INFLUENCE OF DATE OF PLANTING ON SEED YIELD AND QUALITY UNDER TWO FERTILIZER LEVELS IN TOMATO

(*Lycopersicon esculentum* Mill.)

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Influence of date of planting on seed yield and quality under two fertilizer levels in tomato (*Lycopersicon esculentum* Mill.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or society.

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C E R T I F I C A T E

Certified that this thesis, entitled Influence of date of planting on seed yield and quality under two fertilizer levels in tomato (*Lycopersicon esculeutum* Mill.) is a bonafide record of research work done independently by Sri N. Rajan under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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We, the undersigned members of the advisory committee of Sri N. Rajan, a candidate for the degree of Master of Science in Horticulture agree that the thesis entitled Influence of date of planting on seed yield and quality under two fertilizer levels in tomato (*Lycopersicon esculentum* Mill.) may be submitted by Sri N. Rajan, in partial fulfilment of the requirement for the degree.

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CONTENTS

		PAGE
1.	INTRODUCTION	1
11.	REVIEW OF LITERATURE	4
111.	MATERIALS AND METHODS	35
IV.	RESULTS	50
V.	DISCUSSION	99
	SUMMARY	111
	REFERENCES	
	APPENDICES	
	ABSTRACT	

LIST OF TABLES

Table No.	Title
Table 1	Mechanical composition of the soil.
Table 2	Physical constants of the soil
Table 3	Chemical properties of the soil
Table 4	Influence of date of planting and fertilizer levels on number of days taken to first flower
Table 5	Influence of date of planting and fertilizer levels on mean number of days taken to 50% flowering
Table 6	Influence of date of planting and fertilizer levels on plant height
Table 7	Influence of date of planting and fertilizer levels on number of secondary branches
Table 8	Influence of date of planting and fertilizer levels on mean number of inflorescences/plant
Table 9	Influence of date of planting and fertilizer levels on number of flowers/cluster
Table 10	Influence of date planting and fertilizer levels on pollen sterility (%)
Table 11	Influence of date of planting and fertilizer levels on number of fruits/ cluster
Table 12	Influence of date of planting and fertilizer levels on fruit set (%)
Table 13	Influence of date of planting and fertilizer levels on fruits/ plant
Table 14	Influence of date of planting and fertilizer levels on days to first harvest
Table 15	Influence of date of planting and fertilizer levels on days to last harvest.
Table 16	Influence of date of planting and fertilizer levels on fruit weight
Table 17	Influence of date of planting and fertilizer levels on fruit yield/plant

(Contd..)

Table	18	Influence of date of planting and fertilizer levels on seed yield/plant
Table	19	Influence of date of planting and fertilizer levels on seeds/fruit
Table	20	Influence of date of planting and fertilizer levels on seed weight/fruit
Table	21	Influence of date of planting and fertilizer levels on 1000 seed weight
Table	22	Influence of date of planting and fertilizer levels on 1000 seed volumes
Table	23	Influence of date of planting and fertilizer levels on germination (%)
Table	24	Influence of date of planting and fertilizer levels on field emergence of seedling
Table	25	Influence of date of planting and fertilizer levels on seedlings length after 14th day of sowing
Table	26	Influence of date of planting and fertilizer levels on seed vigour
Table	27	Influence of date of planting and fertilizer level on fruit yield/plot (13.5 m^2)
Table	28	Influence of date of planting and fertilizer level on seed yield/plot (13.5 m^2)
Table	29	Influence of date of planting and fertilizer level on estimated fruit yield/ha
Table	30	Influence of date of planting and fertilizer levels on estimated seed yield/ha
Table	31	Correlation coefficients between pollen sterillity and weather parameters
Table	32	Correlation coefficients between fruit set and weather parameters
Table	33	Correlation coefficients for fruit and seed characters with weather elements

LIST OF ILLUSTRATIONS

Figure No	Title
Fig. 1.	Layout plan
Fig. 2.	Effect of date of planting on days to 50% flowering and crop duration
Fig. 3	Effect of date of planting on flowers and fruits/cluster, pollen fertility and fruit set
Fig. 4	Effect of date of planting on fruits/plant and mean fruit weight
Fig. 5	Effect of date of planting on fruit yield and seed yield/plant
Fig. 6	Effect of date of planting on seed Germination % and vigour index
Fig. 7	Effect of date of planting on fruit yield and seed yield/ha

Plate No.	Title
Plate I	Field crop stands in different dates of planting
Plate II	October planted seedling crop
Plate III	Seed germination study carried in a Tray containing soil as a medium.
Plate IV	Seedling length after 14th day of sowing in October planted seedlings under two fertilizer levels
Plate V	Seedling length after 14th day of sowing in December planted seedlings under two fertilizer levels

introduction

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important fruit vegetable grown in most parts of the world. The lead countries in tomato production are the United States of America, and European countries which contribute 70% of the world production. In India, it is grown in about 85,000 hectares with an average production of 9.84 t/ha (Anon., 1986)

Tomato production in the tropics is characterised by extreme seasonality and low yields. Thus the selection of suitable season is one of the production constraints in tomato in tropical regions. In India tomato production during summer is faced with severe problems of poor fruit set and incidence of viral disease. Most of the tomato growing regions in India experience temperature regimes of 36°C during day and 24°C or above during night in months of April to July, resulting in poor fruit set and low yields in presently available cultivars of tomato. Fruit set in tomato is restricted to a very narrow range of temperature regimes and is affected when the temperatures are above 34/20° (day/night) (Stevens and Rick, 1986).

The agroecological conditions largely comprising of edaphic and environmental factors can have more than one effect on performance of Seed. It is said that seeds are also influenced by memories of their place of birth (Heydecker, 1972). Quality is an integral part of good Seed. Genetic purity, germination capacity and ability to establish into vigorous seedlings are important seed quality parameters. Germinability and storability depend on vigour factor inherent in the seed. Environmental factors have profound influences on seed development and maturity. Similarly, nutrient supply and availability influence tomato fruit and seed production. Effects of fertilizers and weather parameters on fruit and seed yield and their quality in tomato were found to vary according to varieties, soil, and weather conditions.

Sowing date is a non-monetary input and by sowing the crop at the correct time, growth and yield of the crop can be enhanced with no extra effort on the part of the farmer. From the seed production point of view choosing the right season is all the more important for a profitable crop.

By introduction of a bacterial wilt resistant tomato "Sakthi", tomato cultivation became a reality in Kerala, which was hitherto inhospitable to this crop. Standardisation of agrotechniques in tomato is very essential to suit for this region. But so far no detailed studies have been undertaken in Kerala as to know of the effect of date of planting and levels of fertilizers on growth and yield of tomato particularly with regard to seed yield and quality of seeds.

The present investigation was therefore designed with the following objectives.

1. To find the effect of different planting dates on seed yield and quality of seeds.
2. To find the effect of different fertilizer doses on yield and quality of seeds.
3. To find out the interaction, if any, between date of planting and fertilizer use in seed yield and seed quality.
4. To find out correlation between weather parameters and fruit set.

review of literature

REVIEW OF LITERATURE

The literature on the research topic "Influence of date of planting on seed yield and quality under two fertilizer levels in tomato" are reviewed under the following heads.

A. Influence of weather parameters on growth, flowering, pollen and pollination, fruit set and fertilization, fruit yield, in tomato.

B Effect of dates of planting on fruit yield, seed yield and quality in tomato.

C Effect of fertilizers on fruit yield and seed yield and seed quality in tomato.

A. Influence of weather parameters on growth, flowering, pollen and pollination, fruit set and fertilization, fruit yield in tomato.

1. Growth

According to Went (1944), as quoted by Calvert et al. (1956), the growth rate of tomatoes was mainly determined by the temperature at which the tops were grown and root temperature had little effect upon the growth rate of plants. Bendix and Went (1956) found that the tomato seedlings grown at high (30°C) and low (3°C) temperatures and darkness had lower dry weight than the control. They opined that short periods of high or low temperatures produced severe growth limitations.

Learner and Wittwer (1953) noted a significant varietal interaction with night temperature on the growth of varieties Early Chatham, John Boer and Rudgers. Abdel Rahaman et al. (1958) studied the growth and transpiration of tomato in relation to night temperatures under controlled conditions. Low night temperatures 15.6°C to 9.2°C reduced stem length, dry weight/cm^2 of leaf and total dry matter of shoots. Milthrope as quoted by Hussey (1962) opined that the leaf formation was accelerated by both temperature and light intensity. Hussey (1962) noted that increasing light intensity accelarates formation and growth of leaves and hasten enlargement of vegetative apex.

Fuji et al. (1962) opined that maximum tomato growth was obtained with soil temperature of 20°C combined with air temperature of 16°C. Saito and Ito (1962) reported that when tomato seedlings were grown under all combinations of day temperature of 24°C and 30°C and night temperature of 17°C and 30°C, high day temperatures stimulated vigorous growth and earlier flower bud differentiation and development. High night temperatures had reverse effects. Maximum plant growth occurred at day and night temperatures of 24°C and 17°C respectively.

Abdalla and Verkerk (1968) compared high temperature of 35°C during day and 25°C during night with normal temperature of 22°C and 18°C respectively and found that under the former temperature conditions, stem growth was twice, giving thin stems and many trusses with weak flowers. Abdelhafeez (1971) reported that growth of tomato plants was reduced at soil temperature below 20°C and air temperature of 17°C.

According to Shvebs and Crudev (1972) there was relationship between growth rate and diurnal temperature ranges. Hisatomi (1972) reported that leaf area and stem thickness were markedly enhanced by higher (20°C) soil temperature. In the range of 17°C to 31°C soil temperatures, and 24°C to 31°C air temperatures, low soil temperature retarded the early development phases.

Stanev and Angelov (1978) reported effects on tomato cultivar 'Extase' grown in containers and soil kept at constant temperatures of 15, 20, 25, 30 and 35°C. A reduction of soil temperature from 30°C to 15°C decreased the leaf area by 50 to 70% and an increase in soil temperature to 35°C decreased it by 20 to 40%. Net photosynthetic productivity was the highest at 15°C, the peak at 25-30°C and decreased by 60-70% at 50°C and by 22 to 38% at 35°C. According to Longuenesse (1978) the vegetative growth of plants grown under 11°C night temperature was 20% less than under 15°C. Mastalerz (1978) reported that growth of tomato plants was at peak at a constant temperature of 19.7°C to 22.5°C.

Atherton and Rudich (1986) reported that depending upon the cultivar and cultural practices, the proportion of assimilating leaf area of the axillary shoots in relation to whole plant can constitute one third or half of the entire plant weight or leaf area. They also reported that development of the root system differs among tomato cultivars and the day temperature of 26.5°C and night temperature 16-22°C resulted in the heaviest root system.

Heuvelink (1989) found that an increased temperature regime reduced plant growth and development, number of leaves and number of trusses. Growth reduction was caused by a lowering in leaf area ratio (LAR). The decrease in LAR at an inversed temperature regime was caused mainly by a decrease in specific leaf area (SLA). Net assimilation rate (NAR) was not influenced by the temperature regime. For young, widely spaced plants a lower SLA (thicker leaves) results in less light interception and thus in growth reduction.

2. Flowering

Murneek (1926) found that much of the flower bud and flower abortion in green house grown tomatoes was due to carbohydrate shortage. This was due to limited light supply, high temperature and the demand of developing fruits for most of the carbohydrate manufactured. According to Smith (1932), the flower drop was severe when the temperature was high and humidity low. Rosa (1923) viewed that one frequent cause of blossom drop lay in the excess vegetative growth of the plant. Another cause, he observed was the very low air humidity during summer. This is more pronounced when high temperature and high winds prevail.

Smith (1932) noted that a large percentage of shedded blossoms had injured floral parts. This, he attributed to the fact that hot dry winds withdrew moisture from the organs causing them to blacken and die, the injury prevented normal pollination and fertilization. Morris et al., as quoted by Smith (1932) in their investigations to determine the causes of shedding of tomato blossoms conducted at Oklahoma for 14 years, found that extremely hot weather, hot dry winds, extremes of temperature and low humidity are the probable causes. Smith (1932) further stated that pollen tube growth appeared to be slow in tomato. Because of this slow growth of the pollen tube, the stigma, the style and the pollen may be destroyed in periods of unfavourable weather before the pollen tubes reach the embryo sac. According to Nightingale (1933) tomato plant showed good growth, flowering and fruiting at temperature 12.78 to 25°C plant showed good growth, flowering and fruiting at temperature between 12.2°C to 25°C.

Bewley (1934) observed that soil and air temperatures affect the tomato considerably. The most suitable air temperature depends upon the light intensity and day length.. Abundant sunlight induces a mature stocky growth and balances the softening effect of heat and moisture. High temperature and moist conditions stimulate vegetative growth out of all proportions to root development, unless there is sufficient sunlight to counteract them. Experiments conducted at Cheshunt (USA) show that the best night temperature for tomato is 15.6°C to 18.3°C.

Beattie (1935) opined that the day temperature ranging from 21.1°C to 29.4°C is satisfactory for tomatoes; sudden fluctuations as well as excessively low or abnormally high temperature, are extremely injurious to the crop.

Cochran (1936) contended that temperature has a greater effect on flowering and fruiting than any other factor studied. Keyes as cited by Gardner et al. (1952) found in tomato that 15°C is the critical point and still lower temperature results in abscission.

Went (1945) reported that for tomato, the inflorescence size varies very much with night temperature, the warmer the night, the smaller the inflorescence and the flowers. Roodenburg (1947) observed that in tomato culture the place where the first truss is formed depends on temperature and light supply. When the temperature is low, truss appears immediately after the production of minimum number of leaves necessary. Hoare (1948) stated that successful tomato production depends on freedom from extremes of high and low temperature, with a low humidity. He noted that it requires a minimum temperature between 14.4°C and 15.6°C for satisfactory growth and grows freely at temperatures between 15.6°C and 21.1°C. It does not, however, fruit very satisfactorily under conditions of high humidity as seen in wet tropics.

Lewis (1953), stated that branching of inflorescence in tomato was a variable character that is bound physiologically with the number of flowers. He opined that temperature and light are the most important factors affecting the inflorescence size. A low temperature (14°C) the expansion of cotyledons to the appearance of first inflorescence causes an increase in flower production as compared with plants raised at 25°C to 30°C. High light intensity and or day length increases flower production. Alternation of warm days and cool nights and vice versa as opposed to a uniform temperature, has no effect on flower number in plants grown under natural light. The sensitive period of temperature effect on first inflorescence is between eight and twelth day after cotyledon expansion to the emergence of the first inflorescence.

Lawrence (1953) found out that the temperature during the first few weeks of growth controls the number of flowers borne on the inflorescence. The position of the stem at which the first inflorescence develops an increase in the number of leaves to the first inflorescence can offset the early flowering which is normally associated with high temperaturs. Calvert (1953) put forward the relationship between temperature and truss size in tomatoes. His work showed that low temperature during flower initiation can increase the number of flowers borne per inflorescence as observed in variety 'Ailsa Craig' which produced nine flowers in the first truss when the temperature during the initiation was 15.6°C and 14 flowers when the temperature was 12.6°C. For practical purposes, when plants are grown at 15.6°C lowering of temperature during the second week after pricking (Cotyledon expansion) is likely to increase the number of flowers in the first truss. A variation in temperature between sowing and germination did not affect the number of leaves to the first inflorescence. A temperature of 12.8° during the first month from pricking out, reduced the leaf number and increased the number of flowers on the first inflorescence but also reduced the rate of growth. The leaf temperature effect was not apparently influenced by day length and its magnitude which varied with variety (Calvert, 1953). He also noted that the effect of temperature on leaf number to the first infloresence appeared to be controlled by mean temperature in 24 hours and extended approximately to the ninth day after cotyledon expansion. Reduction in night temperature from 21.1°C to 10°C retarded the seedling growth.

In the study of temperature effects on early growth and development of tomato, Calvert (1953) opined that the effect of temperature during the three thermophases are, on production of rogue characters, the size of inflorescence or degree of branching and the determination of inflorescence position.

Johnson and Hall (1955) noted that tomato varieties

'Marglobe' and 'Rutgers' transplanted during period of high temperature and high light intensity did not come to flower. Wittwer an Teubner (1956) with five varieties of tomato showed that earlier and more prolific flower clusters formed and the plants were sturdier when seedlings at cotyledon stage were chilled for two to three weeks 10°C to 12.8°C (night temperature) than when grown continuously at 15.6°C to 12.1°C. The effect was confined to the first two clusers only. They named the two week interval immediately after cotyledon expansion in tomato as the temperature sensitive period when the flower formation took placee in the first inforescence.

Calvert (1957) reported that the low temperature minimised the number of leaves to the first inflorescence while the high temperature maximised it. A high or low day temperature compensates for a low or high night temperature increases the number of flowers, while high temperature decreases it.

Howlett (1958) found that temperature dependent flowering is a varietal character. He recommended a night temperature of 15.6°C for more number of flowers in tomato. According to Calvert (1962) branching of inflorescence takes place below 21°C. According to Hussey (1962), high light intensities or low temperatures promote apical enlargement and flowering.

Fujii <u>et al</u>. (1962) tested tomatoes for a period of 65 days with various combinations of air and soil temperatures ranging from 16° to 24°C. Maximum tomato growth was obtained with a soil temperature of 20° combined with an air temperature of 16°C. They concluded that in all cases, combinations of low air temperature with high soil temperature and vice versa gave good results. Fuji: and Ito (1962) reported an accelerated flowering and fruit development by high night air and soil temperatures Saito and Ito (1962) noted that high day temperatures induced vigorous growth and earlier flower bud differentiation and development in tomato seedlings. High night temperature had the reverse effects. They observed maximum plant growth, flower formation and fruit production at day and night temperatures of 24°C and 17°C respectively; exposure of seedlings to a low night temperature (17°C) for at least two weeks after cotyledon expansion resulted in the development of the least number of leaves per inflorescence. They further noticed that the exposure for three, five and seven weeks to a night temperature of 17°C resulted in the maximum number of flowers being produced in first, second and third inflorescences respectively; higher the carbohydrate and nitrogen content of the plant, fifty days after cotyledon expansion, the greater was the inrease in the total number of flowers up to third inflorescence.

Watanabe (1963) found that natural day length and heavy irrigation increased vegetative growth but did not affect flower bud development in tomato seedlings..

Calvert (1964) studied day and night temperature effects on flowering and found that when day and night temperatures are moderate an equal early flowering is more pronounced. He opined that for the production of commercial single truss tomato, it is imperative to make the stem as short as possible and this is feasible to a great extent by maintaining equal day and night temperatures at the flower initiation and anthesis stage.

Saito and Ito (1971 a) found that exposure of the plants at 9°C for twenty days produced fasciated flowers which might be due to the surplus nutrient supply to the young flower bud just on pre orpost differential stage. They remarked that at low temperature Vegetative growth is restricted which is due to supply of more nutrients for flower development. Saito and Ito (1971 b) studied the combined effects of low temperature and nutritional conditions and found that poorly manured flowers showed slow growth.

Charles and Harris (1972) reported that flower production decreased with an increase in temperature upto 27°C regardless of any heat tolerancce in terms of fruit setting ability. Rylski (1979) observed a significant drop in the average number of flowers per inflorescence with an increase of temperature from 17°C to 27°C. According to Asahira et al. (1976) flowering of tomato was reduced by relatively high temperatures. Abdul and Harris (1978) reported that at high temperature, a high level of endogenous GA_3 was sythesised which ultimately reduced the number of flowers formed in the first inflorescence.

3.. Pollen and pollination

The necessity for high density of pollen for an enhanced fruit set was stressed by many workers (Bailey 1886, Fletdor and Gregy 1907). As early as 1886, Baily assessed the necessity of of sufficient quantity of pollen for an economic fruit set in tomatoes. An abundence of pollen supplied over the entire stigmatic surface not only increased the size of the fruits but the number of seeds also. Fletdor and Gregy (1907) found that insufficient pollen produced small and hollow fruit, whereas excess pollen was responsible for the production of large symmetrical fruits. Irregular and small sized fruits were produced by insufficient and imperfect pollination. Pollen applied to one side of the stigma produced one sided fruit development, only one chamber was full of jelly and seeds, and the other chamber being seedless. A number of flowers did not produce mature fruits, but the calyx remained green and grew a little, but soon withered. Upto a certain limit, more the pollen, more the seeds and more the number of seeds larger was the tomato fruit as a rule.

Burk (1930) working with variety 'Bonney Best' with particularly long styles, found that the style was shorter during the short days of spring and summer. He also found that short pistils are necessary for good self pollination in winter and this is largely a varietal character. Howlett (1939) pointed out that all varieties of tomato showed a definite response to environments in respect of relative length of pistil and stamens. He also reported that maximum length of pistils in relation to the stamen was obtained when the plants were growing under conditions of long day high intensity of light and moderate supply of readily available nitrogen. Verkerk (1957) carried out studies on the effect of pollination on fruit set, fruit growth earliness of growth and size of fruits. A high positive correlation was found between seeds per fruit and fruit weight. Pollination resulted in larger and earlier fruit with more seeds.

Danburg (1959) found varietal difference in stylar elongation at low temperature and this factor had some effect on fruit set. Vankoot and Vanravestijen (1962) observed that poor germination of tomato pollen on the stigma, both in the degree and speed was largely dependent on temperature.

According to Sugiyama et al. (1962), high temperature above 50°C induced necrosis in leaves and stems. They observed that in tomato, the percentage of fruit set was signifiantly lowered and the germination tests of pollen on artificial media revealed that the percentage of germinating pollen was decidedly lowered. This is assumed to be one of the causes for poor setting of fruits.

Vankoot and Vanravetijen (1962) also reported that pollen liberation was low in dull humid weather. Sticking of pollen to the stigma was unfavourably affected by dry and sunny weather. Both degree and speed of germination were largely dependent on temperature.

Sugiyama, et al. (1962) found that ovule development was also affected by high temperature treatment, particularly after meiosis which occurred about a day after meiosis in pollen mother cells. Pollen damage was considered more serious than ovule damage between five and seven days before anthesis, because only in this period, fruit set could be improved by the application of untreated pollen.

Iwahori (1965) reported that exposure of plants to high temperature (40°C) of two to three hour period led to poor pollen development. Pollen injury was more severe when plants were exposed to high temperature five days prior to anthesis when the pollen grains were still developing. However, there was little injury to mature pollen when plants were exposed to high temperature between three days and one day before anthesis.

Abdalla and Verkerk (1968) compared effects of high day temperature of 35°C, 25°C with normal day temperature of 22°C and night temperature of 18°C. They observed that pollen count on the stigma was very little at high temperature when compared to normal.

Charles and Harris (1972) studied effect of 10°C, 12.8°C, 18.3°C, an 26.7°C temperatures on flower production, fruit set and size, pollen viability, stigma receptivity and height of stigma in anthredial cone in tomato lines selected for their ability to set fruit at high or low temperature. They found that low fruit set at 10°C and 12.8°C was due to poor pollen viability and germination and to a lesser extent to high stigma position in the anthredial cones. At 26.7°C, elongation of stigma position was the main factor reducing fruit set; but low stigma receptivity was also a factor in some selections.

The quantity of fertile pollen was more important than the total amount of pollen produced. Pollen production and viability were reduced with an increase in temperature regardless of the heat tolerance or sensitivity of the tested cultivars. It was reported that all the cultivars had reduced pollen production, reduced pollen viability and fruit setting ability as well as greater stigma exertion and anther on splitting under high temperature (Anon, 1981).

Picken (1984) stated that pollen production is sensitive during period of low light which causes carbohydrate deficiency. The different shapes and sizes observed in non-viable pollen grains suggest that pollen developmnt may be influenced by carbohydrate deficiency at a number of stages. In winter and early spring, pollen transfer from anther to stigma is very inefficient in glass house crops and it is essential to vibrate the inflorescence artificially in order to achieve a satisfactory level of fruit set.

Kalloo (1986) reported that efficient pollination is affected by environmental factors like temperature, humidity and wind velocity. He stated high wind velocity reduces the efficiency of fruit set. The receptivity of the stigma and the nutritional status of the plants are some other factors. The stigma should be receptive and the plants should have normal C/N ratio.

4. Fruit set and fertilization

According to Wellington (1922) a tomato crop depends upon sufficient moisture and heat to produce large vigorous plants and sufficient dry weather and heat after the plant has reached its critical period (the time of setting first fruits). The low average number of ripe fruits produced was due to cold weather. In the years when the temperature averaged higher throughout the season, the number of ripe fruits was markedly greater. Talbert and Murneek (1939) observed excessive heat to be harmful when the flowers are in full bloom. An extremely high temperature especially when accompanied by wind may reduce the set by causing the stigma to dry up and to be receptive to pollen only for a short time.

Hardy (1944) observed that frequently one or more trusses either fail to produce fruit or else they are comparatively a few in number. This may be due to excessive rainy intervals with low temperature or sometimes from extremely hot and dry weather..

Went (1944, 1945) observed in tomatoes that at high night temperatures, the rate of sugar translocation has affected vegetative growth and fruit set because of the insufficient sugar that reached the growing regions. As such, with advancing ages of the plant, the length of the translocation system becomes longer with the result, optimal production of flowers and fruits are affected. The temperature should be lower enough to facilitate early translocation of the sugars to the growing plants. A gradual reduction in optimal night temperature for fruit development as age advances may be advisable as recorded in pepper plant by Dorland and Went (1947). Night temperature was a limiting factor for fruit setting in the tomato, more or less regardless of day temperature (Wittwer et al., 1948). Gardner (1952) stated that the tomato sets freely when the day temperature ranged from 21.1°C to 32.2°C but are inclined to abort above 32.2°C due in part to temperature and in part to high transpiration rate.

Osborne and went (1953) studied the influence of day and night temperatures, photoperiod and light intensity upon the effectiveness of NOA on the development of parthenocarpic fruits in tomato. They found lower setting with high day or night temperatures and higher setting with low temperatures compared to the normal set. Under all the conditions of the experiment the chemical (NOA) has consistently prevented the abscission of blossoms even in the absence of the fruit-set. Jakuskina and Kravcova (1953) observed the highest carbohydrate content of leaves in plants grown at high night temperatures. Photosynthesis was reduced only slightly in lower night temperatures when tomato varieties were grown in winter by artificial illumination at (1) Both 23°C day and night temperatures and (2) 23°C day and 15°C night temperatures. When 2, 4-D was applied, the fruiting capacity of all plants were improved, but the greatest yield increases were obtained on those grown under high night temperatures. Johnson and Hall (1955) noted that 'Marglobe' and 'Rutgers' plants transplanted before a period of high temperature and high intensity of light, fruited. High temperature and high intensity of light prevented them to come to flower.

Usik (1958) was able to isolate plants with increased dry matter content by growing seedlings in low temperature and humidity. Though it retarded the growth slightly, the dry matter content increased by one to two% resulting in increased fruit set and reduced flower drop.

Went (1958) reported that the relatively low optimal temperature for growth and fruit set was due to an interaction between temperature effect and certain growth processes. Curme (1962) observed that when tomato variety was grown in varying degrees of night temperatures, percentages of fruit set was high in some varieties, even at a night temperature of 7.2°C and fruit set was higher during summer than during winter.

Iwahori (1966) reported that exposure to high temperature has adverse effects on fertilization or on the process of fruit development.

Rick and Dempsey (1969) reported that stigmatic position having strong association with fruit set is determined by a few genes and highly influenced by environmental factors. Lower stigma position affects better self pollination, and hence improved fruit setting. They also showed that it was possible to select cultivars capable of setting fruit under relatively high temperature conditions. They opined that a reason for low fruit set was style elongation relative to the antheridial cone, of reducing fruit set at high temperature.

Temperature also influences the time at which fertilization occures. At 18°, pollen tubes penetrated the ovary with in 24 hours after pollination, whereas at 10°C penetration occurred only after 84 hours (Charles and Harris , 1972). They also found that low fruit set at low temperature was partially due to high stigma position, but at high temperature exerted stigma was the main factor for reducing fruit set.

Cornillon (1974) reported that flowering and fruit set were optimum at 15 to 18°C. According to Rudich et al. (1977) high day temperature at 39 ± 2°C and night temperature at 22 ± 2°C reduced fruit set to 0 to 22%. They opined that poor fruit set could be associated with a low pollen viability, style elongation and lack of formation of endothecium. There was a considerable decrease in pollen germination above 25°C.

Richard et al. (1978) compared the heat tolerant tomatoes, A.U. 165 and Nagcarlang. The two heat tolerent cultivars had a significantly higher per cent of fruit set under both moderate and high temperature in spring and summer, but fruit set of all the three cultivars was significantly lower at high temperature.

According to Rick (1978) stigmatic position is the main factor for higher temperature fruit set and so far there is no genotype available which has stable stigmatic position. Levy et al. (1978) studied seven tomato cultivars and lines under high temperature conditions in the field and in growth chamber. Fruit set varied between 77.3% in the heat tolerant cultivars Hotset and 62% in cultivar Ormat and 16.3% in the most sensitive cv. Hosen moon. The cause for low fruit set was bud drop, splitting of antheredial cone, style exertion and reduction of quantity and or functionability of the gametes. Low temperature causes low flower production, poor pollination, slow pollen tube growth, and poor fertilization (Hunner and Van Huystee, 1982)

Picken (1984) stated that poor fruit set in the low light conditions of winter and early spring is caused probably more frequently by failure of pollen production or pollination than by failure of pollen germination , pollen tube growth, ovule production, fertilization and fruit swelling etc.

5. Fruit yield

Learner and Wittwer (1952) found that a combination of 15.6°C and low moisture produced better, early and total yields. Wittwer and Teubner (1956) observed early increased yield of 65% by transferring ten tomato varieties from a green house with a night temperature of 18.3°C to the cold frame at 7.2°C to 18.3°C for two or three weeks following cotyledon expansion. They found no difference in the total yield or fruit size. Snyder (1957) established that 17.8°C gave the highest percentage of fruit number and total weight, while 28.9°C was too low for the best quality tomatoes.

Watanabe (1963) obtained maximum early and total yields from plants grown under natural day length conditions at 20 - 25°C Saito and Ito (1962) observed when tomato grown under all combination of day temperature of 24°C and 30°C, maximum fruit production occurred at day an night temperature of 24°C and 17°C respectively. Hisatomi (1972) reported that fruit number unit area and the total yields were greater at lower soil temperature.

Lubnin and Metlyakova (1976 a) studied performance of tomatoes at 17°C to 31°C temperature and 24°C to 31°C air temperature. Low soil temperature retarded the early development phases but had little effect on crop ripening and final yield. Lubnin and Metlyakova (1976 b) found in cultivar Peremaga 165 that raising air temperature from 24°C to 31°C increased yield by 7 to 36%. Raising the air temperature to 38°C decreased the productivity by 15 to 23%. Moshkov et al. (1976) reported that in tomatoes the highest yields were obtained when air and substrate temperature were 25°C to 30°C.

According to Guttormsen (1977) there was a positive correlation between yield and the amount of global radiation (maximum temperature) during the period between flowering and harvest. Stanev and Angelov (1978) recorded the highest yields at 25 to 30°C soil temperature and the lowest at 15°C. Sukurai et al. (1978) studied the effect of night temperatures of 13°C, 18°C or 23°C at various times during the growth cycle. Growing at low night temperature promoted flowering and increased the early yields. Longuenesse (1978) reported a marked positive effect on total yield when the night temperature, during vegetative growth was 15°C but no effect when it was 11°C..

According to Saimbhi (1970), fruits harvested during spring contained less acid and more total solids than autumn crop. Szilagyi and Videki (1970) found high positive correlation between dry matter and sugar contents and temperature, and a week negative correlation between Vitamin C and acid contents and temperature. Dry matter content of fruits showed high correlation with the temperature sum during 15 to 20 days before picking and the sugar content with the temperature sum during 35 to 40 days before picking. The redness of the fruit and the temperature on the day before picking showed a very close correlation.

B. Effect of dates of planting on fruit yield and seed yield, seed quality in tomato

Cooper (1962) pointed out that there was significant interaction between sowing date and temperature in tomato crop. In a glass house tomato crop, he found that yield from each sowing date differed significantly, while sowing made in November and December did not differ significantly. He found that plants sown in the winter months had a longer period of increasing leaf area and attained a larger total maximal leaf area than plants sown in the summer months.

Arora *et al.* (1969) reported that time of transplanting of tomato seedlings played an important part on fruit yield and economic returns. Late planting of summer crop adversely affected the yield because of high day temperature (above 38°C) affecting fruit set.

The experiment conducted at I.A.R.I, New Delhi by Arora *et al.* (1969) on different dates of transplanting of tomato seedlings and their spacing under various levels of nitrogen on the yield of summer tomatoes showed that the optimum time of planting of tomato seedlings appeared to be some time in February - preferably before the 3rd week of Febuary. Later transplanting of seedlings results in considerable reduction of tomato fruits and economic returns.. Fifty kg of nitrogen is adequate for summer crop of tomato when grown on a soil of average fertility.

Nandpuri *et al.* (1971) compared five varieties of tomato transplanted in the middle of November, February and March during 1966 and 1967 at Ludhiana. Varieties differed significcantly from each other under different sowing times. All of them did better when transplanted in November under protection against cold.

Alesksc ev (1981) reported that quality of seeds influenced by method of growing the seed plants, fertilization, Irrigation, date of sowing and geographical region of cultivation, were determined. In a trails with several tomato cultivars he found that seed quality was better from plants raised in the field than in green house. Seeds contents was positively correlated with seed quality. Irrigation to maintain soil water level at 60-65% of field capacity during mass flowering and 70-75°% during fruit formation improved seed quality. Seeds of plants sown in late April gave appreciably higher germination than seeds of plants sown earlier or later. The studies conducted at Coimbatore (Muthukrishnan et al., 1982) on the performance of tomato cultivars at different periods of planting revealed that wide variations in yield were recorded in tomato among different months of planting. The variations were attributed to weather conditions prevailed during different growth periods. The months of May, June, July and November are ideal for planting to get more yield.

The study carried out by Ravikumar and Shanmugavelu (1983) at Coimbatore found that direct sown tomato crop was early in respect of first flowering, first harvest and final harvest. He tried four dates of planting - 15th December, 31st December, 16th January and 1st February. High percentage of pollen germination was recorded in crops sown on 15th December but the style length was comparatively short in 15th December sown crop, while it was longer in the subsequent sowings. The crop sown on 15th December recorded the highest percentage of fruit set, while the lowest set was in February sown crop. Yield per plant was altered by the different dates of sowing.

The per plant yield was high in 15th December sown crop and showed a decreasing trend in the subsequent sowings.

The studies conducted at Ludhiana (Saimbhi and Gill, 1988) on the performance of processing tomatoes at different periods of planting revealed that wide variations in yield and the highest yield per hectare were recorded in December planting followed by January planting. But transplanting done in February and March decreased the yield by more than 50% over December planting.

Vadivelu and Srimathi (1988) reported that the crop raised in May-June season produced maximum quantity of good quality seed.

C. Effect of fertilization on fruit yield, Seed yield and quality in tomato

Effect of fertilizers on the fruit yield and quality was studied in a large number of tomato varieties and the results vary according to varieties, soil and weather conditions. Role of the major nutrients like nitrogen and influence of C/N ratio to crop yield and fruitfulness were well established (Nightingale et al. 1928). A high rate of broad cast nitrogen (208 or 280 kg/ha) increased flower formation on several clusters of processing tomatoes.. Especially, side dressing of nitrogen increased flower formation and fruit set on late clusters (Garrison et al., 1967) The amount of nitrogen to be applied depends upon the season, the type of soil, the nature of fertilizers and the cultivar used. The yield generally increased with nitrogen levels (Anand and Muthukrishnan, 1974, Kuksal et al 1977; Hall, 1983).

Seth and Choudhury (1970) studied the effect of spacing and manures on fruit yield and seed yield in tomato variety Pusa Ruby, using three fertilizer levels - nitrogen 50 kg, 70 kg, 90 kg/ha and two doses of phosphorus - 50 kg, 70 kg/ha. The nitrogen at 90 kg/ha gave the highest fruit and seed yield. The improvement in fruit and seed yield as well as quality was recorded due to interaction between nitrogen and phosporus.

Brar et al. (1971) found that when three levels of nitrogen (50, 88, and 175 kg/ha) and two levels of phosphorus (0 and 62 kg/ha) were tried in Kuluvalley with two varieties of tomato Sioux and Best Of All, that Sioux gave more early yield. Higher levels of nitrogen did not affect early yield in any way whereas total yield and number of fruits were increased as the level of nitrogen increased from 50 to 88 kg/ha. The application of P_2O_5 gave marked increase in early yield and total number of fruits.

Sharma and Mann (1973) found that nitrogen at higher levels had pronounced effect on increasing yield when they used N at 50, 100, 150 kg/ha. The optimum level of phosphorus fertilization was 68.37 and 74.94 kg/ha during autumn and hot weather crops respectively and that of nitrogen fertilization was 127.65 and 134.55 kg/ha in autumn and hot weather crops respectively. Increasing levels of phosphorus increased branches/plant. Nitrogen application also increased number of branches and plant height. They also found that autumn season favoured better growth in relation to summer. The nitrogen content of soil and leaf are positively correlated with fruiting and fruit ripening stages (Anand and Muthukrishnan, 1974 .). Potassium application increased number of flowers, peduncle length, fruit set and number of fruits (Besford and Maw, 1975).

A nutritional and spacing studies in tomato with nitrogen levels of 0, 50, 100 and 150 kg/ha, phosphorus 0, 30, 60 and 90 kg/ha, and potassium 0, 30, 60 kg/ha by Gupta and Shukha (1977) at I.I.H.R Bangalore using tomato variety Sioux revealed that application of nitrogen and phosphorus increased plant height, index of earliness, fruit size, fruit yield/plant and per hectare. The experiment conducted by Kuksal et al. (1977) using tomato variety Chaubattia Red with three levels of nitrogen (60, 90 and 120 kg/ha) and two level of phosphorus (60 and 90 kg/ha), recorded that 90 and 120 kg N/ha increased growth and of fruit yield and seed yield significantly; phosphorus alone was found ineffective. But in combination with nitrogen, phosprous hastened maturity and increased early yield significantly. Randhawa et al. (1977) found in the experiment consisting of three levels of nitrogen 0, 75 and 150 kg/ha and two levels of phosphorus and potash each at 0 and 60 kg/ha using tomato varieties Punjab Chhuhara, S-12 and Punjab Tropic that application of higher doses of nitrogen, phosphorus and potash produced more marketable yield than the control. The maximum marketable yield was obtained when NPK at 150:60:60 kg/ha was applied.

Gupta et al.(1978) studied response of tomato to graded levels of N at 0, 75 and 150 kg/ha, phosphorus at 0, 60 kg/ha and potassium at 0, 60 kg/ha in a sandy loam soil. They found that nitrogen fertilization increased plant height, plant growth, fruit yield and improved fruit quality · The P_2O_5 fertilization also increased plant growth. Fruit size and index to earliness did not show any effect on fruit quality.

Ramakrishnana (1978) studied the effect of NPK at different levels in tomato variety Karnataka Hybrid. He noted that all the growth and yield parameters increased significantly with increase in nitrogen and phosphorus levels. NPK at the rate of 230, 208, 60 kg/ha respectively produced significant increase in dry weight, leaf area index, leaf area, duration, number of fruits, and fruit yield/plant.

George et al. (1980) studied the effect of mineral nutrients on yield and quality of seeds in tomatoes grown in pots. They found that there was a significant interaction between nitrogen and phosphorus treatments, with regard to number of fruits, total fruit and seed weights, 1000 seed weight, germination and seedlings emergence percentage in normal seedlings. The fruit and seed yields were significantly different between 0.12 g and o.24 g phosphorus/pot. The 1000 seed weight was significantly less with high levels of nitrogen. The interaction between nitrogen and phosphorus had a significant effect on germination and seedling emergence rates which were higher at 0.56gN, 0.24 g P_2O_5/pot. No difference were found between treatments with regard to germination and seedling emergence capability or percentage of normal seedlings.

Barooah and Zaman Ahmed (1983) carried out a fertilizer trial using three levels of N at 0, 60 and 120 kg/ha, phosphorus at

0, 60 and 120 kg/ha and potash at 0,60 and 120 kg/ha in all possible combinations on Ponderosa variety of tomato. They found that application of nitrogen brought about a phenomenal increase in plant growth in respect of plant height, number of branches and yield. Nitrogen beyond 60 kg diminished yield, tomato plants receiving higher doses of phosphorus grew much faster. Potash application did not influence yield but increased the ascorbic acid content of fruit. Vadivelu (1983) studied effect of spacing and manuring on seed yield and quality of tomato variety Co-2. He used three NPK levels at 75:100:50; 100:100:100; 150:100:100 kg/ha respectively. He found that application of 100:100:100 kg NPK/ha with a spacing of 75 x 80 cm was the best manurial combination and spacing for production of maximum quantity of good seed. However the percentage of processing loss, germination percentage, field emergence, dry matter production and vigour index of the resulting seed did not differ significantly between treatments.

Kooner and Randhawa (1983) found that yield increased from 10.5 to 24.9 t/ha with the application of N from 0 to 200 kg/ha and response was almost linear upto 150 kg/ha. The growth in terms of plant height and number of branches increase significantly with increase in the level of nitrogen. The application of 200 kg N/ha produced plants with maximum height (57.7 cm) and branches (12.0).

Varis and George (1985) in a nutritional experiment under glass house used tomato cultivar Money Maker grown in pots with nutrient levels of N 50 g and 100g/pot, phosphorus 21.8g and 43.6 g/pot and potash 83 g and 166 g/pot. They found that high nitrogen level increased flower number, fruit and seed yield, and gave early flowering and ripening. The high Phosphorus level increased seed yield. The high nitrogen level increased fruit and seed yields and the 1000 seed weight, caused early flowering and ripening; but the difference between N levels had no effect on fruit setting percentage or fruit number. When the seeds from the treatments were sown, the emergence rate was greater in higher N levels. Subbiah and Raniperumal (1986) found that application of 50 kg k_2O/ha along with a common dose of 120kg N/ha and 0.5% $Cacl_2$ were found to improve the yield and nutrient uptake of tomato varieties co-2 and co-3 respectively. In a fertilizer trial with nitrogen 0,50,100,150 and 200 kg/ha conducted at I.I.H.R., Bangalore during 1987-88, using tomato varieties Pusa Early Dwarf (PED), Arka Vikas, Pusa Ruby, revealed that the tomato varieties did not differ in fruit yield. There was response to N levels up to 150 kg N/ha. Seed yield varied with the variety and N levels. Seed yield was maximum (62 kg/ha) in Pusa Ruby followed by PED (59 kg/ha). Seed yield also increased up to 150 kg N/ha (Anon 1988).

In the fertilizer trial conducted by A.I.C.V.I.P. Coimbatore, using tomato varieties CO-1, CO-2 and CO-3 during Kharif and summer seasons recorded that in variety CO-3 application of NPK at 150:60:60, kg/ha gave maximum yield and maximum fruits/plot. This is followed by a combination of 75,60,60 kg of NPK/ha. The variety CO-1 representing the semi-determinate type yielded maximum yield/plot when NPK was applied at 75:60:60 kg/ha. The indeterminate variety CO-2 performed better for both yield and fruits/plot at a fertilizer dose of NPK 150:60:60 kg/ha. During summer trial, the variety CO-3 responded better to application of 75:60:60 kg of NPK/ha. The variety CO-1 gave maximum yield when fertilizer dose of 75:60:60 kg NPK/ha was applied. The variety CO-2 gave the maximum yield as well as number of fruits when a fertilizer dose of NPK 150:60:60 kg/ha was applied (Anon, 1988). A fertilizeer trial using tomato variety LE-79 was conducted at Bhubanaswer under the auspices of A.I.C.V.I.P. using seven levels of nitrogen showed that the treatment effects varied significantly. The highest yield (29.6t/ha) was obtained when 40 kg N/ha was applied as basal + 30 kg N as foliar application (Anon, 1988).

The fertilizer trial conducted at College of Horticulture, Vellanikkara for three seasons during 1985-86, 1986-87 and 1987-88 using tomato cultivar LE 79 indicated that none of the treatments (nitrogen- 25, 75 and 125 kg/ha phosphorus- 25, 50 and 75 kg/ha and potash- 25, 50 and 75 kg/ha) had any significant influence on yield. However, the fertilizer trial carried out by A.I.C.V.I.P. during 1988 at College of Horticulture, Vellanikara using the tomato variety LE 79 envinced significant difference between treatments with respect to yield of fruits; maximum yield was obtained at 40 kg N/ha as basal + 10 kg N/ha as top dressing by foliar application (Anon, 1988).

materials and methods

MATERIALS AND METHODS

The present study was carried out in the Department of Olericulture, College of Horticulture during 1988-89 to study effect of date of planting on seed yield and quality under two fertilizer levels in tomato

Details of materials used and the techniques adopted during the course of this investigation are presented hereunder.

A Experimental materials

1. Crop variety

The tomato cultivar LE 79 (Sakthi) was selected for this experiment. This is a high yielding and bacterial wilt resistant variety developed by the department of Olericulture, College of Horticulture, Vellanikkara.

2. Location

The experimental site is situated in the central part of Kerala at an elevation of 22.25 m from mean sea level and has a latitude of 10° 32' North and longitude of 76° 10' East. The area enjoys a typical tropical humid climate.

3. Field

The experiment was laid out in the research plot of the Department of Olericulture , College of Horticulture, Vellanikkara.

4. Soil characteristics

Composite soil samples from 0-60 cm depth taken before the commencement of the experiment were used for the determination of physico-chemical properties. (Table 1, 2, and 3).

5. Season

The experiment was conducted during the period from June 1988 to June 1989.

B. Methods

1. Layout and statistical design

Layout plan of the experimental site is given in Fig.I. The experiment was laid out in a split plot design with three replications. The total number of plots were 48. The sub plot size was 3m x 4.5 m each accommodating thirty five plants. The treatments consisted of eight dates of planting in main plots and two levels of fertilizers in sub plots. The details of the different treatments and notation used to represent the treatments are given below.

Main plot treatments (Dates of planting)		Notations
July	15th	T_1
August	15th	T_2
September	15th	T_3
October	15th	T_4
November	15th	T_5
December	15th	T_6
January	15th	T_7
February	15th	T_8

Sub plot treatments (fertilizer levels)		Notations
NPK	75:40:25 kg/ha (Kerala Agrl. University recommendation)	F_1
NPK	150:60:60 kg/ha (ICAR recommendation)	F_2

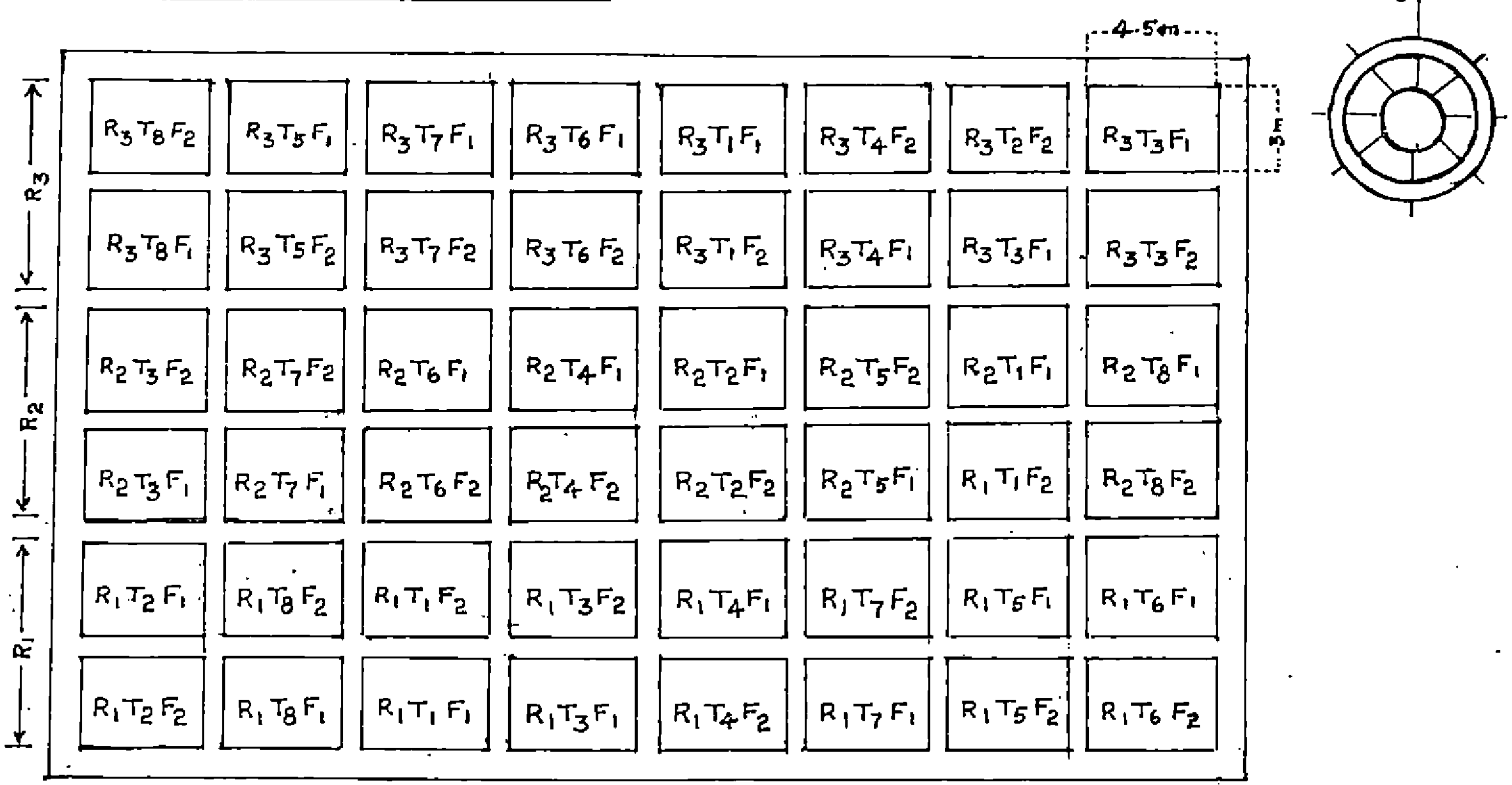
Treatment combinations

T_1 F_2	T_3 F_1	T_5 F_1	T_7 F_1
T_1 F_2	T_3 F_2	T_5 F_2	T_7 F_2
T_2 F_1	T_4 F_1	T_6 F_1	T_8 F_1
T_2 F_2	T_4 F_2	T_6 F_2	T_8 F_2

Table 1. Mechanical composition of the soil

Fractions	Per cent composition	Procedure adopted
Coarse sand	27.15	Robinsons international Pipette Method (Piper, 1950)
Fine sand	27.00	
Clay	36.00	
Silt	10.00	
Textural class	Sandy clay loam	I.S.S.S.system

FIG.1. LAY OUT PLAN



TREATMENTS

DATE OF PLANTING

T_1 – July 15th 1988
T_2 – August 15th '88
T_3 – September 15th '88
T_4 – October 15th '88
T_5 – November 15th '88
T_6 – December 15th '88
T_7 – January 15th 1989
T_8 – February 15th '89

FERTILIZER LEVELS

F_1 – N.P.K. 75:40:25 kg/ha

F_2 – N.P.K. 150:60:60 kg/ha

Table 2. Physical constants of the soil

Constants	Value	Procedure adopted
Field capacity (0.3 bars)	19.1%	Pressure plate apparatus (Richards, 1947)
Moisture per cent 15 bars	10.3%	Pressure plate apparatus (Rihards, 1947)
Bulk density $g\ cm^{-3}$	1.50	Core Method (Blake, 1965 a)
Particle density	2.42	Pychometer method (Blake, 1965 b)

Table 3 Chemical properties of the soil

Description of properties	Value	Method employed
Organic carbon	1%	Walkley and Black rapid titration method (Jackson, 1958)
Available nitrogen	183.23 kg/ha	Alakaline permanganite Method (Subbiah and Asija, 1956)
Available phosphorus	64.8 kg/ha	Chloro Stannoues reduced molybdo phosporic blue colour method in hydro-chloric acid system (Jackson, 1958)
Available potassium	103 kg/ha	Flame photometry neutral normal ammonium acetate extraction (Jackson, 1958)
Soil reaction (pH)	5.63	Soil water suspension of 1:2.5 (Jackson, 1958)
Electrical conductivity	0.43	Soil water extract of 1:2.5 (Jackson, 1958)

C Cultural operations

1. Nursery practice

Nursery was raised by mixing sand, soil and farm yard manure in the ratio of 1:1:1. The soil medium was sterilised by using formaldehyde (0.5%) prior to one week of sowing seeds to reduce mortality of seedlings in the nursery. Care was taken to provide adequate moisture, drainage and plant protection measures in the nursery.

2. Preparation of main field

The experimental field was properly dug and cleared and levelled before the layout was made. Plots of 3 m x 4.5 m size were taken leaving buffer strips of 90 cm width all around the plot. A spacing of 60 m x 60 cm was given to accommodate 35 plants in each treatment.

3. Manures and fertilizers and their application

Well decomposed farm yard manure at the rate of 20 t ha^{-1} was applied uniformly to all plots as basal dose. Urea, superphosphate and muriate of potash were used as fertilizers to supply nitrogen, phosphorus and potassium respectively. The quantities of fertilizers added to each plot under two fertilizer levels were:

Irrigation was given an alternative days during non-rainy spells and during summer months. Staking was given to reduce lodging of plants and to facilitate cultural operations and for precise data collection.

6 Harvesting and seed extraction

Fruits were harvested at ripe stages as indicated by colour change from green to red. Fruits from five plants randomly selected were harvested for observation and further study. Before seed extraction various observations were taken. Fruits were then crushed well in a plastic bucket by hand and made into a paste. The entire mass was kept as such for 48-72 hours to ferment.

The fermented seed mass was thoroughly washed under tap water. The sedimented seeds were collected by decanting water and seeds were dried under shade to a moisture level of 8%.

D Observations

The following observations were recorded on five randomly selected plants for each treatment.

1. Days to first flower

Days to first flower after transplanting were recorded for each treatment and the mean was worked out.

	Urea	Super Phosphate	MOP
K A U Recommendation (F_1)	0.210 kg	0.252 kg	0.053 kg
ICAR recommendation (F_2)	0.420 kg	0.378 kg	0.126 kg

Fertilizer was applied as follows. Half of the nitrogen, full phosphorus and half of potash applied as basal dose at the time of planting. One fourth of nitrogen and half of potash was applied 25 days after transplanting. The remaining nitrogen was applied, one month after the first application.

4. Transplanting

One month old seedlings were transplanted in the main field. During rainy season, seedlings were planted on ridges, and in summer months plantings were done on furrows at a spacing of 60 x 60 cm. Nursery beds were irrigated before pulling out the seedlings and irrigation was given immediately after transplanting. Shading was also provided during summer months and shades were removed after three days. The gap filling was done within one week of transplanting.

5. After cultivation

The plots were kept free of weeds throughout the crop growth period. Plant protection measures were followed as per package of practice recommendation of KAU 1986, to ensure a healthy crop stand.

Irrigation was given an alternative days during non-rainy spells and during summer months. Staking was given to reduce lodging of plants and to facilitate cultural operations and for precise data collection.

6 Harvesting and seed extraction

Fruits were harvested at ripe stages as indicated by colour change from green to red. Fruits from five plants randomly selected were harvested for observation and further study. Before seed extraction various observations were taken. Fruits were then crushed well in a plastic bucket by hand and made into a paste. The entire mass was kept as such for 48-72 hours to ferment.

The fermented seed mass was thoroughly washed under tap water. The sedimented seeds were collected by decanting water and seeds were dried under shade to a moisture level of 8%.

D Observations

The following observations were recorded on five randomly selected plants for each treatment.

1. Days to first flower

Days to first flower after transplanting were recorded for each treatment and the mean was worked out.

2. Days to 50% flowering

Days to 50% flowering for each treatment were recorded as in above case.

3. Plant height

Plant height at peak flowering time was measured from the base and expressed in cm.

4. Number of secondary branches

Total number of main secondary branches were reorded at peak flowering stage.

5. Total inflorescence clusters/plant

The number of inflorescence clusters/plant for each treatment was recorded by taking counts from five plants.

6. Flowers/cluster

Number of flowers from ten randomly selected clusters in five selected plants was recorded for each treatment.

7. Pollen studies

Pollen character like per cent pollen sterility were recorded at 40 x magnification under an ordinary scientific microscope. Freshly opened flowers with bright yellow coloured anthers from five individual plants of each treatment, were collected from the field during morning hours. From these, pollen were extracted on to a clear dry slides and examined after staining under a microscope. The percentage of pollen sterility was worked out as given below.

$$\text{Percentage of sterility} = \frac{\text{Number of pollen with pale colour}}{\text{Total number of pollen}} \times 100$$

From each slide, three different microscopic fields were observed.

8. Fruits/cluster

Total number of fruits in ten randomly selected clusters from each of five plants/treatment were recorded and mean was taken.

9. Fruit set (%)

The loss of grooves between carpels was taken as the criterion for judging fruit set. When the ovary presented a smooth and ungrooved appearance, the fruit set was considered to have occurred (Leopold and Scott, 1952). The fruit set (%) was determined in five plants as follows.

$$\text{Fruit set (\%)} = \frac{\text{Fruits/cluster}}{\text{Flowers/cluster}} \times 100$$

10. Days to first harvest and final harvest

In each treatments days taken from transplanting to first harvest and transplanting to final harvest were recorded from five plants and mean was worked out.

Picking of fruits started when red ripe stage commenced and following observation were recorded.

11. Fruits/Plants

The total of fruits/plant were assessed from five randomly selected plants for each treatment and the mean number of fruits was worked out.

12. Fruit yield/plant and total yield/plot

Total yield/plant was calculated by adding yields of all individual harvest and expressed in grams. The fruits from remaining plants in the plot were harvested and bulk weight was taken and added to get yield/plot. Fruit yield/ha was then worked out on the basis of plot yield and expressed in t/ha.

13. Mean fruit weight

Average fruit weight was calculated from the first three harvests and mean was worked out.

14. Seed yield/plant and/plot

Seeds were extracted from each picking from the marked five plants and summed to get total weight of seeds/plant and expressed in grams. Seeds obtained from the remaining plants in each plot were bulked to get seed yield/plot. Based on seed yield/plot, per hectare seed yield was worked out.

15. Seed content and seeds/fruit

Five well ripened fruits from each of the five plants/ treatment were collected from the third and fourth harvest for seed extraction. The extracted seeds were dried and seeds/fruit and mean seed weight/fruit were recorded.

16. Thousand seed weight

Thousand seeds from each of the five plants/ treatment were taken by count and weighed accurately and expressed in grams.

17. Thousand seed volume

Thousand seeds from each of the five plants from each treatment were taken by count and their volumes were determined by using a measuring jar by water displacement method and expressed in ml.

18. Storage studies

The seeds were stored for three months on completion of final harvest. These seeds were then subjected for the following studies.

a) Germination test

b) Field emergence test

c) Seed vigour test

a) Standard germination test

Germination tests were conducted with three months old seeds adopting the procedure outlined in the ISTA (1976).

Fifty seeds from each treatment were allowed to germinate in sterilised filter paper moist with distilled water in a petridish with glass covering and replicated thrice. Moisture was retained by watering every day. After the 14th day, number of normal seedlings emerged was counted and mean percentage of germination was worked out.

b) Field emergence

Fifty seeds from each of treatment were sown in rows of five c m apart, with a spacing of one cm between seedling in moist bed. There were three replications. Watering was done every day morning. After 14th day, number of normal seedlings emerged was counted and expressed as percentage of field emergence.

c) Seed vigour and calculation of vigour index

The seed vigour was assessed by reckoning vigour index. For this normal seedlings from the field emergence tests were selected at random from each replication. The whole length of seedlings was measured in cm. and by adopting the formula suggested by Abdul-Baki and Anderson (1973), vigour index was calculated and expressed as whole number.

Vigour index = (Root length + Shoot length) x (Germination percentage)

19. Meteorological observations

The meterological data were collected from the meteorological observatory of the College of Horticulture, Vellanikkara. The weekly mean of various weather elements like, maximum temperature, minimum temperature, relative humidity, sunshine hours, evaporation and total rainfall were recorded for the entire period of crop growth. The details of the meterological observations for this period are presented in Appendix I

E Statistical analysis

The data recorded were statistically analysed by applying the analysis of variance techniques for split plot design [Panse and Sukhatme, 1954]. Simple correlations were worked out among important characters, viz., 1000 seed weight, pollen sterility, fruitset, total fruit and seed yield/plant, germination percentage and vigour index with maximum and minimum temperatures, relative humidity and sunshine hours, rain fall and wind speed.

results

IV RESULTS

The data on the investigation were statistically analysed and are presented hereunder:

A Biometric observations

1. Days to first flower

The mean number of days taken for first flower from transplanting are given in Table 4 and its analysis of variance in Appendix I

The date of planting had significant influence on days taken to first flowering. Days taken for first flowering were more in July (T_1) planted seedlings (25.22 days) which did not differ significantly from that of August planting(25.02)and Sept. planting (25.00 days). The treatments T_4, T_5, T_6 and T_7 were on par with each other. The February planted seedlings (T_8) took the shortest number of days (19.83). The number of days taken to first flower showed a decreasing trend from T_1 to T_8.

The fertilizer treatment F_1 [75:40:25 kg NPK/ha] took more days (23.56) than when NPK applied at 150: 60: 60 kg/ha (F_2) (22.69 days).

The interaction between date of planting and two levels of fertilizers had no significant influence on time taken to first flower.

Table 4. Influence of dates of planting and fertilizer levels on number days taken to first flower.

Dates of planting (Main plot treatments)	Mean number of days to first flower	Fertilizer levels (sub plot treatments)	Mean number of days to first flower	Main plot x sub plot MF_1	MF_2
T_1	25.22	F_1	23.56	26.07	24.37
T_2	25.02			25.13	24.90
T_3	25.00			23.70	24.80
T_4	22.75	F_2	22.69	23.63	21.87
T_5	22.82			23.23	22.40
T_6	22.88			23.47	22.30
T_7	22.23			22.73	21.73
T_8	19.83			20.50	19.17
F test	**		**	N.S.	N.S.
SEM ±	0.46		0.27	0.78	0.78
CD (P=0.05)	1.00		0.59	1.67	1.67

* Significant at 5% level
** Significant at 1% level

NS Not significant

2. Days to 50% flowering

The data on the number of days to 50% flowering are presented in Table 5 and the analysis of variance in Appendix I, and illustrated in Fig. 2.

The data showed that time of planting had significant influence on days taken to 50% flowering. The treatments T_3 and T_1 (September and July plantings) had taken maximum days 35.45 and 35.38 respectively. The treatment T_8 (February) took shorter number of days (29.25) for 50% flowering.

The fertilizer levels also exerted a significant influence on days to 50 per cent flowering. Fertilizer applied at F_1 (75: 40: 25 kg NPK/ha) took more number of days (33.73 days) than F_2 (32.82 days).

The interaction effect of date of planting and level of fertilizers had a significant influence on days taken to 50 per cent flowering. The long duration resulted in July planting under F_1 (36.17 days) and September planting under F_2 (35.43 days). It was observed that February planting took the shortest days (28.83 days) under F_2 which was on par with F_1 (29.67 days).

Fertilizer level F_2 (NPK 150:60:60 kg/ha) was found to be significantly superior to F_1 for shortening the time for 50% flowering.

Table 5. Influence of dates of planting and fertilizer levels on mean number of days taken to 50% flowering

Dates of planting (Main plot treatments)	Mean number of days taken to 50% flowering	Fertilizer levels (sub plot treatments)	Mean No. of days to 50% flowering	Main plot x sub plot	
				MF_1	MF_2
T_1	35.38	F_1	33.74	36.17	34.60
T_2	33.83			35.30	32.34
T_3	35.45			35.47	35.43
T_4	34.20	F_2	32.82	34.37	34.03
T_5	33.88			34.00	33.77
T_6	32.92			33.30	32.53
T_7	31.32			31.63	31.00
T_8	29.25			29.67	28.83
F test	**		**	*	*
SEM ±	0.72		0.17	0.50	0.50
CD (P = 0.05)	1.56		0.37	1.06	1.06

* Significant at 5% level
** Significant at 1% level

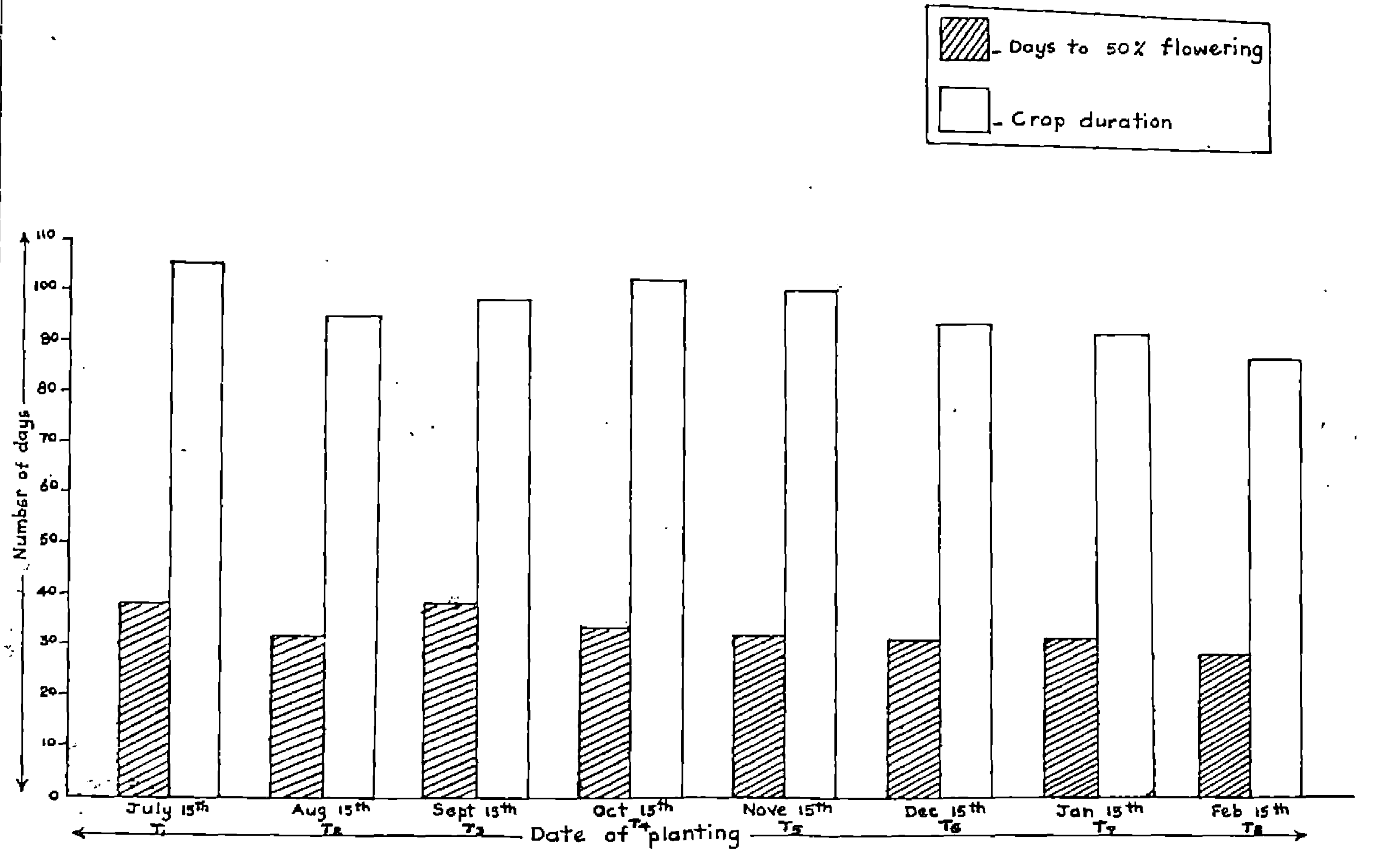


Fig.2. EFFECT OF DATE OF PLANTING ON DAYS TO 50% FLOWERING AND CROP DURATION.

3. Plant height at 50% flowering

The mean values of height at 50% flowering are presented in table 6 and analysis of variance in Appendix II.

The mean plant height was not significantly altered by different dates of planting. However the two fertilizer levels envinced significant influence on plant height. The fertilizer level tried at F_2 (150: 60: 60 kg NPK/ha) showed a higher value (59.85 cm) than F_1 level (57.03 cm). The interaction between date of planting and fertilizer levels had no significant influence on plant height.

4. Main secondary branches

The data on mean number of secondary branches per plant at 50% flowering are presented in Table 7 and analysis of variance in Appendix II.

Significant differences were observed on the number of branches produced under different dates of planting. The maximum number of branches were produced in November planting (T_5, 3.30) closely followed by October planting (3.28). The treatments T_2 and T_3 were on par with each other. The least number of branches was recorded in February planting (T_8, 2.08).

Between the fertilizer levels, F_2 (150 : 60 : 60 kg NPK/ha) significantly influenced number of branches with a maximum (2.96)

Table 6. Influence of dates of planting and fertilizer levels on plant height

Dates of planting (Main plot treatments)	Mean Plant height (cm)	Fertilizer levels (sub plot treatments)	Mean plant height (cm)	Main plot x Sub plot	
				MF_1	MF_2
T_1	57.77	F_1	57.03	54.97	60.57
T_2	57.65			56.06	59.23
T_3	58.92			57.70	60.13
T_4	61.80	F_2	59.85	59.43	64.16
T_5	56.90			58.57	55.23
T_6	59.12			57.13	61.10
T_7	57.70			56.30	59.10
T_8	57.70			56.10	59.30
F test	N.S.		**	N.S.	N.S.
SEM ±	1.98		0.95	2.70	2.70
CD (P=0.05)	2.02		2.02	5.73	5.73

* Significant at 5% level
** Significant at 1% level
NS Not Significant

Table 7. Influence of dates of planting and fertilizer levels on number of secondary branches

Dates of planting (Main plot treatments)	Mean number of secondary branches	Fertilizer levels (sub plot treatments)	Mean number of Secondary branches	Main plot x sub plot	
				M F_1	MF_2
T_1	2.98	F_1	2.58	2.87	3.10
T_2	2.55			2.37	2.73
T_3	2.58			2.43	2.73
T_4	3.28			3.10	3.47
T_5	3.30	F_2	2.96	2.96	3.63
T_6	2.87			2.66	3.06
T_7	2.50			2.40	2.60
T_8	2.08			1.83	2.33
F test	**		**	N.S.	N.S.
SEM ±	0.15		0.05	0.17	0.17
CD (P = 0.05)	0.39		0.12	0.36	0.36

* Significant at 5% level
** Significant at 1% level
NS - Not significant

for F_2 and minimum (2.58) for F_1 . The interaction effect between dates of planting and levels of fertilizers had no pronounced influence on number of branches.

5. Total inflorescences/plant

The data on total inflorescences per plant are presented in Table 8 and its analysis of variance in Appendix III.

The influence of date of planting on the total number of inflorescences produced/plant was significant. October planted seedlings recorded the highest number (22.46, T_4) and the least value in February planting (11.73, T_8). The treatment T_4 (October planting) was significantly superior to all other treatments.

The fertilizer level F_2 (150:60:60 kg NPK/ha) significantly produced more inflorescences (17.58) as compared to F_1 fertilizer level (15.28). The interaction effect between date of planting and fertilizer levels showed a significant change. October planting resulted in the highest number of inflorescence under F_1 and F_2 though it did not differ from November planting under F_1. The least number of inflorescence was observed from February planting under F_1 and F_2, while it was on par with July and January plantings under F_2 level. Fertilizer level F_2 was found to be significantly superior to F_1 for August, September, October, December and February plantings. For the month of July, November and January planting F_1 level in sufficient.

Table 18. Influence of dates of planting and fertilizer levels on mean number of inflorescences/plant

Dates of planting (Main plot treatments)	Mean number of inflores-cences/plant	Fertilizer levels (sub plot treatments)	Mean number of inflores-cences/plant	Main plot x sub plot	
				MF_1	MF_2
T_1	15.72	F_1	15.28	15.17	16.27
T_2	13.37			12.33	14.40
T_3	16.27			14.80	17.73
T_4	22.47	F_2	17.58	20.00	24.93
T_5	19.68			19.20	20.17
T_6	17.95			16.87	19.03
T_7	14.27			13.60	14.13
T_8	11.73			10.27	13.20
F test	**		**	**	**
SEM ±	0.36		0.20	0.57	0.57
CD (P =0.05)	0.77		0.43	1.22	1.22

* Significant at 5% level
** Significant at 1% level

6. Flowers/cluster

The data on mean number of flowers per cluster are presented in Table 9 and analysis of variance in Appendix III and illustrated in Fig. 3.

There was significant difference in flowers/cluster with respect to different dates of planting. The October planting (T_4) recorded the highest value (5.71) followed by T_5 (4.88). The treatment T_2 and T_3 were at par. The least number of flowers/cluster was produced in February planting (T_8 ,3.73), which was on par with August planting (3.92).

The fertilizer treatment also had significant effect on the number of flowers produced. The F_2 level recorded more flowers/cluster (4.60) than F_1 level (4.31).

The interaction between date of planting and fertilizer levels also envinced significant influence on number of flowers per cluster. October planting resulted in maximum number of flowers/cluster under both fertilizer levels. The lowest number of flowers/cluster was observed for February planting under F_1 and F_2 and was on par with August planting, and September planting under F_1 . More number of flowers/cluster was recorded for July,September and October plantings under F_2 level.

Table 9. Influence of dates of planting and fertilizer levels on number of flowers/cluster

Dates of planting (Main plot treatments)	Mean number of flowers/cluster	Fertilizer levels (sub plot treatments)	Mean number of flowers/cluster	Main plot x Sub plot	
				MF_1	MF_2
T_1	4.40	F_1	4.31	4.20	4.60
T_2	3.92			3.80	4.03
T_3	4.17			3.77	4.57
T_4	5.71	F_2	4.60	5.37	6.06
T_5	4.88			4.87	4.90
T_6	4.58			4.57	4.60
T_7	4.27			4.20	4.33
T_8	3.73			3.73	3.73
F test	**		**	*	*
SEM ±	0.13		0.05	0.16	0.16
CD (P = 0.05)	0.29		0.12	0.34	0.34

* Significant at 5% level
** Significant at 1% level

7. Pollen sterility

Data on pollen sterility are depicted in Table 10 and its analysis of variance in Appendix III and illustrated in Fig.3.

A significant difference in the percentage of pollen sterility was observed with respect to different dates of planting. The highest percentage of pollen sterility recorded in February planting (T_8, 49.69) which is significantly different from all other treatments. The lowest percentage of pollen sterility was recorded in October planting (T_4, 12.47) followed by November planting (18.19%).

The fertilizer levels tried had no significant influence on percentage of pollen sterility. The interaction effect had no significant impact on pollen sterility.

8. Fruits/cluster

Data on this parameter are presented in Table II and its analysis of variance in Appendix III and illustrated in Fig 3.

The mean number of fruits per cluster was significantly influenced by different dates of planting. The highest number of fruits/cluster was recorded in October planting (T_4, 4.23) followed by November planting (3.85). The lowest number was recorded in February planting (1.98).

Table 10. Influence of dates planting and fertilizer level on pollen sterility (%)

Dates of planting (Main plot treatments)	Mean value of pollen sterility (%)	Fertilizer level (sub plot treatments)	Mean valu of pollen sterility (%)	Main plot x Sub plot MF$_1$	MF$_2$
T_1	21.27	F_1	26.06	21.78	20.77
T_2	26.37			26.17	26.58
T_3	19.30			19.88	18.73
T_4	12.47	F_2	25.34	12.84	12.10
T_5	18.19			18.73	17.66
T_6	25.98			26.52	25.45
T_7	32.35			32.20	32.51
T_8	49.69			50.43	48.95
F test	**		N.S.	N.S.	N.S.
SEM±	1.18		0.39	1.10	1.10
CD(P =0.05)	2.53		0.83	2.34	2.34

* Significant at 5% level
** Significant at 1% level
NS Not significant

Table 11 Influence of dates of planting and fertilizer levels on fruits/cluster

Dates of planting (Main plot treatments)	Mean fruits/ cluster	Fertilizer levels (sub plot treatments)	Mean fruits/ cluster	Main plot x sub plot	
				MF_1	MF_2
T_1	2.92	F_1	3.07	2.87	2.96
T_2	2.42			2.30	2.53
T_3	2.93			2.63	3.23
T_4	4.23	F_2	3.25	4.13	4.33
T_5	3.85			3.80	3.90
T_6	3.68			3.60	3.76
T_7	3.23			3.26	3.20
T_8	1.98			1.93	2.03
F test	**		**	N.S.	N.S.
SEM ±	0.10		0.04	0.14	0.14
CD (P =0.05)	0.22		0.10	0.29	0.29

* Significant at 5% level
** Significant at 1% level
N.S. Not significant

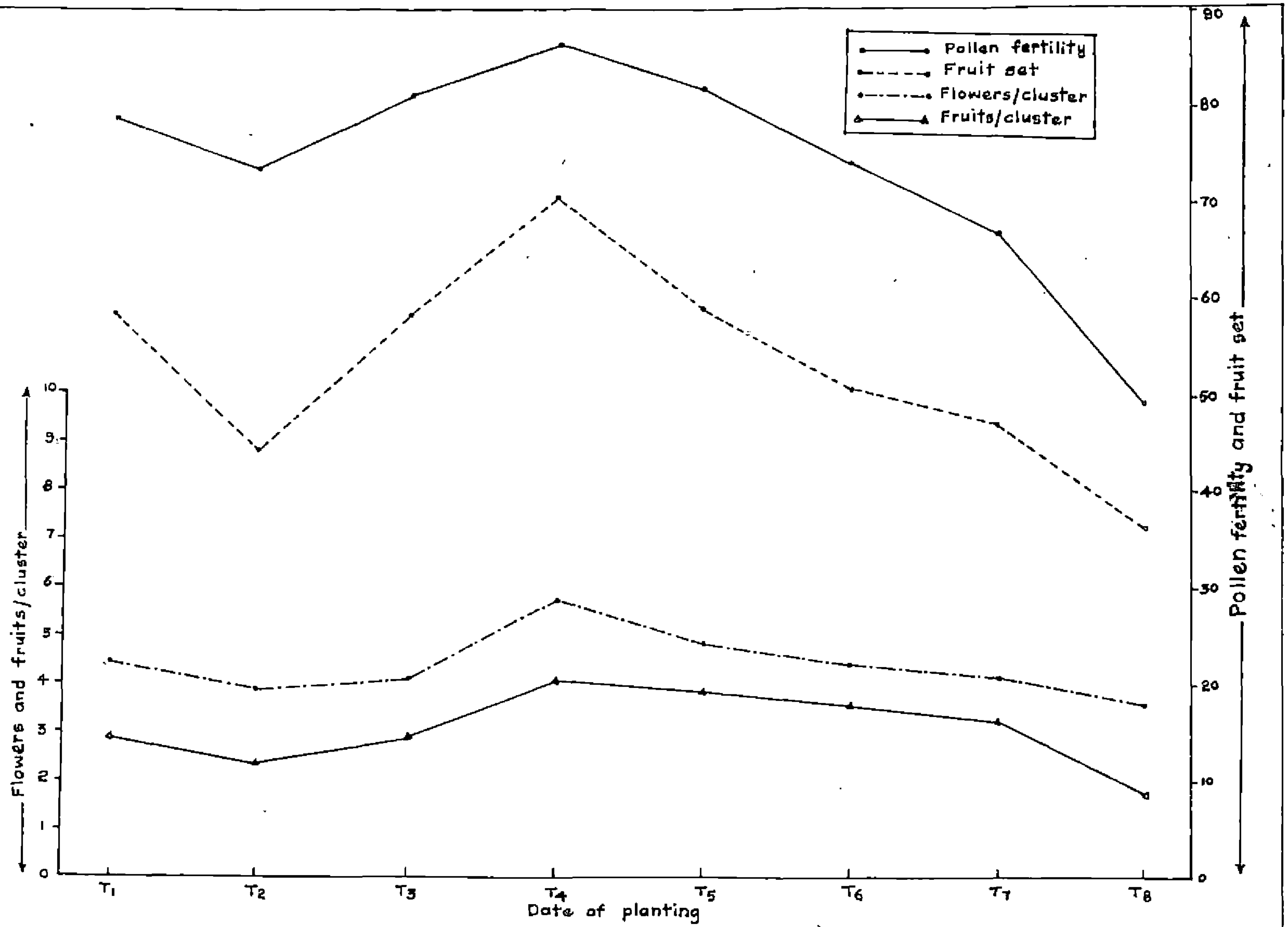


Fig.3. EFFECT OF DATE OF PLANTING ON FLOWERS AND FRUITS/CLUSTER, POLLEN FERTILITY AND FRUIT SET.

The higher level of fertilizer (F_2 150:60:60 kg NPK/ha) recorded more number of fruits/cluster (3.25) which differed significantly from F_1 (3.07). The interaction effect of date of planting and level of fertilizers had no pronounced influence on fruits/cluster.

9. Fruit set (%)

The data on mean fruit set are presented in Table 12 and analysis of variance in Appendix III and illustrated in Fig. 3.

The dates of planting had a significant influence on fruit set. The highest percentage of fruit set was recorded in October planting (70.07%, T_4) which was significantly superior to all other treatments. The least fruit set was recorded in February planting (36.06%, T_8). The treatments T_6 and T_7 were at par.

Of the two fertilizer levels the higher level of NPK (150: 60:60 kg/ha) recorded more fruit set (53.46%) than lower level (52.40%) which were significantly different. The interaction effect of date of planting and levels of fertilizers had a significant influence on fruit set. F_2 was found to be superior to F_1 for the month of August, October and February only.

10. Fruits/plant

The data are presented in Table 13 and analysis of variance in Appendix IV, and illustrated in Fig. 4.

Table 12. Influence of date of planting and fertilizer levels on fruit set (%)

Dates of planting (Main plot treatments)	Mean value of fruit set (%)	Fertilizer levels (sub plot treatments)	Mean value of fruit set (%)	Main plot x sub plot	
				MF_1	MF_2
T_1	58.29	F_1	52.40	57.75	58.83
T_2	44.82			43.90	45.73
T_3	58.33			58.47	58.20
T_4	70.07	F_2	53.46	68.40	71.73
T_5	58.18			58.03	58.33
T_6	50.17			50.20	50.13
T_7	47.50			47.10	47.90
T_8	36.06			35.33	36.80
F test	**		**	*	*
SEM ±	1.06		0.21	0.60	0.60
CD (P =0.05)	2.28		0.45	1.26	1.26

* Significant at 5% level
** Significant at 1% level

Table 13. Influence of dates of planting and fertilizer levels on fruits/plant

Dates of planting (Main plot treatments)	Total fruits/ plot	Fertilizer levels (sub plot treatments)	Total fruits/ plant	Main plot x sub plot	
				MF_1	MF_2
T_1	26.30	F_1	24.40	24.60	28.00
T_2	14.75			13.17	16.33
T_3	27.92			25.93	29.90
T_4	38.15	F_2	26.69	36.50	39.80
T_5	29.67			28.97	30.36
T_6	29.28			27.83	30.73
T_7	26.98			26.80	27.16
T_8	11.31			11.43	11.20
F test	**		**	N.S.	N.S.
SEM ±	1.11		0.50	1.42	1.42
CD (P = 0.05)	2.39		1 06	3.01	3.01

* Significant at 5% level
** Significant at 1% level
NS - Not significant

Fruits/plant differed significantly between treatments. The highest number of fruits/plant recorded in October planting (38.15, T_4) and the lowest number in February planting (11.31, T_8). The treatments T_5, T_6 and T_7 are on par with each other.

The fertilizer application also effected significant changes on the number of fruits per plant. The F_2 level of fertilizer (NPK 150: 60: 60 kg/ha) recorded higher fruits/plant. The interaction between date of planting and fertilizer levels was not significant.

11. Days to first harvest and final harvest

The data on mean number of days taken to first and final harvest were presented in Tables 14 and 15 respectively.

The date of planting effected a significant influence on days taken to first harvest. The August planting took maximum number of days (58.50, T_2)which was on par with July & September planting. January planting recorded the shortest number of days (53.52, T_7), which was on par with December and February plantings. The treatments T_4, T_5 and T_6 were on par with each other.

The treatments under F_1 level (NPK 75:40:25 kg/ha) took more number of days (55.73) which were significantly different from F_2 level (54..72 days). The interaction effect of date of planting and fertilizer treatments also had a significant influence on number of

Table 14. Influence of dates of planting and fertilizer levels on days to first harvest

Dates of planting (Main plot treatments)	Mean days to first harvest	Fertilizer levels (sub plot treatments)	Mean days to first harvest	Main plot x Sub plot	
				MF_1	MF_2
T_1	57.30	F_1	55.73	59.47	55.13
T_2	58.50			58.57	58.43
T_3	57.63			56.73	58.53
T_4	54.30	F_2	54.72	56.06	52.53
T_5	54.82			54.87	54.77
T_6	53.68			53.50	53.87
T_7	52.52			52.67	52.33
T_8	53.05			53.97	52.13
F test	**		**	**	**
SEM ±	0.66		0.35	1.00	1.00
CD (P = 0.05)	1.42		0.74	2.12	2.12

* Significant at 5% level
** Significant at 1% level
NS Not significant

Table 15 Influence of dates of planting and fertilizer levels on number of days to last harvest

Dates of planting (Main plot treatments)	Mean number of days to last harvest	Fertilizer levels (Sub plot treatments)	Mean days to last harvest	Main plot x Sub plot	
				MF_1	MF_2
T_1	105.20	F_1	96.01	105.20	105.20
T_2	95.67			94.00	97.33
T_3	99.50			97.13	101.87
T_4	102.75	F_2	98.42	101.77	103.73
T_5	99.13			97.10	101.67
T_6	94.80			94.57	95.03
T_7	92.71			91.33	94.10
T_8	88.00			87.03	88.97
F test	**		**	N.S.	N.S.
SEM ±	2.00		0.56	1.58	1.58
CD (P = 0.05)	4.30		1.18	3.35	3.35

* Significant at 5% level
** Significant at 1% level

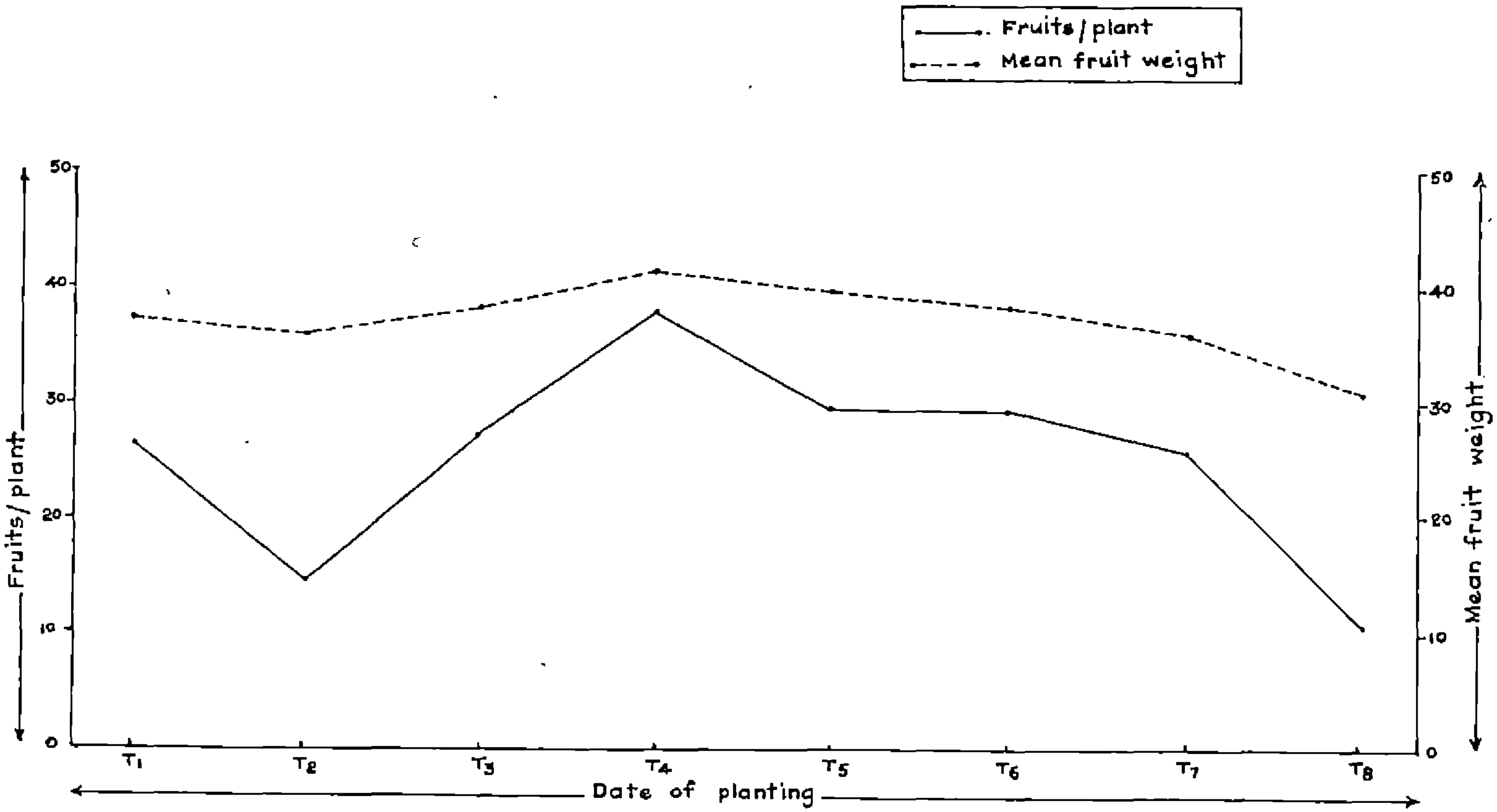


Fig. 4. EFFECT OF DATE OF PLANTING ON FRUITS/PLANT AND MEAN FRUIT WEIGHT

Plate I Field crop stands in different dates of planting

Plate II October planted seedling crop

Plate III Seed germination study carried in a Tray containing soil as a medium

Plate IV Seedling length after 14th day of sowing in October planted seedlings under two fertilizer levels

Plate V Seedling length after 14th day of sowing in December planted seedlings under two fertilizer levels

discussion

DISCUSSION

Plant productivity is the result of interaction of plant with environment. Consequently improvements in plant performance could occur with manipulation of environment to provide a more suitable mileu for growth. Genetic and environmental improvements can together interact to manifest maximum plant productivity (Maynard, 1978).

Successful cropping in tomato is a complex phenomenon governed by a number of factors such as variety, season, nutrition and other environmental factors. As a consequence, numerous variations are met with in the yield potential of tomato varieties; the environmental stress poses a constant threat to the tomato crop particularly in summer. Cultural and agronomic practices exert a profound influence on tomato cropping. Unbalanced use of NPK fertilizers not only affects the growth and yield of the plant but the fruit set and quality also. Seed yield and quality in tomato as influenced by various agro-climatic conditions are important information for tomato seed producers.

Growing of tomato in Kerala is very much limited, but on the advent of new varieties the farmers, have become more conscious of the vast potentialities of tomato growing in the State. The present study was therefore designed with the specific objectives of studying the influence of date of planting and fertilizer levels on seed yield and quality in tomato, using a bacterial wilt resistant variety -

Shakthi, grown throughout the state. Detailed observations on vegetative characters, yield parameters and influence of various weather elements on fruit and seed yield and quality were critically examined. The salient findings are discussed hereunder.

A. Vegetative characters

1. Plant growth

The differences in plant height as affected by dates of planting were not significant. Between two fertility levels, the higher level of NPK (150:60:60 kg/ha) was superior to lower level (75:25:40 kg/ha). The result showed that NPK application increased plant height significantly. The interaction effect between date of planting and fertilizers on plant height was null and void. The increase of plant height due to fertilization was reported by many workers earlier (Randhawa et al., 1977; Gupta and Shukla, 1978). The predominant role of nitrogen to enhance vegetative growth is associated with high synthesis of biochemical substances which are essential for plant growth. Obviously the higher level of nitrogen in the present study did show a significant change.

2. Secondary branches

The number of secondary branches/plant significantly varied with different dates of planting. The highest number of secondary branches was recorded in September planting, followed by October planting. The effect of fertilization was also significant on the production of branches. The higher level of NPK effected more number of branches. The more number of branches produced in October, November and December may be due to more favourable conditions-mild winter temperatures (22 to 23°C) — prevailed during that period. It is also possible that development of lateral shoots is altered by mineral nutrition, hormones, photoperiods, moisture and temperature as reported by Abdalhafeez and Verkerk, 1969 and Tucker, 1976.

B Yield characters

1. Inflorescence clusters/plant

The total number of inflorescence/plant was the highest in October planting followed by November and December plantings. The fertilizer application also had an influence on the number of inflorescences. Significant increase in number of inflorescence was observed with higher level of NPK. The date of planting and the fertilization interacted on the inflorescence production. So with manipulation of the environment and fertilization the productivity of tomato can be favourably changed.

2. Flowers/cluster

The total flowers/cluster was maximum in October planting followed by November and December plantings. This character also is favourably changed by low temperature conditions prevailed during the period. The flower production was drastically reduced in February, when there existed a higher temperature conditions (36 to 37°C). The negative effect of high temperature for flower initiation and development was already reported by Went (1945) and Calvert (1953).

The significant effect of fertilizers and their interaction with date of planting was observed. The efficiency of fertilizer application always depends on the effective utilization by plants. Higher uptake of nutrients helped by the environmental conditions tell upon the crop performance. So in this study not only the quantity of fertilizers, but the time of application is important to bring about the desired effect on the plant characters.

3. Pollen sterility, fruit set and fruits/cluster

The essential processes for fruitset are (i) production of viable pollen (ii) transfer of pollen to the stigma (iii) germination of the pollen grains and growth of the pollen tube down , the style and (iv) union of male gamete with viable ovule (Calvert, 1964). All of these processes are temperature sensitive and have revealed that steps, first and second, are severely affected by timing factors (Abdalla and Verkerk, 1968; Charles and Harris, 1972; and Levy, 1972).

In the present study, time of planting was found to exert a marked influence on pollen sterility, fruit set and fruits/cluster. The pollen fertility, fruit set and fruits/cluster were found maximum in October planting and minimum in February planting. Of the two fertilizer levels, higher rate of fertilization (NPK 150:60:60 kg/ha) showed significant effect on fruitset, and fruits/cluster. The pollen fertility decreased as the temperature increased, as there was a positive correlation between pollen sterility and maximum temperature. This finding is in confirmation with the earlier reports of Balakrishnan (1963) and Paul Devakumar (1965).

Pollen sterility recorded in the July and August plantings were high. This may be due to poor nutritional uptake under high rainfall conditions and inadequate sunlight. Correlation studies also showed that there was positive correlation between rainfall and pollen sterility. Howlett (1936 and 1936) opined that carbohydrates are essential for the normal anther development and their deficiency leads to microspore degeneration and pollen sterility. This observation fits well in this context.

Negative correlation of fruit set with minimum temperature and the rainfall established the fact that high temperature and high rainfall conditions hamper fruit set in tomato. The influence of rainfall and high temperature on pollen sterility can be one of the factors for low fruit set. The adverse effect of rainfall is also due to washing away of pollen grains and poor germination of pollen. This could be the main reason for low fruit set in the August planted seedlings. The high fruit set in October and November planted seedlings can be attributed to high pollen fertility, lower temperature conditions present during these periods. The correlation studies further substantiate this point.

The maximum pollen sterility and the lowest fruit set were obtained in February planting. The style elongation and exertion of stigma under high temperature conditions can be yet another reason for low fruit set under higher temperatures as reported by Rick and Dempsey (1969). High temperature also results in bud drop, splitting of antheridial cone, reduction of quantity and functionability of gamates which can collectively contribute to low fruit set (Levy et al., 1978). The higher number of fruits/cluster observed in the October planting is due to the higher fruit set during these periods.

4. Fruits/plants, fruit yield and average fruit

Tomato yield is mainly decided by number of plants/ unit area, number of flowers/cluster, mean percentage of fruit set and fruit weight. But environmental factors such as light intensity, temperature and moisture stress affect these yield components (Lipton, 1970; Kinit, 1977; Villareal et al., 1978).

The present study revealed that dates of planting had significant influence on fruits/plant, average fruit weight and fruit yield/plant. The October planting recorded the maximum fruits/plant, mean fruit weight and fruit yield/plant. This character showing a decreasing trend can be well ascribed to increase of temperature during these periods (32°C to 37°C). Prevalence of high temperature can cause water deficit in plants which leads to formation of abscission layer and blossom and fruit drops. Similar observation was recorded by Gardner et al. as early as in 1952. The correlation studies also proved that with increase of temperature there was increase of pollen sterility and poor fruit set. Lack of pollination due to insufficient fertile pollen can affect fruit set and seed content of the fruits. Temperature during summer ranged from 36 to 37°C.

The fruit yield/plot and estimated yield/ha were more in October planting, followed by November and December plantings. The poor yield in August planting attributed to poor establishment of seedling due to heavy rains existed during this period (1152 to 1675 mm). Yield/plot and estimated yield/ha showed a decreasing trend from December to February which was keeping in line with the similar trend in fruits/plant and fruit yield/plant.

There was significant increase in fruits/plant, fruit yield/plant on NPK fertilization. The higher level of NPK (150:60:60 kg/ha) was better than lower level. Since the higher level of NPK is effective to increase yield components, still higher level of NPK fertilization can be tried to boost up tomato production.

The wide variations in performance of tomato under different situations are attributed to differences in weather conditions prevailing in the locality. Similar observations were recorded by many workers

(Arora et al., 1969; Nandpuri et al., 1971; Muthukrishnan et al., 1982). The effect of NPK fertilization on significant increase in fruit yield is in agreement with the finding of Randhawa et al. (1977); Gupta et al, (1978); and George et al(1980). High soil temperature during summer can adversely affect yield components as reported by Hisatomi (1972).

5. Earliness and crop duration

The transplantings made at different times showed significant differences in days to first flower, 50% flowering and days to first harvest. Days to first flower and 50% flowering were more in July planting, and it decreased slowly as the date of planting progressed from July to February. The time taken for first harvest was more in July, August and September plantings as compared to December, January and February plantings. The months of July to September marked with high rainfall are attributed to these differences.

The fertilizer treatment was significant to bring about earliness for first flowering, 50% flowering and for first harvest. The higher level of NPK (150:60:60 kg/ha) was more efficacious than the lower level.

As is evident with increase of temperature the earliness is also increased. Most of the bio-chemical reactions proceed faster at higher temperatures so plant growth is quicker under warmer conditions. The higher temperature helps in better uptake of nutrients and catalyses for early completion of vegetative phase. Earliness in this crop was influenced by environmental conditions. Higher temperature conditions convert vegetative phase to reproductive phase, resulting in earlier flower bud differentiation and development. The reports of Saito and Ito (1962) draw a parallel to the present findings in tomato.

Crop duration significantly varied with different dates of planting. The July planting took maximum crop duration, while February planted seedlings recorded the minimum duration. The crop duration decreased with the increase in day and night temperatures, which favours an early bud differentiation and development. Higher level of fertilizer was found lengthened the crop duration significantly in comparison with lower level. Wittwer (1960) opined that by advancing the photoperiod upto 16-17 hours, seedling growth was increased. Thus flowering in tomato plants could be modified by light intensity and photoperiod.

C. Seed yield

Seed yield/plant, seeds/fruit, seed weight/fruit and seed yield/plot varied significantly with changes in dates of planting. October planting recorded the maximum seed yield/plant, seeds/fruit and seed weight/fruit. But planting from November to February showed a decreasing trend on seed number and seed yield. Correlation studies showed that, there was positive correlation between fruit yield and seed yield. Seeds/fruit and seed weight/fruit increased when fruit weight increased. So the seed content of the fruit and fruit weight are interrelated. The seed weight and fruit weight decreased as the planting season advanced from October to February. The difference is attributed to the variance in climatic factors as there was in inrease of temperature from 32°C to 37°C during the period.

A positive correlation between seed content and fruit size, and fruit weight was projected by Verkerk (1957), Paul Devakumar (1965), and Dempsey and Boynton (1965). The variation in tomato seed yield during different dates of planting was reported by Vadivelu and Srimathy in 1988.

The present study also showed that NPK fertilization influences seed yield/plant and seed weight/fruit as higher fertilizer level significantly improved seed yield and seed weight. Fruit and seed yield increased with higher fertilization which was also reported by workers like Kuksal et al. (1977), and Varis and George (1985).

D. Seed quality

The most important aspect of quality of seeds is that it should be highly viable and vigorous. These characters are often affected by pre-harvest and post-harvest factors. Pre harvest factors like planting time and mineral nutrition can be of considerable influence on seed quality.

The results of the present study showed that the date of planting affected 1000 seed weight and 1000 seed volume significantly.

The high seed weight and volume was found in October planting followed by November and December plantings. The fertilizers applied at two levels did not evince any change on these characters.

The germination percentage, field emergence of seedlings, seedling length and seed vigour index have been significantly influenced by date of planting. The highest seed germination and field emergence were recorded in November planting followed by October planting. So far as seedling length and vigour index are concerned, October and November plantings behaved in the same manner. The higher level of fertilizer had a significant effect on seed germination, field emergence, seedling length and vigour index. From the data, it could be seen that certain seed quality parameters are improved by high fertility level. So these aspects needs a detailed study to know which of the NPK components twilts more favourably to seed quality.

The findings of Vadivelu (1983), showed that with the higher dose of NPK, the higher germination % was recorded in tomato. The influences of weather parameters on seed yield characters are more conspicuous than seed quality characters as evident from the present study. There was no strong correlation between weather parameters and seed quality characters.

E. Crop weather relation ships

From the correlation studies it was found that maximum temperature during 3rd, 4th and 5th week and total rainfall during 4th week and 5th week after planting had significant positive correlation with pollen sterility. This finding was in conformity with results of Stevens and Rudich (1978), that pollen production and viability are reduced at high temperature. The minimum temperature and the total rainfall had a negative correlation with fruitset. Other characters like fruits/plant, fruit yield/plant and seed yield/plant also had a significant negative correlation with minimum temperature.

It may be summed up that apart from inherent varietal characters seasonal and other environmental conditions largely decide upon the pattern of fruit production and seed quality in tomatoes. The role of temperature is the one and the most decisive factor for tomato production. For most part of Kerala and Central Kerala in particular, October to December are more ideal for tomato production. This part of year is better for seed production also. The weather parameters prevailed during the october crop were as follows; maximum temperature 31.5°C to 32.5°C, minimum temperature 20°C to 23.5°C, relative humidity 50% to 71%, sunshine hours, 6 to 9.3 and total rain fall 1.2 to 6.8 mm. This climatic condition seem ideal for tomato production especially with regard to the variety Sakthi. A higher fertility level (NPK 150: 60: 60 kg/ha) is better than the lower level. The complementary effect of fertilizer application to seasonal influence was evident from the study.

summary

SUMMARY

The present study was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara, Kerala Agricultural University to find out the effect of different dates of planting on seed yield and seed quality of tomato under two fertility levels. The plantings were carried out from July 1988 to February, 1989. The following are the salient findings of the study.

1. The days taken to first flowering and 50% flowering varied with planting dates. The July planting took the longest time (25.21 days) and the least time was (19.83) in February planting. Of the two fertility levels, lower level (NPK 75:40:25 kg/ha) hastened time taken for flowering.

2. The number of secondary branches, total inflorescences/plant, flowers/cluster and fruits/cluster varied with date of planting. October planting recorded higher values as 3.28, 22.46, 5.71 and 4.23 respectively. February planting recorded lower values as 2.08, 11.73, 3.73 and 1.98 respectively for these characters. Of the two fertility levels, the higher level of NPK (150:60:60 kg/ha) was significant for these characters.

3. Pollen sterility and fruit set were changed with different dates of planting. The crop planted on October 15th recorded

the highest pollen fertility (87.53%) and fruit set (70.07%) while it was the lowest in February planted crop (50.31% and 36.06% respectively).

4. The earliness as well as total duration of the crop was found influenced by time of planting. More days were taken for first harvest in August planting (58.50) while January planting took the lowest number of days (52.52 days). The duration for July planting was more (105.20 days) while February planting took the shortest duration (88.00 days).

5. Yield/plant was altered by the time of planting. The total fruits/plant (38.15) average fruit weight (41.67 g), fruit yield per plant (1672.25 g) and seed yield per plant (8.06 g) were maximum in October planting and the lowest was in February planting (11.31, 31.62 g, 347.48g, 1.50 g respectively). Of the two fertility levels, the total number of fruits/plant, fruits and seed yield/plant were significant at higher level of fertility.

6. The seed number and seed weight/fruit were altered by time of planting. The higher was in October planting (63.25, 0.417 g respectively) and the lowest in February planting (48.07, 0.351g respectively).

7. The seed quality characters like thousand seed weight and thousand seed volume varied with different dates of plantings..

The maximum values were recorded in October planting (3.48 g, and 2.697 ml respectively). The 1000 seed weight was minimum in September planting (3.24 g) while 1000 seed volume was minimum at February planting (2.642 ml.)

8. Germination percentage of seed and field emergence were modified by time of planting. The maximum values were recorded in November planted crop (88.36% and 83.03% respectively) and minimum in August planted crop (84.20% and 80.43% respectively). Higher level of fertilization (NPK 150:60:60 kg/ha) resulted in faster and high seed germination and field emergence.

9. The seedling length and vigour index of seedlings also varied with different planting dates. It was maximum in October and November plantings and minimum in August planting.

10. The fruit yield and seed yield/plot were maximum in October planting (49.72 kg and 249.32 g respectively) and minimum in February planting (9.46 kg and 88.47 g respectively). The higher level of fertilization was significant for fruit yield and seed yield /plot. The dates of planting also significantly affected fruit yield and seed yield/hectare and the highest values were obtained in October planting (37.27 t/ha and 186.98 kg/ha respectively) and the lowest in February planting (7.09 t/ha and 30.07 kg/ha) respectively.

11. There was significant positive correlation between pollen

sterility and maximum temperature and total rainfall and negative correlation with relative humidity during third week after transplanting. The fruit set was negatively correlated with minimum temperature during 5th week after transplanting and total rainfall during fourth and fifth week.

Fruits/plant, fruit yield/plant and seed yield/plant were negatively correlated with minimum temperature.

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* Originals not seen

appendices

APPENDIX - I.

Mean weekly weather parameters during the crop growth period

Period No.	Week No.	Dates	Maximum tempera- ture (°C)	Minimum tempera- ture (°C)	Relative humi- dity (%)	Sun shine hours	Mean evapora- tion (mm/day)	Total rain- fall (mm)	Wind Spread (km/day)
1	2	3	4	5	6	7	8	9	10
VII	29	16 to 22	28.2	22.8	83.00	0.3	1.5	245.9	4.5
July 1988	30	23 to 29	27.6	23.3	88.0	0.5	2.1	134.9	3.3
	31	30 to 5	29.9	24.5	86.0	3.6	2.9	89.9	1.7
VIII	32	6 to 12	28.9	23.9	87.5	2.9	2.8	61.2	3.2
August 1988	33	13 to 19	28.2	24.3	89.0	3.2	2.6	177.6	1.7
	34	20 to 26	29.7	24.6	83.5	5.1	3.6	72.1	3.2
	35	27 to 2	29.6	23.6	84.0	3.9	3.5	200.8	4.3
IX	36	3 to 9	29.6	23.6	84.5	4.9	3.1	153.7	4.1
Sept. 1988	37	10 to 16	30.5	23.4	85.0	6.1	3.4	113.7	3.5
	38	17 to 23	29.6	23.4	85.5	4.5		240.0	3.5
	39	24 to 30	29.7	22.4	85.0	4.1	3.7	123.2	4.3
X	40	1 to 7	30.4	23.4	82.0	6.5	3.7	29.8	4.9
October 1988	41	8 to 14	31.8	23.3	78.0	7.7	4.1	19.6	3.5
	42	15 to 21	31.8	24.0	78.5	7.6	3.8	6.8	3.6
	43	22 to 28	31.9	22.8	77.5	6.0	3.3	6.0	3.4
	44	29 to 4	33.3	23.4	71.0	8.1	3.8	6.8	3.3

(Contd...)

APPENDIX - I (Contd.)

1	2	3	4	5	6	7	8	9	10
XI November	45	5 to 11	31.3	23.9	70.0	5.6	3.7	2.0	7.3
	46	12 to 18	33.2	23.2	67.5	9.3	3.3	2.2	4.1
	47	19 to 25	32.6	22.6	65.5	7.7	3.8	-	9.1
	48	26 to 2	32.6	20.6	65.0	7.9	3.9		5.4
XII December	49	3 to 9	31.9	22.7	63.0	7.2	4.8	2.3	4.6
	50	10 to 16	33.4	22.8	62.5	9.3	4.6	1.2	5.6
	51	17 to 23	32.6	23.2	49.5	7.4	4.8	-	6.5
	52	24 to 31	33.0	21.7	53.5	10.3	7.8	-	6.8
I January 1989	1	1 to 7	33.0	23.5	53.5	9.6	8.8	-	13.5
	2	8 to 14	33.3	21.2	56.5	8.8	8.1	-	10.6
	3	15 to 21	33.1	22.7	55.5	5.7	7.7	-	12.3
	4	22 to 28	33.6	21.2	48.5	7.4	7.3	-	7.2
	5	29 to 4	34.9	20.3	38.0	4.1	9.4	-	10.6
II Febraary 1989	6	5 to 11	36.1	19.1	42.0	10.4	8.0	-	6.4
	7	12 to 18	36.8	21.8	53.5	9.8	7.6	-	6.0
	8	19 to 25	36.6	23.6	50.5	9.6	7.5	-	7.1
	9	26 to 4	37.1	21.3	40.0	8.2	9.1	-	6.9

(Contd...)

APPENDIX - I (Contd.)

1	2	3	4	5	6	7	8	9	10
III	10	5 to 11	36.8	23.1	55.0	9.5	7.4	-	6.4
March, 1989	11	12 to 18	36.6	23.7	64.0	11.4	8.0	-	5.1
	12	19 to 25	35.3	23.6	66.0	9.7	4.2	-	4.8
	13	26 to 1	36.8	29.9	62.0	9.4	7.7	15.8	6.4
IV	14	2 to 5	35.7	25.2	67.0	8.9	6.2	-	5.0
April, 1989	15	6 to 15	36.4	25.6	66.5	9.4	6.9	-	5.2
	16	16 to 22	34.5	24.0	71.0	6.5	-	47.3	6.2
May	17	23 to 29	34.3	25.3	73.0	7.9	-	4.3	5.3
	18	30 to 6	35.4	25.0	72.0	8.8	-	23.8	5.5

APPENDIX - II

Analysis of variance for days to 1st flower, Days to 50% flowering, height at peak flowerings, and Main secondary branches.

Source	Degree of free-dom	Mean sum of squire			
		Days to first flower	Days to 50% Flower-ing	Height at peak flowering	Number of main secondary branches
Replication	2	0.56688	0.01646	6.20413	0.21063
Main plot	7	18.12286**	26.46608**	14.15709	1.05164**
Error (a)	14	0.65973	1.59313	11.77289	0.10182
Sub plot	1	9.01334**	10.08333**	95.51341**	1.72521**
Interaction	7	1.30714	1.32571*	10.92870	0.03378
Error (b)	16	0.92979	0.38104	10.95242	0.04208

* Significant at 5% level
** Significant at 1% level

APPENDIX - III

Analysis of variance table for total inflorescences/plant, flowers/cluster pollen sterility, fruits/cluster and fruits set(%)

Source	Degree of free-dom	Mean sum of square				
		Total inflo-rescence cluster/ plant	Flower cluster	Pollen sterility	Fruits/ cluster	Fruit set %
Replication	2	1.06188	0.2146	10.04279	0.01187	8.17078
Main plot	7	73.70925**	2.33476**	782.11989**	3.38997**	657.02180**
Error (a)	14	0.38926	0.05646	4.15983	0.033211	3.40102
Sub plot	1	63.71020**	1.02083**	6.30605	0.38521*	13.49380**
Interaction	7	2.56307**	0.14655*	0.73523	0.05568	2.05856*
Error (b)	16	0.50083	0.03958	1.84072	0.02875	0.533141

* Significant at 5% level
** Significant at 1% level

APPENDIX - IV

Analysis of variance table for total fruits/per plant, average fruit weight, total fruit yield/plant and total seed yield/plant.

Source	Degree of free-dom	Mean sum of square			
		Mean fruits/ plant	Average fruit weight	Total fruit yield/plant	Total seed yield/plant
Replications	2	0.05146	0.4164	1402.32124	0.05739
Main plot	7	443.22037**	54.91241**	902,625.17929**	24.42386**
Error (a)	14	3.72527	3.58455	7,757.78579	0.21941
Sub plot	1	62.56334**	11.60334*	101324.34368**	2.06670**
Interaction	7	3.65619	1.79109	10,334.66100	0.21770
Error (b)	16	.03271	1.68732	3961.37619	0.10152

* Significant at 5% level
** Significant at 1% level

APPENDIX - V

Analysis of variance table seeds/fruit, seed weight/fruit, 1000 seed weight and 1000 seed volume

Source	Degree of free-dom	Mean sum of square			
		Mean seeds/ fruit	Seed weight/ fruit	1000 seed weight	1000 seed volume
Replications	2	12.56453	0.00006	0.00006	0.00004
Main plot	7	151.02664**	0.00356**	0.00266**	0.00211**
Error (a)	14	4.18715	0.00011	0.00025	0.00027
Sub plot	1	11.65256	0.00255**	0.00010	0.00041
Interaction	7	8.84255	0.00011	0.00031	0.00009
Error (b)	16	3.50599	0.00014	0.00032	0.0020

* Significant at 5% level
** Significant at 1% level

APPENDIX - VI

Analysis of variance table for germination percentag; field emergence, seedling length and vigour index.

Source	Degree of free-dom	Mean sum of square			
		Germination %	Field emergence %	Seedlings length	Vigour index
Replications	2	4.64085	6.20147	0.11083	2 655.43293
Main plot	7	14.41003**	6.13116**	1.25402**	16316.09201**
Error (a)	14	1.30488	0.78533	0.10893	1214.02192
Sub plot	1	21.81604**	5.40020	2.05021**	39 954.95605**
Interaction	7	0.90647	1.294500	0.10449	883.05368
Error (b)	16	1.12701	0.68168	0.05208	538.73872

* Significant at 5% level
** Significant at 1% level

APPENDIX - VII

Analysis of variance table for total fruit yield/plot, total seed yield/plot and fruit yiel'/ha and seed yield/ha.

Source	Degree of free-dom	Mean sum of square			
		Total fruit yield/plot	Total seed yield/ plot	Fruit yield per ha.	Seed yield per ha.
Replications	2	1.08042	116.55150	0.49225	64.64422
Main plot	7	958.48035**	27 407.92751**	540.65294**	15301.26237**
Error (a)	14	7.87571	169.05952	4.46925	95.96100
Sub plot	1	60.36810**	1810.56356**	39.27700**	1058.53486**
Interaction	7	9.52254*	240.96715*	5.69700*	127.15609*
Error (b)	16	2.44872	61.42105	1.23175	35.0329

* Significant at 5% level
** Significant at 1% level

INFLUENCE OF DATE OF PLANTING ON SEED YIELD AND QUALITY UNDER TWO FERTILIZER LEVELS IN TOMATO

(*Lycopersicon esculentum* Mill.)

BY

N. RAJAN

ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE

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VELLANIKKARA, TRICHUR

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ABSTRACT

An experiment was conducted at the Department of Olericulture, College of Horticulture, Vellanikkara during the period from July, 1988 to February, 1989 to study the effect of date of planting on seed yield and quality under two fertility levels in tomato variety Sakthi (LE 79). The experiment was laid out in a split plot design with three replications, as date of planting in the main plots and fertilizer levels in sub plots.

The date of planting had a significant impact on various growth and yield characters. The plant height and the number of secondary branches were maximum in October planting. Inflorescence clusters/ plant, flowers per cluster, fruits/cluster, pollen fertility and fruit set were also maximum in October planting followed by November planting. The February planted crops recorded the lowest value for these characters.

The July planting took longest time for crop duration while February planting registered the shortest duration. Fruits/plant, fruit yield/plant, average fruit weight and seed yield/plant were higher in October planting followed by November planting. The lowest value for these characters was in February crop. The high level of fertilization (NPK 150:60:60 kg/ha) brought a significant improvement on these characters.

The seed quality characters like seed weight/fruit and seeds/fruit, 1000 seed weight and 1000 seed volume were maximum in October planting followed by November planting. The germinability and field emergence were maximum in November planted crop, and August planting recorded the lowest value. The seedlings length and vigour index were more and were same in October and November plantings.

The maximum temperature and total rainfall were found positively correlated with pollen sterility while negative correlation was found between fruit set with minimum temperature and rainfall. A negative correlation was found for total fruits/plant, fruit yield/plant and seed yield/plant with minimum temperature.