RESPONSE OF SLICING CUCUMBER (*Cucumis sativus* L.) TO POPULATION DENSITY, TRAILING SYSTEMS AND NUTRIENTS

By

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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM

1998

DECLARATION

I hereby declare that this thesis entitled "**Response of slicing cucumber (*Cucumis sativus* L.) to population density, trailing systems and nutrients**" is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled "**Response of slicing cucumber (*Cucumis sativus* L.) to population density, trailing systems and nutrients**" is a record of research work done independently by Miss. Renji. C. R under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ACKNOWLEDGEMENT

I feel immense pleasure in extending my unbounded gratitude and sincere thanks to Dr. M. Abdul Vahab, Associate Professor, Department of Horticulture, College of Agriculture, Vellayani and Chairman of the Advisory Committee for his valuable guidance, constant encouragement, kind treatment, untiring interest, constructive criticism, sincere help, goodwill and gesture of affection bestowed throughout the course of this investigation and for his contribution in preparation of this thesis in its entireness.

I am also grateful to Dr. S. Ramachandran Nair, Professor and Head, Department of Horticulture and Dr. L. Rajamony, Associate Professor and Head, Department of Olericulture, members of Advisory Committee for their valuable counselling critical and indispensable suggestions for the consummation of the thesis.

I wish to express my thanks to Dr. Vijaya Raghavakumar, Associate Professor, Department of Agricultural Statistics and members of Advisory Committee for his help and guidance in statistical analysis and interpretation of the data.

I avail myself of this opportunity to thank Dr P. Reghunath, Associate Professor, Department of Entomology and teaching staff of Department of Horticulture for their generous help and sincere co-operation.

I express my deep sense of gratitude to Sri. C. E. Ajith Kumar, Programmer, Department of Statistics, College of Agriculture, Vellayani for the pains he has taken in computer programming and analysis of the data. Also to

Mr. H. Gopinanthan, Farm Assistant and the labourers of the Department of Horticulture for their co-operation in carrying out the field work.

I take this opportunity to express my thanks to the non-teaching staff of Department of Horticulture, College of Agriculture, Vellayani, my classmates and friends for their whole hearted support, co-operation and help rendered to me. Also I am thankful to National Seed Co-operation, Karamana for providing me with seeds used in the study.

I sincerely acknowledge ARDRA Computers for the prompt and timely help rendered in typing the thesis.

I acknowledge with thanks the Kerala Agricultural University for granting me the Junior fellowship.

Words cannot express what I owe to my dear Achan, Amma, grandmothers, brother, sister, brother in law and Chinnu who have been a reservoir of strength and support throughout their love, affectionate prayers and blessings.

Above all I bow my head before God Almighty whose blessings were always with me, enabling me to undertake this endeavour successfully.

RENJI. C. R.

Dedicated to

MY PARENTS

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INTRODUCTION

1. INTRODUCTION

Vegetables play a vital role in the health and nutrition of people throughout the world. The food experts and nutritionists have realised and appreciated the food value of vegetables because of the low calorific value and high contents of protein, vitamins and minerals. Recently our country was striving hard to achieve nutritional security because of the scarce supply of vegetables.

India, with a production of 46 metric tonnes from an area of 4.5 million hectares, is the second largest producer of vegetables in the world next to China. However, there is a wide gap between the per capita availability (135 g / day) and requirement of vegetables (285 g / day). The low per capita consumption of vegetable is mainly due to the low production levels. Hence in India, with a large vegetarian population, vegetable production need to be greatly augmented by the adoption of various technologies.

Cucumber (*Cucumis sativus* L.) is an important cucurbitaceous vegetable grown in lower as well as higher altitudes. It is one of the most economical cucurbits whose immature fruits are consumed as salad as well as pickle and is sold at premium price especially in the off season. Besides, it possesses medicinal, cosmetic, cooling tonic and diuretic properties (CSIR, 1950) also.

In India, cucumbers are cultivated on an area of 16,288 hectares with the total estimated production of 1,05,690 tonnes (Anon, 1991). The production of cucurbits in general and cucumber in particular has considerably increased in India in the past two decades. Tremendous increase in production has been due to the popularisation of improved cultivars and advances in production technology (Chadha and Kalloo, 1993).

There exists considerable variation in the spacing and population density in cucumber. The yield as well as size and shape of the fruits are affected by the density of planting to a great extent. It also varies with the type of cucumber viz. slicing, pickling or parthenocarpic. The population density also varies with growth habit *viz.* determinate and indeterminate. The sex expression is also influenced by planting density, crop arrangement and genotype. Therefore, standardisation of population density in respect of maximum yield and quality with optimum cost / benefit ratio would be an important contribution in cucumber cultivation.

Uniformily long fruits of cylindrical shape without crooked neck and rotting constitute marketable yield. In addition, intact carpels without hollow spots and tender seeds at edible maturity forms the quality attributes in cucumber. In kharif season, unsuitable soil condition lead to deshaping and rotting of fruits which greatly affect the yield as well as quality. Trellising / trailing is appreciated for getting higher marketable yields in cucumber (Konsler and Strider, 1973). There exists different systems of trailing *viz.*

trailing on ground, mulches, pandals, trellis etc. Staking can be done with sticks cheaply available on the farm which make it feasible for poor farmers.

Growth, development, sex expression, fruit yield and quality are affected by the method of trailing. The trailing systems affect pollination and uniform development of fruits. The size and shape of the fruits are also influenced by the system of trailing. Trailing the plants on support also helps in cultural operation like irrigation, fertilizer application , plant protection and harvesting. So information on optimum trailing system under different plant population is very important.

The nutrient requirement also vary with plant population per unit area. The nutrient levels affect plant growth, earliness, sex expression and ultimate yield and quality. Arriving at optimum nutrient requirement is an important economic consideration in cucumber cultivation.

The present study is therefore undertaken considering above facts with following objectives.

i. To standardise the trailing system in cucumber for maximum yield.

ii. To arrive at optimum population density for maximum marketable yield in cucumber.

iii. To find out optimum nutrient requirement for maximum yield.

iv. To work out optimum benefit : cost ratio in cucumber cultivation and

v. To study the interaction effect of trailing systems with population density and nutrients.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Cucumber (*Cucumis sativus* L.) is an important vegetable in the tropical parts of the world. It is one of the most economical cucurbits grown for the immature fruits which are consumed as a salad or cooked vegetable. The fruits are also pickled and processed. Cucumber is sold at premium prices in off season. The fruits vary in size, shape and colour and are considered nutritious. Possible improvement in yield and quality through use of F_1 hybrids, improved open pollinated varieties and modified cultural practices including judicious use of fertilizers have been well established in foreign countries. In Kharif season, unsuitable soil conditions lead to deshaping and rotting of fruits which greatly affect the yield and quality. The yield, size and shape of fruits are affected by the density of planting to a great extent. The nutrient levels affect plant growth, earliness, sex expression and ultimate yield and quality. Cucumber responds well to manures and fertilizers. Similarly, all these characters are highly influenced by trailing systems, population density and soil nutrition. The works on these management aspects in cucumber are rather limited in our country. The available literature on cucurbitaceous vegetables pertaining to the present study is reviewed under the following subheads.

2.1 Population density

2.2 Trailing systems

2.3 Plant nutrition

2.1 Population density

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

2.1.1 Growth, flowering and fruit set

Density of population affects plant growth, flowering pattern and fruit set in any crop. In cucumber the best plant growth, development, photosynthesis and greatest yields were obtained when plants were grown at 1.5 plants per m^2 (Karataev and Salnikova, 1983).

The effect of population density varies with hybrids, 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.

In an experiment with muskmelon, Nerson *et al.* (1984) observed faster vegetative growth per unit area with the population of 31250 plants than with 13500 plants per hectare. There were more leaves per m^2, higher leaf area index and more dry matter accumulation per m^2 with higher population density.

In a study with ridgegourd, Arora and Malik (1989) observed early appearance of pistillate flowers and highest number and weight of fruits when the plants were grown at a population density of 11250 per hectare.

In a study with parthenocarpic cucumber cv. Marboson, the timing of fruit production, sex expression and flower abortion were not affected by plant density and row arrangement (Kasrawi, 1989). However shoot dry weight per plant decreased linearly or quadratically with increasing plant density.

In pumpkin, number of branches, average length of internode and induction of male flowers was not affected by different spacings (Kulbir Singh *et al.*, 1990). However closer spacing of 3m x 75 cm resulted in earlier production of female flowers than with wider spacing.

2.1.2 Yield and yield components

Population density and spacing affects yield and its components to a great extent. In an experiment with watermelon, Petkov (1970) observed that closer spacing produced higher yield with negligible effect on fruit size. Halling and Amsen (1970) recorded highest yield when the number of plants was increased and distance between the rows was shortened at same time. High yield of 31.7 tperha was obtained from cucumber cultivar Ashely spaced at 1.4 x 0.4 m (Marin Hautrive and Peres Guerra, 1976).

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

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 as between row spacing was increased from 1.5 m to 4.5 m and within row spacing from 50 cm to 250 cm.

Effect of population density on the performance of cucumber was investigated by Mangal and Yadav (1979) using two spacings *viz.* 100 cm x 60 cm and 100 cm x 90 cm. They observed maximum yield per hectare at closer spacing of 100 x 60 cm. Burgmans (1981) conducted an experiment in gherkins to study the effect of spacing on growth and yield using two varieties *viz* "Green spear" and "SG-812". From the results of three years trial he observed highest salable and total yield with highest plant population (1,20,000 plants per ha).

Wehner and Miller (1983) compared the performance of determinate and indeterminate cultivars of cucumber under varying planting densities. They observed higher optimum population density for higher yield in the case of indeterminate cultivar 'Table green 65' than that of the determinate cultivars.

The yield of bottlegourd as affected by various levels of spacing was investigated by Vishnushukla and Prabhakar (1987). In a study with the cultivar 'Arka Bahar' using various levels of spacing, they observed highest yield (38.5 t per ha) when plants were spaced at 300 x 45 cm with 3 plant per hill compared to other spacing.

The response of parthenocarpic cucumber cv. Marbason to plant density and row arrangement was investigated in plastic green houses by Kasrawi (1989) over two growing seasons with four planting densities. It was found that the yield per unit area was increased linearly when the population density was increasd from 2.4 to 5.4 plants per m^2 and the increase was greater in a two row arrangement than in one, three or four row arrangements.

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 training on different varieties of pointedgourd. Three varieties *viz.*, FP-1, FP-3, FP-4 and two spacings *viz.*, 1.5 x 1.5 m and 3 x 1.5 m were considered for the study. Maximum yield of 110.32 q per ha was recorded under bower system of planting with narrow spacing (1.5 x 1.5 m) in the variety FP-4.

Effect of four plant spacings (3 m x 60 cm, 4 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 Punjab Agricultural University. The different spacing did not change 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 per ha.

Wann (1993) conducted an experiment to identify adapted cultivars, optimum population density and plant spacial arrangement of cucumber. The cultivars were grown in population densities ranging from 26,000 to 130,000 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.

2.1.3 Quality parameters

By increasing the density of greenhouse cucumber from 2 to 2.6 plants per m^2 Kretschmer (1970) observed enhanced fruit quality. In an experiment with 'PMR 45' and 'Top Mark' cantaloupe cultivars planted at a population density of 7000, 16,000, 28000 and 63000 plants per acre Zahara (1972) reported increased sucrose content of mature fruits at wider spacing. The number of marketable melons were also greater with PMR-45 at population density of 16,000 plants per acre.

Effect of planting density and shading on fruit curvature in cucumber was studied by Kanahama and Saito (1984). Cucumber plants were grown at densities 7.3, 5.5 and 2.2 plants per m^2 and shaded with one, two or three layers of cheese cloth. They observed that the angle of curvature of fruit was not affected by planting density but increased with increased shading.

2.2 Trailing systems

Growth, development, sex expression, fruit yield and quality are affected by the method of trailing. There exists different systems of trailing *viz.* trailing on ground, mulch, pandals, trellis. etc. The trailing systems affect pollination and uniform development of fruits. The size, shape and quality of fruits are also influenced by the systems of trailing. Staking is one of the tools that can be employed to increase yield as well as quality of cucumber fruits. Trailing plants on support also helps in cultural operations like irrigation, fertilizer application, plant protection and harvesting.

2.2.1 Growth, flowering and fruitset

Different trailing systems affect growth, flowering and fruit set in cucumber. In glasshouse cucumbers, Kooistro (1967) observed that male flowers were far less numerous on the vines topped at the fourth axillary joint but the three stem plants would appear to have no advantage in this respect. It has been reported that vertical training resulted in slight loss of earliness as compared with the conventional flat system (Anon, 1969). Pinching back the lower side shoots to 1-2 leaves also increased the earliness in cucumber [Vogel *et al.* (1971)]. However Kobza and Stambera (1972) reported temporary increase in leaf area by cutting back the main axis above the first and fourth leaf. Different pruning methods reported by Yurina and Ganichkina (1975) changed the plant branching habit, and the short pinching method improved leaf photosynthetic productivity. The early harvest due to pergola system in green house cucumber has been reported by Stan *et al.* (1980).

Hanna and Adams (1984) reported greater plant weight, greater weight and dimension of leaves in staked cucumber plants though the number of female flowers did not vary between staked and unstaked plants. Vertical training system recorded significantly increased fruit set.

In a field trial with bottlegourd cv. 'Pusa Summer Prolific Long', lowest number of female flowers, lowest number of branches and fruits per plant were recorded in treatments where branching on the main shoot was allowed from the nineth to fifteenth node (Sharma *et al.*, 1988).

Effect of pruning on the growth, flowering and earliness in ridgegourd cv. 'Pusa Nasdar' was studied by Arora and Mallik (1989). The plants were pruned to leave two, four or six primary branches with a no pruning control. Plants pruned to six primary branches gave the longest plants with highest number of secondary branches and showed early appearance of pistillate flowers. However the duration of flowering and fruit maturation were shorter when pruned in summer season (Gobeil and Gosselin, 1989).

Matiar Rahman and Monowar Hossain (1989) conducted an experiment to study the performance of three advanced bottlegourd lines *viz.* BG-0009, BG-0011 and BG-0003 with trellis and non trellis. They reported that plants on trellies produced flower earlier than those on non-trellis. Also the length of the main vine ranged from 6.03 to 8.20 m with trellis while without trellis it ranged from 4.05 to 6.07 m in all three lines. In an experiment with different varieties of pointed gourd *viz.* FP-1, FP-3 and FP-4 Yadav *et al.* (1989) recorded increased vine length in trained plants. The favourable response of training was observed on branching pattern, varieties FP-4 and FP-3 produced higher number of branches. Also the flowering was initiated earlier when the plants were trained.

Growth and flowering of bittergourd cv. 'Co-white Long' as influenced by different training systems *viz.* bower, kniffin, bush and ground was studied by Joshi *et al.* (1994). They recorded vigorous vine length, number of branches per plant on bower system. The appearance of female flower was slightly earlier in bower and kniffin system than in bush and ground system.

2.2.2 Yield and yield components

Training systems have its desirable effects with respect to yield and yield components. Hosslin (1966) reported higher per plant yield in comparison of cordon cucumber with vertical wire espaliers which also resulted in greater amount of marketable fruits. According to Raether (1966) higher yield per vine in cucumber was obtained with two shoots per plant with fruits left on main stem and lowest with no pruning. Weichold (1967) concluded that plant density affected the yield of the cordon cucumbers.

Light pruning resulted in more uniform cropping and considerably heavier yield (Wikesjo, 1971 and Kurki, 1972). In a three year trial by Konsler and Strider (1973) the results revealed that the marketable yields of trellised cucumber were double compared to those obtained with ground culture. However, Santos and Diaz (1974) reported that vertical training in cucumber had given higher yield, than oblique training system. Training of shoots by various systems reduced yield by 40.5 to 69.1 per cent compared with untrained cucumbers (Yurina and Ganichkina, 1975).

Effect of pruning on performance of cucumber was studied by Mangal and Yadav (1979). They reported that pruning of all secondary shoots upto fifth node gave significantly higher yield than unpruned control. The average weight, diameter and fruit length were slightly more in the case of fruits harvested from pruned plants.

The fruit numbers differed slightly between single stem and double stem. Vines spaced at 86 cm, but closely spaced two stem plants gave highest fruit numbers (Enthoven, 1980). Singh *et al.* (1982) opined that the training of pruned plants on bamboos and reduction in plant to plant spacing to 30 cm resulted in further increase in fruit yield. Greater fruit number per plant was reported by Duyn (1984) when growing point is retained. Hanna and Adams

(1984) reported that vertical training significantly increased the marketable yield more than double in the normal cultivar and also noticed increase in fruit length. Liebig (1984) stated that none of the pruning methods significantly affected the yield of the gynoecious cucumber cultivar Pepinex nor reduced the yield rhythm.

Bakker and Vooren (1985) found that the highest productivity was obtained with 'V' system at high density but mean fruit weight decreased. Pruning of muskmelon varieties, Punjab Sunehri, Punjab Hybrid, Pusa Sharbati and Hara Madhu upto third, fourth, sixth and seventh node respectively reported to enhance the fruit yield (Mangal and Pandita, 1985). Moerman (1985) found that pruning enhanced the total yield per m^2 of Lucinde but depressed the early yields of Corona. Uffelin (1986) observed significant difference in fruit weight though yield were slight in pruned plants. The removal of laterals reduced early yields, the total yields and returns (Botos and Baboth, 1988).

According to Duranti and Lanza (1988) in muskmelon, shoot pruning alone did not increase fruit yield. The shoot pruning along with traditional treatment gave the highest yields (4.8 to 5.7 kg), the earliest ripening and greatest profit. Poll *et al.* (1988) assessed that gherkins grown as double row vertical system gives yield of 80 t per ha compared with 75 t per ha in the single row vertical system. The unfavourable effect of pruning methods on yield of bottlegourd was reported by Sharma *et al.* (1988).

Hanna *et al* (1989) reported that the marketable yield was slightly lower when tomato stakes were reused for cucumber growing. The out door cucumbers trained by traditional twine method produced more fruits although the fruits were shorter than those supported by nylon netting (Makus, 1989). Matiar Rahman and Monowar Hossain (1989) recorded more fruits per plant on trellis than on those without trellies in bottle gourd. The fruit size and weight were also increased on trellis compared to non-trellis. According to Yadav *et al* (1989), in pointed gourd the number of days for first picking of fruits was significantly lesser in flat system than that of bower. Growing cucumbers in a field trained on the used vine yard espaliers with hybrid cultivar 'Levina' yielded 48.6 and 46 t per ha in 1987 and 1988 respectively compared with the average yield of 17.2 t per ha given by the conventionally grown crops (Derevencha and Derevencha, 1990). From an experiment with bitter gourd 'Cv. Co-whitelong' Joshi *et al.* (1994) reported maximum number of fruits per vine (90) in bower system followed by Kniffin (60) ground (45) and bush (40) systems. Bower system recorded higher yield (143 %) than ground and bush systems.

2.2.3 Quality parameters

The various characters including quality of fruit, pest and disease incidence are highly influenced by different training systems. Lightly pruned plants were less susceptible to mildew than in severely pruned plants in glass house cucumber (Hosslin, 1956). Konsler and Strider (1966) reported that in cucumber fruit colour and shape was better on trellised plants and more thorough harvesting could be carried out than from the ground plots. They also reported 63 per cent greater top grade total yield from trellis than plants of ground culture. Kurki (1972) assessed that light pruning did not affect fruit quality of glasshouse cucumber adversely. However fruit quality was some what lower with extensive pruning than with normal pruning (Wikesjo and Nilsson, 1972).

Fruit quality was much higher with trellised cucumbers compared to ground culture, by improved control of scab and eliminated losses by fungi (Konsler and Strider, 1973). Significantly decreased fruit rot incidence was reported by Hanna and Adams (1984) when cucumber grown on vertical training system. Leaf pruning increased the proportion of high quality fruit but this was economically significant only in cucumber cultivar 'Sprou' (Liebig, 1984). Maximum light penetration is important in cucumber crop since darker green the fruit colour the better is the shelf life. Periods of low light intensity during may-June resulted in poor fruit colour and shorter shelf life (Janse, 1985). In a trail with cucumber cv. 'corona', Moerman (1985) recorded best coloured fruits with a hedge system both initially and after storage.

The percentage of culled fruits and of rotten fruits of cucumber were unaffected by staking system (Hanna *et al.*, 1989). Matiar Rahman and Monowar Hossain (1989) observed that fruits borne in bottle gourd plants without trellis had white spot in portion that was attached to the ground and were susceptible to insect damage. The fruits of non-trellis have poor market quality. The fruit fly incidence was the lowest in bower system followed by kniffin, ground and bush systems in bitter gourd (Joshi *et al.*, 1994).

2.3 Plant nutrition

The nutrient requirement for plants vary with plant population per unit area. Cucumber respond well to manures and fertilizers. The doses of fertilizer depend upon the soil type, climate and system of cultivation. The nutrient levels affect plant growth earliness, sex expression and ultimate yield and quality. Application of nitrogen decreased dry matter production, rates of nitrogen uptake and soil nitrogen level. 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 optimum nutrient requirement is an important economic consideration in cucumber cultivation.

2.3.1 Growth, flowering and fruit set

Plant nutrition affects the growth, flowering and fruit set. Application of nitrogen increased the pistillate flower and fruit set in muskmelon (Brantley and Warren, 1958). According to Brantley and Warren (1961) and Flocker *et al.* (1965), nitrogen is an essential nutrient element to promote vegetative growth and its ample supply ensures adequate size of plant and early initiation of pistillate flower at lower nodes on the main axis. The number of female flower production was increased with increasing nitrogen (100-300 kg as calcium nitrate per ha) fertilization in cucumber as reported by Tayal *et al.* (1965).

Rekhi *et al.* (1968) found that application of 120 and 180 kg nitrogen per ha 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 per ha (Parikh and Chandra, 1969). Higher nitrogen dose of 120 kg per ha delayed the appearance of first female flower in cucumber (Parikh and Chandra, 1970). Mc Collum and Miller (1971) observed that application of potassium at 80 lb per acre increased vine length, leaf area, total dry matter production and higher fruits (10 t per acre) in pickling cucumber. According to Pew and Gardner (1972) nitrogen deficiency delayed the appearance of flower buds in cantaloupe and markedly reduced the vegetative growth.

Jassal *et al* (1972) obtained more female flowers at 165 kg N per ha and improved growth parameter with increasing levels of nitrogen in muskmelon. 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 plants produced maximum number of female flowers in nitrogen deficit soil. Brinen and Locascio (1979) reported that application of 1680 kg per ha NPK mixed fertilizer increased vine growth and more female flower production in watermelon. In "Tinda" increasing levels of nitrogen significantly increased vine length, stem diameter, number of leaves and female flower per plant (Singh *et al.*, 1982).

Raychaudury *et al.* (1984) found reduced vine growth, size of leaves and number of flower in roundgourd due to nitrogen deficiency. Srinivas and Doijode (1984) recorded the highest number of perfect flowers in muskmelon with 60 kg P_2O_5 per ha. The plant growth in pointed gourd was increased with increasing levels of P_2O_5 (Das *et al.*, 1987). 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.

Siyag and Arora (1988) reported that application of 75 kg nitrogen per ha increased the length of main vine in spongegourd. While 50 kg nitrogen per ha 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. 'Mati Tonh', Maurya (1989) observed highest number of female flowers, the best fruit quality with 80 kg nitrogen per ha and Boron application. However nitrogen at 90 kg per ha applied to cucumber enhanced female flower and leaf production (Stoliarov and Fanina, 1989).

Increase in nitrogen level caused a significant enhancement in the length of main shoot in pumpkin, while the number of branches and average internodal length remained unaffected by various levels of nitrogen (Kulbir Singh *et al.*, 1990).

Suresh and Pappiah (1991) reported that in bittergourd 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 bittergourd (Samdyan *et al.*, 1992). Avakvan *et al.* (1992) reported that increase in nitrogen application from 90 to 210 kg per ha resulted in delay flowering. As the rate of applied nitrogen increased, the concentration of chlorophyll in the leaves of cucumber incresed and concentration of potassium, calcium and magnesium in the fruits decreased (Um *et al.*, 1995). Maximum number of staminate and pistillate flower was observed in the vines applied with nitrogen and potassium at 150 : 100 kg per hectare. Also the vines applied with nitrogen and potassium at 50 : 100 kg per hectare produced the first pistillate flowers earlier in gherkins var. 'Calypso Hybrid' (Premalakshmi, 1997).

2.3.2 Yield and yield components

Brantley (1958) observed that nitrogen at 100 lb per acre increased the total yield and fruit size in watermelon. Significant influence of nitrogen on yield in Squash melon was reported by Dhesi *et al.* (1964). 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. Highest fruit yield in bitter gourd was recorded at 56 kg of nitrogen per hectare (Dhesi *et al.*, 1966). Application of potassium at 100 kg per ha recorded marked increase in fruit yield in squash reported by Lachovev (1968).

Bishop *et. al.* (1969) reported a positive yield response against application of phosphorus fertilizer in cucumber. Highest yield of 11.28 kg per plant was obtained with 110 kg nitrogen per hectare as against yield of 10.18 kg with 165 kg nitrogen in musk melon (Jassal *et al.*, 1972). Patil and Bhosale (1976) recorded the highest number and weight of fruits at 75 kg nitrogen per ha in watermelon. In watermelon Bhosale *et al.* (1978) obtained the highest fruit yield of 26 tonnes per ha with 30 kg P_2O_5 per ha. Highest yield of 66.1 tonnes per ha marketable watermelon fruits were harvested with the application of nitrogen at 1680 kg mixed fertilizer per ha reported by Brinen and Locascio (1979).

Bomme (1981) reported increased yield in cucumber by spraying urea three per cent thrice at weekly interval starting from first picking in cucumber. However Randhawa *et al.* (1981) noticed that nitrogen at 75 kg per ha increased fruit per vine, average fruit weight and total marketable yield in muskmelon. By applying 112 kg nitrogen per ha at soil pH 6.0 in watermelon, 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 per acre) and also application of NPK mixture (13 : 13 : 13) from 0 to 800 lb per acre recorded higher yield in staked cucumber cv. Sprint. According to Srinivas and Prabhakar (1984) in musk melon response of nitrogen was marked up to 50 kg per ha P_2O_5 and K_2O each at 60 kg per ha led to yield increase. Mangal *et al.* (1985) recorded double the number of fruits per plant in roundmelon at 80 kg nitrogen per ha. Increased total yield in pointedgourd at high dose of 90 kg nitrogen was found by Das *et al.* (1987). The average yield in bottlegourd variety 'Arka Bahar' was 385.37 q per ha with full dose (180 : 100 : 100 kg per ha) of nitrogen, phosphorus potassium and 300.74 q per ha with reduced dose (Vishnushukla and Prabhakar, 1987). Increased yield of cucumber (30 t per ha) was also reported by Stoliarov and Fanina (1989) by the application of phosphorus at 90 kg per ha.

Kulbir Singh *et al.* (1990) recorded increased total yield in pumpkin with an increase in nitrogen level from 40 to 80 kg per ha and highest level of nitrogen (120 kg per ha) depressed yield. 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 plastichouse grown cucumber (EI - Hassan, 1991). He also reported that application of phosphorus at 7.6 to 15.2 kg per ha increased the fruit yield in cucumber. Suresh and Pappiah (1991) opined that application of nitrogen and Maleic hydrazide significantly increased the fruit weight, number of fruits per plant, yield per plant and yield per hectare.

Adams *et al.* (1992) reported a reduction in early yield due to lower level of potassium (47%) where as increase in potassium application resulted in higher fruit yield in cucumber. Higher yield of cucumber was recorded by Avakvan *et al.* (1992) by application of phosphorus at 90 kg per ha. Maximum early fruit yield in bittergourd was recorded with the application of 50 kg N per ha (Šamdyan *et al.*, 1992). Application of nitrogen had significantly increased the fruit size, number of fruits, weight of fruit per plant as well as yield in pointedgourd (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 per ha produced good 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 per ha (Premalakshmi, 1997).

2.3.3 Quality parameters

Plant nutrition affects vegetable quality. Application of 100 kg nitrogen per hectare improved the quality characters like TSS in melons (Saqdullaev and Umarove, 1975). Randhawa *et al.* (1981) noticed that increasing levels of nitrogen increased the TSS and vitamin C content in musk melon. Highest levels of P_2O_5 increased the percentage of flesh (62.14 %) and TSS (10.01 %) [Deswal and Patil, 1984] in watermelon. However application of 40 kg nitrogen per ha improved the pulp thickness, Tss and ascorbic acid contents (Yadav and Mangal, 1984). Increase in potassium concentration (0 to 4.0 mol per litre) in the nutrient solution improved potassium and glucose content of the leaves in pumpkin (Badr - El-Din, 1985).

Prabhakar *et al.* (1985) observed improved size of fruits and TSS by the application of 50 kg nitrogen per ha in muskmelon. There was an improvement in protein (14.28%) and vitamin C (12.9 mg $100g^{-1}$) contents in cucumber with increasing levels of nitrogen upto 80 kg per ha (Das *et al.*, 1987). Hariprakasa Rao and Srinivas (1990) noticed significantly increased TSS with increased nitrogen in muskmelon. Maximum TSS content was observed at the highest nitrogen level of 120 kg per ha (Kulbir Singh *et al.*, 1990). Valenzuela *et al.* (1990) reported that the cucumber plants treated with highest amount of nitrogen contained maximum carbohydrate and chlorophyll A, B and total Chlorophyll content.

Annanurova *et al.* (1992) reported that the application of nitrogen at 220 kg per ha recorded higher sugar content in tomatoes. According to Avakvan *et al.* (1992) application of potassium at 90 kg per ha increased the leaf chlorophyll and protein content. Total marketable fruit yield also differed significantly due to nitrogen application in bittergourd (Samdyan *et al.*, 1992). Increasing level of nitrogen from 40 to 120 kg, phosphorus and potassium. 40 to 80 kg per ha brought significant improvement in TSS and specific gravity in muskmelon (Yadav *et al.*, 1993). Arora *et al.* (1995) recorded maximum TSS of fruits in ridge gourd with nitrogen at 60 kg per ha and least at 30 kg per ha. The relative number of clubbed and blemished cucumber fruits were increased when nitrogen was not applied (Um *et al.*, 1995). Lamarani *et al.* (1996) reported that the concentration of chlorophyll A, B and total carotene content were increased with increasing rate of nitrogen in cucumber.

Effect of nitrogen and potassium nutrition on quality of gherkin var. 'Calypso Hybrid' was studied by Premalakshmi (1997). Highest percentage of first and second grade fruits was recorded in the vines applied with nitrogen and potassium at 50 : 100 and 50 : 50 kg per ha.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field investigation was carried out during April - June 1998 to find out the response of slicing cucumber to population density, trailing systems and nutrients. The materials used and method adopted are given below.

3.1 Experimental site

The experiment was carried out at the Instructional Farm, College of Agriculture, Vellayani. It is situated at 8.5^0 N latitude, 76.9^0 E longitude at an altitude of 29 m above mean sea level. Soil of the experimental site was lateritic red loam belonging to the Vellayani series.

3.2 Season

The experiment was carried out during April - June 1998. The crop was raised as summer crop.

3.3 Materials

3.3.1 Planting material

The seeds of cucumber variety 'Poinsette' collected from National Seed Corporation, Karamana, Thiruvananthapuram was used for this study. This variety was selected on the basis of its performance in Vellayani as per preliminary studies (Gayathri, 1997).

3.3.2 Trailing materials

For trailing on twigs branched twigs of 5 feet height were used. Casurina poles of 6 feet height and coir ropes were used for making pandals. Dried coconut leaves were used as mulches for trailing the cucumber vines.

3.4 Method

3.4.1 Design and layout

The experiment was laid out in split plot design with 4 replications. Trailing systems were assigned to the main plots and spacing and nutrient levels to the subplots. The details of the lay out were as follows.

Net plot size	- $18m^2$
No. of main plots	- 4
Replication	- 4
No. of sub plots / main plot	- 10
Total number of plots	- 40

The lay out plan is shown in Fig.1.

3.4.2 Treatments

Main plot	- 4 (Trailing systems)
Sub plot	- 10 (Combination of population density and nutrient levels)
Total	- 40

3.4.2.1 Trailing methods

T_1 - Trailing on ground

T_2 - Trailing on mulches

T_3 - Trailing on trellises / twigs

T_4 - Trailing on pandals

3.4.2.2 Population density

D_1 - 3, 333 plts / ha (Spacing 2 x 1.5 m)

D_2 - 5, 000 plts / ha (Spacing 2 x 1 m)

D_3 - 6, 666 plts / ha (Spacing 1.5 x 1 m)

D_4 - 10, 000 plts / ha (Spacing 2 x 0.5 m)

D_5 - 13, 333 plts / ha (Spacing 1.5 x 0.5 m)

3.4.2.3 Fertilizer levels

L_1 - 75 : 25 : 25 kg / ha
(POP recommendation of KAU)

L_2 - 112.5 : 37.5 : 37.5 kg / ha
(1 1/2 times of recommended dose)

3.4.3 Field culture

3.4.3.1 Land preparation

The experimental field was dug twice, stubbles removed, clods broken and the field was laid out into main plots and sub plots. Single main plot consist of ten sub plots where the combination of population density and nutrient levels were assigned.

Fig. 1. Lay out of the experiment

Rep I

T_5	T_3	T_4	T_2	T_1	T_{10}	T_8	T_9	T_7	T_6
T_{13}	T_{15}	T_{14}	T_{11}	T_{12}	T_{18}	T_{20}	T_{19}	T_{16}	T_{17}
T_{25}	T_{23}	T_{21}	T_{22}	T_{24}	T_{30}	T_{28}	T_{26}	T_{27}	T_{29}
T_{33}	T_{35}	T_{32}	T_{34}	T_{31}	T_{38}	T_{40}	T_{37}	T_{39}	T_{36}

Rep II

T_5	T_3	T_2	T_1	T_4	T_{10}	T_8	T_7	T_6	T_9
T_{13}	T_{15}	T_{11}	T_{12}	T_{14}	T_{18}	T_{20}	T_{16}	T_{17}	T_{19}
T_{23}	T_{25}	T_{21}	T_{22}	T_{24}	T_{28}	T_{30}	T_{26}	T_{27}	T_{29}
T_{35}	T_{33}	T_{32}	T_{34}	T_{31}	T_{40}	T_{38}	T_{37}	T_{39}	T_{36}

Rep III

T_2	T_4	T_1	T_5	T_3	T_7	T_6	T_{10}	T_8	T_9
T_{15}	T_{11}	T_{13}	T_{14}	T_{12}	T_{18}	T_{16}	T_{19}	T_{17}	T_{20}
T_{24}	T_{21}	T_{25}	T_{23}	T_{22}	T_{30}	T_{26}	T_{29}	T_{27}	T_{28}
T_{33}	T_{31}	T_{35}	T_{32}	T_{34}	T_{38}	T_{40}	T_{37}	T_{39}	T_{36}

Rep IV

T_1	T_5	T_3	T_2	T_4	T_8	T_{10}	T_7	T_9	T_6
T_{14}	T_{11}	T_{13}	T_{15}	T_{12}	T_{17}	T_{19}	T_{16}	T_{18}	T_{20}
T_{23}	T_{25}	T_{22}	T_{24}	T_{21}	T_{26}	T_{29}	T_{27}	T_{30}	T_{28}
T_{31}	T_{35}	T_{33}	T_{32}	T_{34}	T_{36}	T_{40}	T_{37}	T_{39}	T_{38}

Treatment combinations

$T_1L_1D_1$ - T_1
$T_1L_1D_2$ - T_2
$T_1L_1D_3$ - T_3
$T_1L_1D_4$ - T_4
$T_1L_1D_5$ - T_5
$T_1L_2D_1$ - T_6
$T_1L_2D_2$ - T_7
$T_1L_2D_3$ - T_8
$T_1L_2D_4$ - T_9
$T_1L_2D_5$ - T_{10}

$T_2L_1D_1$ - T_{11}
$T_2L_1D_2$ - T_{12}
$T_2L_1D_3$ - T_{13}
$T_2L_1D_4$ - T_{14}
$T_2L_1D_5$ - T_{15}
$T_2L_2D_1$ - T_{16}
$T_2L_2D_2$ - T_{17}
$T_2L_2D_3$ - T_{18}
$T_2L_2D_4$ - T_{19}
$T_2L_2D_5$ - T_{20}

$T_3L_1D_1$ - T_{21}
$T_3L_1D_2$ - T_{22}
$T_3L_1D_3$ - T_{23}
$T_3L_1D_4$ - T_{24}
$T_3L_1D_5$ - T_{25}
$T_3L_2D_1$ - T_{26}
$T_3L_2D_2$ - T_{27}
$T_3L_2D_3$ - T_{28}
$T_3L_2D_4$ - T_{29}
$T_3L_2D_5$ - T_{30}

$T_4L_1D_1$ - T_{31}
$T_4L_1D_2$ - T_{32}
$T_4L_1D_3$ - T_{33}
$T_4L_1D_4$ - T_{34}
$T_4L_1D_5$ - T_{35}
$T_4L_2D_1$ - T_{36}
$T_4L_2D_2$ - T_{37}
$T_4L_2D_3$ - T_{38}
$T_4L_2D_4$ - T_{39}
$T_4L_2D_5$ - T_{40}

Treatment T_1 - Trailing on ground

Treatment T_2 - Trailing on mulch

Plate 1.

Plate 2.

Treatment T_3 - Trailing on twigs

Treatment T_4 - Trailing on pandals

Plate 3.

Plate 4.

3.4.3.2 Manure and fertilizer application

Manure was applied as per the Package of Practices recommendations of Kerala Agricultural University (KAU, 1996). Fertilizer was applied as per the schedule of treatments. The entire dose of phosphorus and potassium and half dose of nitrogen were applied as basal dressing. Remaining half dose of nitrogen was applied after twenty five days of sowing.

3.4.3.3. Seeds and sowing

Plumpy seeds were selected for sowing. The seeds were sown in channels as per the spacings given in treatments.

3.4.3.4 After cultivation

At fifteen days after sowing, the plant population was adjusted to two in each pit, in the sub plot. Thirty days after sowing the vines were trailed as per the schedule of treatments. The vines were allowed to trail on the interspaces of the channels for the first treatment (T_1). For T_2, dried coconut leaves were spread on the interspaces and vines were allowed to trail on it. Branched twigs of 5 feet height were fixed near each plant and the plants allowed to trail on it (T_3). Pandals at a height of 6 feet were erected and the vines were trailed on the pandals regularly (T_4). Regular weeding operations were carried out to keep the plot free of weeds and the crops were irrigated every day.

3.4.3.5 Plant protection

To prevent the infestation of damping off, Thiride at the rate of 1g / lit was drenched at 2-3 leaf stage. Neem kernel extract was sprayed against serpentine leaf miner. After fruit set no chemicals were sprayed.

3.4.3.6 Harvesting

Harvesting started when fruit reached optimum size and still tender. The crop was harvested once in three days. The fruits were harvested at vegetable maturity stages as judged by visual observations.

3.4.4. Observations

Four plants were selected at random and the following observations were taken.

3.4.4.1 Days to first male flower opening

The number of days taken from sowing to opening of first male flower was recorded.

3.4.2 Days to first female flower opening

The number of days taken from sowing to the blooming of first female flower was recorded.

3.4.4.3 Nodes to first female flower

The nodes were counted from the lowest portion to the one at which the first female flower opened and recorded.

3.4.4.4 Days to first harvest

Duration from sowing to first harvest of the fruits from each treatment was recorded and expressed in days.

3.4.4.5 Branches / plant

The number of branches / plant was counted, after the final harvest.

3.4.4.6 Main vine length (cm)

Length from the collar region to the tip of the main vine was measured using the measuring tape after pulling out the vine after the final harvest and expressed in centimeters.

3.4.4.7 Fruits / plant

The total number of fruits from each plant in each treatment were counted and average worked out.

3.4.4.8 Deshaped fruits / plot

The total number of deshaped (crooked, bent or curved) fruits were counted from each plant in a plot and average worked out.

3.4.4.9 Average fruit weight (g)

Weight of two fruits from each observation plants at the third harvest were taken and average worked out and expressed in grams.

3.4.4.10 Fruit length (cm)

The length of the fruit was measured from the stalk end to the tip of the fruit and average worked out in centimeters.

3.4.4.11 Fruit girth (cm)

The girth at the middle of the same fruit used for length measurement were measured and the mean girth worked out in centimeters.

3.4.4.12 Fruit volume (m^3)

The fruits used for length measurement were dipped in a measuring cylinder with water up to a level and the rise in the water level is taken. This reading is then subtracted with the initial level of water and expressed as the fruit volume in metre cube.

3.4.4.13 Fruit diameter (cm)

After cutting the fruits in to two halves, the diameter at the middle of the fruits were taken and average worked out in centimeter.

3.4.4.14 Seeds / fruit

The number of seeds in the randomly selected fruits were counted and the average number of seeds per fruit was recorded.

3.4.4.15 100 Seed weight (g)

A random sample of 100 fully developed seeds / fruit were weighed using an electric precision balance and weight recorded in grams.

3.4.4.16 Yield / plot (kg)

The weight of fruits from each treatment at each harvest was taken using a top loading balance and added to get the total and average was recorded in kilograms.

3.4.4.17 Incidence of important pest and disease

The incidence of important pest (fruit fly) and disease through out the duration of the crop was recorded.

3.4.5 Economics of cultivation

The economics of cultivation was worked out based on the various input cost.

Net income (Rs. ha^{-1}) = Gross income - Cost of cultivation

$$\text{Benefit-Cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.4.6 Statistical analysis

The experimental data were analysed statistically by applying the technique of analysis of variance for split plot design (Gomez and Gomez, 1984).

In case where the effects were found to be significant, critical difference were calculated for making multiple comparisons among the means. The critical difference for comparison of all the main effect and interaction effect were also computed based on the formula for split plot design. Suitable transformations were applied to the data wherever necessary. Break up of total degrees of freedom in the analysis of variance for the present study is as given below.

Source	df
Replications	3
Main plot	
Trailing systems (T)	3
Error (a)	9
Sub plot	
Population density (D)	4
Nutrient levels (L)	1
Interactions	
i) Trailing systems x Popualtion density (T x D)	12
ii) Trailing systems x Nutrient levels (T x L)	3
iii) Nutrient levels x Population density (L xD)	4
iv) Trailing systems x Nutrient levels x Popualtion density (T x L x D)	12
Error (b)	108
Total	159

RESULTS

4. RESULTS

The results of the present experiment depicting the response of cucumber (*Cucumis sativus.* L.) to trailing systems (T), population density (D) and nutrient levels (L) are presented in this chapter. The data on earliness, morphological and yield characters were statistically analysed, their direct and interaction effects worked out and presented in the tables.

4.1 Earliness

4.1.1 Days to first male flower opening

4.1.1.1 Effect of trailing system

Perusal of the data revealed that different trailing systems exerted a significant influence on the number of days taken for first male flower opening in cucumber (Table 1 a). Among the four systems, plants trailed on pandals (T_4) were significantly late than other three systems in first male flower opening (33.88 days). All the other methods viz trailing on ground, mulches and twigs were on par in the first male flower opening. The earliest being trailing on mulches (T_2) which took 32.51 days.

4.1.1.2 Effect of population density

Different planting densities showed a significant influence on the days to first male flower opening (Table 1 a). Among the five levels tried, plants at wider spacing of 3,333 plants ha^{-1} (D_1) were earliest (32.64 days) in the opening of first male flower compared to other levels. Plants grown at a density of 5,000 plants ha^{-1} (D_2) were the last which took 33.84 days for opening.

4.1.1.3 Effect of nutrients

Application of different levels of nutrients did not produce any marked variation on days to first male flower opening (Table 1 a). Both levels took 32.99 days for the blooming of first male flower.

4.1.1.4 Effect of T x D interaction

There was significant interaction between trailing systems (T) and population density (D) on the character days to first male flower opening (Table 1 a). Among the various treatment combinations, plants grown on mulches at the lowest population density (T_2 D_1) were significantly earlier in the first male flower opening (31.75 days) than most of the other T x D combinations. The plants trailed on pandals at a density of 5,000 plants ha^{-1} (T_4 D_2) were the last in male flower opening (35.25 days). The T_1 D_1 and T_1 D_3 plants took lesser number of days (31.88 days) than T_1 D_4, T_1 D_5 and T_1 D_2. Among the T_2 treatment combinations, T_2 D_3 were found to be late (33.44 days) in the male, flower opening than T_2 D_2, T_2 D_4, T_2 D_5 and T_2 D_1. The T_3 D_1 plants showed early male flower opening (32 days) than other T_3 combinations and among the combinations containing T_4, T_4 D_4 resulted in early male flower opening (32.75 days).

4.1.1.5 Effect of T x L interaction

Interaction effect between trailing systems (T) and levels of nutrients (L) was significant with regard to first male flower opening (Table 1a). The plants grown on twigs at the lower level of nutrients (T_3 L_1) were the earliest (32.23 days) and those on pandals at the same level of nutrients (T_4 L_1) were late in male flower opening (33.90 days). T_1 L_2 showed early flowering (32.25 days) than T_1 L_1 (33.35 days).

4.1.1.6 Effect of L x D interaction

Days to first male flower opening was significant with regard to nutrient levels (L) and population density (D) interaction (Table 1 b). Early emergence of male flower was noticed (32.41 days) in L_1 D_1 combination and late emergence in L_1 D_2 (33.88 days). Under L_2 combinations, L_2 D_4 was significantly early (32.47 days) in first male flower opening than other L_2 combinations.

4.1.1.7 Effect of T x L x D interaction

The interaction between trailing systems, population density and nutrient levels showed considerable significant difference among the number of days taken for first male flower opening (Table 1 c). The plants of T_2 L_1 D_1, T_3 L_1 D_1 and T_3 L_1 D_2 combinations were significantly earliest with 31 days and those of T_1 L_1 D_2 were significantly late (36.13 days). Among the combinations under T_1, T_1 L_2 D_1 resulted in early opening (31.25 days) than

Table 1 a : Effect of trailing systems, population density, nutrient levels and their interaction on days to first male flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	31.88	34.69	31.88	32.63	32.94	32.80	33.35	32.25	32.80
T_2	31.75	32.69	33.44	32.63	32.06	32.51	32.50	32.53	32.51
T_3	32.00	32.75	32.25	33.63	33.31	32.79	32.23	33.35	32.79
T_4	34.94	35.25	33.25	32.75	33.19	33.88	33.90	33.85	33.88
Mean (D)	32.64	33.84	32.70	32.91	32.88	Mean (L)	32.99	32.99	

C.D (P = 0.05)

Trailing systems (T) - 0.45 | T x D = 0.83

Levels of nutrients (L) - N.S.* | T x L = 0.53

Population density (D) - 0.42

Table 1 b : Interaction of nutrient levels X population density on days to first male flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	32.41	33.88	32.78	33.34	32.56	32.99
L_2	32.88	33.81	32.63	32.47	33.19	32.99
Mean (D)	32.64	33.84	32.70	32.91	32.88	

C. D (P = 0.05)

L x D - 0.59

*N.S. - Not significant

Table 1 c : Interaction of trailing systems, nutrient levels and population density on days to first male flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	32.50	36.13	32.13	33.63	32.38	33.35
$T_1 L_2$	31.25	33.25	31.63	31.63	33.50	32.25
$T_2 L_1$	31.00	33.50	33.13	32.88	32.00	32.50
$T_2 L_2$	32.50	31.89	33.75	32.38	32.13	32.53
$T_3 L_1$	31.00	31.00	32.13	34.00	33.00	32.23
$T_3 L_2$	33.00	34.50	32.38	33.25	33.63	33.35
$T_4 L_1$	35.13	34.88	33.75	32.88	32.88	33.90
$T_4 L_2$	34.75	35.63	32.75	32.63	33.50	33.85
Mean (D)	32.64	33.84	32.70	32.91	32.88	

C.D (P = 0.05)

T x L x D - 1.18

the others. Among the combinations under T_4, T_4 L_2 D_4 resulted in early opening (32.63 days) than the others.

4.1.2. Days to first female flower opening

4.1.2.1 Effect of trailing systems

It is evident from the table 2 a that there was marked difference on days to first female flower opening due to different trailing systems. The plants trailed on mulches (T_2) were significantly early in first female flower opening (36.04 days) and it was on par with those trailed on ground (T_1) without any mulches (36.18 days). Whereas the plants trailed on pandals (T_4) appeared to be late in its appearance of female flower (37.70 days).

4.1.2.2 Effect of population density

Significant difference was found with different planting densities for days to first female flower opening (Table 2 a). The plants at wider spacing of 3,333 plants ha^{-1} (D_1) were earliest in female flower opening (36.34 days) which was on par (36.38 days) with plants grown at a density of 6,666 plants ha^{-1} (D_3). However the plants grown at a density of 5,000 plants ha^{-1} (D_2) were the latest which took 37.27 days.

4.1.2.3 Effect of nutrients

The levels of nutrients produced variation on days to first female flower opening (Table 2 a). Among the two levels tried, the plants receiving L_1 (75 :

25 : 25 kg ha^{-1}) had an early appearance (36.43 days) of female flower than those receiving L_2 (112.5 : 37.5 : 37.5 kg ha^{-1}) which took 37.12 days.

4.1.2.4 Effect of T x D interaction

The T x D interaction effect was significant with regard to the days to first female flower opening (Table 2 a). The combinations T_2 D_1 and T_3 D_1 resulted in early appearance (34.94 days) of female flowers and T_4 D_1 resulted in late appearance (39.63 days). Among the combinations under T_1, T_1 D_5 was significantly early in the appearance of female flower (35.44 days) than others and among T_4 combinations, T_4 D_3 was the earliest (35.38 days).

4.1.2.5 Effect of T x L interaction

Significant interaction was found between trailing systems and nutrient levels for days to first female flower opening (Table 2 a) and it was early in T_2 L_1 combination (34.95 days) and late in T_4 L_1 (39.15 days). Under T_1 combinations early emergence (35.40 days) was noticed in T_1 L_1 compared to T_1 L_2 (36.95 days). Under T_3, T_3 L_1 showed early appearance (36.23 days) compared to T_3 L_2 and T_4 L_2 showed early appearance (36.25 days) in T_4 combinations.

4.1.2.6 Effect of L x D interaction

Days to first female flower opening was significantly affected with L x D interaction (Table 2 b). L_1 D_3 showed early appearance (35.38 days) of female flower and L_2 D_5 showed late appearance (38.06 days). Among L_2

combinations, L_2 D_4 resulted in early emergence of female flower (36.06 days) than others.

4.1.2.7 Effect of T x L x D interaction

Interaction effect of trailing systems nutrient levels and population density had a significant influence on days to first female flower opening (Table 2 c). The combination T_1 L_1 D_5 was the earliest (33.38 days) which was on par with T_2 L_1 D_1 (33.50 days) and $T_1L_2D_3$ (33.88 days). First female flower was late in $T_3L_2D_5$ (42.13 days). Among the combinations of T_3, T_3 L_1 D_1 was earlier (34.13 days) than others and under T_4 combinations, T_4 L_2 D_3 resulted in early appearance (34.25 days) of female flower than others.

4.1.3 Nodes to first female flower

The trailing systems, population density, nutrient levels and their interaction did not produced any marked difference on nodes to first female flower opening (Table 3 a and 3 b).

4.1.4 Days to first harvest

4.1.4.1 Effect of trailing systems

The days to first harvest differed significantly with systems of trailing (Table 4 a). Significantly early harvest (49.93 days) was recorded in plants trailed on pandals (T_4) than other systems. The plants trailed on ground (T_1) being the last which took 52.74 days.

Table 2 a : Effect of trailing systems, population density, nutrient levels and their interaction on days to first female flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	35.88	36.56	36.81	36.19	35.44	36.18	35.40	36.95	36.18
T_2	34.94	35.63	37.31	36.69	35.63	36.04	34.95	37.13	36.04
T_3	34.94	38.19	36.00	37.69	39.13	37.19	36.23	38.15	37.19
T_4	39.63	38.69	35.38	36.13	38.69	37.70	39.15	36.25	37.70
Mean (D)	36. 34	37.27	36.38	36.67	37.22	Mean (L)	36.43	37.12	

C. D (P = 0.05)

Trailing systems (T) - 0.32 T x D = 0.66

Nutrient levels (L) - 0.21 T x L = 0.42

Population density (D) - 0.33

Table 2 b : Interaction of nutrient levels X population density on days to first female flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	36.16	36.97	35.38	37.28	36.38	36.43
L_2	36.53	37.56	37.38	36.06	38.06	37.12
Mean (D)	36.34	37.27	36.38	36.67	37.22	

C.D (P = 0.05)

L x D - 0.47

Table 2 c : Interaction of trailing system, nutrient levels and population density on days to first female flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	35.63	37.00	35.38	35.63	33.38	35.40
$T_1 L_2$	36.13	36.13	38.25	36.75	37.50	36.95
$T_2 L_1$	33.50	36.00	33.88	36.38	35.50	34.95
$T_2 L_2$	36.38	35.25	40.75	37.00	36.25	37.13
$T_3 L_1$	34.13	35.63	35.75	39.50	36.13	36.23
$T_3 L_2$	35.75	40.75	36.25	35.88	42.13	38.15
$T_4 L_1$	41.38	39.25	36.50	37.63	41.00	39.15
$T_4 L_2$	37.88	38.13	34.25	34.63	36.38	36.25
Mean (D)	36.34	37.27	46.38	36.67	37.22	

C. D (P = 0.05)

T x L x D - 0.94

Table 3 a : Effect of trailing systems, population density, nutrient levels and their interaction on nodes to first female flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	2.00	2.13	2.13	2.00	2.25	2.10	2.10	2.10	2.10
T_2	2.00	2.00	2.00	2.00	2.13	2.03	2.00	2.05	2.03
T_3	2.00	2.13	2.00	2.00	2.00	2.03	2.05	2.00	2.03
T_4	2.00	2.00	2.13	2.13	2.00	2.05	2.00	2.10	2.05
Mean (D)	2.00	2.06	2.06	2.03	2.09	Mean (L)	2.04	2.06	

C. D (P = 0.05)

Trailing systems (T) - N.S.*

Population density (D) - N. S.*

Nutrient levels (L) - N. S.*

T x D - N. S.*

T x L - N. S.*

Table 3 b : Interaction of nutrient levels X population density on nodes to first female flower opening

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	2.00	2.06	2.06	2.00	2.06	2.04
L_2	2.00	2.06	2.06	2.06	2.13	2.06
Mean (D)	2.00	2.06	2.03	2.03	2.09	

C.D (P = 0.05)

L x D - N. S.*

*N.S. - Not significant

4.1.4.2 Effect of population density

It is evident from Table 4 a that different population densities showed variation on days to first harvest. Plants grown at a density of 10,000 plants ha^{-1} (D_4) recorded early harvest (50.34 days) whereas plants at closer spacing of 13,333 plants ha^{-1} (D_5) was late in fruit picking (51.48 days). The plants grown at a density of 6,666 plants ha^{-1} (D_3) which took 51.13 days for the first harvest and those at wider spacing (D_1) which took 51.19 days were found to be on par.

4.1.4.3 Effect of nutrients

Days taken for first fruit picking was significantly affected by the levels of nutrients (Table 4 a). It was significantly earlier (50.91 days) in plants receiving the higher fertilizer level of 112.5 : 37.5 : 37.5 : kg NPK per ha (L_2) than those receiving the lower level of 75 : 25 : 25 kg NPK ha^{-1} (L_1).

4.1.4.4 Effect of T x D interactions

The interaction effect between T and D was significant with regard to the days to first harvest (Table 4 a). The T_4 D_3 and T_4 D_2 plants showed early harvest than those receiving other T D combinations and among these, T_4 D_3 being the earliest (48.56 days). Harvesting was late in T_1 D_2 (54.88 days).

4.1.4.5 Effect of T x L interaction

T x L interaction for days to first harvest was highly significant (Table 4 a). The plants with T_4 L_1 combination recorded early harvest (49.38

days) and those with T_1 L_1 recorded late harvest (52.88 days). Among the combinations under T_2, T_2 L_2 showed early harvest (50.70 days) than T_2 L_1 and the combination T_3 L_2 showed early harvest (49.85 days) than T_3 L_1.

4.1.4.6 Effect of L x D interaction

Significant L x D interaction was observed for days to first harvest (Table 4 b) in which the combination L_2 D_3 was the earliest (49.81 days) and L_1 D_3 the last (52.44 days). Among the L_1 combinations, L_1 D_4 showed early harvest (50.03 days). Harvesting was late in L_2 D_1 (51.63 days) which was on par with L_2 D_5 (51.47 days).

4.1.4.7 Effect of T x L x D interaction

The T x L x D interaction showed marked variation on the number of days taken for fruit picking (Table 4 c). The harvest was significantly earlier in T_4 L_1 D_3 (46.75 days) and the combinations T_1 L_1 D_2, T_1 L_1 D_3 and T_1 L_2 D_2 recorded late harvests (54.88 days). Among the T_1 combinations, T_1 L_2 D_3 showed earlier harvest (49 days) than other combinations and among the T_2 combinations, early harvest was noticed in T_2 L_2 D_4 which took 48.38 days. The plants with T_3 L_2 D_3 combination showed early harvest (48 days) than other T_3 combinations.

4.2 Morphological characters

4.2.1 Branches / plant

Table 4 a : Effect of trailing systems, population density, nutrient levels and their interaction on days to first harvest

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	52.44	54.88	51.94	51.88	52.56	52.74	52.88	52.60	52.74
T_2	51.44	51.06	52.94	49.56	51.69	51.34	51.98	50.70	51.34
T_3	49.75	50.56	51.06	49.38	51.13	50.38	50.90	49.85	50.38
T_4	51.13	48.81	48.56	50.56	50.56	49.93	49.38	50.48	49.93
Mean (D)	51.19	51.33	51.13	50.34	51.48	Mean (L)	51.28	50.91	

C. D (P = 0.05)

Trailing systems (T) - 0.28 T x D = 0.50

Nutrient levels (L) - 0.16 T x L = 0.32

Population density (D) - 0.25

Table 4 b : Interaction of nutrient levels X population density on days to first harvest

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	50.75	51.69	52.44	50.03	51.50	51.28
L_2	51.63	50.97	49.81	50.66	51.47	50.91
Mean (D)	51.19	51.33	51.13	50.34	51.48	

C.D (P = 0.05)

L x D - 0.36

Table 4 c : Interaction of trailing systems, nutrients levels and population density on days to first harvest

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	50.75	54.88	54.88	50.00	53.88	52.88
$T_1 L_2$	54.13	54.88	49.00	53.75	51.25	52.60
$T_2 L_1$	51.50	51.88	54.00	50.75	51.75	51.98
$T_2 L_2$	51.38	50.25	51.88	48.38	51.63	50.70
$T_3 L_1$	49.75	50.25	54.13	49.38	51.00	50.90
$T_3 L_2$	49.75	50.88	48.00	49.38	51.25	49.85
$T_4 L_1$	51.00	49.75	46.75	50.00	49.38	49.38
$T_4 L_2$	51.25	47.88	50.38	51.13	51.75	50.48
Mean (D)	51.19	51.33	51.13	50.34	51.48	

C. D (P = 0.05)

T x L x D - 0.71

4.2.1.1 Effect of trailing systems

There was a significant variation on number of branches / plant due to different trailing systems (Table 5 a). The number of branches were maximum (5.93) with the plants trailed on pandals (T_4) and minimum (4.96) with those trailed on twigs (T_3). However the number of branches in plants trailed on ground (T_1) was on par (5.36) with those trailed on mulches (T_2).

4.2.1.2 Effect of population density

Population densities showed significantly different effect on the number of branches / plant (Table 5 a). Among the five densities tried, the plants grown at a population of 6,666 plants ha^{-1} (D_3) showed maximum number of branches (5.55) which was on par (5.5) with those grown at a density of 10,000 plants ha^{-1} (D_4). Minimum number of branches (5.14) was recorded in plants at closer spacing of 13,333 plants ha^{-1} (D_5).

4.2.1.3 Effect of nutrients

Application of two levels of nutrients showed a significant effect on number of branches / plant (Table 5 a). Among the two levels, the plants receiving 112.5 : 37.5 : 37.5 kg NPK ha^{-1} (L_2) had a maximum number of branches (5.46) and the plants receiving a level of 75 : 25 : 25 kg NPK ha^{-1} (L_1) had a minimum number of branches (5.31).

4.2.1.4 Effect of T x D interaction

The interaction between trailing systems and population density on the number of branches / plant was significant (Table 5 a). Maximum number (6.34) of branches was noticed in T_4 D_4 and minimum (4.69) in T_3 D_5. Among the T_1 combinations, maximum number of branches was recorded in T_1 D_3 (6.06) and among the T_2 combinations maximum number of branches was noticed in T_2 D_4 (5.63). T_3 D_2 and T_3 D_3 recorded maximum number of branches (5.19) than other T_3 combinations.

4.2.1.5 Effect of T x L interaction

The trailing systems and nutrient levels interaction on the number of branches / plant also differed significantly (Table 5 a). T_4 L_1 recorded maximum number of branches (6.05) whereas the T_3 L_1 had the minimum (4.33). Under T_1, T_1 L_1 had more branches (5.6) than T_1 L_2 (5.13). In T_2, the number of branches / plant of T_2 L_1 (5.28) was on par with that of T_2 L_2 (5.33). Among the T_3 combinations, T_3 L_2 showed maximum number (5.60) of branches.

4.2.1.6 Effect of L x D interaction

Significant L x D interaction was observed in number of branches / plant (Table 5 b). Among the combinations, maximum number of branches was recorded (5.84) in L2 D_3 and minimum (5.00) in L_1 D_5. Under L_1 combinations, L_1 D_2 recorded maximum number (5.56) of branches which was on par with L_1 D_4 (5.44).

4.2.1.7 Effect of T x L x D interaction

The interaction effects of trailing systems and L x D combinations were significant for number of branches / plant(Table 5c). Among the combinations $T_4\ L_2\ D_4$, $T_4\ L_1\ D_2$, $T_4\ L_1\ D_4$, $T_3\ L_2\ D_3$ and $T_1\ L_1\ D_3$ showed maximum number (6.38) of branches. Minimum number (3.89) of branches was recorded in $T_3\ L_1\ D_5$ which was on par with $T_3\ L_1\ D_3$ (4.00). The combination $T_2\ L_1\ D_5$ had maximum number (6.00) of branches among the T_2 combinations.

4.2.2 Vine length (cm)

4.2.2.1 Effect of trailing systems

The vine length of the cucumber plants was significantly influenced by different trailing systems (Table 6 a). It ranged from 145.89 cm in T3 to 219.30 cm in T2. Maximum vine length (219.30 cm) was observed in plants trailed on mulches T2). Minimum vine length (145.89 cm) being noticed in plants Trailed on Twigs (T_3).

4.2.2.2 Effect of population density

Table 6 a showed a significant difference in vine length with different population densities. Among the densities, maximum vine length (189.36 cms) was observed in plants grown at a population density of 6,666 plants ha^{-1} (D_3) and minimum (184.68 cms) in plants grown at a population density of 5,000 plants ha^{-1} (D_2).

Table 5 a : Effect of trailing systems, population density, nutrient levels and their interaction on branches / plant

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	5.06	5.56	6.06	5.12	5.00	5.36	5.60	5.13	5.36
T_2	5.13	5.06	5.25	5.63	5.44	5.30	5.28	5.33	5.30
T_3	4.88	5.19	5.19	4.88	4.69	4.96	4.33	5.60	4.96
T_4	6.13	6.00	5.69	6.34	5.44	5.93	6.05	5.80	5.93
Mean (D)	5.30	5.45	5.55	5.50	5.14	Mean (L)	5. 31	5.46	

C. D (P = 0.05)

Trailing systems (T) - 0.11 T x D = 0.32

Nutrient levels (L) - 0.10 T x L = 0.20

Population density (D) - 0.16

Table 5b : Interaction of nutrient levels X population density on branches / plant

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	5.31	5.56	5.25	5.44	5.00	5.31
L_2	5.28	5.34	5.84	5.56	5.28	5.46
Mean (D)	5.30	5.45	5.55	5.50	5.14	

C.D (P = 0.05)

L x D - 0.22

Table 5 c : Interaction of trailing systems, nutrient levels and population density on branches / plant

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	5.75	5.75	6.38	5.63	4.50	5.60
$T_1 L_2$	4.38	5.38	5.75	4.63	5.50	5.13
$T_2 L_1$	4.63	5.38	5.00	5.38	6.00	5.28
$T_2 L_2$	5.63	4.75	5.50	5.88	4.88	5.33
$T_3 L_1$	4.63	4.75	4.00	4.38	3.89	4.33
$T_3 L_2$	5.13	5.63	6.38	5.38	5.50	5.60
$T_4 L_1$	6.25	6.38	5.63	6.38	5.63	6.05
$T_4 L_2$	6.00	5.63	5.75	6.38	5.25	5.80
Mean (D)	5.30	5.45	5.55	5.50	5.14	

C. D (P = 0.05)

T x L x D = 0.45

4.2.2.3 Effect of nutrients

The different nutrient levels showed a marked difference in vine length (Table 6 a). The plants receiving the higher fertilizer level of 112.5 : 37.5 : 37.5 kg NPK ha^{-1} (L_2) had longer vines (188.82 cms) than those, receiving the lower level of 75 : 25 : 25 kg NPK ha^{-1} (186.32 cms).

4.2.2.4 Effect of T x D interaction

The interaction between T and D on vine length was significant (Table 6 a). It varied from 140.13 cm in T_3 D_2 to 219.74 cm in T_2 D_5. Maximum vine length (219.74 cms) was observed in T_2 D_5 which was on par with T_2 D_3 (219.69 cms) and T_2 D_4 (219.63 cms). Minimum vine length (140.13 cms) was observed in T_3 D_2. The T_1 D_1 plants had longer vines (211.26 cms) than other T_1 combinations. The T_4 D_3 combination showed a maximum vine length of 179.72 cms than other T_4 combinations.

4.2.2.5 Effect of T x L interaction

The T x L interactions were differed significantly on the vine length (Table 6 a) in which maximum vine length (219.57 cms) was noticed in T_2 L_1 combination. T_3 L_1 plants had minimum vine length (142.98 cm) and the T_2 L_2 plants had longer vines (219.04 cm) compared to the rest.

4.2.2.6 Effect of L x D interaction

The interaction between the nutrient levels and population density on vine length was significant (Table 6 b). The plants with L_1 D_3 combination had the maximum vine length (190.36 cm) and the plants with L_1 D_2 combinations had the minimum vine length (181.14 cm). Among the L_2 combinations, L_2 D_1 had longer vines (189.98 cm) than other combinations.

4.2.2.7 Effect of T x L x D interaction

Vine length of cucumber was favourably influenced by T x L x D interaction (Table 6 c) which ranged from 129.00 cm in T_3 L_1 D_2 to 220.26 cm in T_2 L_1 D_5 and T_2 L_2 D_4. T_2 L_1 D_5 and T_2 L_2 D_4 gave the longest vines (220.26 cm) and T_3 L_1 D_2 gave the shortest (129 cm). Among the TLD combinations involving T_4, T_4 L_2 D_5 had longer vines (179.88 cm) than others and among the combinations under T_1, T_1 L_2 D_1 had longest (212.29 cm).

4.3 Yield and yield components

4.3.1 Fruits / plant

4.3.1.1 Effect of trailing systems

The systems of trailing showed considerable influence on number of fruits / plant (Table 7 a). The number varies from 5.85 in T_1 and T_2 to 14.38 in T_4]. It was significantly higher (14.38) in plants trailed on pandals (T_4) compared to other trailing systems. The plants trailed on ground (T_1) and on mulches (T_2) showed least number of fruits (5.85).

4.3.1.2 Effect of population density

There was significant variation in number of fruits / plant due to different population densities (Table 7 a). Maximum number (9.5) of fruits

Table 6 a : Effect of trailing systems, population density, nutrient levels and their interaction on vine length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	211.26	207.78	210.85	210.83	205.26	209.19	208.47	209.92	209.19
T_2	219.16	218.28	219.69	219.63	219.74	219.30	219.57	219.04	219.30
T_3	147.34	140.13	147.19	147.94	146.88	145.89	142.98	148.81	145.89
T_4	174.84	172.53	179.72	174.63	177.72	175.89	174.26	177.52	175.89
Mean (D)	188.15	184.68	189.36	188.25	187.40	Mean (L)	186.32	188.82	

C. D (P = 0.05)

Trailing systems (T) - 0.29   T x D = 0.47

Nutrient levels (L) - 0.15   T x L = 0.30

Population density (D) - 0.24

Table 6b : Interaction of nutrient levels X population density on vine length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	186.32	181.14	190.36	187.16	186.59	186.32
L_2	189.98	188.21	188.36	189.35	188.20	188.82
Mean (D)	188.15	184.68	189.36	188.25	187.40	

C.D (P = 0.05)

L x D - 0.33

Table 6 c : Interaction of trailing systems, nutrient levels and population density on vine length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	210.23	205.20	211.34	210.21	205.36	208.47
$T_1 L_2$	212.29	210.36	210.36	211.44	205.15	209.92
$T_2 L_1$	220.19	218.20	220.16	219.00	220.26	219.56
$T_2 L_2$	218.14	218.36	219.21	220.26	219.21	219.04
$T_3 L_1$	143.50	129.00	150.19	147.00	145.19	142.98
$T_3 L_2$	151.19	151.25	144.19	148.88	148.56	148.81
$T_4 L_1$	171.38	172.18	179.75	172.41	175.56	174.26
$T_4 L_2$	178.31	172.88	179.69	176.84	179.88	177.52
Mean (D)	188.15	184.68	189.36	188.25	187.39	

C. D (P = 0.05)

T x L x D = 0.66

was reported in plants at a density of 5,000 (D_2) and 6,666 plants ha^{-1} (D_3) which was on par with the plants spaced at a wider spacing of 3,333 plants ha^{-1} (9.47). The plants grown at a closer spacing of 13,333 plants ha^{-1} (D_5) resulted in minimum number (8.56) of fruits / plant.

4.3.1.3 Effect of nutrients

Application of different nutrient levels recorded no variation in number of fruits / plant (Table 7 a). The plants receiving a dose of 75 : 25 : 25 kg NPK ha^{-1} (L_1) had 9.33 fruits / plant which was on par with those receiving 112.5 : 37.5 : 37.5 kg NPK ha^{-1} (9.2).

4.3.1.4 Effect of T x D interaction

The interaction between T and D on number of fruits / plant was significant (Table 7 a) which ranged from 5.00 in T_1 D_5 to 15.25 in T_4 D_2. Maximum number (15.25) of fruits was noticed in T_4 D_2 which was on par (14.88) with T_4 D_4, T_1 D_5 recorded lowest number (5.00) of fruits which was on par (5.23) with T_2 D_5. The number of fruits per plant was maximum (6.75) in T_1 D_2 among the T_1 combinations and in T_3 D_3 (12.38) among T_3 combinations. Among T_2 combinations, T_2 D_1 had maximum number (6.38) of fruits per plant.

4.3.1.5 Effect of T x L interaction

T x L interaction effect was significant with regard to the number of fruits / plant (Table 7 a), in which maximum number (15.05) was observed in

T_4 L_2. Minimum number (5.2) of fruits was seen in T_1 L_2 which was on par with T_2 L_1 (5.65). T_2 L_2 showed more number of fruits (6.05) compared to T_2 L_1 (.5.65) and T_3 L_1 showed more number (11.45) of fruits compared to T_3 L_2 (10.50) in the corresponding systems of trailing.

4.1.3.6 Effect of L x D interaction

The number of fruits / plant varied significantly with L x D interaction (Table 7 b). It was significantly higher (10.00) in L_1 D_3 which was on par with L_1 D_1 and L_1 D_2. Least number (7.88) of fruits was recorded in L_1 D_5 combination. All the combinations under L_2 were on par with each other (9.00 to 9.38).

4.3.1.7 Effect of T x L x D interaction

From table 7 c it is evident that the interaction between trailing systems and L D combinations on number of fruits / plant was significant. Among the combinations, T_4 L_2 D_2 and T_4 L_2 D_5 showed more fruits (15.75) which were on par with T_4 L_1 D_4 (15.00) and T_3 L_1 D_3, T_4 L_1 D_2, $T_4L_2D_3$ and $T_4L_2D_4$ (14.75). Under T_1, T_1 L_1 D_2 had more fruits / plant (8.25) which was on par with T_1 L_1 D_1 (7.75) and among TLD combinations of T_2, T_2 L_2 D_1 and T_2 L_2 D_2 had more fruits (7.00) than the others.

4.3.2 Deshaped fruits / plot

4.3.2.1 Effect of trailing systems

There was a marked variation on number of deshaped fruits per plot due to different trailing systems (Table 8 a). The plants trailed on pandals (T_4)

Table 7 a : Effect of trailing systems, population density, nutrient levels and their interaction on fruits / plant

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	6.25	6.75	5.63	5.63	5.00	5.85	6.50	5.20	5.85
T_2	6.38	6.00	5.75	5.88	5.23	5.85	5.65	6.05	5.85
T_3	11.00	10.00	12.38	10.75	10.75	10.98	11.45	10.50	10.98
T_4	14.25	15.25	14.25	14.88	13.25	14.38	13.70	15.05	14.38
Mean (D)	9.47	9.50	9.50	9.28	8.56	Mean (L)	9.33	9.20	

C. D (P = 0.05)

Trailing systems (T) - 0.49 T x D = 0.93

Nutrient levels (L) - N.S.* T x L = 0.59

Population density (D) - 0.46

Table 7 b : Interaction of nutrient levels X population density on fruits / plant

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	9.69	9.63	10.00	9.44	7.88	9.33
L_2	9.25	9.38	9.00	9.13	9.25	9.20
Mean (D)	9.47	9.50	9.50	9.28	8.56	

C.D (P = 0.05)

L x D - 0.65

*N.S. - Not significant

Table 7 c : Interaction of trailing systems, nutrient levels and population density on fruits / plant

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
T_1 L_1	7.75	8.25	5.25	6.00	5.25	6.50
T_1 L_2	4.75	5.25	6.00	5.25	4.75	5.20
T_2 L_1	5.75	5.00	6.25	6.00	5.25	5.65
T_2 L_2	7.00	7.00	5.25	5.75	5.25	6.05
T_3 L_1	11.00	10.50	14.75	10.75	10.25	11.45
T_3 L_2	11.00	9.50	10.00	10.75	11.25	10.50
T_4 L_1	14.25	14.75	13.75	15.00	10.75	13.70
T_4 L_2	14.25	15.75	14.75	14.75	15.75	15.05
Mean (D)	9.47	9.50	9.50	9.28	8.56	

C. D (P = 0.05)

T x L x D = 1.31

showed less (1.63) deshaped fruits than other trailing systems. Maximum number (2.33) of deshaped fruits was noticed in plants trailed on ground (T_1).

4.3.2.2 Effect of population density

The population densities had significant effect on number of deshapted fruits per plot (Table 8 a). It was found to be least (1.91) in plants grown at a spacing of 6,666 plants ha^{-1} (D_3) which was on par (1.93) with plants grown at wider spacing (D_1) and those with a spacing of 5,000 plants ha^{-1} (1.97). The plants grown at a spacing of 10,000 plants ha^{-1} (D_4) showed maximum number (2.13) of deshaped fruits and were on par (2.07) with those grown at closer spacing (D_5).

4.3.2.3 Effect of nutrients

The number of deshaped fruits per plot was not significantly affected by the two nutrient levels (Table 8 a).

4.3.2.4 Effect of T x D interaction

There was significant variation in number of deshaped fruits / plot with the interaction between trailing systems and population densities (Table 8 a). Significantly least number (1.53) of deshaped fruits per plot was observed in T_4 D_3 than other combinations which was on par with T_4 D_5 (1.57) and T_4 D_1 (1.61). Number of deshaped fruits was more (2.54) in T_1 D_5 which was on par with T_2 D_4 (2.50) and T_1 D_4 (2.41). The T_1 D_2 plants had least number

(2.21) of deshaped fruits compared to other T1 combinations which was on par with $T_1 D_3$ (2.22) and $T_1 D_1$ (2.24).

4.3.2.5 Effect of T x L interaction

The number of deshaped fruits / plot was found to be significantly affected by the interaction between trailing systems and nutrient levels (Table 8 a). Least number (1.63) of deshaped fruits was noticed in $T_4 L_1$ and $T_4 L_2$ and maximum in $T_1 L_1$ (2.33) which was on par with $T_1 L_2$ (2.32). The $T_3 L_1$ plants showed less (1.73) deshaped fruits than $T_3 L_2$ (2.04).

4.3.2.6 Effect of L x D interaction

Significant difference was observed in deshaped fruits per plot with the interaction between nutrient levels and population density (Table 8 b). It was minimum (1.83) in $L_2 D_1$ and $L_1 D_3$ and maximum (2.23) in $L_2 D_4$ which was on par with $L_2 D_5$ (2.13).

4.3.2.7 Effect of T x L x D interaction

It is evident from the table 8c that there was marked variation on number of deshaped fruits due to interaction between trailing systems and LD combinations. Minimum (1.49) deshaped fruits was noticed in $T_4 L_1 D_3$, $T_4 L_1 D_5$ and $T_4 L_2 D_1$ compared to other combinations which were on par with $T_3 L_1 D_2$, $T_4 L_2 D_3$, T_3 L1 D_4, $T_4 L_1 D_4$, $T_4 L_2 D_2$, $T_4 L_2 D_5$, $T_4 L_1 D_1$ and $T_3 L_1 D_3$. More (2.59) deshaped fruits was noticed in $T_1 L_2 D_5$ which was on par with $T_1 L_2 D_3$, $T_1 L_1 D_2$, $T_2 L_2 D_4$, $T_1 L_1 D_5$, $T_1 L_2 D_4$ and $T_2 L_1 D_4$.

Table 8 a : Effect of trailing systems, population density, nutrient levels and their interaction on deshaped fruits / plot

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	2.24	2.21	2.22	2.41	2.54	2.33	2.33	2.32	2.33
T_2	1.96	2.08	1.99	2.50	2.29	2.16	2.21	2.11	2.16
T_3	1.90	1.88	1.89	1.89	1.89	1.89	1.73	2.04	1.89
T_4	1.61	1.73	1.53	1.73	1.57	1.63	1.63	1.63	1.63
Mean (D)	1.93	1.97	1.91	2.13	2.07	Mean (L)	1.98	2.03	

C. D (P = 0.05)

Trailing systems (T) - 0.09   T x D = 0.18

Population density (D) - 0.09   T x L = 0.11

Levels of nutrient (L) - N. S.*

Table 8 b : Interaction of nutrient levels X population density on deshaped fruits / plot

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	2.02	1.98	1.83	2.03	2.02	1.98
L_2	1.83	1.97	1.99	2.23	2.13	2.03
Mean (D)	1.93	1.97	1.91	2.13	2.07	

C.D (P = 0.05)

L x D - 0.13

*N.S. - Not significant

Table 8 c : Interaction of trailing systems, nutrient levels and population density on deshaped fruits / plot

	D_1	D_2	D_3	D_4	D_5	Mean (TL)
$T_1 L_1$	2.38	2.44	2.05	2.28	2.49	2.31
$T_1 L_2$	2.10	1.99	2.40	2.54	2.59	2.32
$T_2 L_1$	2.06	2.11	2.06	2.55	2.29	2.21
$T_2 L_2$	1.87	2.05	1.93	2.45	2.28	2.11
$T_3 L_1$	1.93	1.57	1.73	1.65	1.79	1.73
$T_3 L_2$	1.87	2.18	2.05	2.12	2.00	2.04
$T_4 L_1$	1.73	1.80	1.49	1.65	1.49	1.63
$T_4 L_2$	1.49	1.65	1.57	1.80	1.65	1.63
Mean (D)	1.93	1.97	1.91	2.13	2.07	

C. D (P = 0.05)

T x L x D = 0.25

4.3.3 Average fruit weight (g)

4.3.3.1 Effect of trailing systems

The trailing systems showed a profound influence on average fruit weight (Table 9 a). The average fruit weight was significantly higher (219.91 g) in plants trailed on pandals (T_4). The plants trailed on ground (T_1) had minimum fruit weight (189.43 g) which was on par with (189.58 g) with those trailed on mulches (T_2).

4.3.3.2 Effect of population density

Significant difference in average fruit weight was observed with different population densities (Table 9 a). Highest fruit weight (206.35 g) was recorded in plants spaced at 6,666 plant ha^{-1} (D_3) and lowest (197.96 g) in plants with wider spacing (D_1).

4.3.3.3 Effect of nutrients

Application of different nutrient levels recorded significant influecnce on average fruit weight (Table 9 a). The plants receiving a fertilizer level of 75 : 25 : 25 kg NPK ha^{-1} (L_1) had higher fruit weight (204.85 g) than those (201.63 g) receiving 112.5 : 37.5 : 37.5 kg NPK ha^{-1} (L_2).

4.3.3.4 Effect of T x D interaction

The interaction effect between trailing systems and population density, produced marked difference in average fruit weight (Table 9 a). The average fruit weight of T_4 D_2 (226.00 g) was higher than other combinations. Minimum fruit weight (176.19 g) was recorded in T_1 D_1. T_1 D_3 plants had highest average fruit weight (206.13 g) compared to other T_1 combinations. Among T_2 combinations, T_2 D_4 recorded highest average fruit weight (207.59 g). T_3 D_5 recorded the maximum average fruit weight (223.63 g) among T_3 combinations.

4.3.3.5 Effect of T x L interaction

The average fruit weight differed significantly with T x L interaction (Table 9 a) recording highest in T_4 L_1 (220. 23 g) which was on par with T_4 L_2 (219. 6 g) and lowest in T_2 L_2 (185.58 g). Fruit weight of T_1 L_1 plants was higher (191.13 g) than that of T_1 L_2 (187.74 g) and the fruit weight of T_3 L_1 (214.48 g) was found to be on par with T_3 L_2 (213.59 g).

4.3.3.6 Effect of L x D interaction

The average fruit weight was significantly influenced by L x D interaction (Table 9 b). Maximum average fruit weight (209.16 g) was noticed in L_2 D_4 and it was on par (208.11 g) with L_1 D_2. However the fruit weight was minimum (190.78 g) in L_2 D_1.

4.3.3.7 Effect of T x L x D interaction

The T x L x D interaction effect on average fruit weight was significant (Table 9 c). T_4 L_1 D_1 resulted in a higher fruit weight (226.38 g) which was on par with the combinations T_4 L_2 D_2, T_4 L_1 D_2, T_4 L_1 D_5, T_3 L_2 D_5 and T_3 L_1 D_1. Minimum fruit weight was recorded (162.50 g) in T_2 L_2 D_2. Among

Table 9 a : Effect of trailing systems, population density, nutrient levels and their interaction on average fruit weight (g)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	176.19	187.00	206.13	194.34	183.50	189.43	191.13	187.73	189.43
T_2	178.97	182.59	193.09	207.59	185.63	189.58	193.58	185.58	189.58
T_3	217.75	214.56	209.69	204.53	223.63	214.03	214.48	213.59	214.03
T_4	218.94	226.00	216.50	215.38	222.75	219.91	220.23	219.60	219.91
Mean (D)	197.96	202.54	206.35	205.46	203.88	Mean (L)	204.85	201.63	

C. D (P = 0.05)

Trailing systems (T) - 1.55 T x D = 2.10

Nutrient levels (L) - 0.67 T x L = 1.33

Population density (D) - 1.05

Table 9 b : Interaction of nutrient levels X population density on average fruit weight (g)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	205.14	208.11	205.27	201.77	203.97	204.85
L_2	190.78	196.97	207.44	209.16	203.78	201.63
Mean (D)	197.96	202.54	206.35	205.46	203.88	

C.D (P = 0.05)

L x D - 1.49

Table 9 c : Interaction of trailing systems, nutrient levels and population density on average fruit weight (g)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	183.63	190.00	204.00	185.00	193.00	191.13
$T_1 L_2$	168.75	184.00	208.25	203.69	174.00	187.74
$T_2 L_1$	186.56	202.69	203.44	201.19	174.00	193.58
$T_2 L_2$	171.38	162.50	182.75	214.00	197.25	185.58
$T_3 L_1$	224.00	214.00	197.25	213.88	223.25	214.48
$T_3 L_2$	211.50	215.13	222.13	195.19	224.00	213.59
$T_4 L_1$	226.38	222.75	216.38	207.00	225.63	220.23
$T_4 L_2$	211.50	226.25	216.63	223.75	219.88	219.60
Mean (D)	197.96	202.54	206.35	205.46	203.88	

C. D (P = 0.05)

T x L x D = 2.98

T_1 combinations, T_1 L_2 D_3 recorded maximum (208.25 g) fruit weight than other combinations.

4.3.4 Fruit length (cm)

4.3.4.1 Effect of trailing systems

The fruit length was significantly influenced by different trailing systems (Table 10 a). It was longest (24.49 cm) in plants trailed on pandals (T_4). Those trailed on ground (T_1) had shortest fruits (14.14 cm).

4.3.4.2 Effect of population density

Fruit length was non-significant with different population densities (Table 10 a).

4.3.4.3 Effect of nutrients

The two levels of nutrients (L_1 and L_2) had no effect on fruit length (Table 10 a). Both the nutrient levels was on par with each other (18.62 to 18.74 cm).

4.3.4.4 Effect of T x D interaction

The interaction between trailing systems and population density on fruit length was significant (Table. 10 a). Maximum fruit length (25.25 cm) was noticed in T_4 D_3 which was on par (25.13 cm) with T_4 D_1. The T_1 D_1 combination had minimum fruit length of 12. 94 cm. Under T_1, fruit length of T_1 D_3 was maximum (15.09 cm) than other combinations. Among T_2

combinations, $T_2 D_1$ had longer fruits (15.06 cm) than other combinations and among T_3 combinations, $T_3 D_5$ had longer fruits (21.88 cm) which was on par with $T_3 D_2$, $T_3 D_1$ and $T_3 D_4$.

4.3.4.5 Effect of T x L interaction

Significant difference in fruit length was observed with the interaction between trailing systems and nutrient levels (Table 10 a) in which longer fruits (24.69 cm) were recorded in $T_4 L_2$. Fruit length was minimum (13.89 cm) in $T_1 L_1$ plants. T2 L1 (14.98 cm) showed maximum fruit length compared to $T_2 L_2$ (14.40 cm) and $T_3 L_2$ showed maximum fruit length (2.48 cm) which was on par with $T_3 L_1$ (21.33 cm).

4.3.4.6 Effect of L x D interaction

The table 10 b showed a significant difference in fruit length due to interaction between nutrient levels and population density. The fruit length was found to be maximum (19.42 cm) with $L_2 D_3$ and minimum (18.23 cm) with $L_2 D_4$ which was on par with $L_1 D_3$, $L_2 D_1$ and $L_1 D_2$.

4.3.4.7 Effect of T x L x D interaction

The T x L x D interaction effect was significant with regard to fruit length (Table 10 c). Longer fruits (25.38 cm) were noticed in $T_4 L_2 D_3$ than other combinations, which was on par with $T_4 L_2 D_1$, $T_4 L_1 D_3$, $T_4 L_2 D_5$ and $T_4 L_1 D_1$. The combination $T_2 L_2 D_4$ recorded smaller fruits (12.44 cm) which

Table 10 a : Effect of trailing systems, population density, nutrient levels and their interaction on fruit length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	12.94	14.44	15.09	14.25	14.00	14.14	13.89	14.40	14.14
T_2	15.06	14.56	14.72	14.31	14.78	14.69	14.98	14.40	14.69
T_3	21.56	21.78	20.38	21.41	21.88	21.40	21.33	21.48	21.40
T_4	25.13	23.84	25.25	23.94	24.31	24.49	24.30	24.69	24.49
Mean (D)	18.67	18.66	18.86	18.48	18.74	Mean (L)	18.62	18.74	

C. D (P = 0.05)

Trailing systems (T) - 0.14 T x D = 0.52

Nutrient levels (L) - N.S.* T x L = 0.33

Population density (D) - N.S.*

Table 10 b : Interaction of nutrient levels X population density on fruit length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	18.88	18.48	18.30	18.72	18.73	18.62
L_2	18.47	18.83	19.42	18.23	18.75	18.74
Mean (D)	18.67	18.66	18.86	18.48	18.74	

C.D (P = 0.05)

L x D - 0.36

*N.S. - Not significant

Table 10 c : Interaction of trailing systems, nutrient levels and population density on fruit length (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
T_1 L_1	13.25	13.00	15.06	14.00	14.13	13.89
T_1 L_2	12.63	15.88	15.13	14.50	13.88	14.40
T_2 L_1	15.88	14.25	13.25	16.19	15.31	14.98
T_2 L_2	14.25	14.88	16.19	12.44	14.25	14.40
T_3 L_1	21.38	22.31	19.75	21.31	21.88	21.33
T_3 L_2	21.75	21.25	21.00	21.50	21.88	21.48
T_4 L_1	25.00	24.38	25.13	23.38	23.63	24.30
T_4 L_2	25.25	23.31	25.38	24.50	25.00	24.69
Mean (D)	18.67	18.66	18.86	18.48	18.74	

C. D (P = 0.05)

T x L x D = 0.73

was on par with $T_1 L_2 D_1$ and $T_1 L_1 D_2$. Among the T_3 combinations fruit length was maximum (22.31 cm) in $T_3 L_1 D_2$.

4.3.5 Fruit girth (cm)

4.3.5.1 Effect of trailing systems

The fruit girth was significantly different among the trailing systems (Table 11 a). Maximum fruit girth (15.78 cm) was seen in plants trailed on mulches (T_2) and minimum (13.80 cm) in those trailed on twigs (T_3) which was on par with T4 (13.91 cm).

4.3.5.2 Effect of population density

The effect of various planting densities on fruit girth was highly significant (Table 11 a). The plants at closer spacing of 13,333 plants ha^{-1} (D_5) had maximum fruit girth (15.04 cm) and it was minimum (14.20 cm) in plants at density of 5,000 plants ha^{-1} (D_2).

4.3.5.3 Effect of nutrients

The two levels of nutrients showed significant effect on fruit girth (Table 11 a). The plants receiving lower level of 75 : 25 : 25 kg NPK ha^{-1-} (L_1) recoreded a maximum (14.65 cm) fruit girth than those (14.40 cm) receiving higher level of nutrient (L_2).

4.3.5.4 Effect of T x D interaction

Interaction between trailing systems and population density on fruit girth was significant (Table 11 a). $T_2 D_5$ showed the maximum fruit girth

(17.09 cm) and T_4 D_2 the minimum (13.01 cm) which was on par with T_3 D_4. Under T_1 combinations, T_1 D_4 had maximum fruit girth (15.19 cm) and under T_3, maximum fruit girth (14.25 cm) was seen in T_3 D_5.

4.3.5.5 Effect of T x L interaction

There was no variation in fruit girth due to interaction between trailing systems and nutrient levels (Table 11 a).

4.3.5.6 Effect of L x D interaction

Significant L x D interaction was observed in fruit girth (Table 11 b). Among the combinations, fruit girth was more in L_1 D_5 (15.13 cm) which was on par with L_1 D_3 and L_1 D_1. However less in L_2 D_1 (13.89 cm) and L_1 D_2 (13.94 cm). Under L_2 combinations L_2 D_5 recorded maximum (14.95 cm) fruit girth.

4.3.5.7 Effect of T x L x D interaction

Significant difference was observed in fruit girth with T x L x D interaction (Table 11 c). T_2 L_1 D_5 (17.25 cm), T_4 L_1 D_3 and T_2 L_1 D_1 (17.13 cm) gave the maximum fruit girth. Minimum fruit girth (12.71 cm) was noticed in T_4 L_1 D_2 which was on par with (12.81 cm) T_3 L_2 D_1. Under T_1 combinations, T_1 L_1 D_4 recorded maximum fruit girth (15.50 cm) and under T_3 combinations, it was in T_3 L_2 D_5 (14.38 cm).

Table 11 a : Effect of trailing systems, population density, nutrient levels and their interaction on fruit girth (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	14.31	14.03	14.44	15.19	15.06	14.61	14.64	14.58	14.61
T_2	15.88	15.88	14.66	15.38	17.09	15.78	15.89	15.66	15.78
T_3	13.47	13.88	14.09	13.31	14.25	13.80	14.00	13.60	13.80
T_4	14.06	13.01	15.28	13.44	13.75	13.91	14.07	13.75	13.91
Mean (D)	14.43	14.20	14.62	14.33	15.05	Mean (L)	14.65	14.40	

C. D (P = 0.05)

Trailing systems (T) - 0.20 T x D = 0.40

Nutrient levels (L) - 0.13 T x L = N.S.*

Population density (D) - 0.20

Table 11 b : Interaction of nutrient levels X population density on fruit girth (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	14.97	13.94	15.00	14.20	15.13	14.65
L_2	13.89	14.45	14.23	14.45	14.95	14.40
Mean (D)	14.43	14.20	14.62	14.33	15.04	

C.D (P = 0.05)

L x D - 0.28

*N.S. - Not significant

Table 11 c : Interaction of trailing systems, nutrient levels and population density on fruit girth (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	15.38	13.68	13.63	15.50	15.00	14.64
$T_1 L_2$	13.25	14.38	15.25	14.88	15.13	14.58
$T_2 L_1$	17.13	15.38	15.06	14.63	17.25	15.89
$T_2 L_2$	14.63	16.38	14.25	16.13	16.94	15.66
$T_3 L_1$	14.13	14.00	14.19	13.56	14.13	14.00
$T_3 L_2$	12.81	13.75	14.00	13.06	14.38	13.60
$T_4 L_1$	13.25	12.71	17.13	13.13	14.13	14.07
$T_4 L_2$	14.88	13.31	13.44	13.75	13.38	13.75
Mean (D)	14.43	14.20	14.62	14.33	15.04	

C. D (P = 0.05)

T x L x D = 0.57

4.3.6 Fruit volume (m^3)

4.3.6.1 Effect of trailing systems

The systems of trailing exerted a considerable influence on fruit volume (Table 12 a). Maximum fruit volume (224.18 m^3) was estimated in plants trailed on pandals (T_4) and minimum (164.16 m^3) in plants trailed on mulches (T_2).

4.3.6.2 Effect of population density

Fruit volume was significant among population densities (Table 12 a). Highest volume (198.52 m^3) was recorded in plants spaced at 6,666 plants ha^{-1} (D_3) which was on par (198.28 m^3) with those at closer spacing of 13,333 plants ha^{-1} (D_5). Lowest fruit volume (197.22 m^3) was recorded in plants spaced at 5,000 plants ha^{-1} (D_2).

4.3.6.3 Effect of nutrient

The two levels of nutrients did not influence (Table 12 a) fruit volume (197.85 to 198.04 m^3).

4.3.6.4 Effect of T x D interaction

The interaction effect between trailing systems and population density on fruit volume was significant (Table 12 a). T_4 D_3 had a maximum fruit volume (225.25 m^3) which was on par with T_4 D_1 and T_4 D_5. Minimum fruit volume was in T_2 D_2 (163.25 m^3) which was on par with T_2 D_4 (163.31 m^3) and T_2 D_5 (163.75 m^3). Under T_1 combinations, T_1 D_4 had higher fruit volume

(183.94 m^3). Maximum fruit volume (222.00 m^3) was noticed in T_3 D_5 under T_3 combinations.

4.3.6.5 Effect of T x L interaction

The T x L interaction was significant in fruit volume (Table 12 a) which was highest (224.85 m^3) in plants grown on pandals at the higher nutrient levels (T_4 L_2). Lowest fruit volume was noticed (163.93 m^3) in plants trailed on mulches with higher nutrient level (T_2 L_2). Under T_1 combinations, T_1 L_2 had a higher fruit volume (182.23 m^3) and under T_3 it was in T_3 L_1 (220.75 m^3).

4.3.6.6 Effect of L x D interaction

Significant interaction was found between nutrient levels and population density for the fruit volume (Table 12 b). Maximum fruit volume (198.91 m^3) was observed in plants grown with a combination of higher level of nutrients and closer spacing (L_2 D_5) and minimum (196.81 m^3) in those grown with the same level of nutrients at a density of 5,000 plants ha^{-1} (L_2 D_2). Under L_1 combinations, L_1 D_3 showed maximum fruit volume (198.41 m^3)

4.3.6.7 Effect of T x L x D interaction

The interaction between trailing systems, nutrients levels and population density produced marked difference in fruit volume (Table 12 c). The combination T_4 L_2 D_3 had a highest fruit volume (225.88 m^3) which was on par with T_4 L_2 D_1 and T_4 L_2 D_5 (225.63 m^3) and the combination T_2 L_2 D_2 had

Table 12 a : Effect of trailing systems, population density, nutrient levels and their interaction on fruit volume (m^3)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	182.58	182.69	182.88	183.94	182.88	182.99	182.76	183.23	182.99
T_2	164.75	163.25	165.75	163.31	163.75	164.16	164.40	163.93	164.16
T_3	220.81	218.94	220.19	220.31	222.00	220.45	220.75	220.15	220.45
T_4	224.63	224.00	225.25	222.50	224.50	224.18	223.50	224.85	224.18
Mean (D)	198.19	197.22	198.52	197.52	198.28	Mean (L)	197.85	198.04	

C. D (P = 0.05)

Trailing systems (T) - 0.48   T x D = 0.94

Nutrient levels (L) - N.S.*   T x L = 0.59

Population density (D) - 0.47

Table 12 b : Interaction of nutrient levels X population density on fruit volume (m^3)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	198.07	197.63	198.41	197.50	197.66	197.85
L_2	198.31	196.81	198.63	197.53	198.91	198.04
Mean (D)	198.19	197.22	198.52	197.52	198.28	

C.D (P = 0.05)

L x D - 0.66

*N.S. - Not significant

Table 12 c : Interaction of trailing systems, nutrient levels and population density on fruit volume (m^3)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
T_1 L_1	180.91	181.63	183.88	184.38	183.00	182.76
T_1 L_2	184.25	183.75	181.88	183.50	182.75	183.23
T_2 L_1	166.88	165.88	165.50	162.25	161.50	164.40
T_2 L_2	162.63	160.63	166.00	164.38	166.00	163.93
T_3 L_1	220.88	219.13	219.63	221.38	222.75	220.75
T_3 L_2	220.75	218.75	220.75	219.25	221.25	220.15
T_4 L_1	223.63	223.88	224.63	222.00	223.38	223.50
T_4 L_2	225.63	224.13	225.88	223.00	225.63	224.85
Mean (D)	198.19	197.22	198.52	197.52	198.28	

C. D (P = 0.05)

T x L x D = 1.33

a lowest fruit volume (160.63 m^3). Among the T_1 combinations, T_1 L_1 D_4 showed maximum (184.38 m^3) fruit volume and among T_2, it was in T_2 L_1 D_1 (166.88 m^3). Under T_3 combinations, higher fruit volume (222.75 m^3) was recorded in T_3 L_1 D_5.

4.3.7 Fruit diameter (cm)

4.3.7.1 Effect of trailing systems

The fruit diameter was significantly different among the trailing systems (Table 13 a). Maximum diameter (3.89 cm) was recorded in plants trailed on pandals (T_4) compared to other trailing systems. Those trailed on mulches (T_2) showed minimum fruit diameter (3.58 cm).

4.3.7.2 Effect of population density

The effect of population densities on fruit diameter (3.67 cm to 3.74 cm) was not significant (Table 13 a).

4.3.7.3 Effect of nutrients

Fruit diameter (3.67 to 3.73 cm) was not significantly affected by the two levels of nutrient (Table 13 a).

4.3.7.4 Effect of T x D interaction

The effect of interaction between trailing systems and population density on fruit diameter was significant (Table 13 a). Fruit diameter was maximum (4.21 cm) in $T_1 D_4$ and minimum (3.49 cm) in $T_1 D_3$ which was on par with $T_2 D_2$, $T_2 D_1$, $T_4 D_4$, $T_3 D_5$, $T_2 D_5$, $T_3 D_2$, $T_1 D_5$ and $T_2 D_4$.

4.3.7.5 Effect of T x L interaction

The interaction effect between trailing systems and nutrient levels on fruit diameter was not significant (Table 13 a).

4.3.7.6 Effect of L x D interaction

Fruit diameter was not significantly different with regard to interaction between nutrient levels and population density (Table 13 b).

4.3.7.7 Effect of T x L x D interaction

The effect of interaction between trailing systems, nutrient levels and population density on fruits diameter was also not significant (3.38 to 4.25 cm).

4.3.8 Seeds / fruit

4.3.8.1 Effect of trailing systems

The number of seeds / fruit differed among trailing systems (Table 14 a). More number of seeds was (529.84) observed in plants trailed on pandals (T_4) where as less number (462.04) in plants trailed on ground (T_1).

4.3.8.2 Effect of population density

No significant difference was noticed in number of seeds / fruit among the population densities (Table 14 a).

Table 13 a : Effect of trailing systems, population density, nutrient levels and their interaction on fruit diameter (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	3.75	3.65	3.49	4.21	3.59	3.74	3.74	3.74	3.74
T_2	3.54	3.53	3.66	3.59	3.56	3.58	3.63	3.52	3.58
T_3	3.65	3.56	3.66	3.60	3.55	3.60	3.69	3.52	3.60
T_4	3.93	4.00	3.99	3.54	3.99	3.89	3.87	3.91	3.89
Mean (D)	3.72	3.69	3.70	3.74	3.67	Mean (L)	3.73	3.67	

C. D (P = 0.05)

Trailing systems (T) - 0.08 	T x D = 0.21

Nutrient levels (L) - N.S.* 	T x L = N.S.*

Population density (D) - N.S.*

Table 13 b : Interaction of nutrient levels X population density on fruit diameter (cm)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	3.72	3.76	3.69	3.80	3.68	3.73
L_2	3.71	3.61	3.71	3.67	3.66	3.67
Mean (D)	3.72	3.69	3.70	3.74	3.67	

C.D (P = 0.05)

L x D - N.S.*

*N.S. - Not significant

4.3.8.3 Effect of nutrient

Maximum number of seeds (492.88) was noticed in plants receiving higher level of nutrient (L_2) compared to those receiving lower level (Table 14 a).

4.3.8.4 Effect of T x D interaction

The effect of interaction between trailing systems and population density on number of seeds / fruit was significant (Table 14 a). The combination T_4 D_4 showed maximum number of seeds / fruit (530.13) which was on par with T_4 D_5, T_4 D_3 and T_4 D_1. T_1 D_4 showed minimum number of seeds (461.50). Under T_2 combinations, maximum number of seeds was reported in T_2 D_2 (477.56) and under T_3, it was in T_3 D_5 (502.25).

4.3.8.5 Effect of T x L interaction

Significant difference in number of seeds / fruit was observed with the interaction between trailing systems and nutrient levels (Table 14 a) in which more number of seeds were recorded in T_4 L_1 (530.18) and less number in T_1 L_1 (461.68). Among T_2 combinations, T_2 L_2 reported more number of seeds (477.25) which was on par with T_2 L_1 (477). Under T_3, T_3 L_2 recorded maximum number of seeds (502.18) than T_3 L_1.

4.3.8.6 Effect of L x D interaction

The number of seeds / fruit was significantly influenced by L x D interaction (Table 14 b). Maximum number of seeds was noticed in L_2 D_3

(493.22) which was on par with $L_2 D_2$, $L_2 D_1$, $L_1 D_5$ and $L_1 D_2$. The combination $L_1 D_1$ recorded minimum number of seeds (492.16).

4.3.8.7 Effect of T x L x D interaction

The T x L x D interaction effect on number of seeds / fruit was significant (Table 14 c). $T_4 L_1 D_2$ and $T_4 L_1 D_4$ resulted in maximum number of seeds (530.50) which was on par with $T_4 L_2 D_5$, $T_4 L_1 D_1$, $T_4 L_2 D_3$, $T_4 L_1 D_5$, $T_4 L_2 D_4$, $T_4 L_1 D_3$ and $T_4 L_2 D_1$. Minimum number of seeds was recorded in $T_1 L_1 D_1$ and $T_1 L_2 D_5$ (460.63) which were on par with $T_1 L_1 D_3$, $T_1 L_1 D_4$ and $T_1 L_2 D_4$. Under T_2 combinations, $T_2 L_1 D_2$ reported maximum seed number (478) and under T_3, $T_3 L_2 D_2$ reported maximum (502.63).

4.3.9 100 Seed weight (g)

Average hundred seed weight was 2.25 g irrespective of treatments. There was no variation among the treatment main effects T, L or D or among the interactions TD, TL and LD.

4.3.10 Yield / plot (kg)

4.3.10.1 Effect of trailing systems

The trailing systems differed significantly in fruit yield / plot (Table 15 a). Fruit yield varied from 14.75 kg in T1 to 43.02 kg in T4. It was maximum 43.02 kg) in plants trailed on pandals (T_4) and minimum (14.75 kg) in those trailed on ground (T_1).

Table 14 a : Effect of trailing systems, population density, nutrient levels and their interaction on number of seeds / fruit

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	461.75	463.19	461.81	461.50	461.94	462.04	461.68	462.40	462.04
T_2	477.38	477.56	477.25	476.44	477.00	477.13	477.00	477.25	477.13
T_3	501.44	502.00	501.94	501.81	502.25	501.89	501.60	502.18	501.89
T_4	529.94	529.56	530.00	530.13	530.06	529.94	530.18	529.70	529.94
Mean (D)	492.63	493.08	492.75	492.47	492.81	Mean (L)	492.61	492.88	

C. D (P = 0.05)

Trailing systems (T) - 0.001 T x D = 0.92

Nutrient levels (L) - N.S.* T x L = 0.58

Population density (D) - 0.25

Table 14 b : Interaction of nutrient levels X population density on number of seeds / fruit

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	492.16	492.97	492.28	492.56	493.09	492.61
L_2	493.09	493.19	493.22	492.38	492.53	492.88
Mean (D)	492.63	493.08	492.75	492.47	492.81	

C.D (P = 0.05)

L x D - 0.65

*N.S. - Not significant

Table 14 c : Interaction of trailing systems, nutrient levels and population density on number of seeds / fruit

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	460.63	462.00	461.00	461.50	463.25	461.68
$T_1 L_2$	462.88	464.38	462.63	461.50	460.63	462.40
$T_2 L_1$	476.88	478.00	476.75	476.63	476.75	477.00
$T_2 L_2$	477.88	477.13	477.75	476.25	477.25	477.25
$T_3 L_1$	500.88	501.38	501.63	501.63	502.50	501:60
$T_3 L_2$	502.00	502.63	502.25	502.00	502.00	502.18
$T_4 L_1$	530.25	530.50	529.75	530.50	529.88	530.18
$T_4 L_2$	529.63	528.63	530.25	529.75	530.25	529.70
Mean (D)	492.63	493.08	492.75	492.47	492.81	

C. D (P = 0.05)

T x L x D = 1.30

4.3.10.2 Effect of population density

A profound influence on yield / plot was observed among population densities (Table 15 a). Fruit yield varied from 11.63 kg in D_1 to 43.46 kg in D5. Maximum fruit yield (43.46 kg) was noticed in plants at a closer spacing of 13,333 plants ha^{-1} (D_5) and minimum at wider spacing (D_1).

4.3.10.3 Effect of nutrients

Nutrient levels found to be non-significant with yield per plot (25.93 to 26.60 kg).

4.3.10.4 Effect of T x D interaction

The yield was increasing for each level of T as 'D' levels increased (Table 15 a). Fruit yield varied from 6.68 kg in T_1 D_1 to 70.66 kg in T_4 D_5. Maximum yield / plot (70.66 kg) was observed in plants trailed on pandals at closer spacing (T_4 D_5). The plants trailed on ground at wider spacing (T_1 D_1) showed minimum yield / plot (15.38 kg) which was on par with T_2 D_1. Under T_2 combination, T_2 D_5 recorded highest yield / plot (23.40 kg) compared to other T_2 combinations and under T_3, T_3 D_5 recorded highest yield / plot (57.67 kg).

4.3.10.5 Effect of T x L interaction

Significant TL interaction was observed for yield / plot (Table 15 a). Fruit yield varied from 13.53 kg in T_1 L_2 to 46.21 kg in T_4 L_2. Highest yield (46.21 kg) was recorded in T_4 L_2 and lowest in T_1 L_2 (13.53 kg) which was on par with T_2 L_1 (14.90 kg). Under T_3 combinations, T_3 L_1 recorded highest yield (33.03 kg).

4.3.10.6 Effect of L x D interaction

The L x D interaction effect was significant on yield / plot (Table 15 b). D_5 recorded maximum yield and D_1 recorded minimum yield at all levels of L. Fruit yield varied from 11.01 kg in L_2 D_1 to 47.07 kg in L_2 D_5. The plants receiving higher level of nutrient and at closer spacing (L_2 D_5) recorded highest yield / plot (47.07 kg) whereas lowest yield (11.01 kg) at wider spacing (L_2 D_1). Among L_1 combinations, L_1 D_5 had a maximum yield (39.84 kg).

4.3.10.7 Effect of T x L x D interaction

The Yield / plot was favourably influenced by interaction effect of trailing systems and the LD combination combinations (Table 15 c). Fruit yield varied from 4.81 kg in T_1 L_2 D_1 to 83.12 kg in T_4 L_2 D_5. Among the TLD combinations, T_4 L_2 D_5 recorded a highest yield (83.12 kg) and T_1 L_2 D_1 the lowest (4.81 kg). Under T_2 combinations T_2 L_2 D_5 had a highest yield (24.87 kg) and under T_3 combinations it was in T_3 L_2 D_5 (60.46 kg).

4.3.11 Yield / plant (kg)

4.3.11.1 Effect of trailing systems

Significant difference in yield / plant was observed with different trailing systems (Table 16 a). Fruit yield varied from 1.09 kg in T_2 to 3.16 kg in T_4.

Table 15 a : Effect of trailing systems, population density, nutrient levels and their interaction on yield / plot

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	6.68	11.41	13.94	19.62	22.11	14.75	15.97	13.53	14.75
T_2	6.82	9.69	13.38	21.94	23.40	15.05	14.90	15.19	15.05
T_3	14.29	18.87	30.82	39.57	57.67	32.24	33.03	31.46	32.25
T_4	18.73	31.03	37.02	57.65	70.66	43.02	39.82	46.21	43.02
Mean (D)	11.63	17.75	23.79	34.69	43.46	Mean (L)	25.93	26.60	

C. D (P = 0.05)

Trailing systems (T) - 1.56 T x D = 2.78

Nutrient levels (L) - N.S.* T x L = 1.76

Population density (D) - 1.39

Table 15 b : Interaction of nutrient levels X population density on yield / plot

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	12.24	18.14	24.68	34.75	39.84	25.93
L_2	11.01	17.36	22.90	34.64	47.07	26.60
Mean (D)	11.63	17.75	23.79	34.69	43.46	

C.D (P = 0.05)

L x D - 1.97

*N.S. - Not significant

Table 15 c : Interaction of trailing systems, nutrient levels and population density on yield / plot (kg)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	8.54	14.10	12.86	19.98	24.36	15.97
$T_1 L_2$	4.81	8.71	15.03	19.25	19.86	13.53
$T_2 L_1$	6.44	9.13	15.26	21.75	21.93	14.90
$T_2 L_2$	7.20	10.25	11.50	22.12	24.87	15.19
$T_3 L_1$	14.63	19.34	34.91	41.38	54.89	33.03
$T_3 L_2$	13.96	18.40	26.73	37.77	60.46	31.46
$T_4 L_1$	19.36	29.97	35.71	55.88	58.20	39.82
$T_4 L_2$	18.09	32.07	38.34	59.43	83.12	46.21
Mean (D)	11.63	17.75	23.79	34.69	43.46	

C. D (P = 0.05)

T x L x D = 3.93

Maximum yield / plant (3.16 kg) was in plants trailed on pandals (T_4) and minimum (1.09 kg) in those trailed on mulches (T_2) which was on par with (1.11 kg) plants trailed on ground (T_1).

4.3.11.2 Effect of population denstiy

Yield / plant was found to be maximum (1.98 kg) in plants grown at a spacing of 6,666 plants / ha (D_3) and it was on par with D_1, D_2 and D_4 (Table 16 a). Minimum yield / plant (1.81 kg) was recorded in plants at closer spacing (D_5).

4.3.11.3 Effect of nutrients

Both the levels of nutrient (L_1 and L_2) were found to be on par with each other (1.91 to 1.94 kg) regarding yield / plant (Table 16 a).

4.3.11.4 Effect of T x D interaction

Interaction between trailing systems and population density were significant with yield / plant (Table 16 a). The yield ranged from 0.92 kg in $T_1 D_5$ to 3.45 kg in $T_4 D_2$. Among the combinations $T_4 D_2$ recorded maximum yield (3.45 kg) whereas $T_1 D_5$ recorded minimum (0.92 kg) which was on par with $T_2 D_5$ and $T_2 D_2$. Under T_2 combination $T_2 D_4$ recorded maximum yield (1.22 kg) and under T_3 combination it was in $T_3 D_3$ (2.57 kg).

4.3.11.5 Effect of T x L interaction

Highest yield (3.31 kg) was observed in $T_4 L_2$ combination (Table 16 a) and lowest in $T_1 L_2$ (0.98 kg). Under T_3, $T_3 L_1$ recorded highest yield / plant

(2.42 kg) than T_3 L_2 (2.25 kg). T_2 L_1 and T_2 L_2 were found to be on par (1.09 kg).

4.3.11.6 Effect of L x D interaction

Significant L x D interaction was observed for yield / plant (Table 16 b). Yield / plant ranged from 1.66 kg in L_1 D_5 to 2.06 kg in L_1 D_3. The combination L_1 D_3 recorded highest yield (2.06 kg) whereas L_1 D_5 recorded lowest (1.66 kg). Under L_2, L_2 D_5 had highest yield (1.96 kg) which was on par with L_2 D_4 and L_2 D_3.

4.3.11.7 Effect of T x L x D interaction

T x L x D interaction exerted a greater influence on yield / plant (Table 16 c). It ranged from 0.80 kg in T_1 L_2 D_1 to 3.56 kg in T_4 L_2 D_2. Among TLD combinations. T_4 L_2 D_2 recorded highest yield (3.56 kg) which was on par with T_4 L_2 D_5 (3.46 kg). Minimum yield was recorded in T_1 L_2 D_1 (0.80 kg) which was on par with T_1 L_2 D_5, T_2 L_1 D_5, T_2 L_2 D_3, T_1 L_2 D_2 and T_2 L_2 D_2. Under T_3 combinations, T_3 L_1 D_3 recorded highest yield / plant (2.91 kg).

4.3.12 Incidence of fruit fly

4.3.12.1 Effect of trailing systems

Trailing systems exerted a greater influence on number of fruits affected by fruit fly (Table 17 a). Minimum number of damaged fruits (1.48) was recorded in plants trailed on mulches (T_2) and maximum (1.70) in those trailed on twigs (T_3).

Table 16 a : Effect of trailing systems, population density, nutrient levels and their interaction on yield / plant (kg)

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	1.11	1.27	1.16	1.09	0.92	1.11	1.24	0.98	1.11
T_2	1.14	1.01	1.12	1.22	0.98	1.09	1.09	1.09	1.09
T_3	2.38	2.10	2.57	2.20	2.41	2.33	2.42	2.25	2.33
T_4	3.12	3.45	3.09	3.21	2.95	3.16	3.01	3.31	3.16
Mean (D)	1.94	1.96	1.98	1.93	1.81	Mean (L)	1.94	1.91	

C. D (P = 0.05)

Trailing systems (T) - 0.11 T x D = 0.19

Nutrient levels (L) - N.S.* T x L = 0.12

Population density (D) -0.09

Table 16 b : Interaction effect of nutrient levels X population density on yield / plant (kg)

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	2.04	2.02	2.06	1.93	1.66	1.94
L_2	1.84	1.89	1.91	1.92	1.96	1.91
Mean (D)	1.94	1.96	1.98	1.93	1.81	

C.D (P = 0.05)

L x D - 0.13

*N.S. - Not significant

Table 16 c : Interaction of trailing systems, nutrient levels and population density on yield / plant (kg)

	D_1	D_2	D_3	D_4	D_5	Mean (T L)
$T_1 L_1$	1.42	1.57	1.07	1.11	1.02	1.24
$T_1 L_2$	0.80	0.97	1.26	1.06	0.83	0.98
$T_2 L_1$	1.08	1.02	1.27	1.21	0.91	1.09
$T_2 L_2$	1.20	0.99	0.96	1.23	1.04	1.09
$T_3 L_1$	2.44	2.15	2.91	2.30	2.29	2.42
$T_3 L_2$	2.33	2.05	2.23	2.10	2.52	2.25
$T_4 L_1$	3.23	3.33	2.98	3.11	2.43	3.01
$T_4 L_2$	3.02	3.56	3.20	3.31	3.46	3.31
Mean (D)	1.94	1.96	1.98	1.93	1.81	

C. D ($P = 0.05$)

T x L x D = 0.26

4.3.12.2 Effect of population density

The number of fruits damaged by fruit fly incidence differed significantly among population densities (Table17 a) in which minimum number (1.53) was in plants at wider spacing of 3,333 plants ha^{-1} (D_1). The plants at a spacing of 10,000 plants ha^{-1} (D_4) showed maximum number (1.68) of damaged fruits which was on par (1.65) with those at closer spacing (D_5).

4.3.12.3 Effect of nutrients

The two levels of nutrients showed a significant influence on number of fruits damaged by fruit fly (Table17 a). The plants receiving the higher level of nutrients (L_2) recorded minimum number (1.55) of damaged fruits whereas those receiving the lower level of nutrients (L_1) recorded maximum number (1.65) of damaged fruits.

4.3.12.4 Effect of T x D interaction

The effect of interaction between T and D on number of fruits damaged by fruit fly was significant (Table 17 a). Minimum number of damaged fruits (1.32) was recorded in T_1 D_3 which was on par with T_2 D_2, T_2 D_4, T_2 D_5, T_1 D_1, T_4 D_2 and T_2 D_1. Maximum number (1.84) was seen in T_1 D_4 which was on par with T_1 D_5, T_3 D_4, T_3 D_3, T_3 D_2 and T_4 D_5.

4.3.12.5 Effect of T x L interaction

The effect of interaction between trailing systems and nutrient levels on number of fruits damaged by fruit fly incidence was not significant (Table 17 a).

4.3.12.1.6 Effect of L x D interaction

Significant difference was observed in number of fruits damaged by fruit fly incidence with LD interaction (Table 17 b). The plants receiving highest level of nutrients and at wider spacing (L_2 D_1) recorded minimum number (1.45) of damaged fruits which was on par with L_1 D_2, L_2 D_5, L_2 D_4, L_1 D_3 and L_2 D_3. The plants with L_1 D_4 combination recorded maximum number (1.78) of damaged fruits which was on par with L_1 D_5 (1.76).

4.3.12.7 Effect of T x L x D interaction

The effect of interactions between trailing systems with LD combinations on number of damaged fruits was not significant.

4.3.13 Economics of production

Details of economics of production was furnished in Table 18a. $T_4L_2D_5$ recorded highest benefit : cost ratio (3.50) followed by $T_3L_2D_5$ (2.80). Lowest benefit : cost ratio recorded by $T_1L_2D_1$ (0.28).

Table 17 a : Effect of trailing systems, population density, nutrient levels and their interaction on incidence of fruit fly

	D_1	D_2	D_3	D_4	D_5	Mean (T)	L_1	L_2	Mean (T)
T_1	1.47	1.63	1.32	1.84	1.75	1.60	1.72	1.48	1.60
T_2	1.49	1.43	1.58	1.45	1.45	1.48	1.49	1.47	1.48
T_3	1.61	1.73	1.74	1.75	1.68	1.70	1.70	1.70	1.70
T_4	1.54	1.47	1.71	1.69	1.72	1.63	1.69	1.57	1.63
Mean (D)	1.53	1.57	1.59	1.68	1.65	Mean (L)	1.65	1.55	

C. D (P = 0.05)

Trailing systems (T) - 0.12 T x D = 0.22

Nutrient levels (L) - 0.07 T x L = N.S.*

Population density (D) - 0.11

Table 17 b : Interaction of nutrient levels X population density on incidence of fruit fly

	D_1	D_2	D_3	D_4	D_5	Mean (L)
L_1	1.61	1.52	1.59	1.78	1.76	1.65
L_2	1.45	1.61	1.59	1.58	1.54	1.55
Mean (D)	1.53	1.57	1.59	1.68	1.65	

C.D (P = 0.05)

L x D - 0.16

*N.S. - Not significant

Table 18 a. Economics of cultivation (ha^{-1})

Treatments	Cost of production (Rs.)	Yield (t / ha)	Gross income (Rs.)	Benefit / cost ratio
$T_1L_1D_1$	Rs.35,000/-	3.56	Rs.17,800/-	0.51
$T_1L_1D_2$	Rs.35,200/-	5.88	Rs.29,400/-	0.84
$T_1L_1D_3$	Rs.35,400/-	5.36	Rs.26,800/-	0.76
$T_1L_1D_4$	Rs.35,600/-	8.33	Rs.41,650/-	1.16
$T_1L_1D_5$	Rs.35,800/-	10.15	Rs.50,750/-	1.42
$T_1L_2D_1$	Rs.35,690/-	2.00	Rs.10,000/-	0.28
$T_1L_2D_2$	Rs.35,890/-	3.63	Rs.18,150/-	0.51
$T_1L_2D_3$	Rs.36,090/-	6.26	Rs.31,300/-	0.87
$T_1L_2D_4$	Rs.36,290/-	8.02	Rs.40,100/-	1.10
$T_1L_2D_5$	Rs.36,490/-	8.28	Rs.41,400/-	1.10
$T_2L_1D_1$	Rs.39,000/-	2.68	Rs.13,400/-	0.34
$T_2L_1D_2$	Rs.39,200/-	3.80	Rs.19,000/-	0.48
$T_2L_1D_3$	Rs.39,400/-	6.36	Rs.31,800/-	0.81
$T_2L_1D_4$	Rs.39,600/-	9.06	Rs.45,300/-	1.14
$T_2L_1D_5$	Rs.39,800/-	9.14	Rs.45,700/-	1.15
$T_2L_2D_1$	Rs.39,690/-	3.00	Rs.15,000/-	0.38
$T_2L_2D_2$	Rs.39,890/-	4.27	Rs.21,350/-	0.54
$T_2L_2D_3$	Rs.40,090/-	4.80	Rs.24,000/-	0.60
$T_2L_2D_4$	Rs.40,290/-	9.22	Rs.46,100/-	1.14
$T_2L_2D_5$	Rs.40,490/-	10.36	Rs.51,800/-	1.28
$T_3L_1D_1$	Rs.43,000/-	6.10	Rs.30,500/-	0.71
$T_3L_1D_2$	Rs.43,200/-	8.06	Rs.40,300/-	0.93
$T_3L_1D_3$	Rs.43,400/-	14.55	Rs.72,750/-	1.68
$T_3L_1D_4$	Rs.43,600/-	17.24	Rs.86,200/-	1.98
$T_3L_1D_5$	Rs.43,800/-	22.87	Rs.114,350/-	2.61
$T_3L_2D_1$	Rs.43,690/-	5.82	Rs.29,100/-	0.67
$T_3L_2D_2$	Rs.43,890/-	7.67	Rs.38,350/-	0.87
$T_3L_2D_3$	Rs.44,090/-	11.14	Rs.55,700/-	1.26
$T_3L_2D_4$	Rs.44,290/-	15.74	Rs.78,700/-	1.78
$T_3L_2D_5$	Rs.44,490/-	25.19	Rs.125,950/-	2.80

Treatments	Cost of production (Rs.)	Yield (t / ha)	Gross income (Rs.)	Benefit / cost ratio
$T_4L_1D_1$	Rs. 47,000/-	8.07	Rs.40,350 /-	0.86
$T_4L_1D_2$	Rs. 47,200/-	12.49	Rs.62,450/-	1.32
$T_4L_1D_3$	Rs. 47,400/-	14.88	Rs.74,400/-	1.56
$T_4L_1D_4$	Rs. 47,600/-	23.28	Rs.116,400/-	2.45
$T_4L_1D_5$	Rs. 47,800/-	24.25	Rs.121,250/-	2.50
$T_4L_2D_1$	Rs. 47,690/-	7.54	Rs.37,700/-	0.79
$T_4L_2D_2$	Rs. 47,890/-	13.36	Rs.66,800/-	1.39
$T_4L_2D_3$	Rs. 48,090/-	15.98	Rs.79,900/-	1.60
$T_4L_2D_4$	Rs. 48,290/-	24.76	Rs.123,800/-	2.56
$T_4L_2D_5$	Rs. 48,490/-	34.63	Rs.173,150/-	3.50

*Rate was taken as Rs. 5/- per kilogram

*Data statistically not analysed

DISCUSSION

5. DISCUSSION

The production and productivity of any crop depends primarily on its genetic set up. The potential yield of a crop is fully expressed only when they are grown in the best environment. This emphasizes the need for optimum management practices specific for the crop. The best management is one which accommodates optimum number of plants per unit area, provides favourable growing conditions and judicious use of nutrients and plant protection chemicals. For viny crops like cucurbits, the method of trailing is a very important management practice in achieving maximum yield and best quality.

Cucumber (*Cucumis sativus* L.), an important cucurbitaceous vegetable is grown for their immature fruits which are used as salad and as cooked vegetable. It is often pickled and processed. Much work has been done and considerable genetic improvement made in this crop. The genetic variability, heritability, genetic advance and correlation of characters have been explored leading to the development of certain promising varieties / hybrids to suit specific purposes in different parts of the world. In our country also much improvement has been achieved in various institutes. However despite its economic, medicinal, cosmetic and nutritional importance its cultivation is yet to be popularised in Kerala, which warrants the need for standardisation of management practices of this vegetable. As cucumber fruits are harvested at miniature stage, the plants continue production of more and more fruits in the lower portions of the vines. The ultimate yield therefore depends on the varieties and their cultivation practices. This inclu des optimisation of population density method of trailing and levels of nutrient.

The present experiment was therefore carried out with the objective of studying the response of cucumber to five levels of population density, four methods of trailing and two levels of nutrients. Their direct and interaction effects were studied on attribute of earliness, yield, yield components and incidence of fruit fly in cucumber.

5.1 Trailing systems

The study included four trailing systems viz trailing on ground, mulches, twigs and on pandals. The response of cucumber to the above trailing systems revealed significant differences in respect of earliness, yield and yield components and incidence of fruit fly.

Of the various methods tried, plants trailed on mulches were significantly earlier and those trailed on pandals were significantly later in respect of male and female flower opening. It is generally accepted that in the case of vining crops, plants grown on pandals or other supports have better, faster, vigorous and longer vegetative growth resulting in late initiation of reproductive phase. On the other hand plants on ground or other flat material may experience a little restriction on vegetative growth which favours early onset of reproductive phase. More over, flat growing plants on mulches or ground have better exposure to sunlight which might have contributed to early flowering. Slight loss in earliness in vertical trailing as reported earlier also supports the present finding (Anon, 1969). The nodes to first female flower opening was not affected by trailing systems.

Despite late flowering, early harvest of fruits was in plants trailed on pandals. It is generally understood that plants trailed on pandals or other supports facilitate better pollination, fruit set and fruit development favouring early attainment of marketable size. Early harvest of fruits due to pergola system of trailing in green house cucumber as reported by Stan *et al.* (1980) is in line with the present observation.

The systems of trailing had a greater influence on the morphological characters as well. The number of branches were maximum on plants grown on pandals. This could be due to better branching condition available in pandals. Yadav *et al.* (1989) reported higher number of branches in pointed gourd due to bower system of trailing. However the main vine length was maximum in plants trailed on mulches and ground. This could be due to better elongation of main vine when they are grown flat as on the ground or on mulches as against their growth on supports where the condition is rather limited. Reduced vine length in staked vines is due to the disturbance of the normal auxin movement which in turn affects phloem transport. This assumes that gravity affects the pattern of auxin distribution across the stem (Janick, 1972).

Trailing systems exerted profound influence on yield and yield components. In the present experiment maximum fruits / plant was observed in plants trailed on pandals whereas minimum fruits was in plants trailed on ground and on mulches. Increase in number of fruits per vine by staking may be due to enhanced fruit set, increased number of nodes per branch, more number of leaves and higher leaf area. Pandal grown plants experience optimum micro climate, better photosynthesis and mobilization to fruits, better pollination by insects and have better fruit development. All these have contributed to the present observation. The earlier findings of more fruits / plant trailed on support as in cucumber (Hosslin, 1966 and Makus, 1989) and in bitter gourd (Joshi *et al.*, 1994) support the present finding.

Other yield components like number of deshaped fruits, average fruit weight, fruit length, fruit girth, fruit diameter and fruit volume are also influenced by trailing systems. The minimum number of deshaped fruits observed in pandal grown plants could be attributed to better pollination as the shape and size of fruits are determined by the number of pollens falling on stigma and the total auxin content available for fruit growth. This is in agreement with the findings of Nitsch *et al.* (1950) in straw berry. Other parameters like fruit weight, length, fruit volume and diameter were also more in plants trailed on pandals. Since the fruit remain hanging freely on pandals they increased in length, diameter and weight.. Similar observation was made by Matiar Rahman and Monowar Hossain (1989) in bottle gourd and Joshi *et al.* (1994) in bitter gourd. Maximum number of seeds were observed in plants trailed on pandals and minimum in those trailed on ground. Higher bee activity due to ease of flower exposure on staking which resulted in better pollination may be the reason for more number of seeds in plants trailed on pandals.

As far as yield is concerned plants trailed on pandals had the highest. Yield is a function of net photosynthetes accumulated by plants. Plants trailed on pandals have better opportunity to accumulate more synthates. Besides, greater leaf area per vine, better pollination, fruit set and fruit development also constitute to more number of fruits / plant which in turn resulted in higher yield in pandal trailed plants. Similar reports of higher yield in plants grown on support had also been reported by several workers in cucumber (Hosslin, 1966 ; Konsler and Strider, 1973 ; Bakker and Vooren, 1985 ; Poll *et al.*, 1988 and Derevencha and Derevencha, 1990).

Management practices are related to the incidence and intensity of pest and diseases in any crop. In the present study fruit fly incidence was minimum on plants trailed on mulches as evidenced by minimum number of damaged fruits by fruit flies. This highlights the desirable effect of mulches and similar material in reducing the pest attack and thereby the application of hazardous chemicals. This is especially important in crops whose produce is used as salad such as cucumber. The beneficial effect of mulching in reducing the pest attack and its use in integrated pest management is being understood in the sustainable system of vegetables cultivation.

5.2 Population density

Population density ie., the number of plants / unit area is an important criterion which decides the vegetative as well as reproductive growth of plants. The final yield is a function of the number of plants / unit area as well the management practices. In the present study five densities of population viz. 3,333, 5,000, 6,666, 10,000 and 13,333 plants / ha tried, revealed the significant effects on majority of the characters. Though a definite trend is not shown in respect of characters of earliness, with increasing density plants grown at wider spacing were in general early for male and female flower opening. Despite early flowering they were not earliest in respect of days to first harvest which indicates that earliness in flowering need not always result in early harvest. In the present study, range for days to first harvest is very narrow being 50.34 days in plots of 10,000 plants per hectare to 51.48 days in plots of high density of 13,333 plants per hectare. Earliness is a varietal character which resulted in a narrow range. The early flowering in plants at wider spacing could be attributed to enhanced axillary bud production as a result of suppressed main vine growth. The findings of Pandey *et al.* (1996) that earliness in flowering is not always related to early harvest is in line with the present result. The another character of earliness ie., the nodes to first female flower opening was non-significant with the different population density.

Population density affects vegetative characters. The present study revealed profound influence on the number of branches / plant and main vine length. The plants at closer spacing had minimum number of branches compared to those at wider spacing. It is a general tendency in almost all crops to branch heavily in widely spaced plants of the same genotype due to their sufficient availability of sunlight, moisture and aeration and lesser degree of mutual competition. Similar tendency of increased branching due to wider spacing have been reported in tomato also (Pandey *et al.*, 1996).

The main vine length was also influenced by the population density. Though a definite trend was not observed for vine length with change in population density, longest vines were seen in plants of moderate population densities. The shortest vines were observed in plants of wider spacing though not from the widest plots. The absence of definite trend in vine length with increase or decrease in population density as observed in other erect growing type of plants could be attributed to the viny nature of cucumber. The favourable conditions of wider spacing like larger ground area per plant, sufficient sunlight, moisture, air, greater availability of plant nutrient and enhanced axillary bud production could have restricted vine elongation. Similar results have been reported in tomato by Dimri and Gulshan Lal (1988).

The response of cucumber to population density for yield and yield attributes was very significant. Maximum yield was noticed at the highest population density and minimum at the lowest. As far as the number of fruits per plant is concerned, plots of highest densities had the minimum whereas maximum fruits were seen in the lower second and third levels of population. It is quite natural that as the number of plants per unit area increases the number of fruits in individual plant decreases though the total number per plot increases. The trend indicates that although the per plant yield was lower at narrow spacing the higher population density increases the yield per hectare.

Highest per hectare yield with closer spacing reported earlier in cucumber by Karataev and Salnikova (1983), Water melon by Petkov (1970) and Pumpkin by Noon (1977) support the present findings.

The fruit parameters like weight, girth and volume were also influenced by the population density. In the present study plants of moderate and higher population densities possessed higher weight and volume of fruits. This could be due to proper pollination and consequent better development of fruits. This is also supported by the least number of deshaped fruits observed in the corresponding plots. No significant difference was noticed in the total number of seeds and hundred seed weight due to varying population densities.

The incidence of fruit fly was minimum in plots of wider spacing. In general multiplication of pest and disease organisms is favoured by humidity and shade which are comparatively less in widely spaced population.

5.3 Nutrients

The growth, development and productivity of any crop are influenced by the available nutrients in the soil. In the present study two levels of nutrient tried indicated significant difference for majority of vegetative as well as productive characters. The attributes of earliness *viz* days to first female flower opening as well as the time taken for the first harvest were considerably influenced by nutrient levels tried in the present experiment. Despite early female flowering noticed in the lower levels, early harvest was in pots receiving higher levels of nutrients. The late flowering in plots receiving higher nutrient doses could be due to longer vegetative growth under higher nitrogen levels. Early induction of female flowers at lower level of nitrogen reported early by Kulbirsingh *et al.* (1990) in pumpkin was in close conformity with the above findings. Though the difference was very narrow the early attainment of harvest size could be attributed to better availability of nutrient for the growth and development of fruit.

Similar early harvest due to increased or better fertilization has been reported in tomato by Singh and Verma (1991). The nutrient levels had no significant effect on nodes to first female flower opening.

The levels of nutrition affected the vegetative characters as well. The higher levels of nutrient increased branches per plant and main vine length. The increased availability of nutrient might have enhanced branching as well as elongation of main branch. Similar increased branches / plant and vine length in response to higher nutrient levels reported in cucumber (Manuca, 1989) ; water melon (Brinen *et al.*, 1979) ; Tinda (Singh *et al.*, 1982) and pointed gourd (Srinivas and Doijode, 1984) confirm the present findings.

Yield and yield parameters were also affected by levels of nutrient. The number of fruits per plant and the yield were not significantly affected by fertilizer application . Whereas the yield per plot was slightly higher in plots receiving higher levels of nutrients.

Similar increased yield due to fertilizer application have been reported earlier in many crops like water melon (Brantley, 1958) ; Bitter gourd (Dhesi *et al.*, 1966) ; Musk melon (Jassal *et al.*, 1972); cucumber (Bomme, 1981) and pointed gourd (Das *et al.*, 1987).

The total number of seeds / fruit was slightly higher in plants receiving higher levels of nutrient. This may be due to better plant growth and yield attributes resulting in greater synthesis of carbohydrates. The result of present finding was in agreement with Pandey and Singh (1979) in okra. But the hundred seed weight found to be unaffected by the nutrient levels.

Minimum incidence of fruit fly was noticed in plants receiving higher level of nutrients than those receiving lower level. Of the two levels tried, the lower level might be insufficient for proper plant growth and development so as to restrict the insect attack.

5.4. Interaction between trailing systems and population density

The effect of interaction between trailing systems and population density was significant for majority of the characters in the present study.

Among the various combinations of trailing systems and population density, plants grown on mulches at the lowest population density produced earlier male flowers while pandal grown plants with a lower population density were late in male flowering. Female flowers production was also earlier in the lowest density grown on mulches and twigs while it was late in pandal grown plants at the lowest density. Node to first female flower production was not significantly affected by T x D interaction. As far as first harvest is concerned earliness was observed in pandal trailed plants at the second and third levels of population density and in plants trailed on twigs at the fourth level of population density. Late harvest was observed in ground trailed plants at the second level of population density. The results clearly indicate that the earliness in respect of male and female flower production and harvest is dependent on the system of trailing and spacing of plants. Therefore the trailing systems have to be suitably modified to suit the levels of population density. The results suggest that when the population density is increased plants prefers trailing on supports like pandals or twigs for early harvest.

The interaction between trailing systems and population density is also important in respect of vegetative characters like branches / plant and main vine length. Branches / plant was maximum in plants trailed on pandals at the fourth level of population density whereas it was minimum in plants grown on twigs with the highest population density. Main vine length was maximum in plants grown on mulches with varying levels of population densities where as it was shortest in plants of second level of population when trailed on twigs.

This also indicates that the population level per unit area is dependent on trailing systems in respect of vegetative characters.

The yield and yield components are highly influenced by the interaction of trailing systems and population density. Maximum number of fruits per plant was observed at the second and fourth levels of population when grown on pandals whereas it was minimum in ground and mulch trailed plants at highest density. Slightly lesser number of fruits produced in bower system and closer spacing in pointedgourd as reported by Yadav *et al.* (1989) was in close agreement with the present result.

Interaction of trailing systems and population densities on number of deshaped fruits showed that plants trailed on pandals at densities of 3,333, 6,666 and 13,333 plants / ha minimised this tendency. The plants trailed on ground at 10,000 and 13,333 plants / ha and plants trailed on mulches at 10,000 plants / ha increased the tendency of deshaped fruit production in cucumber. As far as average fruit weight is concerned maximum weight was observed in pandal grown plants at a density of 5,000 plants / ha where as it was minimum in ground trailed plants at the lowest density of 3,333 plants / ha. The fruit length was influenced by the interaction between trailing systems and population densities. Pandal grown plants at densities of 6,666 and 3,333 plants / ha enhanced this character while ground trailed plants at the lowest density reduced this character. Fruit girth was maximum in plants grown on mulches at highest population density while it was minimum in pandal grown plants at 5,000 plants / ha and plants grown on twigs at a density of 10,000 plants / ha.

Maximum fruit volume was observed in pandal grown plants at densities of 5,000 and 6,666 plants / ha while plants trailed on mulches at densities of 5,000, 10,000 and 13,333 plants / ha had minimum volume. Fruit diameter was enhanced by the population density of 10,000 plants / ha trailed on ground. While all other combinations minimised the fruit diameter.

Seeds per fruit was maximum in pandal grown plants at a population density of 10,000 plants / ha. Seeds per fruit was reduced in plants trailed on pandals at all other population densities and in ground trailed plants at density of 10,000 plants / ha. Yield per plot was influenced by the interaction between trailing systems and population density. The highest density of population trailed on pandals had maximum yield whereas plants trailed on ground and on mulches at the lowest population density had minimum yield. Yield per plant was maximum in pandal trailed plants at a density of 5000 plants per ha.

The result revealed significant influence of interaction between trailing systems and population density in respect of various productive characters such as number of fruits and their parameters. The number of normal and deshaped fruits is decided by the genotype as well as the management practices which affects the pollination by insects which in turn affect the growth and development of fruits. The fruit parameters like weight, length, girth, volume, diameter and yield are also affected by the treatment interactions. Fruit elongation is influenced by trailing systems as hanging fruits on support may have the tendency to elongate more than those resting on ground or on mulches. The trailing systems and population density influence the sunlight penetration, root growth, nutrient uptake, transpiration, photosynthesis and mobilization of photosynthates. The study indicates the need for specific systems of trailing in cucurbits in relation to the change in plant spacing. The results are in close conformity with the finding of Bakker and Vooren (1985).

With respect to attack of fruit fly plants trailed on ground at densities of 3,333 and 6,666 plants / ha, those trailed on mulches at 3,333, 5,000, 10,000 and 13,333 plants / ha and pandal grown plants at a population of 5,000 plants / ha had minimum incidence. This points out the need for specific trailing systems to suit the specific population density depending on the soil, climate and genotype.

5.5 Interaction between trailing systems and nutrient levels

The characters like earliness, morphology, yield and yield components were significantly influenced by the interaction between trailing systems and nutrient levels. The plants trailed on twigs receiving the lowest level of nutrient (75 : 25 : 25 kg / ha) were earlier in male flower opening whereas those trailed on pandals receiving same level of nutrients were late in male as well as female flower opening. Female flower opening was earlier in plants receiving lower level of nutrient grown on mulches. The interaction did not influence the nodes to first female flower opening. Despite late flowering, early harvest was noticed in plants trailed on pandals receiving lowest level of nutrient. The late harvest was found in those with lesser nutrient level and trailed on ground. The reduction in vegetative growth at lowest nutrient level and the better pollination due to pandal system might have resulted in early harvest.

Among the morphological characters, maximum branches / plant was found in plants trailed on pandals with lowest level of nutrient and the longest main vine was seen in plants trailed on mulches with same level of nutrient. Both the characters were minimum in plants receiving lower level of nutrient but trailed on twigs. This indicate that the vegetative characters on different trailing systems are dependent on the nutrient levels.

The fruit parameters and yield were influenced significantly by interaction between trailing systems and nutrient levels. The number of fruits per plant, average fruit weight, fruit length and fruit volume were maximum in plants trailed on pandals receiving higher level of nutrient (112.5 : 37.5 : 37.5 kg / ha). The number of fruits was minimum in plants trailed on ground at highest nutrient level and those trailed on mulches at lowest nutrient level. The plants trailed on mulches with highest nutrient level had minimum fruit weight and volume. The fruit length was minimum in plants trailed on ground receiving lower nutrient levels. Interaction was not significant for fruit girth and diameter. The result thus indicates that the pandal system with highest level of nutrient is the best combination for getting maximum number of fruits and better fruit parameters. This may be due to the better vegetative growth, sufficient light penetration, better aeration which led to enhanced photosynthesis and better mobilization to developing fruits more over the pollination by bees is better in exposed system of trailing as in pandals. The minimum deshaped fruits in pandal growing plants receiving both the levels of nutrient may also be due to the above reason. The relatively higher number of clubbed, blemished and curved fruits in the absence of nitrogen or potassium application was also reported in cucumber by Um *et al.* (1995).

The number of seeds / fruit was maximum in pandal trailed plants receiving lowest nutrient level whereas it was minimum in ground trailed plants with same level of nutrient. Seed yield is a function of number of pollens fertilizing the ovules, which in turn dependent on pollinating agents. Better exposure of flowers in pandals favours the visit by pollinators which might have increased the seed in fruits. Maximum yield was reported in plants trailed on pandals receiving higher level of nutrient.

5.6 Interaction between nutrient levels and population density

The performance of a crop with respect to earliness, vegetative and productive characters depends on the levels of nutrients which vary with the population density. In the present study the two nutrient levels tried interacted significantly with the population density for majority of the morphological and productive characters. Plants receiving the lower level of nutrients were earlier in male flower production when grown at wider spacing where it was late in plants grown at a moderate density of 5,000 plants / ha at the same nutrient level. With respect to female flower opening earliness was observed at the next higher density of 6,666 plants / ha at the same nutrient level and those grown at the highest level of both population and nutrients were the last. Fruits attained harvest stage earlier in plots with a density of 6,666 plants / ha at higher nutrient level. It is clear from the results that the nutrient requirement varies with population density in cucumber as in any other crops. Flowering in plants, especially cucurbits is affected considerably by the environmental factors such as light, temperature, day length, moisture and nutrient availability. The effect of day length in combination with temperature affects the auxin content which decides earliness in flowering as well as the sex ratio. The present interaction of population density and nutrient levels could be explained in terms of their effect on the auxin levels through the plant environment which is highly specific.

The interaction of nutrients and population density also expressed their impact on vegetative characters such as branches / plant and main vine length. Branches / plant was maximum in plants grown at a density 6,666 plants / ha a higher nutrient level and minimum in plants at closer spacing with lower nutrient level. Main vines were longer in plants at the density of 6,666 plants / ha with lower nutrient level. This indicates that wider spacing with adequate nutrient level favours branching tendency which may be due to better exposure to sunlight, adequate space for root spread and better aeration. However the same density of population for better branching favours vine elongation at low nutrient level rather than branching. The morphological characters like branching and vine elongation are therefore dependent on nutrient availability at a particular population density.

The number of fruits per plant was maximum in plants receiving lower nutrient level and at densities of 3,333, 5,000 and 6,666 plants / ha and minimum in same level of nutrient but at closer spacing. The deshaped fruits were lesser in plants at highest nutrient level and closer spacing and at lower nutrient level with a medium density (6,666 plants / ha). This reveals that the optimum density varies with nutrient levels for fruit se and development. At optimum density, plant's experience better environment for proper fruit growth reducing the deshaped fruits.

The fruit parameters like weight, length, girth and volume were influenced significantly with interaction. Average fruit weight was maximum in plants receiving higher nutrient level and at a density of 10,000 plants / ha and in plants receiving lower of nutrient at second level of density. Minimum weight was seen in plants receiving higher nutrient level but at wider spacing. Longer fruits were observed in plants receiving higher nutrient level and at a density of 6,666 plants / ha. The plants with higher level of nutrient and at densities 3,333, 10,000 plants / has showed shorter fruits.

The fruit girth was maximum in plants with lowest nutrient level and at wider and medium spacing. Whereas the plants receiving higher nutrient level and at closest spacing showed maximum fruit volume. The fruit diameter and hundred seed weight were not influenced by the interaction between nutrient level and population density. Maximum number of seeds was recorded in plants receiving higher nutrient level but at densities ranging from 3,333 to 6,666 plants / ha and also in closely spaced plants receiving lower nutrient level. Plants at lowest nutrient level and population density showed minimum number of seeds.

Higher fruit yield was obtained from plants at higher nutrient level and population density and lower in plants at wider spacing with same nutrient level. This shows the significant effect of higher population density at higher nutrient level. This could be due to the optimum density and nutrients for better utilization of nutrients, moisture and sunlight giving letter harvest index. The yield per plant was found to be maximum in plants receiving lower nutrient level at a density of 6,666 plants per ha.

The fruit fly incidence was minimum in plants receiving higher nutrient levels and at varying densities. Maximum incidence was in plants receiving lower nutrient level at closer spacing, which might have created better environment for the attack of the insect.

5.7 Interaction between trailing systems, population density and nutrient levels

Interaction of trailing systems with population density and nutrient levels was prominent for most of the characters in the present study.

Attributes of earliness such as male and female flower opening, node to first female flower opening an days to first harvests were significantly influenced by the interaction of the three treatments. Male flower opening was considerably early in plants trailed on mulches and on twigs at lower levels of both population density and nutrients. However it was late in pandal grown plants at the second levels of population and nutrients. With respect to female flowers; plants trailed on ground with lower nutrient level at the highest population density were the earliest. The lowest population density with lower nutrient level also enhanced early female flowering when grown on twigs. Latest flowering was observed in plants trailed on twigs with the highest density of 13,333 plants / ha at the higher nutrient level.

With respect to days to first harvest pandal grown plants at lower nutrient level with moderate population density were the earliest. Plants trailed on ground at lower nutrient level were late at moderate densities of population. The significance of three way interaction of trailing systems, population density and nutrient levels reveal the differential response of cucumber in its attributes of earliness. In cucurbits flowering is governed by internal as well as external factors. Flowering and sex ratio is decided by the auxin content of the plant which in turn decided by the environmental factors such as temperature, light, humidity, day length and nutrient availability.

The different population levels in the present study presents varying plant spread which affects shading, moisture level and temperature in the plant environment. This could have attributed to the difference in earliness in various combinations of trailing population and nutrients.

Vegetative characters such as branches / plant and vine length were also influenced by the interaction of the three treatments. Among the combinations, maximum branches / plant were seen in pandal grown plants at lower nutrient level with densities of 5000 and 10000 plants / ha. At higher nutrient also pandal grown plants produced more branches at a density of 10,000 plants / ha. At the moderate density of 6,666 plants per ha; plants grown on twigs at higher nutrient level and those trailed on ground at lower nutrient levels had more branches / plant. Plants trailed on twigs at lower nutrient level at moderate and at highest densities had least number of branches / plant.

Vine elongation was favoured by ground trailing at lowest nutrient level with highest population density and at higher nutrient level with higher population density. Plants trailed on twigs at the lower level of nutrient with a density of 5000 plants / ha produced shortest vines. The result shows differential response of cucumber for vine elongation under varying levels of nutrients and population density. It is seen that plants on twigs prefer vine elongation at lower nutrient level and at higher densities, whereas at higher nutrient level elongation is favoured at little lesser population.

Yield and yield components were also influenced by the interaction of trailing systems with the levels of nutrients and population. Pandal grown plants at higher nutrient level had more number of fruits / plant with the population of 5000 and 13,333 plants / ha. Deshaped fruits were minimum in pandal grown plants at lower nutrient levels with population densities of 6,666 and 13,333 plants / ha and at higher level with the lowest population density of 3,333 plants per ha. Plants trailed on ground at higer levels of nutrient and population density had maximum deshaped fruits / plant. Individual fruit weight was higher in pandal grown plants at lowest levels of both population and nutrients whereas it was minimum in plants trailed on mulches with second population level and with higher nutrient doses.

Other fruit parameters like fruit girth, volume, diameter were influenced by the three way interaction. Plants trailed on mulches and on pandals had maximum fruit girth at L_1 D_5 and L_1 D_3 respectively. It was minimum on pandals and on twigs at L_1 D_2 and L_2 D_1 combinations respectively. Longer fruits were seen in pandal grown plants at L_2 D_3, L_2 D_1, L_1 D_3, L_2 D_5 and L_1D_1 combinations. Plants trailed on mulches and on ground had shorter fruit in combinations of L_2D_4, L_2D_1 and L_1D_2. It is clear that plants when grown on pandals, with favourable combinations of nutrients and population density, fruits had the tendency to elongate.

Pandal grown plants with favourable combinations also had higher fruit weight. This could be due to the reason that fruits hanging freely always have the tendency to elongate owing to the gravitational force under favourable conditions.

Seeds / fruits was more in pandal grown plants at lower nutrient level with moderate population desity. This indicates the suitability of combination for seed production programme. Number of seeds per fruit depends on the number of pollen grains falling the ovules which is highly influenced by the visit of pollinating agents . The visit of bees and pollination are influenced by the plant canopy and spread which in turn are influnced by the various systems of trailing , population density and nutrient level. However hundred seed weight, an indication of seed quality is not affected by the three way interaction. This indicates that whatever seeds formed develops into nrmal size irrespective of the treatments.

Yield / plot was significantly influenced by the interaction of trailing systems, population density and nutrients. Among the combinations pandal trailed plants at highest levels of population desity and nutrients had maximum yield. Plants trailed on ground with lowest population density had least yield despite the higher fertilizer level. The highest yield in the present combination could be attributed to the combination of favourable plant spread on pandal under highest number of plants per unit area with sufficient nutriet level. When plants get an opportunity to proper spreading, flowering and fruiting are favoured leading to better fruit yield. Similar increase in yield due to bower system of trailing has also been reported in bittergourd (Joshi *et al.*, 1994).

The highest benefit : cost ratio (3.50) was also observed in plants trailed on pandals at the higher level of nutrients and population densitiy.

Fig. 2. Interaction of trailing systems, nutrient levels and population density on vine length

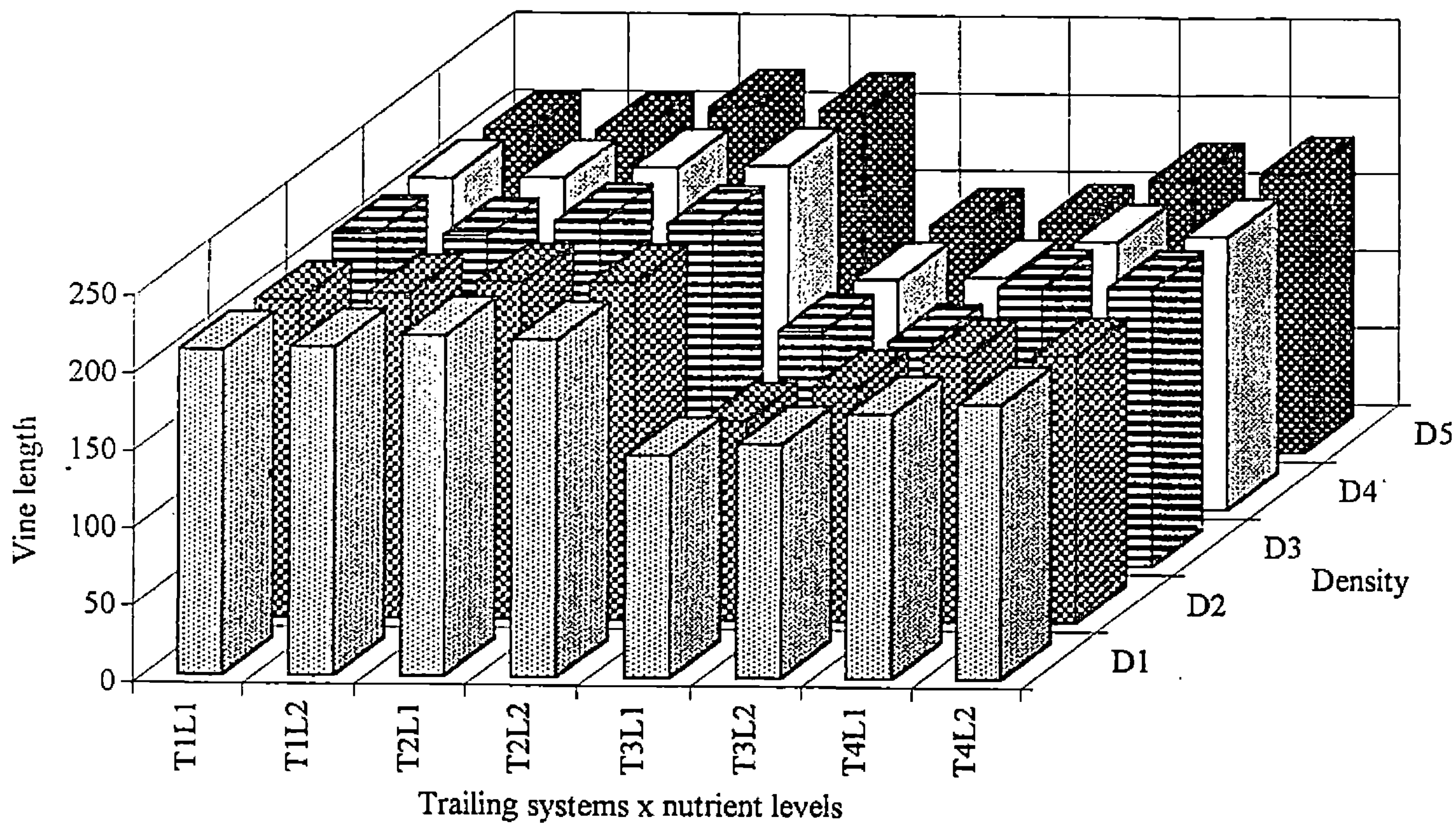


Fig. 3. Interaction of trailing systems, nutrient levels and population density on fruits per plant

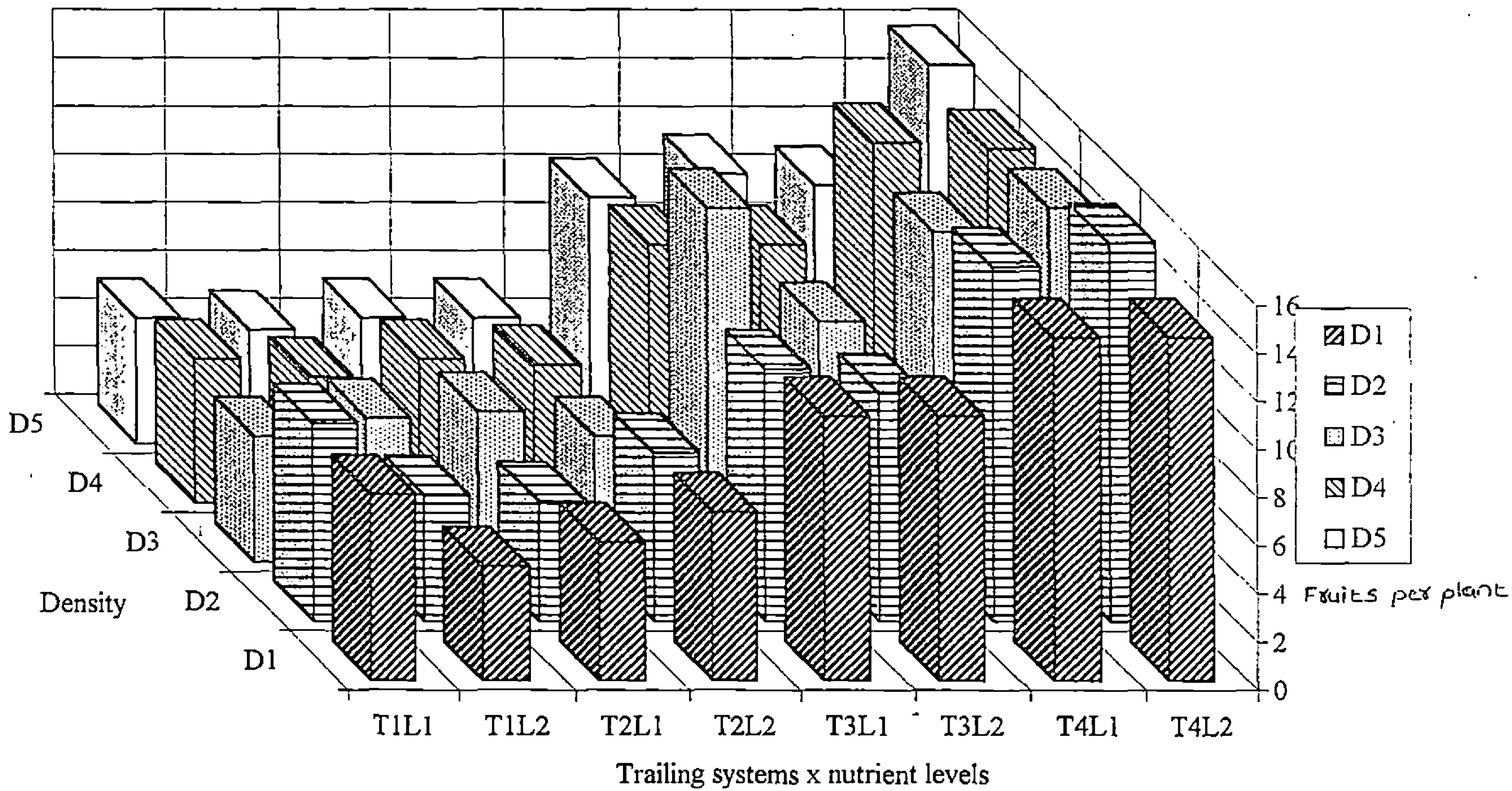


Fig. 4. Interaction of trailing systems, nutrient levels and population density on deshaped fruits per plot

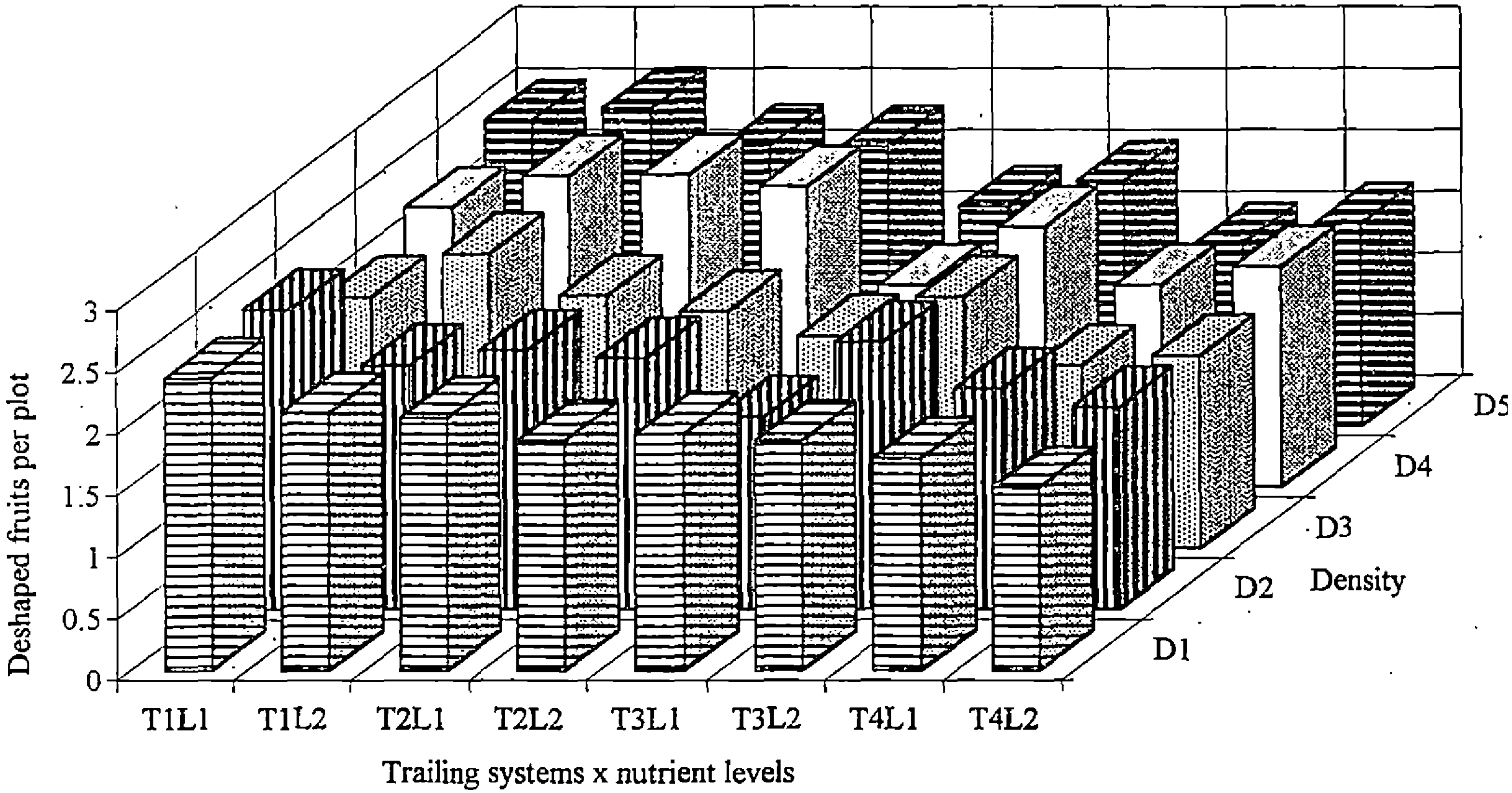
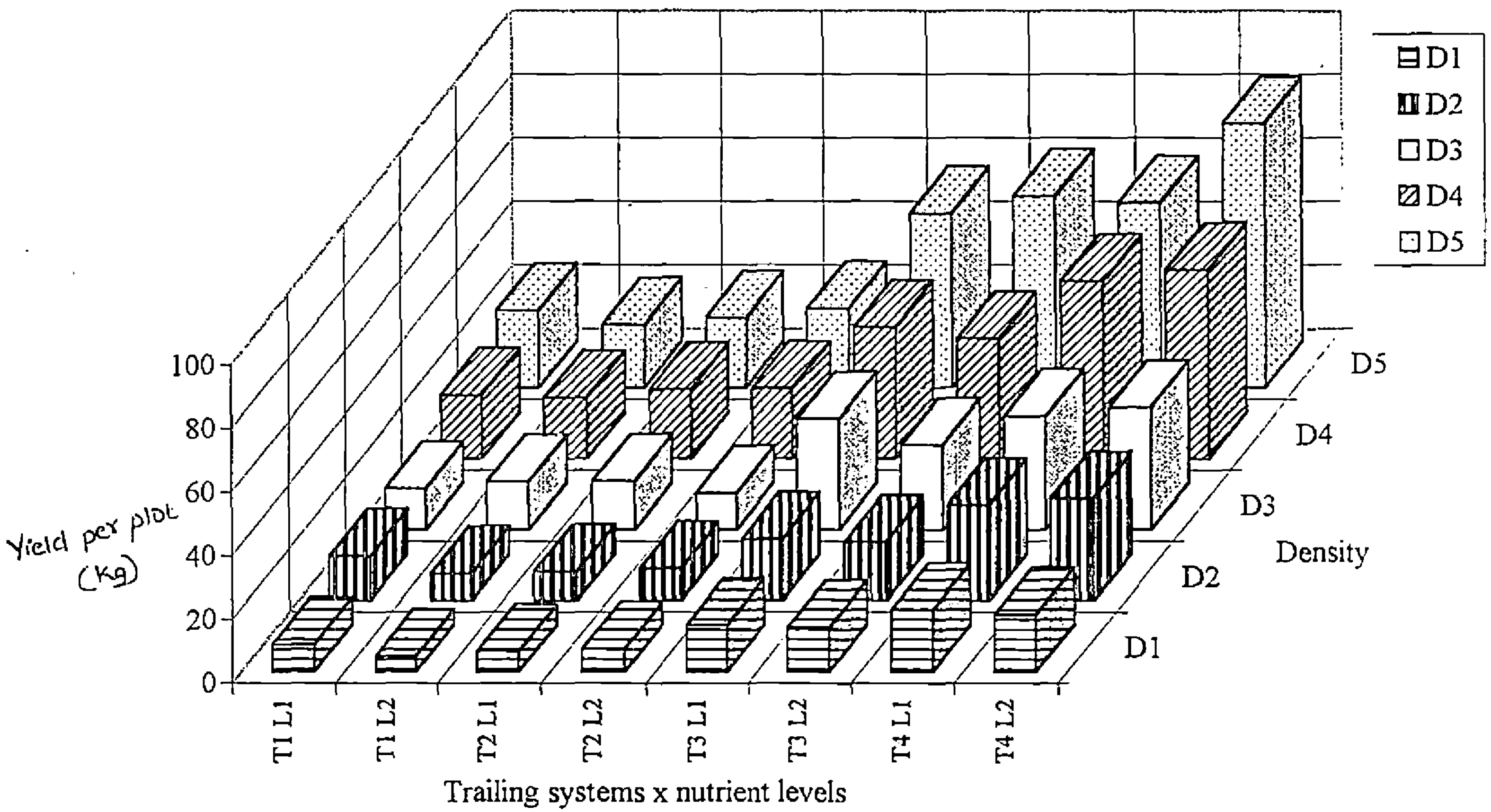


Fig. 5. Interaction of trailing systems, nutrient levels and population density on yield per plot



SUMMARY

6. SUMMARY

The study entitled 'Response of slicing cucumber (*Cucumis sativus.* L) to population density, trailing systems and nutrients' was carried out at the Instructional Farm, College of Agriculture, Vellayani during April to June 1998. The main objective of the study was the standardization of trailing systems, population density and nutrient requirement in slicing cucumber for maximum yield and acceptable table quality with optimum benefit : cost ratio.

The experiment was laid out in a split plot design with four trailing systems as the main plot treatment and ten combination of five population density and two levels of nutrients as the subplot treatments constituting forty treatments with four replication. The trailing systems consited of trailing on ground (T_1), mulches (T_2), twigs (T_3) and pandals (T_4). The population density were 3,333 plants per ha (D_1 - 2 x 1.5 m spacing), 5,000 plants per ha (D_2 - 2 x 1 m spacing), 6,666 plants per ha (D_3 - 1.5 x 1 m spacing), 10,000 plants per ha (D_4 - 2 x 0.5 m spacing) and 13,333 plants per ha (D_5 - 1.5 x 0.5 m spacing). The nutrient levels were 75 : 25 : 25 kg NPK per ha (L_1) and 112.5 : 37.5 : 37.5 kg NPK per ha (L_2).

Observations were recorded on important morphological and yield attributes. The data generated were analysed, presented in tables and discussed in the previous chapters. The findings of the study are summarised below.

1. The direct effects of the treatments showed that plants trailed on mulches (T_2) and the lowest population density of 3,333 plants / ha (D_1) were earlier in male flower opening. Nutrient levels did not affect the days to first male flower opening.

The interaction between trailing systems and population density (T x D interaction) showed significant earliness in plants grown on mulches at wider spacing ($T_2 D_1$). The interaction between trailing systems and nutrient levels (T x L interaction) showed that plants trailed on twigs with lowest level of nutrient were earlier in male flower opening. Plants receiving lower level of nutrients at wider spacing ($L_1 D_1$) was earlier among LD combination.

Interaction of trailing systems, nutrients and population density (T x L x D interaction) revealed that at lowest nutrient level plants trailed on mulches with the lowest density ($T_2 L_1 D_1$) and plants trailed on twigs with the two lower densities ($T_3 L_1 D_1$ and $T_3 L_1 D_2$) produced early male flowers.

2. The direct effects of treatments were significant with the female flower opening. It was early in plants trailed on mulches (T_2), those at wider spacing (D_1) and in plants receiving lower nutrient level (L_1).

Among TD combinations, plants grown on mulches and twigs at the lowest density ($T_2 D_1$ and $T_3 D_1$ respectively) and among TL combinations, plants trailed on mulches receiving lowest nutrient level ($T_2 L_1$) were earlier in female flower opening.

The plants at a density of 6,666 plants / ha at lower level of nutrients (L_1 D_3) and among TLD combinations, T_1 L_1 D_5 and T_2 L_1 D_1 were earlier in female flower production.

3. The trailing systems, population density, nutrient levels and their interaction did not produce any marked difference on nodes to first female flower opening.
4. Significantly early harvest was recorded in plants trailed on pandals (T_4) plants grown at a density of 10,000 plants / ha (D4) and in those receiving higher nutrient level (L_2).

Trailing systems and population density (TD) in combination could influence the first harvest which was earlier in T4 D3 and T4 D2. Also trailing systems with nutrient level (TL) significantly affected the first harvest which was earlier in pandal trailed plants receiving lowest nutrient level (T_4 L_1).

The plants with highest nutrient level at moderate density (L_2 D_3) showed early harvest. Among TLD combinations, pandal grown plants at moderate population density with lower nutrient level (T4 L_1 D_3) was earlier.

5. Among morphological characters maximum branches / plant was observed in pandal grown plants (T_4), plants grown at densities of 6,666 and 10,000 plants / ha (D3 and D4 respectively) and in plants receiving higher nutrient level (L_2).

The plants trailed on pandals at a density of 10,000 plants per ha (T_4D_4), those trailed on pandals receiving lowest nutrient levels (T_4L_1) and plants receiving highest nutrient level at density of 6,666 plants per ha (L_2D_3) recorded maximum branches. Maximum branches were seen in pandal grown plants at lower nutrient level with densities of 5,000 and 10,000 plants / ha (T_4 L_1 D_2 and T_4 L_1 D_4 respectively). At higher nutrient level also pandal grown plants produced more branches at a density of 10,000 plants / ha (T_4 L_2 D_4).

6. Main vine length was maximum in plants trailed on mulches (T_2), at a density of 6,666 plants / ha (D_3) and in plants receiving higher nutrient level (L_2).

Plants trailed on mulch at densities of 6,666, 10,000 and 16,666 plants / ha (T_2 D_3, T_2 D_4 and T_2 D_5 respectively) had longer vines. Trailing systems and nutrient levels (TL) in combination influenced the main vine length which was maximum in mulch trailed plants receiving lower nutrient level (T_2 L_1). The plants at a density of 6,666 plants / ha with lowest nutrient level (L_1 D_3) and in three way combinations, T_2 L_1 D_5 and T_2 L_2 D_4 gave the longest main vines.

7. Yield and yield components varied significantly with trailing systems, population density, nutrients and their interactions. Maximum number of fruits were in pandal trailed plants (T_4) and in plants grown at first three densities (D_1, D_2 and D_3). The nutrient levels were found to be on par with each other.

Pandal grown plants at densities of 5,000 and 10,000 plants / ha (T_4 D_2 and T_4 D_4 respectively) showed higher fruit number. Among T x L interactions, maximum number was observed in T_4 L_2.

The plants receiving lower nutrient level at densities of 3,333, 5,000 and 6,666 plants per ha (L_1 D_1, L_1 D_2 and L_1 D_3 respectively) recorded maximum number of fruits. The pandal grown plants receiving higher nutrient levels at densities 5,000 and 13,333 plants / ha (T_4 L_2 D_2 and T_4 L_2 D_5 respectively) showed more fruits.

8. Deshaped fruits / plot was minimum in pandal trailed plants, (T4) and in plants grown at densities of 3,333 and 6,666 plants / ha (D_1 and D_3).

Pandal grown plants at densities of 3,333, 6,666 and 13,333 plants per ha (T_4 D_3, T_4 D_5 and T_4 D_1 respectively) recorded least number of deshaped fruits whereas among TL combinations, least number was noticed in pandal trailed plants grown at both the nutrient levels (T_4 L_1 and T_4 L_2).

It was minimum in L_2 D_1 and L_1 D_3 and among TLD combinations, T_4 L_1 D_3, T_4 L_1 D_5, T_4 L_2 D_1, T_3 L_1 D_2, T_4 L_2 D_3, T_3 L_1 D_4, T_4 L_1 D_4, T_4 L_2 D_2, T_4 L_2 D_5, T_4 L_1 D_1 and T_3 L_1 D_3 showed minimum deshaped fruits.

9. The fruit parameters like fruit length, weight, volume, diameter, girth and seeds / fruit varied significantly with both direct and interaction effects.

Pandal grown plants (T_4) showed maximum fruit weight, length, volume, diameter and seeds / fruit. The plants grown at density of 6,666 plants / ha (D_3) showed maximum fruit weight and volume. The plants receiving lower level of nutrient (L_1) recorded higher fruit weight whereas maximum seed number was in those receiving higher nutrient level (L_2).

10. Among the TD combinations, maximum fruit weight was observed in pandal grown plants at a density of 5,000 plants / ha (T_4 D_2) and pandal grown plants at densities of 3,333 and 6,666 plants / ha (T_4 D_1 and T_4 D_3) showed longer fruits. Fruit volume and diameter were maximum in pandal grown plants at densities of 3,333, 6,666, 3,333 and 13,333 plants / ha (T_4 D_4, T_4 D_3, T_4 D_1 and T_4 D_5) and in ground trailed plants at a density of 10,000 plants per ha (T_1 D_4) respectively. Seeds per fruit was maximum in pandal grown plants at densities of 10,000, 6,666, 3,333 and 13,333 plants per ha (T_4 D_4, T_4 D_3, T_4 D_1 and T_4 D_5)
11. The fruit parameters were influenced significantly by T x L, L x D and T x L x D interactions. Average fruit weight was maximum in pandal grown plants with both the nutrient levels (T_4 L_1 and T_4 L_2). Fruit length and fruit volume were maximum in plants trailed on pandals receiving higher nutrient level. Pandal grown plants receiving lower nutrient level (T_4 L_1) recorded maximum number of seeds.

The plans receiving higher nutrient level at a density of 10,000 plants per ha (L_2 D_4) and those receiving lower nutrient level at 5,000 plants per ha (L_1 D_2) showed maximum fruit weight. Longer fruits were seen in plants receiving higher nutrient levels at a density of 6,666 plants / ha (L_2 D_3) and the plants with same level of nutrient at closer spacing showed maximum fruit volume. Seeds / fruit was maximum in L_2 D_3, L_2 D_2, L_2 D_1, L_1 D_5 and L_1 D_2.

Among T x L x D interactions, T_4 L_1 D_1, T_4 L_2 D_2, T_4 L_1 D_2, T_4 L_1 D_5, T_3 L_2 D_5 and T_3 L_1 D_1 had maximum fruit weight whereas longer fruits were seen in combinations T_4 L_2 D_3, T_4 L_2 D_1, T_4 L_1 D_3, T_4 L_2 D_5 and T_4 L_1 D_1. Pandal grown plants with higher nutrient level showed maximum fruit volume when grown at densities 3,333, 6,666 and 13,333 plants / ha (T_4 L_2 D_3, T_4 L_2 D_1 and T_4 L_2 D_5). Seeds / fruit was more in pandal grown plants at lower nutrient level with densities 5,000, 10,000 3,333 and 13,333 plants / ha (T_4 L_1 D_2, T_4 L_1 D_4, T_4 L_1 D_1 and T_4 L_1 D_5).

12. Fruit girth was significantly increased in plants trailed on mulches (T_2), at closer spacing (D_5) and in plants receiving lower nutrient level (L_1).

The interaction between trailing systems and population density (T x D) on fruit girth was significant and it was maximum in plants trailed on mulches at closer spacing (T_2 D_5).

Significant difference in fruit girth was observed with L x D and T x L x D interactions. The plants receiving lower nutrient level at densitites of 3,333, 6,666 and 13,333 plants per ha (L_1 D_1, L_1 D_3 and L_1 D_5 respectively) recorded maximum fruit girth whereas $T_2 L_1 D_5$, $T_4 L_1 D_3$ and $T_2 L_1 D_1$ have maximum fruit girth.

13. Fruit yield / plot was maximum in plants trailed on pandals (T_4), plants grown at closer spacing (D_5) and those receiving higher nutrient level (L_2)

Among the T D combinations, plants trailed on pandals at closer spacing ($T_4 D_5$) had maximum yield and among L D combinations, maximum yield was in plants receiving higher nutrient level and at closer spacing ($L_2 D_5$). The T x L and T x L x D interactions were significant for yield per plot. Plants trailed on pandals receiving higher nutrient level ($T_4 L_2$) recorded higher yield whereas the plants trailed on pandals at highest population and nutrient level ($T_4 L_2 D_5$) had maximum yield.

14. The per plant yield was maximum in pandal trailed plants (T_4) and plants grown at medium spacing (D_3).

The plants trailed on pandals at a density of 5,000 plants per ha ($T_4 D_2$), pandal grown plants at highest nutrient level ($T_4 L_2$) and the plants receiving the lower level of nutrients at medium spacing ($L_1 D_3$) recorded highest yield per plant. Among the TLD combinations pandal grown plants at highest nutrient level grown at densities of 5,000 and 13,333 plants per ha had highest yield.

15. As far as fruit fly incidence is concerned, minimum incidence was in plants trailed on mulches (T_2) plants at wider spacing (D_1) and in those receiving

higher nutrient level (L_2). The combinations TD and LD had significant effect on number of fruits damaged by fruit fly. T_1 D_3, T_2 D_2, T_2 D_4, T_2 D_5, T_1 D_1, T_4 D_2 and T_2 D_1 recorded minimum damage. The plants receiving highest nutrient level at densities 3,333, 6,666, 10,000 and 13,333 plants / ha (L_2 D_1, L_2 D_3, L_2 D_4 and L_2 D_5 respectively) recorded minimum number of damaged fruits.

16. The economics of production was found to be highest in pandal grown plants at highest nutrient level and population density followed by those grown on twigs at highest nutrient level and population density.

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RESPONSE OF SLICING CUCUMBER (*Cucumis sativus* L.) TO POPULATION DENSITY, TRAILING SYSTEMS AND NUTRIENTS

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ABSTRACT OF THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR
THE DEGREE
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM

1998

ABSTRACT

The present investigation on "Response of slicing cucumber (*Cucumis sativus* L.) to population density, trailing systems and nutrients" was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram during April to June, 1998. The cucumber variety 'poinsette' collected from National Seed Corporation, was raised in split plot design with four replications. Four trailing systems, five population density and two levels of nutrients were tried to find out their direct and interaction effects on morphological as well as yield attributes. Majority of the characters were significantly influenced by the direct as well as interaction effects of the trailing systems, population density and nutrient levels.

Among the trailing systems, plants trailed on mulches were earlier for male and female flower opening, whereas first harvesting was in pandal grown plants which also had largest values for yield and fruit characters.

In general plants grown under wider spacing were earlier in flowering. The range for days to harvest was narrow for the various population densities. Highest density of 13,333 plants / ha gave the highest yield / plot.

The nutrient levels significantly influenced majority of the vegetative as well as productive characters. Higher levels of nutrients gave early harvest, increased vegetative growth and higher yield / plot.

The interaction between trailing systems and population density revealed that plants trailed on mulches and twigs at lowest density were earlier in female flower opening. Plants trailed on pandals at the moderate levels of

density and those trailed on twigs at the fourth level were earlier in first harvesting. Plant grown on pandals at closer spacing had maximum yield / plot.

Trailing systems interacted significantly with nutrient levels. Plants receiving lower nutrient level grown on mulches were earlier in first female flower opening where as harvesting was early in pandal grown plants receiving lower nutrient levels. Yield per plot was maximum in pandal grown plants at highest nutrient level.

Plots with a moderate population density with higher nutrient level gave early harvesting. Maximum yield / plot was at closer spacing with higher nutrient level.

The three way interaction of trailing systems, population density and nutrient was prominent for most of the characters. Plants trailed on ground with lower nutrient level at the highest population density were the earliest in first female flower opening. However harvesting was first in pandal grown plants at lower nutrient level with moderate population density. Yield per plot and per plant were maximum in pandal grown plants at the highest level of nutrients and population density. This treatment combination also had the highest benefit : cost ratio 3.50.