THE EFFECTS OF CCC, PRUNING, SPACING, AND VARIETY ON EARLY YIELD AND GROWTH OF TOMATO

by

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ABSTRACT

This experiment was conducted to study the effects of CCC; pruning; and five within the row spacings of 30, 45, 60, 75 and 90 cms; on growth and early yield of three varieties of tomato - Marglobe, Big Boy and Malty (local).

CCC was applied at 1 ml. per liter of transplant water per plant. Two stems were left per pruned plants - which were staked. Rows were 120 cms. apart.

CCC had no effect on growth of yield.

Pruning increased stem diameter, enhanced maturity, decreased marketable early yield and total midseason and marketable yields, reduced fruit number per plant and per dunum, increased cracking, and decreased sunscald injury.

Close spacing reduced stem diameter, increased total early and marketable early yields, increased early fruit number per dunum but decreased the number per plant in both harvests, and reduced midseason cracking.

Big Boy and Marglobe had longer stems, earlier dates of fruit set and maturity, lower marketable midseason yield, higher number of fruits per plant and per dunum in both harvests, higher per cent small of midseason yield, smaller fruits, lower number of locules, and thicker walls than Malty. Big Boy produced the highest total early yield. Marglobe showed the highest susceptibility to cracking.

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INTRODUCTION

"A garden curiosity when the United States was a pioneer country, the tomato has now become one of the most popular vegetable crops" (21). It is used in juice, salads, soups, preserves, pickles, sauces, catsup and is served cooked in many forms (16). In 1963 its world production was 17,420,000 metric tons, which was obtained from 890,000 hectars of land. In Lebanon an area of 2000 hectars produced 32,000 metric tons (9).

Tomato, Lycopersicon esculentum L., a native of tropical America is a subtropical plant and needs for its healthy growth a moderately high temperature, a dry atmosphere, an abundance of air, and a full exposure to sunlight. The site should be protected from cold and strong winds (12). Tomatoes are grown on a wide range of soils ranging from mucks and heavy clays to light sands. Good drainage in any type of soil, however, is essential. A deep, fertile, well-drained loamy soil that is retentive of moisture is most satisfactory for heavy production of high-quality tomatoes (21).

The first two weeks of the tomato season are usually the most remunerative for the market gardener. Therefore, any practice that is capable of inducing earlier yields can be of considerable importance (26). Consequently, much attention has been directed toward ways of securing a good first early crop. Development of early varieties, planting at close spacings, and various methods of pruning and staking have been shown to affect either early or total yields or both.

This paper presents the results of the influence of CCC, pruning, five within-the-row spacings, and three varieties on the early yield of tomatoes grown at the Agricultural Research and Educational Center of the American University of Beirut during 1963-64.

REVIEW OF LITERATURE

CCC

In 1949, Mitchell, et al (6) reported that the nicotinumes reduced stem elongation of bean plants. Since then many chemicals have been reported to be effective on a number of species. The term "growth-retarding chemical" or "growth retardant" is applied to those chemicals which slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects (6). Since the inhibitory effects of some of them can be overcome by treatment with gibberellins, these growth retarding chemicals have also been termed "anti-gibberellins" (7).

In 1960, the activity of a new group of quarternary ammonium compounds was reported by Tolbert (6). These compounds tend to duplicate the effects of a short-photoperiod, high light intensity, and low temperature. There is no evidence that these new growth substances occur as natural hormones in plants. The most active compound, (2-chloroethyl) trimethylammonium chloride, with the chemical formula, $CH_2Cl\text{-}CH_2N(CH_3)_3.CL$, is an analog of choline, in that the hydroxy group in choline is replaced by chlorine. Its trivial name chlorocholine chloride is commonly abreviated to CCC. The chemical has been reported to retard the growth of a larger number of species than any of the earlier known compounds (6). It is highly soluble in water and has a fishy odor. It melts at 300^0 though decomposition begins between $240-245^o$ (27). It does not persist in the soil for more than three to four weeks; it is not stable in steam sterilized soil (5). The mode of action of CCC as a plant growth substance is unknown. However, a high specificity of chemical structure for biological activity has been demonstrated which suggests that plant growth substances act by attachment to an equally specific site. Compounds of the structure $(CH_3)_3N+CH_2 - CH_2x$ have proven to be active as plant growth-substances when x was a Cl, Br, or = CH_2 group. The trimethyl ammonium cation was necessary for activity, and the ethyl carbon chain with the substituent x had the optimal length for maximum actiyity (6,27). The growth retardants inhibited cell division in the subapical meristem. The cambium and the vascular elements continued to develop over a much longer period than typical for the plant and the individual cell sizes, and ultimately the cell number, were reduced. The vascular system was thus altered beneath the unaffected and still functioning apical meristem.[1] It was thought that this change in the stem could have altered the pattern of transport of many growth substances and metabolites to and from the apical meristem. The evidence presently available indicates that the growth-retarding effect of CCC is due to the lowering

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[1] Phytochrome in the leaves, which is involved in the control of flowering and plant habit expressed at the apical meristem, exhibited no direct interaction with growth substances (6).

of the auxin level in plants (6,17). A high auxin content inhibits the formation of the floral stimulus (8). This might explain the effects of CCC in inducing early flower set on tomatoes as reported by some workers (1,26,31,32).

Growth retardants thus far discovered have been active primarily on plants of Dicotyledonae but they were effective on a few species of Monocotyledonae. For example, CCC is effective only on certain species in the family Gramineae. Growth retardants have shown no effect on plants from the subdivision Gymnospermae and the division Pteridophyta (6). The type of plants reported most sensitive to growth-retarding substances were those which grow slowly and constantly such as *Chrysanthemum* and lily which exhibited almost rosette growth upon treatment. Plants which grow in flushes such as oak and holly required much higher dosages. Foliage plants such as *Philodendrons*, *Dieffenbachia* and *Peperonia* grew without response to even massive amounts of CCC (6). Cathey and Stuart (5) have indicated the susceptibility to CCC of plants of different genera and species with the variety names when known. Thus more than 46 species are affected by CCC including:

apple	tomato	red maple	snapdragon
Jerusalem cherry	cucumber	red oak	*Coleus*
	tobacco	summer cypress	carnation
	peas		
	beans		
	corn		

Among the 8 or more they reported not affected were: cotton and Gladiolus spp.

Plants become less sensitive with increasing age. The time to noticable response after treatment is one week or less. The response is affected by the concentration from no response to toxicity symptoms. Overtreatment induces a pale green chlorisis of the base of the leaf blade which later recovers. Response to CCC is much less in summer than in winter. Treatment with CCC delays germination of seeds. Root development is initially inhibited, but effects are seldom apparent at the flowering time. Leaves become dark green in color. Plants weigh less--fresh and dry. Days to flowering and size of flowers are not affected. The most obvious response is the reduced stem elongation (5).

According to Wittwer and Tolbert (31), foliar spray of CCC on tomato plants, though effective, produced only temporary results and were discontinued in favor of the more lasting effects of soil treatments. The growth changes were similar to those produced by exposure to high light intensities and low temperatures and opposite to the effects produced by gibberellin. In this connection, plant response to the chemical treatment progressively decreased with the longer days, higher temperatures and more sunlight of spring and summer. Seedlings produced for field transplanting had shorter stems, stronger laterals, heavier roots, and set flowers and fruits earlier. The results of excessive application were in agreement with those reported by Cathey and Stuart (5). Besides the results obtained from this experiment, Wittwer and Tolbert (32) have reported finding a consistent acceleration of flowering by tomato plants over a rather wide range of concentrations which shorten stem length. This response is unlike that reported for any other plant growth substance.

The results obtained by Tiessen (26), in general, are in agreement with those reported by other workers. In addition, he reported a reduction in fruit number and size following CCC application. He also reported that the number of flowers decreased in the first cluster and increased in the second cluster.

In general, CCC on tomatoes induces shorter, thicker stems; stronger laterals; heavier roots; greener, savoyed leaves; and a reduction in the top-root ration. Plants flower earlier and at lower nodes with an increase in flower number in the first inflorescence (1, 26, 31, 32).

Pruning

According to Leopold and Lam (18), a role for young expanding leaves has been pointed out by de Zeeuw who concluded that the expanding leaves provide an inhibitory effect on the development of flowers, and interpreted this as an expression of a general antagonism between reproductive and vegetative development. Verkerk (28) concluded that an increase in number of leaves per cluster results in a delay in harvest.

Various methods of removing plant parts in attempting to increase early yield have been practiced by growers. However, the observation that most types of pruning reduce the yield of plants casts doubt on the wisdom of these practices (15). Still, reduction of vine growth by pruning plants to two or three main branches has been a successful means of increasing yield in areas where the prevailing low night temperatures in spring and early summer lead to poor set of fruit (19). Training plants onto stakes or trellises after pinching out all but one or two of the laterals increases the early yield since the plants are spaced more closely, resulting in more early clusters of fruits contributing to the first harvest. The total yield may not be much different from that of unpruned plants (16). Porte (21), on the contrary stated that training and pruning, because of closer planting, results in heavier total yield.

In the usual method of pruning tomatoes, the buds that would develop into lateral branches are removed. The buds appear in the axils of the leaves at the point where the leaf petiole joins the main stem. It is best to pull or break them out of the leaf axils, as pinching or cutting them off is likely to spread virus diseases. For support the stems are tied to 6- to 8- foot wooden stakes driven into the ground 3 inches from the base of each plant (21).

According to Knott (16) pruning facilitates picking of fruits and, in humid areas, prevents rotting of fruits due to their touching wet soil. However, the development of the root system is retarded approximately to the same degree as the top. In a dry season this may reduce the ability of the plant to replace the water lost by transpiration. Thus, more blossom end rot may develop. Sunscald and cracking are likely to be increased with sparse foliage.

Moore (19) compared the yields of plants pruned to two or three branches with unpruned plants. All plants were staked and spaced 3 feet by 5 feet. There were no significant differences between the early yields of the pruned plots and the check, but the total yield of the check plots significantly exceeded that of the plots pruned to three branches per plant. Plots pruned to two branches per plant were intermediate in total yield. Fruit size of the early crops was affected by neither of the pruning systems. In general, fruits became smaller in later pickings with all systems.

Halsey and Jamison (11) investigated the influence of pruning and staking on the yields of 21 varieties of tomato during three seasons. The staked and pruned plants were spaced at 21-inch and unstaked-unpruned plants at 42-inch intervals. The rows were 42 inches apart. The data showed that although the total yield per acre from staked-pruned plants was significantly greater than from unstaked-unpruned plants --because of a larger number of plants per acre in the first case--the difference in yield of marketable quality fruit was not significant due to a greater incidence of fruit cracking due to pruning and staking. The varieties responded differently to treatments.

The results of a number of experiments reviewed by Campbell (4) are as follows. Deonier, et al (1944), in Mississippi, made the following comparisons: (a) staked and pruned at 4ft x 2ft, (b) staked and nonpruned at 4ft., and (c) nonstaked and nonpruned at 4ft. They found that the yields per acre and size of fruit were greatest with the first treatment. In Puerto Rico, over two seasons, Riollano, using the indeterminate variety Marglobe at a spacing of 4ft. x 2.5ft., found that the yield of fruit was reduced significantly by staking and that the combination of staking and pruning caused further reduction. Work in Trinidad showed no significant differences between total yields of staked-pruned and unstaked-unpruned plants set at 4ft. x 2ft. The latter treatment, however, gave a higher proportion of fruits of exportable quality. Topper, using similar treatments, at spacings of 3ft. x 1ft., 3ft. x 1.5ft. and 3ft. x 2ft. showed that staked-pruned plants gave greater yields than unstaked-unpruned plants and also tended to give larger fruit size, but resulted in an increase of physiological disorders, Such as fruit cracking.

Campbell (4), working with an indeterminate variety, tried three treatments of: (a) nonstaked-nonpruned, (b) staked-nonpruned (c) staked-pruned. Plants were spaced 3ft. x 1.5ft. The results over a three-year period showed that staking had no effect on total yield or size of fruits, and that pruning significantly reduced the yield. No observable difference in earliness of fruiting between the three treatments could be seen though weekly yields from the staked-pruned treatment fell off markedly from the tenth week, whereas the other two treatments, whose yield curves followed each other very closely, attained their maximum two weeks later.

Currence (7) incorporated spacing, staking, and pruning in an experiment on tomato varieties with three different habits of growth. The spacings were 4 feet by 1, 1.5, 2, and 3 feet. The treatments were: pruning and staking, staking only, and untreated. The results concerning the standard variety showed an increase in early yield and fruit size, and a decrease in total yield due to pruning. The 4 feet by 1 foot spacing gave highest early and total yield for all treatments.

That an increase in early yield occurs at the expense of total yield was concluded by Verkerk (28) after reviewing a number of papers.

Spacing

The first picking is obtained chiefly from the crown cluster of blossoms, and the more plants per acre, the more crown clusters there are. Theorectically, equidistant spacing of plants within the row and between the rows should give the largest return per plant because of the more equal exposure of the foliage to sunlight and more uniform feeding area for the roots. However, for commercial harvesting by hand, the minimum practical spacing between the rows is 4 to 5 feet. Consequently, the plants must be spaced closer in the rows to increase the population per acre (23). The spacing between tomato plants depends on: the fertility of the soil, the variety, and seasonal variations in climatic environment (3).

Olden (20), working with the varieties Penharvest (determinate) and Rutgers (undeterminate), tried 2-, 3-, 4- and 6- feet within-the-row spacings in rows 4 feet apart. The spacing of 2 feet by 4 feet produced the highest yields in both the early and late harvests without any significant effect on fruit (fruits with cracks and other blemished excluding decayed ones) in the 2 foot by 4 foot spacing than in the 6 foot by 4 foot spacing and it seemed reasonable to conclude that the regression of spacing on the percentage of second grade fruits was essentially a straight line.

Vittum and Tapley (29) compared the three plant spacings of 2, 2.5 and 3 feet in rows 5 feet apart. Their results, from four years of field experiments, indicated that close spacing (2 feet by 5 feet) considerably increases the acre yield, slightly reduces the number of fruits per plant, and slightly reduces the average weight of fruits per plant.

Sayre (23), in a factorial experiment, tried three spacings of 4, 5, and 6 feet within the rows in a normal row pattern and a twin-row pattern with 18 inches between each pair of rows. The spacing of 1.5 feet by 4 feet resulted in higher early and total yield. However, as the season progressed and plants became crowded, the number of fruits per plant decreased. There was no significant difference between the row-patterns.

According to a number of experiments reviewed by Schmidt (22), the differences between intermediate plant spacings--those devoting 10.5 to 16 square feet to each plant--were negligible. However, pronounced yield increases resulted when the spacing was altered to permit 7-8 square feet per plant but yield fell off sharply when it exceeded 16 square feet. There was a trend toward smaller fruit size with close spacing.

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<u>Variety</u>

Earliness of flowering is a feature of plants which has been exploited widely in the development of varieties for different yield patterns. However, little is known of the physiological features which may be responsible for earliness and lateness. In species which are sensitive to photoperiods, earliness is generally explained as a consequence of this feature. In many other species, such as tomato, there is no apparent photoperiodic control of flowering[1] and yet striking differences in earliness are well established among varieties (18). In 46 varieties studied in Michigan, most of the differences in earliness between early, midseason, and late varieties were accounted for in the differences in the interval between blossoming and fruit setting. Early varieties were early in those studies because they set fruit at lower temperatures than late varieties (14).

Marglobe is a medium-large plant, semierect, with medium-dense foliage that shades the fruit well. The season is 70 to 80 days from the time of transplanting medium-sized plants that have not reached flowering stage to first harvest. The peak harvest arrives at 100-110 days (21). Its pedigree (13) is:

Stone   Ponderosa   Marveille de Marches

Globe   Marvel

Marglobe

[1]Tomato is one of the plants in which control of flowering is possible by regulating the light intensity and the temperature (8, 30).

The average yields of the three varieties, Marglobe, Malty (local), and Big Boy in trials between 1959 and 1964 are as follows (2):

Marglobe	3 year average	2100 Kgs. per du.
Malty	6 year average	4916 Kgs. per du.
Big Boy	5 year average	3665 Kgs. per du.

No further information was available on the varieties Malty and Big Boy.

MATERIALS AND METHODS

Three varieties of tomatoes-- Marglobe, Big Boy and Malty (local)--were seeded in flats containing a soil mixture of two parts soil to one part sand on March 18, 1964 in the greenhouse on the campus of the American University of Beirut in Beirut. The seeds were treated with Captan before seeding. The seedlings were pricked off into potting soil mix in 2 x 2 inch vitabands on April 8, 1964 and kept in the green-house. They were hardened in the open for one week in Beirut before being transplanted to the field at the Agricultural Research and Education Center of the American University of Beirut in the Beqa'a plain on May 6. The soil on which the experiment was conducted is a clay type, calcareous, low in organic matter and available phosphorus, and has a pH of about 8.0.

The area devoted to the experiment had been plowed, disked fertilized and disked in the fall of 1963. The fertilizer application consisted of 12 kilograms of N and 817 kilograms of P per dunum spread by a Gandy spreader.

A split split plot design with three replications was used in which three varieties, Marglobe, Big Boy, and Malty, were assigned to the main plots; five within the row spacings, 30, 45, 60, 75 and 90 cms., to the sub plots; and three treatments, CCC, pruning and none, to the sub sub plots. Each sub sub plot consisted of one four meter row separated from its neighbor by a single border row planted to the corresponding main plot variety with an interplant spacing of 70 cms. Rows were 120 cms. apart. Each plant was irrigated with one liter of water following transplanting. In plots treated with CCC, the water contained 1 ml. of the chemical (a formulation containing 50% active ingredient). On June 13, for each plant in the plots to be pruned, a stake was driven into the ground about 10 cms. from the plant. Plants were tied to the stakes with tying bands. Pruning to two stems per plant was started on June 15 and was carried out weekly thereafter until the first fruit of the individual plants were 3-4 cms. in diameter. Pruning was usually done by snapping off the axillary shoot buds. A pair of scissors was used only to cut thick shoots on Marglobe and Big Boy and for Malty due to its peculiar habit of side shoot development (Fig. 5). Furrow irrigation was started on May 7 and was carried out weekly throughout the growing season.

On June 6, ammonium sulfonitrate supplying nitrogen at a rate of four kilograms per dunum was applied on to the soil surface in bands 10 centimeters from the plants on both sides of each row. This was covered by hilling with a furrow opener on June 12. The following preventative and corrective measures were applied:

June 6, Diptrex 1:1000, sprayed against aphids

August 1, August 7, and September 10, Dithane M22, 1Kg. per 100 gal. was sprayed to prevent leaf fungus diseases and was repeated every 10 to 15 days up to November 12 inclusive.

September 3, Ascop 100 grams per 20 liter sprayed instead of dithane.

Plots were hand weeded about every 15 days. Starting August 7, Orobanchy (Orobanche sp.) was removed from the plots bi-weekly.

The average sunrise to sunset intervals for the months during which measurements for the stem length were taken are presented in Table 1.

Table 1. The Average monthly sunrise to sunset interval in hours in Beirut in 1964.

Month	Ave. sunrise-sunset in hrs.
March	12:00
April	12:00
May	13:50
June	14:20
July	14:20

The average maximum and minimum temperatures for the same months are presented in Table 2.

Table 2. The average monthly maximum and minimum temperatures at the Agricultural Research and Education Center of the American University of Beirut in the Beqa'a plain in 1964.

Month	Ave. mx. temp. in ^{o}C.	Ave. min. temp. in ^{o}C.
March	14.43	3.67
April	16.03	3.24
May	20.90	4.63
June	28.50	12.40
July	31.80	14.40

The length of the stem from the growing point to the ground was measured on May 28, June 4, July 1, and July 8. The thickness of the stem between the second and the third internode subtending the first inflorescence was recorded on July 13. For these measurements three plants per plot were used. For all plots the plant on each end was considered a border plant and was excluded from the plot. Plot sizes varied due to plant spacings, so all production data were calculated on per dunum basis (one dunum equals 1000 square meters). Starting on July 5, the date of fruit set (when more than half of the plants per plot set fruit), and starting on August 5, the date of maturity (when more than half of the plants per plot bore pinkish fruits) were recorded. Starting on August 6, fruits were harvested weekly; fruits were harvested when about half of their surfaces were pink. Measurements were obtained on the total number of fruits, weight of small fruits, i.e. fruits less than 60 grams in weight, weight of cracked fruits, weight of marketable fruits and number of fruits showing sunscald injury. The fruits with no blemishes other than superficial cracks were considered marketable. On September 8, data were taken on the width and length of the fruits, the thickness of the rind, and the number of locules per fruit.

The harvesting season was divided into three parts: the first four harvests (Aug. 6 to Aug. 26) were considered early; the second four harvests (Sept. 1 to Sept. 22), midseason; and the last six harvests (Sept. 30 to Nove. 4), late. The experiment was not terminated until after the first killing frost in the fall but the data for the late season harvest were invalid due to heavy infestation of Eatetranychus cinabarinus.

Data were analyzed according to the method suggested by Snedecor (23). Duncen's multiple range test was used to test significance of differences between the treatments. Lack of significant differences are indicated by underlining or assigning identical letters to the corresponding treatments. In this paper the following denotations and abbreviations will be used.

- * significant at 5% level
- ** significant at 1% level
- V Variety
- S Spacing
- P Practice

RESULTS

Effects of CCC, Pruning, Spacings, and Varieties on Growth.

The analyses of variances for the length and diameter of the stems are presented in Table 19, and those for the date of fruit set and maturity in Table 22.

Length of stem:- Varieties Big Boy and Marglobe showed significantly longer stems than Malty measured on May 28 and June 4 (Tables 13 and 14). Subsequent measurements on June 15 indicated highly significant differences due to varieties and spacings (Table 15), summarized as follows:

Variety	Big Boy	Marglobe	Malty
Length in cms.	37	35	30

Spacings in cms.	S-90	S-30	S-60	S-75	S-45
Length in cms.	37	35	35	34	31

On July 1 there was a difference (1% level) only between the varieties (Table 16).

Variety	Big Boy	Marglobe	Malty
Length in cms.	67	64	55

The last measurement on July 8 indicated a reduction of about 4 cms. (5% level) in the stem due to pruning. Although this was the first week in which the difference was significant, the effect was observed to be developing steadily since the beginning of the measurements. Big Boy and Marglobe had significantly longer stems than Malty as before (Table 17).

Diameter of stem:- Measurements of the stem diameter on July 5 showed that both wide spacing and pruning resulted in thicker stems (1% level) than narrow spacing, non-pruning, or CCC application (Table 18).

Spacing in cms.	S-90	S-75	S-60	S- 45	S-30
Diameter in cms.	1.2	1.2	1.1	1.1	1.0

Practice	Pruning	CCC	None
Diameter in cms.	1.2	1.0	1.0

Date of fruit set:- As seen in Table 17, both Big Boy and Marglobe were earlier than Malty. This difference was significant at 5% level. There was a trend toward earlier set due to pruning (Table 20).

Variety	Big Boy	Marglobe	Malty
Days after July 5	5	6	14

Date of Maturity:- Big Boy produced the earliest fruit of the three varieties and pruning maturity (5% level) (Table 21).

Variety	Big Boy	Marglobe	Malty
Days after August 5	8	12	18

Practice	Pruning	None	CCC
Days after August 5	10	13	14

Effects of CCC, Pruning, Spacings, and Varieties on Early Yield.

The analyses of variances for the weight of total and marketable fruits per dunum, number of fruits per dunum and per plant, per cent cracking by weight, per cent fruits sunscalded, per cent small by weight, and weight per fruit are presented in Table 31; those for the number of locules per fruit and the ration of wall thickness to average radius in per cent in Table 34.

Total Early Yield:- Of the three varieties, Bigh Boy and Marglobe had higher total early yield than Malty and the within-the-row spacing of 30 cms. increased early yield significantly over all other spacings (Table 23) (Figs. 1, 2, and 3).

Variety	Big Boy	Marglobe	Malty
Yield in kgs. per dunum	1896	1449	908

Spacings in cms.	S-30	S-45	S-60	S-90	S-75
Yield in kgs. per dunum	2031	1545	1302	1216	994

Marketable Early Yield:- Close spacing increased and pruning decreased marketable early yield (5% level). Big Boy yielded twice as much as any of the other two varieties. There was an interaction between variety and practice with Big Boy-none and Big Boy-CCC having the highest yields (Tables 3, 24).

Spacings in cms.	S-30	S-45	S-60	S-90	S-75
Yield in kgs. per dunum.	1048	758	708	619	431

Table 3. Effect of interaction between variety and practice on marketable early yield in Kgs. per du.

	Practice			
Variety	None	CCC	Pruning	Mean
Big Boy	1415^{a}	1391^{a}	474^{bcd}	1093
Malty	821^{b}	642^{bc}	155^{d}	539
Marglobe	566^{bcd}	688^{bc}	261^{cd}	505
Mean*	938	913	297	

Total number of early fruits:- Big Boy and Marglobe produced a significantly higher number of fruits per dunum than Malty. Close spacing increased and pruning decreased the total number of fruits (5% level). There was an interaction between variety and spacing with Big Boy and Marglobe at 30 cms. spacing producing the largest number of fruits and Malty at 75 cms. the smallest (Table 4 and 25).

Table 4. Effect of interaction between variety and spacing on total early fruit number per dunum.

	Spacing					
Variety	S-30	S-45	S-60	S-90	S-75	Mean*
Big Boy	23851^{a}	18753^{bc}	15586^{bcd}	12242^{de}	12037^{de}	16494
Marglobe	20820^{ab}	15667^{cd}	12685^{cde}	10219^{defg}	11605^{def}	14199
Malty	5949^{fghi}	4791^{ghi}	2913^{hi}	7751^{efgh}	1358^{i}	4754
Mean*	16873	13070	13070	10071	8333	

Practice	CCC	None	Pruning
Number	13160	12368	9920

Number of early fruits per plant:- Big Boy and Marglobe produced significantly higher numbers of fruits per plant during the early harvest period. The number was decreased due to both close spacing and pruning (Table 26).

Variety	Big Boy	Marglobe	Malty
Number	11	9	3

Spacing in cms.	S-90	S-60	S-75	S- 45	S- 30
Number	10	8	8	7	6

Practice	CCC	None	Pruning
Number	9	8	6

Fruit Cracking:- Pruning more than doubled the per cent cracking on the weight basis during the early harvest period (5% level). There was an interaction between variety and practice with fruits of Malty, Marglobe, and Big Boy showing the largest cracking percentages when pruned (Table 5). There was a trend toward a high percentage of cracking in case of Marglobe and a relatively low one with Bigh Boy (Table 27).

Table 5. Effect of interaction between variety and practice on per cent cracked by weight of early yield.

	Practice			
Variety	Pruning	None	CCC	Mean
Marglobe	77^{a}	56^{b}	49^{b}	61
Malty	80^{a}	25^{c}	31^{c}	45
Big Boy	72^{a}	26^{c}	21^{c}	40
Mean*	76	36	34	

Sunscald of fruit:- Although none of the varieties tested were seriously injured, Malty proved to be the least susceptible of the three to sunscald measured on a per cent fruit number basis (5% level). Among the other treatments, only pruning had any appreciable effect; it caused a highly significant decrease in the percentage of injured fruit (Table 28).

Variety	Big Boy	Marglobe	Malty
Per cent sunscalded	3	3	
Practice	CCC	None	Pruning
Per cent sunscalded	4	3	0

Small fruit:- Measured on a weight basis, none of the treatments except variety had any significant effect upon the per cent of undersized fruit (less than 60 grams) produced. Malty had the lowest and Marglobe the highest percentage of small fruit (Table 29).

Variety	Marglobe	Big Boy	Malty
Per cent small	5	3	1

Average weight per fruit:- Malty produced significantly larger fruits than the other varieties (Table 30).

Variety	Malty	Big Boy	Marglobe
Weight in grams	213	116	104

There was a tendency for larger fruits due to pruning.

Fruit Locules and wall thickness:- Variety was the only treatment affecting the number of locules per fruit and the relative thickness of the walls of the fruits. Malty had more than twice the number of locules that Big Boy or Marglobe had--a difference significant at the 1% level. (Table 32). Conversely, Marglobe and Big Boy had highly significantly thicker walls than Malty as determined by the ratio of wall thickness to average radius of the fruit in per cent (Table 33).

Variety	Malty	Big Boy	Marglobe
Number per fruit	11	5	5

Variety	Marglobe	Big Boy	Malty
Ratio in per cent	19	17	13

Effects of CCC, Pruning, Spacings, and Varieties on Midseason Yield.

The analyses of variances for the weight of total and marketable fruits per dunum, number of fruits per dunum and per plant, per cent cracking by weight, per cent fruit sunscalded, per cent small by weight, and average weight per fruit are presented in Table 42.

Total Midseason Yield:- Pruning significantly decreased the yield. There was an interaction between variety and practice with Malty-none and Malty-CCC resulting in higher yields than any other variety-practice combination (Table 6). Malty showed a tendency toward highest yield (Table 35), (Figs. 1, 2 and 3).

Table 6. Effect of interaction between variety and practice on total midseason yield in Kgs. per dunum.

	Practice			
Variety	None	CCC	Pruning	Mean
Malty	1803[a]	1623[ab]	1045[cd]	1490
Marglobe	1316[bcd]	1423[abc]	1183[cd]	1307
Big Boy	1185[cd]	929[d]	1023[cd]	1023
Mean*	1435	1325	1061	

Marketable midseason yield:- Malty produced the highest marketable midseason yield (5% level). Pruning resulted in a reduction in marketable yield. There was an interaction between variety and paractice with Malty-none and Malty-CCC resulting in highest yields (Table 7). Marketable yield was also affected significantly by spacing, although it had no correlation with spacing (Table 36).

Spacing in cms.	30	45	90	60	75
Yield in Kgs. per dunum	672	627	620	501	455

Table 7. Effect of interaction between variety and practice on marketable midseason yield in Kgs. per dunum.

	Practice			
Variety	None	CCC	Pruning	Mean*
Malty	1322^{a}	1059^{b}	186^{e}	856
Big Boy	771^{c}	621^{cd}	235^{e}	542
Marglobe	449^{d}	479^{d}	53^{e}	327
Mean*	847	720	158	

Total number of midseason fruits:- Marglobe produced the highest number of midseason fruits per dunum (5% level). The number was reduced due to pruning. Spacing and practice interacted resulting in highest number being produced in case of (S-90) -- none combination (Tables ' and 37).

Table 8. Effect of interaction between spacing and practice on total midseason fruit number per dunum.

	Spacing					
Practice	S-90	S-30	S-45	S-60	S-75	Mean*
None	13992^{a}	12094^{ab}	12786^{ab}	11296^{ab}	10524^{bed}	12108
CCC	12139^{ab}	10803^{bc}	11669^{ab}	11821^{ab}	10031^{bcd}	11298
Pruning	8539^{cd}	11364^{ab}	7672^{d}	8858^{cd}	8858^{cd}	9059
Mean	11557	11420	10709	10658	9804	

<u>Number of midseason fruits per plant</u>:- Marglobe had a significantly higher number of midseason fruits per plant than Malty and a moderate but non-significantly higher number than Big Boy. The number was reduced by both close spacing and pruning. Among the combinations of practices and spacings, (S-90)-none and (S-90)-CCC produced the highest fruit numbers (Tables 9 and 38).

Variety	Marglobe	Big Boy	Malty
Number per plant	10	8	6

Table 9. Effect of interaction between spacing and practice on number of midseason fruits per plant.

	Spacing					
Practice	S-90	S-75	S-60	S-45	S-30	Mean*
None	15	10	8	7	4	9
CCC	14	9	9	6	4	9
Pruning	9	8	6	4	4	6
Mean*	13	9	8	6	4	

Fruit Cracking:- Marglobe was the most and Big Boy the least susceptible of the three varieties to fruit cracking (5% level).

Although there was no correlation between the two, per cent cracking was significantly affected by spacing. Pruning again doubled the per cent cracking. There was an interaction between variety and practice with Big Boy and Malty showing the least susceptibility to cracking when not pruned (Tables 10 and 39).

Spacing in cms.	S-60	S- 75	S-45	S-90	S-30
Per cent cracking	55	52	48	47	41

Table 10. Effect of interaction between variety and practice on per cent cracked by weight of midseason yield.

	Practice			
Variety	Pruning	None	CCC	Mean*
Marglobe	83[a]	53[b]	52[b]	63
Malty	76[a]	29[c]	29[c]	45
Big Boy	71[a]	23[c]	20[c]	38
Mean*	77	35	34	

Sunscald of fruit:- Sunscald in midseason, just as in the early season, was not important; pruning, however, reduced the incedence of the injury, as measured in per cent of fruit number, significantly (Table 40).

Practice	CCC	None	Pruning
Per cent sunsccalded	7	6	1

Small fruit:- Malty showed the lowest percentage of small fruits measured on the weight basis (5% level). There was an interaction between variety and practice with Malty in combination with any of the practices resulting in the least percentage of undersized fruits (Tables 11 and 41).

Table 11. Effect of interaction between variety and practice on per cent small by weight of midseason yield.

Practice	Variety: Marglobe	Big Boy	Malty	Mean
None	7^{a}	8^{a}	1^{bc}	5
CCC	8^{a}	7^{a}	0^{c}	5
Pruning	9^{a}	4^{b}	2^{bc}	5
Mean*	8	6	1	

Average weight per fruit:- Malty produced significantly larger fruits than the other two varieties. There was a tendency toward larger fruits due to pruning (Table 42).

Variety	Malty	Big Boy	Marglobe
Weight in gms.	196	100	89

DISCUSSION

As noticed in the results, CCC showed no effect on growth or yield of tomato plants throughout the experiment. Some of the probable causes for this lack of effect are discussed here. CCC, as mentioned before, duplicates the effects of high light intensity, cold temperature and short photoperiod. Light intensity is rather high in the area of the experiment and temperature is low at night[1] early in the spring (Table 1). However, the days are rather long in Lebanon in the spring and early summer (Table 2); in spite of this no response to CCC in respect to flowering was observed due to the fact that there is no apparent photoperiodic control of flowering in tomatoes--this character being controlled mainly by light intensity and temperature. Therefore, there could be no effect due to photoperiodism to be counteracted by CCC. It should also be mentioned that growth retardants are highly specific and different varieties vary greatly in the responsiveness to the applied chemical (6).

It would be worthwhile to try CCC on tomato seedlings in the greenhouse. It might counteract the effects of low light intensity and the rather high temperature of the greenhouse and cause shortness and stockiness of the seedlings and even lead to earlier flower and fruit set. Higher dosages could be tried too. The author, however, does not believe that this could bring about results as useful as those of the greenhouse application. It might be that,

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[1]Night temperature is very important in tomato stem elongation.

due to the presence of the high light intensity and cold temperature, no stunting would be obtained by increasing the dosage till injury results.

The lack of an appreciable effect due to pruning on the length of the stem might suggest that either (a) almost the same amount of photosynthates drawn by the developing axillary shoots at the beginning of their growth is returned to the main stem later after their leaves mature, (b) the developing shoots manufacture their own building material, or (c) tomatoes, under a given environmental condition, tend to follow a growth pattern characteristic of their variety and the roots develop accordingly. Due to removal of an axillary bud a corresponding amount of roots fail to form. As a result the main stems are supplied with a given amount of raw material irrespective of the presence or absence of side-shoots. This hypothesis, if true, could be a specific aspect of the general top-root ration theory. Removing the axillary shoots at different stages of their growth and studying the consequent changes in the growth of the main stems would throw some light on these suggestions. More elaborate studies involving root measurements could be of further help. The increase in diameter could be a reaction of the plants to the vertical stress brought about by staking rather than due to pruning. This might account for the trend toward shorter stems which culminated in significance with the last measurement. Some of the photosynthates could have been used in producing more supporting tissues and consequently increasing the diameter. It would appear to be worthwhile to determine whether this increase in the diameter was due to pruning, staking or both in a simple factorial experiment.

Apparently, the removal of the axillary shoots containing young expanding leaves and/or the reduction in the number of leaves per cluster are the reasons for early maturity and a trend toward earlier fruit set due to pruning (18, 28). Pruning, in this experiment, did not increase total early yield which is in disagreement with the results from most of the experiments reviewed. In this connection it should be mentioned that most experiments have been conducted in areas with short harvest seasons--2 to 50 days--and early yields were considered as those of the first 10 to 14 days. The harvest season in the Beqa'a is about 100 days and the early harvest was arbitrarily considered that of the first four harvests (August 6 to August 26). A significant effect due to pruning might have been revealed, had it been marked off at the third or the second harvest (Fig. 1). However, tonnagewise, this yield would not have been important. Apparently the effect of the reduction in fruit number per plant and consequently on yield per dunum was offset by early maturity in the pruned plants.

Subsequently, when maturity began in other treatments, the reduction in fruit number in spite of a tendency for larger fruits due to pruning led to a reduction in yield (Fig. 1). The only way to increase the early yield of the pruned plants and especially to bring theyield of the first one-to three-weeks' harvests to a commercially important tonnage would be to allow less space per pruned plants. Since a within-the-row spacing of 30 centimeters is practically about the limit, a reduction in space per plant can be obtained only by decreasing the between the row spacings. This might not be practical in case of nonpruned-non-staked plants; however, with pruned-staked plants a spacing as close as 3' x 1.5' has been tried with successful results (4). This practice is likely to alleviate the maleffect of pruning on midseason yield which might be due to a reduction in efficiency per plant and/or per area. This could have been studied by comparing the ratios of yields per plant weights of pruned and non-pruned plants. Unfortunately, because of the mite infestation late in the season and its consequent leaf drop, no data could be taken on the weight of the plants. It should be mentioned that pruning caused a mild leaf roll of the old leaves (Fig. 6). No doubt this cut down on the photosynthetic activity of the leaves; however, this is a normal reaction of the tomato plants to pruning and is believed not to be serious. From Table 6 it can be concluded that pruning had a more drastic effect on total midseason yield in the case of Malty than in the case of Marglobe. This is, actually, the consequence of the tendency for a bigger reduction in Malty's fruit number per dunum than that of Marglobe due to pruning (Table 37), and the difference in fruit size between the two varieties. Malty had larger fruits; thus, even for the same per cent reduction in fruit number, it would show a more pronounced decrease in yield than Marglobe. The reduction in early marketable yield due to pruning was attributed to an increase in cracking because of this practice. The reduction in marketable midseason yield due to pruning was more with Malty than with Big Boy (Table 7). This was because of pruning's increasing the per cent small of Malty while decreasing that of Big Boy (Table 11), and its causing a tendency for a lower reduction in per cent sunscald by number of Malty than that of Big Boy (Table 40) together with Malty's having the larger fruit of the two varieties. The need for close spacing to increase the yield of pruned plants is further supported by the interaction between spacing and practice in the number of midseason fruits per dunum (Table 8). It indicates that pruning decreases the fruit number to a much lower extent in the case of close spacing (S-30) than with wide spacing (S-90).

Pruning increased per cent cracking very significantly in both early and midseason yields. The results of the variety-practice interaction in per cent cracking of both early and midseason harvests (Tables 5 and 10) are combined in table 12 which represents the per cent increase in per cent cracking due to pruning over non-treatment.

Table 12. Per cent increase in per cent cracking of the varieties due to pruning in early and midseason harvest.

	Variety			
Harvest	Marglobe	Malty	Big Boy	Mean
Early	38	220	180	146
Midseason	57	162	209	143
Mean*	47	191	194	

From this table it is apparent that susceptibility to cracking is increased by pruning to a much lesser extent with Marglobe than with the other two varieties. The table also indicates a trend toward an interaction between variety and season, with an increase in susceptibility to cracking of Marglobe and Big Boy and a decrease in that of Malty due to pruning as the season progresses. Radial cracking was almost the only type present.

Apparently there are many causes of cracking, some of which have been reviewed by Frazier (10). Those which seem to be applicable under the conditions of this experiment are as follows: susceptibility both to type and severity of cracking is reported to be a varietal characteristic: In this connection Marglobe showed the highest percentage of cracking which is in agreement with Frazier's results. Secondly, the relatively high temperature during the day may lead to the expansion of the tissues underlying the cutin causing its rupture. Therefore the exposure of fruits to sunlight because of the reduction in the leaf canopy was probably the cause for the increase in cracking due to pruning.

Pruning decreased the incidence of sunscald injury which was unexpected (16). It seems, therefore, that there must have been an interaction between pruning and environment. Perhaps due to the denser foliage of nonpruned plants a higher relative humidity resulted around the fruits which led to water condensing in the form of drops which worked as lenses in concentrating sun rays on the fruit. In a rainy, humid climate, however, droplets form on fruits of both non-pruned and pruned plants, and in that case pruning provides a better exposure of the droplets to sun rays.

Close spacing reduced stem diameter. This is a normal response of most plants to shading. The effect of overcrowding was further revealed by a reduction in number of fruits per plant in early and especially in midseason harvests as expected (23, 29). This maleffect was counterbalanced by the higher number of plants per area to the extent that the numbers of fruits per dunum--early and midseason--were greater in the case of close spacing resulting in higher yields in both harvests (Fig. 2). Due to the mite infestation the data on total season yield are not presented. However, according to a variety trial conducted simultaneously with this experiment, the sum of early and midseason yields constituted about 81% of the total yield in the case of Marglobe, 73% in the case of Big Boy, and 51% in the case of Malty. This, together with the fact that the growth rate of tomato plants after fruit set drops steadily, supports the idea that (a) there might not have been any reduction in the late harvest of Marglobe and Big Boy due to close spacing, and (b) even if there were, it would not have been large enough to offset the results (in total yield) in favor of wide spacings. Therefore it appears safe to assume that besides increasing early and midseason yields, close spacing increases total yields of Marglobe and Big Boy as well. The increase in early and total yields by close spacing is supported by other workers (7, 20, 22, 23, 29).

The higher early yields of Big Boy and Marglobe were due to their earlier fruit set and maturity. Big Boy showed a tendency for higher early yield than Marglobe because of its higher number of fruits per plant and its larger fruits. This tendency together with Big Boy's relatively low cracking percentage resulted in its having a marketable yield twice as large as Marglobe which, due to its susceptibility to cracking, was lower even than that of Malty (Table 3). In the midseason period, Malty showed a tendency for higher yield (Table 6), in spite of its fewer fruits per plant, than the other two varieties, due to its larger fruits. Its marketable yield, however, was significantly greater than the other varieties because of its lower percentage of small fruits and relatively moderate percentage of cracking.

It was observed that the local seed of Malty was not true to variety. At least four types of fruits, as to color and shape, had been noticed by the author, One of them has an undesirable humpy surface (Fig. 7). Shapes and section-views of the three varieties are presented in Figure 8.

Among the weeds Crobanchy presented the main problem. However, it was distributed rather uniformly throughout the experimental area, and it is unlikely that it caused any appreciable error in the results.

To get a rough estimation of the effect of the mite infestation on yield, 22 plots which showed the heaviest infestation were compared with plots of the corresponding treatments which were mite-free. The weekly yields of these plots are presented in figure 4. The curves indicate a drop in yield at the beginning of the late harvest due to the infestation.

SUMMARY AND CONCLUSION

This study was conducted to find the effects of CCC; pruning; five within-the-row spacings of 30, 45, 60, 75, and 90 cms.; and three varieties, Marglobe, Big Boy, and Malty (local) on the growth and early yield of tomato plants at the Agricultural Research and Educational Center of the American University of Beirut during 1963-64.

The length of the stem was mainly a function of varieties with Big Boy and Marglobe having longer stems than Malty. The diameter of the stem, however, was increased due to wide spacing and pruning. Dates of fruit set and maturity were earlier in case of Big Boy and Marglobe than in case of Malty. Pruning enhanced the date of maturity.

Big Boy had the highest total early yield. Close spacing increased the total and marketable early yield. Marketable early yield was decreased due to pruning because it caused a high per cent of cracking. Big Boy produced the highest number of early fruits per plant and consequently per dunum. Close spacing reduced the number per plant and increased the number per dunum. Pruning resulted in a reduction in number of fruits per plant and per dunum. Per cent sunscalded and per cent small of early fruits were lowest in case of Malty. Pruning reduced the percentage of sunscald injury. Malty had the largest fruits, highest number of locules, and the lowest wall thickness to average radius ratio.

Total and marketable midseason yields were reduced due to pruning. Malty had the highest marketable midseason yield. Marglobe and Big Boy had the highest number of midseason fruits per plant and consequently per dunum. Marglobe showed the highest susceptibility to cracking. Pruning decreased the number of fruits per plant and per dunum. Close spacing also reduced the number per plant. Per cent cracking was decreased due to pruning which also reduced the per cent sunscald injury. Malty had the lowest per cent of small fruits, and the largest fruits.

The results of this experiment indicate the application of CCC to tomatoes in the Beqa'a plain is ineffective due to the high light intensity and cold night temperature in the area early in the growing season. Pruning cannot be recommended because it reduces the total yield and the marketable early yield (due to cracking), it spreads virus diseases of which three--big bud, fern leaf, and bushy stunt--have been noticed in the area by the author, and it involves too much labor. Close spacing (30 cms. by 120 cms.) increases early and total yield of both Big Boy and Marglobe. Variety Big Boy appears to be the better choice because of its high early and total yield, relatively low susceptibility to cracking, and good quality (low number of locules and a thick outer wall).

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APPENDIX

Table 13. Effects of practices, spacings, and varieties on the length of stem in cms. on May 28.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	16	18	17	15	15	16
CCC	18	15	15	13	14	15
Pruning	16	15	17	16	15	16
Mean	17	16	16	15	15	16
			Malty			
None	11	14	12	14	13	13
CCC	12	11	14	11	15	13
Pruning	12	15	15	14	11	13
Mean	12	13	14	13	13	13
			Big Boy			
None	16	15	17	16	18	16
CCC	16	14	16	16	17	16
Pruning	17	13	17	17	15	16
Mean	16	14	17	16	17	16

$S_{\bar{x}}$ for Vs = 0.5

Table 14. Effects of Practices, spacings, and varieties on the length of stem in cms. on June 4.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	20	20	21	19	20	20
CCC	22	19	20	17	17	19
Pruning	20	21	19	21	20	20
Mean	21	20	20	19	19	20
			Malty			
None	14	17	15	19	20	17
CCC	17	14	18	13	18	16
Pruning	14	18	17	16	16	16
Mean	15	16	17	16	18	16
			Big Boy			
None	21	20	21	22	22	21
CCC	21	17	21	23	20	20
Pruning	21	17	21	22	20	20
Mean	21	18	21	22	21	20

$S_{\bar{x}}$ for Vs = 0.6

Table 15. Effects of practices, spacings, and varieties on the length of stem in cms. on June 15.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	39	34	36	34	34	35
CCC	36	32	32	35	34	34
Pruning	37	35	35	38	39	37
Mean	37	34	34	36	36	35
			Malty			
None	29	28	31	36	36	32
CCC	33	27	33	26	38	31
Pruning	26	26	27	28	33	28
Mean	29	27	30	30	36	30
			Big Boy			
None	38	33	40	37	37	37
CCC	41	32	42	36	41	38
Pruning	37	31	37	37	37	36
Mean	39	32	40	37	38	37

$S_{\bar{x}}$ for Vs = 0.4

$S_{\bar{x}}$ for Ss = 0.9

Table 16. Effects of practices, spacings, and varieties on the length of stem in cms. on July 1.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	72	57	65	71	59	65
CCC	68	63	68	64	59	64
Pruning	63	66	62	68	63	64
Mean	68	62	65	68	60	64
			Malty			
None	51	55	54	59	67	57
CCC	57	53	61	53	62	57
Pruning	52	51	53	49	57	52
Mean	53	53	56	54	62	55
			Big Boy			
None	74	64	70	69	67	69
CCC	70	64	72	69	66	68
Pruning	65	59	70	68	62	65
Mean	70	62	71	68	65	67

$S_{\bar{x}}$ for Vs = 1.3

Table 17. Effects of practices, spacings, and varieties on the length of stem in cms. on July 8.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	76	80	70	76	73	75
CCC	76	76	77	74	69	74
Pruning	76	76	73	76	73	75
Mean	76	77	73	76	72	75
			Malty			
None	65	67	63	66	77	68
CCC	67	65	72	63	74	68
Pruning	64	61	62	62	64	63
Mean	65	64	66	64	72	66
			Big Boy			
None	86	76	84	86	79	82
CCC	84	79	84	79	74	80
Pruning	71	73	84	80	77	77
Mean	80	76	84	82	77	80

$S_{\bar{x}}$ for Vs = 2.3

$S_{\bar{x}}$ for Ps = 1.4

Table 18. Effects of practices, spacings, and varieties on the diameter of stem in cms. on July 5.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	1.1	1.2	1.1	1.2	1.3	1.2
CCC	1.0	1.1	1.1	1.2	1.2	1.1
Pruning	1.2	1.3	1.3	1.4	1.3	1.3
Mean	1.1	1.2	1.2	1.3	1.2	1.2
			Malty			
None	0.8	0.8	0.9	1.0	1.1	0.9
CCC	0.9	0.9	1.1	1.0	1.1	1.0
Pruning	1.0	1.2	1.2	1.2	1.3	1.2
Mean	0.9	1.0	1.1	1.0	1.1	1.0
			Big Boy			
None	1.1	1.1	1.1	1.0	1.1	1.1
CCC	1.0	1.1	1.1	1.2	1.1	1.1
Pruning	1.1	1.3	1.3	1.2	1.3	1.2
Mean	1.1	1.2	1.2	1.1	1.2	1.2

$S_{\bar{x}}$ for Ss = 0.02

$S_{\bar{x}}$ for Ps = 0.01

Table 19. Analyses of variances for the length and the diameter of stems in cms.

		Mean Square					
		Length in cms.					Diameter in cms.
Source	d.f.	May 28	June 4	June 15	July 1	July 8	July 5
Main Plots							
Blocks	2	107*	134*	229*	540	329	0.06
V	2	147*	230*	496**	1643**	2090*	0.30
Error (a)	4	13	16	7	80	243	0.05
Sub plots							
S	4	5	6	116**	98	11	0.12**
S x V	8	8	16	37	116	114	0.01
Error (b)	24	7	11	24	52	51	0.02
Sub sub plots							
P	2	4	12	24	141	152*	0.42**
P x V	4	8	2	50*	30	46	0.02
P x S	8	3	10*	16	32	41	0.01
P x V x S	16	5	6	14	33	31	0.01
Error (c)	60	6	5	15	77	35	0.01

Table 20. Effects of practices, spacings, and varieties on the date of fruit set in days after July 5.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	5	7	6	5	7	6
CCC	7	9	9	7	7	8
Pruning	7	5	4	7	4	5
Mean	6	7	6	6	6	6
			Malty			
None	14	16	17	14	7	14
CCC	15	13	12	19	13	14
Pruning	13	15	13	16	8	13
Mean	14	15	14	18	9	14
			Big Boy			
None	4	6	3	7	5	5
CCC	4	8	4	5	7	6
Pruning	3	6	3	5	3	4
Mean	4	7	3	6	5	5

$S_{\bar{x}}$ for Vs = 0.6

Table 21. Effects of practices, spacings, and varieties on the date of maturity in days after August 5.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	10	13	16	12	12	13
CCC	11	11	13	14	17	13
Pruning	9	8	8	12	10	9
Mean	10	11	12	13	13	12
			Malty			
None	15	21	17	22	14	18
CCC	18	20	17	23	22	20
Pruning	15	15	14	22	16	16
Mean	16	19	16	22	17	18
			Big Boy			
None	8	12	7	11	10	10
CCC	4	13	9	9	11	9
Pruning	3	11	4	2	4	5
Mean	5	12	7	7	8	8

$S_{\bar{x}}$ for Vs = 1.1

$S_{\bar{x}}$ for Ps = 0.5

Table 22. Analyses of variances for the dates of fruit set and maturity in days.

Source	d.f.	Mean square	
		Date of fruit set	Date of maturity
Main plots			
Blocks	2	88	60
V	2	970^{**}	1166^{**}
Error (a)	4	17	56
Sub plots			
S	4	32	71^{*}
S x V	8	23	37
Error (b)	24	16	21
Sub sub plots			
P	2	30^{*}	189^{**}
P x V	4	6	12
P x S	8	1	10
P x V x S	16	11	12
Error (c)	60	9	12

Table 23. Effect of practices, spacings, and varieties on total early yield in kgs. per dunum.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	2147	1340	1204	1176	1204	1414
CCC	1911	1658	1713	1148	998	1486
Pruning	2071	1772	1157	1157	1080	1447
Mean	1043	1590	1358	1160	1094	1449
			Malty			
None	960	1040	1046	556	1728	1066
CCC	1280	944	981	130	1183	904
Pruning	1288	996	528	315	638	753
Mean	1176	993	852	334	1183	908
			Big Boy			
None	3064	2046	1685	1481	1358	1927
CCC	2753	2310	1768	1602	1379	1962
Pruning	2803	1799	1639	1380	1379	1800
Mean	2873	2052	1697	1488	1372	1896

$S_{\bar{x}}$ for Vs = 179

$S_{\bar{x}}$ for Ss = 127

Table 24. Effects of practices, spacings, and varieties on marketable early yield in kgs. per dunum.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	918	547	583	370	412	566
CCC	918	750	889	380	504	688
Pruning	219	229	435	93	329	261
Mean	685	507	636	281	415	505
			Malty			
None	842	846	713	407	1296	821
CCC	943	529	787	130	823	642
Pruning	471	123	28	28	124	155
Mean	752	499	509	188	748	539
			Big Boy			
None	2340	1384	1333	1083	936	1415
CCC	2104	1622	1157	1176	895	1391
Pruning	673	794	444	213	247	474
Mean	1706	1267	978	824	693	1093

$S_{\bar{x}}$ for Vs = 122

$S_{\bar{x}}$ for Ss = 89

$S_{\bar{x}}$ for Ps = 62

$S_{\bar{x}}$ for VSs with Vs the same = 107

$S_{\bar{x}}$ for VSs with Vs different = 150

Table 25. Effects of practices, spacings, and varieties on the number of early fruits per dunum.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	22813	13492	10648	12222	12140	14263
CCC	20708	18606	17222	12870	10288	15939
Pruning	18940	14962	10185	9722	8230	12396
Mean	20820	15667	12685	11605	10219	14198
			Malty			
None	5303	4497	3981	2037	13066	5777
CCC	6314	4409	5370	463	7202	4752
Pruning	6229	5467	2407	1574	2984	3732
Mean	5949	4791	3919	1358	7751	4754
			Big Boy			
None	24412	16931	17129	13981	12860	17063
CCC	25843	25220	17685	11203	13992	18789
Pruning	21298	14109	11944	10926	9876	13631
Mean	23851	18753	15586	12037	12242	16494

$S_{\bar{x}}$ for Vs = 1142

$S_{\bar{x}}$ for Ss = 960

$S_{\bar{x}}$ for Ps = 540

$S_{\bar{x}}$ for VSs with Vs the same =1664

$S_{\bar{x}}$ for VSs with Vs different = 1876

Table 26. Effects of practices, spacings, and varieties on the number of early fruits per plant.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	8	7	8	11	13	9
CCC	8	10	12	12	11	11
Pruning	7	8	7	9	9	8
Mean	8	8	9	11	11	9
			Malty			
None	2	2	3	2	14	5
CCC	2	2	4	0	8	3
Pruning	2	3	2	1	3	2
Mean	2	2	3	1	8	3
			Big Boy			
None	9	9	12	13	14	11
CCC	9	14	13	10	15	12
Pruning	8	8	9	10	11	9
Mean	9	10	11	11	13	11

$S_{\bar{x}}$ for Vs = 1.0

$S_{\bar{x}}$ for Ss = 0.9

$S_{\bar{x}}$ for Ps = 0.5

Table 27. Effects of practices, spacings, and varieties on per cent cracked by weight of early yield.

Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Spacing			
			Marglobe			
None	53	46	63	62	55	56
CCC	46	45	48	66	41	49
Pruning	87	84	58	90	67	77
Mean	62	58	56	73	54	61
			Malty			
None	10	43	33	24	14	25
CCC	47	55	12	15	26	31
Pruning	68	87	96	82	66	80
Mean	42	62	47	40	35	45
			Big Boy			
None	21	28	34	22	27	26
CCC	21	18	27	12	26	21
Pruning	74	53	71	79	83	72
Mean	39	33	44	38	45	40

$S_{\bar{x}}$ for Ps = 2.4

$S_{\bar{x}}$ for VPs with Vs the same = 4.2

$S_{\bar{x}}$ for VPs with Vs different = 5.4

Table 28. Effects of practices, spacings, and varieties on per cent sunscalded by number of early yield.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	1	7	3	3	3	3
CCC	2	6	4	5	5	5
Pruning	0	0	0	0	1	0
Mean	1	4	2	3	3	3
			Malty			
None	0	0	1	6	3	2
CCC	0	1	2	3	3	2
Pruning	0	0	0	0	0	0
Mean	0	0	1	3	2	1
			Big Boy			
None	2	6	3	4	6	4
CCC	3	6	1	4	8	4
Pruning	0	0	0	0	0	0
Mean	2	4	1	3	5	3

$S_{\bar{x}}$ for Vs = 0.3

$S_{\bar{x}}$ for Ps = 0.5

Table 29. Effects of practices, spacings and varieties on per cent small by weight of early yield.

Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Spacing			
			Marglobe			
None	4	6	1	5	5	4
CCC	7	11	3	3	6	6
Pruning	3	3	4	4	10	5
Mean	5	7	3	4	7	5
			Malty			
None	1	0	0	1	6	2
CCC	0	0	2	0	1	1
Pruning	1	1	0	0	3	1
Mean	1	0	1	0	3	1
			Big Boy			
None	1	2	6	5	4	4
CCC	2	7	8	5	2	5
Pruning	1	2	1	2	1	1
Mean	1	4	5	4	2	3

$S_{\bar{x}}$ for Vs = 0.5

Table 30. Effects of practice, spacings, and varieties on average weight in grams per fruit of early yield.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	94	101	111	97	98	100
CCC	91	88	97	92	105	95
Pruning	110	119	109	119	135	118
Mean	98	102	106	103	113	104
			Malty			
None	184	188	256	280	154	212
CCC	195	176	256	278	202	222
Pruning	198	155	212	193	264	204
Mean	193	173	242	250	207	213
			Big Boy			
None	123	120	96	105	107	110
CCC	106	92	100	123	103	105
Pruning	131	124	139	126	142	132
Mean	120	112	112	118	117	116

$S_{\bar{x}}$ for Vs = 5.3

Table 31. Analyses of variances for early yield.

Source	d.f.	Mean square: Total yield kgs/du	Marketable yield Kgs/du	No. of fruits per du.	No. of fruits per plant	Per cent cracked by wt.	Per cent sunscalded by no.	Per cent small by wt.	Ave. wt. per fruit in gms.
Main plots									
Blocks	2	7378808	3750728	129234630	40	858.1	10.8	46.6	5021.2
V	2	11033244*	4927384*	1742399730**	676*	5242.7	35.8*	167.7*	159846.1**
Error (a)	4	1451749	666552	58790780	48	786.5	4.8	11.6	1285.4
Sub plots									
S	4	4222174	1388892	293664580**	77*	157.3	21.1	17.6	3522.7
S x V	8	745453	402362	68594167*	16	741.6	7.8	24.6	3223.1
Error (b)	24	431709	215658	24907870	21	382.0	13.4	13.6	2139.7
Sub sub plots									
P	2	242980	5949084**	128384375**	70**	26225.6**	165.0**	23.6	1851.8
P x V	4	126910	499105*	18913892	8**	1271.5**	10.1	21.2	2368.0
P x S	8	140831	93968	22562659	21**	266.4	6.1	13.8	2299.2
P x V x S	16	145339	122655	12237804	6**	406.2	4.3	8.8	1447.2
Error (c)	60	211766	172525	13117828	1	265.2	11.0	9.3	1361.9

Table 32. Effects of practices, spacings, and varieties on number of locules per fruit.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	5	5	4	5	6	5
CCC	4	5	5	5	6	5
Pruning	5	6	5	5	5	5
Mean	5	6	5	5	6	5
			Malty			
None	12	12	13	12	10	12
CCC	10	12	13	11	11	11
Pruning	11	12	10	11	8	10
Mean	11	12	12	11	10	11
			Big Boy			
None	5	5	5	5	5	5
CCC	5	5	5	5	5	5
Pruning	5	5	5	6	6	5
Mean	5	5	5	5	5	5

$S_{\bar{x}}$ for Vs = 0.3

Table 33. Effects of practices, spacings, and varieties on the ratio of wall thickness to average radius fruit in per cent.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	18	19	19	19	20	19
CCC	21	19	21	19	18	19
Pruning	18	18	18	18	19	18
Mean	19	19	19	19	19	19
			Malty			
None	13	13	11	12	15	13
CCC	14	13	13	13	12	13
Pruning	12	12	14	12	15	13
Mean	13	13	13	12	14	13
			Big Boy			
None	17	17	17	16	16	17
CCC	17	18	18	18	16	17
Pruning	17	17	16	17	16	17
Mean	17	17	17	17	16	17

$S_{\bar{x}}$ for Vs = 0.4

Table 34. Analyses of variances for the number of locules per fruit and the ratio of wall thickness to average radius of fruits in per cent.

		Mean square	
Source	d.f.	No. of locules per fruit	Wall thickness x 100 / ave. radius
Main plots			
Blocks	2	3	9
V	2	572^{**}	411^{**}
Error (a)	4	4	8
Sub plots			
S	4	2	1
S x V	8	3	3
Error (b)	24	1	3
Sub sub plots			
P	2	2	7
P x V	4	1	3
P x S	8	5	4
P x V x S	16	1	4
Error (c)	60	2	12

Table 35. Effects of practices, spacings, and varieties on total midseason yield in kgs. per dunum.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	1194	1408	1543	1080	1356	1316
CCC	1296	1313	1493	1407	1606	1423
Pruning	1616	899	1389	1045	965	1183
Mean	1369	1207	1475	1177	1309	1307
			Malty			
None	1825	2395	1578	1390	1829	1803
CCC	1914	2147	1320	1006	1728	1623
Pruning	1282	1191	869	1022	860	1045
Mean	1674	1911	1256	1139	1472	1490
			Big Boy			
None	1344	1204	1046	1129	1200	1185
CCC	584	990	1016	1054	1001	929
Pruning	913	856	797	1191	1012	954
Mean	947	1017	953	1125	1071	1023

$S_{\bar{x}}$ for Ps = 45

$S_{\bar{x}}$ for VPs with Vs the same = 78

$S_{\bar{x}}$ for VPs with Vs different = 129

Table 36. Effects of practices, spacings, and varieties on marketable midseason yield in kgs. per dunum.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	429	521	573	279	441	449
CCC	480	443	484	327	662	479
Pruning	98	82	12	52	23	53
Mean	337	349	356	219	375	327
			Malty			
None	1418	1630	1003	1185	1376	1322
CCC	1476	1103	936	612	1167	1059
Pruning	305	276	86	125	139	186
Mean	1066	1003	675	641	894	856
			Big Boy			
None	959	775	618	682	822	771
CCC	503	648	595	676	681	621
Pruning	380	161	206	159	270	235
Mean	614	528	473	506	591	542

$S_{\bar{x}}$ for Vs = 40

$S_{\bar{x}}$ for Ss = 53

$S_{\bar{x}}$ for Ps = 42

$S_{\bar{x}}$ for VPs with Vs the same = 74

$S_{\bar{x}}$ for VPs with Vs different = 76

Table 37. Effects of practices, spacings, and varieties on number of midseason fruits per dunum.

Practice	Spacing S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	14226	16842	15185	12407	15329	14798
CCC	16583	14902	16944	14814	16769	16002
Pruning	17678	9435	14722	10740	11214	12759
Mean	16162	13726	15617	12654	14437	14520
			Malty			
None	9765	10229	6944	6481	13169	9317
CCC	9176	10141	7500	4167	8745	7946
Pruning	7576	6437	4815	5648	5144	5924
Mean	8839	8936	6420	5432	9019	7729
			Big Boy			
None	12290	11287	11759	12685	13477	12210
CCC	6650	9964	11018	11111	10905	9930
Pruning	8839	7143	7037	10185	9259	8493
Mean	9260	9465	9938	11327	11214	10211

$S_{\bar{x}}$ for Vs = 1114

$S_{\bar{x}}$ for Ps = 337

$S_{\bar{x}}$ for SPs with Ss the same = 753

$S_{\bar{x}}$ for SPs with Ss different = 946

Table 38. Effects of practices, spacings, and varieties on number of midseason fruits per plant.

Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	5	9	11	11	16	11
CCC	6	8	12	13	19	11
Pruning	6	5	10	10	12	9
Mean	6	7	11	11	16	10
			Malty			
None	4	6	5	6	14	7
CCC	3	6	5	4	10	6
Pruning	3	4	4	5	6	4
Mean	3	5	5	5	10	6
			Big Boy			
None	4	6	8	11	14	9
CCC	2	5	8	10	13	8
Pruning	3	4	5	9	10	6
Mean	3	5	7	10	12	8

$S_{\bar{x}}$ for Vs = 0.8

$S_{\bar{x}}$ for Ss = 0.6

$S_{\bar{x}}$ for Ps = 0.3

$S_{\bar{x}}$ for SPs with Ss the same = 0.7

$S_{\bar{x}}$ for SPs with Ss different = 1.0

Table 39. Effects of practices, spacings, and varieties on per cent cracked by weight of midseason yield.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	44	82	58	61	55	53
CCC	49	45	56	58	53	52
Pruning	75	82	89	83	87	83
Mean	56	58	68	67	65	63
			Malty			
None	26	26	50	30	14	29
CCC	17	37	35	31	24	29
Pruning	72	66	90	72	79	76
Mean	38	43	58	44	39	45
			Big Boy			
None	21	32	19	22	19	23
CCC	14	18	28	25	17	20
Pruning	53	78	69	81	73	71
Mean	29	43	39	43	36	38

$S_{\bar{x}}$ for Vs = 4.2

$S_{\bar{x}}$ for Ss = 2.4

$S_{\bar{x}}$ for Ps = 1.9

$S_{\bar{x}}$ for VPs with Vs the same = 3.2

$S_{\bar{x}}$ for VPs when Vs different = 5.0

Table 40. Effect of practices, spacings, and varieties on per cent sunscalded by number of midseason yield.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	11	5	5	8	8	7
CCC	6	15	5	9	4	8
Pruning	0	0	0	2	0	0
Mean	6	7	3	6	4	5
			Malty			
None	3	6	3	3	6	4
CCC	7	9	5	2	5	6
Pruning	3	2	0	0	3	2
Mean	4	6	3	2	5	4
			Big Boy			
None	6	5	13	5	5	6
CCC	8	8	6	6	8	7
Pruning	0	7	0	2	2	2
Mean	5	7	6	4	5	5

$S_{\bar{x}}$ for Ps = 0.7

Table 41. Effects of practices, spacings, and varieties on per cent small by weight of midseason yield.

	Spacing					
Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Marglobe			
None	13	12	4	6	2	7
CCC	11	10	8	8	4	8
Pruning	11	7	10	8	10	9
Mean	12	10	8	7	5	8
			Malty			
None	0	0	0	2	5	1
CCC	0	0	0	0	1	0
Pruning	2	1	3	2	3	2
Mean	1	0	1	1	3	1
			Big Boy			
None	6	2	12	13	9	8
CCC	7	7	8	6	9	7
Pruning	5	8	0	5	2	4
Mean	6	6	7	8	7	7

$S_{\bar{x}}$ for Vs = 0.5

$S_{\bar{x}}$ for VPs with Vs the same = 1.1

$S_{\bar{x}}$ for VPs with Vs different = 1.1

Table 42. Effects of practices, spacings, and varieties on average weight in grams per fruit of midseason yield.

Practice	S-30	S-45	S-60	S-75	S-90	Mean
			Spacing			
			Marglobe			
None	83	83	100	86	87	88
CCC	78	88	88	91	93	88
Pruning	90	94	93	97	91	93
Mean	84	88	93	92	90	89
			Malty			
None	188	235	224	214	146	202
CCC	208	220	179	207	197	202
Pruning	182	180	181	182	194	184
Mean	193	212	195	201	179	196
			Big Boy			
None	108	101	89	90	90	96
CCC	88	96	92	94	91	92
Pruning	102	130	110	118	108	114
Mean	100	109	97	101	96	101

$S_{\bar{x}}$ for Vs = 4.8

Table 43. Analyses of variances for midseason yield.

Source	d.f.	Mean square: Total yield kgs/du	Marketable yield kgs/du	No. of fruits per du.	No. of fruits per plant	Per cent cracked by wt.	Per cent sunscalded by no.	Per cent small by wt.	Ave. wt. per fruit in gms.
Main plots									
Blocks	2	3532191	718357*	146735935	67	154.4	42.1	23.3	6255.7
V	2	2503592	3185640**	530450850*	265*	7471.2*	31.1	601.5**	154488.5**
Error (a)	4	570487	70228	55814412	33	801.5	15.6	9.4	1062.9
Sub plots									
S	4	218249	221001	13320910	273*	743.7**	22.1	4.0	812.6
S x V	8	421386	84396	19378489	15	204.3	14.4	31.5	417.9
Error (b)	24	204560	75847	13987113	9	155.6	15.9	19.6	747.8
Sub sub plots									
P	2	1664208**	6025789**	113979590**	71**	26596.0**	389.6**	3.2	84.4
P x V	4	602148**	630390**	12769450	7	536.0*	18.4	48.5*	1844.4
P x S	8	175910	33689	13288252*	11**	69.8	19.5	4.8	528.3
P x V x S	16	102426	58571	10140699	4	147.1	21.1	33.6	678.5
Error (c)	60	90618	81556	5100052	4	155.8	22.4	18.8	7133.3

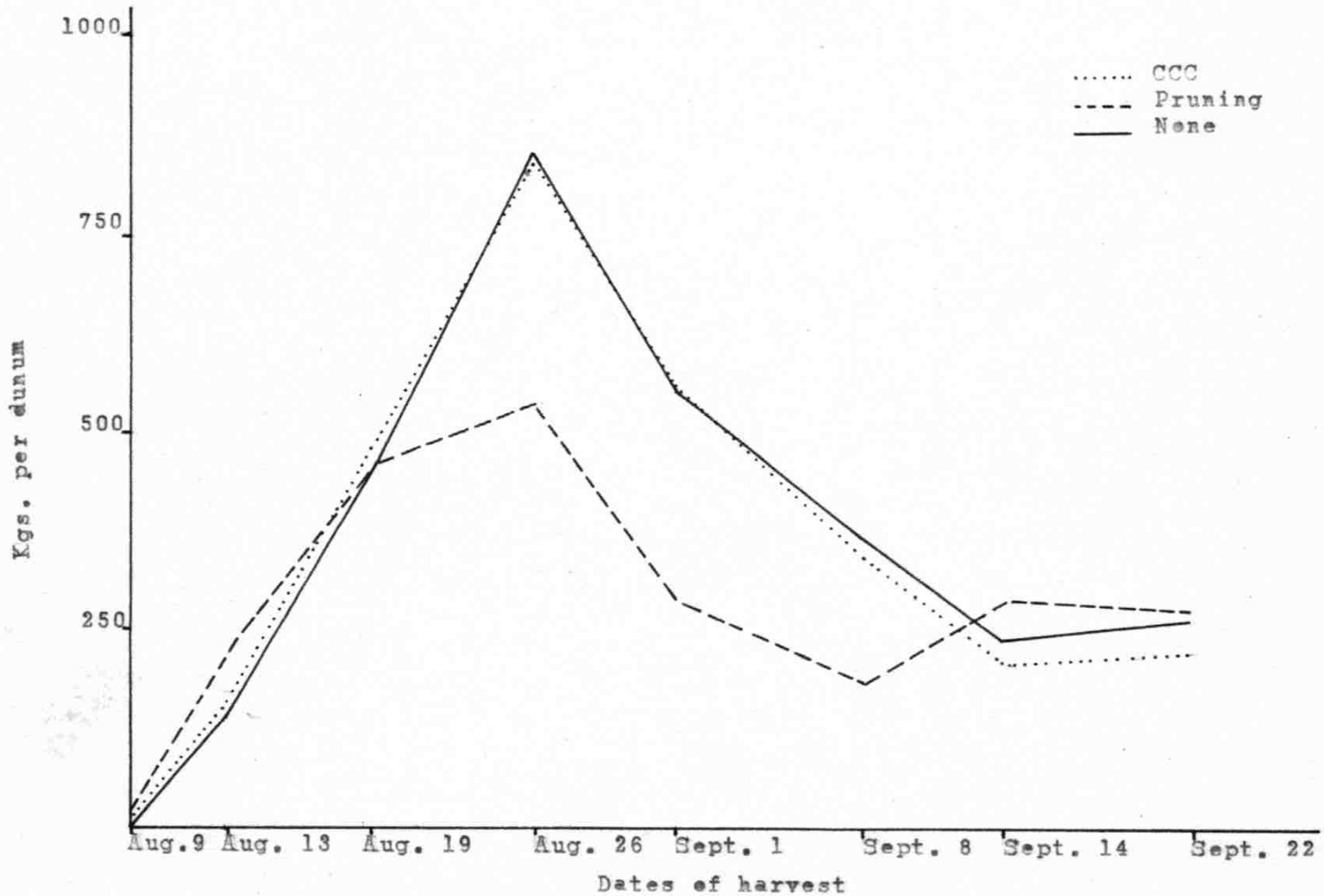

Fig. 1. Effects of CCC and Pruning on yield in Kgs. per dunum

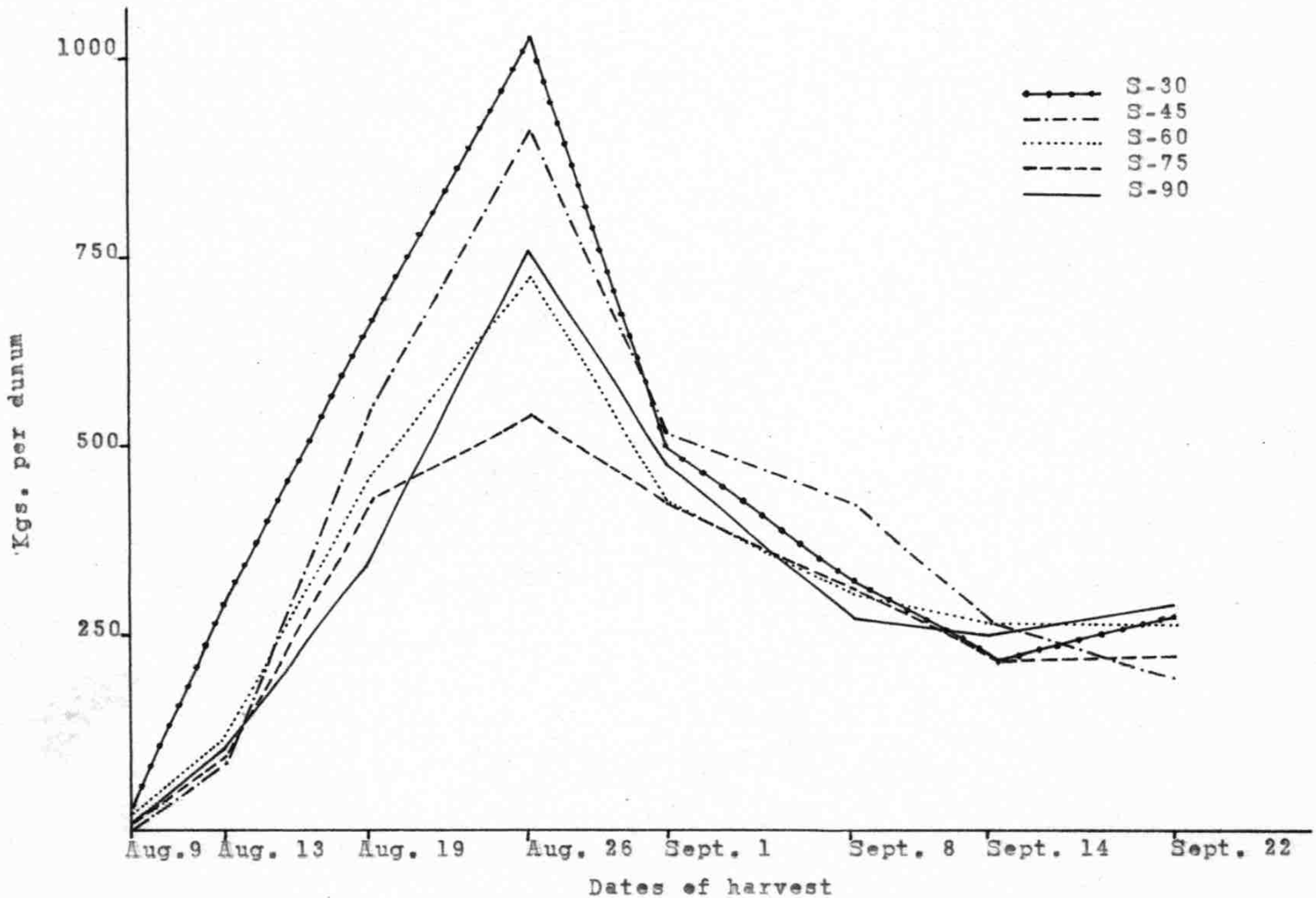

Fig. 2 Effects of spacing on yield in Kgs. per dunum

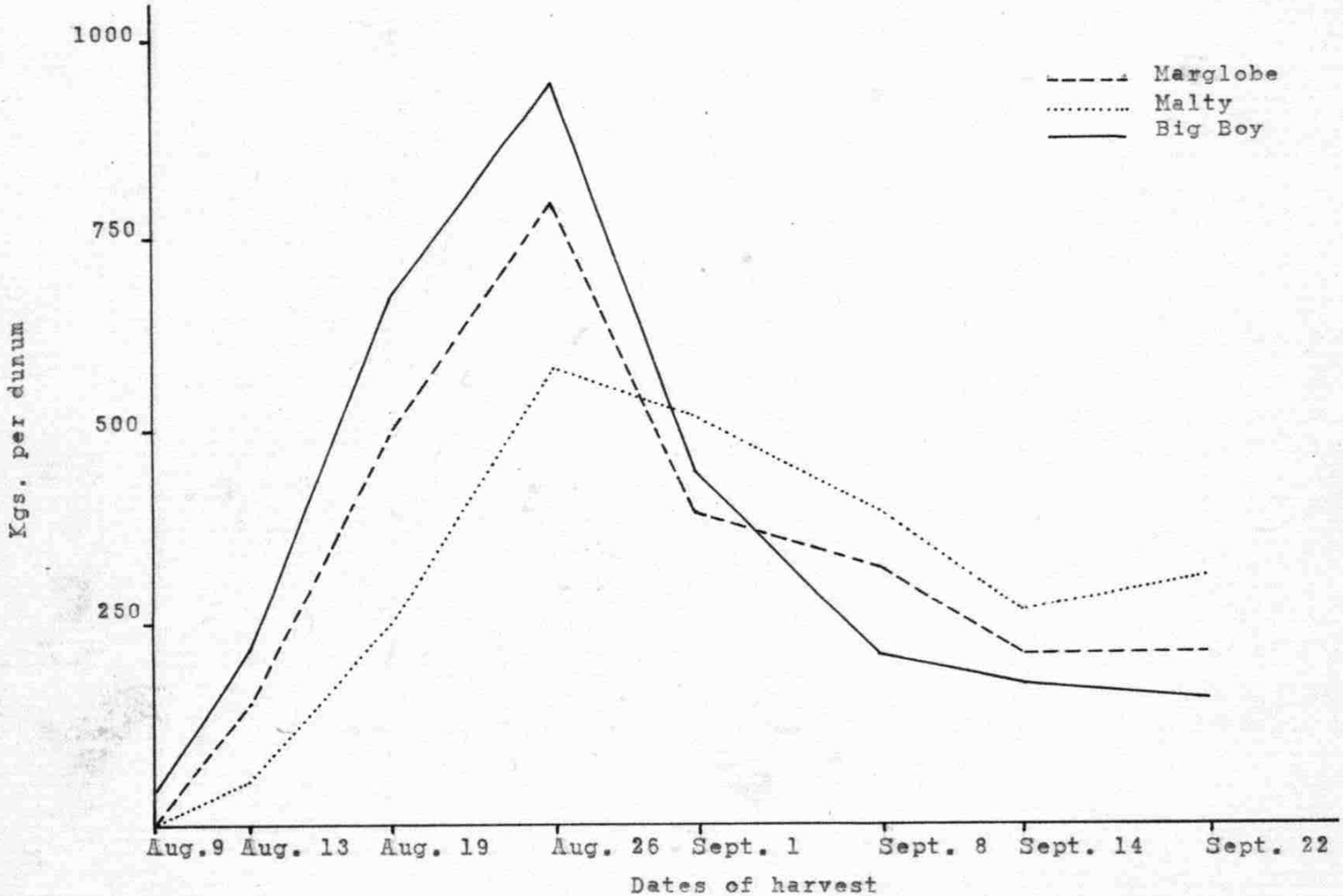

Fig. 3. Yield of three varieties in Kgs. per dunum

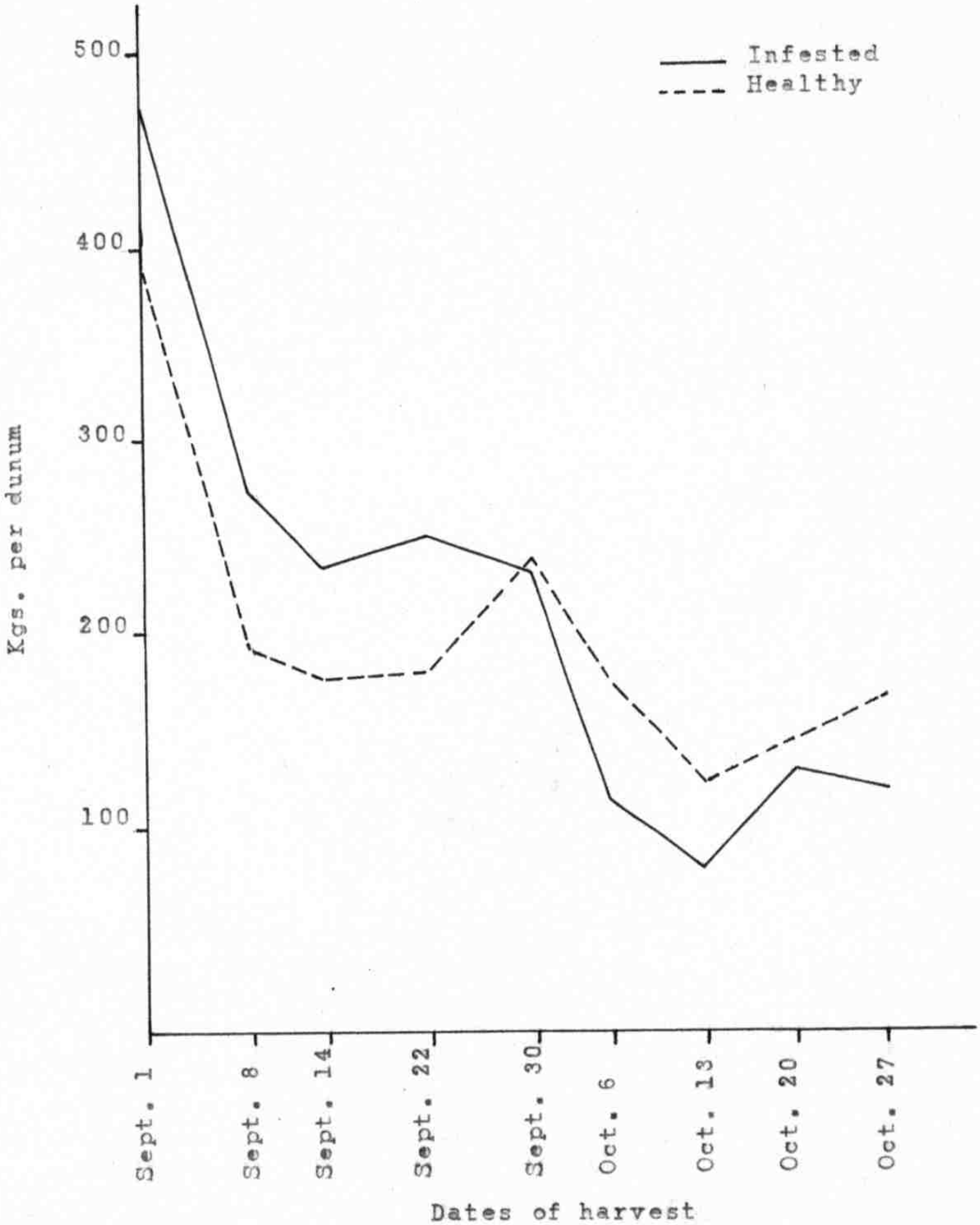

Fig. 4. Effect of mite infestation on yield in Kgs per dunum

Fig. 5. Stem of Malty showing
typical side shoot growth.

Fig. 6. Staked tomato plant showing
leaf roll resulting from pruning.

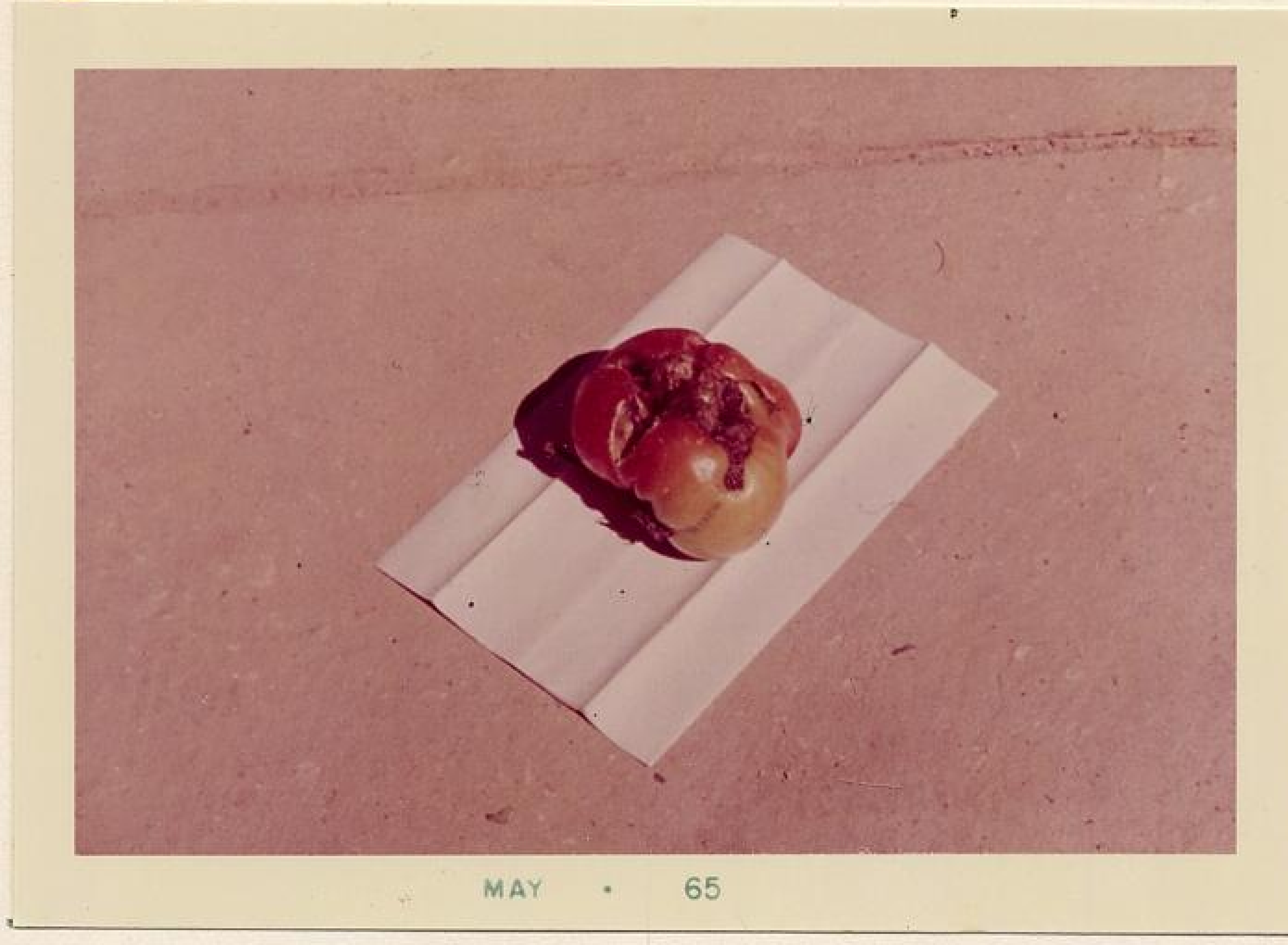

Fig. 7. One type of Malty
fruits with humpy surface

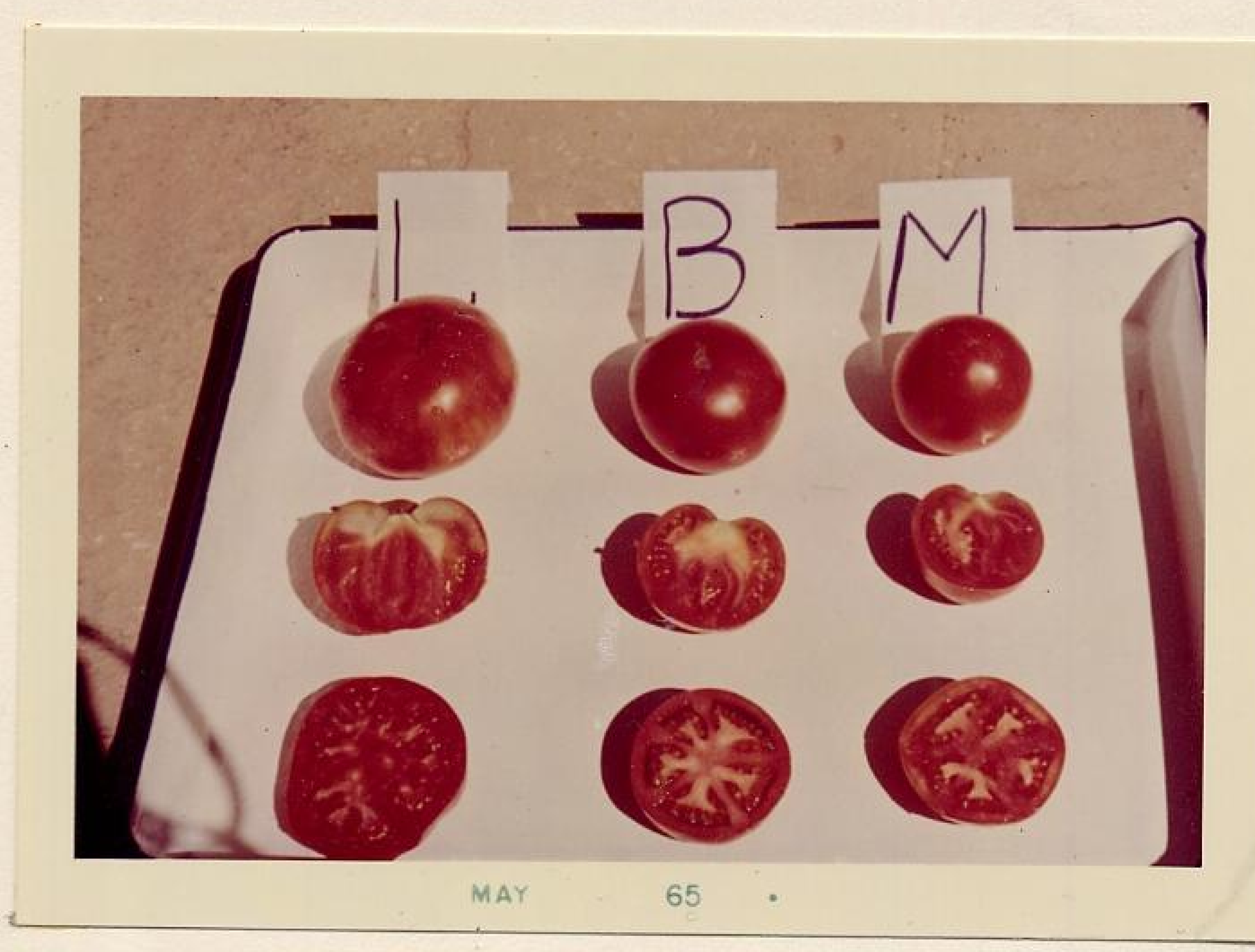

Fig. 8. Blossom end view, longitudinal and cross sections of fruits of the three varieties.

L= Local (Malty)

B= Big Boy

M= Marglobe

Fig. 5. Stem of Malty showing
typical side shoot growth.

Fig. 6. Staked tomato plant showing
leaf roll resulting from pruning.

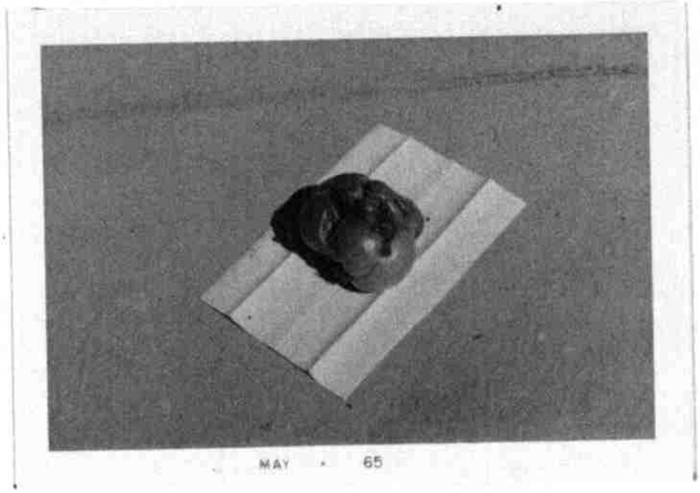

Fig. 7. One type of Malty

fruits with humpy surface

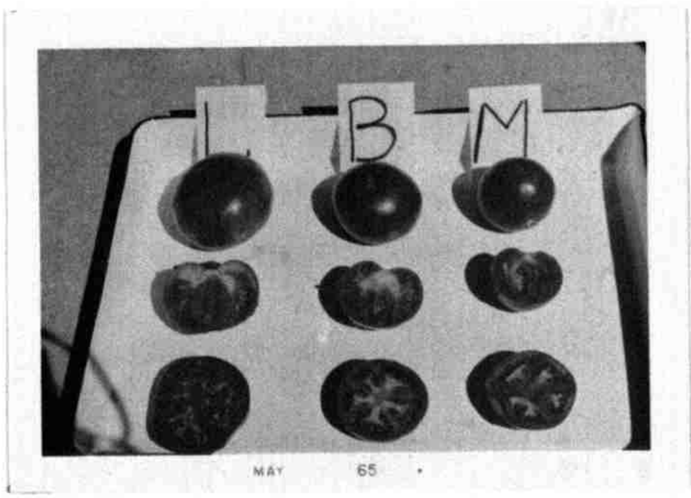

Fig. 8. Blossom end view, longitudinal

and cross sections of fruits of the three

varieties.

L= Local (Malty)

B= Big Boy

M= Marglobe