STANDARDISATION OF AGROTECHNIQUES FOR TROPICAL GYNOECIOUS CUCUMBER (*Cucumis sativus* L.) HYBRIDS

By

RAJESH NAMDEVRAO BADE

(Reg. No. 97173)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI - 413 722, DIST. AHMEDNAGAR

MAHARASHTRA STATE (INDIA)

In partial fulfilment of the requirements for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

In

HORTICULTURE

DEPARTMENT OF HORTICULTURE

POST GRADUATE INSTITUTE

MAHATMA PHULE KRISHI VIDYAPEETH,

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M.S. (INDIA)

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Approved by

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(Chairman and Research Guide)

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MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR
MAHARASHTRA STATE (INDIA)

1999

CANDIDATE'S DECLARATION

I hereby declare that this thesis of part thereof has not been submitted by me or any other person to any other University or Institute for Degree or Diploma

Place : M.P.K.V., Rahuri

Dated : 13/12/ 1999

(R.N. BADE)

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CERTIFICATE

This is to certify that the thesis entitled, **"STANDARDISATION OF AGROTECHNIQUES FOR TROPICAL GYNOECIOUS CUCUMBER (*Cucumis sativus* L.) HYBRIDS"**, submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India, for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTIC**[redacted] embodies the results of piece of *bona fide* research work carried out by **Shri. Rajesh Namdevrao Bade** under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and help received during the course of this investigation have been acknowledged.

Place : M.P.K.V., Rahuri
Dated : 13 / 12 /1999

(S.M. Chaudhari)

Dr. S.S. Kadam
Associate Dean,
Post Graduate Institute,
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Maharashtra State (India).

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Place : M.P.K.V., Rahuri
Dated : 2-1/1/99

(S.S. Kadam)

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Place : MPKV, Rahuri

Date : 13 /12/1999

(R.N. Bade)

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LIST OF ABBREVIATIONS

@	:	At the rate of
C.D.	:	Critical difference
cm	:	Centimetre (s)
Cv.	:	Cultivar
FYM	:	Farm yard manure
g	:	Grammes (s)
ha.	:	Hectare
kg.	:	Kilogram (s)
lb	:	Pound (s)
m	:	Metre (s)
ml	:	Mililitre (s)
N	:	Nitrogen
NS	:	Non significant
%	:	Per cent
P	:	Phosphorus
q	:	Qunital (s)
S.E.	:	Standard error
i.e.	:	That is
t	:	Tonne (s)
viz.,	:	Namely
/	:	Per

ABSTRACT

STANDARDISATION OF AGROTECHNIQUES FOR TROPICAL GYNOECIOUS CUCUMBER (*Cucumis sativus* L.) HYBRIDS

By

BADE RAJESH NAMDEVRAO

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722

1999

Research Guide : Dr. S.M. Chaudhari
Department : Horticulture

The present investigation was conducted during the summer season of 1998 at the Instructional-cum-Research Farm, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.) with the view to work out optimum plant spacing and nutritional requirement of tropical gynoecious cucumber hybrids. The experiment was laid out in a Factorial Randomised Block Design with 18 treatment combinations, comprising of three spacings (1.8 x 0.3 m, 1.8 x 0.45 m, 1.8 x 0.6 m) three combinations of fertilizers (100:75:75, 150:100:100, 200:125:125 NPK kg ha^{-1}) and two cultivars (Hybrid No. 26, Hybrid No. 41). The results indicated that length of main vine was significantly more in medium spacing of 1.8 x 0.45 m, compared to close or wide spacing. But

Abstract Contd....

length of lateral branches and number of lateral branches was significantly higher in wider spacing of 1.8x0.6 m.

Maximum number of fruits per vine, yield per vine, yield per plant and yield per hectare was recorded in medium spacing of 1.8 x 0.45 m. Minimum residues of nutrients in the soil and maximum content of nutrients in the plant after harvesting was also recorded in 1.8 x 0.45 m spacing.

The length of main vine and lateral branches was significantly more when 200:125:125 NPK kg ha^{-1} was applied. The appearance of male and female flower significantly earlier and significantly at lower node was with the application of 200:125:125 NPK kg ha^{-1}. Also the diameter and weight of the fruit was recorded highest with the same fertilizer level.

Highest number of fruits per vine, yield per vine, yield per plot and yield per hectare was recorded when 200:125:125 NPK kg ha^{-1} was applied. Maximum residues of nutrients in the soil and maximum nutrient content in plant after harvesting of crop was recorded with the same fertilizer level.

The results obtained in the present investigation indicated that the medium spacing of 1.8 x 0.45 m and fertilizer dose of 200:125:125 NPK kg ha^{-1} gave the highest yield of better quality fruits and the same can be advocated for the tropical gynoecious cucumber hybrids.

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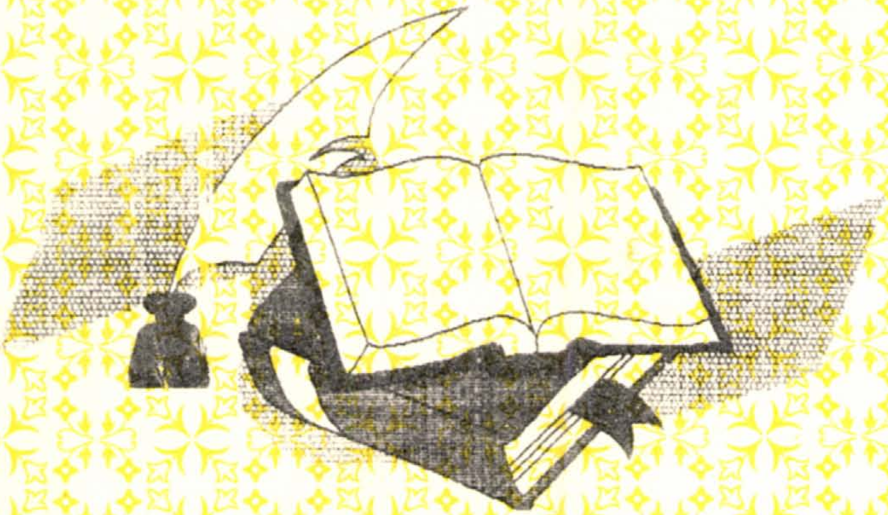


INTRODUCTION

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the important vegetable crops grown all over the world. It is one of the most popularly grown cucurbitaceous vegetable. Cucumber is believed to be native of tropical region of Africa, tropical America. Some authorities claim that it was originated in India from where it spread to Asia, Africa and Europe. India, especially the South-east Himalayas is an important region of Asiatic group. In India it is said to be cultivated for over 3000 years.

In India, the total area under vegetable cultivation in 1995-96 was 53. 35 lakh hectares with the total production of 715.95 lakh metric tonnes. In Maharashtra the total area under vegetables in 1995-96 was reported to be 2.16 lakh hectares with the total production of 29.57 lakh metric tonnes. Out of the total area under vegetables in India, the area under this crop is 16,288 hectares which produced 1,05,690 tonnes of cucumber fruits. In Maharashtra, it is cultivated over 1604 hectares area which produced 24,060 tonnes of cucumber fruits.(Anon., 1999).

Cucumber is a warm season crop and grown mostly during *kharif* and summer season in all parts of the country including hilly parts of North India. It has wide adaptability to varying soils and climatic conditions both in tropical and sub-tropical regions. The cucumber is a short duration crop which needs to look after very critically for input supply.

The gynoecious cucumber hybrids are developed at Mahatma Phule Agricultural University, Rahuri by Dr. T.A. More, These gynoeicous hybrids are having high yield potential due to production of more female flowers. Considering the high yield potential it is anticipated that, there must be high fertilizers requirement for these hybrids and the yield potential of these hybrids needs to be explored by applying optimum dose of nitrogenous, phosphatic and potassium fertilizers and adopting varying plant spacings. Growth and production of the crop plants are governed by their genetic make up and environmental factors in which they grow. The factors like soil type, climatic factors, nutrition, cultural practices and diseases and pests are the limiting factors for growth and production. Amongst them nutrition and spacing plays important role.

There are several reports of various scientists for input requirements of cucumbers. Choudhary (1967) reported that cucubmer yielding 30 tonnes per hectare removed 55 kg of nitrogen, 45 kg of phosphorus and 85 kg of potassium from the soil. Prem Nath (1976) recommended application of 370-490 quintals of farm yard manures and 24 to 34 kg of nitrogen per hectare. Katyal (1980) advised 35 to 45 tonnes of farm yard manure, 50 kg ammonium sulphate, 100 kg superphosphate and 55 kg of potassium sulphate per hectare for cucumber. Yawalkar (1980) recommended the application of 30 to 50 tonnes of farm yard mannure and 1.5 to 2 quintals of ammonium sulphate per hectare. Kasrawi (1990) reported that cucumber with plant density, 5.5 plants/m2 gives the highest yield. Silva *et al.* (1990) reported the highest commercial yield of 15.6 to 15.8 t/ha with 80,000 plants per hectare in pickling cucumber.

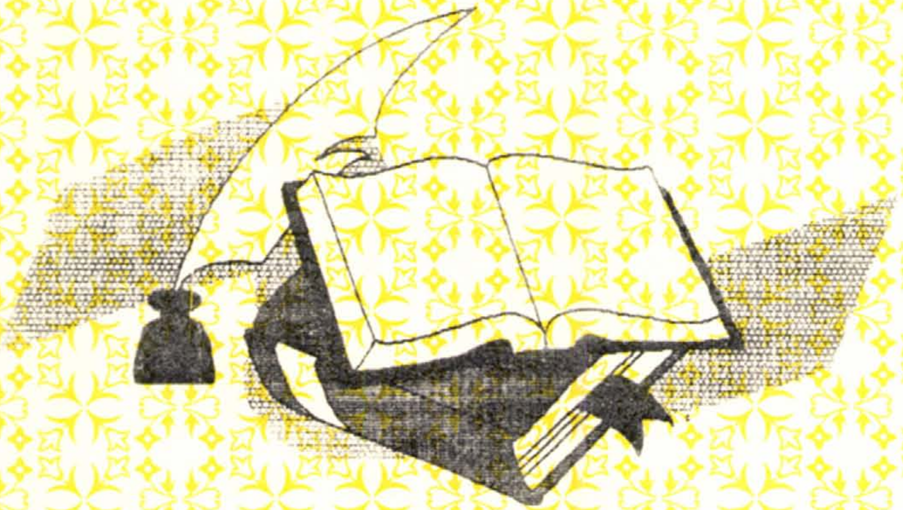
The above recommendations made are for different varieties and for different climatic conditions. Moreover, the varieties used in their studies were of monoecious in nature which have limited yield potential compared to the gynoecious sex form. Recently tropical gynoecious cucumber hybrids with higher productivity have been developed at MPKV, Rahuri by Dr. T.A. More. It was therefore, felt necessary to find out the nutritional cum spacing requirement of these newly developed gynoecious cucumber hybrids. Hence, the present investigation was undertaken with the following main objectives :

1. To find out the optimum levels of nitrogen, phosphorus and potassium for optimum yield of tropical gynoecious cucumber hybrids.

2. To study the effect of different spacings and fertilizer doses on yield and quality of tropical gynoecious cucumber hybrids.

3. To standardize the optimum spacing for newly developed tropical gynoecious cucumber hybrids.

Chapter Opener Page



REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Balanced nutrition and proper spacing, these two factors are very essential for proper growth, development and maximum productivity of any crop. The researchers all over the world have devoted considerable attention to the nutrition of plants, since nutrient supply is generally considered to be the most important factor limiting growth and productivity. A good deal of literature is available on judicious manuring practices in cucumber. But there exist considerable difference among the results obtained and recommendations made by different workers. This is mostly attributed to the varying spacing requirement of crop which usually varies according to the morphological characters of the plant, variety, soil type, availability of land and the season of growth. The nutritional requirement also varies according to the fertility of soil, availability of irrigation and capital. These factors must be known before initiating the experiment for assessing nutritional requirement of this crop.

The literature available on this aspect has been reviewed in this chapter under suitable headings.

2.1 Effect of spacing

Nicklow (1966) reported that for high plant population (1,95,000 plants per acre) of pickling cucumber needed 120 lb N, 120 lb P_2O_5 and 240 lb K_2O per acre for higher yields.

Lesic (1977) reported that hybrid pickling cucumber can be grown at 4.6 times higher plant densities than normal density. He also found that higher plant density did not affect the length of main vine but decrease the length of auxillary shoots. The best results were obtained with the plant population 2,00,000 plants/hectare.

Moerman (1985) conducted a trial on plant spacing with cucumber on substrate. The experiment was conducted where in cucumber were planted on rock wool at the spacing of 40, 46, 55 and 67 cm in each 6 m. long gully. It was observed that at the first harvest the highest yields were obtained at the spacing of 46 cm, however, subsequently the closest spacing (40 cm) gave the best results.

Bakker *et al.* (1986) had concluded the effect of plant densities and training system of green house cucumber. They obtained the highest yields from the plants trained on the 'V' system with close spacing. They also observed that the mean fruit weight decreased as the spacing between two plant is decreased.

Kasrawi (1990) studied the response of parthenocarpic cucumber plants. The plants were grown to densities of 2.4, 3.6, 4.8

and 5.4 plants/m^2 to with various row arrangement in plastic green house. It was observed that the yield per unit area increased linearly with increase in plant density and the highest yields were obtained in two row arrangement with 5.5 plants/m^2.

Silva *et al.* (1990) recorded the highest commercial yield 15.6 to 15.8 t/ha when sown in September and with 80,000 plants/ha in pickling cucumber.

Suchkova *et al.* (1990) while working with hybrid cucumber for seed production recorded the best results with plant density 2.2 - 2.3 plants/m^2.

Widders *et al.* (1990) conducted an experiment to see the effect of plant density on growth and biomass in pickling cucumber and reported that increased spacings resulted in significantly total above ground plant DW, growth rates and total leaf area index.

Hanna *et al.* (1991) reported that spacing plants 9 to 12 inches apart in the row produced the best yields of good quality cucumber. Also found that planting at both sides of the row generally produced higher yields than planting on either side alone.

Florescu *et al.* (1992) recorded the highest commercial yields 64.6 t/ha and 50.0 t/ha from the cv. Pliska and cv. Cornichon respectively with 287770 plants/ha.

Grimstad (1992) recorded the highest commercial yields 30.5 kg/m2 area when plants were spaced at 0.4 m. Also reported that fruit quality increased with increasing spacings.

More *et al.* (1992) reported that a plant spacing of 60 x 60 cm with pruning of the primary branches above 2 nodes gave the highest yields (190 t/ha) under plastic greenhouse condition in winter season.

EL-Aidy (1994) conducted trials on various locations to determine the effect of planting date, spacing, cultivar on the yield of cucumber grown under tunnels during the winter and summer season in Egypt and found that yields from planting densities of 2, 2.5 or 3 plants/m^2 were not significantly different from each other.

Wann (1995) tested various gynoecious cucumber cultivars to determine the effects of plant population density and found that 65,000 - 87,000 plants/acre with row x plant spacings, 15 x 4 inches gave the best results.

2.2 Effect of fertilizers

Shear *et al.* (1948) stressed the importance of nutrient element balance. Adequate and timely application of manures and fertilizers was very essential for the higher production and quality of vegetables. The literature regarding the effect of nitrogen, phosphorus and potassium on growth, yield and quality of cucurbitaceous crops is reviewed below.

Various workers have recommended the fertilizer application to cucumber at variable rates. Katyal (1980) recommended 35 to 45 tonnes of FYM, 50 kg ammonium sulphate, 100 kg superphosphate and 55 kg potassium sulphate per hectare at the time of planting and 40 to 60 kg ammonium sulphate per hectare as top dressing in two split doses for cucumber.

Choudhary (1967) reported application 50 to 60 tonnes of FYM or compost per hectare for cucurbits. Prem Nath (1976) reported that for the cucumber crop a dose of 370-490 quintal farm yard manure and 24 to 35 kg nitrogen per hectare was sufficient. Yawalkar (1980) advocated the application of 35 to 50 tonnes of FYM as a basal dose and 1.5 to 2 quintals of ammonium sulphate as top dressing in two split doses for cucumber.

Mc-collum and Miller (1971) reported that the total N, P and K uptake was 90, 12 and 145 lb per acre, respectively and nutrient removed by the harvested fruit was estimated at 40 lb N, 6 lb P and 55 lb K per acre.

Stolyarov (1973) reported that mineral fertilizer application increased cucumber yields by 25 to 30 per cent and improved the quality. He further reported that ammonium sulphate was more suitable and potassium chloride was the better K source.

2.2.1 Nitrogen

Nitrogen is a constituent of protein and therefore a constituent of every living cell. Nitrogen as a plant food affects growth attributes to a marked degree. Nitrogen deficiency results in a heavy reduction in growth and yield. Majority of Indian soils are deficient in nitrogen and as such the crop grown on them responds very favourably to its application.

2.2.1.1 Effect of nitrogen on growth

The growth of most of the vegetable crops is influenced by nitrogen supply. Thompson (1949) reported that of the three elements supplied by commercial fertilizers, nitrogen was the quickest and showed pronounced effects on crops. It tends to encourage the development of vegetative, above ground portion of the plant and imparts a deep green colour to leaves. Ntirogen tends to produce succulence, a quality of great importance in many vegetables.

Flocker *et al.* (1965) reported that the nitrogen fertilization to cantaloups resulted in increased vine growth and succulence. Yield response to fertilization was by increase in fruit size.

Funamato and Masuda (1965) while working with cucumbers found that the best vine growth, largest flower numbers and highest yield were obtained when the fertilizer was given in five split applications. However, single application of the same total amount of fertilizers at planting gave the poorest results.

Rajkumar (1962) reported that about 56 to 80 kg nitrogen per hectare was needed for good crop of parwal.

Choudhary (1967) reported that 50 to 60 tonnes of FYM or compost was used for cucurbits. He further recommended to apply 50 kg N/ha to bottle gourc.

Randhawa *et al.* (1981) concluded the muskmelon plants receiving nitrogen at 25 to 75 kg/ha recorded the best plant growth and yield.

Kadam (1983) reported that optimum dose of N, P, K for better growth, yield and quality of cucumber cv. Poona khria was 79:32:32 kg/ha.

Singh and Chhonkar (1986) observed that in muskmelon, application of 100 kg N, 60 kg P and 50 kg k/ha gave the best vegetative growth and fruit weight and yield.

Patil (1993) concluded that fertilization of bottle gourd with 135:50:58 NPK kg per hectare gave best plant growth and yield of crop.

2.2.1.2 Effect of nitrogen on flowering

Nitrogen plays an important role in sex expression in cucurbits.

Brantley (1958) observed increase in number of pistillate flowers and fruit set in watermelon with increasing level of nitrogen application but increase was only slight at the rates about 100 lb of nitrogen per acre. He also noted that high nitrogen levels and long days increased the number of staminate flower in muskmelon.

*Brantley and Warren (1960) reported that increase in supply of nitrogen resulted in increased number of pistillate flowers in watermelon. In another study, Brantley and Warren (1961) found that application of 100 lb nitrogen per acre to muskmelon has no effect on number of perfect flowers and fruit set or early yields of muskmelons. However, 250 lb of nitrogen per acre caused significant decrease in each of the above observations (perfect flowers).

Grozdova (1970) reported that cucumbers required higher N doses from the time of flower bud formation till the end of growth.

Parikh and Chandra (1970) concluded that cv. Long Green of cucumber produced most female flowers at 80 kg N/ha. However, higher level of nitrogen application delayed the apperance of the first female flower.

Pandey and Singh (1973) concluded that application of N alone increased the number of pistillate and staminate flowers, fruits and yield per plant over the control in bottle gourd. There was practically no difference in number of pistillate flowers, fruits and yield per plant beyond 100 kg ha^{-1}.

The female : male flower ratio did not seem to be influenced by N treatment.

Srinivas and Doijode (1984) obtained a significant incrase in the number of perfect flowers in muskmelon with NPK at 50:60:60 kg ha^{-1}.

Arora and Siyag (1989) studied the effect of N and P on yield and quality of sponge gourd and concluded that the highest early and total yield could be obtained with 50 kg nitrogen per hectare and 20 kg phosphate per hectare.

2.2.1.3 Effect of nitrogen on fruiting

Nitrogen not only affects the production of staminate and pistillate flowers but it also plays a role in fruit setting.

Brantely (1958) observed increased fruit set with increase of nitrogen in watermelon and muskmelon, but the increase was only slight at rates above 100 lb of nitrogen per acre. The beneficial effects of nitrogen on fruit set were not observed by Brantley and Warren (1961) in muskmelon when nitrogen was applied upto the level of

100 lb/acre. However, the higher dose of 250 lb N per acre had an adverse effect and showed significant reduction in fruit set percentage.

2.2.1.4 Effect of nitrogen on yield

The production of vegetable corp is greatly influenced by nitrogen. Peterson (1958) reported that the highest yield of melons was obtained with medium level (50 lb/acre) of nitrogen. However, the average weight of fruit and the maturity period were not significantly affected with this level and further reported that the time of application of N had little effect on yield.

Masui (1960) reported that increased amounts of N reduced the weight of fruit of muskmelon.

Lingle and Wight (1960) reported that increased N application upto 120 lb per acre resulted in increased yield of cantaloups.

Brantley and Warren (1961) reported that the application of 100 lb nitrogen per acre had effect on early yield of muskmelon, but the time of application of nitrogen had effect on yield. 30 lb/acre applied before planting or 60 lb N per acre in split doses resulted in increase in yields as against no application or application of nitrogen 5 weeks after planting.

Malik (1964) working on bottle gourd fertilization obtained the highest yield with 50 lb nitrogen per acre in one year and with 25 lb in succeeding year.

Dhesi *et al.*, (1964) noticed a significant increase in yield of squashmelon with increasing N application and the most profitable treatment observed was 50 lb N per acre.

Flocker *et al.* (1965) stated that nitrogen fertilization to cantaloups resulted in increased number of cull fruits and associated with increased vine growth and succulence.

Funamato and Masuda (1965) working with cucumbers found that highest yield was obtained when the fertilizer was given in five split application.Of the same, total amount of fertilizer at planting showed the poor results.

Dhesi (1966) also reported an increase in yield of bittergourd with nitrogen application. The level of 56 kg N/acre gave the maximum yield.

Sutton (1966) observed most promising effects of N application on yield of squash. However, the higher levels of nitrogen produced fruits with rough surface.

From a four year trial on muskmelon, Padda *et al.* (1969) concluded that application of nitrogen at 56 kg ha^{-1} proved to be the most profitable in muskmelon.

Jassal *et al.* (1970) reported that fruit weight was significantly increaed by nitrogen application in muskmelon.

Pandey and Singh (1973) reported that in the case of bottle gourd cv. Pusa summer prolifice Long, nitrogen alone at 50 or 100 kg increased yield than other treatments.

Bhosale *et al.* (1978) concluded that application of 75 and 100 kg N ha^{-1} gave significantly more yield of watermelon fruits than 50 kg N ha^{-1}. While levels of 75 and 100 kg N ha^{-1} were at par with the mean yield of water melon fruit was 22.104 and 22.357 t ha^{-1}, respectively.

Randhawa *et al.* (1981) reported that the best result with regard to yield (fruit per vine and fruit weight) of muskmelon was obtained with 50 kg N ha^{-1}.

Kadam (1983) reported that yield attributing characters *viz.*, number of flowers, fruit set, size, weight and volume of fruit were favourably influenced by both the levels i.e. 50 and 100 kg N ha^{-1} and low level (30 kg each) of phosphorus and potassium in cucumber cv. Poona khira

Deswal and Patil (1984) found that in case of watermelon the weight of fruit was influenced significantly by nitrogen application. The highest yields (467 q ha^{-1}) were obtained with 70:70:50 NPK kg ha^{-1}.

Application of nitrogen increased fruit yield of watermelon and the maximum yield was obtained with 120 kg N ha^{-1} as reported by Hegde (1987).

Shukla and Prabhakar (1987) observed that 190 kg N ha^{-1} gave highest yield in bottle gourd.

Lingaiah *et al.* (1988) reported that bitter gourd gave maximum yield (17.12 t ha^{-1}) at 80 kg N and 30 kg P_2O_5 over other levels.

Arora and Siyag (1989) recorded longest fruits in sponge gourd with 50 kg N/ha in rainy season.

2.2.1.5 Effect of nitrogen on availability of nutrients in plant

The application of nitrogen at various levels also reflects the nitrogen content of the leaves. Tayel (1965) reported that the application of N fertilizer increased N percentage and total N content of different plant parts in cucumber. Masui and others (1960) reported that increasing amount of N reduced the Ca, Mg and K content of whole muskmelon plant.

2.2.2 Phosphorus

Phosphorus is another important element required in larger quantities for crop production. It is an essential constituent of many vital compounds like nucleotide, lecithin and most enzymes.

2.2.2.1 Effect of phosphorus on growth

Masui (1960) observed that increasing the P level promoted vigorous growth and improved external appearance and raised the fruit and seed weight and total amount of NPK in muskmelon plants.

Gomi (1962) reported that the effect of P nutrition was greatest during the first 20-30 days after germination and gradually decreased thereafter in cucumber . The supply of P until at least 10 to 15 days after germination was considered indispensible and early germination caused severe reduction in growth rate. Plants supplied with P during later stages of development yielded poorly.

Grozdova (1970) reported that the need for P was increased during flower bud formation, decreased slightly during flowering and rose again during cropping in cucumber. According to Pettiet (1971) P favoured early growth and hastened maturity of pickling cucumber.

Lingel and Wight (1960) reported that phosphate fertilization was also necessary to give the earliest possible maturity in cantaloup.

2.2.2.2 Effect of phosphorus on yield

Euerett (1961-62) while studying the effect of super phosphate on watermelon concluded that increasing levels of P_2O_5

resulted in linear increase in yields, but differences were only significant between 0 and 200 per acre. He further noticed reduction in yield and fruit size due to application of triple super phosphate.

Gomi (1962) reported that cucumber plants supplied with P during later stages of development yielded poorly.

Malik (1965) concluded that in bottle gourd application of phosphorus and potash at 25 lb per acre level proved uneconomical.

Sutton (1966) observed a positive yield reponse for P appliation in squash.

Pelaez *et al.* (1984) observed in squash, that high level of phosphorus (300 P_2O_5 kg ha^{-1}) resulted in highest yield and largest fruits.

Buwalda and Freeman (1986) observed that in hybrid squash fruit yields closely reflected difference in early growth increasing from22 to 45 t ha^{-1} with P addition upto 320 kg ha^{-1}.

Arora and Siyag (1988) reported that in sponge gourd early and total yields and longest fruits were obtained in rainy season with 50 kg N and 20 P kg ha^{-1} .

Rajeshkumar *et al.* (1990) observed that in pointed gourd number of fruits per plant increased from 130.82 at zero P to 150.8 at the highest P rate of 60 kg P ha^{-1}.

Patil (1993) observed that application of phosphorus at low level (50 kg ha^{-1}) significantly increased growth of vine as well as yield attributing characters in bottle gourd.

2.2.2.3 Effect of phosphorus on fruit characters

Masui (1960) reported that the P level raised the fruit and seed weights in muskmelon.

The improvement in fruit quality due to phosphorus has been reported by Largskii (1971) in cucumber.

2.2.2.4 Effect of phosphorus on availability of nutrient in plant

Masui (1960) reported that increasing the P level, the total amount of N, P and K in plants, were increased in muskmelon.

2.2.3 Potassium

Potassium plays an important role in crop growth, yield and quality of final product.

Dhesi (1966) observed a slight reduction in yield with K in bitter gourd.

Sutton (1966) observed positive yield response to K in squash.

Grozodva (1970) reported that K was readily absorbed during early growth period and declined during flower bud formation but again rose in fruit development stage in cucumber.

Pettiet (1971) noticed that the annual application rate greater than 80 lb K per acre delayed the maturity in cucumber.

Further, Pettiet (1971) observed that lack of K did not inhibit early growth but additions of K were beneficial to growth and cropping in cucumber.

In melons, Roorda Van Eysings *et al.* (1982) concluded that K application increased average fruit weight in melon.

Kadam (1983) reported that maturity period was slightly reduced with 60 kg P and K per hectare respectively, low levels (30 kg of each) of P and K significantly increased growth of vine.

Pelaez *et al.* (1984) studied the response of squash to fertilization with nitrogen, phosphorus, potassium and organic manure. They concluded that the yield and number of marketable fruits were highest from plots receiving 10 t ha^{-1} poultry manure, followed by plots receiving 100 N kg ha^{-1}, 300 P_2O_5 kg ha^{-1} and 75 K_2O kg ha^{-1} (21.24 t ha^{-1} and 3.2 fruits/plant).

Deswal and Patil (1984) noticed that application of 50 K_2O kg ha^{-1} along with 70 kg each of N and P recorded the highest yield in watermelon cv. Ashai yamato.

Hassan *et al.* (1984) studied the response of oriental pickling melons to graded levels of NPK. They concluded that response to N was quadratic and optimum level was 96.6 kg ha^{-1} but the most economic level was 45.38 kg ha^{-1} had no appreciable effect and the response to K was linear.

In hybrid squash, addition of K upto 320 kg ha^{-1} gave 25 to 38 t ha^{-1} yield (Buwalda and Freeman, 1986). Spirescu (1986) reported that in watermelon 100 K_2O kg ha^{-1} along with 100 P_2O_5 kg ha^{-1}, 150 N kg ha^{-1} produced maximum leaf photosynthetic activity and highest fruit yield (42.4 t ha^{-1}).

Patil (1993) observed in bottle gourd that maximum yield of 49.853 t ha^{-1} was recorded when N, P, K were applied in combination of 150:50:50 kg ha^{-1}, respectively. Maturity period was increased with higher dose of nitrogen while it was slightly reduced with higher levels of phosphorus and potassium application (100 kg ha^{-1}).

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The details of materials used and methods followed in carrying out the present investigation are given in this chapter.

3.1 Experimental material

3.1.1 Experimental site and preparation of land

The present experiment was carried out at the Instructional-cum-Research Orchard, Department of Horticulture, Mahtma Phule Agricultural University, Rahuri during the year 1998-99.

The site selected for the experiment was uniform and well levelled. In order to study the physical and chemical properties of the soil, a composite soil sample was taken from 0.30 cm soil depth by adopting appropriate soil sampling technique before sowing. The relevenet data on the chemial properties of the soil along with analytical methods used for estimation are presented in Appendix - I. The soil selected for experiment was medium black with good texture and drainage. The land was prepared in usual manner by ploughing, harrowing, clod crushing and was brought to the fine tilth. The ridges and furrows were opened at 1.8 m distance for layout.

3.1.2 Layout and experimental design

The object of this investigation was to study the effect of nitrogen, phosphorous and potash on the growth, yield and quality of gynoecious cucumber hybrids in relation to different plant spacings. The details of the treatments and symbols used are presented in Table a. The plan of layout of experiment is given in Fig. 1.

The experimental details are as

1.	Design	:	Factorial randomised block design
2.	Number of factors	:	3
3.	Number of treatment combinations	:	18
4.	Number of replications	:	3
5.	Total number of plots	:	54
6.	Gross plot size	:	1.8x3, 1.8 x 4.5 and 1.8x6m for spacing S_1, S_2 and S_3, respectively
7.	Net plot size	:	1.5 x 3 m
8.	Number of plants in a net plot	:	10, 6 and 5 for spacing S_1, S_2 and S_3, respectively

The treatments were randomised using random number table.

Table a. Details of treatments and symbols used

Sr. No.	Factor	Treatment details	Symbol used
1.	Spacing	Three spacings	
		1. 1.8 x 0.3 m	S_1
		2. 1.8 x 0.45 m	S_2
		3. 1.8 x 0.6 m	S_3
2.	Fertilizers	Three fertilizer combinations	
		1. 100:75:75, NPK kg ha^{-1}	F_1
		2. 150: 100: 100 NPK kg ha^{-1}	F_2
		3. 200 : 125 : 125 NPK kg ha^{-1}	F_3
3.	Cultivars	Two cultivars	
		1. Gynoecious Hybrid No. 41	C_1
		2. Gynoecious Hybrid No. 26	C_2

3.1.3 Details of application of fertilizer treatment

The quantity of fertilizers to be applied to the gross plot was calculated as per the schedule of treatments. Nitrogen was applied in the form of Urea (46% N). Half quantity of the total dose

Figure 1 : Plan of layout

R-I	R-II	R-III
$S_1F_1C_1$	$S_2F_3C_1$	$S_2F_2C_1$
$S_2F_2C_1$	$S_1F_3C_1$	$S_1F_1C_1$
$S_1F_2C_2$	$S_3F_1C_1$	$S_3F_3C_1$
$S_3F_3C_1$	$S_2F_2C_2$	$S_1F_2C_2$
$S_2F_2C_2$	$S_2F_3C_2$	$S_1F_3C_2$
$S_1F_3C_2$	$S_2F_2C_1$	$S_2F_2C_2$
$S_3F_1C_2$	$S_1F_1C_1$	$S_2F_3C_1$
$S_2F_3C_1$	$S_3F_2C_2$	$S_3F_1C_2$
$S_1F_3C_1$	$S_3F_3C_1$	$S_2F_1C_1$
$S_2F_1C_1$	$S_2F_1C_2$	$S_1F_3C_1$
$S_3F_3C_2$	$S_1F_2C_2$	$S_1F_1C_2$
$S_1F_2C_2$	$S_3F_3C_2$	$S_3F_3C_2$
$S_2F_1C_2$	$S_1F_2C_1$	$S_3F_2C_1$
$S_3F_2C_1$	$S_1F_3C_2$	$S_2F_1C_2$
$S_2F_3C_2$	$S_3F_1C_2$	$S_3F_1C_1$
$S_3F_1C_1$	$S_2F_1C_1$	$S_3F_2C_2$
$S_1F_2C_1$	$S_3F_2C_1$	$S_3F_2C_2$
$S_3F_2C_2$	$S_1F_1C_2$	$S_1F_2C_1$

S_1 = 1.8 m x 0.30 m F$_1$ = 100:75:75 NPK kg ha^{-1}
S_2 = 1.8 m x 0.45 m F$_2$ = 150:100:100 NPK kg ha^{-1}
S_3 = 1.8 m x 0.60 m F$_3$ = 250:125:125 NPK kg ha^{-1}

Gross plot size = 1.8 m x 3m, 1.8 x 4.5m and 1.8 x 6 m for spacing S_1, S_2 and S_3, respectively
Net plot size = 1.5 m x 3 m
Design = Factorial Randomised Block Design

of urea as per the treatment was applied at the time of sowing and remaining half of it's quantity was applied thirty days after sowing. Entire dose of phosphorus as per the treatment was applied through single super phosphate (16% P_2O_5) at the time of sowing. The entire dose of potash as per the treatment was applied at the time of sowing through murite of potash (60% K_2O).

The fertilizers as per the treatments were applied to the spot of planting in rings and were throughly mixed in the soil with the help of weeding hook.

3.1.4 Planting material and sowing

Seeds of gynoecious cucumber hybrids were obtained from net work scheme for promotion of hybrids of vegetable crops.

The furrow were opened at 1.8 m distance. Two seeds were dibbled at each hill in a furrow at 30 cm, 45 cm and 60 cm distance for S_1, S_2 and S_3 spacings respectively. The seeds were dibbled 5 cm apart and at 2 cm depth. For pollination and fruiting of the gynoecious lines, seeds of cucumber cv. Himangi were dibbled in irrigation channel . Thinning of seedling was done within a period of three weeks and a single healthy plant was maintained at each hill in a furrow.

The cultural practices such as irrigation, weeding and plant protection measures were carrried out uniformly as and when required.

3.2 Methods

Observations

The observations were recorded from randomly selected five plants. These plants were labelled in each plots. The observations on growth, flowering, fruit characters and yield were recorded from these plants only.

3.2.1 Growth

Length of main vine (cm)

The length of main vine of each observation plant was measured from the base upto the growing tip after final harvesting and mean length of main vine was worked out.

Length of lateral branch (cm)

The total length of lateral branches was measured after final harvesting for each observational plant, the average length of lateral branches was worked out.

Number of branches

The number of branches for each vine were counted at the time of final harvesting and average number of branches per vine was computed.

3.2.2 Flowering

Days to appearance of first male flower

The days required for appearance of first male flower were noted for each observational vine. The average period in days was calculated.

Days to appearance of first female flower

The days required for appearance of first female flower was noted for each observational vine and the average period in days was worked out.

Node number of which the first male flower appeared

The node number of main vine at which the first male flower appeared was counted for each observational vine. The average of each observational plant was computed.

Node number of which the first female flower appeared

The node number of main vine at which the first female flower appeared was counted for each observational vine. The average of each observational plant was computed.

3.2.3 Physical characters

The observations on physical characters of fruit such as length, diameter, weight, were recorded from randomly selected two fruits of each observational plant. The average of each character was worked out.

Length of fruit(cm)

Length of two fruits from observational plants was measured from stalk end to styler end in centimeters and the aveage length of fruit in centimetrers was calculated.

Diameter of fruit(cm)

The average diameter of fruits was recorded from same fruits which were used for calculating length of fruits. The average was worked out in centimeters.

Weight of fruit(g)

The average weight of fruits in gm was recorded from some fruits which were used for measuring length and diameter of fruits.

3.2.4 Yield

Number of fruits per vine

Number of fruits harvested from each observational vine at each harvesting was counted and average number of fruits per vine harvested during the season was worked out.

Yield of fruits per vine(kg)

The weight of fruits harvested from the observational plants at different pickings was recorded in kg and average yield of fruits per vine in kg was calculated.

Total yield per plot (kg)

The weight of fruits harvested form all the plants from net plot at different pickings was recorded and total yield of fruits per plot in kg was worked out.

Total yield per hectare (q ha^{-1})

Total yield per hectare was worked out by using total yield per plot with respect of each treatment.

3.2.5 Chemical analysis

3.2.5.1 Soil analysis

N,P, K status before planting

In order to study the physical and chemical properties of the soil, samples from 0-30 cm layer were taken at random at eight different spots over the experimental area before layout. After thorough mixing of these samples a composite sample was drawn by quadrant method.

The chemical anlaysis of initial soil sample was done by following methods.

The available nitrogen was estimated by modified alkaline permangnate method (Saharwat and Burford, 1982). The available phosphorus was estimated by "Klett summerson method" (Jackson, 1973).

Available potassium was estimated by "flame photometer method" (Hanway and Heidal, 1967) and pH was estimated by "Backman's glass electrode method" (Piper, 1966). Electric conductivity of soil was estimated by conductivity meter (Jackson, 1973).

N,P, K status after final harvesting

The soil from every experimental plot was analised for it's available nitrogen, phosphorus and potassium content, according to the methods described earlier in this chapter. For this purpose, soil sample were taken from three selected spots from every plot soon after the final harvesting was over.

3.2.5.2 N, P, K status of the plant after final harvesting

Collection of samples

The homogenous plant samples containing leaves, stems were collected after the final harvesting from each of the treatment. before uprooting the plant for estimation of nitrogen, phosphorus and potassium in plant.

Pretreatment

After collection, plant samples were immediately brought to laboratory where each sample was cleaned. The samples were then fully dried in hot air oven at 60°C temperature for about 24 hrs. After drying the plant samples were powdered with the help of grinder. They were stored in air tight amber coloured bottles.

Digestion

For digestion, 0.2 g of powdered plant sample in 30 ml digestion flask was taken in which 5 ml of 30% hydrogen peroxide and 5 ml of concentrated sulphuric acid were slowly added. It was digested in a chamber for about 24 hours as per the procedure laid down by A.O.A.C. (1975) in Microkjeldhal flask method.

Determination of nitrogen

Nitrogen was estimated with Microkjeldhal flask method as advocated by A.O.A.C. (1975) 10 ml of aliquote was distilled in microkjeldahl distillation unit and ammonia evolved was received in 2% boric acid and it was titrated with standard (0.02 N) sulphuric acid. Nitrogen in plant sample was worked out and expressed as percent.

Determination of phosphorus

By calorimetric method

10 ml plant aliquote was taken in 50 ml volumetric flask to which 10 ml vanado-molybdate reagent was added and diluted to 50 ml with distilled water. Read intensity after 20 minutes at 470 nm wavelength on spectronic - 20 (Jackson, 1973). The phosphorus content was worked out and expressed as per cent.

Determination of potassium

By flame photometer method

Potassium content of plant sample was determined with the help of flame photometer (Hanway and Heidal, 1967). The instrument was standardized with standard K^+ solution. The readings were recorded and potassium content in plant samples was worked out and expressed as per cent.

3.2.6 Statistical analysis and interrelation of data

The statistical analysis of the data was carried out by 'Analysis of Variance' method (Panse and Sukhatme, 1967).

Standard error (S.E.) of the means were worked out for each factor. Their interactions were also worked out. Whereever the results were significant, critical difference (C.D.) at 5% level of probability was worked out and presented. Similarly, the significant interactions have been given and discussed.

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The results of the present investigation, " Standardisation of agro-techniques for tropical gynoecious cucumber hybrids (*Cucumis sativus* L.)", are presented in this chapter.

The periodically effect of spacing and fertility levels on growth, yield and quality were recorded and same were analysed statistically. The data obtained for various characters as influenced by various treatments have been presented in this chapter under appropriate headings and sub-headings.

4.1 Growth

4.1.1 Mean length of main vine (cm)

The data on mean length of main vine as influenced by various treatments is presented in table 1

Perusal of data revealed that there were significant influences of spacing, fertilizer levels, cultivar and their interactions on mean length of main vine. Data in the table 1 revealed that S_2 (1.8 x 0.45m) level of spacing putforth significantly more (190.66 cm) length of main vine than that produced in S_1 (1.8 x 0.3 m) (178 cm).

Table 1. Effect of various treatments on mean main vine length (cm)

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	177	164	170.50	186	171	178.50	194	176	185.00	178.00
S_2	182	173	177.50	203	177	190.00	221	188	204.50	190.66
S_3	196	180	188.00	194	188	191.00	200	181	190.50	189.83
Mean (C)	185.00	172.33		194.33	178.66		205.00	181.66		186.16
Mean (F)	178.66			186.50			193.33			

Mean of (C)
C_1 = 194.77
C_2 = 177.55

Factors	S	F	C	SF	SC	FC	SFC
SE±	1.494	1.494	1.494	2.587	2.112	2.112	3.659
CD (0.05%)	4.293	4.293	3.505	7.435	NS	6.071	NS

The fertility level F_3 (200: 125 : 125 NPK kg ha^{-1}) produced the highest mean length of main vine (193.33 cm) than rest of the fertility levels.

It is evident from data (Table 1) that the cultivar C_1 (Hybrid No. 41) produced significantly more (194.77 cm) mean length of main vine than that by C_2 (Hybrid No. 26) (177.55 cm)

There was significant difference in the average length of main vine due to spacing and fertility levels interaction. The treatment S_2 x F_3 (1.8 x 0.45 m with 200 : 125 : 125 NPK kg ha^{-1}) gave the maximum (204.50 cm) vine length than rest of all the interactions.

The effect of spacing x cultivar and spacing x fertility level x cultivar was not statistically significant.

4.1.2 Mean number of lateral branches

The data regarding mean number of lateral branches as influenced by interaction between spacing and fertility levels are presented in Table 2. Perusal of data revealed significant influence of spacing, cultivar and their interaction on number of lateral branches. The mean number of lateral branches obtained during growth period were 5.53. The number of branches was maximum (6.23) in S_3 (1.8 x 0.6 m) level of spacing than that was produced in the treatments S_1 (5.00) and S_2 (5.36).

Table 2. Effect of various treatments on mean number of lateral branches

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	5.00	4.80	4.90	5.20	5.00	5.10	5.20	4.80	5.00	5.00
S_2	5.40	5.20	5.30	5.20	5.40	5.30	5.40	5.60	5.50	5.36
S_3	6.40	5.80	6.10	6.80	5.80	6.30	6.60	6.00	6.30	6.23
Mean (C)	5.60	5.26		5.73	5.40		5.73	5.46		5.53
Mean (F)	5.43			5.56			5.60			

Mean (C)
C_1 = 5.68
C_2 = 5.37

Factors	S	F	C	SF	SC	FC	SFC
SE ±	0.083	0.083	0.068	0.144	0.118	0.118	0.204
CD (0.05%)	0.239	NS	0.195	NS	0.328	NS	NS

The mean number of branches (5.68) produced (Table 2) by cultivar C_1 (Hybrid No. 41) were significantly more than that produced by C_2 (Hybrid No. 26) (5.37).

The effects of fertility levels on the number of lateral branches in both cultivars were at par as results obtained were non-significant.

The interaction effect of spacing and cultivar on number of lateral branches was found to be statistically significant. The maximum number of lateral branches (6.6) were obtained from treatment S_3 x C_1 (Hybrid No. 41 in 1.8 x 0.60 m) which was at par with S_3 x C_2. However the lowest number of lateral branches (4.86) were obtained from S_1 x C_2 interaction.

There was no significant influence of spacing x fertility level, fertility level x cultivar, spacing x fertility level x cultivar interaction on number of lateral branches.

4.1.3 Mean length of lateral branches (cm)

The data regarding mean length of lateral branches as influenced by various treatments are presented in table-3.

Perusal of data revealed significant influence of spacing, fertilization, cultivar and their interaction on mean length of lateral branches.

From table 3 it is seen that F_3 level (200: 125: 125 NPK kg ha^{-1}) produced significantly highest (551.33 cm) mean length of lateral branches than by F_1 level (100: 75: 75 NPK kg ha^{-1}) and F_2 level (150: 100: 100 NPK kg ha^{-1})

Similarly the S_3 level (1.8 x 0.6 m) produced significantly more (562.66 cm) mean length of lateral branches than by S_1 level (1.8 x 0.3 m) and S_2 level (1.8 x 0.45 m)

The mean length of lateral branches (538.22 cm) obtained from C_1 (Hybrid No. 41) was significantly more than that produced by C_2 (Hybrid No. 26) (Table 3).

The interaction effects of spacing and fertilizer were worked in increasing the length of lateral branches. The interaction S_3 x F_3 (1.8 x 0.6 m with 200: 125: 125: NPK kg ha^{-1}) had produced the maximum length of lateral branch (591.00 cm) than rest of the interactions except S_3 x F_2 which was at par. The interaction S_1 x F_1 (1.8 x 0.30 m with 100: 75: 75 NPK kg ha^{-1}) produced significantly the lowest (501.00 cm) mean length of lateral branches. The interaction effects of spacing x cultivar, fertility level x cultivar and spacing x fertilizer x cultivar together were non-significant.

Table 3. Effect of various treatments on mean length of lateral branches (cm)

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	506	496	501	517	521	519	524	524	524	514.66
S_2	520	518	519	529	520	524.5	542	536	539	527.50
S_3	542	532	537	564	556	560	600	582	591	562.66
Mean (C)	522.66	515.33		536.66	532.33		555.33	547.33		534.94
Mean (F)	519			534.5			551.33			

Mean (C)
C_1 = 538.22
C_2 = 531.66

Factors	S	F	C	SF	SC	FC	SFC
SE±	2.46	2.46	2.01	4.26	3.48	3.48	6.02
CD (0.05%)	7.07	7.07	5.77	12.25	NS	NS	NS

4.2 Flowering

4.2.1 Day to first male flower

The data on mean number of days for appearance of first male flower as influenced by different treatments is presented in table-4.

It is evident from above table that spacing level S_1 (1.8 x 0.3m) had taken significantly maximum number of days (34.30) for the appearance of first male flower. S_3 level (1.8 x 0.6m) recorded significantly the minimum number of days (33.50) for appearance of first male flower.

Significantly more number of days (34.36) were required for appearance of first male flower by the application of Fertilizer level F_1 (100: 75: 75 NPK kg ha^{-1}) while F_3 level (200: 125: 125 NPK kg ha^{-1}) required 31.20 days.

Similarly cultivar C_1 (Hybrid No.41) required significantly more number of days (35.88) for the appearance of first male flower than the cultivar C_2 (Hybrid No. 26) in which earlier (31.62 days) flowering was observed. The interaction effect of

Table 4 Mean number of days to appear male flower as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	36.60	32.80	34.70	36.20	32.40	34.30	35.80	32.00	33.90	34.30
S_2	36.20	32.20	34.20	35.60	31.60	33.60	35.00	30.20	32.60	33.46
S_3	36.40	32.00	34.20	35.80	30.60	33.20	35.40	30.80	33.10	33.50
Mean (C)	36.40	32.33		35.86	31.53		35.40	31.00		33.75
Mean (F)	34.36			33.70			33.20			

Mean (C)
C_1 = 35.88
C_2 = 31.62

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.159	0.159	0.13	0.275	0.225	0.225	0.389
CD (0.05%)	0.457	0.457	0.373	NS	NS	NS	NS

spacing x fertility level, spacing x cultivar, fertility level x cultivar and spacing x fertility level x cultivar together were non-significant.

4.2.2 Day to first female flower

The data on mean number of days needed for appearance of first female flower as influenced by different treatments is presented in table 5.

It is seen from the table 5 that in the spacing level S_1 (1.8 x 0.30m), significantly more number of days (38.36) were required for appearance of first female flower than the days required (37.83) in S_3 level of spacing (1.8 x 0.6m).

The data also indicated that appearance of first female flower was significantly earliest (37.23) with the application of F_3 fertilizer level (200: 125: 125 NPK kg ha^{-1}) than that incase of F_1 level (100: 75: 75 NPK kg ha^{-1})

However incase of cultivar, C_1 (Hybrid No.41) required significantly more number of days (40.13) for the appearance of first female flower than that of cultivar C_2 (Hybrid No.26) (35.69)

All the interaction effects of spacing x fertilizer, spacing x cultivar, fertilizer x cultivar, spacing x fertilizer x cultivar were non-significant.

Table 5. Mean number of days to appear female flower as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	41.20	33.60	38.90	40.60	36.20	38.40	40.00	35.60	37.80	38.36
S_2	40.60	36.067	38.33	39.80	35.40	37.60	39.00	34.40	36.70	37.54
S_3	40.60	36.40	38.50	40.00	35.60	37.80	39.40	35.00	37.20	37.83
Mean (C)	40.80	36.35		40.13	35.73		39.46	35.00		37.91
Mean (F)	38.57			37.93			37.23			

Mean (C)
C_1 = 40.13
C_2 = 35.69

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.141	0.141	0.115	0.245	0.200	0.200	0.346
CD (0.05%)	0.406	0.406	0.331	NS	NS	NS	NS

4.2.3 Number of node at which first male flower appeared

The data on mean node number at which first male flower appeared as influenced by various treatments is presented in table 6.

The perusal of the data revealed significant influence of spacing, fertility level and cultivar on node number at which the first male flower appeared. However the various interaction effects were found to be non-significant.

Spacing level S_2 (1.8 x 0.45m) significantly influenced production of first male flower at the lowest node (5.03) than rest of the levels of spacing.

The fertilizer level F_3 (200: 125: 125 NPK kg ha^{-1}) significantly influenced production of first male flower at the lowest node (4.90) than F_1 and F_2 levels of fertility.

Incase of cultivar, C_1 (Hybrid No.41) produced first male flower significantly at the lowest node (5.11) than that by C_2 (Hybrid No.26) which produced the first male flower at 5.47^{th} node.

4.2.4 Number of node at which the first female flower appeared

The data on mean node number at which first female flower appeared as influenced by various treatments is presented in Table 7.

Table 6. Mean node number at which the first male flower appeared as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	5.80	6.20	6.00	5.40	5.80	5.60	5.20	5.60	5.4	5.66
S_2	5.40	5.80	5.60	5.00	5.20	5.1	4.20	4.60	4.4	5.03
S_3	5.20	5.60	5.4	5.00	5.40	5.2	4.80	5.033	4.9	5.17
Mean (C)	5.46	5.86		5.13	5.46		4.73	5.07		5.29
Mean (F)	5.66			5.3			4.9			

Mean (C)
C_1 = 5.11
C_2 = 5.47

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.079	0.079	0.065	0.137	0.112	0.112	0.194
CD (0.05%)	0.228	0.228	0.186	NS	NS	NS	NS

Table 7. Mean node number at which the first female flower appeared as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	8.00	8.20	8.10	7.40	7.80	7.60	6.80	7.20	7.00	7.56
S_2	7.40	7.40	7.40	6.60	6.80	6.70	5.80	6.00	5.90	6.66
S_3	7.60	7.80	7.70	6.60	7.00	6.80	6.20	6.20	6.20	6.90
Mean (C)	7.66	7.80		6.86	7.20		6.26	6.46		7.04
Mean (F)	7.73			7.03			6.36			

Mean (C)

C_1 = 6.93

C_2 = 7.15

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.080	0.080	0.065	0.138	0.113	0.113	0.196
CD (0.05%)	0.229	0.229	0.187	NS	NS	NS	NS

The perusal of data revealed the significant influence of spacing, fertilizer and cultivar on node number at which the first female flower appeared. However the various interaction effects were found to be non-significant.

The spacing level S_2 (1.8 x 0.45m) significantly influenced production of first female flower at the lowest node (6.66) than rest of the levels of spacing.

The fertility level F_3 (200: 125: 125 NPK kg ha^{-1}) significantly influenced production of first female flower at the lowest node (6.36) than other level of fertility (F_1 and F_2)

It is evident from the data in table 7 that cultivar C_1 (Hybrid No. 41) produced first female flower significantly at the lowest node (6.93) than that by C_2 (Hybrid No. 26) which produced the first female flower at 7.15th node.

4.3 Physical characteristics

4.3.1 Fruit diameter (cm)

The data on mean diameter of fruit as influenced by various treatments is presented in table 8.

Perusal of data revealed significant influence of spacing and fertilizer on mean diameter of fruit while the influence of cultivar was observed to be non-significant.

Table 8. Effect of various treatments on mean diameter of fruit (cm)

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	3.68	3.62	3.65	3.76	3.73	3.74	3.85	3.83	3.84	3.74
S_2	3.75	3.71	3.73	3.82	3.79	3.80	3.98	3.94	3.96	3.83
S_3	3.74	3.68	3.71	3.77	3.73	3.75	3.85	3.79	3.82	3.76
Mean (C)	3.72	3.67		3.78	3.75		3.89	3.85		3.77
Mean (F)	3.69			3.76			3.87			

mean (C)
C_1 = 3.80
C_2 = 3.75

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.023	0.023	0.018	0.039	0.032	0.032	0.055
CD (0.05%)	0.065	0.065	NS	NS	NS	NS	NS

The spacing level S_2 (1.8 x 0.45m) induced significantly maximum diameter of fruit (3.83 cm) while it was minimum (3.74 cm) with spacing level S_1 (1.8 x 0.30m).

Incase of fertility levels, the F_3 level (200: 125: 125 NPK kg ha^{-1}) induced significantly the highest diameter (3.87 cm) than rest of the fertility levels

The various interaction effects spacing x fertilizer, spacing x cultivar, fertilizer x cultivar and spacing x fertilizer x cultivar together were found to be non-significant.

4.3.2 Average fruit weight (g)

The data on average fruit weight as influenced by different treatments is presented in table 9.

Perusal from the data indicated significant response of spacing, fertilizer and cultivar in increasing average fruit weight.

The S_2 level of spacing (1.8 x 0.45 m) significantly produced the heaviest mean weight of fruit (226.50 g) than other levels. However the S_1 level (1.8 x 0.30 m) produced fruits having significantly less mean fruit weight (209.80 g)

The fertility level F_3 (200: 125: 125 NPK kg ha^{-1}) significantly induced more average weight of fruit (233.16 g) than

Table 9. Effect of various treatments on mean weight of fruit (g)

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	197	189	193	214	209	211.50	229	221	225	209.83
S_2	213	207	210	231	224	227.50	247	237	242	226.50
S_3	208	199	203.50	224	213	218.50	236	229	232.50	218.16
Mean (C)	206.00	198.33		223.00	215.33		237.33	229.00		218.16
Mean (F)	202.16			219.16			233.16			

Mean (C)
C_1 = 222.11
C_2 = 214.22

Factors	S	F	C	SF	SC	FC	SFC
SE±	1.730	1.730	1.412	2.996	2.446	2.446	4.237
CD (0.05%)	4.971	4.971	4.059	NS	NS	NS	NS

other levels. However fertility level F_1 (100: 75: 75 NPK kg ha^{-1}) recorded significantly the lowest average weight of fruit (202.16 g)

It is noticed (Table 9) that higher mean weight of fruit (222.11g) was produced by cultivar C_1 (Hybrid No.41) while the cultivar C_2 (Hybrid No.26) recorded the lower mean weight (214.22 g) of fruit.

The interaction effects of spacing x fertilizer, spacing x cultivar, fertilizer x cultivar, spacing x fertilizer x cultivar together were non-significant.

4.3.3 Average fruit length (cm)

Average length of fruit as influenced by various treatments is presented in table 10.

The perusal from data in table 10 revealed that there was significant influence of spacing and cultivar on mean fruit length. The influence of various fertility levels on fruit length was observed to be non-significant.

The spacing level S_3 (1.8 x 0.6m) had given significantly the longest mean length of fruit (20.40 cm) than rest of the spacing levels. However the spacing level S_1 (1.8 x 0.30 m) had produced short fruits having mean length (17.35 cm)

Table 10. Effect of various treatments on mean length of fruit (cm)

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	16.50	18.60	17.55	16.20	17.90	17.05	16.70	18.20	17.45	17.35
S_2	18.30	20.30	19.30	17.80	20.50	19.15	17.767	20.10	18.93	19.12
S_3	16.867	21.70	19.28	19.90	22.20	21.05	19.70	22.033	20.86	20.40
Mean (C)	17.22	20.20		17.96	20.20		18.05	20.11		18.95
Mean (F)	18.71			19.08			19.08			

Mean (C)
C_1 = 20.17
C_2 = 17.74

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.325	0.325	0.265	0.563	0.460	0.460	0.796
CD (0.05%)	0.935	NS	0.763	NS	NS	NS	NS

It is also evident from the data in table 10 that cultivar C_1 (Hybrid No.41) produced significantly longer fruit (20.17 cm) than that produced by C_2 (Hybrid No. 26) (17.24 cm)

The various interaction effects spacing x fertilizer, spacing x cultivar, fertilizer x cultivar, spacing x fertilizer x cultivar together were non-significant.

4.4 Yield observations

4.4.1 Average fruit number per vine

The data in Table 11 revealed that there was significant influence of various treatments on fruit number per vine. The spacing level S_2 (1.8 x 0.45m) yielded the highest fruit number (13.20) per vine than rest of the spacing levels. The lowest number of fruits per vine (9.33) was obtained in S_1 (1.8 x 0.30) level of spacing. As regards the fertility levels, the F_3 level (200: 125: 125 NPK kg ha^{-1}) produced the maximum fruit number (12.96) per vine. However the F_1 (100: 75: 75 NPK kg ha^{-1}) fertility level induced the minimum fruit number (10.16) per vine. In case of cultivars, C_1 (Hybrid No. 41) produced more number of fruits per vine than C_2 (Hybrid No. 26) which had yielded 12.00 and 11.15 fruits per vine respectively.

The interaction effects of spacing x fertility, spacing x cultivar, fertility x cultivar and spacing x fertility x cultivar together were found to be statistically non-significant.

Table 11. Mean number of fruits per vine as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	8.40	7.80	8.10	9.60	8.80	9.20	11.00	10.40	10.70	9.33
S_2	11.40	10.80	11.10	13.80	12.80	13.30	15.60	14.80	15.20	13.20
S_3	11.60	11.00	11.30	13.00	11.60	12.30	13.60	12.40	13.00	12.20
Mean (C)	10.46	9.86		12.13	11.06		13.40	12.53		11.57
Mean (F)	10.16			11.60			12.96			

Mean (C)
C_1 = 12.00
C_2 = 11.15

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.098	0.098	0.080	0.170	0.139	0.139	0.241
CD (0.05%)	0.283	0.283	0.231	0.489	NS	NS	NS

4.4.2 Average yield of fruits per vine (kg)

The data pertaining to the average yield of fruits per vine are computed in table 12. The results indicated that the various spacing and fertility levels application significantly increased the yield of fruits per vine incase of both the cultivars. The mean yield of fruits per vine was noted 2.55 kg. The effect of various factors individually and in combination under study produced significantly more yield per vine. However the spacing fertility levels and cultivar together (SFC interactions) had no significant influence the yield per plant.

It is noticed From table 12, that the widely spaced (S_3) and narrowly spaced (S_1) plants significantly produced less yields (2.67 kg and 1.97 kg respectively) than medium spaced S_2 (1.8 x 0.45m) plants which produced the highest yield (3.01 kg) per vine.

On perusal of data presented in same table it is seen that application of fertilizer at high fertility level F_3 (200: 125: 125 NPK kg ha^{-1}) significantly produced more fruit yield (3.03 kg) per vine as compared to lower fertility levels F_2 and F_1.

Table 12. Mean yield of fruits (kg) per vine as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	1.635	1.480	1.55	2.065	1.845	1.95	2.530	2.285	2.40	1.97
S_2	2.450	2.255	2.35	3.175	2.880	3.62	3.850	3.500	3.67	3.01
S_3	2.375	2.200	2.28	2.925	2.495	2.71	3.195	2.850	3.02	2.67
Mean (C)	2.15	1.97		2.72	2.40		3.19	2.87		2.55
Mean (F)	2.06			2.56			3.03			

Mean (C)
C_1 = 2.68
C_2 =. 2.42

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.020	0.020	0.017	0.035	0.029	0.029	0.050
CD (0.05%)	0.059	0.059	0.048	0.102	NS	0.083	NS

As regards the cultivars, C_1 (Hybrid No. 41) produced more yield (2.68 kg) per plant than C_2 (Hybrid No. 26) which produced 2.42 kg yield of fruits per vine.

From the table 12, it is indicated that S_2F_3 combination (1.8 x 0.45 m with 200: 125: 125 NPK kg ha^{-1}) induced significantly more yield (3.67 kg) per vine as compared to all other combinations. The lowest yield (1.55 kg) per vine was harvested from S_1F_1 treatment.

Statistically significant more yield per vine was observed due to fertility levels and cultivars interaction together. The treatment F_3 x C_1 produced the highest fruit yield (3.19 kg) per vine that rest of the interactions. The lowest fruit yield (1.97 kg) per vine was recorded from F_1 C_2 combination.

It is seen from the data displayed in table 12 that the interactions of spacing x cultivar, spacing x fertility level x cultivar together had statistically non-significant effect on yield of fruits per vine.

4.4.3 Yield per plot (kg)

Data concerned to mean total yield per plot as influenced by different treatment is presented in table 13.

Table 13. Mean total yield per plot (kg) as infuenced by different treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	13.080	11.840	12.46	16.520	14.760	15.64	20.240	17.613	18.92	15.67
S_2	19.060	17.880	18.47	25.400	23.040	24.22	27.800	28.00	27.900	23.53
S_3	19.000	17.600	18.30	22.733	19.960	21.34	26.560	22.800	24.18	21.27
Mean (C)	17.04	15.77		21.55	19.55		24.53	22.80		20.16
Mean (F)	16.41			20.40			23.66			

Mean (C)
C_1 = 21.04
C_2 = 19.27

Factors	S	F	C	SF	SC	FC	SFC
SE ±	0.371	0.371	0.303	0.643	0.525	0.525	0.910
CD (0.05%)	1.067	1.067	0.872	1.088	NS	NS	NS

It is noticed from the data that the spacing level S_2 (1.8 x 0.45 m) recorded the highest yield (23.53 kg) per plot than rest of the spacing levels. However the lowest yield (15.67 kg) per plot was obtained in S_1 (1.8 x 0.30m) level of spacing.

It is also noticed that application of fertilizer at high fertility level F_3 (200: 125: 125 NPK kg ha^{-1}) significantly produced more fruit yield (23.66 kg) per plot as compared to lower fertility levels F_2 and F_1.

In case of cultivars, C_1 (Hybrid No. 41) produced more yield (21.04 kg) per plot than C_2 (Hybrid No. 26) which yielded (19.27 kg) fruits per plot.

It is indicated from the table 13, that S_2 x F_3 treatment (1.8 x 0.45 m with 200: 125: 125 NPK kg ha^{-1}) induced significantly more yield (27.90 kg) per plot than rest of the treatments. The lowest yield (12.46 kg) per plot was harvested from S_1 x F_1 treatment.

The interaction effects of spacing x cultivar, fertility level x cultivar and spacing x fertility x cultivar together were found tobe statistically non-significant.

4.4.4 Total yield per hectare (q ha^{-1})

The data related to the total yield per hectare as influenced by different treatments is given in table 14.

Table 14. Mean total yield per hectare (q) as influenced by different treatments

Spacing/ fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	242.220	219.250	230.73	305.920	273.330	289.62	374.810	334.943	354.87	291.74
S_2	275.303	254.073	264.68	313.580	284.440	299.01	380.240	345.670	362.95	308.88
S_3	175.920	162.960	169.44	216.660	184.810	200.73	236.660	211.110	223.88	198.02
Mean (C)	231.14	212.09		278.72	247.52		330.57	297.24		266.21
Mean (F)	221.62			263.12			313.90			

Mean (C)
C_1 = 280.14
C_2 = 252.28

Factors	S	F	C	SF	SC	FC	SFC
SE±	4.422	4.422	3.610	7.658	6.253	6.253	10.831
CD (0.05%)	12.708	12.708	10.376	22.010	NS	NS	NS

From the data, it is observed that the spacing level S_2 (1.8 x 0.45 m) produced the highest yield (308.88 q) per hectare than rest of the spacing levels. The lowest yield per hectare (198.02 q) was obtained from S_3 (1.8 x 0.60 m) level of spacing.

As regards the fertility levels, the F_3 level (200: 125: 125 NPK kg ha^{-1}) produced the highest yield (313.90 q) per hectare. However the F_1 (100: 75: 75 NPK kg ha^{-1}) fertility level induced the lowest yield (221.62 q) per hectare.

In case of cultivars, C_1 (Hybrid No. 41) produced high yields (280.14 q) per hectare than C_2 (Hybrid No.26) which yielded 252.28 q per hectare.

It is observed that S_2F_3 combination (1.8 x 0.45 m with 200: 125: 125 NPK kg ha^{-1}) induced significantly more yield (362.95 q) per hectare as compared to all other combinations. The lowest yield (169.44 q) per hectare was recorded from S_3 F_1 treatment.

Interactions of spacing x cultivar, fertility level x cultivar, spacing x cultivar, fertility level x cultivar, spacing x fertility level x cultivar together induced statistically non-significant effect on total yield per hectare.

4.5 Soil nutrient status after harvesting

4.5.1 Residual available soil nitrogen (kg ha^{-1})

The data related to residual nitrogen after harvesting of the crop as influenced by different treatments is presented in table 15.

Perusal of the data revealed that there wee significant influences of spacing, fertilizer levels and cultivars on residual availability of nitrogen after crop harvest. Data in the table 15 revealed that the spacing level S_3 (1.8 x 0.60 m) indicated the highest residuel nitrogen (185.96 kg ha^{-1}) than other levels. However the spacing level S_2 (1.8 x 0.45 m) showed the minimum nitrogen residues (154.58 kg ha^{-1}).

Incase of fertility levels, F_3 level (200 : 125 : 125 NPK kg ha^{-1}) showed maximum residual nitrogen (212.04 kg ha^{-1}) while F_1 level (100:75:75 NPK kg ha^{-1}) showed the minimum residual nitrogen (138.21 kg ha^{-1}) after harvesting of the crop.

As regards the cultivars, C_1 (Hybrid No. 41) indicated less residual nitrogen (162.37 kg ha^{-1}) while C_2 (Hybrid No. 26) indicated significantly more residual nitrogen (177.84 kg ha^{-1}) in the soil after the crop harvest.

The various interaction effects of spacing levels, fertility levels and cultivars were found tobe non-significant.

Table 15. Mean nitrogen (kg ha^{-1}) in soil harvesting as influenced by various treatments

Spacing fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	134.447	141.520	137.98	148.34	162.56	155.45	209.81	220.76	215.28	169.57
S_2	122.47	127.96	125.21	136.91	160.44	148.67	170.38	210.52	190.45	154.78
S_3	145.41	157.49	151.45	169.43	182.67	176.05	224.13	236.64	230.38	185.96
Mean (C)	134.10	142.32		151.56	168.55		201.444	222.64		170.10
Mean (F)	138.21			160.06			212.04			

Mean (C)
C_1 = 162.37
C_2 = 177.84

Factors	S	F	C	SF	SC	FC	SFC
SE ±	3.444	3.444	2.812	5.966	4.871	4.871	8.437
CD (0.05%)	9.899	9.899	8.082	NS	NS	NS	NS

4.5.2 **Residual available soil phosphorus (kg ha^{-1})**

The data related to residual soil phosphorus after harvesting of the crop as influenced by various treatments is presented in Table 16. The data indicated that the various spacing and fertility levels application significantly influenced the residual phosphorus in the soil.

It is indicated (Table 16) that spacing level S_3 (1.8 x 0.6 m) showed the highest residual phosphorus (12.8 kg ha^{-1}) while the S_2 level (1.8 x 0.45 m) indicated the minimum residues of phosphorus (11.6 kg ha^{-1}) in the soil after the crop harvest.

On perusal of data presented in same table, it is indicated that the fertility level F_3 (200:125: 125 NPK kg ha^{-1}) showed significantly maximum residual phosphorus (13.3 kg ha^{-1}) while the F_1 level (100:75:75 NPK kg ha^{-1}) showed the minimum (10.9 kg ha^{-1}).

As regards the cultivars, C_1 (Hybrid No. 41) indicated less residual phosphorus (12.0 kg ha^{-1}) while C_2 (Hybrid No. 26) indicated significantly more residual phosphorus (12.5 kg ha^{-1}) in the soil after the crop harvest.

It is observed that the interaction of spacing and fertility level showed significant effect on residuel phosphorus and the maximum residues phosphorus(13.9kgha^{-1}) was recorded from

Table 15. Mean phosphorus (kg ha^{-1}) in soil after harvesting as influenced by various treatments

Spacing fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	10.7	11.0	10.8	12.5	13.0	12.8	13.2	13.6	13.4	12.3
S_2	9.9	10.4	10.2	11.7	12.0	11.9	12.4	12.8	12.6	11.6
S_3	11.4	11.9	11.7	12.7	13.1	12.9	13.6	14.2	13.9	12.8
Mean (C)	10.7	11.1		12.3	12.7		13.1	13.5		12.2
Mean (F)	10.9			12.5			13.3			

Mean (C)
C_1 = 12.0
C_2 = 12.5

Factors	S	F	C	SF	SC	FC	SFC
SE ±	0.232	0.232	0.190	0.402	0.328	0.328	0.569
CD (0.05%)	0.667	0.667	0.545	1.556	NS	NS	1.635

S_2 x F_3 combination (1.8 x 0.60 m with 200 : 125 : 125 NPK kg ha^{-1}) while the minimum (10.20 kg ha^{-1}) was recorded with the interaction S_2 x F_1 (Table 16).

The interactions of spacing x cultivar, fertility level x cultivar indicated statistically non-significant effect on residual phosphorus in the soil after the crop harvest.

4.5.3 Residual available soil potassium (kg ha^{-1})

The residual potassium after crop harvest as influenced by various treatments is presented in Table 17. Perusal of the data revealed that there were significant influences of spacing, fertilizer levels, cultivars and their interactions on residual availability of potassium after crop harvest.

The data in Table 17 revealed that the spacing level S_3 (1.8 x 0.6 m) indicated the highest residual soil potassium (548.50 kg ha^{-1}) than other levels. However the spacing level S_2 (1.8 x 0.45 m) showed the minimum potassium residues (506.17 kg ha^{-1}).

In case of fertility levels, F_3 level (200:125:125 NPK kg ha^{-1}) showed maximum residual potassium (626.88 kg ha^{-1}) after crop harvest.

At regards the cultivars, C_1 (Hybrid No. 41) indicated less residual potassium (527.20 kg ha^{-1}) while C_2 (Hybrid No. 26)

Table 17. Mean potassium available (kg ha^{-1}) in soil after crop harvest as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	436.61	452.58	444.59	547.69	529.81	538.75	624.42	637.37	630.89	538.08
S_2	427.24	439.69	433.45	469.79	481.27	475.53	602.34	616.74	609.54	506.17
S3	444.96	456.60	450.78	558.54	550.47	554.50	633.27	647.17	640.72	548.50
Mean (C)	436.27	449.61		523.34	520.51		620.01	633.76		530.91
Mean (F)	442.94			522.92			626.88			

Mean (C)
C_1 = 527.20
C_2 = 534.63

Factors	S	F	C	SF	SC	FC	SFC
SE ±	2.039	2.039	1.665	3.531	2.883	2.883	4.994
CD (0.05%)	5.860	5.860	4.784	10.149	NS	8.287	NS

indicated significantly more residual potassium (534.63 kg ha^{-1}) in the soil after the crop harvest.

The interactions of spacing x fertility levels and fertility levels x cultivar significantly influence the residual available potassium in the soil. The highest residual potassium (640.22 kg ha^{-1}) was observed from interaction S_3 x F_3 (1.8 x 0.60 cm with 200:125:125 NPK kg ha^{-1}) while lowest (4.33.45 kg ha^{-1}) was recorded from the interaction S_2 x F_2.

In case of fertility level and cultivar interactions, the highest residues of potassium (633.76 kg ha^{-1}) was observed with interaction F_3 x C_2 while the lowest (436.27 kg ha^{-1}) was recorded with the interaction F_1 x C_1.

The interaction effects of spacing x cultivar, spacing x fertility level x cultivar were non significant.

4.6 Plant nutrient status after crop harvest

4.6.1 Percent nitrogen available in plant after harvesting

The data concerned to the percent nitrogen available in plant after crop harvest as influenced by various treatments is presented in Table 18. Perusal of data revealed that there were significant influences of spacing, fertility level, cultivar and their interactions on percent nitrogen available in plant after crop harvest.

It is also revealed that the spacing level S_2 (1.8 x 0.45 m) indicated the highest percent nitrogen in plant (1.328) after crop harvest. However, the spacing level S_1 (1.8 x 0.30 m) showed the minimum per cent nitrogen in plant (1.263) after the crop harvest while spacing level S_3 (1.327) was at par with S_2 (Table 18).

On perusal of the data presented in same table it is indicated that the fertility level F_3 (200:125:125 NPK kg ha^{-1}) showed significant maximum per cent nitrogen in plant (1.373) while the F_1 level (100:75:75 NPK kg ha^{-1}) showed the minimum (1.250).

As regards the cultivars, C_1 (Hybrid No. 41) indicated significantly high per cent nitrogen in plant (1.346) than C_2 (Hybrid No. 26) which indicated 1.267 per cent nitrogen in plant after crop harvest.

The interactions of spacing x fertility level and spacing x cultivar significantly influenced the plant nitrogen content after crop harvest. The interaction S_2 x F_3 recorded the highest per cent nitrogen in plant (1.425) while the lowest (1.215) was recorded with interaction S_1 x F_1.

In case of spacing level and cultivar interaction, the highest per cent nitrogen in plant (1.377) was recorded with the interaction S_2 x C_1. The interaction S_3 x C_1 was at par. However, the

Table 18. Mean percent nitrogen available in plant after crop harvest as influenced by different treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	1.24	1.19	1.215	1.29	1.23	1.260	1.33	1.30	1.315	1.263
S_2	1.29	1.21	1.250	1.35	1.27	1.310	1.49	1.36	1.425	1.328
S_3	1.32	1.25	1.285	1.37	1.26	1.315	1.43	1.33	1.380	1.327
Mean (C)	1.283	1.217		1.337	1.253		1.417	1.330		1.306
Mean (F)	1.250			1.295			1.373			

Mean (C)
C_1 = 1.346
C_2 = 1.267

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.005	0.005	0.004	0.008	0.007	0.007	0.012
CD (0.05%)	0.014	0.014	0.011	0.024	0.019	NS	NS

minimum per cent nitrogen in plant (1.240) was recorded with the interaction S_1 x C_2.

The interaction effects of fertility level x cultivar, spacing x fertility level x cultivar was found statistically non-significant.

4.6.2 Percent phosphorus available in plant after harvesting

The data concerned to the percent phosphorus available in plant after crop harvest as influenced by various treatments is presented in Table 19.

It is revealed that the spacing level S_3 (1.8x 0.60 m) indicated the highest percent phosphorus in plant (0.270) while S_1 level (1.8 x 0.30 m) indicated the lowest (0.220). However S_2 (1.8 x 0.45 m) was at par with S_3 showing 0.265 per cent plant phosphorus

In case of fertility levels, F_3 level (200:125:125 NPK kg ha^{-1}) showed the maximum percent phosphorus in plant (0.282) after crop harvest while the F_1 level (100:75:75 NPK kg ha^{-1}) showed the minimum per cent phosphorus in plant (0.226) after crop harvest.

It is observed that the cultivar, C_2 (Hybrid No.41) indicated the significantly high per cent phosphorus in plant (0.265) while C_2 (Hybrid No. 26) indicated low per cent phosphorus in plant (0.239) after crop harvest (Table 19).

Table 19. Mean percent phosphorus available in plant after harvesting as influenced by various treatments

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	0.210	0.180	0.195	0.240	0.200	0.220	0.260	0.230	0.245	0.220
S_2	0.237	0.213	0.225	0.280	0.240	0.260	0.330	0.290	0.310	0.265
S_3	0.253	0.263	0.258	0.270	0.250	0.260	0.303	0.280	0.292	0.270
Mean (C)	0.233	0.219		0.263	0.230		0.298	0.267		0.252
Mean (F)	0.226			0.247			0.282			

Mean (C)
C_1 = 0.265
C_2 = 0.239

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.006	0.006	0.005	0.010	0.008	0.008	0.014
CD (0.05%)	0.016	0.016	0.013	NS	NS	NS	NS

The various interaction effects of spacing levels, fertility levels and cultivars on availability of phosphorus in plant were found non-significant.

4.6.3 Per cent potassium available in plant after harvesting

The data concerned to the per cent potassium available in plant after crop harvest as influenced by various treatments is presented in Table 20. Perusal of data revealed that there were significant influences of spacings, fertility levels and cultivars on per cent potassium available in plant after crop harvest.

It is revealed that the spacing level S_2 (1.8 x 0.45 m) indicated the highest per cent potassium in plant (0.965) while S_1 (1.8 x 0.30 m) indicated the lowest per cent potassium in plant (0.927) after the crop harvest (Table 20).

On perusal of data presented in same Table it is indicated that the fertility level F_3 (200:125:125 NPK kg ha^{-1}) showed significantly maximum per cent potassium in plant (0.980) while the F_1 level (100:75:75 NPK kg ha^{-1}) showed the minimum (0.915).

As regards the cultivars, C_1 (Hybrid No. 41) indicated significantly high per cent potassium in plant (0.968) than C_2 (Hybrid No. 26) which indicated 0.929 per cent potassium in plant after crop harvest.

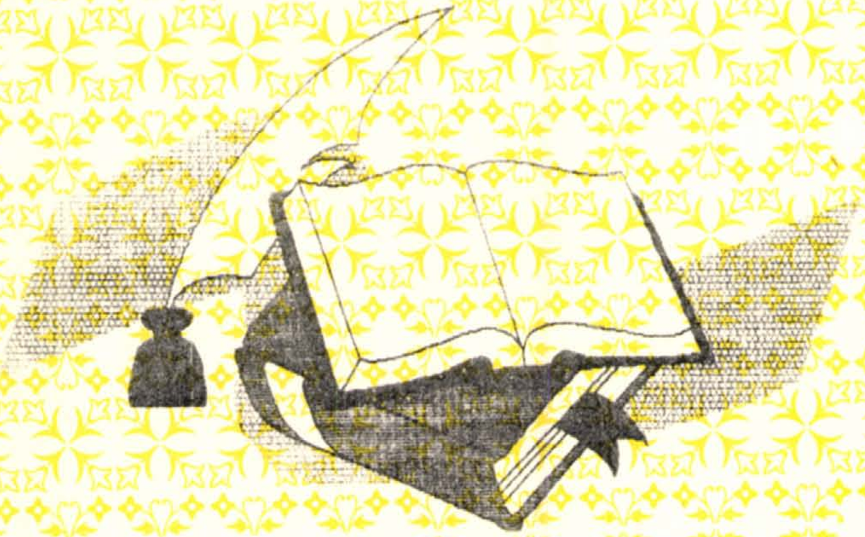
The effects of various interactions were found to be non-significant.

Table 20. Effect of various treatments on mean percent potassium available in plant after crop harvest

Spacing/fertility levels	F_1			F_2			F_3			Mean (S)
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
S_1	0.910	0.880	0.895	0.960	0.910	0.935	0.970	0.930	0.950	0.927
S_2	0.940	0.900	0.920	0.990	0.930	0.960	1.030	1.000	1.015	0.965
S_3	0.950	0.910	0.930	0.970	0.940	0.955	0.990	0.960	0.975	0.953
Mean (C)	0.933	0.897		0.973	0.927		0.997	0.963		0.948
Mean (F)	0.915			0.950			0.980			

Mean (C)
C_1 = 0.968
C_2 = 0.929

Factors	S	F	C	SF	SC	FC	SFC
SE±	0.005	0.005	0.004	0.009	0.008	0.008	0.013
CD (0.05%)	0.016	0.016	0.013	NS	NS	NS	NS



DISCUSSION

5. DISCUSSION

The results presented in chapter IV, in respect of growth characters, flowering characters, fruit characters, yield attributes and nutritional status in plant and soil after crop harvest as influenced by various treatments are discussed in this chapter in the following paragraphs under suitable headings

5.1 Effect of spacing

A well known vigorous and productive plant is a function of many factors. Availability of sufficient land surface to plant is one of the factor which influenced the growth of plant and it's productivity. The productivity of any crop plant depends on water requirements, nutritional requirement and the requirement of sunlight for photosynthesis. For commercial purpose, the crop performance needs tobe studied under suitable conditions. The yield potential needs to be studied by providing the favourable conditions. For this goal, Horticultural Scientists and agriculturists are studying the crop requirement since age of augment of agriculture. Efforts have been made to increase crop productivity. For achievement of this goal, various methods are recommended from time to time. It included development of new desirable cultivar, finding out the optimum requirements of various practices to newly developed cultivar or hybrids.

In present investigation, tropical gynoecious cucumber hybrids (No. 41 and No. 26) were taken. The optimum plant density requirement for their commercial cropping needs to be studied. Therefore, optimum spacing recommended for different cucumber cultivar for different regions were taken into account. Spacing levels within this range were fixed as treatments, avoiding the extremes. Bedside, the growth characters (vine size) described for various cucumber cultivars were also taken into consideration. In the present study, three types of plant spacing viz. 1.8 x 0.3 m, 1.8 x 0.45 m and 1.8 x 0.60 m were taken. By adopting these spacings, the yield potential is studied.

5.1.1 Effect of spacing on growth characters

It was observed in the present studies that the growth characters viz., main vine length, number of lateral branches, length of lateral branches was the highest in wider spacing (1.8 x 0.45 and 1.8 x 0.60 m). However, all the three spacings showed significant influence on crop growth in general and vine length in particular.

The vigorous growth in respect of length of main vine, number of lateral branches and their length obtained in this investigation might be due to more space available to the plant for growth. The similar results had been reported by Widders *et al.* (1990) and Lesic (1977).

It is clear from the result that under closer spacing nutrients area available per plant is less than that in wider spacing. Secondly, the radiation energy available in wider spacing is also more and there is competition for nutrient and radient energy in closer spacing. Therefore, the plant with wider spacing showed the tendency of spreading with more number of branches.

5.1.2 Effect of spacing on flowering characters

Early flowering and fruitfulness, flowering at lower node are same of the important aspects from commercial point of view of crop. These characters are influenced by both the genotype and cultural management. In present investigation though gynocecious cucumber hybrids were taken, first 1 or 2 male flower were appeared but they dropped down sooner. The characters such as number of days for the appearance of first male and female flower and node number at which the first male and female flower appeared were significantly influenced by various levels of spacing. The results obtained indicate that the wider spacing (1.8 x 0.6 m) gave early initiation of flowering. Similarly, the appearance of first male and female flower were noted from the lowermost node in the spacing (1.8 x 0.45 m) than in closer spacing. This indicate that for earliness of cropping in tropical gynoecious cucumber hybrids, the wider spacing is good. However, this will not be true for total yield. The total yield might be less in the wider spacing due to less plant population.

5.1.3 Effect of spacings on fruit characters

The different spacings adopted had significant influence on fruit characters such as fruit diameter, length and weight. The weight of fruits registered higher values with wider spacings. From the wider spacings (1.8 x 0.45 m) both the fruit diameter and weight were better than the closest spacing (1.8 x 0.30 m). From the widest spacing (1.8 x 0.60 m) the length of fruit was the highest than that from closer spacing.

The results obtained in the present investigation were similar to those obtained by Grimstad (1992), Bakker *et al.* (1986). These workers recorded higher yield from wider spacing as compared to closer spacings. This might be because of the fact that more nutrient area (land area) and more radient energy was available per plant in wider spacing which led to less competition for nutrient and radient energy. This might have given more scope for the growth of individual fruit in it's diameter, length and weight.

5.1.4 Effect of spacing on yield attributing characters

The results obtained regarding the yield characters such as number of fruits per vine, yield of fruits per vine, per plot and per hectare indicated significant influence of different spacing levels. The total number of fruits varied from 9.33 to 13.20, yield per vine varied form 1.97 to 3.01 kg, yield per plot varied form 15.67 to 23.33 kg with closer and medium spacing, respectively.

The yield per hectare was the lowest (198.02 q) in 1.8 x 0.60 m spacing and it was the highest (308.88 q) in 1.8 x 0.45 m.

This indicate that for getting higher yields per hectare of the gynoecious cucumber hybrids, the spacing of 1.8 x 0.45 m is good. Though the yield per vine was high, the total yield per hectare was obtained less in wider spacing due to less plant population per hectare.

The results are in close agreement with those reported by Moreman (1985), Grimstad (1992) and More *et al.* (1992).

5.1.5 Effect of spacing on nutrient status of soil

The nutrient status of soil in respect of N,P and K after crop harvest was significantly influenced by the spacing levels. Minimum residual availability of nutrients was recorded with closer spacing while the maximum was recorded with wider spacing. In the present investigation, nitrogen residues in soil varied from 169.57 to 185.96 kg ha^{-1}, P residues from 12.30 to 12.80 kg ha^{-1} and K residues from 538.08 to 548.50 kg ha^{-1} due to influence of spacings.

5.1.6 Effect of spacing on nutrient status of plant

The nutrient content in plant in respect of N, P and K was significantly influenced by spacing levels. Uptake of nutrients increased in wider spacings as compared to closer spacings. This might be because of the fact that in wider spacing the roots grow profusely and absorb more amount of nutrients. In the present investigation nitrogen content of plant varied form 1.263 to 1.327 per cent, the P content from 0.220 to 0.270 per cent and the K content from 0.927 to 0.953 per cent due to influence of spacings. Similar results have been reported by Singh *et al.* (1981).

5.2 Effect of fertilizer levels

Nutrient supply is one of the most important factors limiting for growth and productivity of any crop plant. The balanced nutrition is very essential for proper development of the crop plant and for optimum production. Nitrogen is a constituent of protein nucleotides, RNA, DNA and chlorophyll. Nitrogen deficiency results in a heavy reduction in growth and yield and causes yellowing appearance in crop plant. Phosphorus is second important element required in measurable quantities for crop production. It is an essential constituent of many vital compounds like nucleotides, lecithin, ATP, ADP, RNA and DNA. It is also involved in energy transfer. Potassium plays on important role in chlorophyll synthesis and carbohydrate translocation and also play important role in crop growth, production and disease resistance.

5.2.1 Effect of fertilizer levels on growth characters

It was observed in the present investigation that the growth characters viz. main vine length, number of lateral branches, length of lateral branches were the highest with the application of higher fertility level (200:125:125 NPK kg ha^{-1}) as compared to lower fertility level (100: 75 : 75 NPK kg ha^{-1}). There is linear increase in length of main vine and lateral branches with the increasing level of fertilizers. The results obtained are in general agreement with those of Flocker *et al.* (1965), Funamato and Masuda (1965), Pettiet (1971). Kadam (1983) in cucumber, Singh and Chhonkar (1986) in muskmelon and Patil (1993) in bottle ground, also reported beneficial effects of added fertilizers on various growth contributing characters.

In the present investigation, tropical gynoecious cucumber hybrids were taken. As these were hybrids, the plants were having vigorous growing potential and might be due to this the requirement of fertility level was also high. The plants showed linear increase in the growth characters with increasing level of fertilizers.

5.2.2 Effect of fertilizer levels on flowering characters

Flowering characters such as number of days for the appearance of first male and female flower, node number at which the first male and female flower appeared were significantly influenced by various fertility levels.

The results obtained indicated that the higher fertilizer level (200:125:125 NPK kg ha^{-1}) gave early initiation of flowering. Similarly, the appearance of first male and female flower were noted from lowermost node with the application of higher fertility level. Equchi *et al.* (1961) also reported the similar results.

5.2.3 Effect of fertilizer levels on fruit characters

Different fertilizer levels adopted had significant influence on diameter and weight of fruit. However, it was observed that the fruit characters were better from higher level of fertilizers (200:125:125 NPK kg ha^{-1}). In the present investigation, the diameter of fruit varied from 3.69 to 3.87 cm and weight of fruit varied from 202.16 to 233.16 g , indicating the influence of fertilizers on fruit growth. However, there was no significant effect of fertilizer levels on fruit length. The beneficial effects of fertilizers on fruit size and weight of many cucurbitaceous vegetables have been reported by many workers (Thompson, 1949, Pandey and Singh, 1973). These results are in general agreement with those reported by Masui (1960), Jassal *et al.*, (1970), Randhawa *et al.*, (1981), Deswal and Patil (1984), Flocker *et al.* (1965), Singh and Chhonkar (1986) who reported increase in size and weight of fruit due to increased fertilizer application.

However, it was noticed that eventhough the fruit size obtained was bigger, it was uniform and seems to be commercially acceptable.

5.2.4 Effect of fertilizer levels on yield attributing characters.

The results obtained regarding the yield characters such as number of fruits per vine, yield of fruits per vine, per plot and per hectare indicated influence of different fertility levels. The total number of fruits varied form 10.16 to 12.16, yield per vine varied from 2.06 to 3.03 kg, yield per plot varied form 16.41 to 23.66 kg with the application of 100:75:75 and 200:125:125 NPK kg ha^{-1} respectively.

The yield per hectare was the lowest (221.62 q) at 100:75:75 NPK kg ha^{-1} and it was the highest (313.90 q) at 200:125:125 NPK kg ha^{-1}. Thus, influence of fertilizer application on yield of fruits (both by number and weight) was evident.

In the present investigation, gynoecious hybrid cultivars were grown. Due to high yield potential and more femaleness, these hybrids might have required high dose of fertilizers. The plant showed linear increase in yield attributing characters with increasing level of fertilizers.

The results obtained in present investigation are in close agreement with those reported by Sutton (1966), Jassal *et al.* (1970), Randhawa *et al.* (1981), Deswal and Patil (1984), Pelaez *et al.* (1984), Singh and Chhonkar (1986). Increased yields due to fertilizer application have also been reported by Malik (1965) and Patil (1993) in bitter ground.

5.2.5 Effect of fertilizers levels on nutrient status of soil

The nutrient status of soil in respect of N, P and K after crop harvest was significantly influenced by the fertilizer levels. Minimum residual availability of nutrients was recorded with lower levels of fertilizer application, while the maximum residues of nutrients were recorded with higher fertilizers levels. In the present investigation, nitrogen residues in soil varied form 138.21 to 212.04 kg ha^{-1}, P residues from 10[illegible].90 to 13[illegible].30 kg ha^{-1} and the K residues from 442.94 to 626.88 kg ha^{-1}. Similar results have been reported by Tayel (1965) and Masui (1960).

5.2.6 Effect of fertility levels on nutrient status of plant

The nutrient content of plant in respect of N, P and K was significantly influenced by the fertilizer levels. The uptake of nutrients increased with higher levels of fertilizer as compared with lower levels of fertilizer application. Similar results have been reported by Singh *et al.* (1981). In the present investigation the nitrogen content of plant varied from 1.250 to 1.373 percent, the P content from 0.226 to 0.282 per cent, and the K content from 0.915 to 0.980 per cent.

The results of the present trial, however indicate that for higher total yield of tropical gynoecious cucumber hybrids, a dose of 200:125:125 NPK kg ha^{-1} may be applied with this treatment the spacing of 1.8 x 0.45 m may be employed for obtaining the good yield with quality fruits

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

Cucumber (*Cucumis sativum* L.) is one of the most important vegetable crop. The plant growth and production of higher yield of better quality cucumber fruits are closely related to the plant population per unit area and the nutrient supply.

With the view of finding out optimum spacing and fertilizer dose for the tropical gynoecious cucumber hybrids, the present investigation was carried out in the Instructional cum Research Orchard, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. Dist. Ahmednagar during year 1998.

6.1 Effect of spacing

6.1.1 Growth characters

The growth of the plant represented by number of lateral branches, length of lateral branches was significantly increased with increasing level of spacing the (1.8 x0.6 m) while the length of main vine was maximum in 1.8 x 0.45 m spacing.

6.1.2 Flowering characters

Flowering characters viz., number of days required for the appearance of first male and female flower, node number at which the first male and female flower appeared, were significantly influenced by the spacing treatments. Earlier appearance of first male and female flower at lower node was observed with 1.8 x 0.45 m spacing adopted.

6.1.3 Fruit characters

Fruit characters such as diameter of fruit, weight of fruit, length of fruit were significantly influenced by the spacing treatments. Higher level of spacing (1.8 x 0.6 m) significantly increased the length of fruit while diameter and weight of fruit was the highest in spacing 1.8 x 0.45 m.

6.1.4 Yield

The yield contributing characters such as number of fruits per vine, yield per vine, yield per plot and yield per hectare were favourably influenced by spacing treatments. Yield per vine, yield per plot, yield per hectare were highest in 1.8 x 0.45 m spacing.

6.1.5 Residual nutrient status of soil

Residual nitrogen, phosphorus and potassium in the soil after harvesting of the crop were significantly influenced by the spacing treatments. The highest residual availability of nutrients in the soil was observed with wider spacing.

6.1.6 Plant nutrient status

The spacing treatments significantly influenced the plant nutrient status. The highest availability of percentage nitrogen, phosphorus and potassium in plant was recorded with 1.8 x 0.45 m spacing.

6.2 Effect of fertilizer

6.2.1 Growth characters

The length of main vine and the length of lateral branches was significantly influenced by the fertilizer treatments. The highest length of main vine and lateral branches was recorded with the application of 200:125:125 NPK kg ha^{-1}. The effect of fertilizer was found to be non significant on production of number of lateral branches.

6.2.2 Flowering characters

Flowering characters such as number of days required for the appearance of first male and female flower node number at which the first male and female. However appeared, were significantly influenced by the fertilizer treatments. Earlier appearance of male and female flower at lower node was observed when the of 200:125:125 NPK kg ha^{-1} was applied.

6.2.3 Fruit characters

Fruit characters such as diameter of fruit, weight of fruit were significantly influenced by the fertilizer treatments and the high diameter and weight was observed by the application of

200:125:125 NPK kg ha^{-1}. While there was no significant effect of fertilizers treatments on length of the fruit.

6.2.4 Yield

The yield contributing characters such as number of fruits per vine, yield per vine, yield per plot and yield per hectare significantly increased with the increasing fertilizer levels. The highest yield was recorded in the treatment of 200:125:125 NPK kg ha^{-1}.

6.2.5 Residual nutrient status of soil

Residual nitrogen, phosphorus and potassium in the soil after harvesting of the crop were significantly influenced by the fertilizer treatments. The highest residual availability of nutrients in the soil was observed in 200:125:125 NPK kg ha^{-1} fertilizer level.

6.2.6 Plant nutrient status

The fertilizer treatments significantly influenced the plant nutrient status. The highest availability of percentage nitrogen, phosphorus and potassium in plant was recorded with the highest fertilizer level.

6.3 Effect of cultivar

The growth of the hybrids No.41 was found more vigorous than that of hybrid No.26.

It was observed that flowering was earlier in hybrid No.26 but it was at lower node incase of hybrid No. 41.

There was no significant difference between the two cultivars in respect to the diameter of fruit but the length and weight of fruit was significantly more incase of hybrid No.41.

Number of fruits per vine, yield per vine and yield per hectare was significantly high with the hybrid No. 41.

Due to it's vigorous growing nature, the hybrid No. 41 might have observed more nutrients from soil showing minimum residual nutrients in soil and maximum concentration in plant body.

It can be concluded from present investigation that the tropical gynoecious cucumber hybrids (No. 41 and No. 26) should be sown at the spacing 1.3 x 0.45 m with 200:125:125 NPK kg ha^{-1} for successful commercial yield.

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* Originals not seen.

APPENDICES

8. APPENDICES

APPENDIX - I

Data on initial soil analys s

Available nitrogen	:	140 kg ha^{-1}
Available phosphorus	:	17 kg ha^{-1}
Available potassium	:	369 kg ha^{-1}
Soil pH	:	7.7
Electric conductivity	:	0.419 E.C. mmhos/cm^2

VITA

9. VITA

RAJESH NAMDEVRAO BADE
A Candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)

Title of the thesis	:	Standardisation of Agrotechniques for Tropical Gynoecious Cucumber (*Cucumis sativus* L.) Hybrids
Major field	:	Horticulture
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