' could be increased by high density planting at 1.0 x 0.3 m over the recommended spacing of 2.0 x 1.5 m when the crop was planted during December. When oriental pickling melon was planted during February, highest fruit yield was observed at 1.0 x 0.45 m spacing, which was 173 percent higher than that of recommended spacing. Hence there is scope for increasing the productivity of oriental pickling melon by high density planting. Saubhagya, which is a short duration high yielding variety of oriental pickling melon maturing in 65-70 days and suited for high density planting, has other good qualities like concentrated fruiting and small attractive fruits. Saubhagya has gained wide acceptance among the vegetable growers of the state. In the above studies the productivity of oriental pickling melon at high density planting was assessed at the recommended dose of 70:25:25 kg NPK per ha which was standardized for a population of 10,000 plants per ha at the recommended spacing of 2.0 x 1.5 m. For achieving the maximum production potential of the crop at high density planting, the optimum nutrient requirement also needs to be studied. High density planting along with optimum dose of nutrients is likely to increase the productivity of oriental pickling melon many fold.

Under this context, an investigation on the "Yield maximization of oriental pickling melon **(***Cucumis melo* (L.) Makino**)** by high density planting and nutrient management" was conducted with the following objectives:

- To standardize the spacing in oriental pickling melon variety ‘saubhagya’ for maximizing the marketable yield.
- To study the effect of different levels of nutrients in oriental pickling melon variety ‘saubhagya’.
- To study the interaction effect of spacing and nutrient management in oriental pickling variety ‘saubhagya’.
- To work out the economics.

Review of literature

2. REVIEW OF LITERATURE

Cucurbits are the largest group of summer vegetable crops grown in the state of Kerala. They belong to the family cucurbitaceae and are grown for their ripe and unripe fruits. Cucurbits are good sources of carbohydrates, vitamin-A, vitamin-C and minerals (Yawalker, 1980). Among the agronomic practices, ideal plant population and an appropriate nutrition of the crop are important parameters to achieve the maximum productivity. Several studies have indicated the possibility of increasing the fruit yield of cucurbits by adopting high density planting. The nutrient requirement of the crop varies according to the planting density. Therefore it would become necessary to adjust the crop nutrition according to planting density. Attempts have therefore been made to review the works conducted in India and abroad on cucurbits and other vegetables on high density planting and nutritional management of the vegetable crops, particularly cucurbits. Among the cucurbits grown in the state, oriental pickling melon is more popular.

1. POPULATION DENSITY

There exists considerable variation in the spacing and population density in cucumber which varies with the type of cucumber *viz*. slicing, picking or parthenocarpic. The sex expression is also influenced by planting density, crop arrangement and genotype.

1.1. Growth, flowering and fruit set

Bach and Hruska (1981) reported in cucumber that when planted at different densities (56 and 77 cm between plants), density had greater values for most of parameters such as vine length, leaf area, number of flowers than plants at higher densities. But leaf area alone was increased at high density planting.

Cucumber when planted at different densities, the lower density had greater values for growth parameters such as wine length and number of flowers. But leaf area alone was increased at high density planting (Bach an Hruska, 1981). In an experiment to study the effect of spacing on growth and yield, Burgmans (1981) opined an increase in total yield with increase in plant density (1, 26,000 plants ha^{-1}). Studies by Al- Khayer (1982) revealed that among different spacings of1.5, 2.0, 2.5 and 3.0 plants m^{-2}, increase in plant densities increased fruit number and weight per plot. In an experiment with hybrids and open pollinated varieties of cucumber, Lower et al. (1983) found more staminate flowers and less pistillate flowers with an increase in plant density.

Singh (1990) observed introduction of early female flowers and total yield at a closer spacing of 90 x 22.5 cm in melons. A wider spacing 90 x 45 cm produced more vine length, branches and leaves per plant in melons. In a spacing trial in muskmelon variety Superstar, Elizabeth and Dennis (1998) reported yield and number of fruits per ha generally increased with plant population from 3074 to 10,076 plants, but number of fruits per plant and fruit weight decreased linearly with decrease in row spacing. Further studies by Nerson *et al*. (1984) revealed an increase in vegetable growth with increase in population from 13,500 to 31,250 plants per ha in muskmelon.

Population density affects plant growth, flowering pattern and fruit set in any crops. In parthenocarpic cucumber, the best plant growth, development, photosynthesis and yield were obtained when plants were grown at 1.5 plants per m^2 (Karataev and Slanikova, 1983).

Hafidh (2001) observed significant increase in staminate flowers and decrease in pistilate flowers and fruit flowers when plant spacing decreased from 30 to 20 cm and 20 to 10 cm. Further studies to determine the effect of plant spacing on yield and quality of pickling cucumber, Paroussi and Saglam (2002) observed that among different row spacing (20, 30, and 40 cm), highest yield was recorded in 20 cm compared to 30 and 40 cm.

According to Pandit *et al*. (1997), total number of fruits per plant and fruit length increased with decrease in plant spacing in pointed gourd cv. Damodarpandit.

In an experiment with musk melon, Nerson *et al*. (1984) observed faster vegetative growth per unit area with population of 31,250 plants than with 13,500 plants per hectare. There were more leaves per m^2, higher leaf area index and more dry matter accumulation with higher population density.

Kasrawi (1989) in an experiment with parthenocarpic cucumber cv. Marbasen to planting density reported that the timing of fruit production, sex expression and flower abortion were not affected by planting density. However, the shoot dry weight per plant decreased linearly and quadratically with the increase in plant density.

Arora and Malik (1990) conducted work in *Luffa acutangula* cv. Pusa Nasdar and revealed that when seeds were sown at 12, 9 and 6 plants per bed and where grown at a population density of 11,250 per hectare, the spacing of nine plants per bed gave the longest plant with highest secondary branches. It also resulted in early appearance of pistillate flowers and gave the highest number and weight of fruits.

Effect of population density on the performance of bitter gourd was investigated by Parekh (1990) using three levels of spacing (1.5 x 0.5 m, 1.5 x 1.0 m, 1.5 x 1.5 m). He observed that the wider spacing of 1.5 x 1.5 m gave the maximum vine length and number of primary branches per plant. The spacing of 1.5 x 1.0 m produced the wider sex ratio. Different levels of spacing showed non-significant effect on days to appearance of first female flower.

Effect of population density on the performance of squash melon was investigated by Bikramjit Singh (1990) using two spacing *viz*. 90 x 22.5 cm and 90 x 45 cm. He observed that closer spacing of 90 x 22.5 cm helped in introducing early female flowers. But spacing of 90 x 45 cm produced more vine length, branches and leaves.

Response of slicing cucumber (*Cucumis sativus* L.) to different planting densities was studied by Renji (1998). The study revealed that planting at the widest spacing of 2 x 1.5 m was the earliest for the male and female flower production.

The effect of population density varies with hybrids and open pollinated varieties and parthenocarpic cucumbers. In an experiment with hybrids and open pollinated varieties of cucumber, Lower *et al*. (1983) observed that by increasing density, the pistillate flowers per plant were reduced and staminate flowers increased in hybrids. However in open pollinated varieties population density had no effect on sex expression.

An experiment was carried out in tropical gynoecious cucumber hybrid (Phule Prachi) to standardize the fertigation requirements of the crop (Choudhari and More, 2002).The highest number of fruits per vine, yield per vine, yield per ha, vine length, content of nutrients in the plant after harvesting and lowest residues of nutrients in the soil were recorded in 1.80 m × 0.45 m spacing. The highest vine length, fruit diameter, fruit weight, number of fruits per vine, yield per vine and yield/ha, and highest nutrient content in the crop, as well as the lowest nutrient residues in the soil after harvest were recorded when 200:125:125 kg NPK/ha was applied.

1.2. Yield and yield components

Effect of plant population densities on performance of pickling cucumber was studied in the variety Spartan Dawan using three spacings by Wiebe (1965). Closer spacing resulted in increased yield per acre.

Pickling cucumber were planted at 1, 2 and 3 plants per hill with a spacing of 20, 40 or 60 cm and row width of 1m. The greatest number of fruits of acceptable size per hectare was obtained with 40 cm between hills and three plants per hill (Garica *et al*., 1973). Mangal and Yadav (1979) recorded maximum yield in cucumber grown at a spacing of 100 x 60 cm compared to 100 x 90 cm. similar studies in cucumber revealed that fruit number and yield per m² increased with increase in closer spacing (Enthoven, 1980).

According to Lazin and Simonds (1982) melons when spaced at 1, 2 and 3 feet within rows, decrease in spacing increased the number of fruits per plant but deceased mean fruit size and weight. The yield and quality of muskmelon as affected by various levels of spacings was investigated by Prabhakar *et al*. (1985) at Bangalore. In the study with the cv. Haramadhu using various levels of spacing, they observed highest yield of 45q ha^{-1} when plants were spaced at 60 x 60 cm compared to other spacings. In addition to the yield increase, the total soluble solids also increased.

Cucumber yields were higher in weight and number from beds spaced 1.20 m apart than from beds 1.50 m or 1.80 m apart in the studies of Halling and Amsen (1967).

Population density and spacing affect yield and its components to a greater extent. In watermelon, Petkov (1970) observed higher yield at a closer spacing with negligible effect on fruit size.

In an attempt to study the effect of plant density on performance of cucumber, Staub *et al*. (1992) observed that increased population density increased the number and weight of the fruit per ha but decreased the fruit weight. Wann (1993) observed that, among three different spacings 15 x 4, 22 x 3 and 33 x 2 inches, plant spaced at 15 x 4 inches produced higher yield compared to other treatment. Further studies by Hanna and Adams (1993) revealed high plant population achieved by decreasing spacings with in row from 12 to 6 inches increased total yield than plant spaced at 18 inches. In a work with cucumber cv. Japanese, Choigounghah *et al*. (1995) found maximum yield of 3, 80,020 kg ha^{-1} at planting density of 45,000 plants per hectare.

In an experiment with the slicing cucumber (Renji, 1998) reported that highest yield from the highest density of 13,333 plants per ha. Kanthaswamy et al. (2000) observed maximum yield of cucumber (125.82 t/ha) at 60 x 60 cm spacing with pruning of all primary branches after two nodes.

Borrelli (1971) observed increased yield per m ^{2}in melons but the yield per plant and fruit weight fell with increasing density. The rate of ripening and refractive index of the fruit was inversely related to the number of plants in the row. It was also seen that among the melon cultivars Vendrantais, Rafon and Ogen, Vendrantais performed best for closer spacing.

Belik and Veselovskii (1972) observed that in trials with the cv. Melitopol'skii 142 of watermelon, when planted from 1700 to 20,400 plants per hectare, leaf area, photosynthesis and total yield increased with planting density but greatest yield of marketable fruits was obtained from plots with 5000 to 10,000 plants per hectare.

In field trial with watermelon variety Sugar Baby at Agriculture College Farm, Dapoli by Patil and Bhosale (1973), it was revealed that row spacing of 2.4 x 2.4 m resulted in low yield, but as the spacing was reduced to 1.2 x 1.2 m, there was a progressive increase in yield.

Pickling cucumber cv. Chicago was planted at 1, 2 and 3 plants per hill with spacings of 20, 40 or 60 cm between and row width of 1 m. The greatest number of fruits of acceptable size per hectare was obtained with 40 cm between hills and 3 plants per hill (Garica *et al*., 1973).

In a trial with pickling cucumber cultivars Wisconsin, SMR and Pioneer, spacings of 30 x 30 cm to 15 x 15 cm, Hogue and Hemey (1974) obtained highest yield from those plants spaced at 15 x 15 cm.

Choudhari and More (2002) reported among three spacings (1.8 x 0.3m, 1.80 m x 0.45 m and 1.80 m x 0.60 m) highest number of fruits, yield per vine and yield per ha were recorded at 1.80 m x 0.40 m in cucumber. In an experiment to find out the effect of plant density on fruit growth when cucumber was grown at a spacing of 1.8 and 2.3 plants per m^2, Nishimura and Lopezgalvezig (2002) found that increased density decreased the total above ground biomass and the number of fruits but enhanced the biomass allocation to the vegetative shoot.

Echevarria and Castro (2002) observed among four plant densities (2, 1.67, 1.43 and 1.25 plants/m^2), production per plant increased with decrease in spacing (6.6, 19.2, 19.7 and 20.7 kg/plant). Earliness and quality were not influenced by plant density.

After evaluating the effect of plant density on growth and yield of watermelon var. Sugarbaby, Bindukala, (2000) found maximum fruits per plot and marketable yield per plant at highest density of 10,000 plants ha^{-1}.

In an attempt to study the effect of density on growth, development and yield on winter squash, Bortwright et al. (1998) found maximum marketable yield of 18 t/ha at 1.1 plants/m^2. In an experiment to find the effect of four plant spacings (3.0 x 0.60 m, 4.0 x 0.60 m, 3.0 x 0.75 m and 4.0 x 0.75 m) on growth, yield and quality of pumpkin, Singh and Naik (1989) observed significant increase in fruit yield per plant with increase in intra row spacing from 60 cm to 75 cm. The closer spacing of 3 m x 60 cm recorded maximum yields of 108.12 q/ha and induced early female flowers.

Yadav *et al*. (1989) studied the effect of spacing on different varieties of pointed gourd and revealed that among two spacings, 1.5 x 1.5 m and 3 x 1.5 m, maximum yield of 110.32 q/ha was recorded at a spacing of 1.5 x 1.5 m.

When the cultivars of pickling cucumber, Pioneer and Premier were grown at 50 and 70 cm between the rows, yield and returns were higher at 70 cm row spacing with Pioneer. However, in Premier, 50 cm spacing was preferable (Kretchman, 1974). In another trial with cultivars Earlipik, Peerfectoverde and Pioneer spaced at 1, 2 or 3-4 feet within the row, yields and returns of all cultivars were highest at the closest spacing. Highest yield of 31.7 t $ha^{-1}$of cucumber was obtained in cultivar Ashely spaced at 1.4 x 0.4 m (Marin Hautrive and Perez Guerra, 1976).

In the spacing cum varietal trial using three varieties of pumpkin and three levels of spacing, Noon (1977) obtained highest yield, highest number of mature fruits and lowest number of immature fruits per plant from ‘Lady Godiva’ at the closest spacing of 1 m x 1 m.

Ko *et al*. (1978) planted *Luffia cylindrica (aegyptica)* at 90 and 60 cm apart in rows of 150 cm and observed the optimum spacing as 150 x 90 cm.

Response of watermelon cv. ‘Charleston Gray’ to within row and between row spacing was studied with identical experiments at two locations viz. Gainesville and Leesburg by Brinen *et al*. (1979). In both the locations they observed decreased fruit yield and increased fruit size when between row spacing was increased from 1.5 m to 4.5 m and within row spacing from 50 cm to 250 cm.

In a trial with cucumber, cultivars Stereo, Corona and Sandra, Enthoven (1980) reported that the fruit number and yield per m^2 increased with increase in closer spacing. Though plants were spaced at 80 and 50 cm, the closely spaced plants of 50 x 50 cm gave the highest fruit number.

Bicano and Micols (1980) observed that when the pickling cucumber cultivars were spaced at the rate of 11 to 66 plants per m^2, increase in planting density also increased the number of small fruits and the gynoecious hybrid cultivar Pioneer was more productive up to 554 q ha^{-1} than the cultivar SMR-18 which produced 446 q ha^{-1}.

Burgmans (1981) conducted an experiment in gherkins to study the effect of spacing on growth and yield by using two varieties *viz.* “Green Spear” and “SG-812”. From the results of three years of trial, he observed the highest stable and total yield with highest plant population (1, 20,000 plants ha^{-1}).

According to Bach and Hruska (1981), when cucumbers were planted at different densities (56 and 77 cm between plants), low density showed greater value for fruit yield. Liebig (1981) reported that when five weeks older plants of the cucumber cv. Pepinese were planted at 1.1 to 4.9 plants per m^2, fruit yield increased with plant density but allowing for the cost of transplants, the advantageous spacing was 2 plants per m^2.

Tesi *et al*. (1981) observed that Albatross, F_1 hybrid of Courgettes when grown at different spacings of 2.25, 1.48, 1.2 plants per m^2, the widely spaced plants gave the heaviest but shortest individual fruits.

Mangal *et al*. (1981) conducted spacing experiment on watermelon cv. Sugar Baby. The plants spaced at 30 cm gave best results with regard to yield (32.2 – 42.2 kg) and showed slight delay in ripening.

Baljeet Sing *et al*. (1982) in trials with muskmelon cultivar Haramadhu found that the yield loss of 151.8 q ha^{-1} at 60 cm spacing and 333.6 q ha^{-1} at 30 cm spacing but the quality parameters like total soluble solids (TSS), vitamin C, reducing sugar contents and pulp thickness remained unchanged.

Lazin and Simonds (1982) reported that, two cultivars namely Early Dew and Tam Dew of melons when spaced at 1, 2 and 3 feet within spacing increased number of fruits per plant. But the mean fruit size and weight of the fruit were decreased.

Al-Khayer (1982) studied the effect of spacing with two hybrids of salad cucumber Ksalata F_1 and Fembaby F_1. He found that, of the different spacings of 1.5, 2.0, 2.5 and 3.0 plants per m^2; increase in plant densities increased the fruit number and weight per plot in different hybrids.

Douglas *et al*. (1982) observed the performance of Buttercup squash (*Cucurbita maxima*) planted in 1.5 and 3 m row and spaced at 29 – 100 cm, the highest yield of 27 t ha^{-1} was obtained at the closest spacing. It was also observed that increasing density gave a progressive decline in the size of the individual plant and number and weight of the fruit. Significant numbers of fruits weighing more than 2 kg were only achieved at low population, but a considerable loss of potential yield was observed at low population.

McGowan and Slak (1982) in a trial with two Buttercup squash cultivar spaced at 0.26 to 1.5 m^2 per plant observed higher total yield with increase in plant density. Marketable yields, however was highest at 0.38 m^2 per plant.

Nelson *et al*. (1983) conducted an experiment in Buffalo gourd to study the effect on population density on root yield. They found that a maximum yield of 34,500 kg was obtained from the highest density of 5, 55,000 plants per hectare.

Wehner and Miller (1983) compared the performance of determinate and indeterminate cultivars of cucumber under varying plant densities. They reported that, higher optimum density gave higher yields for the indeterminate cultivar ‘Table green 65’.

In a spacing trial of watermelon cultivars such as Baby Fun, Minilee and Mickylee, fruit yields were highest when plants were grown at 24 inches in rows spaced at 5 ft. apart rather than 16 or 32 inches of the same row spacing (Elmstrom and Crall, 1986). Minilee fruits were smaller than Mickylee. Fruits of all the cultivars remained productive for a longer period and had good fruit quality.

Nerson *et al*. (1986) in their experiment with *Cucurbita pepo* cv. Goldy at different plant densities ranging from 10,000 to 66,666 plants per hectare, obtained highest yield with densities ranging from 40,000 to 50,000 plants ha^{-1}. There was no delay in the time of first harvest at high densities compared with lower densities, but yield, quality and number of fruits were low at the lowest planting density. Fewer oversized and virus affected fruits were produced at higher densities, where as fewer off shape fruits were produced at the lower densities.

The yield of bottle gourd was affected by various levels of spacing in the investigations of Shukla and Prabhakar (1987). In the study with cv. 'Arka Bahar' at various levels of spacing, they observed highest yield of 38.5 t ha^{-1} when plants were spaced at 300 x 45 cm with three plants per hill compared to other spacings.

Gilreath *et al*. (1988) in their studies with cultivars of watermelon, Baby Fun and Minilee, highest yields for both the cultivars were obtained at 1.5 ft in row spacing. However the highest proportions of optimum sized fruits were produced at one foot row spacing for Baby Fun and 2 feet in row spacing for Minilee.

Silva *et al*. (1988) in the study with pickling cucumber, seeds of female cultivars namely Ging A.77 and Score were sown at four densities (13, 333 – 80, 000 plants ha^{-1}). The highest commercial yield (15.6 to 15.8 t ha^{-1}) was obtained at the densities of 80,000 plants ha^{-1}.

Aurin and Rasco (1988) observed in *Luffa cylindrica*, that an increase in plant density from 40,000 to 1, 06,666 plants per hectare increased both the yield (from 17.5 to 37.1 t ha^{-1}) and the marketable fruits.

The responses of parthenocarpic cucumber cv. Marbason to planting density and row arrangements were investigated in plastic green house by Kasrawi (1989) over two growing seasons with four planting densities. It was found that the yield per unit area increased linearly when the population density was increased from 2.4 to 5.4 plants per m^2.

Yadav *et al*. (1989) conducted an experiment at the vegetable research farm of Narendra Deva University of Agriculture and Technology, Faizabad to study the influence of spacing and methods of trailing on different varieties of pointed gourd. Three varieties viz. FP-1, FP-3, FP-4 and two spacing viz., 1.5 x 1.5 m and 3 x 1.5 m were considered for study. Maximum yield of 110.32 q ha^{-1} was recorded under bower system of planting with narrow spacing (1.5 x 1.5 m) in the variety FP-4.

In a two season trial with *Cucumis melo* var. flexuosus and different densities, it was found that fruit yield increased with planting density, highest being in 30 cm spacing in one season and 15 cm in the other season (Mohammed *et al*., 1989).

In the study of cultivar response and different planting densities, Widders and Price (1989) reported that leaf lamina and fruit tissues exhibited largest reduction in tissues when planting density was increased from 4.5 to 20 plants per m^2 (45, 000 to 200, 0000 plants ha^{-1}). Lower fruit productivity per plant at higher plant densities resulted from fewer fruit set per plant and lower fruit shoot ratio. But unit leaf area was not affected by plant spacing. Total fruit yield with a single harvest did not increase above 77, 000 $plantsha^{-1}$ for both cultivars.

Edelstein *et al*. (1989) in field trials with two *Cucurbita pepo* cultivars which were spaced 1000, 2000, 3000 and 4000 plants per unit area, observed that total yield remained unaffected by population density but there was negative relationship between plant densities and number of fruits per plant. In the plants of vine type, increase in plant density decreased the ratio of large to small fruits, where as in bush type plants, their ratio remained unaffected

Singh and Naik (1989) opined that in a two year trial with cultivar 'Arka Manik' of watermelon and different spacings, the optimum conditions for higher yields of 253.2 and 282.5 q ha^{-1} in the first year and 467.0 to 506.3 q ha^{-1}in the next year was obtained at 2.0 x 1.2 m spacing.

Effect of the plant spacing (3 m x 60 cm, 3 m x 75 cm and 4 m x 75 cm) on growth, yield and quality of pumpkin was studied by Kulbir Singh *et al*. (1990) in the loamy sand soils of Panjab Agricultuiral University. The different spacings did not changed the number of fruits per vine but the fruit yield per plant was increased significantly with increase in intra row spacing from 60 cm to 75 cm. The closer spacing of 3 m x 60 cm produced the maximum yield of 108.12 q ha^{-1} and the closer spacing induced early female flowers.

Different planting densities have desirable effects with respect to yield and vegetative characters. Bikramjit Singh (1990) reported that a closer spacing of 90 x 22.5 cm helped to induce early female flowers and total fruit yield in squash melon but spacing of 90 x 45 cm produced more vine length, branches, leaves, fruit number and yield per plant.

EL-Aidy (1991) reported that cucumber cultivar Sahara F_1, when grown at different plant densities of 2, 2.5 and 3.3 plants per m^2 did not differ significantly from each other in their yield.

Effect of high plant density on performance of cucumber was studied by Staub *et al*. (1992). They reported that although the number and weight of the fruits per ha increased with increasing plant density, fruit weight per plant decreased with increase in plant density.

Wann (1993) conducted an experiment to identify adapted cultivars, optimum population density and plant spatial arrangement in cucumber. The cultivars were grown in population density ranging from 26,000 to 1,30,000 plants per acre. The study indicated increased yield at densities above 26,000 plants per acre, but no increase was observed above 65,000 plants per acre.

Islam *et al*. (1994) reported that tuberous roots of *Momordica dioica* when planted at 3.0 m x 3 m spacing have the highest yield of 3,80,020 kg ha^{-1} and also had the highest yield of marketable fruits.

In a trial with spine gourd by Puzari (1997), the results revealed that, there was a significant interaction between tuber size and spacing only in the main crop where the yield was 13.1 t ha^{-1}. The ratoon crop produced 9 t ha^{-1}but was more susceptible to fungal pathogens and physiological degeneration.

In a trial with root cuttings of pointed gourd cv. ‘Damodar’Pandit *et al*. (1997) reported that total number of fruits per plant and fruit length increased with plant spacing. Total and early fruit yields were highest (101.71 and 169.82 q ha^{-1}) when plants were spaced at 60 cm apart in rows.

Nerson (1998) concluded from the experiment at Bet Hashita and Neweyaar, Israel that the two near Isogenic Cucumber Lines viz., WI 1983G Normal and WI 1983G Little Leaves when planted at the closest spacing of five plants per m^2, gave the highest yield.

Elizabeth and Dennis (1998) in their field studies during 1993 and 1994 to determine the optimal plant spacing for muskmelon cv. ‘Superstar’ reported that yield and number of fruits per ha generally increased as plant population increased from 3074 to 10,764 plants ha^{-1}, but the number of fruits harvested per plant and average fruit mass decreased linearly as in row spacing decreased.

Botwright *et al*. (1998) did experiment with *Cucurbita maxima* to find the effect of density on growth, development and yield. It was observed that marketable yield increased to maximum of 18 t ha^{-1} at 1.1 plants per m^2 and declined at higher densities because of increased number of undersized fruits. High plant density reduced the vegetative growth and also the yields were found to be less due to less female flower and increased abortion per plant.

In an experiment done with slicing cucumber, *Cucumis sativus* (Renji, 1998) reported that highest yield per plot (43.46 kg) was obtained from the highest density of 13.333 plants ha^{-1} (1.5 x 0.5 m).

Halling and Amsen (1970) recorded highest yield when the number of plants was increased and distance between the rows was shortened at the same time. High yield of 3.17 t ha^{-1} was obtained from cucumber cultivar Ashley spaced at 1.4 x 0.4 m (Marin Hautrive and Perez Guerra, 1976).

Choudhari and More (2002) reported that the highest number of fruits per vine, yield per vine, yield per ha, vine length, content of nutrients in the plant after harvesting and lowest residues of nutrients in the soil were recorded in 1.80 m × 0.45 m spacing.

Devi and Gopalakrishnan (2004) reported that, the closest spacing of 1.0 x 0.30 m, accommodating 33,333 plants/ha yielded 28.4 t/ha, which was 184% greater than the yield obtained in the conventional pit planting method (2.0 x 1.5 m).Furthermore, average weight of fruits and productivity increased significantly when the trench-to-trench spacing was reduced from 2 to 1 m, implying a general favourable impact of closer trench/row spacing on the performance of less spreading oriental pickling melon cultivars, which are particularly suitable for the summer rice fallows of Kerala.

Eifediyi *et al.* (2011) conducted an experiment to evaluate the relationship between farmyard manure, inorganic fertilizer and dry matter weights on the yield of cucumber. The result of the study indicated that increasing the farmyard manure and fertilizer levels led to an increase in dry matter production and the yield of cucumber. There was a positive correlation between the total dry matter production and yield components of cucumber.

Onvia *et al.* (2012) done an experiment to determine the interrelationship between yield and different yield components in cucumber (*Cucumis sativus*) using organic and inorganic fertilizers. Correlation analysis showed that in all the stages, plant height was positively and significantly correlated with number of leaves while number of flowers was positively correlated with fruit weight and fruit yield. Based on the results obtained, the use of urea will greatly enhance the production of cucumber more than the use of poultry manure or NPK.

2. NUTRIENT MANAGEMENT

The nutrient requirement for plants varies with plant population per unit area. Cucumber responds well to manures and fertilizers. Plant nutrition affects the growth, flowering and fruit set. The doses of fertilizer depend upon the soil type, density of planting, climate and system of cultivation. The nutrient level affects plant growth, earliness, sex expression and ultimate yield and quality. Application of nitrogen induces an early vegetative growth, more flowers, fruit set and higher yield. The phosphorus requirement of cucumber was the greatest during the first 20 to 30 days after germination. The deficiency of potassium decreased plant growth, fruit size and yield. Arriving at an optimum nutrient requirement is an important consideration of fertilizer trials of various crops.

2.1. Effect of nitrogen

Nitrogen plays a key role for proper growth and development of all cultivated crops. As nitrogen levels increased, proportionate increase was also observed in growth and yield parameters.

Application of nitrogen increased the pistillate flower and fruit set in musk melon (Brantley and Warren, 1958). According to Brantley and Warren (1961) and Flocker *et al*. (1965), nitrogen is an essential nutrient element to provide vegetative growth, and its ample supply ensures adequate size of plant and early initiation of pistillate flower at the lower nodes of the main axis. Number of female flower production was increased with increasing nitrogen (100 to 300 kg as calcium nitrate ha^{-1}) fertilization in cucumber as reported by Tayal *et al*. (1965)

Rekhi *et al*. (1968) found that application of 120 and 180 kg nitrogen ha^{-1} increased both perfect and staminate flowers, but the rate of increase was the greatest in perfect flower in musk melon. Cucumber cv. “Long Green” produced maximum and minimum number of female and male flowers respectively where nitrogen was applied at 80 kg ha^{-1} (Parekh and Chandra, 1969). Higher nitrogen dose of 120 kg ha^{-1} delayed the appearance of first female flower in cucumber (Parekh and Chandra 1970). According to Pew and Gardner (1972), nitrogen deficiency delayed the appearance of flower bud in cantaloupe and marketedly reduced the vegetative growth.

Jassal *et al*. (1972b) obtained more female flowers at 165 kg N ha^{-1} and improved growth parameter with increasing levels of nitrogen in musk melon. Increased number of male and female flowers in bottle gourd with the application of nitrogen and Maleichydrazide was noticed by Pandey and Singh (1973). According to Berezhnova and Agzamova (1976) the musk melon plant produced maximum number of female flowers in nitrogen deficit soil. Brinen *et al.* (1979) reported that application of 1680 kg ha^{-1} NPK mixed fertilizer increased vine growth and more female flower production in water melon. In "Tinda" increasing level of nitrogen significantly increased vine length, stem diameter, number of leaves and female flowers per plant (Singh *et al*., 1982)

Raychaudury *et al*. (1984) found reduced vine growth, size of leaves and number of flowers in round gourd due to nitrogen deficiency. Siyag and Arora (1988) reported that application of 75 kg nitrogen ha^{-1} increased the length of main vine in sponge gourd. While 50 kg nitrogen ha^{-1} gave maximum number of branches at final harvest. Highest number of female flower production was observed by Arora (1989) in sponge gourd by the application of nitrogen and phosphorus. In a trial with cucumber cv. "Tonh", Maurya (1989) observed highest number of female flowers and the best fruit quality with 80 kg nitrogenha^{-1} with boron application. However nitrogen at 90 kg per ha applied to cucumber enhanced female flower and leaf production (Stoliarov and Fanina, 1989).

Suresh and Pappiah (1991) reported that in bitter gourd, the vine length, number of leaves per plant and dry matter production per plant increased significantly due to nitrogen doses. The length of main vine and number of branches per plant were significantly influenced by the application of nitrogen levels in bitter gourd (Samdyan *et al*., 1992). Avakvan *et al*. (1992) reported that increase in nitrogen application from 90 to 210 kg ha^{-1} resulted in delayed flowering. As the rate of applied nitrogen increased, the concentration of chlorophyll in the leaves of cucumber increased and concentration of potassium, calcium and magnesium in the fruits decreased (Um *et al*., 1995).

Brantley (1958) observed that nitrogen at 100 lb $acre^{-1}$ increased the total yield and fruit size in water melon. Significant influence of nitrogen on yield in squash melon was reported by Dhesi *et al*. (1964). Highest fruit yield in bitter gourd was recorded at 56 kg nitrogen ha^{-1} (Dhesi *et al*., 1966).

Highest yield of 11.28 kg $plant^{-1}$ was obtained with 110 kg nitrogen ha^{-1} as against yield of 10.18 kg with 165 kg nitrogen in musk melon (Jassel *et al*., 1972a). Patil and Bhosale (1976) recorded the highest number and weight of fruits at 75 kg nitrogen ha^{-1} in water melon. Highest yield of 66.1 t ha^{-1} marketable water melon fruits were harvested with the application of nitrogen at 1680 kg mixed fertilizer per ha by Brinen *et al*. (1979). Bomme (1981) reported increased yield in cucumber by spraying urea 3 % thrice at weekly interval starting from first picking in cucumber. However Randhawa *et al*. (1981) noticed that nitrogen at 75 kg ha^{-1} increased fruit per vine, average fruit weight and total marketable yield in muskmelon. By applying 112 kg nitrogen ha^{-1} at soil $_{P}$H 6.0 in water melon, maximum yield was reported by Sundstrom and Carter (1983).

Maximum fruit yield in cucumber was obtained with supply of 300 ppm nitrogen (Alan, 1984). Hanna and Adams (1984) reported significant yield increase in cucumber due to high dose of nitrogen (600 to 800 lb $acre^{-1}$) and also application of NPK mixture (13: 13: 13) from 0 to 800 lb $acre^{-1}$ recorded higher yield in staked cucumber cv. Sprint. According to Srinivas and Prabhakar (1984), in muskmelon response of nitrogen was marked up to 50 kg ha^{-1} P_2O_5 and K_2O each at 60 kg ha^{-1} led to yield increase. Mangal *et al*. (1985) recorded double the number of fruits per plant in round melon at 80 kg N ha^{-1}. Increased total yield in pointed gourd at high dose of 90 kg nitrogen was found by Das *et al*. (1987). Kulbir Singh *et al*. (1990) recorded increased total yield in pumpkin with increase in total nitrogen from 40 to 80 kg ha^{-1} and highest level of nitrogen (120 kg ha^{-1}) depressed yield. Suresh and Pappiah (1991) opined that application of nitrogen and Maleic hydrazide significantly increased the fruit weight, number of fruits per plant, yield $plant^{-1}$ and yield ha^{-1}

Maximum early fruit yield in bitter gourd was recorded with the application of 50 kg N ha^{-1} (Samdyan *et al*., 1992). Application of nitrogen significantly increased the fruit size, number of fruits, and weight of fruit per plant as well as yield in pointed gourd (Yadav *et al*., 1993). Yingjajaval and Markmoon (1993) found that application of nitrogen increased the fruit yield in cucumber. Um *et al*. (1995) found that nitrogen at 400 kg ha^{-1} produced good yield in cucumber.

Ferrante et al. (2008) studied the effect of nitrogen fertilization levels on the fruit quality at harvest time and during storage in melon. The total marketable fruit yield and fruit nitrogen content linearly increased with N levels. Antioxidant compounds decreased after storage but were not affected by N fertilization levels.

Barros et al. (2012) reported that the maximum commercial production of water melon was 40,428 kg ha^{-1} with a nitrogen level of 144.76 kg ha^{-1}.

Jungic et al. (2012) reported that increasing N fertilizing rates did not affect significantly on higher yield of watermelon, but it caused a large amount of leached mineral N. Satiable yield of watermelon was achieved at fertilization with 60 kg N/ha.

Colla et al. (2012) reported that increasing the nitrogen fertilization rate from 0 to 60 kg ha^{-1} increased melon yield by 21%, whereas increasing the nitrogen rate from 60 to 120 kg ha^{-1} increased melon productionby only 10%.

2.2. Effect of phosphorus

Srinivas and Doijode (1984) recorded the highest number of perfect flowers in musk melon with 60 kg P_2O_5 ha^{-1}. The plant growth in pointed gourd was increased with increasing levels of P_2O_5 (Das *et al*., 1987).

Downes and Lucas (1965) reported that application of super phosphate in bands two inches to the side and two inches below the seed level at planting time consistently and substantially increased the yield of pickling cucumber. Bishop *et al*. (1969) reported a positive yield response against application of phosphorus fertilizer in cucumber.

In water melon, Bhosale *et al*. (1978) obtained the highest fruit yield of 26 tonnes ha^{-1} with 30 kg P_2O_5 ha^{-1}. Increased yield of cucumber (30 t ha^{-1}) was also reported by Stoliarov and Fanina (1989) by the application of phosphorus at 90 kg/ ha. Experiments on vegetable cowpea in general revealed that the crop responded well to P_2O_5 levels from 30-50 kg ha^{-1} (Chandran, 1987, Jyothi, 1995).

Singh (1985) observed an increase in plant height in summer cowpea when phosphorus was applied at 60 kg P_2O_5 ha^{-1}. Chandran (1987) obtained higher number of leaves and increased vine length at the same level of phosphorus. Swaroop *et al*. (2002) reported that in vegetable cowpea, phosphorus had no significant effect on plant height, length of roots, number of branches per plant and number of leaves per plant.

Singh (2000) observed that in French bean application of phosphorus did not show any significant effect on plant height and whole weight of plant Highest early yield and highest total yield (6.52 kg per m^2) was obtained by the application of mixed fertilizer (19: 6: 20) in plastic house grown cucumber (E1–Hassan, 1991). He also reported that application of phosphorus at 7.6 to 15.2 kg ha^{-1} increased the fruit yield in cucumber. Higher yield of cucumber was recorded by Avakvan *et al*. (1992) by application of phosphorus at 90 kg ha^{-1}.

Barker (2012) assessed the effectiveness of amendment of acidic soil with limestone and organic matter on growth of tomato (*Lycopersicon esculentum* Mill.), corn (*Zea mays* L.), and cucumber (*Cucumis sativus* L.) with different P fertilizers. The results shown that superphosphate was the superior P source to sustain crop growth, limit deficiency symptoms, and enhance P accumulation. Bone meal was less effective than superphosphate but exceeded rock phosphate in these capacities. Rock phosphate was better than adding no P fertilizer. The amendments of limestone or organic matter singly or together had little effect on growth, appearance, or P accumulation. The availability of P in the fertilizers governed the growth responses of the plants.

Cheraghi *et al.* (2012) studied the effects of phosphate fertilizer application on the heavy metal content in agricultural soils with different cultivation patterns. The results shows that Soils used for the cultivation of the three types of crop were not contaminated with As, Cr, Cu, Pb, or Zn. However, the pollution indices for Cd were 1.1, 4.4, and 3.8 in cucumber, potato, and sugar beet fields, respectively, which indicated moderate, high, and high levels of contamination, respectively. Soils from potato and sugar beet fields were heavily contaminated with Cd, which may have resulted from long-term overuse of phosphate fertilizers.

2.3. Effect of potassium

Plant requirement for available potassium is quite high. It plays an important role in enzyme activation, water relations, energy relations, translocation of assimilates, nitrogen uptake and protein synthesis (Tisdale *et al*., 1993).

Mc Collum and Miller (1971) observed that the application of potassium at 80 lb acre^{-1} increased vine length, leaf area, total dry matter production and higher fruit (10 t acre^{-1} with pickling cucumber).

Manuca (1989) opined that higher rate of K_2O application improved the vine growth, more female flower production and 10 to 40 per cent increased fruit yield in cucumber. Maximum number of staminate and pistillate flower was observed in the vines applied with nitrogen and potassium at 150: 100 kg ha^{-1}.

Application of potassium at 100 kg ha^{-1} recorded marked increase in fruit yield in squash reported by (Lachovev, 1968). Adams *et al*. (1992) reported a reduction in early yield due to lower level of potassium (47%) whereas increase in potassium application resulted in higher fruit yield in cucumber. The number and weight of fruits per vine in gherkin was more with the application of nitrogen and potassium at 150: 100 kg ha^{-1} (Premalakshmi, 1997). Also the vines applied with nitrogen and potassium at 50: 100 kg ha^{-1} produced the first pistillate flowers earlier in gherkins var. 'Calypso Hybrid' (Premalakshmi, 1997).

Joseph (1982) found that potassium exerted appreciable influence on plant height at the time of finale harvest. Significant increase in plant height due to application of potassium was reported by Lakatos (1982). Similar results were obtained by Zayed *et al*. (1985), Shukla *et al*. (1987) and Damke *et al*. (1988).

Demiral and Koseoglu (2005) reported that it is possible to improve fruit quality by applying as much as 600 mg L^{-1} additional K to the plants without a reduction in yield.

El-Bassiony *et al*. (2012) reported that all watermelon fruits characters except mean fruit weight were increased gradually by increasing potassium application levels, since the highest values of fruit diameter, fruit length, T.S.S., N%, P% and K% were obtained with the highest potassium application levels.

Pan Yan Hua*et al*. (2012) reported that potassium concentration was beneficial to the growth of watermelon seedlings; it could improve the quality of seedlings growth, root growth and development.

3. NUTRIENT INTERACTIONS

An interaction occurs when the response or a series of factors is modified by the effects of one or more factors. When this is between plant nutrients it is termed as nutrient interaction. When the response to two or more nutrients used together is greater, less and equal than the sum of their individual response, a positive, negative and no interaction respectively is said to have occurred. A balanced application of all the essential plant nutrients would result in balanced growth.

3.1. Nutrient interactions on growth and yield

In melon, level of nitrogen application did not affect early yield or average weight of fruit (Peterson, 1958). Lingle and Wight (1961) conducted a fertilizer trial in melon with four levels of N (0, 60, 120 & 240 kg ha^{-1}) and three levels of P_2O_5 (0, 25 & 125 kg ha^{-1}) and found that P fertilization was necessary for early maturity. Increased nitrogen application increased yield, but fertilizer treatment had no effect on fruit size. Shortage of nitrogen or potassium adversely affects cucumber shape (Bradley *et al*., 1961). Everett (1963) recorded a significant yield increase with organic and inorganic fertilizer combinations in cucumber.

Positive yield response for phosphorus and potassium in melon was reported by Sutton (1965). Haworth *et al*. (1996) reported that in potato, FYM with fertilizer produced much higher yield than mineral fertilizer alone. Calcium, magnesium and potassium contents in leaf tissues of squashes were dependent on the amount of nitrogen and phosphorus applied (Thomas, 1966). Increased application of nitrogen raised the nitrogen content and reduced the phosphorus and potassium contents in squashes (Thomas and MacLean, 1967).

Application of 25 t ha^{-1} of fresh cattle manure increased the yield of egg plant and cabbage but reduced the yield of cucumber and tomato (Omori *et al*., 1972).

Mathan *et al*., (1974) reported that inorganic form of nitrogen, phosphorus and potassium nutrients produced the maximum yield whereas organic form produced the minimum yield. Nath (1976) reported that P need not be applied to cucumber under tropical conditions. Cantliffe (1977) reported that nitrogen had a direct influence on the mineral nutrient composition of pickling cucumber leaf tissues. Nilson (1979) reported that organic fertilizers increased the contents of phosphorus and calcium in the dry matter where as the amount of potassium and magnesium were uninfluenced by the fertilizer used. In a comparison study with N (0, 60 and 120 kg ha^{-1}), P_2O_5 (0, 45 and 90 kg ha^{-1}) and K_20 (0, 45 and 90 kg ha^{-1}) in oriental pickling melon, response to N was observed to be quadratic and the optimum level was 96.6 kg ha^{-1} but P_2O_5 application did not show any significant effect. Response of K_2O was linear with respect to the fruit yield (Hassan *et al*., 1984).

Joseph (1985) reported that the highest dose of N, P and K gave the highest values for N content in melon fruits. Ragimova (1987) observed that FYM at 20 t ha^{-1} with N: P: K at 90: 90: 60 kg ha^{-1} along with Mn, Cu and Co produced highest yield in cucumber. An increase in leaf nitrogen content up to 4.33 per cent of dry weight as reported in cucumber, when a nitrogen dose 300 per cent or more than that of recommended dose was applied (Al-Sahaf and Al-Khafagi, 1990). In *Cucumis melo*, no nitrogen accumulation occurred at normal fertilizer rate (80 g N, 12 g P_2O_5, 10 g K_2O and 40 g CaO per plant) during warm season. But during the cool season, nitrogen accumulation occurred even at a fertilizer rate half of the normal amount (Kim *et al*., 1991). In *Cucumis melo*, Buzetti and Hernandez (1993) reported that when different doses of nitrogen were applied, the leaf content increased correspondingly.

Yalcan and Topcuoglu (1994)reported that in cucumber, plant dry weight, fruit yield and concentrations of N, P, K, Ca and Mg increased with increasing rate of P application. Park and Chiang (1997) reported that in aeroponic study of *Cucumis sativus* the leaf nitrogen content increased with the concentration of nitrogen in the nutrient solution. Sirohi (1997) reported that an application of 120-150 kg urea, 250 kg SSP and

80 kg potassium sulphate is useful for raising a successful cucurbit vegetable. Patil *et al*. (1998) conducted experiment in cucumber var. Himangi with nitrogen fertilizer at 50, 100, 150 or 200 kg ha^{-1}, phosphorus at 50 or 100 kg ha^{-1} and potassium at 50 or 100 kg ha^{-1} and it was shown that average yields were highest (145.5 kg ha^{-1}) with 150 kg N + 50 kg P + 50 kg K ha^{-1} and average fruit diameter, number of fruits per plant were also highest in this treatment. Navarro *et al*. (1999) reported that the increase of Ca^{2+} concentration in the nutrient solution under saline conditions improved vegetative growth and fruit yield in melon. In nutrient culture experiments, cucumber var. Chinesische, Si had no direct effect on P uptake or translocation to the shoot. It is suggested that Si could act as a beneficial element under conditions of nutrient imbalance (Marschner *et al*., 1999).

Tuncay *et al*. (1999) reported that in cucumbers, when the effect of leaf nutrient contents on quality characteristics (fruit diameter, fruit length, TSS, acidity, $_{P}H$, dry matter, fruit firmness and colour) were considered, K had significant positive direct effect on all of the quality traits. In cucumber, Alphonse and Saad (2000) observed an increase in vine length and yield on combined application of FYM and chicken manure. In pumpkin Bage *et al*. (2000) reported an early yield with application of cow dung compared to other organic manures like mahua cake, mustard cake and surja. Hadid *et al*. (2001) recorded higher fruit weight in cucumber by application of chicken manure compared to other organic manures.

In a field experiment conducted in southern Greece, Panagiotopoulos (2001) observed that nitrogen and potassium levels did not alter significantly the fruit yield in *Cucumis melo* and he also reported that nitrogen concentration of the recently matured leaves at the initial fruit stage reached high levels ranging between 4.8 and 5.3 per cent while decreasing to 2.5 – 3.6 per cent at harvest time and the same trend was found for leaf P, K and Mg but the opposite trend for Ca.

An experiment was carried out in Nagaland, India, to assess the appropriate nitrogen levels for the optimum growth, yield and quantity of cucumber and it was reported that nitrogen application markedly influenced the vegetative growth, bearing habit, yield and quality of fruits. In general nitrogen applied at 50 kg ha^{-1} gave the best results (Jaksungnaro and Akali, 2001). Potassium fertilizer application significantly enhanced the contents of ascorbic acid of cucumber (Guo *et al*., 2004). Rodriguez and Pire (2004) conducted a study in Cantaloup crop in Venezuela and it was reported that at harvest, the highest level of K. Ca and Mg were found in the petioles and the lowest values were found in the lamina, root and ripe fruits. The highest levels of N and P were found in the lamina and ripe fruits and the lowest in the roots. They also reported the total extraction of macronutrients were 75 kg N, 7 kg P, 64 kg K, 62 kg Ca and 10 kg Mg per hectare when 28,440 kg of fruits were harvested. K fertilizer application reduced the content of other nutrients in cucumber, although low K rates increased the nutrient uptake of the crop (Guo *et al*., 2004).

Experiments were conducted in Bangalore, Karnataka and it was reported that in cucumber the effect of varying N levels was significant on the weight, length, girth, volume and flesh thickness of fruits and plant N, P, K uptake and the application of various P levels also had positive influence on fruit length and volume and plant NPK uptake, whereas the different K levels had no significant effect on the fruit characters and P and K uptake by the plant (Umamaheswarappa *et al*., 2005). In *Cucumis melo,* the yield and uptake of nitrogen, phosphorus, potassium and Magnesium were greater with nutrient solutions containing high levels of Ca and there was no significant difference observed among the nutrient solutions studied for the quality parameters of fruits measured (Salas *et al*., 2005). Gul *et al*. (2007) reported that organic manuring decreased the total yield by 22.4 per cent in comparison to inorganic nutrient solution in cucumber.

In cucumber cultivars increasing N concentration in nutrient solution caused reduction in fruit yield and number, decreased fruit dry matter and increased total nitrogen and amount of phosphorus, but decreased potassium and calcium. This showed antagonistic effect of elements (Soltani *et al*., 2007). Experiments were performed in an open field using melon plants (*Cucumis melo* var. Prodigio). The total marketable fruit yield and fruit nitrogen content linearly increased with N levels. Antioxidant compounds decreased after storage but were not affected by N fertilization levels (Ferrante *et al*., 2008).

A hydroponic culture was carried out to study the effects of N, P, K deficiencies on root traits of cucumber, including root length, root surface area, projected area, average root diameter and biomass (Zhang Bai Ge*et al*., 2012). The results showed that compared with control, N and K deficiencies reduced cucumber shoot weight by 17.39 g/plant and 7.31 g/plant, root mass by 5.68 and 7.05 g/plant correspondingly, and decreased all values of root traits. P deficiency lessened 9.72 g/plant shoot weight but increased 0.45 g/plant root weight by raised 71.1% root volume, 31.4% total root length, 44.3% surface area, 48.7% projected area and 8.8% average diameter. The ratio of root/shoot was enhanced by 101.8% in N deficiency and 74.1% in P deficiency, but reduced by 33.3% in K treatment. It reveals a potential of shaping root system by deficient nutrient application.

An experiment was laid condition to evaluate the response of cucumber (*Cucumis sativus* L.) to different levels of NPK fertilizers under soilless culture (Kurup *et al.*, 2011). Application of optimum level of inorganic fertilizers is highly essential to meet the entire nutrient requirement of the crop when soil less cultivation is adopted. It has been well established that the applied inorganic fertilizers not only increased the growth of the plants but also increased the yield. It is also proved that using perlite as a growing media in soilless culture has definitely prevented the incidence of pests and diseases attack due to less involvement of harmful microorganisms as experienced in soil culture.

3.2. Interaction between N and P

Among the major nutrients, role of N and P are dominant in most cropping systems, their interaction are probably the most important of all interactions. Since the use of major nutrients especially N and P is very liberal due to high response of urea and comparatively less price of both sources of fertilizers, interaction fetches less importance. It is well known that increased growth requires more of both N and P, indicating that mutually synergistic effects result in both growth stimulation and enhanced uptake of the two nutrients.

Terman *et al*. (1977) reported that many workers have demonstrated that N-P interaction effects on yield are primarily attributable to N induced increase in P absorption by the plant.

An experiment in black soil at Dharward showed that among the different N and P levels, the N and P_2O_5 (40 kg ha^{-1}) gave the largest yield in groundnut. At higher levels of N and P, no further increase in yield was possible due to high fertility of soil (available P 48 kg ha^{-1}, and total N (0.063 per cent) (Biswas and Prasad, 1991).

3.3. Interaction between N and K

A study on tropical oil plants concluded the absence of a clear NK interaction. This may be consequence of the small number of N deficiencies in plants and very slight action of N and K metabolism (Ollagmier and Ocho, 1973).

The application of potassium influences nitrogen use efficiency at higher levels of N application. Application of 20 kg K_2O resulted in a yield increase of rice (3 q/ha at 40 kg N level). However the increase was three times more as N level increased from 40-120 kg/ha at the same K level (Biswas and Prasad, 1991).

The application of N and K doses did not alter fruit chemical characteristics but their increasing doses decreased the fruit texture of musk melon (Fernandes and GrassiFilho, 2003).

Contreras *et al.* (2012) conducted an experiment to study the effects of different nitrogen-potassium (N-K) fertilizers applications and two types of irrigation water on yield and nutritional behavior of melon. The increase in the NK concentration of the nutritive solution produced a rise in commercial production. The salinity of irrigation water did not affect marketable yield but had an effect on the fruit size, which was compensated for by an increase in the amount of fruit produced. Salinity and NK nutrition levels significantly affected dry matter and N and K uptake by melon plant. Nitrogen and K uptake present interesting correlations with production and with each other, as established by mean regression analysis.

Oliveira *et al.* (2008) evaluated the effect of nitrogen and potassium doses on fertilization efficiency of melon crop. Agronomic efficiency was influenced by N and K doses, irrigation depths and by factor interaction.

3.4. Interaction between P and K

A positive significant correlation between P and K contents of 14^{th} leaf in coconut was observed by Wahid *et al*. (1977). In coconut highest yield of 8491 nuts ha^{-1} was obtained in P_1K_2 combination followed by P_1K_1 and P_2K_2 with 7561 and 7377 nuts ha^{-1} respectively and on par with each other. Application of K at K_1 (450 g $palm^{-1}$) and K_2 (900 g $palm^{-1}$) showed a depression in yield when the dose of P was increased to P_2 level.

Spencer (1966) showed that high Cu levels applied to soil reduced the Fe content in leaves of citrus. Chashier *et al*. (1967) showed that nutrient interactions involving Fe and Cu explained the frequent occurrence of Cu deficiency on solids of high organic matter content rather than chemical fixation of Cu. Applied Fe reduced the uptake and concentration of Cu in oats only where Cu had been added to peat.

4. Effect of season and climatic factors on growth and yield

Ivanov (1978) observed negative correlation between growth characters and temperature when cucumber was sown at six different dates in April and May. Toka (1978) reported that temperature regime of 16ºC in the evening followed by low temperature of 10º to 12ºC in night increased yield by 12 per cent compared with the conventional cultivation under normal night and day temperature. Further studies by Slack and Hand (1981) revealed that increasing night temperature up to 23ºC increased early fruit yield in cucumber, though increase in day temperature above 22ºC had no influence on yield.

Hessiner and Drews (1985) in an experiment on green house cucumber observed that neither planting date nor night temperature affects total yield. Studies by Palkin (1987) revealed that air temperature of 20-30ºC, night temperature not below 12ºCand soil temperature not below 17ºC up to flowering and optimal day, night and ground temperature combination of 25-27ºC, 17ºC, 12-25ºC during flowering and fruiting lead to increase in yield in cucumber

Uffelen (1988) in an experiment with cucumber hybrid cv.TSKGA-77 observed that increase in night temperature advanced harvest by 4 days, however rise in day temperature advanced harvest by 12 days with increase in plant vigour and decrease in female flower production.

Wacquant (1989) observed that fruit development in cucumber was faster and fruits were larger at 19ºC night temperature, temperature above 35-45ºC decreased the sugar content and increased the proportion of glossy fruits. Further study by Markovskaya (2004) revealed that day and night temperature ranging from 28-32ºC at juvenile stage and 19-27ºC at flowering stage were optimum for cucumber growth.

In an experiment to find the effect of difference in day and night temperatures on growth of cucumber, Abouhadid *et al*. (1993) observed that night temperature higher than day temperature reduced the plant height mainly due to decrease in intermodal length. Medany (1995) in an experiment to find out fruit growth rate of cucumber in relation to night temperature observed that 18ºC had highest fruit growth rate compared to 10ºC night set point.

In an experiment to find the effect of temperature and light on growth of cucumber, Chen-quingjun *et al.* (1996) observed that under low light number of leaf and leaf area plant^{-1} were reduced with an intermodal length. Yield was mainly affected by sunshine hours, amount of solar radiation and air temperature. Robert *et al.* (2000) reported that leaf number, flower number and fruit growth rates were linearly increased with increasing air temperature and ideal temperature for cucumber was 82ºF. Temperature above 90ºF and below 60ºF caused slow growth.

In water melon, more number of female flowers per plant is produced in spring than in autumn (Padda and Kumar, 1971). However the proportion of female flowers was greater in autumn in the cultivars Midget, Verona and Sugarbaby.

Kamalnathan and Thamburaj (1972) studied the influence of weather factors on sex expression of pumpkin and reported that pre flowering and flowering phase were altered by change in day length and temperature. Cloudiness favoured the production of pistillate flowers.

Ma Dong *et al*. (2012) studied dissolved nitrogen and phosphorus concentrations in the runoff water under heavy rain. The results of correlation analysis between rainfall characteristics and nitrogen and phosphorus transport in the runoff plots showed that the transport load was positively correlated with rainfall and maximum rainfall intensity.

Materials and methods

3. MATERIALS AND METHODS

Investigation on "Yield maximization of oriental pickling melon *(Cucumis melo* var. *conomon*) by high density planting and nutrient management" was carried out at College of Horticulture, Vellanikkara, Thrissur, Kerala. The field experiment was conducted during December 2011 to February 2012 at Agricultural Research Station, Kerala Agricultural University, Mannuthy. The details of materials used and techniques adopted during the course of investigation are presented below.

3.1. LOCATION

The experimental site is situated at 12º 32' N latitude and 74º 20' E longitude at an altitude of 22.5 m above mean sea level. The area enjoys a typical warm humid tropical climate.

3.2. CROPPING HISTORY

The experimental site is a paddy field in which a transplanted wet crop (June-August) was regularly cultivated. The land is left fallow during summer season. Soil type of the experimental field is sandy clay loam. The soil characteristics of the experimental field are given in Table 1.

3.3. CROP AND VARIETY

Oriental pickling melon variety Saubhagya developed at the Department of Olericulture, College of Horticulture, Vellanikkara was utilized for the study. Its fruits are small to medium in size with uniform oblong shape. The developing fruits are green with light green lines and turn attractive golden yellow on ripening. Specific advantage of the variety is its short duration (60-65 days), less vegetative growth and small to medium sized attractive fruits.

3.4. SEASON

Field experiment was conducted during summer rice fallow season from December 2011 to February 2012. Meteorological data during the cropping period are presented in Table 2. The experiment was laid out in a Randomized Block Design with combinations of 5 planting densities and 3 doses of NPK. The layout of the experimental field is displayed in Fig.1. and the details are given below:

3.5. METHODS

3.5.1. Densities of planting

Spacing	No. of plants per plot (12 m²)	Population density (plants ha^{-1})
S_1:2.0×1.5m	12	10,000
S_2:1.25×0.45m	21	17,777
S_3:1.0×0.45	28	22,222
S_4:1.25×0.30 m	30	26,666
S_5:1.0×0.30m	40	33,333

S_1: Sowing in pits (pop recommended spacing)

S_2 to S5: Sowing in channels of size 3 m length, 30 cm width and 15 cm depth

Plate 1. Field layout preview

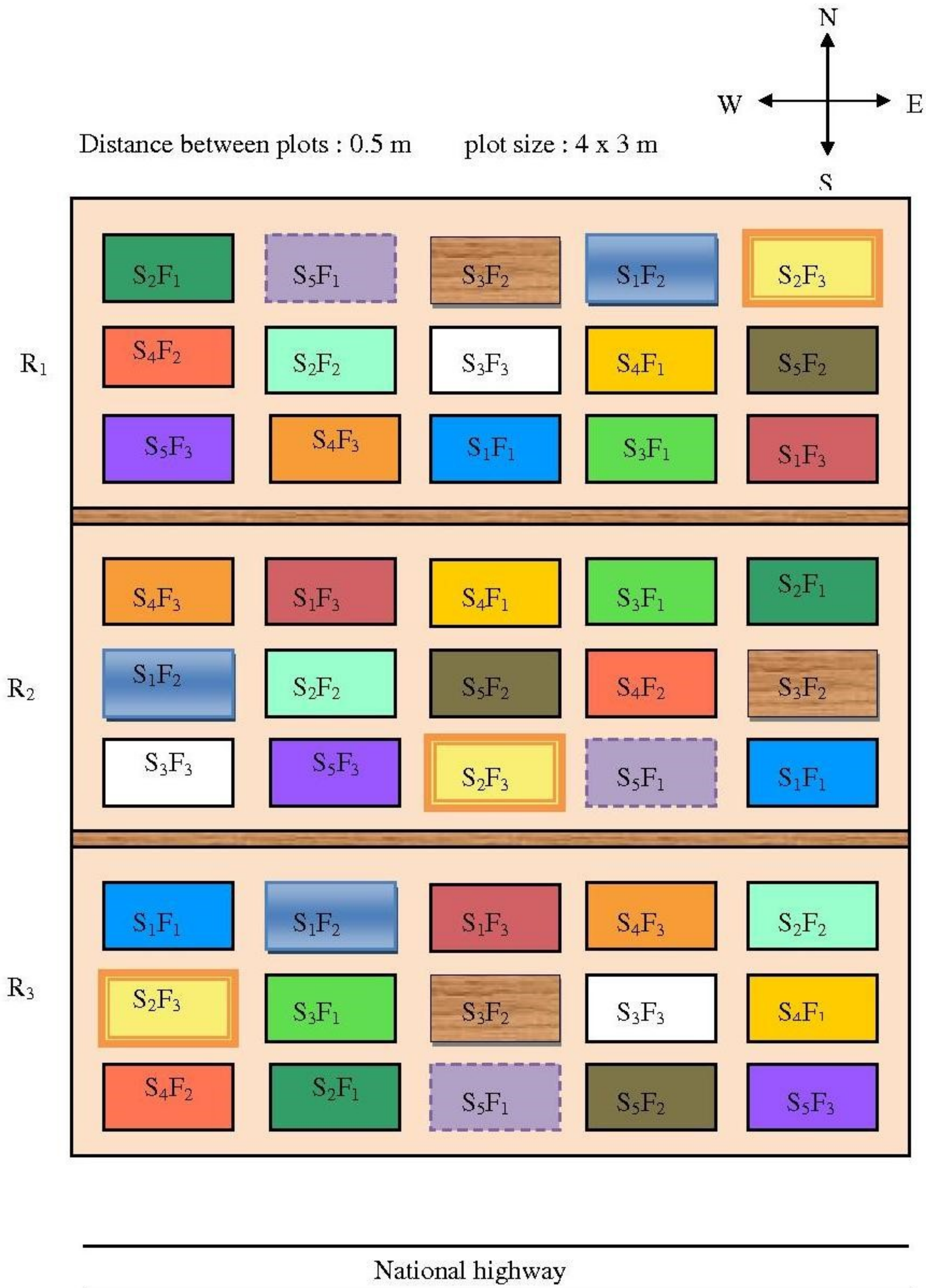

Fig 1. Experimental plot lay out

Table 1. Soil characteristics of the experimental field

Particulars	Value	Procedure adopted
1) Mechanical composition		
Coarse sand (%)	27.1	Robinson's international pipette method (Piper, 1950)
Fine sand (%)	23.9	
Silt (%)	22.8	
Clay (%)	26.2	I.S.S.S. system (ISSS, 1992)
Textural class	Sandy clay loam	
2) Physical constants of the soil		
Field capacity (0.3 bars)	21.82	Pressure plate apparatus (Richard, 1947)
Permanent wilting point (15 bars)	9.34	
Bulk density (g cm^{-3})		
0-30 cm	1.34	Core method (Blake, 1965)
30-60 cm	1.36	
Particle density (g cm^{-3})	2.16	Pycnometer method (Blake, 1965)
3) Chemical properties		
Organic carbon (%)	0.43	Chromic acid wet digestion method (Walkley and Black, 1934)
Available nitrogen (kg ha^{-1})	227.4	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	21	Bray and Kurtz method (Bray and Kurtz, 1947)
Available potassium (kg ha^{-1})	71	Neutral normal ammonium acetate extract using flame photometer (Jackson,1958)
Soil reaction (p^H)	5.4	1:2.5 soil : water suspension using p^H meter (Jackson, 1973)
Electrical conductivity (dS m^{-1})	1.25	Supernatant of 1:2.5 soil : water suspension using EC bridge (Jackson, 1973)

Table 2. Mean weekly weather parameters during the crop growth period (December 2011 – February 2012

Standard Week No.	Month and Date	Surface air Temperature (ºC)		Relative humidity (%)		Wind speed (km/hr)	Sunshine (hrs/day)	Evaporation (mm)		Rainfall (mm)	Soil temperature (15 cm depth)
		Max.	Min.	Morning	Evening					Morning	Evening
	2011										
50	December 12-18	32.5	23.9	73	46	8.0	8.9	40.7	0.0	27.3	30.4
51	December 19-25	31.0	23.5	62	44	9.8	6.1	44.8	0.0	26.7	29.6
52	December 26-31	31.7	20.1	81	50	4.4	6.4	28.6	2.4	26.6	29.8
	2012										
1	January 01-07	33.1	21.6	84	44	5.5	9.8	33.7	0.0	26.4	29.8
2	January 08-14	33.2	22.6	81	44	6.0	9.6	33.4	0.0	27.1	31.2
3	January 15-21	32.2	20.2	71	38	5.5	9.1	32.0	0.0	26.6	29.8
4	January 22-28	32.6	20.8	67	34	8.0	9.8	41.5	0.0	26.6	30.0
5	Janu. 29- Feb.04	32.7	22.3	66	39	8.9	9.3	46.3	0.0	27.1	30.7
6	February 05-11	34.9	23.0	78	41	4.6	8.9	35.8	0.0	28.3	32.1
7	February 12-18	35.1	22.5	83	38	4.7	8.9	36.9	0.0	29.0	32.4
8	February 19-25	36.0	21.0	74	22	4.9	8.8	42.3	0.0	28.2	32.1

3.5.2. Fertilizer doses

F_1: NPK : 70 - 25 - 25 kg ha^{-1} (RDF)F_2: NPK : 87.5 - 31.25 - 31.25 kg ha^{-1} (125% of RDF)

F_3: NPK : 105 - 37.5 - 37.5 kg ha^{-1} (150% of RDF)

3.5.3. Treatments

The treatments consisted of a combination of five planting densities and three doses of NPK. The details are given below.

Number of treatments: 15

Number of replications: 3

Plot size : 4 × 3 m (12 m²)

Sl No.	Treatment	Treatment particulars
1	T_1	S_1F_1
2	T_2	S_1F_2
3	T_3	S_1F_3
4	T_4	S_2F_1
5	T_5	S_2F_2
6	T_6	S_2F_3
7	T_7	S_3F_1
8	T_8	S_3F_2
9	T_9	S_3F_3
10	T_{10}	S_4F_1
11	T_{11}	S_4F_2
12	T_{12}	S_4F_3
13	T_{13}	S_5F_1
14	T_{14}	S_5F_2
15	T_{15}	S_5F_3

3.6. CULTURAL PRACTICES

3.6.1. Land preparation

The land was ploughed using tractor drawn disc plough, clods broken, stubbles were removed and the experimental plot was laid out. Channels and pits were taken with the spacing mentioned above. A total of 45 plots (15 treatments × 3 replications) were made with boundaries of width 50 cm.

3.6.2. Manure and fertilizer application

Farmyard manure at the rate of 25 t ha^{-1} was applied uniformly in all the channels and pits as basal dose. After thorough mixing with top soil, plots were irrigated using hose. Fertilizers applied were Urea, Factomphos and Muriate of potash at three different doses. Half of nitrogen and entire dose of phosphorus and potassium were applied as basal dose on 14^{th} DAS. The remaining 50% nitrogen was applied at the time of flowering and fruiting (35 DAS). The different doses of fertilizer is given in the table 3.

3.6.3. Sowing

Two seeds were uniformly sown at a point in each channel and three seeds were sown at a point in the pits. Gap filling was done on 12^{th} day after sowing and thinning was done on 17^{th} day after sowing by retaining only one plant per hill.

Table 3.Fertilizer schedule (per plot of 12 m²)

F_1 Basal			**Top dress**
Urea (g)	Factomphos (g)	MOP (g)	Urea (g)
26	150	50	91
F_2 Basal			**Top dress**
Urea (g)	Factomphos (g)	MOP (g)	Urea (g)
33	188	63	114
F_3 Basal			**Top dress**
Urea (g)	Factomphos (g)	MOP (g)	Urea (g)
39	225	75	136.5

3.6.4. Irrigation

A pre-sowing irrigation was given uniformly to all the channels and pits. After sowing, light irrigation with a rose can was given @ 10 l / channel^{-1} and 5 l pit^{-1} for 10 days. After that irrigation was given to the plots with the help of hose @ 2 irrigations per week. At the time of fertilizer application, irrigation was given with rose can for correct distribution of fertilizers.

3.6.5. Aftercare

Hand weeding was done on 14th and 28thday after sowing. Earthing up was done on 20th day after sowing. During fertilizer applications, gentle raking was given to the soil with the help of hand fork. After the second hand weeding, the whole field except channels and pits was mulched with coconut fronds.

3.6.6. Plant protection

Imidachloprid spaying was given on 10th and 30th days after sowing to control the attack of red pumpkin beetle, serpentine leaf minor and other small sucking pests @ 5 ml / 10 litre. At fruit development stage, attack of fruit flies were brought under control by spraying ekalux @ 4 ml / litre.

3.6.7. Harvesting

Fruits were harvested when they were fully matured (when they got attractive golden yellow stripes from stalk end to pedicel end).

3.7. BIOMETRICAL OBSERVATIONS

For understanding the effects of treatments on growth and development of the crop, growth and yield parameters were recorded. Growth and yield attributes were recorded from randomly selected five plants per plot and the average was worked out.

3.7.1. Number of vines per plant

The number of vines per plant was counted from four plants per plot at harvest.

3.7.2. Length of vines (cm)

The length of vines were observed and measured from the base to the tip at final harvest.

3.7.3. Number of leaves per vine

Total number of leaves per vine was recorded from two plants per plot at harvest.

3.7.4. Leaf area index

Leaf area index was calculated by dividing the total leaf area by the land area occupied by the plant (Watson, 1947). Leaf area was measured by leaf area meter on 45^{th} day after sowing.

Plate 2. Plant leaf coverage at 30 DAS as influenced by treatment

3.7.5. Shoot dry matter production at harvest

Shoots of four plants were taken from each field and the average was taken to get the fresh weight. After that it was dried in oven to find out the dry weight.

3.7.6. Days to first flowering

Number of days taken for first blooming of flower was recorded in all the four observational plants and average worked out.

3.7.7. Days to harvest

The crop was harvested in the third week of February 2012. It took about 66 days for harvest.

3.7.8. Volume of fruits (cm^3)

Volume of fruits from each plot was found from the selected fruits having mean weight using water displacement method.

3.7.9. Weight of fruits (g)

The weight of a fruit was calculated from total fruit yield and total number per plot.

3.7.10. Number of fruits per plant

The fruits harvested from all the plants in a plot were counted and the average number of fruits per plant was worked out.

3.7.11. Yield of fruits per plant and per hectare

Total weight of fruits harvested from each plot was recorded and the yield in kg $plant^{-1}$ and yield in tones $hectare^{-1}$ were worked out.

3.8. INCIDENCE OF PESTS AND DISEASES

Serpentine leaf minor and red pumpkin beetles were seen from the initial stages of crop growth. Fruit flies were found in the fruit development stages. All of them where brought under control by appropriate spraying of insecticides. Downy mildew was observed during harvesting time. However, it was not severe to take up plant protection measure.

3.9. NUTRIENT STATUS OF SOIL AFTER THE EXPERIMENT

3.9.1. Available nitrogen

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

3.9.2. Available phosphorus

The available phosphorus content of soil was determined by Bray and Kurtz method (Bray Kurtz, 1945).

3.9.3. Available potassium

The available potassium content of soil was determined byneutral normal ammonium acetate extract using flame photometer (Jackson,1973).

3.10. PLANT ANALYSIS

Leaf samples were collected at two stages of crop viz, 30 and 60 days after sowing. Fruit and shoot samples were collected at the time of harvest. Samples were oven dried, ground and used for N, P and K analysis.

3.10.1. Nitrogen content

The plant samples were digested by micro kjeldahl method (Jackson, 1973). Estimation was done by distillation and titration.

3.10.2. Phosphorus content

The plant samples were digested by diacid digestion (Jackson, 1973). Spectrophotometer was used for reading the colour intensity developed by Vanado-molybdate yellow colour method.

3.10.3. Potassium content

The potassium contents of samples were determined with diacid extract, reading in an EEL flame photometer (Jackson, 1973).

3.11. ECONOMICS OF PRODUCTION

The economics of production was worked out based on the input costs, labour charges and the price at which the local sellers accepted the fruits of cucumber at the time of harvest. Input costs were taken as the actual cost of the materials at the time conduct of the experiment. Labour charges considered were the prevailing labour wages of the locality at the time of conduct of the experiment. Based on this the total cost and return was worked out. From this the net income and the net profit per rupee invested was calculated.

3.12. STATISTICAL ANALYSIS

Analysis of variance was done separately for all the characters at different stages as per the statistical design of RBD with two factor combinations and significance was tested by 'F' test (Snedecor and Cochran, 1967). DMRT was used to identify homogenous group of treatments.

Results

4. RESULTS

The results obtained from the experiment on "Yield maximization of oriental pickling melon by high density planting and nutrient management" are furnished in this chapter.

4.1. Growth components

4.1.1. Number of vines per plant

The data on number of vines per plant at harvest are given in Table 4 and the analysis of variance in Appendix I.

The results indicated that, plant population and fertilizer treatments had significant influence on number of vines per plant, where as their interaction was not significant (Appendix I).

The number of vines per plant decreased with increase in plant population from S_1 to S_5. Among the different plant populations, highest number of vines per plant was recorded in S_1 and was significantly superior to all other plant populations. Second highest number of vines per plant was observed in S_2 and the lowest in S_5.

Number of vines per plant increased significantly with increase in fertilizer level. Among the fertilizer levels, highest number of vines per plant was observed in F_3 and was significantly superior to other levels.

4.1.2. Length of vine at harvest

The data on length of vine at harvest are given in Table 4 and the analysis of variance in Appendix. The results indicated the significant influence of plant population and fertilizer treatments on length of vines at harvest, and their interaction also was statistically significant (Appendix I).

Table 4. Influence of spacing and fertilizer levels on days to flowering and vegetative growth characteristics

Treatment	Days to first flowering	No. of vines per plant	Length of vine at harvest (cm)	No. of leaves per vine	Leaf Area Index
Spacing					
S_1	25.2[a]	5.33[a]	187.7[a]	19.7[a]	1.21[e]
S_2	25.0[a]	4.97[b]	176.7[b]	19.5[a]	2.01[d]
S_3	24.7[a]	4.67[c]	163.4[c]	17.3[b]	2.34[c]
S_4	24.8[a]	4.37[d]	157.0[d]	16.9[b]	2.65[b]
S_5	24.8[a]	4.13[d]	149.3[e]	15.7[c]	3.11[a]
Fertilizer level					
F_1	24.8[a]	4.30[c]	155.0[c]	16.4[c]	2.11[c]
F_2	24.8[a]	4.76[b]	166.2[b]	17.8[b]	2.27[b]
F_3	25.1[a]	5.02[a]	179.3[a]	19.4[a]	2.41[a]
Interaction	NS	NS	Sig.	Sig.	Sig.

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 5. Length of vines at harvest (cm) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	174.0[d]	186.0[c]	203.0[a]
S_2	162.0[ef]	174.0[d]	194.0[b]
S_3	153.0[gh]	168.0[de]	169.3[de]
S_4	147.0[h]	155.0[fgh]	169.0[de]
S_5	139.0[i]	148.0[h]	161.0[efg]

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

The length of vine decreased with increase in plant population from S_1 to S_5. Among the plant populations, significantly the maximum length of vine was observed in S_1. Minimum length of vine was observed in S_5 and it was significantly inferior to others.

Length of vine increased significantly with increase in fertilizer level. F_3 recorded the maximum vine length and it was significantly superior to other levels.

The interaction between plant population and fertilizer levels significantly influenced the length of vine at harvest (Table 5). In each plant population, length of vine increased with increase in fertilizer level up to F_3. But there was reduction in vine length under each fertilizer level when plant population was increased from S_1 to S_5. The increased application of fertilizer was significantly evidenced with a decreased plant population with S_1F_3 having the maximum vine length. The minimum length of vine at harvest was noticed in the combination of S_5F_1, which was inferior to all other combinations.

4.1.3 Number of leaves per vine at harvest

The data on number of leaves per vine at harvest are given in Table 4 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant influence on number of leaves per vine at harvest, and their interaction also was statistically significant (Appendix I).

Number of leaves per vine decreased with increase in plant population from S_1 to S_5 and increased with increase in fertilizer level from F_1 to F_3. Among the different plant populations, maximum number of leaves per vine was observed in S_1 spacing and it was at par with S_2 and was significantly superior to other populations. Minimum number of leaves per vine was observed in S_5. Out of the three fertilizer levels, F_3 showed highest number of leaves per vine, and was significantly superior to others.

The interaction between spacing and fertilizer levels significantly influenced the number of leaves per vine at harvest (Table 6). In each spacing, number of leaves per vine increased steadily with increase in fertilizer level up to F_3. At the same time, there was reduction in number of number of leaves per vine under each fertilizer level with increase in plant population up to S_5. The increased application of fertilizer was evidenced with a decreased plant population with S_1F_3 having the maximum number of leaves per vine. Lowest number of leaves per vine was observed in S_5F_1.

4.1.4. Leaf Area Index

The data on leaf area index at 45 DAS are given in Table 4 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatment had significant influence on leaf area index and their interaction also was statistically significant (Appendix I).

Leaf area index increased progressively and significantly with an increase in plant population and fertilizer level. Significantly the highest LAI was recorded in S_5 plant population and the lowest in S_1 spacing. Among the fertilizer levels, highest LAI was observed in F_3 and was significantly superior to F_2 and F_1.

The interaction between spacing and fertilizer levels significantly influenced the leaf area index (Table7). In each spacing, LAI increased steadily with increase in fertilizer level. At the same time, there was increase of LAI under each level of fertilizer with increase in plant population. The increased application of fertilizer was significantly evidenced with an increased plant population with S_5F_3 having the maximum LAI. The lowest LAI observed in S_1F_1 was significantly inferior to all other treatment combinations.

Table 6. Number of leaves per vine as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	18.1^{cde}	19.9^{b}	21.2^{a}
S_2	17.5^{def}	18.8^{c}	22.1^{a}
S_3	16.2^{gh}	17.4^{ef}	18.4^{cde}
S_4	15.6^{hi}	16.8^{fg}	18.5^{cd}
S_5	14.7^{i}	15.9^{gh}	16.6^{fgh}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 7. Leaf Area Index as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	1.10^{k}	1.24^{j}	1.30^{j}
S_2	1.83^{i}	2.04^{h}	2.15^{g}
S_3	2.20^{g}	2.35^{f}	2.46^{e}
S_4	2.48^{e}	2.60^{d}	2.88^{c}
S_5	2.95^{c}	3.10^{b}	3.28^{a}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

4.1.5. Dry weight of vegetative growth at harvest (g plant^{-1})

The data on dry weight of vegetative growth at harvest are given in Table 1_3 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatments had significant influence on dry weight of vegetative growth at harvest, and their interaction also was statistically significant (Appendix I).

Dry weight of vegetative growth per plant at harvest decreased significantly with increase in plant population from S_1 to S_5 and increase in fertilizer level from F_1 to F_3. Among spacing, S_1 recorded significantly the highest dry matter production per plant at harvest and minimum in S_5. Significantly the highest vegetative growth per plant at harvest was noticed in F_3 and minimum F_1.

The interaction between spacing and fertilizer levels significantly influenced the dry weight of vegetative growth at harvest (Table14). In each plant population, dry weight of vegetative growth per plant at harvest increased significantly with increase in fertilizer level up to F_3. At the same time, there was significant reduction in dry weight per plant under each fertilizer level when plant population was increased from S_1 to S_5. The increased application of fertilizer was significantly evidenced with a decreased plant population with S_1F_3 having the maximum dry weight of vegetative growth per plant at harvest. The lowest value was observed in S_5F_1 and was significantly inferior to all other treatment combinations.

4.1.6. Dry weight of total vegetative growth at harvest (kg ha^{-1})

The data on dry weight of vegetative growth at harvest are given in Table 13 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on total dry weight of vegetative growth at harvest, and their interaction also was statistically significant (Appendix I).

Total dry weight of vegetative growth at harvest increased significantly with increase in plant population from S_1 to S_5 as well as with increase in fertilizer level from

Table 8. Influence of spacing and fertilizer levels on dry matter production

Treatments	Dry weight of vegetative growth at harvest (g plant^{-1})	Dry weight of vegetative growth at harvest (kg ha^{-1})	Fruit dry weight (kg ha^{-1})
Spacing			
S_1	87.1^{a}	871.0^{e}	3668.0^{d}
S_2	81.3^{b}	1445.2^{d}	5899.0^{c}
S_3	74.9^{c}	1664.9^{c}	6198.0^{b}
S_4	71.7^{d}	1907.2^{b}	6664.0^{a}
S_5	66.7^{e}	2222.6^{a}	5963.0^{c}
Fertilizer level			
F_1	70.8^{c}	1506.3^{c}	5383.8^{b}
F_2	76.0^{b}	1614.2^{b}	5859.6^{a}
F_3	82.2^{a}	1746.0^{a}	5791.8^{a}
Interaction	Sig.	Sig.	Sig.

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 9. Dry weight of vegetative growth at harvest (g plant^{-1}) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	80.0^{c}	87.5^{b}	93.8^{a}
S_2	75.0^{d}	80.4^{c}	88.5^{b}
S_3	69.5^{f}	75.3^{d}	79.9^{c}
S_4	67.2^{g}	71.0^{ef}	77.0^{d}
S_5	62.4^{h}	65.9^{g}	71.7^{e}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 10. Dry weight of vegetative growth at harvest (kg ha^{-1}) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	800.0^{l}	875.0^{k}	938.0^{j}
S_2	1333.0^{i}	1429.3^{h}	1573.3^{g}
S_3	1544.7^{g}	1674.3^{f}	1775.7^{e}
S_4	1774.3^{e}	1893.3^{d}	2054.0^{c}
S_5	2079.7^{c}	2199.0^{b}	2389.0^{a}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

F_1 to F_3. Among plant population, S_5 recorded significantly the maximum total dry matter production at harvest and minimum in S_1. In the case of fertilizer levels, maximum total vegetative growth at harvest was noticed in F_3 followed by F_2 and F_1 respectively. F_3 was significantly superior to F_2 and F_1.

The interaction between spacing and fertilizer levels significantly influenced the total dry weight of vegetative growth at harvest (Table15). In all the plant populations, total dry weight of vegetative growth at harvest increased with increase in fertilizer level up to F_3. Similarly, there was significant increase in total dry weight of vegetative growth at harvest with increase in plant population from S_1 to S_5 under each fertilizer level. The increased application of fertilizer was significantly evidenced with an increased plant population with S_5F_3 having maximum production of dry weight of vegetative growth at harvest. The lowest value was observed in S_1F_1.

4.1.7. Fruit dry weight (kg ha^{-1})

The data on fruit dry weight at harvest are given in Table 13 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on fruit dry weight, and their interaction also was statistically significant (Appendix I).

Fruit dry weight increased significantly with increase in plant population up to S_4 and fertilizer level of F_2 and then decreased. Fruit dry weight was significantly the highest in S_4 and the lowest in S_1. Among the three fertilizer levels, maximum fruit dry weight was observed in F_2 and it was on par with F_3. Fruit dry weight was lesser in F_1.

The interaction between spacing and fertilizer levels significantly influenced the fruit dry weight (Table16). Dry weight of fruits per ha increased with increase in fertilizer level in S_1, S_2 and S_3 with fertilizer levels up to F_3. In S_4 it increased up to F_2 and then decreased. In S_5 there was slight decrease in fruit dry weight with increase in fertilizer level. There was increase in dry weight of fruits per ha under each fertilizer level with increase in plant population up to S_4 and then decreased under S_5. The increased application of fertilizer up to F_2 was significantly evidenced with an increased plant population up to S_4 with S_4F_2 having the maximum fruit dry weight at harvest. The lowest value was observed in S_1F_1.

4.2. Yield and yield attributes

4.2.1. Days to first flowering

The data on days to first flowering are given in Table 4 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had no significant effect on days to first flowering. It was also found that their interaction was not statistically significant (Appendix I). Days to flowering almost concentrated around 25 days.

4.2.2. Number of fruits per plant

The data on number of fruits per plant at harvest are given in Table 8 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on number of fruits per plant, and their interaction also was statistically significant (Appendix I).

There was a significant reduction in fruit number per plant with increase in plant population from S_1 to S_5. Among the different plant populations, maximum number of fruits per plant was observed in S_1 population and the minimum number in S_5. S_1 was significantly superior to all other plant populations. Number of fruits per plant significantly increased with increase in fertilizer level up to F_2. It was the highest in F_2 and was on par with F_3.F_1 was inferior to all other levels tried.

The interaction between spacing and fertilizer levels significantly influenced the number of fruits per plant (Table9). In each plant population, fertilizer level behaved differently on number of fruits per plant. In S_1, S_2 and S_3, number of fruits per plant increased up to F_2 and then remained without much change under F_3.Under S_4 and S_5, increase in fertilizer level did not influence fruit number per plant. There was a steady

Table 11. Fruit dry weight (kg ha^{-1}) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	3546.0^{h}	3771.0^{h}	3687.0^{h}
S_2	5100.0^{g}	6246.0^{cde}	6351.0^{bcd}
S_3	5742.0^{f}	6426.0^{bc}	6426.0^{bc}
S_4	6486.0^{bc}	6921.0^{a}	6585.0^{b}
S_5	6045.0^{def}	5934.0^{ef}	5910.0^{f}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 12. Influence of spacing and fertilizer levels on fruit characteristics, yield and days to harvest

Treatment	No. of fruits per plant	Average weight of one fruit (g)	Volume of one fruit (cm^3)	Mean fruit weight per plant (kg)	Mean fruit yield (t/ha)	Days to harvest
Spacing						
S_1	6.26^{a}	651.7^{a}	569.6^{a}	4.08^{a}	40.8^{d}	66.4^{a}
S_2	5.83^{b}	633.3^{b}	553.6^{b}	3.69^{b}	65.8^{c}	66.4^{a}
S_3	4.96^{c}	625.0^{b}	546.2^{b}	3.09^{c}	68.9^{b}	66.4^{a}
S_4	4.59^{d}	605.0^{c}	528.7^{c}	2.78^{d}	74.0^{a}	66.3^{a}
S_5	3.34^{e}	594.4^{c}	519.7^{c}	1.99^{e}	66.3^{c}	66.8^{a}
Fertilizer level						
F_1	4.77^{b}	615.3^{b}	537.8^{b}	2.95^{b}	59.9^{b}	66.1^{b}
F_2	5.12^{a}	627.7^{a}	548.6^{a}	3.23^{a}	65.1^{a}	66.6^{a}
F_3	5.10^{a}	622.7^{ab}	544.2^{ab}	3.19^{a}	64.4^{a}	66.8^{a}
Interaction	Sig.	NS	Sig.	Sig.	Sig.	NS

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

and significant decline in fruit number per plant under each fertilizer level with increasing plant population from S_1 to S_5.The increased application of fertilizer up to F_2 was significantly evidenced with decreased plant population with S_1F_2 having the maximum fruit dry weight at harvest. It was the lowest in S_5F_2 and S_5F_3.

4.2.3. Average weight of one fruit (g)

The data on average weight of one fruit is given in Table 8 and the analysis of variance in Appendix. The results indicated that, spacing and fertilizer treatments had significant influence on average weight of one fruit, where as their interaction was not significant (Appendix I).

Increase in plant population from S_1 to S_5 decreased the mean weight of one fruit, whereas it was increased by increase in fertilizer level up to F_2.Among the spacing, significantly the highest weight of one fruit was observed in S_1 and the minimum in S_5. Second highest weight of one fruit was observed in S_2 and was at par with S_3. Weight of fruit was maximum in F_2 followed by F_3 and F_1 respectively.

4.2.4. Mean volume of one fruit (cm^3)

The data on volume of one fruit at harvest are given in Table 8 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on volume of one fruit, and their interaction also was statistically significant (Appendix I).

Volume of one fruit declined with increase in plant population from S_1 to S_5.Among the spacing, significantly the highest volume of fruit was observed in S_1 and the minimum in S_5. S_1 was significantly superior to all mother plant populations. Volume of one fruit was maximum in F_2 fertilizer level followed by F_3 and F_1 respectively.

The interaction between spacing and fertilizer levels significantly influenced the mean volume of one fruit (Table10). The mean volume of one fruit did not differ very

Table 13. Number of fruits per plant as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	6.07^{b}	6.40^{a}	6.30^{ab}
S_2	5.20^{c}	6.10^{b}	6.20^{ab}
S_3	4.67^{d}	5.10^{c}	5.10^{c}
S_4	4.47^{d}	4.47^{d}	4.60^{d}
S_5	3.43^{e}	3.30^{e}	3.30^{e}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

much in each plant population with change in fertilizer levels. But there was steady decline in volume of fruit under each level of fertilizer when plant population increased from S_1 to S_5. The increased application of fertilizer up to F_2 was significantly evidenced with decreased plant population with S_1F_2 having the maximum volume of one fruit. The lowest fruit volume was noticed in S_5F_1.

4.2.5 Mean fruit weight per plant (kg)

The data on mean fruit weight per plant at harvest are given in Table 8 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on mean fruit weight per plant, and their interaction also was statistically significant (Appendix I).

Mean fruit weight per plant decreased significantly with increase in plant population. Among the spacing, significantly the highest mean fruit weight per plant was observed in S_1 and the minimum weight in S_5. Mean weight of fruit per plant was maximum in F_2 and it was on par with F_3. Among the fertilizer levels, lowest fruit weight observed in F_1 and it was significantly inferior to F_2 and F_3.

The interaction between spacing and fertilizer levels significantly influenced the mean fruit weight per plant (Table11). In S_1, S_2, S_3 and S_4, mean fruit weight per plant increased significantly up to F_2 and changed slightly only under F_3. In S_5, the mean fruit weight per plant slightly decreased with increase in fertilizer level. There was steady and significant reduction in mean fruit weight per plant under each fertilizer level when plant population was increased. The mean fruit weight per plant was maximum in S_1F_2 followed by S_1F_3 and it was lowest in S_5F_3. In all the three fertilizer levels, S_1 spacing recorded the maximum weight of fruit and the lowest in S_5. All the three fertilizer levels in S_5 spacing was on par with each other.

4.2.6. Mean fruit yield (t/ha^{-1})

The data on mean fruit yield are given in Table 8 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatments had significant influence on mean fruit yield, and their interaction also was statistically significant (Appendix I).

Total fruit yield per ha increased significantly with increase in plant population up to S_4 and thereafter decreased. Among the spacing, significantly the highest total fruit yield per ha was observed in S_4 and the lowest yield in S_1. Total fruit yield in S_1 (PoP recommendation) was significantly inferior to all the other plant populations. Yield of fruit was highest in F_2 and it was on par with F_3. Among the fertilizer levels, lowest fruit yield observed in F_1.

The interaction between spacing and fertilizer levels significantly influenced the total fruit yield (Table12). In S_1, total fruit yield did not vary significantly under the fertilizer levels. In S_2, total fruit yield increased up to F_3 but F_2 and F_3 were on par. In S_3 and S_4, total fruit yield increased significantly up to F_2 and S_3F_2 and S_3F_3 remained on par, whereas S_4F_3 was significantly inferior to S_4F_2. In S_5, slightly but non- significant reduction in fruit yield was observed with increase in fertilizer levels. There was significant increase in total fruit yield with increase in plant population under all the fertilizer levels up to S_4 and thereafter decreased. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2having maximum fruit yield per ha. The total fruit yield per ha was the lowest in S_1F_1.

4.2.7. Days to harvest

The data on days to harvest are given in Table 8 and the analysis of variance in Appendix I. The results indicated that while spacing had no effect on days to harvest, fertilizer levels had significant effect. There was a significant reduction in the number of days taken to harvest at the lowest level of fertilizer applied. But this amounted to a

Table14. Mean volume of one fruit (cm^3) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	568.0^{ab}	572.3^{a}	568.3^{ab}
S_2	541.7^{cde}	559.7^{abc}	559.3^{abc}
S_3	537.7^{de}	550.7^{bcd}	550.3^{bcd}
S_4	528.7^{ef}	536.0^{de}	521.3^{ef}
S_5	513.0^{f}	524.3^{ef}	521.7^{ef}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 15. Mean fruit weight per plant (kg) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	3.94^{bc}	4.19^{a}	4.09^{ab}
S_2	3.22^{d}	3.90^{c}	3.97^{bc}
S_3	2.87^{e}	3.21^{d}	3.21^{d}
S_4	2.70^{f}	2.88^{e}	2.74^{ef}
S_5	2.02^{g}	1.98^{g}	1.97^{g}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 16. Mean fruit yield (t ha^{-1}) as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	39.4^{g}	41.9^{g}	40.9^{g}
S_2	57.3^{f}	69.4^{bcd}	70.6^{bc}
S_3	63.8^{e}	71.4^{b}	71.4^{b}
S_4	72.1^{b}	76.9^{a}	73.2^{b}
S_5	67.2^{cde}	65.9^{de}	65.7^{e}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

reduction of only one day. It was found that the interaction between population and fertilizer level was not statistically significant (Appendix I).

4.3. Nutrient composition of leaf

4.3.1. Leaf nitrogen content (%)

The data on leaf nitrogen content at 30 DAS and 60 DAS are given in Table 17 and the analysis of variance in Appendix. The results indicated that while spacing had no significant effect on leaf nitrogen content, fertilizer level significantly influenced leaf nitrogen content at 30 DAS. Leaf nitrogen content increased with increase in fertilizer levels and the difference between F_3 and F_2 was not significant. F_3 was significantly superior to F_1. At 60 DAS, both spacing and fertilizer levels significantly influenced leaf nitrogen content. Leaf nitrogen content decreased significantly with increase in plant population. Significantly the highest leaf nitrogen content was observed in S_1 and lowest in S_5. Leaf nitrogen content was the highest in F_3 and the lowest in F_1.F_3 was significantly superior to F_1 and F_2. It was also found that their interaction was not statistically significant (Appendix I).

4.3.2. Leaf phosphorus content (%)

The data on leaf phosphorus content at 30 DAS and 60 DAS are given in Table 18 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatment had significant effect on leaf phosphorus content. But their interaction was not statistically significant (Appendix).

At 30 and 60 DAS, leaf P content decreased significantly with increase in plant population and increased significantly with increase in fertilizer levels. At 30 DAS, S_1 and S_2 recorded significantly the highest leaf phosphorus content and S_5 recorded the lowest. At 60 DAS, S_1 recorded significantly the highest leaf P content and the lowest in S_5. At 30 and 60 DAS, F_3 recorded significantly the highest leaf P content and the lowest in F_1.

Table 17. Influence of spacing and fertilizer levels on leaf nitrogen content (%)

Treatments	30DAS	60DAS
Spacing		
S_1	4.13^{a}	2.47^{a}
S_2	4.20^{a}	2.32^{b}
S_3	4.17^{a}	2.15^{c}
S_4	4.13^{a}	2.04^{d}
S_5	4.15^{a}	1.87^{e}
Fertilizer level		
F_1	4.09^{b}	2.02^{c}
F_2	4.16^{ab}	2.18^{b}
F_3	4.23^{a}	2.31^{a}
Interaction	NS	NS

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 18. Influence of spacing and fertilizer levels on leaf phosphorus content (%)

Treatments	30DAS	60DAS
Spacing		
S_1	0.47^{a}	0.33^{a}
S_2	0.47^{a}	0.29^{b}
S_3	0.46^{b}	0.28^{c}
S_4	0.45^{b}	0.25^{d}
S_5	0.44^{c}	0.23^{e}
Fertilizer level		
F_1	0.44^{c}	0.25^{c}
F_2	0.46^{b}	0.28^{b}
F_3	0.47^{a}	0.30^{a}
Interaction	NS	NS

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

4.3.3. Leaf potassium content (%)

The data on leaf potassium content at 30 DAS and 60 DAS are given in Table 19 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on leaf phosphorus content. But their interaction was not statistically significant (Appendix I).

Both at 30 and 60 DAS, leaf K content decreased significantly with increase in plant population and increased significantly with increase in fertilizer level. At 30 and 60 DAS, S_1 recorded significantly the highest leaf potassium content and S_5 recorded the lowest. Among fertilizer levels, F_3 recorded significantly the highest leaf K content both at 30 and 60 DAS.

4.4. Nitrogen content and uptake by shoot and fruit

4.4.1. Nitrogen content of shoot at harvest (%)

The data on nitrogen content of shoot at harvest are given in Table 20 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatment had significant effect on shoot nitrogen content. But their interaction was not statistically significant (Appendix).

Nitrogen content of shoot at harvest decreased significantly with increase in plant population and increased with increasing levels of fertilizer. Among the spacing, significantly the highest nitrogen content was noticed in S_1 and the lowest in S_5. Highest nitrogen content noticed in F_3 was on par with F_2 and the lowest content recorded in F_1.

4.4.2. Nitrogen uptake by shoot at harvest (kg ha^{-1})

The data on nitrogen uptake by shoot at harvest are given in Table 20 and the analysis of variance in Appendix. The results indicated that spacing and fertilizer treatment had significant effect on shoot nitrogen uptake. But their interaction was not statistically significant (Appendix).

Table 19. Influence of spacing and fertilizer levels on leaf potassium content (%)

Treatments	30DAS	60DAS
Spacing		
S_1	2.69^{a}	1.76^{a}
S_2	2.65^{b}	1.70^{b}
S_3	2.62^{b}	1.67^{b}
S_4	2.57^{c}	1.60^{c}
S_5	2.52^{d}	1.51^{d}
Fertilizer level		
F_1	2.57^{c}	1.60^{c}
F_2	2.60^{b}	1.65^{b}
F_3	2.65^{a}	1.69^{a}
Interaction	NS	NS

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 20. Influence of spacing and fertilizer levels on nitrogen content and uptake at harvest

Treatments	Nitrogen (%) of shoot at harvest	Nitrogen uptake by shoot at harvest (kg ha^{-1})	Nitrogen (%) of fruit at harvest	Nitrogen uptake by fruit at harvest (kg ha^{-1})	Total Nitrogen uptake at harvest (kg ha^{-1})
Spacing					
S_1	1.55^{a}	13.49^{d}	1.45^{a}	53.31^{d}	66.8^{d}
S_2	1.46^{b}	21.19^{c}	1.45^{a}	85.36^{c}	106.6^{c}
S_3	1.38^{c}	21.94^{c}	1.45^{a}	89.86^{b}	112.9^{b}
S_4	1.31^{d}	24.91^{b}	1.45^{a}	96.86^{a}	121.8^{a}
S_5	1.19^{e}	26.53^{a}	1.45^{a}	86.66^{c}	114.3^{b}
Ferti. levels					
F_1	1.33^{b}	19.54^{c}	1.45^{a}	77.84^{b}	97.4^{b}
F_2	1.39^{a}	21.26^{b}	1.45^{a}	85.23^{a}	107.2^{a}
F_3	1.41^{a}	24.04^{a}	1.45^{a}	84.17^{a}	108.9^{a}
Interaction	NS	NS	NS	Sig.	Sig.

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Nitrogen uptake by shoot at harvest increased steadily and significantly with increase in plant population and levels of fertilizer. Among the plant population, significantly the highest nitrogen uptake was noticed in S_5 and the lowest in S_1. Highest nitrogen uptake noticed in F_3 fertilizer level and the lowest in F_1. Effect of F_3 was significantly superior to F_2 and F_1.

4.4.3. Nitrogen content of fruit at harvest (%)

The data on nitrogen content of fruit at harvest are given in Table 20 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had no effect on nitrogen content of fruit at harvest. It was also found that their interaction was not statistically significant (Appendix I).

4.4.4. Nitrogen uptake by fruit at harvest (kg ha^{-1})

The data on nitrogen uptake by fruit at harvest are given in table 20 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on nitrogen uptake by fruit, and their interaction also was statistically significant (Appendix I).

Nitrogen uptake by fruits increased significantly up to S4 and then decreased. Among the plant population, S_4 recorded significantly the highest value and S_1 recoded the minimum uptake and it was inferior to all other populations. F_2 recorded maximum uptake and it was on par with F_3. F_1 showed the lowest uptake.

The interaction between spacing and fertilizer levels significantly influenced the nitrogen uptake by fruit (Table21). In S_1, S_3 and S_4 uptake of nitrogen by fruits increased significantly up to F_2 and thereafter decreased. Nevertheless, the nitrogen uptake by fruits was on par at F_2 and F_3. In S_2, nitrogen uptake by fruits increased up to F_3. Nitrogen uptake by fruits increased steadily under each fertilizer level up to S_4 and then decreased. In S_5 maximum uptake was in F_1. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum nitrogen uptake by fruits. The lowest uptake in nitrogen was recorded by S_1F_1.

4.4.5. Total nitrogen uptake at harvest (kg ha^{-1})

The data on total nitrogen uptake at harvest are given in table 20 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on nitrogen uptake, and their interaction also was statistically significant (Appendix).

Total nitrogen uptake increased significantly with increase in plant population up to S_4 and then decreased. Among the spacing, S_4 spacing recorded significantly the highest nitrogen uptake and S_1 recoded the minimum uptake and it was inferior to all other populations. Total nitrogen uptake increased with increase in fertilizer level and the highest uptake was observed in F_3. The effect of F_3 was on par with F_2 and both of which were significantly superior to F_1.

The interaction between spacing and fertilizer levels significantly influenced the total nitrogen uptake (Table22). In each plant population, total nitrogen uptake at harvest increased with increasing level of fertilizers. And the uptake was maximum under F_3 except in the case of S_4. In the case of S_4, uptake was maximum at F_2 and was significantly higher than that under F_3.In S_1, S_2, S_3 and S_5 the differences between F_2 and F_3 were not significant. Total nitrogen uptake increased significantly under each fertilizer level up to S_4 and then decreased. Under each fertilizer level, significantly highest uptake of nitrogen was observed under S_4. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum total nitrogen uptake by the crop at harvest. Lowest uptake of total nitrogen by the crop was noticed in S_1F_1.

Table 21. Nitrogen uptake by fruit as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	51.42^{h}	54.68^{gh}	53.82^{g}
S_2	73.44^{f}	90.56^{d}	92.09^{cd}
S_3	82.63^{e}	93.81^{cd}	93.15^{bc}
S_4	94.05^{cd}	101.05^{a}	95.49^{ab}
S_5	87.65^{b}	86.05^{cd}	86.29^{bc}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 22. Total nitrogen uptake by the crop as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	63.2^{h}	68.4^{h}	68.9^{h}
S_2	92.1^{g}	111.7^{cd}	115.8^{bc}
S_3	103.5^{f}	117.1^{bc}	118.2^{bc}
S_4	115.9^{bc}	126.2^{a}	123.2^{b}
S_5	112.2^{de}	112.4^{ef}	118.3^{ef}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

4.5.Phosphorus content and uptake of shoot and fruit

4.5.1. Phosphorus content of shoot at harvest (%)

The data on phosphorus content of shoot at harvest are given in Table 23 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on shoot phosphorus content. But their interaction was not statistically significant (Appendix I).

Phosphorus content of shoot at harvest decreased with increase in plant population and increased with increase in fertilizer level. Among the plant population, significantly the highest phosphorus content was noticed in S_1 and the lowest in S_5. Highest phosphorus content noticed in F_3 fertilizer level was significantly superior to F_2 and F_1 and the lowest content recorded in F_1.

4.5.2. Phosphorus uptake by shoot at harvest (kg ha^{-1})

The data on phosphorus uptake by shoot at harvest are given in Table 23 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on shoot phosphorus uptake. But their interaction was not statistically significant (Appendix I).

Phosphorus uptake by shoot at harvest increased significantly with increase in plant population and fertilizer level. Among the population, highest phosphorus uptake was noticed in S_5 and it was on par with S_4 and the lowest in S_1. Among the fertilizer levels highest phosphorus uptake was noticed in F_3 1 and the lowest in F_1.F_3 was significantly superior to F_2 and F_1.

4.5.3. Phosphorus content of fruit at harvest (%)

The data on phosphorus content of fruit at harvest are given in Table 23 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had no significant effect on phosphorus content of fruit at harvest. It was also found that their interaction was not statistically significant (Appendix I).

4.5.4. Phosphorus uptake by fruit at harvest (kg ha^{-1})

The data on phosphorus uptake by fruit at harvest are given in table 23 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on phosphorus uptake by fruit, and their interaction also was statistically significant (Appendix I).

Phosphorus uptake by fruits at harvest increased significantly with increase in plant population up to S_4 and by fertilizer levels up to F_2. Among the spacing, S_4 recorded maximum phosphorus uptake and S_1 recoded the minimum uptake and it was inferior to all other spacing. F_2 recorded the maximum uptake and it was on par with F_3. F_1 fertilizer level showed the lowest uptake.

The interaction between spacing and fertilizer levels significantly influenced the phosphorus uptake by fruit (Table24). In S_1 and S_5, phosphorus uptake by fruits at harvest remained almost same under the fertilizer levels. In S_2 and S_3, P uptake increased significantly up to F_2 and then leveled under F_3.In S_4, P uptake by fruits increased significantly up to F_2 and then decreased significantly. Phosphorus uptake by fruits under F_1 and F_2 increased significantly up to S_4 and then decreased and under F_3 up to S_3 and then decreased. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum phosphorus uptake by fruits. Lowest uptake of phosphorus by fruits was in S_1F_1.

Table 23. Influence of spacing and fertilizer levels on phosphorus content and uptake at harvest

Treatment	Phosphorus (%) of shoot at harvest	Phosphorus uptake by shoot at harvest (kg ha^{-1})	Phosphorus (%) of fruit at harvest	Phosphorus uptake by fruit at harvest (kg ha^{-1})	Total Phosphorus uptake at harvest (kg ha^{-1})
Spacing					
S_1	0.24^{a}	2.11^{d}	0.29^{a}	10.48^{d}	12.59^{d}
S_2	0.23^{b}	3.28^{c}	0.29^{a}	17.27^{c}	20.22^{c}
S_3	0.21^{c}	3.56^{b}	0.29^{a}	18.41^{b}	21.97^{b}
S_4	0.21^{c}	4.13^{a}	0.29^{a}	19.55^{a}	23.57^{a}
S_5	0.19^{d}	4.32^{a}	0.29^{a}	17.83^{bc}	22.14^{b}
Fert. levels					
F_1	0.21^{c}	3.13^{c}	0.29^{a}	15.78^{b}	18.84^{b}
F_2	0.22^{b}	3.41^{b}	0.29^{a}	17.42^{a}	20.62^{a}
F_3	0.23^{a}	3.90^{a}	0.29^{a}	16.92^{a}	20.83^{a}
Interaction	NS	NS	NS	Sig.	Sig.

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 24. Phosphorus uptake by fruit as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	9.81^{f}	10.93^{f}	10.69^{f}
S_2	15.29^{e}	18.11^{bc}	18.41^{bc}
S_3	16.67^{d}	19.27^{b}	19.28^{b}
S_4	18.80^{b}	20.76^{a}	19.09^{b}
S_5	18.34^{bc}	18.00^{bc}	17.14^{cd}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

4.5.5. Total phosphorus uptake at harvest (kg ha^{-1})

The data on total phosphorus uptake at harvest are given in table 23 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on phosphorus uptake, and their interaction also was statistically significant (Appendix I).

Total phosphorus uptake at harvest increased significantly with increase in plant population up to S_4 and by fertilizer levels up to F_2. Among the plant population, S_4 spacing recorded significantly the highest phosphorus uptake and S_1 recoded the minimum uptake and it was inferior to all other populations. F_3 fertilizer level recorded the maximum uptake and it was on par with F_2. F_1 fertilizer level showed the lowest uptake.

The interaction between spacing and fertilizer levels significantly influenced the total phosphorus uptake (Table 25). In S_1, S_2 and S_3 total phosphorus uptake increased with increase in fertilizer level up to F_3. In S_4 the uptake increased significantly up to F_2 and then decreased though F_2 and F_3 were on par. In S_5, the total P uptake remained almost constant at F_1, F_2 and F_3. There was increase in total P uptake under each fertilizer level with increase in plant population up to S_4 and then decreased. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum total phosphorus uptake by the crop. The minimum uptake of total phosphorus by the crop was in S_1F_1.

4.6. Potassium content and uptake of shoot and fruit

4.6.1. Potassium content of shoot at harvest (%)

The data on potassium content of shoot at harvest are given in Table 26 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on shoot potassium content. But their interaction was not statistically significant (Appendix I).

Table 25. Total phosphorus uptake by the crop as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	11.6^{f}	13.1^{f}	13.1^{f}
S_2	18.2^{e}	20.3^{cd}	22.2^{b}
S_3	19.8^{de}	22.8^{b}	23.4^{ab}
S_4	22.3^{b}	24.7^{a}	23.6^{ab}
S_5	22.3^{b}	22.2^{b}	21.9^{bc}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 26. Influence of spacing and fertilizer levels on potassium content and uptake at harvest

Treatment	Potassium (%) of Shoot at harvest	Potassium uptake by shoot at harvest (kg ha^{-1})	Potassium (%) of fruit at harvest	Potassium uptake by fruit at harvest (kg ha^{-1})	Total potassium uptake (kg ha^{-1})
Spacing					
S_1	1.32^{a}	11.48^{e}	1.12^{a}	40.96^{d}	52.5^{d}
S_2	1.27b	18.49^{d}	1.12^{a}	66.08^{c}	84.6^{c}
S_3	1.25^{c}	20.88^{c}	1.12^{a}	69.22^{b}	90.1^{b}
S_4	1.20d	22.97^{b}	1.12^{a}	74.42^{a}	97.4^{a}
S_5	1.13^{e}	25.19^{a}	1.11^{a}	66.47^{c}	91.7^{b}
Fert. levels					
F_1	1.22^{b}	18.14^{c}	1.11^{a}	59.93^{b}	78.1^{b}
F_2	1.24^{ab}	19.70^{b}	1.12^{a}	65.55^{a}	85.3^{a}
F_3	1.25^{a}	21.57^{a}	1.12^{a}	64.81^{a}	86.4^{a}
Interaction	NS	Sig.	NS	Sig.	Sig.

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Potassium content of shoot at harvest decreased significantly with increase in plant population and with fertilizer level up to F_2. Among the plant population, significantly the highest potassium content was noticed in S_1 and the lowest in S_5. Highest potassium content was noticed in F_3 but was at par with F_2.The lowest potassium content in shoot was recorded in F_1.

4.6.2. Potassium uptake by shoot at harvest (kg ha^{-1})

The data on potassium uptake by shoot at harvest are given in table 26 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on potassium uptake, and their interaction also was statistically significant (Appendix I).

Potassium uptake by shoot at harvest increased significantly with increase in plant population and with fertilizer levels. Among the plant population, S_5 spacing recorded significantly the highest uptake of potassium and S_1 recoded the lowest uptake and it was inferior to all other populations. Potassium uptake was significantly the highest in F_3 and the lowest in F_1.

The interaction between spacing and fertilizer levels significantly influenced the potassium uptake by shoot at harvest (Table26). In all the plant populations, the uptake of potassium increased significantly with increase in fertility level and highest uptake was recorded in F_3. Similarly, uptake of potassium by shoot increased significantly under each fertilizer level with increase in plant population up to S_3. Increased application of fertilizer up to F_3 was significantly evidenced with an increase in population up to S_5 with S_5F_3 having maximum potassium uptake by shoot and the lowest in S_1F_1.

4.6.3. Potassium content of fruit at harvest (%)

The data on potassium content of fruit at harvest are given in Table 26 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had no effect on potassium content of fruit at harvest. It was also found that their interaction was also not statistically significant (Appendix I).

4.6.4. Potassium uptake by fruit at harvest (kg ha^{-1})

The data on potassium uptake by fruit at harvest are given in table 26 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on potassium uptake by fruit, and their interaction also was statistically significant (Appendix I).

Potassium uptake by shoot at harvest increased significantly with increase in plant population up to S_4 and by with fertilizer levels up to F_2. Among the spacing, S_4 recorded significantly the maximum potassium uptake and S_1 recoded the minimum uptake and it was inferior to all other populations. F_2 recorded maximum uptake and it was on par with F_3. F_1 fertilizer level showed the lowest uptake of potassium by fruits.

The interaction between spacing and fertilizer levels significantly influenced the potassium uptake by fruit (Table28). Potassium uptake by fruits in S_1 and S_5 almost remained constant among the fertilizer levels. It increased significantly in S_2, S_3 and S_4 up to F_2 and did not change significantly when fertilizer level was increased to F_3. Similarly uptake of potassium increased significantly under each spacing up to S_4 and then decreased. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum potassium uptake by fruits. The lowest potassium uptake by fruits was in S_1F_1.

4.6.5. Total potassium uptake at harvest (kg ha^{-1})

The data on total phosphorus uptake at harvest are given in table 26 and the analysis of variance in Appendix I. The results indicated that spacing and fertilizer treatment had significant effect on potassium uptake, and their interaction also was statistically significant (Appendix I).

Total potassium uptake at harvest increased significantly with increase in plant population up to S_4 and fertilizer level up to F_2. Among the spacing, S_4 population recorded significantly the highest uptake and S_1 the lowest uptake and it was inferior to all other populations. F_3 level recorded maximum uptake and it was on par with F_2. F_1 fertilizer level showed the lowest total uptake of potassium by the crop.

The interaction between spacing and fertilizer levels significantly influenced the total potassium uptake (Table29). Total potassium uptake in S_1 and S_5 almost remained constant among the fertilizer levels. In S_2, potassium uptake at harvest increased significantly up to F_3. In S_2 and S_3, total potassium uptake increased significantly up to F_2 and then remained without much change under F_3. Under each fertilizer level, uptake of total potassium at harvest increased significantly up to S_4 and then decreased. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum uptake of total potassium at harvest. The lowest uptake of total potassium by the crop at harvest was in S_1F_1.

4.7. Nutrient status of soil after the experiment

4.7.1 Available nitrogen in soil (kg ha^{-1})

The data on available nitrogen in soil after the experiment are given in table 30. Except in S_1F_2 and S_1F_3 available nitrogen in soil after the trial was less than its content before the trial. In general, available nitrogen in soil after the trial increased with increase in fertilizer levels in all the plant populations and decreased with increase in plant population up to S_4 under each fertilizer level. The results indicated that,

Table 27. Potassium uptake by shoot at harvest as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	10.32^{k}	11.55^{j}	12.57^{i}
S_2	16.79^{h}	18.39^{g}	20.29^{e}
S_3	19.14^{f}	20.93^{e}	22.56^{d}
S_4	20.94^{e}	22.78^{cd}	25.19^{b}
S_5	23.49^{c}	24.85^{b}	27.23^{a}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 28. Potassium uptake by fruit as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	39.71^{f}	42.24^{f}	40.92^{f}
S_2	57.12^{e}	69.96^{bc}	71.16^{b}
S_3	63.72^{d}	71.98^{b}	71.97^{b}
S_4	71.98^{b}	77.51^{a}	73.76^{ab}
S_5	67.01^{cd}	66.06^{cd}	66.24^{cd}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

Table 29. Total potassium uptake by the crop as influenced by combination of spacing and fertilizer levels

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	50.1^{f}	53.8^{f}	53.5^{f}
S_2	73.9^{e}	88.4^{c}	91.5^{b}
S_3	82.9^{d}	92.9^{bc}	94.6^{b}
S_4	92.9^{bc}	100.3^{a}	98.9^{a}
S_5	90.7^{bc}	90.9^{bc}	93.5^{b}

Figures with same alphabets in superscript do not differ significantly at 5 % level in DMRT

maximum content of available nitrogen after the trial was recorded in S_1F_3 treatment and the minimum in S_4F_1 treatment.

4.7.2. Available phosphorus in soil (kg ha^{-1})

The data on available phosphorus in soil after the experiment are given in table 31.Available phosphorus in soil after the trial was less than its content in soil before the trial in all the treatments except S_1F_3.There was increase in available phosphorus in soil in all plant populations with increase in fertilizer level and decreased with increase in plant population up to S_4 under each fertilizer level. The results indicated that, maximum content of available phosphorus in soil after the trial was recorded in S_1F_3 and the minimum in S_4F_1 and S_5F_1.

4.7.3. Available potassium in soil (kg ha^{-1})

The data on available potassium in soil after the experiment are given in table 32. Available potassium in soil after the trial was less than its content in soil before the trial in all the treatments except S_1F_1, S_1F_2 and S_1F_3. It increased in all plant populations with an increase in fertilizer level. It decreased under each fertilizer level with increase in plant population up to S_4.The results indicated that, maximum available potassium in soil after the trial was recorded in S_1F_3 treatment and the minimum in S_4F_2 treatment.

Table 30. Available nitrogen in soil after the experiment (kg ha^{-1})

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	222.7	230.3	240.8
S_2	204.7	203.5	211.8
S_3	198.0	200.0	210.3
S_4	190.0	194.0	208.3
S_5	192.3	203.0	213.9

Available nitrogen in soil before trial was 227.4 kg ha^{-1}

Table 31. Available phosphorus in soil after the experiment (kg ha^{-1})

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	18.4	20.3	21.9
S_2	17.9	18.8	20.0
S_3	17.5	18.3	19.6
S_4	17.0	17.8	19.5
S_5	17.0	18.4	20.0

Available phosphorus in soil before trial was 21.0 kg ha^{-1}

Table 32. Available potassium in soil after the experiment (kg ha^{-1})

Spacing	Fertilizer levels		
	F_1	F_2	F_3
S_1	78.8	79.9	82.0
S_2	62.7	57.8	60.0
S_3	58.1	55.4	57.5
S_4	51.4	50.6	54.9
S_5	52.8	56.0	58.2

Available potassium in soil before trial was 70.4 kg ha^{-1}

Table 33. Available nutrients after the experiment (kg ha^{-1})

Treatments	Available nitrogen	Available phosphorus	Available potassium
S_1F_1	222.7	18.4	74.8
S_1F_2	228.3	20.1	76.9
S_1F_3	235.8	21.5	80.0
S_2F_1	204.7	17.9	62.7
S_2F_2	203.5	18.8	57.8
S_2F_3	211.8	19.8	60.0
S_3F_1	198.0	17.5	58.1
S_3F_2	200.0	18.3	55.4
S_3F_3	210.3	19.6	57.5
S_4F_1	190.0	17.0	51.4
S_4F_2	194.0	17.8	50.6
S_4F_3	208.3	19.5	54.9
S_5F_1	192.3	17.0	52.8
S_5F_2	203.0	18.4	56.0
S_5F_3	213.9	20.0	58.2

Available nutrients before the trial are nitrogen: 227.4 , phosphorus : 21.0 and potassium : 70.4 kg ha^{-1} respectively

4.8. Economics of cultivation

The data on economics of cultivation are given in the tables 34 and 35 (Appendix II-IV). Total cost of production increased with increase in plant population. Total cost of production was higher in S_3 and S_5 populations compared to S_2 and S_4 because of more number of channels taken at every 1.00 m in these treatments compared to taking channels at every 1.25 m in S_2 and S_4. The increase in total cost of production with increase in fertilizer level was very less. Among the five plant populations, gross return was maximum in S_4 and among the fertilizer levels, it was highest under F_2. Net return also followed the same trend as under gross return.Net income per rupee invested was the highest in S_4 and under fertilizer levels it was maximum in F_2.Among the treatment combinations, cost of production was higher in S_3 and S_5 plant populations with fertilizer levels.Net profit per ha was the highest in the treatment combination of S_4F_2 followed by S_4F_3.From among the treatment combinations, S_4F_2 also recorded the highest net income per rupee invested followed by S_4F_3.

Plate 3. View of different treatments at harvesting stage

2.0 m x 1.5 m, 100% of RDF
Yield: 39.4 t/ha

2.0 m x 1.5 m, 125% of RDF
Yield: 41.9 t/ha

2.0 m x 1.5 m, 150% of RDF
Yield: 40.9 t/ha

1.25 m x 0.45 m, 100% of RDF
Yield: 57.3 t/ha

1.25 m x 0.45 m, 125% of RDF
Yield: 69.4 t/ha

1.25 m x 0.45 m, 150% of RDF
Yield: 70.6 t//ha

1.0 m x 0.45 m, 100% of RDF
Yield: 63.8 t/ha

1.0 m x 0.45 m, 125% of RDF
Yield: 71.4 t/ha

1.0 m x 0.45 m, 150% of RDF
Yield: 71.4 t/ha

1.25 m x 0.30 m, 100% of RDF
Yield: 72.1 t/ha

1.25 m x 0.30 m, 125% of RDF
Yield: 76.9 t/ha (Best treatment)

1.25 m x 0.30 m, 150% of RDF
Yield: 73.2 t/ha (2^{nd} best treatment)

1.0 m x 0.30 m, 100% of RDF
Yield: 67.2 t/ha

1.0 m x 0.30 m, 125% of RDF
Yield: 65.9 t/ha

1.0 m x 0.30 m, 150% of RDF
Yield: 65.7 t/ha

Plate 4. View of experimental field at harvest

Plate 5. Total fruit yield

Table 34. Economics of oriental pickling melon production per hectare as influenced by spacing and fertilizer levels

Treatments	Total cost of production (Rs)	Gross return (Rs)	Net return (Rs)	Net income per rupee invested
Spacing				
S_1	117054	407333	290280	2.48
S_2	144163	657667	521392	3.61
S_3	173255	688667	515412	2.97
S_4	148196	740667	592471	4.00
S_5	177170	662667	485497	2.74
Ferti. Level				
F_1	150844	599600	453489	3.00
F_2	152315	651000	498685	3.27
F_3	152744	643600	490856	3.21

Table 35 . Economics of oriental pickling melon production per hectare as influenced by combinations of spacing and fertilizer levels

Treatments	Total cost of production per hectare (Rs)	Gross income ha^{-1}		Net return per hectare (Rs)	Net income per rupee invested
		Yield (t ha^{-1})	Value (Rs)		
S_1F_1	116342	39.4	394000	277658	2.39
S_1F_2	117009	41.9	419000	301991	2.58
S_1F_3	117810	40.9	409000	291190	2.47
S_2F_1	142831	57.3	573000	453832	3.18
S_2F_2	144428	69.4	694000	549572	3.80
S_2F_3	145229	70.6	706000	560771	3.86
S_3F_1	171853	63.8	638000	466147	2.71
S_3F_2	173660	71.4	714000	540340	3.11
S_3F_3	174251	71.4	714000	539749	3.10
S_4F_1	147244	72.1	721000	573756	3.90
S_4F_2	148631	76.9	769000	620369	4.17
S_4F_3	148712	73.2	732000	583288	3.92
S_5F_1	175948	67.2	672000	496052	2.82
S_5F_2	177845	65.9	659000	481155	2.70
S_5F_3	177716	65.7	657000	479284	2.69

Discussion

5. DISCUSSION

The results obtained from the experiment on “Yield maximization of oriental pickling melon by high density planting and nutrient management” are briefly discussed below.

5.1 Crop growth

High density planting had significant influence on number of vines per plant, length of vine at harvest, number of leaves per vine, per plant dry matter production of vegetative growth, per hectare dry matter production of vegetative growth and leaf area index. While the first four growth parameters decreased significantly with increase in plant population. Per hectare dry matter production of vegetative growth and LAI increased significantly with increase in plant population (Table 5-7 and Figure 2-5).

When plants are widely spaced, there is no competition for soil and environmental factors and as such number of vines per plant, length of vine, number leaves per vine and consequently per plant dry matter production of vegetative growth were highest in the population of 10,000 plants per hectare. When per hectare plant population were increased from 10,000 to 17,777 (S_2), 22,222 (S_3), 26,666 (S_4) and 33,333 (S_5), the above growth parameters decreased proportionately. The decrease in per plant dry matter production of vegetative growth was in the order of 6.7, 14.0, 17.7 and 23.4 per cent respectively under S_2, S_3, S_4 and S_5 populations. As plant population increases, competition for water, nutrients, light, CO2 etc. increases and the per plant growth is affected proportionately to the extent of competition brought in.

Maximum per hectare dry matter production of vegetative growth and LAI obtained from plant population which does not allow the individual plants to achieve their maximum potential. In the trial, the per hectare dry matter production of vegetative

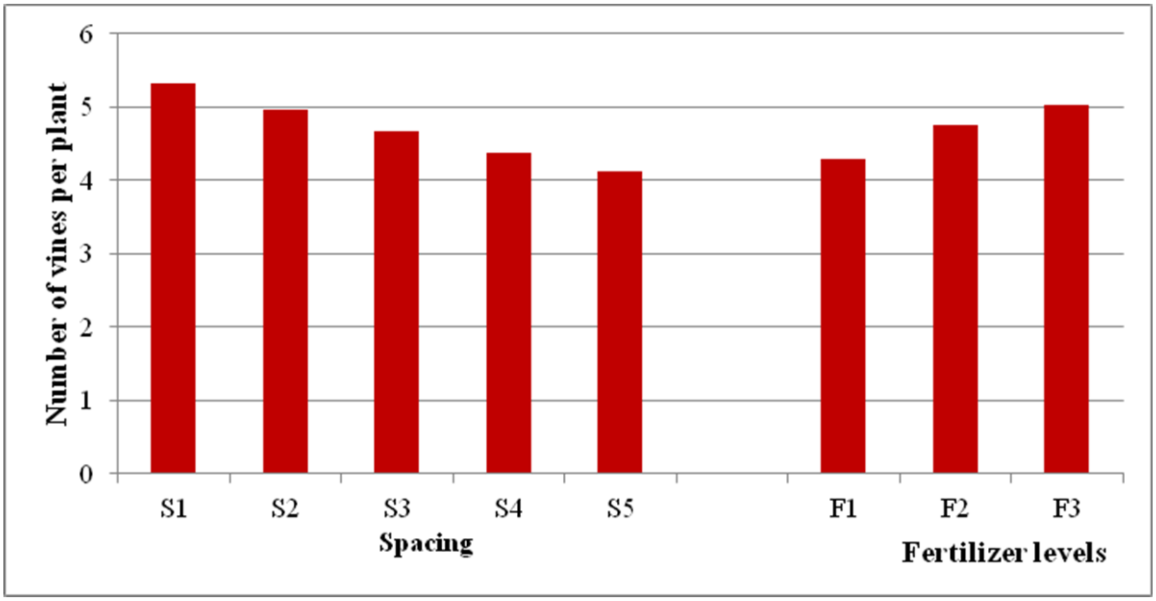

Fig 2. Number of vines per plant as influenced by spacing and fertilizer levels

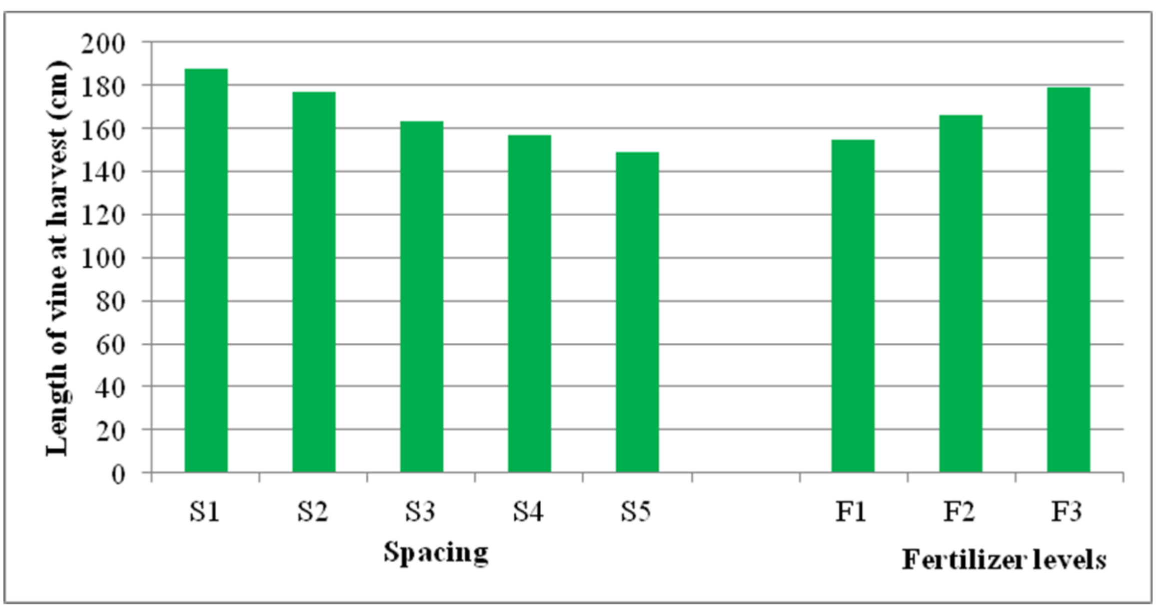

Fig 3. Length of vine at harvest as influenced by spacing and fertilizer levels

growth increased by 66, 91, 119 and 155 per cent respectively and LAI by 66, 93, 119 and 157 per cent respectively over the recommended plant population of S_1 with increase in plant population under S_2, S_3, S_4 and S_5. Thus the entire plant population is important for higher per hectare dry matter production of vegetative growth and LAI. The results obtained in this study are in conformity with the results of Bach and Hruska (1981), Parekh (1990), Arora and Mallik (1990), Bikramjit Singh (1990) and Choudhari and More (2002)in different vegetable crops.

Growth characters also varied significantly among the fertilizer levels. In general, all the parameters like number of vines per plant, length of vine at harvest, number of leaves per vine, per plant dry matter production of vegetative growth, per hectare dry matter production of vegetative growth and leaf area index increased significantly with increase in fertilizer level up to F_3. The per plant dry matter production increased by 7.3 and 16.1 per cent respectively at F_2 and F_3 over F_1. The corresponding increases in per hectare dry matter production of vegetative growth at F_2 and F_3 over F_1 were 7.2 and 15.9 per cent respectively and 9.6 and 14.2 per cent respectively in the case of LAI. Vegetative growth characters expressed a linear increase with increase in fertilizer levels tried. This trend was noticed even at the lowest plant population of 10,000 plants/ha. Similar results have also been reported by Alphonse and Saad (2000), Jaksungnaro and Akali (2001) and Kurup *et al.* (2011).

Interaction between plant population and fertilizer levels was significant in the case of length of vine at harvest, number of leaves per vine, leaf area index, per plant dry matter production of vegetative growth and per hectare dry matter production of vegetative growth. In each plant population, the growth parameters increased with increase in fertilizer level up to F_3.Under each fertilizer level, length of vines, number of leaves per vine and per plant dry weight of vegetative growth decreased with increase in plant population and LAI and per hectare dry weight of vegetative growth increased with increase in plant population. Interaction between plant population and fertilizer level was linear up to S_5F_3 on LAI and per hectare dry weight of vegetative growth at

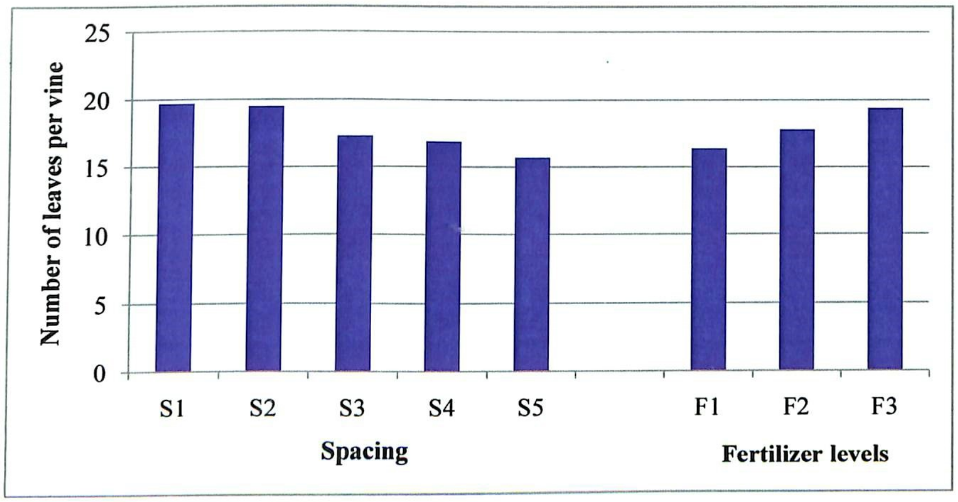

Fig 4. Number of leaves per vine as influenced by spacing and fertilizer levels

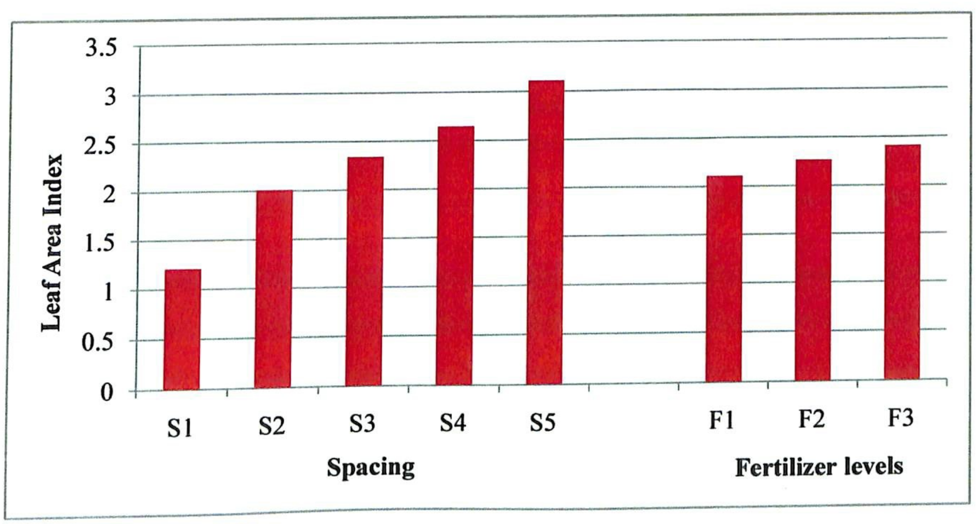

Fig 5. Leaf Area Index as influenced by spacing and fertilizer levels

harvest. These two parameters express the overall effect of individual plant growth parameters on the community growth expression

5.2 Yield and yield attributes

Yield attributes like number of fruits per plant, average weight of one fruit and mean volume of one fruit declined significantly with increase in plant population. Consequently, the mean fruit weight per plant also declined significantly with increase in plant population (Table 8-11 and Figure 6-9). The decrease in fruit weight per plant with increase in plant population over S_1 amounted to 9.6, 24.3, 31.9 and 51.2 per cent respectively.

Mean fruit yield per hectare increased significantly with increase in plant population up to S_4 and thereafter decreased significantly. The increases in per hectare fruit yield over S_1 at S_2, S_3, S_4 and S_5 populations were in the order of 61.3, 68.9, 81.4 and 62.5 per cent respectively. Fruit yield per hectare is a function of number of fruits produced per hectare and average weight of one fruit. The number of fruits produced per hectare in S_1, S_2, S_3, S_4 and S_5 populations were in the order of 62,600, 1,03,640, 1,10,221, 1,22,397 and 1,11,332. Though the average weight of one fruit decreased with increase in plant population, fruit number produced per hectare had more influence in per hectare yield and hence S_4 recorded the highest per hectare fruit yield. At S_4 planting density (26,666 plants per hectare) plant population is optimum which is respond to utilize the growth factors like water, nutrients, sunlight, CO2 etc.

LAI is an important factor that affects crop performance and fruit yield. Statistical analysis revealed that the optimum LAI that favored highest fruit yield in this study under different spacing was 2.65 which was the LAI recorded under S_4 (Figure 11).

Among the fertilizer levels, number of fruits per plant, average weight of one fruit and volume one fruit increased significantly up to F_2 and slightly decreased at F_3. But the differences between F_2 and F_3 were not significant. Consequently, mean fruit

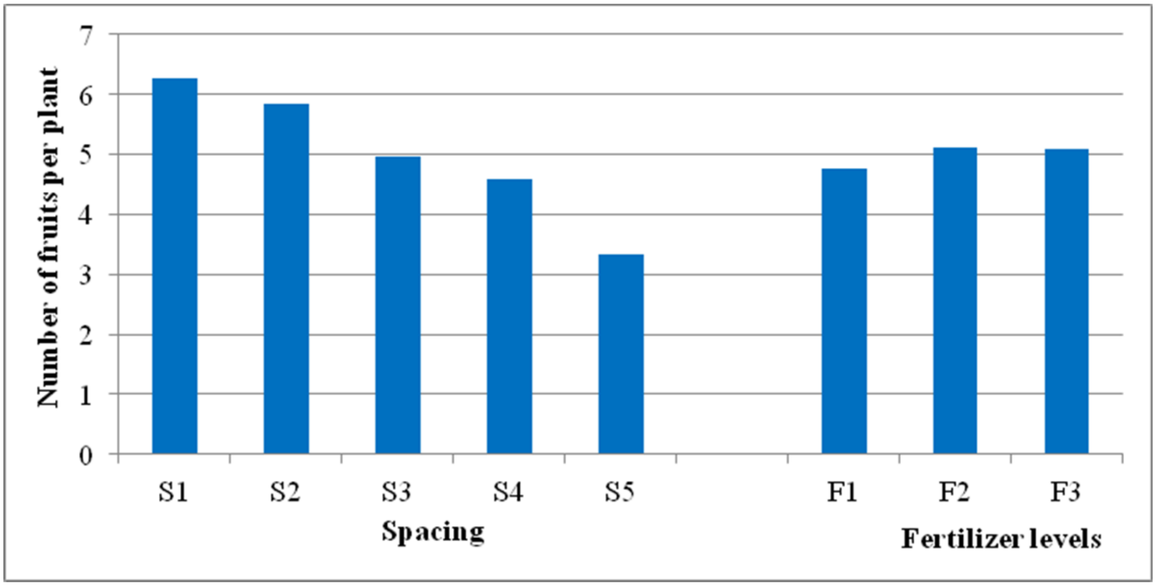

Fig 6. Average weight of one fruit (g) as influenced by spacing and fertilizer levels

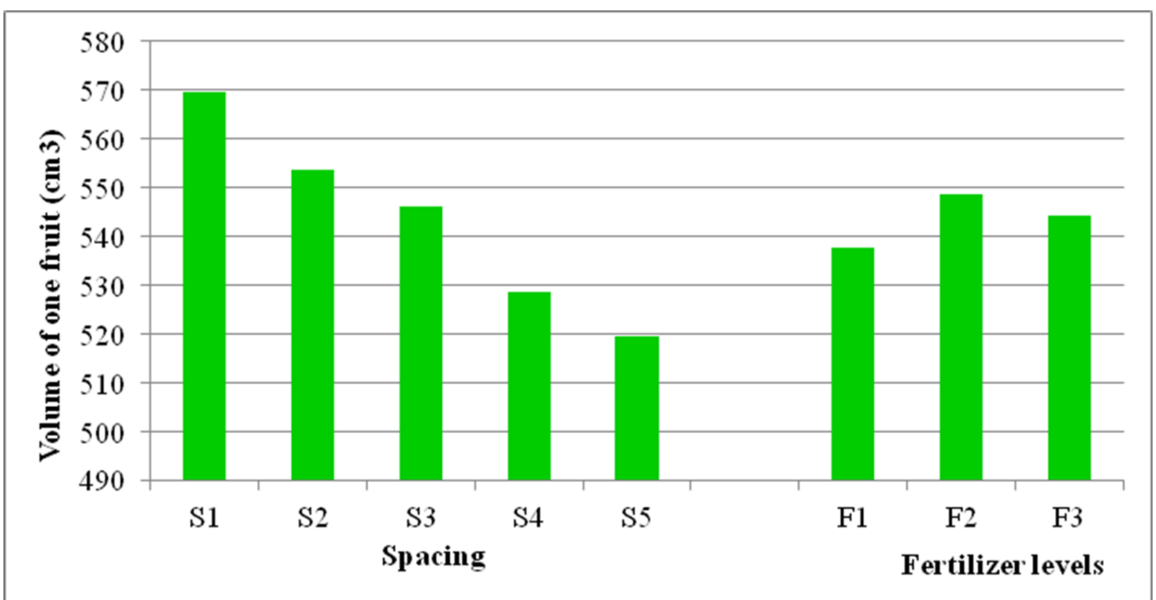

Fig 7. Volume of one fruit (cm^3) as influenced by spacing and fertilizer levels

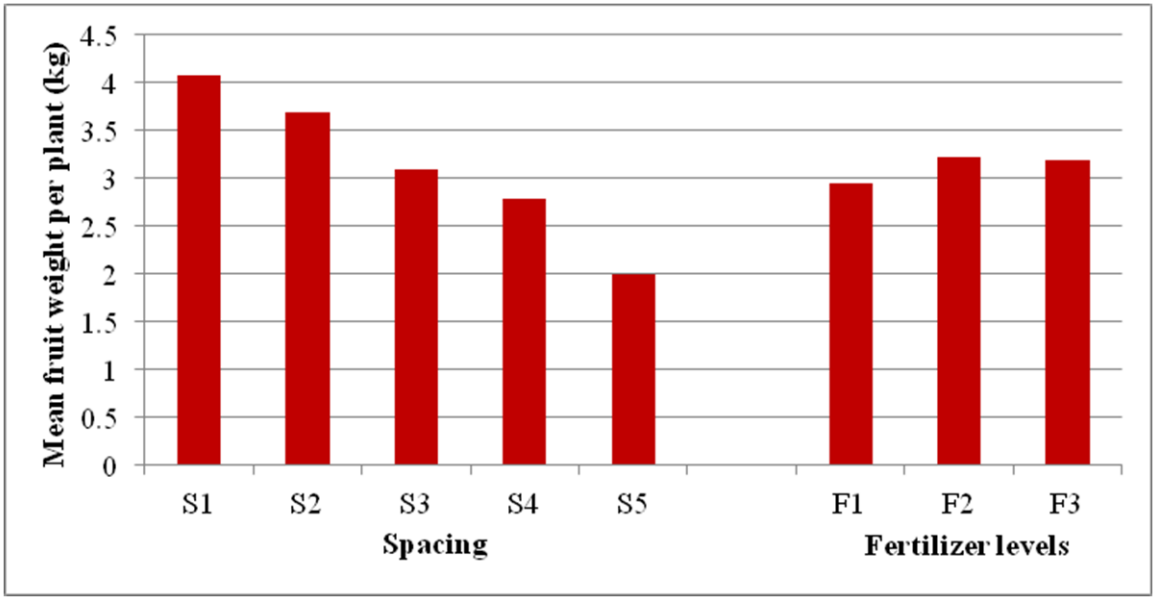

Fig 8. Mean fruit weight per plant (kg) as influenced by spacing and fertilizer levels

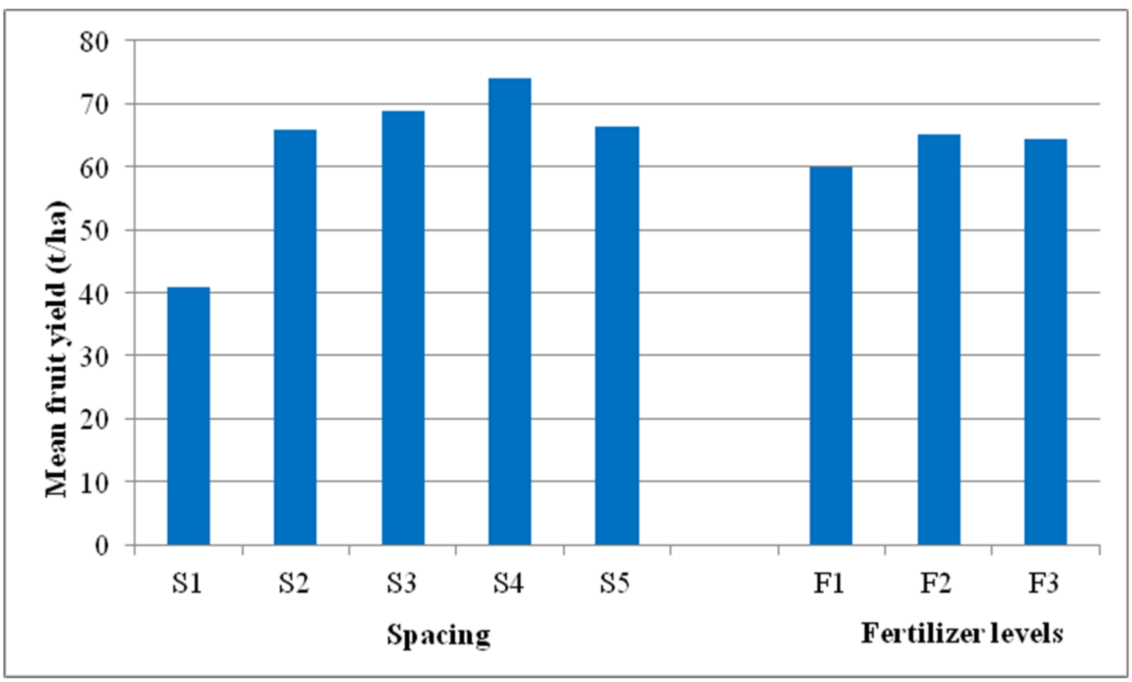

Fig 9. Mean fruit yield (t/ha) as influenced by spacing and fertilizer levels

yield per plant and per hectare also showed the same trend. The increase in fruit yield per hectare at F_2 and F_3 over F_1 were in the order of 9.3 and 7.5 per cent respectively.

The optimum LAI under fertilizer levels that contributed to maximum fruit yield was 2.27 and this corresponded to the LAI recorded at F_2 fertilizer level (Figure 10). Interaction between spacing and fertilizer levels revealed that the optimum LAI corresponding to the maximum per hectare fruit yield of 76.9 tones was 2.6 as observed at S_4F_2 (Figure 12). The effect of spacing on enhancing per hectare fruit yield was far significant than that of fertilizer level.

Interaction between plant population and fertilizer levels was significant in the case of number of fruits per plant, mean volume of one fruit, mean fruit weight per plant and mean fruit weight per hectare. There was a study decline in number of fruits per pant, mean fruit volume and mean fruit weight per plant under each fertilizer level with increase in plant population. But in the case of mean fruit yield per hectare, fruit yield increased substantially under each fertilizer level when plant population increased from S1 to S_4 and then declined. Fruit yield per hectare is a function of fruit number per hectare and average weight of one fruit. The interaction between plant population and fertilizer level was non-significant on average fruit weight. Therefore the highest interaction observed on per hectare fruit yield at S_4 population with fertilizer levels was solely due to the higher number of fruits produced in these combinations (S_4F_1, S_4F_2 and S_4F_3). Though in the case of LAI and per hectare production of dry weight of vegetative growth at harvest, interaction between population and fertilizer level was linear up to S_4F_2 only in the case of fruit yield per hectare and thereafter declined. Fruit yield per hectare declined over an LAI of 2.6 observed at S_4F_2. Above an optimum LAI, the crop was seen contributing more to vegetative growth than the fruit yield. This results is in conformity with the findings of Al-Khayer (1982), Lower *et al*. (1983), Arora and Malik (1990), Nerson *et al*. (1984), Pandit *et al.* (1997), Hafidh (2001), Soltani *et al*., (2007) and levels Ferrante *et al*., (2008).

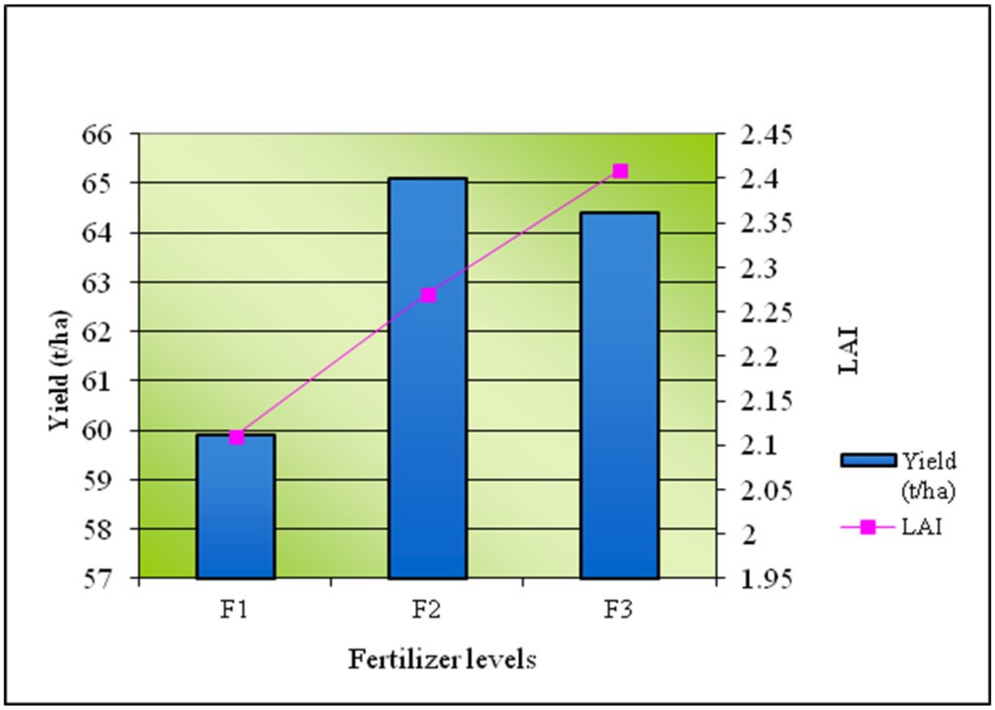

Fig. 10 Effect of LAI on yield at different fertilizer levels

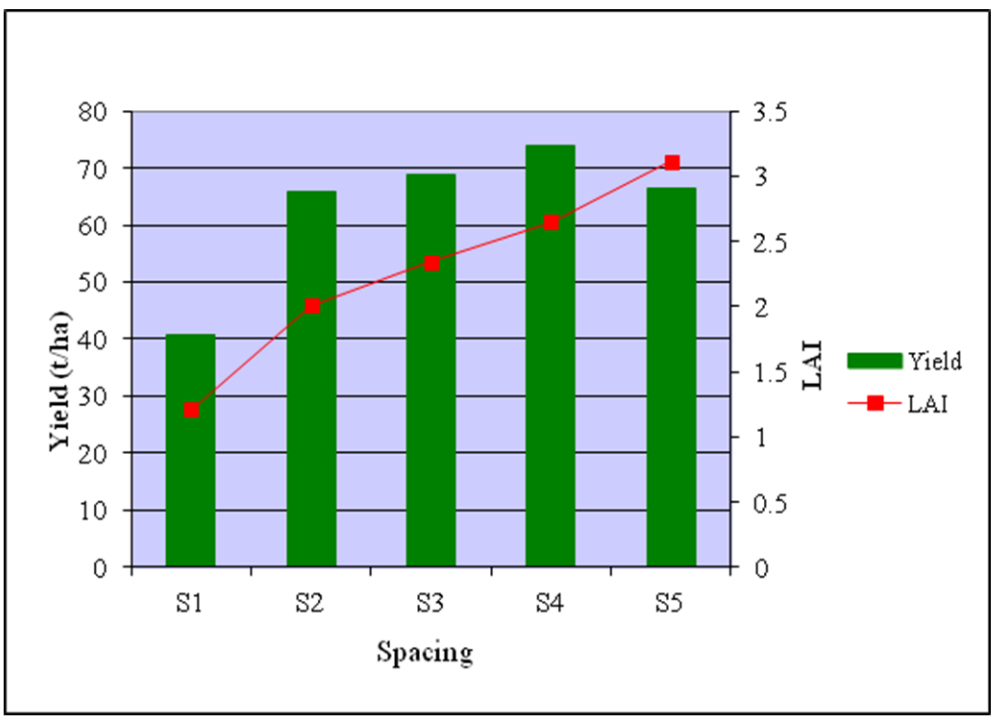

Fig.11 Effect of LAI on yield at different population density

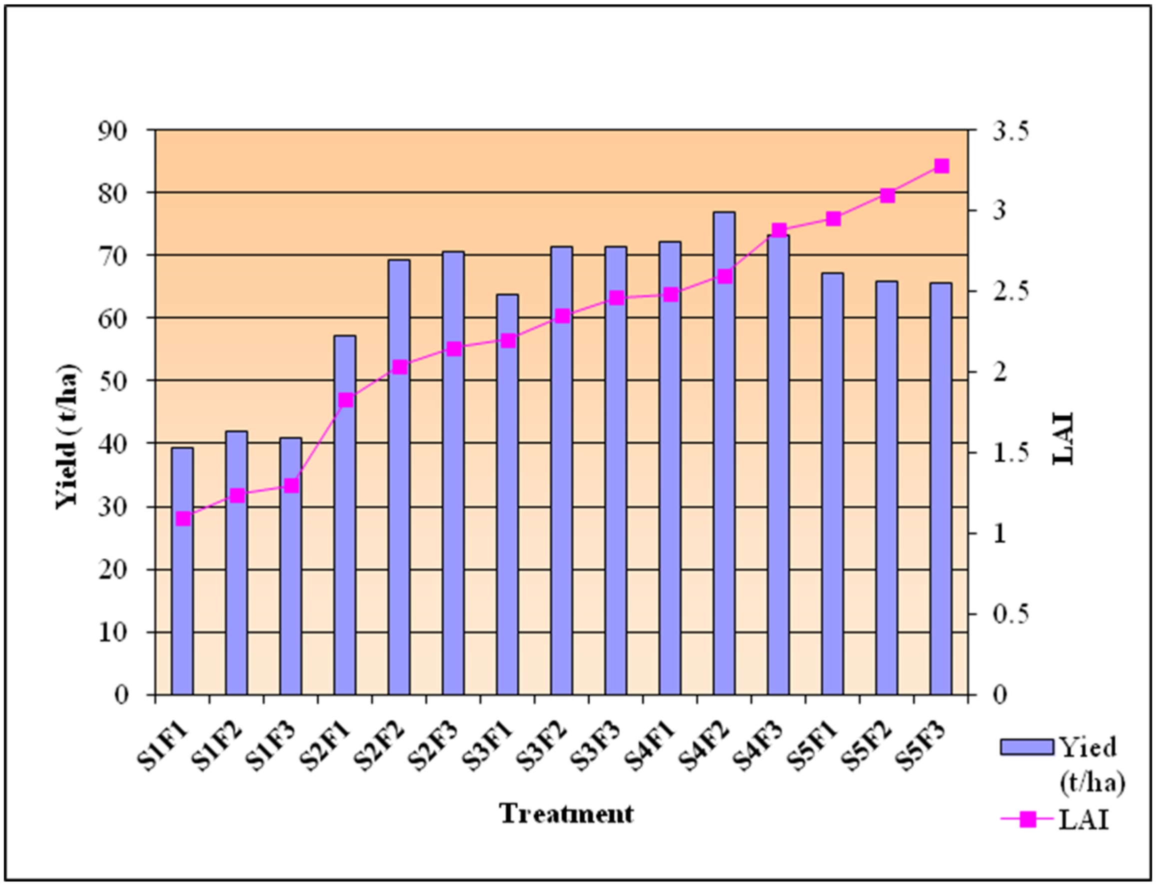

Fig. 12 Effect of LAI on yield among all the treatments

5.3 Fruit dry weight

Fruit dry weight followed the same trend as that of per hectare fruit yield (Table 13 & 16, Figure 14). Interaction between plant population and fertilizer levels was also significant in the case of fruit dry weight.

5.4 Days to first flowering and harvest

These two parameters did not show significant change under spacing or fertilizer levels (Table 4 & 8). The interaction between them also was not significant. In general, days to flowering and harvest were 25 and 67 days respectively.

5.5 Chemical composition of leaves

High density planting and levels of NPK had significant effect on leaf Nitrogen, Phosphorus and Potassium contents both at 30 and 60 DAS (Table 17-19 and Figure 15-17). Though leaf nitrogen content did not vary significantly between plant populations at 30 DAS, there was a decreasing trend with increase in plant population at 60 DAS.

In the case of leaf phosphorus and potassium content, there was a significant reduction due to increase in plant population both at 30 and 60 DAS. The decrease in leaf nutrient content with increase in plant population as recorded above was due to the corresponding increase in LAI and dry matter production with increase in plant population. This may be due to the dilution effect.

Leaf nitrogen, phosphorus, and potassium content increased significantly with increase in fertilizer level up to F_3 both at 30 and 60 DAS. With increase in the levels of application of nutrients, the trend to absorb and accumulate more nutrients in the leaves is evident. However the rate of increase of nutrients in leaves due to increasing levels of NPK addition is comparatively lesser. Excess nutrients are believed to be stored in the vacuoles of the leaf cells. There was no interaction between plant densities and levels of nutrients applied. This result is in conformity with the results of Al-Sahaf and Al-Khafagi (1990) and Tuncay *et al.* (1999).

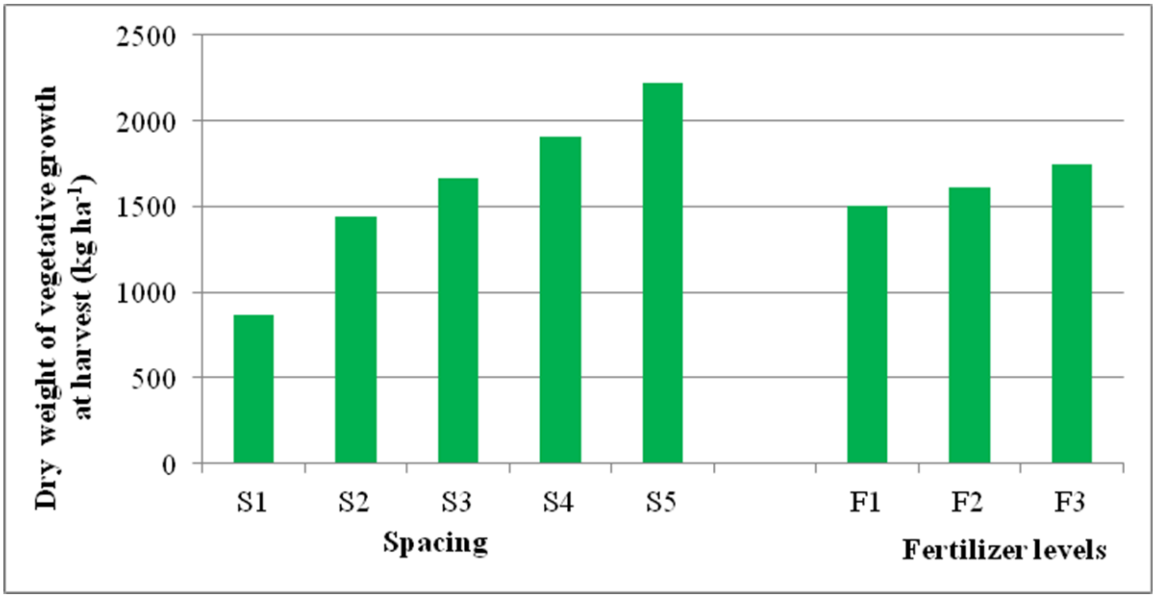

Fig 13. Dry weight of vegetative growth at harvest (kg ha^{-1}) as influenced by spacing and Fertilizer levels

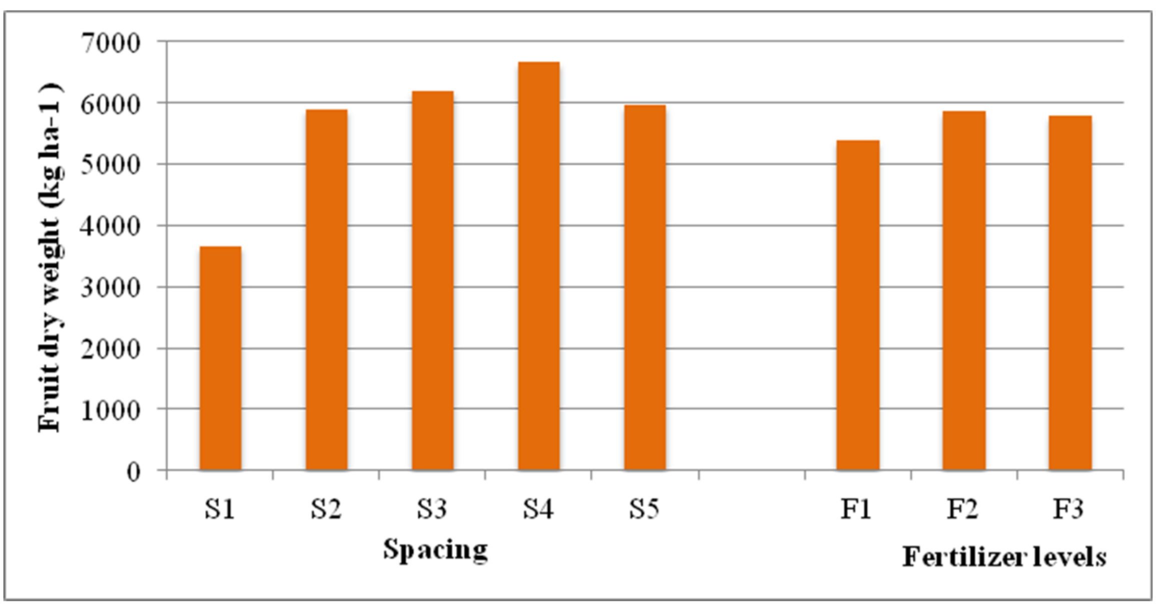

Fig 14. Fruit dry weight (kg ha^{-1}) as influenced by spacing and fertilizer levels

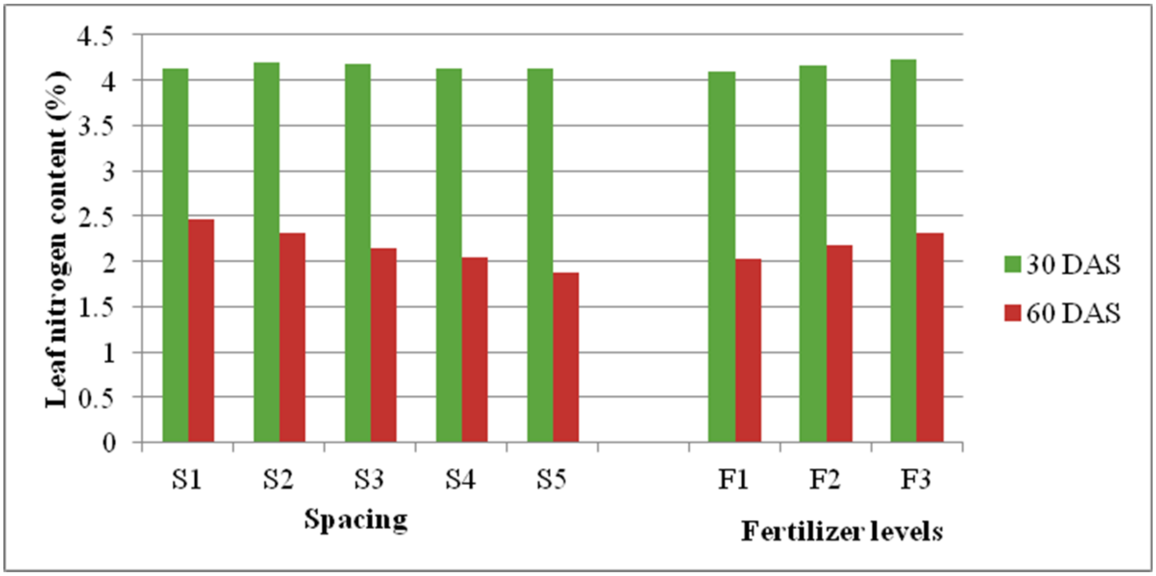

Fig 15. Leaf nitrogen content (%) as influenced by spacing and fertilizer levels

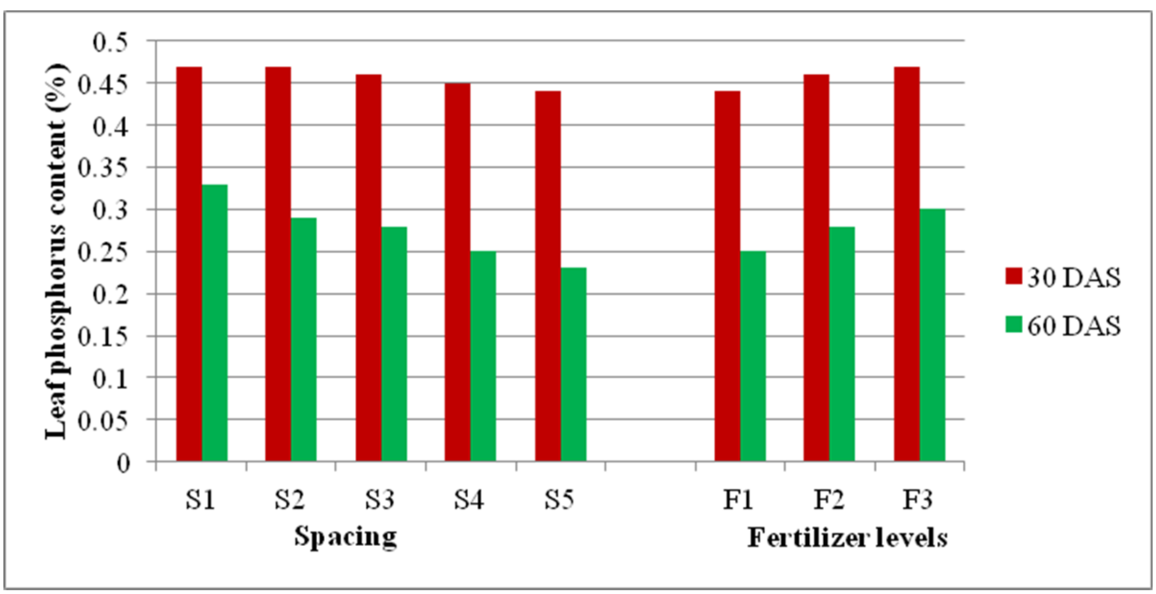

Fig 16. Leaf phosphorus content (%) as influenced by spacing and fertilizer levels

5.6 Nitrogen content of shoot and fruit at harvest and uptake

Density of planting and nutrient levels significantly affected shoot nitrogen content at harvest and uptake of N by the crop (Table 20-22 and Figure 18). The N content of fruit at harvest remained constant at 1.45 per cent irrespective of planting densities. Shoot N content decreased significantly with increase in plant population and the decrease was from 1.55 per cent in S_1 to 1.19 per cent in S_5. This reduction in the shoot N content in different plant populations was in direct proportion to the increase in dry matter production of shoot at harvest. N uptake by shoot therefore was a multiple of shoot N content and dry matter production by the shoot. Hence N uptake by shoot increased significantly with increase in plant population from S_1 to S_5. N uptake by fruits increased significantly up to S_4 and then decreased as fruit yield also increased significantly up to S_4 and then decreased. Total uptake of N by the crop also increased significantly with increase in plant population upto S_4 and then decreased because of reduced N uptake by fruits in S_5. The percentage increase in N uptake by the crop under S_2, S_3, S_4 and S_5 planting populations over S_1 where in the order of 59.6, 69.0, 82.3 and 71.1 respectively.

The shoot N content increased significantly upto F_2 fertilizer level and then steadied. The uptake of N by shoot varied according to the dry matter production of shoot. Under varying fertilizer levels, uptake of N by shoot at harvest was significantly highest in F_3 because of the significant increase of shoot dry matter at harvest up to F_3. Fruit N content was not at all affected by nutrient levels applied and hence N uptake by fruits depended solely on the fruit dry weight, which was maximum in F_2. Total N uptake by the crop was maximum in F_3, which was higher by only 1.5 kg per hectare over F_2 and 11.5 kg over F_1.

The interaction between plant population and fertilizer level was significant in the case of total N uptake. Total N uptake by the crop increased significantly under each fertilizer level upto S_4 only and then decreased. Similarly in each planting density significant response to fertilizer level was observed up to F_2 only. Therefore S_4F_2

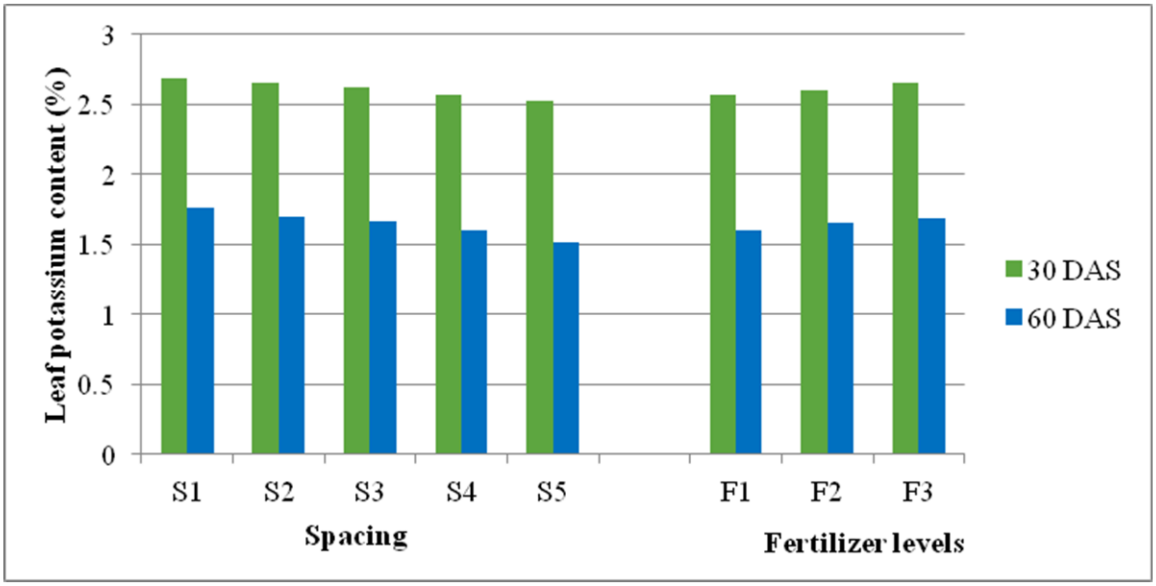

Fig 17. Leaf potassium content (%) as influenced by spacing and fertilizer levels

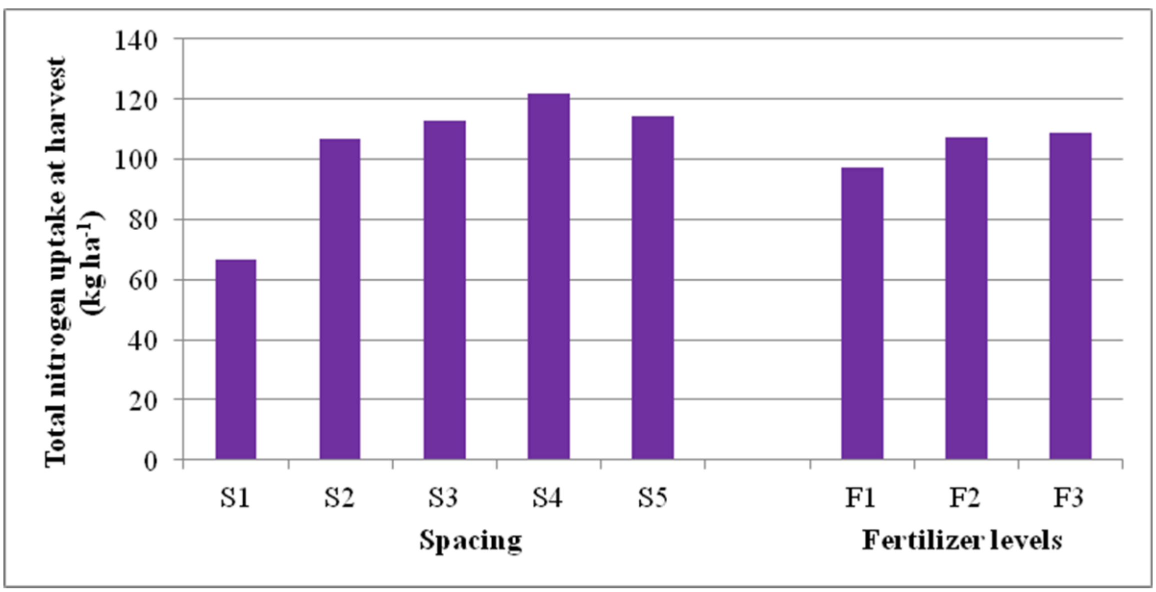

Fig 18. Total Nitrogen uptake at harvest (kg ha^{-1}) as influenced by spacing and fertilizer levels

recorded the highest uptake of N by the crop, which also recorded the highest fruit yield in the experiment. This is in conformity with the results of Pew and Gardner (1972), Singh *et al*.(1982), Siyag and Arora (1988), Suresh and Pappiah (1991), Um *et al*.(1995), Ferrante *et al.* (2008) and Barros *et al*. (2012).

5.7 Phosphorus content of shoot and fruit at harvest and uptake

Density of planting and nutrient levels significantly influenced P content of shoot at harvest, its uptake, P uptake by fruits and total P uptake at harvest (Table 23-25 and Figure 19). Shoot P content decreased significantly with increase in plant density due to proportionate increase in shoot dry matter production with increase in plant population from S_1 to S_5. But P uptake by shoot at harvest increased significantly, with increase in plant population from S_1 to S_5. P uptake is a multiple of P content and dry matter production. Dry matter production of shoot at harvest exerted more influence on P uptake rather than P content in the shoot. Plant population had no influence on P content of the fruit and therefore fruit yield determined the uptake of P by fruit. P uptake by fruit increased significantly from S_1 to S_4 and then decreased because fruit yield increased significantly up to S_4 and then decreased. Total P uptake by the crop increased significantly up to S_4 and then decreased because of reduced fruit yield and P uptake by fruit in S_5. The percentage increases in total P uptake by the crop under S_2, S_3, S_4 and S_5 plant populations or S_1 were in the order of 60.6, 74.5, 87.2 and 75.8 respectively.

The shoot P content and uptake increased significantly up to F_3. Higher P content and dry matter production with increase in fertilizer level up to F_3 contributed to higher P uptake by shoot at harvest in F_3. P content in fruits was not at all affected by fertilizer levels, but P uptake by fruits increased significantly up to F_2 and then decreased because fruit yield was maximum in F_2. Total P uptake by the crop at harvest was maximum in F_3, but it was only higher by 1.99 kg over F_1 and 0.21 kg over F_2.

The interaction between plant population and fertilizer levels was also significant in the case of total P uptake by the crop as in the case of N uptake. Total P uptake increased significantly up to S_4 and thereafter remained constant or decreased. Similarly, in each plant population, response to P uptake was observed mostly up to F_2 level. Therefore S_4F_2 recorded the highest total P uptake by the crop, which also recorded the highest fruit yield. This is in conformity with the results of Stoliarov and Fanina (1989), El-Hassan (1991), Avakvan *et al.* (1992), Jyothi (1995), Cheraghi *et al.* (2012) and Barker (2012) in different vegetable crops.

5.8 Potassium content of shoot and fruit at harvest and uptake

Density of planting and fertilizer levels significantly influenced potassium content of shoot, its uptake by shoot and fruits and total uptake at harvest (Table 26-29 & Figure 20). As in the case of N and P, potassium content in shoot at harvest also decreased significantly with increase in plant population due to dilution effect. The decrease was in direct proportion to the increase in dry matter production of shoot with increase in plant population from S_1 to S_5. But the K uptake by shoot at harvest increased significantly with increase in plant population irrespective of the decrease in K content of the shoot with increase in plant population. Dry matter production influenced K uptake more than that influenced by its content in the shoot.

Potassium content of the fruits was not at all influenced by the plant population, but K uptake by fruits was influenced by the fruit yield. K uptake by fruit increased significantly up to S_4 and then declined in direct proportion to the increase in fruit yield up to S_4 and is declining after S_4. Total K uptake by the crop increased significantly up to S_4 and then decreased because of reduced fruit yield and K uptake by fruits at harvest in S_5. The total uptake of K at harvest was higher by 61.0, 71.6, 82.5 and 74.7 per cent respectively under S_2, S_3, S_4 and S_5 over S_1.

Potassium uptake by shoot increased significantly up to F_2 fertilizer level of fertilizer application and then steadied, but uptake was significantly highest in F_3 due to more dry matter production in F_3. Here also K content of fruits remained unchanged due to influence of fertilizer levels and K uptake by fruits was in direct proportion to the fruit yield. K uptake by fruits was maximum in F_2 due to maximum fruit yield in F_2. Total K uptake was maximum in F_3 and it was higher by 8.3 kg over F_1 and 1.1 kg over F_2. There was no significant difference between total K uptake at F_2 and F_3 fertilizer levels.

The interaction between plant population and fertilizer level was significant in the case of K uptake by shoot, fruit and total uptake. Total K uptake increased significantly up to S_4 under each fertilizer level and then decreased. Similarly total K uptake in plant populations increased up to F_2 under S_1 and S_4 and then declined and increased up to F_3 in S_2, S_3 and S_5. However, significantly the highest total K uptake was obtained in S_4F_2 followed by S_4F_3 because of the highest uptake by fruit under S_4F_2 followed by S_4F_3 and high uptake by shoot under S_4F_3. Significantly the highest fruit yield was recorded by S_4F_2 also. This is in conformity with the results of Mc Collum and Miller (1971), Adams *et al*. (1992), Tisdale *et al*. (1993), Premalakshmi (1997), Demiral and Koseoglu (2005) and El-Bassiony *et al*. (2012).

5.9 Available nitrogen in soil after the experiment

Available nitrogen in soil after the trial increased with fertilizer level up to F_3 in all the plant populations (Table 30). In all the plant populations except S_1, the available N in soil after the experiment was less than that of the pre-trial available nitrogen content. But in the lowest population of S_1, available N in the soil after the trial was more than the pre-trial content by 2.9 and 13.4 kg respectively in S_1F_2 and S_1F_3. For a population of S_1 (10,000 plants per hectare) higher contribution of available nitrogen from higher levels of F_2 and F_3 have contributed to the buildup of more available N in soil. The recommended plant population for oriental pickling melon is S_1 and the crop was liberally manured with farm yard manure at the rate of 25 t/ha and nitrogen at the

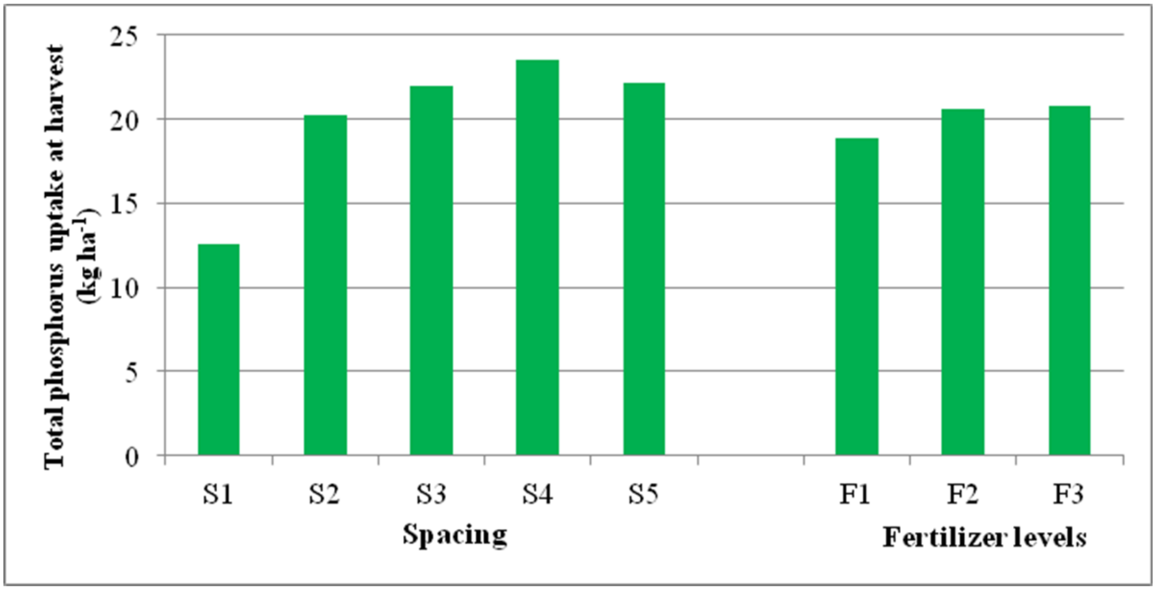

Fig 19. Total phosphorus uptake at harvest (kg ha^{-1}) as influenced by spacing and fertilizer levels

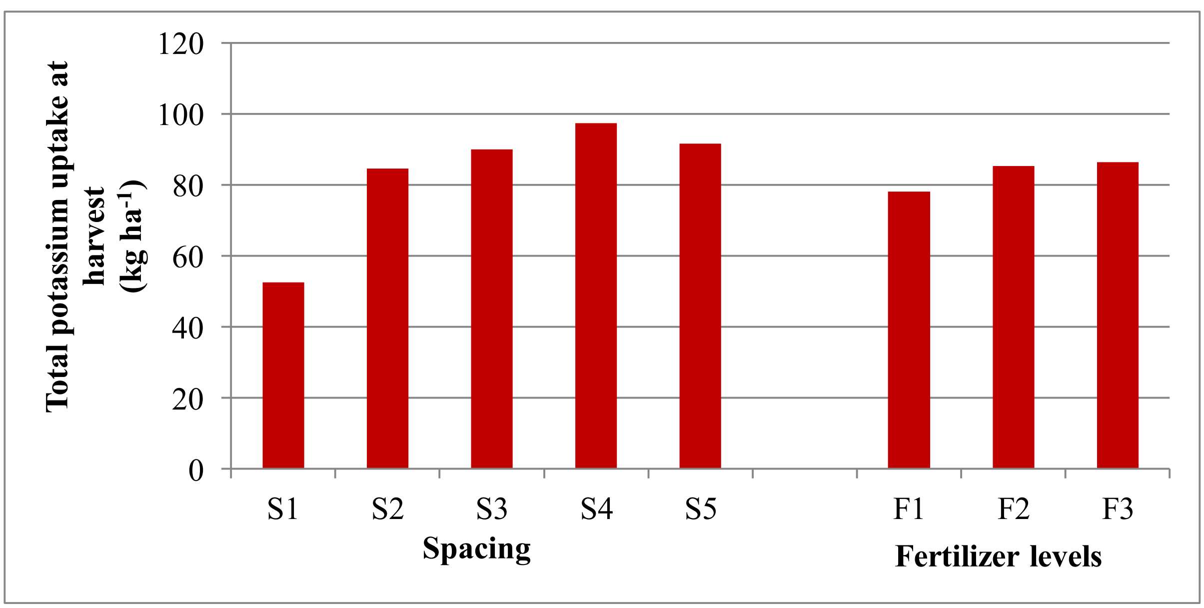

Fig 20. Total potassium uptake at harvest (kg ha^{-1}) as influenced by spacing and fertilizer levels

rate of 70 kg/ha. This much manurial schedule is sufficient to the crop at the recommended spacing of S_1. Generally vegetables are soil fertility building crops and they seldom deplete the soil fertility because of high manuring with both organic and inorganic fertilizers. But when the plant population was steadily increased from S_1 (10,000 plants per hectare) to S_5 (33,333 plants per hectare) there was depletion of available N in soil after the trial even at F_2 and F_3 fertilizer levels. But the depletion decreased with increase in fertility level up to F_3 under S_2 to S_5. Higher N levels have contributed more to available N in soil after the trial in all the plant populations.

At each fertilizer level, available N in soil after the trial decreased. The decrease in available N in soil after the trail was in direct proportion to the dry matter produced by the shoot as well as fruits with increase in plant population from S_1 to S_4 and then increased slightly in S_5. Compared to the pre-trial available N content in soil, the depletion of available N in soil after the trial amounted to 4.7 kg, -22.7, -29.4, -37.4 and -35.1 kg per hectare respectively in S_1, S_2, S_3, S_4 and S_5 at F_1 fertilizer level. The same depletion in S_1, S_2, S_3, S_4 and S_5 in F_2 fertilizer level amounted to 2.9, -23.9, -27.4, -33.4 and -24.4 kg per hectare respectively. In F_3 fertilizer levels the same depletions in S_1, S_2, S_3, S_4 and S_5 were in the order of 13.4, -15.6, -17.1, -19.1 and -13.5 kg per hectare respectively. From among the treatment combinations, available N in the soil after the trial was the lowest in S_4F_2. Higher depletion of available nitrogen in soil in S_4F_2 was because of more uptake and utilization in the production of shoot and fruit dry matter.

5.10 Available phosphorus in soil after the experiment

As in the case of available N, available P in the soil after trial also increased with fertilizer level up to F_3 at all the plant populations indicating the influence of higher levels of P applied on available P (Table 31). Except in S_1F_3, all the treatments had lesser available P content in the soil after the trial compared to the pre-trial content, but that too was negligible to the extent of only 0.9 kg per hectare. When the plant population steadily increased from 10,000 hectare (S_1) to 33,333 hectare (S_5) there was depletion of available P in the soil after the experiment in all the plant populations up to S_4, but the trend was not continued in S_5. The extend of decrease was in direct proportion to the production of dry matter by the shoot as well as by the fruit. The depletion of available P in soil after the trial compared to pre-trial amounted to -2.6, -3.1, -3.5, -4.0 and -4 kg per hectare respectively in S_1, S_2, S_3, S_4 and S_5 at F_1 fertilizer level. The same depletion under F_2 fertilizer level was in the order of -0.7, -2.2, -2.7, -3.2 and -2.6 kg per hectare respectively in S_1, S_2, S_3, S_4 and S_5. In the F_3 fertilizer level, the same depletions inS_1, S_2, S_3, S_4 and S_5 were in the order of 0.9, -1.0, -1.4, -1.5 and -1.0 kg per hectare respectively. From among the spacing and fertilizer combinations, available P in soil after the trial was lowest in S_4F_2, as in the case of available N in the soil after the trial. This is due to higher uptake and utilization of P in S_4F_2 for the highest dry matter production by shoot and fruits.

5.11 Available potassium in soil after the experiment

Available K in soil after the trial, increased with increasing level of fertilizer up to F_3 in all the plant populations indicating the influence of higher levels of applied K on available K in soil after the trial (Table 32). Except in S_1F_1, S_1F_2 and S_1F_3 all the treatments had lesser available K content in soil after the trial compared to the pre-trial K content of 70.4 kg/ha. In S_1F_1, S_1F_2 and S_1F_3, the K content in soil after the trial increased by 8.4, 9.5 and 11.6 kg/ha respectively compared to the pre-trial available K content of soil.

There was a steady decline in available K content in soil after the trial in all the fertilizer levels when the plant populations increased from 10,000 (S_1) to 26,666 (S_4) and then slightly increased in S_5. This decrease in available K content in the soil after the trial was in direct proportion to the dry matter produced by the shoot as well as fruits. The depletion of available K in soil after the trial compared to the pre-trial content amounted to 8.4, -7.7, -12.3, -19.0 and -17.6 kg/ha respectively in S_1, S_2, S_3, S_4 and S_5 at F_1 fertilizer level. The same depletion under F_2 fertilizer level was in the order of 9.5, -12.6, -15.0, -19.8 and -14.4 kg/ha respectively in S_1, S_2, S_3, S_4 and S_5. In the F_3

fertilizer level, the same depletions in S_1, S_2, S_3, S_4 and S_5 were in the order of 11.6, -10.4, -12.9, -15.5 and -12.2 kg/ha respectively. From among the treatment combinations, available K in the soil after the trial was the lowest in S_4F_2 as in the case of available N and P in the soil after the trial. This is due to the higher uptake and utilization of K for the highest dry matter production by fruits and shoots at harvest in this treatment combination.

5.12 Economics of cultivation

High density planting had significant influence on total cost of production, gross returns, net returns and net income per rupee invested (Table 34-35 & Figure 21). Cost of cultivation was very less in S_1, because of wider planting in pits taken at 2 x 1.5 m apart. Cost of cultivation was very high in S_3 and S_5 due to more number of channels taken at every one metre. The increases in cost of cultivation in S_2, S_3, S_4 and S_5 over S_1 were in the order of Rs.27109, 56201, 31142 and 60116 respectively. Since S_2 and S_4 were planted in channels taken 1.25 m apart, its cost of cultivation was less compared to S_3 and S_5. Net return increased with increase in plant population up to S_4 and then decreased. This was in direct proportion to the yield recorded in each treatment. Fruit yield was the highest in S_4. Because of the highest net returns and lower total cost of cultivation compared to S_3 and S_5, net income per rupee invested was the maximum in S_4. The increases in net return in rupees per hectare in S_2, S_3, S_4 and S_5 over S_1 were in the order of 2,31,112, 2,25,132, 2,25,132, 3,02,191 and 1,95,217 respectively. The net return in rupees per hectare obtained in the recommended plant population of S_1 (10,000 plants/ha) is 2,90,280 and that in S_4 (26,666 plants/ha) was 5,92,471. This indicates that, S_4 is 104 per cent more profitable than S_1.

The increases in cost of cultivation per hectare due to F_2 and F_3 fertilizer levels over F_1 were Rs.1,471 and 1,900 respectively. However, the net return per hectare increased in F_2 and F_3 over F_1 by Rs.42,196 and 37,367 respectively because of more fruit yield. Compared to F_3, F_2 gave more net return per hectare by an increase of

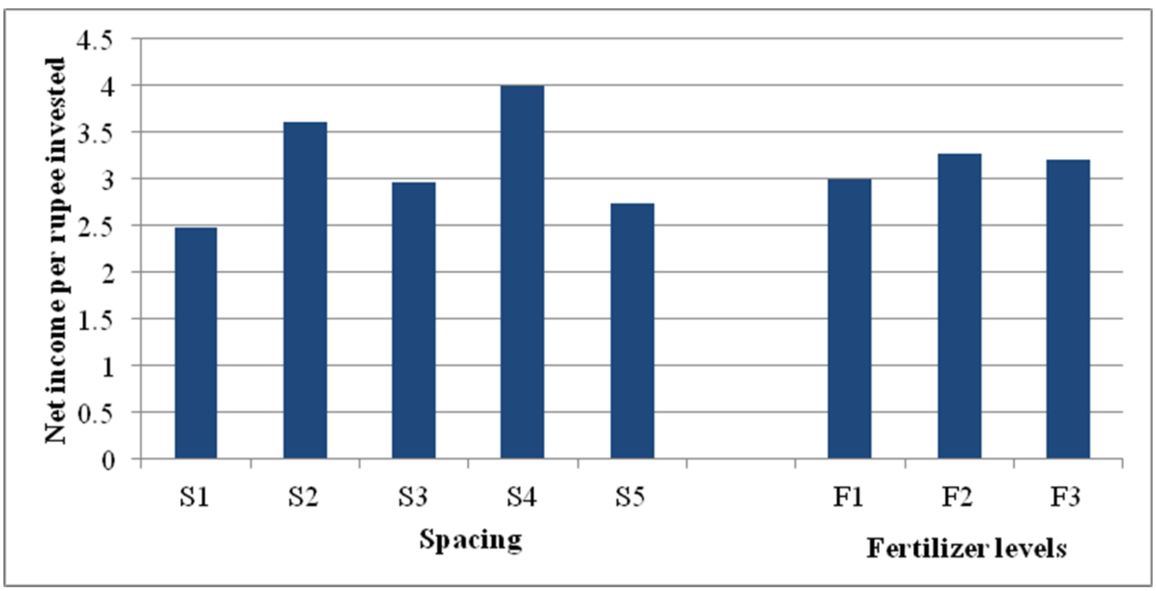

Fig 21. Net income per rupee invested as influenced by spacing and fertilizer levels

Rs.4829. Net income per rupee invested was 3.27 in F_2 and 3.21 in F_3 compared to the value of 3.0 in F_1.

The result of economic analysis of treatment combinations also indicated highest net profit per hectare in S_4F_2. This is due to the highest fruit yield of 76.9 t/ha recorded in S_4F_2 and a moderate cost of production compared to other treatment combinations. The combination of S_4F_2 also recorded the highest net income (Rs.6,20,369) and net income per rupee invested. Second highest net income per hectare (Rs.5,83,288) was recorded in S_4F_3 which was closely followed by S_4F_1 (Rs.5,73,756).

5.13 Future thrust

High density planting with increased dose of fertilizer levels gives good yield. It is necessary to find found out the water requirement of oriental pickling melon under high density planting. As the water and nutrient requirements of op melon under high density planting are high, fertigation studies are needed to find out efficient levels of water and nutrients. Fertigation studies can be carried out under different forms of mulching and polyhouse conditions. Because of higher dose of chemical fertilizers, the shelf life is likely to be reduced. Shelf life of the fruits of op melon is to be evaluated under fertigation studies with high density planting.

Summary

6. SUMMARY

A field experiment was conducted at the Agricultural Research Station, Kerala Agricultural university, Mannuthy during the rice fallow summer season of December 2011 to February 2012 on "Yield maximization of oriental pickling melon *(Cucumis melo* var. *conomon*) by high density planting and nutrient management" grown in summer rice fallows.

The soil of the experimental field was sandy clay loam with bulk density of 1.34 g cm^{-3}. It was acidic in reaction, medium in organic carbon, available nitrogen and potassium and low in available phosphorus. The experiment was laid out in randomized block design (RBD) with three replications. The treatments consist of five population densities and three fertilizer levels. So there were 15 treatments. Oriental pickling melon variety *Saubhagya* was used in the present study.

Important results obtained and conclusions drawn out from the investigation are summarized here under,

- The number of vines per plant decreased with increase in plant population and increased significantly with increase in fertilizer level. Highest number of vines per plant was recorded in S_1 and was significantly superior to all other plant populations. Among fertilizer levels, highest number of vines was observed in F_3. The interaction between plant population and fertilizer levels was not significant.

- The length of vine decreased with increase in plant population from S_1 to S_5. Among the plant populations, significantly the maximum length of vine was observed in S_1. Length of vine increased significantly with increase in fertilizer level. In each plant population, length of vine increased with increase in fertilizer level up to F_3. But there was reduction in vine length under each

fertilizer level when plant population was increased from S_1 to S_5. The interaction between plant population and fertilizer levels significantly influenced the length of vine at harvest. The increased application of fertilizer was significantly evidenced with a decreased plant population with S_1F_3 having the maximum vine length.

- Number of leaves per vine decreased with increase in plant population from S_1 to S_5 and increased with increase in fertilizer level from F_1 to F_3. Among the different plant populations, maximum number of leaves per vine was observed in S_1 spacing and it was at par with S_2 and was significantly superior to other populations. In each spacing, number of leaves per vine increased steadily with increase in fertilizer level up to F_3. At the same time, there was reduction in number of leaves per vine under each fertilizer level with increase in plant population up to S_5. The interaction between spacing and fertilizer levels significantly influenced the number of leaves per vine at harvest. The increased application of fertilizer was evidenced with a decreased plant population with S_1F_3 having the maximum number of leaves per vine.

- Leaf area index increased progressively and significantly with an increase in plant population and fertilizer levels. Significantly the highest LAI was recorded in S_5 plant population and F_3 fertilizer level. The increased application of fertilizer was significantly evidenced with an increased plant population with S_5F_3 having the maximum LAI. The interaction between spacing and fertilizer levels significantly influenced the leaf area index. The increased application of fertilizer was significantly evidenced with an increased plant population with S_5F_3 having the maximum LAI.

- Dry weight of shoot growth per plant at harvest decreased significantly with increase in plant population from S_1 to S_5 and increased with increase in fertilizer level from F_1 to F_3.In each plant population, dry weight of shoot growth per plant at harvest increased significantly with increase in fertilizer level up to F_3. At the same time, there was significant reduction in dry weight per plant under each fertilizer level when plant population was increased from S_1 to S_5. The interaction between spacing and fertilizer levels significantly influenced the dry weight of shoot growth at harvest. The increased application of fertilizer was significantly evidenced with a decreased plant population with S_1F_3 having the maximum dry weight of shoot growth per plant at harvest.

- Total dry weight of shoot growth at harvest increased significantly with increase in plant population from S_1 to S_5 as well as with increase in fertilizer level from F_1 to F_3.In all the plant populations, total dry weight of shoot growth at harvest increased with increase in fertilizer level up to F_3. Similarly, there was significant increase in total dry weight of shoot growth at harvest with increase in plant population from S_1 to S_5 under each fertilizer level. The interaction between spacing and fertilizer levels significantly influenced the total dry weight of shoot growth at harvest. The increased application of fertilizer was significantly evidenced with an increased plant population with S_5F_3 having maximum production of dry weight of vegetative growth at harvest.

- Fruit dry weight increased significantly with increase in plant population up to S_4 and fertilizer level of F_2 and then decreased. Dry weight of fruits per ha increased with increase in fertilizer level in S_1, S_2 and S_3 with fertilizer levels up to F_3. In S_4 it increased up to F_2 and then decreased. In S_5 there was slight decrease in fruit dry weight with increase in fertilizer level. There was increase in dry weight of fruits per ha under each fertilizer level with increase in plant population up to S_4 and then decreased under S_5. The interaction between spacing and fertilizer levels significantly influenced the fruit dry weight. The increased application of fertilizer up to F_2 was significantly evidenced with an increased plant population up to S_4 with S_4F_2 having the maximum fruit dry weight at harvest.

- Spacing and fertilizer treatment had no significant effect on days to first flowering and days to harvest. Days to flowering almost concentrated around 25 days. It took 67 days to harvest the crop.

- Significant reduction in fruit number per plant was observed with increase in plant population from S_1 to S_5. Number of fruits per plant significantly increased with increase in fertilizer level up to F_2. It was the highest in F_2 and was on par with F_3.In each plant population, fertilizer level behaved differently on number of fruits per plant. In S_1, S_2 and S_3, number of fruits per plant increased up to F_2 and then remained without much change under F_3.Under S_4 and S_5, increase in fertilizer level did not influence fruit number per plant. There was a steady and significant decline in fruit number per plant under each fertilizer level with increasing plant population. The interaction between spacing and fertilizer levels significantly influenced the number of fruits per plant. The increased application of fertilizer up to F_2 was significantly evidenced with decreased plant population with S_1F_2 having the maximum fruit dry weight at harvest.

- Increase in plant population from S_1 to S_5 decreased the mean weight of one fruit, whereas it was increased by increase in fertilizer level up to F_2. Weight of fruit was maximum in F_2 fertilizer level followed by F_3 and F_1 respectively.

- Volume of one fruit declined with increase in plant population from S_1 to S_5. Volume of one fruit was maximum in F_2 fertilizer level followed by F_3 and F_1 respectively. The mean volume of one fruit did not differ very much in each plant population with change in fertilizer levels. But there was steady decline in volume of fruit under each level of fertilizer when plant population increased from S_1 to S_5. The interaction between spacing and fertilizer levels significantly influenced the mean volume of one fruit. The increased application of fertilizer up to F_2 was significantly evidenced with decreased plant population with S_1F_2 having the maximum volume of one fruit.

- Mean fruit weight per plant decreased significantly with increase in plant population. Mean weight of fruit per plant was maximum in F_2 fertilizer level and it was on par with F_3.In S_1, S_2, S_3 and S_4, mean fruit weight per plant increased significantly up to F_2 fertilizer level and changed slightly only under F_3. In S_5, the mean fruit weight per plant slightly decreased with increase in fertilizer level. There was steady and significant reduction in mean fruit weight per plant under each fertilizer level when plant population was increased. The interaction between spacing and fertilizer levels significantly influenced the mean fruit weight per plant. The mean fruit weight per plant was maximum in S_1F_2 followed by S_1F_3 and it was lowest in S_5F_3.

- Total fruit yield per ha increased significantly with increase in plant population up to S_4 and thereafter decreased. Yield of fruit was highest in F_2 fertilizer level and it was on par with F_3. Fruit yield increased substantially under each fertilizer level when plant population increased from S_1 to S_4 and then declined. The interaction between spacing and fertilizer levels significantly influenced the total fruit yield. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2having maximum fruit yield per ha.

- Spacing had no effect on leaf nitrogen content. Fertilizer levels significantly influenced leaf nitrogen content at 30 DAS. At 60 DAS, leaf nitrogen content decreased significantly with increase in plant population. Leaf nitrogen content was the highest in F_3 and the lowest in F_1.

- At 30 and 60 DAS, leaf P and K content decreased significantly with increase in plant population and increased significantly with increase in fertilizer levels.

- The shoot N content increased significantly up to F_2 fertilizer level and then steadied. Under varying fertilizer levels uptake of N by shoot at harvest was significantly highest in F_3.Fruit N content was not at all affected by nutrient levels applied. Total N uptake by the crop was maximum in F_3.

- The N content of fruit at harvest remained constant at 1.45 per cent irrespective of planting densities. Shoot N content decreased significantly with increase in plant population uptake by fruits increased significantly up to S_4 and then decreased. Total uptake of N by the crop also increased significantly with increase in plant population up to S_4 and then decreased.

- Total N uptake by the crop increased significantly under each fertilizer level up to S_4 only and then decreased. Similarly in each planting density response to fertilizer level was observed up to S_2. The interaction between spacing and fertilizer levels significantly influences the total nitrogen uptake. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum total nitrogen uptake by the crop at harvest.

- Shoot P content decreased significantly with increase in plant density. But P uptake by shoot at harvest increased significantly, with increase in plant population from S_1 to S_5.Total P uptake by the crop increased significantly up to S_4 and then decreased.

- The shoot P content and uptake increased significantly up to F_3. P content in fruits was not at all affected by fertilizer levels, but P uptake by fruits increased significantly up to F_2 and then decreased.

- Total P uptake increased significantly up to S_4 and thereafter remained constant or decreased. Similarly in each plant population response to P uptake was observed mostly up to F_2 level. Therefore S_4F_2 recorded the highest total P uptake by the crop, which also recorded the highest fruit yield. The interaction between spacing and fertilizer levels significantly influences the phosphorus uptake by fruit.

- Potassium content of shoot at harvest decreased significantly with increase in plant population and with fertilizer level up to F_2. Potassium uptake by shoot at harvest increased significantly with increase in plant population and with fertilizer levels. The interaction between spacing and fertilizer levels significantly influences the potassium uptake by shoot at harvest.

- Spacing and fertilizer treatment had no effect on potassium content of fruit at harvest. Potassium uptake by shoot at harvest increased significantly with increase in plant population up to S_4 and by with fertilizer levels up to F_2.

- Total potassium uptake at harvest increased significantly with increase in plant population up to S_4 and fertilizer level up to F_2. Increased application of fertilizer up to F_2 was significantly evidenced with an increase in population up to S_4 with S_4F_2 having maximum uptake of total potassium at harvest. The interaction between spacing and fertilizer levels significantly influences the potassium uptake by fruit.

- Available nitrogen in soil after the trial increased with increase in fertilizer levels in all the plant populations and decreased with increase in plant population up to S_4 under each fertilizer level.

- Available phosphorus in soil increased in all plant populations with increase in fertilizer levels and decreased with increase in plant population up to S_4 under each fertilizer level.

- Available potassium in soil increased in all plant populations with an increase in fertilizer levels. It decreased under each fertilizer level with increase in plant population up to S_4.

- Total cost of production increased with increase in plant population. The increase in total cost of production with increase in fertilizer level was very less. Among the five plant populations, gross return was maximum in S_4 (1.25 m x 0.30 m) and among the fertilizer levels, it was highest under F_2. Net return also followed the same trend as under gross return. Net income per rupee invested was the highest in S_4 (1.25 m x 0.30 m) plant population and under fertilizer levels it was maximum in 125% of RDF. Among the 15 treatments, S_4F_2 recorded as the best treatment.

- From the study, it can be concluded that a spacing of 1.25 m x 0.30 m with a fertilizer dose of 87.5 : 31.25 : 31.25 NPK Kg/ ha is found to be an appropriate agronomic practice for higher yield and economic returns.

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Appendices

Appendix I

1) ANOVA table for number of vines per plant

Source	Degree of freedom	Mean square
Replication	2	0.069
Spacing (S)	4	2.037**
Fertilizer level (F)	2	1.994*
S X F	8	0.047
Error	28	0.071

** Significant at 1% level

* Significant at 5% level

2) ANOVA table for length of vines (cm) at harvest

Source	Degree of freedom	Mean square
Replication	2	17.689
Spacing (S)	4	2126.589**
Fertilizer level (F)	2	2212.622**
S X F	8	48.539*
Error	28	21.332

** Significant at 1% level

* Significant at 5% level

3) ANOVA table for number of leaves per vine

Source	Degree of freedom	Mean square
Replication	2	0.474
Spacing (S)	4	26.298**
Fertilizer level (F)	2	32.498**
S X F	8	1.105**
Error	28	0.316

** Significant at 1% level

* Significant at 5% level

4) ANOVA table for Leaf Area Index

Source	Degree of freedom	Mean square
Replication	2	0.004
Spacing (S)	4	4.591**
Fertilizer level (F)	2	0.341**
S X F	8	0.007**
Error	28	0.003

** Significant at 1% leveL

5) ANOVA table for dry weight of vegetative growth (g/plant) at harvest

Source	Degree of freedom	Mean square
Replication	2	0.914
Spacing (S)	4	578.021**
Fertilizer level (F)	2	484.994**
S X F	8	4.384**
Error	28	1.341

** Significant at 1% level

6) ANOVA table for dry weight of vegetative growth (kg/ha) at harvest

Source	Degree of freedom	Mean square
Replication	2	963.089
Spacing (S)	4	2337996.089**
Fertilizer level (F)	2	216116.422**
S X F	8	3605.006**
Error	28	718.470

** Significant at 1% level

7) ANOVA table for number of fruits per plant

Source	Degree of freedom	Mean square
Replication	2	0.020
Spacing (S)	4	11.661**
Fertilizer level (F)	2	0.591**
S X F	8	0.163**
Error	28	0.017

** Significant at 1% level

8) ANOVA table for average weight of one fruit (g)

Source	Degree of freedom	Mean square
Replication	2	6.156
Spacing (S)	4	4648.056**
Fertilizer level (F)	2	577.222**
S X F	8	106.389
Error	28	151.513

** Significant at 1% level

9) ANOVA table for mean fruit weight per plant (kg)

Source	Degree of freedom	Mean square
Replication	2	0.009
Spacing (S)	4	5.959**
Fertilizer level (F)	2	0.355**
S X F	8	0.088**
Error	28	0.009

** Significant at 1% level

10) ANOVA table for mean volume of one fruit (cm^3)

Source	Degree of freedom	Mean square
Replication	2	3.800
Spacing (S)	4	3544.800**
Fertilizer level (F)	2	442.400*
S X F	8	81.150
Error	28	114.014

** Significant at 1% level

* Significant at 5% level

11) ANOVA table for mean fruit yield (t/ha)

Source	Degree of freedom	Mean square
Replication	2	7.063
Spacing (S)	4	1506.085**
Fertilizer level (F)	2	116.211**
S X F	8	32.139*
Error	28	4.162

** Significant at 1% level

* Significant at 5% level

12) ANOVA table for days to first flowering

Source	Degree of freedom	Mean square
Replication	2	0.689
Spacing (S)	4	0.444
Fertilizer level (F)	2	0.356
S X F	8	0.411
Error	28	0.332

13) ANOVA table for days to harvest

Source	Degree of freedom	Mean square
Replication	2	1.089
Spacing (S)	4	0.256
Fertilizer level (F)	2	2.156**
S X F	8	0.322
Error	28	0.327

** Significant at 1% level

14) ANOVA table for nitrogen content of shoot at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.001
Spacing (S)	4	0.168**
Fertilizer level (F)	2	0.027**
S X F	8	0.001
Error	28	0.001

** Significant at 1% level

15) ANOVA table for nitrogen uptake by shoot at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	4.089
Spacing (S)	4	227.818**
Fertilizer level (F)	2	77.062**
S X F	8	2.797
Error	28	2.691

** Significant at 1% level

16) ANOVA table for phosphorus content of shoot at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.000
Spacing (S)	4	0.003**
Fertilizer level (F)	2	0.002**
S X F	8	0.000
Error	28	0.000

** Significant at 1% level

17) ANOVA table for phosphorus uptake by shoot at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	0.024
Spacing (S)	4	6.886**
Fertilizer level (F)	2	2.268**
S X F	8	0.041
Error	28	0.074

** Significant at 1% level

18) ANOVA table for potassium content of shoot at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.000
Spacing (S)	4	0.045**
Fertilizer level (F)	2	0.004**
S X F	8	0.000
Error	28	0.000

** Significant at 1% level

19) ANOVA table for potassium uptake of shoot at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	0.170
Spacing (S)	4	250.236**
Fertilizer level (F)	2	44.304**
S X F	8	0.474*
Error	28	0.189

** Significant at 1% level

* Significant at 5% level

20) ANOVA table for fruit dry weight (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	50009.400
Spacing (S)	4	12178712.700**
Fertilizer level (F)	2	993616.200**
S X F	8	282303.450**
Error	28	31568.400

** Significant at 1% level

21) ANOVA table for nitrogen content of fruits at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.000
Spacing (S)	4	0.000
Fertilizer level (F)	2	0.000
S X F	8	0.000
Error	28	0.000

22) ANOVA table for phosphorus content of fruits at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.000
Spacing (S)	4	0.000
Fertilizer level (F)	2	0.000
S X F	8	0.000
Error	28	0.000

23) ANOVA table for K content of fruits at harvest (%)

Source	Degree of freedom	Mean square
Replication	2	0.000
Spacing (S)	4	0.000
Fertilizer level (F)	2	0.000
S X F	8	0.000
Error	28	0.000

24) ANOVA table for nitrogen content of leaf (%)

Source	Degree of freedom	Mean square	
		30 DAS	60 DAS
Replication	2	0.002	0.004
Spacing (S)	4	0.011	0.493**
Fertilizer level (F)	2	0.070**	0.316**
S X F	8	0.002	0.005
Error	28	0.009	0.009

** Significant at 1% level

25) ANOVA table for phosphorus content of leaf (%)

Source	Degree of freedom	Mean square	
		30 DAS	60DAS
Replication	2	0.000	0.000
Spacing (S)	4	0.001**	0.013**
Fertilizer level (F)	2	0.003**	0.012**
S X F	8	0.000	0.000
Error	28	0.000	0.000

** Significant at 1% level

26) ANOVA table for potassium content of leaf (%)

Source	Degree of freedom	Mean square	
		30 DAS	60 DAS
Replication	2	0.005	0.001
Spacing (S)	4	0.041**	0.080**
Fertilizer level (F)	2	0.028**	0.035**
S X F	8	0.000	0.000
Error	28	0.001	0.001

** Significant at 1% level

27) ANOVA table for nitrogen uptake by fruits (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	7.816
Spacing (S)	4	2561.076**
Fertilizer level (F)	2	239.536**
S X F	8	62.943**
Error	28	5.804

** Significant at 1% level

28) ANOVA table for phosphorus uptake by fruits (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	0.207
Spacing (S)	4	115.476**
Fertilizer level (F)	2	10.527**
S X F	8	2.673**
Error	28	0.561

** Significant at 1% level

29) ANOVA table for potassium uptake by fruits (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	7.796
Spacing (S)	4	1519.891**
Fertilizer level (F)	2	139.991**
S X F	8	34.814**
Error	28	5.280

** Significant at 1% level

30) ANOVA table for total nitrogen uptake at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	16.318
Spacing (S)	4	4249.339**
Fertilizer level (F)	2	575.724**
S X F	8	63.766**
Error	28	10.012

** Significant at 1% level

31) ANOVA table for total phosphorus uptake at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	0.230
Spacing (S)	4	171.254**
Fertilizer level (F)	2	17.825**
S X F	8	2.894**
Error	28	1.004

** Significant at 1% level

32) ANOVA table for total potassium uptake at harvest (kg/ha)

Source	Degree of freedom	Mean square
Replication	2	8.124
Spacing (S)	4	2852.177**
Fertilizer level (F)	2	302.608**
S X F	8	36.235**
Error	28	5.912

** Significant at 1% level

Appendix II

A) Quantity (kg/t) and cost of inputs per hectare

Particulars	Treatments														
	S1F1	S1F2	S1F3	S2F1	S2F2	S2F3	S3F1	S3F2	S3F3	S4F1	S4F2	S4F3	S5F1	S5F2	S5F3
1.Seed Quantity (kg)	0.5	0.5	0.5	0.89	0.89	0.89	1.11	1.113	1.11	1.33	1.33	1.33	1.67	1.67	1.67
Total cost	750	750	750	1332	1332	1332	1650	1650	1650	1995	1995	1995	2505	2505	2505
2. FYM Quantity (t)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Total cost	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500
3.Fertilizers a.Factomphos Quantity	125.0	156.3	187.5	125.0	156.3	187.5	125.0	156.3	187.5	125.0	156.3	187.5	125.0	156.3	187.5
Total cost	1844.0	2305.0	2766.0	1844.0	2305.0	2766.0	1844.0	2305.0	2766.0	1844.0	2305.0	2766.0	1844.0	2305.0	2766.0
b.Urea (kg)	97.65	111.2	146.75	97.65	111.2	146.75	97.65	111.2	146.75	97.65	111.2	146.75	97.65	111.2	146.75
Total cost	586.0	667.0	881.0	586.0	667.0	881.0	586.0	667.0	881.0	586.0	667.0	881.0	586.0	667.0	881.0
c.MOP	41.75	52.20	62.63	41.75	52.20	62.63	41.75	52.20	62.63	41.75	52.20	62.63	41.75	52.20	62.63
Total cost	501.0	626.0	752.0	501.0	626.0	752.0	501.0	626.0	752.0	501.0	626.0	752.0	501.0	626.0	752.0
4.Imidacloprid Quantity (ml)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Total cost	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0	900.0
Total cost of all inputs	23081	23748	24549	23663	24330	25131	23981	24648	25449	24326	24993	25794	24836	25503	26304

Cost of oriental pickling melon seed: Rs 1500/kg

Cost of FYM: Rs 700/t

Cost of Factomphos: Rs.14.75/kg

Cost of Urea: Rs 6.00/kg

Cost of MOP: Rs 12/kg

Cost of Imidacloprid: Rs 300.00/100 ml

Appendix III

B. Cost of cultivation (Rs/ha)

Particulars	Treatments														
	S1F1	S1F2	S1F3	S2F1	S2F2	S2F3	S3F1	S3F2	S3F3	S4F1	S4F2	S4F3	S5F1	S5F2	S5F3
1.Ploughing by tractor twice	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs	3.0 hrs
Total cost	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0
2. Digging corner + trimming buds	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M	5 M
Total cost	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
3.Pit/channel preparation	67 M	67 M	67 M	86 M	86 M	86 M	115 M	115 M	115 M	86 M	86 M	86 M	115 M	115 M	115 M
Total cost	20100	20100	20100	25800	25800	25800	34500	34500	34500	25800	25800	25800	34500	34500	34500
4.Transport + applicatn. FYM	16 W	16 W	16 W	20 W	20 W	20 W	26 W	26 W	26 W	20 W	20 W	20 W	26 W	26 W	26 W
Total cost	3360	3360	3360	4200	4200	4200	5460	5460	5460	4200	4200	4200	5460	5460	5460
5. Incorpo. of FYM + filling	23 M	23 M	23 M	33 M	33 M	33 M	44 M	44 M	44 M	33 M	33 M	33 M	44 M	44 M	44 M
Total cost	6900	6900	6900	9900	9900	9900	13200	13200	13200	9900	9900	9900	13200	13200	13200
6.Sowing of seeds	6 W	6 W	6 W	11 W	11 W	11 W	13 W	13 W	13 W	16 W	16 W	16 W	20 W	20 W	20 W
Total cost	1260	1260	1260	2310	2310	2310	2730	2730	2730	3360	3360	3360	4200	4200	4200
7.Pot watering upto 14 DAS(7)	49 W	49 W	49 W	63 W	63 W	63 W	77 W	77 W	77 W	63 W	63 W	63 W	77 W	77 W	77 W
Total cost	10296	10296	10296	13230	13230	13230	16170	16170	16170	13230	13230	13230	16170	16170	16170
8.Basal +weeding, inco.	14 W	14 W	14 W	20 W	20 W	20 W	26 W	26 W	26 W	20 W	20 W	20 W	26 W	26 W	26 W
Total cost	2940	2940	2940	4200	4200	4200	5460	5460	5460	4200	4200	4200	5460	5460	5460
9.Thinning, gap filling	3 W	3 W	3 W	5 W	5 W	5 W	7 W	7 W	7 W	8 W	8 W	8 W	9 W	9 W	9 W
Total cost	630	630	630	1050	1050	1050	1470	1470	1470	1680	1680	1680	1890	1890	1890

Hire charge of tractor: Rs 400/hr Labour wages: Men @ Rs 300/day Women wages: Rs 210/day Cost of one unit of electricity: Rs 2.90

B. Cost of cultivation (Rs/ha) ----contd

Particulars	Treatments														
	S1F1	S1F2	S1F3	S2F1	S2F2	S2F3	S3F1	S3F2	S3F3	S4F1	S4F2	S4F3	S5F1	S5F2	S5F3
10. Weeding	25W	25W	25W	36 W	36 W	36 W	48 W	48 W	48 W	36 W	36 W	36 W	48 W	48 W	48 W
Total cost	5250	5250	5250	7560	7560	7560	10080	10080	10080	7560	7560	7560	10080	10080	10080
11.Top dressing fertilizer, incorpo	14 W	14 W	14 W	20 W	20 W	20 W	26 W	26 W	26 W	20 W	20 W	20 W	26 W	26 W	26 W
Total cost	2940	2940	2940	4200	4200	4200	5460	5460	5460	4200	4200	4200	5460	5460	5460
12.Raking and earthing up	24 W	24 W	24 W	34 W	34 W	34 W	45 W	45 W	45 W	34 W	34 W	34 W	45 W	45 W	45 W
Total cost	5040	5040	5040	7140	7140	7140	9450	9450	9450	7140	7140	7140	9450	9450	9450
13.Mammatty weeding-inter space + bund	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M	30 M
Total cost	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
14.Collection, spread, mulch	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M	22 M
Total cost	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600
15.Imidacloprid spraying (2)	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M	4M
Total cost	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
16.Irrigation from 15-20 DAS(11 irri)	33M	33M	33M	44M	44M	44M	55M	55M	55M	44M	44M	44M	55M	55M	55M
Total cost	9900	9900	9900	13200	13200	13200	16500	16500	16500	13200	13200	13200	16500	16500	16500
17.Harvesting& transportation	5M 16 W	5M 16 W	5M 16 W	7M 21 W	8M 24 W	8M 24 W	8M 24 W	9M 28 W	9M 27 W	9M 28 W	10M 30 W	9M 28 W	8M 27 W	10M 30 W	9M 27 W
Total cost	4860	4860	4860	6510	7440	7440	7440	8580	8370	8580	9300	8580	8070	9300	8370
18.Electricity units for irrigation	98	98	98	127	127	127	156	156	156	127	127	127	156	156	156
Total cost	285	285	285	368	368	368	452	452	452	368	368	368	452	452	452
Total cost of cultivation	93261	93261	93261	119168	120098	120098	147872	149012	148802	122918	123638	122918	151112	152342	151412

Appendix IV

Summary of cost economics per hectare in rupees for each treatment

Treatments	Cost of inputs	Cultivation cost	Total cost	Total return	Net profit
S_1F_1	23081	93261	116342	394000	277658
S_1F_2	23748	93261	117009	419000	301991
S_1F_3	24549	93261	117810	409000	291190
S_2F_1	23663	119168	142831	573000	453832
S_2F_2	24330	120098	144428	694000	549572
S_2F_3	25131	120098	145229	706000	560771
S_3F_1	23981	147872	171853	638000	466147
S_3F_2	24648	149012	173660	714000	540340
S_3F_3	25449	148802	174251	714000	539749
S_4F_1	24326	122918	147244	721000	573756
S_4F_2	24993	123638	148631	769000	620369
S_4F_3	25794	122918	148712	732000	583288
S_5F_1	24836	151112	175948	672000	496052
S_5F_2	25503	152342	177845	659000	481155
S_5F_3	26304	151412	177716	657000	479284

YIELD MAXIMIZATION OF ORIENTAL PICKLING MELON (*Cucumis melo* var. *conomon* (L) Makino) BY HIGH DENSITY PLANTING AND NUTRIENT MANAGEMENT

By

RAJEES P.C.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

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2013

ABSTRACT

A field experiment was conducted at the Agricultural Research Station, Mannuthy, Thrissur during December 2011 to February 2012 to study the effect of "Yield maximization of oriental pickling melon (*Cucumis melo* var. *conomon* (L.) Makino) by high density planting and nutrient management" grown in summer rice fallows. The objective of the study was to achieve maximum production of oriental pickling melon by high density planting and optimum use of nutrients.

The experiment was laid out in Randomised Block Design (RBD) with three replications. Treatments consisted of combinations of five planting densities and three fertilizer levels. The planting densities were 10,000 (S_1), 17,777 (S_2), 22,222 (S_3), 26,666 (S_4) and 33,333 (S_5) plants per hectare and fertilizer levels at 100% (F_1), 125% (F_2) and 150% (F_3) of recommended dose of fertilizers (RDF) respectively.

Plant population, fertilizer levels and their interactions have shown significant effect on growth characteristics. Parameters like number of vines per plant, length of vine at harvest and number of leaves per vine increased with increase in fertilizer dosage but decreased with increase in plant population. LAI and per hectare shoot dry matter production increased with increase in plant population and fertilizer levels. Interactions between plant population and fertilizer levels were linear up to S_5F_3 on LAI and per hectare shoot dry weight.

Yield attributes like number of fruits per plant, mean fruit weight and mean fruit volume declined significantly with increase in plant population. Fruit yield per hectare increased significantly with increase in plant population up to S_4 and thereafter decreased significantly. Among the fertilizer levels, all the yield attributes increased significantly up to F_2 and slightly decreased at F_3. S_4F_2 recorded significantly the highest fruit yield. There was a steady decline in number of fruits per plant, mean fruit volume and mean fruit weight per plant under each fertilizer level with increase in plant population, but the fruit yield per hectare increased substantially.

High density planting and levels of NPK had significant effect on leaf Nitrogen, Phosphorus and Potassium contents both at 30 and 60 DAS. The leaf nutrient contents decreased with increase in plant population. Leaf N, P, and K contents increased significantly with increase in fertilizer level up to F_3 both at 30 and 60 DAS. There was no significant interaction effect between plant population and levels of nutrients applied.

Density of planting and nutrient levels significantly affected shoot nitrogen content at harvest and uptake of N by the crop. The N content of fruit at harvest remained constant at 1.45 per cent irrespective of planting densities. Shoot N content decreased significantly with increase in plant population. N uptake by fruits increased significantly up to S_4. The shoot N content increased significantly up to F_2 fertilizer level. The interaction between plant population and fertilizer level was significant in the case of total N uptake. Total N uptake by the crop increased significantly under each fertilizer level up to S_4 only and then decreased.

Similarly in each planting density, significant response to fertilizer level was observed up to F_2 only. Therefore S_4F_2 recorded the highest uptake of N by the crop. Total P and K uptakes also have shown the same trend and highest uptake was observed in S_4F_2, which recorded the highest fruit yield.

High density planting had significant influence on total cost of production, gross returns, net returns and net income per rupee invested. Cost of cultivation was very less in S_1, because of wider planting in pits taken at 2 x 1.5 m apart. Cost of cultivation was very high in S_3 and S_5 due to more number of channels taken at every one metre. Since S_2 and S_4 were planted in channels taken 1.25 m apart, its cost of cultivation was less compared to S_3 and S_5. Net return increased with increase in plant population up to S_4 and then decreased. Highest net profit per hectare was recorded in S_4F_2. This is due to the highest fruit yield of 76.9 t/ha recorded in S_4F_2 and a moderate cost of production compared to other treatment combinations. Hence a population density of 26,666 plants per hectare and a fertilizer dose of 125% RDF were found to be the best treatment for realising highest profit from the cultivation of oriental pickling melon at high density planting using the less spreading variety “Saubhagya”.