

INVESTIGATIONS INTO DRY-SEASON TOMATO PRODUCTION

IN TRINIDAD.

(With a general review of the literature on tomato
cultivation.)

by

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As to the potato in Cuba value, the heads the list in value among the vegetable vegetables. The average annual production and farm value of the crop grown for the fresh market for the period 1945-52 was 25,345 million bushels and \$133,398 million respectively. For the same period the production and value of the crop for processing were 2,124,700 tons and \$88,398 million (Thompson and Kelly, 1957).

Fresh potatoes in South Africa brought on the farms during 1952-53 21,215,000 on the nine principal districts of the Union.

In Cuba and some of the islands in the Caribbean, principally Jamaica and the Bahamas, potatoes are grown mainly for export to the United Kingdom during the winter and early spring when fresh potatoes are not available in most parts of the latter country. Potatoes are also produced in Southern Caribbean countries like Trinidad and British Guiana. Since the last war the former trade in fresh crops between Canada and the British West Indian Islands, Jamaica, Antigua, St. Kitts, Barbados, Dominica and Barbados has stopped owing to lack of regular shipping.

Other important potato-growing countries are Mexico, Puerto Rico, the Canary Islands and Hawaii.

I N T R O D U C T I O N .

The tomato is one of the most popular as well as one of the most important vegetables in the tropics and temperate region. Rich in vitamin C and minerals especially phosphorus, potassium and calcium, and high in palatibility it is esteemed in various dishes. In the tropics its increased consumption will go a long way in decreasing the many deficiency diseases found there. For most countries it is an important commercial crop bringing in much needed revenue.

Though a native of tropical Central America, the tomato has reached its maximum production in temperate countries. In Britain the green house culture of the tomato now produces up to 60 tons per acre, the average yield being 35.0 tons per acre. This is about $2\frac{1}{2}$ times larger than the average yield of the outdoor crop produced in the U.S.A.

In the U.S.A. the tomato ranks among the vegetable crops second only to the potato in farm value, and heads the list in value among the perishable vegetables. The average annual production and farm value for the crop grown for the fresh market for the period 1948-52 were 33,322 million bushels and \$133,893 million respectively. For the same period the production and value of the crop for processing were 3,144,700 tons and \$88,398 million (Thompson and Kelly, 1957).

Fresh tomatoes in South Africa brought to the farmers during 1952-53 £1,310,000 on the nine principal markets of the Union.

In Cuba and some of the islands in the Caribbean, principally Jamaica and the Bahamas, tomatoes are grown mainly for export to the U.S.A. during the winter and early spring when field production is not possible in most parts of the latter country. Montserrat ships its produce to Eastern Caribbean countries like Trinidad and British Guiana. Since the last war the former trade in fresh fruit between Canada and the British West Indian islands, Jamaica, Antigua, St. Kitts, Montserrat, Bahamas and Bermudas has stopped owing to lack of regular shipping.

Other important tomato-growing countries are Mexico, Puerto Rico, the Canary Islands, and Hawaii.

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In the Canary Islands the crop is grown mostly under irrigation and exported to Europe, the United Kingdom taking the greatest amount. Hawaii tomato cultivation has recently come very much to the fore and much scientific research has gone into it. The Mexican crop is exported to the U.S.A.

In the tropics in general the tomato is grown mainly in the dry season, because high temperatures and continuous heavy rainfall during the wet season create conditions unsuitable for growth. Techniques of cultivation are backward and yields are low. Resistant varieties are not available and a large part of the crop is lost through diseases. Great improvement is therefore needed in the techniques of cultivation of this crop.

For the past five years or more, based on the findings at the John Lanes Horticultural Station that yields of tomatoes depend to some extent on methods of production of seedlings, experiments have been conducted at the I.C.T.A. into methods of raising seedlings with a view to improving on the existing local methods. Three methods have been compared: raising seedlings in 3" clay pots containing specially prepared composts; raising seedlings by the methods of the peasant farmers who sow nursery beds thickly with seed and do not thin out; and producing seedlings by the "improved" method at a spacing of 3" x 3" on open beds. The results have so far indicated that pot raised and "improved" seedlings are superior in yielding capacity than the "peasant" seedlings with the pot raised seedlings giving higher yields than the "improved" seedlings.

Cultivation methods have also been investigated. Plants grown on ridges, on the flat and on the flat with subsequent moulding up have been compared. In most of the experiments ridged and moulded plants have out-yielded those grown on the flat. But there are as yet no clear cut, confirmed differences between ridged and moulded plants.

The effect of Starter solution used in transplanting has also been probed into and found beneficial.

In the experiment reported in this paper the intention was to confirm the effects on yields of the three cultural methods - planting on the flat, moulding and ridging - and also of pruning and staking. It was decided ../

It was decided in raising the Seedlings and in transplanting to use methods which were within the means of the peasant farmer and were capable of giving high yields. The seedlings were therefore raised at a spacing of 3" x 3" straight on open beds instead of in pots or in seed boxes prior to transplanting to a field nursery, and a starter solution was used during transplanting.

REVIEW OF LITERATURE.

Origin of the cultivated tomato.

The centre of origin of the genus *Lycopersicon*, to which the tomato belongs, is on the narrow west coast area of South America, between the Andes and the ocean, extending from the equator to about 30° South latitude. Where the cultivated forms of the genus evolved in this area is however a matter of dispute. Though it is widely believed that the centre of origin of the cultivated forms was in Peru, Jenkins (1948) adduces evidence to shew that Mexico was the centre of domestication of the tomato. Jenkins points out that in Mexico there is a widespread distribution, not found in Peru, of both wild and cultivated tomatoes and of many transitional forms between the wild and cultivated types and also between the cultivated types themselves. He also draws attention to the fact that the name tomato is derived from the *Nahua* word "tomatl" which in Mexico is applied to many different solanaceous plants including *lycopersicon*, *Saracha* and *Physalis* especially the latter which was and still is used as food in many parts of that country. Though the tomato had been called many names including the European one of "Pomi del Peru" Jenkins, in his investigations, found nothing in the historical records to suggest a Peruvian origin.

From the results of his researches Jenkins has put forward the hypothesis that the putative variety *cerasiforme* of *lycopersicon esculentum* was the ancestor of the cultivated tomato. Originally confined to the Peru-Ecuador area, this variety spread in pre Columbian times as a weed throughout much of tropical America. In Mexico owing to its general resemblance to the older food plant *Physalis* it was brought into cultivation.

From Mexico the cultivated forms were taken to Europe soon after the Conquest by Cortez in 1534. In Europe the tomato was at first probably grown in the gardens of herbalists as a curious plant but soon found its way into potions and later became a relished article of food. According to Sturtevant (1919) and McCue (1952) the earliest mention of its use as sauce in Italy was by Matthioli in 1544 in the first edition of his commentary on Dioscorides.

Before 1600, however, it was widely established as a vegetable in many European countries.

From Europe the Spanish and the Portuguese took the tomato to Asia, the Pacific and Africa (Jenkins, 1948).

As regards the introduction of the crop into the United States of America, Thompson and Kelly (1957) record that the first reference to the use of tomato for culinary purposes in the United States was by Jefferson in 1781, although mention had been made of its presence in the Carolinas, Georgia and Florida earlier in the 18th Century.

Botany.

The tomato, botanically known as *Lycopersicon esculentum* Mill, belongs to the family Solanacea (L). Cobley (1956) has given a botanical description of the plant, which is an annual or short lived perennial with weak trailing much branched stems covered with yellow glandular hairs as well as non-glandular ones.

The fruit is a two - to many - celled red or yellowish berry with a smooth skin. The seeds are many, small, hairy, kidney shaped and are borne on fleshy placentae in axile placentation. The red colouration of the fruit is due to the presence of two pigments carotene and lycopersicon occurring in different concentrations and thus bringing about gradation in fruit colour.

Both Muller (1940) and Luckwill (1943) have divided the genus *Lycopersicon* into two subgenera; first, *Eulycopersicon* including the red fruited species *L. esculentum* and *L. Pimpinelli folium*; second, *Eriopersicon*, the green fruited species which according to Muller consist of the Species *L. cheesmanii*, *L. peruvianum*, *L. hirsutum*, and *L. glandulosum*.

The red fruited group including all cultivated forms has a complex geographic distribution that has been greatly influenced by man.

The green fruited group contains no species of economic importance. *L. pimpinelli folium*, one of the two red-fruited species has a restricted range of distribution being confined to Peru, Ecuador, and the Galapagos Islands (Muller, 1940).

The variety *Cerasiforme* and the form *pyriforme* are considered by Muller as distinct entities within the species *esculentum*.

Tomatoes may also be divided into determinate and indeterminate types according to the sequence of formation of flower clusters. Shoemaker (1949) has given the characteristics of the two types. Indeterminate plants are capable of continuing their growth more or less indefinitely. Normally a blossom cluster is produced at every 3rd internode, being separated by 3 leaves from the next flower cluster. Determinate varieties are free blooming. The blossom clusters are produced at every internode, thus being separated by only one leaf. The stem eventually terminates in a blossom cluster.

Climatic Conditions of Growth.

The tomato is mainly a crop for warm conditions, but may be grown in frost-free areas during the winter in temperate regions. To give maximum yields it requires a long growing period of $3\frac{1}{2}$ - 5 months with moderately high temperatures, (Van Blommestein et al, 1954). High temperatures coupled with high humidity, however, favour various fungus diseases, while hot drying winds often result in the dropping of the blossoms, (Thompson & Kelly, 1957). The tomato plant therefore produces largest crops in cool dry regions under irrigation and also under the controlled conditions that obtain in a glass house.

Temperature.

Work by many investigators has shown that temperature has a marked effect on the growth and setting of fruit of the tomato. Watts (1931), found that fruit set was greater at 75° than at 60°F. Moore and Thomas (1952), also found out that when the average maximum day temperature was above 90°F and the average minimum night temperature above 70°F fruit set was low. Went (1945), demonstrated that night temperature was actually the critical factor in the setting of fruit by tomatoes. Fruit set was abundant only at night temperatures between 15° - 20°C under which conditions stem elongation was also optimal. Less growth and much less fruiting occurred at either higher or lower night temperatures. This temperature effect, Went observed was much greater than that of the relative humidity of the air, length of day or day temperature. Went and Cosper (1945), found that in the field the effective low temperatures usually occurred around 30 days before maximum fruit production i.e. they coincided with the period of fruit setting.

The effect of temperature on fruit production and growth of tomatoes has been attributed by Went (1945), to the direct effect of temperature on size of inflorescence and translocation of Sugars. Went in his investigations discovered that the size of the inflorescence varied very much with night temperatures. The warmer the night, the smaller the inflorescence and the flowers. It was only at night temperatures between 13° C and 22° C that fruits started to grow. At higher temperatures no fruit was set at all. Above 18° C night temperature, translocation of Sugars became limiting to the growth processes of the whole tomato plant.

In varieties that Went studied he found thermo-periodicity responses to be consistent and large enough to characterise them.

Light Intensity and Optimal Night and Day Temperatures.

When tomato plants are exposed to lower light intensities there is a shift towards lower optimal day and night temperatures. (Went, 1945). Growth of plants at reduced light intensity and high night temperatures (26° - 30° C) was very small, while at low night temperatures reduced light had no effect. Hoffman in 1938 obtained similar results in Ohio with plants grown in a glass house during the spring. He found that the best day temperature for Globe tomatoes was 18° C on cloudy days and 21° - 24° C on Sunny days.

Light Intensity and Ascorbic Acid content of Fruit.

Of the factors day length, light intensity, temperature, fertiliser, Soil type, and humidity, Hammer et al (1945), have shown that light intensity previous to harvest has the greatest influence on the ascorbic acid content of the fruit. Under low light intensities the ascorbic acid content is much lower than under high light intensities. Increases in the ripe fruit of 66% in ascorbic acid resulted when plants were transferred from shade to sunshine at the time the fruit was mature - green. Hammer and his co-workers suggest that much of the effect on ascorbic acid content ascribed to season and location may be due to variations in light intensity.

Rainfall.

This is important only for the out door crop. In Trinidad (Rombulow-Pearse, 1953) and generally throughout the tropics tomatoes are mainly grown during the dry season usually with irrigation. Excessive rain increases the incidence of disease, destroys newly formed blossoms and according to Young and Mac Arthur (1947), decreases pollination to cause puffed fruits, which contain air spaces in locules incompletely filled

with seeds.

Soil Conditions.

Many types of soils ranging from sands to clays have been found suitable for the cultivation of tomatoes. 66% of the entire crop of Peninsula Florida is grown on sandy soils which are either acid or calcareous, (Spencer, et al. 1955). Hardy and Baker (1952) found tomatoes growing satisfactorily on the highly calcareous black, marly rendzinas of the swash-land in Andros Island. Loamy soils are however preferred for growing tomatoes.

It is agreed by most workers that a well-drained soil is essential for high production. A gradual slope facilitates irrigation and in general provides excellent drainage. Van Elommestein et al, (1954), state that provided the drainage is good the depth of soil below 18" is of less importance.

The tomato has been said to be tolerant of acid soil conditions. Excessively acid soils should however be limed to reduce acidity and create more favourable conditions for the soil bacteria and decomposing organic matter. Sayre (1947), reported an increase of 4.2 tons of fruit per acre from an application of 3 tons of dolomitic limestone to the acre on Fulton loam soil of pH 4.8. Spencer et al (1955) recommended a pH value between 5.5 and 6.0 for tomatoes grown on sandy soils, and at pH values above 6.0 advised no liming but a constant watch for possible trace element deficiency symptoms.

Fertilizers.

Although animal manures are used to fertilise the soil for tomatoes, artificial fertilizers, especially nitrogen, play a greater role in tomato culture.

The amount of nitrogen per acre used by many growers has however varied between very wide limits, and the same amount of nitrogen used in different areas has also been known to give different results. It has also been shown by Kraus and Kraybill (1918), that over fertilisation with nitrogen causes the plant to be vegetative and produce little fruit.

In a review of soil practices with some outstanding crops in New Jersey, Hester (1940), observed that the amount of Nitrogen used by certain growers varied from practically none to 140 pounds per acre and also that in certain cases where different growers used an equal amount of nitrogen, namely 75 lbs. per acre, a tremendous variation in yield from less than 5 tons to nearly 15 tons per acre was obtained.

While other factors influence the yield of tomatoes, the indication of the above results was that response to fertilizer might depend on the time and method of application.

Hester (1938), and Hester et al (1951) doing chemical analyses of tomato plants at monthly intervals showed that a large portion of nutrients is absorbed by the plants between the 2nd and 3rd months after transplanting in the field and that the nutrients absorbed in the largest quantities are potash, nitrogen, and calcium. Hester considers it desirable, therefore, to apply part of the fertilizer before the plants are set out and the remaining part later.

Hester (1941), found on Sassafras fine sandy loam that the use of nitrogen and potash in two side dressings was more efficient than either mixing the fertilizer in the soil in the row before planting or broadcasting and ploughing down later. Hester however quotes the unpublished results of experiments in the middle West States as giving indication that broadcast application and ploughing down on heavy soils of various sources of nitrogen as being the most efficient of all methods tried. Jones and Warren (1954) also compared various methods of placement of phosphorus and found that deep placement under the row was more efficient than banding beside the plants or broadcasting.

Though opinion on the most beneficial fertilizer to the tomato crop is somewhat divided many experiments have indicated that depending on soil type, nitrogen and phosphorus would appear to be the most important fertilizers to the crop and potash probably the least since the element is often not very much lacking in soils.

The use of 100 pounds nitrogen per acre on a Coto clay soil in Puerto Rico gave significantly higher yields of commercial tomatoes per acre, than either none or 200 pounds nitrogen per acre, (Landrau and Samuel, 1955). Increased yields were also obtained on the same soil with phosphate fertilizers, the highest yields being obtained with 200 pounds of $P_2 O_5$ per acre. There was no response to potash on this soil.

Miller (1934) working on the effects of various fertilizer mixtures on the yield and growth of tomatoes found that a complete mixture of NPK used at 14 cwts. per acre produced the highest yields and the best vegetative growth. A fertilizer mixture containing only phosphorus and nitrogen had about the same effect as the complete mixture, while a mixture containing phosphorus and potassium gave the most unthrifty growth and the lowest yields. Miller observed that the absence of nitrogen in a fertilizer mixture caused a marked reduction in growth rate while a complete mixture containing potassium lengthened the period of growth.

Chin (1932) found super phosphate and sulphate of potash at 200 lb. per acre depressed yields of the Marglobe variety while Ammonium Sulphate at 200 lb. per acre definitely increased yields by about 1.2 tons.

Results of long continued experiments in Pennsylvania conducted by Warren et al, (1940) also showed that the greatest yields were always obtained using a complete fertilizer and that as the phosphorus content of the fertilizer increased, yields also increased.

Phosphorus it was found was more effective in increasing yields than either nitrogen or potassium.

Organic manure from various sources has been found on many occasions to increase yields of tomatoes. In the Pennsylvania experiments (Warren et al, 1940) 20 - 40 tons of well rotted farm yard manure were found superior to any commercial fertilizer mixture tried.

In Puerto Rico Landrau et al (1955) obtained significant increases in yields when they used fitter press cake, and organic product of the Sugar mills averaging about 2.5% Na and $P_2 O_5$ at 20 tons per acre. When combined with 100 pounds of nitrogen and 200 pounds of $P_2 O_5$ per acre the yields obtained were higher than those obtained when the fitter press cake or chemical fertilizer was used alone. Cotton seed meal has also been found effective as fertilizer in Montserrat, (Campbell, 1957). Dried blood is also sometimes used as fertilizer especially in green house tomato culture (Allerton, 1954). On Andros Island, Bahamas, Hardy and Baker (1952) found "Milorganite" an American Sewage product containing 6 - 8% Nitrogen and 2 - 3% available phosphate being used with success in combination with inorganic fertilizers.

Fertilizer mixtures recommended for use on tomatoes vary in composition according to soil type. Thompson and Kelly (1957) recommend 1: 2: 1 and 1: 2: 2 mixtures for use on lighter soils where tomatoes are grown in rotation with other cultivated crops. For loam, silt loam, and clay loam soils where also the crop is grown in rotation with field crops they recommend mixtures of 1: 3: 1 and 1: 4: 1. The Florida Agricultural Service recommends for lighter soils a ratio of 4: 7: 5 and 4: 8: 8. Patterson (1932) suggests a mixture of one part nitrate of soda to two parts of superphosphate and one part of muriate of potash applied at the rate of 500 lbs per acre in field dressing before transplanting. A further 600 lbs should be applied later as side dressing.

Starter Solution.

In the United States and in Europe it has long been a common practice among growers to transplant tomatoes with from $\frac{1}{2}$ to 1 pint of solution of sulphate of ammonia or nitrate of soda in water.

Baker working in Northern Indiana in 1937 reported increased yields of tomatoes and earlier ripening where commercial phosphoric acid and mono-ammonium phosphate were used in the transplanting water. Grace (1937) reported better results from very minute quantities of hormones in the transplanting water and stated that with tomato seedlings increased growth was obtained with naphthylacetic acid at a rate corresponding to 200 milli grams per acre.

Sayre (1938) confirmed Baker's results and obtained significant increases in yields with Ammonium phosphate and nitrate of potash in the transplanting water. He also found that the mono-ammonium phosphate was a significantly more effective form of phosphorus than the ortho-phosphoric acid in stimulating plant growth; also that the use of small amounts of borax, manganese sulphate and magnesium sulphate in the transplanting water did not increase yields. As regards the effect of hormones on growth of tomatoes Sayre found contrary to the results of Grace that hormone had a depressing effect on yields, particularly the early yields.

In later investigations Sayre (1939) found that a mixture of two parts of Ammonium phosphate and one part nitrate of potash was as effective and less expensive than any other combinations of chemicals he tried. Sayre also discovered that increasing the concentration and reducing the amount of solution per plant increased the effectiveness of the nutrient solution. These findings have been corroborated by work done by Tremear (1956) and Fenwick (1957) at the Imperial College of Tropical Agriculture. These workers obtained increased growth rate, early flowering and increased yields with starter solutions containing 2 parts of Ammonium phosphate and one part nitrate of potash. Fenwick comparing two levels of Starter Solution also found that, the solution applied at the rate of $\frac{1}{4}$ pint per plant in a more concentrated form was more effective in increasing yields than that applied diluted at $\frac{1}{2}$ pint per plant. Porte (1952) however finds the use of starter solution unnecessary where fertilizer has been placed in the rows before planting.

The principal effect of a Starter Solution used in transplanting tomatoes is to enable the plant to become established quickly. This results in a marked gain in early maturity. Sayre (1939) was of the opinion that the entire nutrient solution being in immediate contact with the roots and in a concentration sufficient to saturate the fixing capacity of the soil, was readily available to the roots just at the critical time of transplanting. A small amount of concentrated solution was more effective because it resulted in less puddling of the soil around the plant with less cracking as the soil dried.

Training and Pruning.

In many tomato growing countries training and pruning tomatoes is a common practice. Various methods of training are employed. The pole or stake method is however the commonest used both for the green house and outdoor crops. In this system a strong stake 5 - 7 feet high is set securely alongside each plant soon after the first blossoms appear. The plant is tied to the stake with soft twine (Thompson and Kelly, 1957), rag string, hemp or raffia (Hieronymus, 1949) Allerton (1954), looped around the plant and tied around the stake. The tying is continued up the stake as the plant grows taller. Where the crop is grown in double rows the stakes may be slanted to meet in wigwam formation at the top where a strong tie is made, (Allerton 1954). This method is particularly suitable for exposed fields which cannot be adequately sheltered artificially. The plants instead of stakes may be supported by heavy twine running from the base of the plant to an overhead attachment.

Pruning is done by removing either by hand or with a knife the new shoots that appear in the leaf axils once every week or ten days. The plant is most commonly pruned to a single stem but there are growers who prefer to have two or three stem plants.

Other methods of trellising are nearly always more elaborate than the stake method described above. In Hawaii the determinate varieties which trail on the ground are supported on low racks 12 - 15 ins. high at the back and sloping to ground level towards the plants, (Hieronymus, 1949). In South Africa several methods are in use. In one method described by Van Blommestein, (1954) 2 - 4 Spanish reeds or stakes are erected in a tripod formation around each plant. In another method, also described by Van Blommestein, 2 - 4 wires one above the other are stretched along light stakes and plants tied to them. In a modification of this method pairs of parallel wires are stretched so that the plants are kept upright between them. This method apparently is also used in New Zealand (Atkinson et al, 1949).

Though there seems to be no agreement as to the value of staking and pruning, the following advantages as summarised by Deonier et al (1944) are usually claimed for this treatment:

- (1) Earlier ripening.
- (2) Larger fruits.
- (3) Less disease injury.
- (4) Larger early yields.
- (5) Cleaner fruit.
- (6) More convenient harvesting.
- (7) Greater convenience for spraying.

The disadvantages usually set against the advantages are, (Deonier et al 1944):

- (1) Greater amount of labour and expense,
- (2) Less total yield per acre,
- (3) Greater loss from blossom end rot,
- (4) More sunburn injury to the fruit,
- (5) Greater number of cracked fruits.

The apparent conflicting results reported by many workers were probably due mainly to the use of less space or more plants per acre for the pruning and staking practices as compared to the untreated plots, and probably also to the wide variations in environmental conditions under which the different trials were conducted. From the results of many experiments, however, it would appear that pruning and staking increase early yields but bring about reduction in total yields. (Thompson, 1934; Hawthorne, 1939; Currence, 1941; Magruder, 1924; Walker, 1927).

Thompson (1934) and Hawthorne (1939) attributed the increase in early yields caused by pruning and staking to the increased number of pruned plants per acre, the result of the closer spacing usually adopted for this treatment. Topper, however, in 1942 obtained at I.C.T.A. greater yields for staked and pruned plants when compared with unstaked and unpruned plants, at the same spacings, these being 2' x 3', 1½' x 3', and 1' x 3'. Results of experiments conducted in Mississippi and reported by Deonier et al (1944) also indicate a decided advantage for staking with pruning, and no advantage for staking without pruning over no staking and no pruning.

Riollano (1944), however, working in Puerto Rico found staking reduced consistently and significantly yields of all grades of fruit when compared with unstaked treatments. Staking however improved percentage of marketable fruit but this was offset by the marked reduction in yield of marketable fruit. The combination of staking and pruning, Riollano found, reduced yields further in a significant way. Styrdom (1955) in South Africa also found staking with pruning to have on yields adverse effects which were more noticeable at closer spacings. Pruning also retarded ripening and did not produce an earlier crop.

Conflicting results of pruning and staking may also follow, according to Currence (1941), when different varieties of tomatoes are subjected to pruning and training. Currence found that pruning was beneficial to the Break-O'Day variety and detrimental to the determinate Pritchard.

The fact that the incidence of the two physiological diseases, blossom end rot and fruit cracking is often more severe on pruned trained plants and also under dry and wet conditions indicates that pruned, trained plants either enable the soil to dry out more quickly or are unable to use soil moisture as well as unpruned plants. Studies by Thompson (1927) suggest that both these factors are probably involved.

Propagation and transplanting.

Tomato seedlings for transplanting can be raised by one of two methods. For the green house crop the seedlings are raised in soil blocks or clay, paper or plastic pots filled with specially composted soils. The seedlings are later transplanted to the field with a ball of soil. In the second method which is mostly adopted in the U.S.A. and in the tropics, seeds are raised on open beds and later transplanted with bare roots to the field.

In the tropics the peasant farmer sows seeds thickly on the open bed and usually fails to thin out, thus producing seedlings which are over crowded, have sparse foliage and roots, and look spindly and weak.

The methods for the propagation of seedlings in the U.S.A. have been outlined by Porte (1952). In areas where the growing season is long seedlings are raised in cold frames or open beds, at a spacing of 12" - 15" between rows and 1" - 2" between plants in the row. Where the growing season is short and where also earliness is important the seeds are sown in

green houses or hotbeds and the seedlings are later transplanted to a wider spacing in hot beds or in cold frames.

Direct seeding in the field is also carried out in the U.S.A. The seed is machine drilled in rows 15" - 18" apart at a rate which gives 15 - 18 plants per foot of row. These are later thinned out to the required spacing. This method is applicable only in places like California, Nevada and parts of Florida where frost is not a hazard and normal soil temperatures are suitable. It has the advantage of saving labour, of transplanting and often reduces loss from damping off. In Trinidad and possibly in other parts of the Tropics, direct seeding may prove a complete failure. Rombulow-Pearse (1953) in Experiments at the I.C.T.A. found it difficult to establish plots by directly seeding in the field because the soil tended to bake hard and ants carried the seeds away.

Where direct seeding in the field has not been done tomato seedlings raised in pots or on open beds are eventually transplanted into the field. Experimental results reported by Loomis (1925) indicate that transplanting does not directly promote the growth of the plant and is of no particular agronomic value, but may be an economic expedient in saving valuable green house or garden space and in allowing for better care of slowly growing seedlings. In the early seedling stage tomato seedlings can be transplanted with little or no injury. With increasing maturity however the danger of injury increases. This is in agreement with the results of Casseres (1947), (Babb 1940), Brasher and Westover (1937) and Porter (1935) which show that young plants that are tender and capable of quick growth resumption after field setting give early and large total yields. Any treatment of the seedlings which results in hardening reduces the early and total yields in proportion to the degree of hardening. In this connection Casseres for plants grown at 60 - 70°F obtained results in which 7 week old seedlings significantly produced higher early and total yields than seedlings 11 weeks old. Under the warmer conditions in Trinidad 4 weeks old seedlings are considered ideal for transplanting (Rombulow-Pearse, 1953; Barrett 1955; Tremeeer, 1956; Fenwick, 1957).

Yields of tomatoes are known to depend very much on the way the seedlings are raised and the treatment given to them.

Working at the John Luns Horticultural Institute, Lawrence (1950) was able to show that the quality of compost used in the pots, the time of pinching out young seedlings from seed boxes to the pots, the size of the pot and hence the spacing between plants, all affected early and total yields.

Work and Amy (1950) found that plants grown in beds and thinned to a spacing of 2" x 2" or 3 or 4 seedlings per inch gave significantly higher yields than plants from overcrowded beds. Similar results were obtained by Smith (1954), Barrett (1955), Treemeer (1956), Fenwick (1957) working at I.C.T.A. They found that "improved" seedlings i.e. seedlings raised on the open bed at a spacing of 3" x 3" gave higher yields and necessitated less supplying than the overcrowded seedlings raised by the methods of the peasant farmer.

Pot raised seedlings are considered superior to seedlings produced in the open bed. Nylund (1956) reported results in which transplants grown in 3-inch pots outyielded those grown on flat open beds at 2" x 2". Snyder showed that seedlings in pots of this size may even outyield seedlings grown at a spacing of 4" x 4" on flat beds. Experiments at I.C.T.A. have also shown that seedlings raised in pots yield better than those produced on beds (Treemeer 1956, Fenwick 1957).

The increased yields and better field establishment given by pot raised seedlings and seedlings produced at a wide spacing on open beds have been attributed to better root and foliage development. At the I.C.T.A. Smith (1954) Treemeer, (1956), Fenwick (1957) found that pot raised and "improved" seedlings had well developed roots and leaves while seedlings raised on overcrowded beds had hardly any roots and leaves. Loomis (1925) also considered the high yields obtained from seedlings raised in pots to be due to the well developed roots and luxuriant foliage of the seedlings. When these well developed seedlings are set in the field they are less subject to mechanical injury, to disease and insect attack, and to destruction through drought.

Methods of Cultivation.

Field tomatoes may be transplanted on ridges or on the level and earthed up later when found necessary. In Puerto Rico level or flat planting with irrigation is favoured during the dry season while on heavy soils during the rainy season ridge planting is considered best, (Childers et al 1950.) In Ceylon planting on ridges in wet districts and on the flat with subsequent moulding up in dry areas is also practised, (Senaratire and Senathiraja, 1927). In the Canaries tomatoes are grown only on ridges, (Holmes, 1931). In Trinidad the peasant farmer who grows tomatoes mainly in the dry season usually plants on the level and earths up later. (Rumbulow-Pearse 1953). Experiments at the I.C.T.A. have demonstrated that plants grown on ridges and on the flat with subsequent moulding up give higher yields than those planted on the level and not earthed up, (Barett, 1955; Fenwick 1957; Smith, 1954).

Spacing in the Field.

The spacing given to plants in the field varies greatly according to variety grown, methods of cultivation, and whether the plants are pruned and staked or allowed to trail over the soil. Many experiments conducted on field spacing have, however, shown that close spacing results in larger yields than wider spacing.

Currence (1941) working in Minnesota reported results in which closer spacings uniformly increased yields which reached a maximum at a spacing of 1' x 4'. There was a tendency to smaller fruits at the closer spacings but the tendency was not uniform and definite enough to show significance. Reeve and Schmidt (1952) also obtained higher total yields from plants given 7 square feet of space than those given greater space. Similar results have been obtained in St. Kitts, and Antigua. In St. Kitts (Anon. 1931) a spacing of 4' x 2' gave yields significantly better than 4' x 3', and in Antigua (Anon. 1949) higher yields were obtained at a spacing of 3' x 1' than at 3' x 2'.

Large-growing spreading varieties require more room than small-growing ones. Spacing for the spreading varieties should however not be so large as to reduce yields. Where large mechanical equipment is used for spraying and dusting wide spacing is also required. In the U.S.A. a compromise is reached by having rows 4 - 5 or more feet apart and setting the plants close in the rows. (Thompson and Kelly, 1957).

Staked and pruned plants are usually planted at closer spacing than unstaked and unpruned plants. (See also training and pruning).

Varieties and Horticultural Characters of Tomatoes.

Tomato exists in many distinct varieties and in numerous strains, and selections of the varieties. The choice of any particular variety for growing depends on soil type, climate, length of growing season of the area or whether an early crop is desired or whether the crop is being produced for processing. The ideal variety for any region should, however, combine most of the desirable characters including prolific fruiting habit, production of early fruits, large spherical fruits, large upright stems and immunity or resistance to disease and pests.

Many of the characters of tomato have a genic basis, while others are polygenic and cannot be identified with any particular gene. Of the horticultural characters of tomatoes, Young and Mac Arthur (1947) list 49 that may be designated by genic symbols and more than 60 others which are polygenic and cannot be so designated.

Among the pairs of characters which show a simple dominance and F_2 segregation of 3 : 1 are large and small numbers of locules, normal and fasciated fruits, nipple tip and normal fruit, globe and pear shapes, tall and dwarf plants, (Boswell, 1937); elongated and short fruits, (Lindstrom, 1927); and determinate and indeterminate habits, (Mac Arthur 1952; Boswell 1937).

According to Butler (1941) and Mac Arthur (1930) size of fruit and earliness of fruit maturity are quantitative characters, (Boswell, 1937; Currence, 1938), size of fruit depends on 3 - 5 pairs of major genes affecting locule members and twice as many genes affecting mature locule sizes. Boswell (1937) states that there is intermediate segregation for fruit size in the F_1 generation and all gradations in the F_2 .

The concentration of vitamin C. (ascorbic acid) in tomato is inherited (Young and Mac Arthur, 1947), but the range in concentration with each variety may vary with differences in growing conditions especially exposure to sunlight (MacLinn and Fellers, 1938; see also light intensity and ascorbic acid content of fruit).

In the development of tomato varieties *Lycopersicon esculentum* has been crossed with other species of tomatoes especially the wild types to add genes that give the hybrids resistance to disease and other desirable characters. In Hawaii *Lycopersicon pimpinellifolium* was used to confer triple resistance to the diseases fusarium wilt, spotted wilt, gray leaf spot on seven new varieties, (Frazier et al, 1950). In Texas vigorous hybrids secured from crosses involving *L. esculentum*, *L. peruvianum*, *L. hirsutum*, *L. glandulosum*, have played a great part in the improvement of commercial varieties of tomatoes.

Of the varieties grown in Britain, Allerton (1954) mentions the following as the best known: Potentate, Ailsa Craig, Harbinger, ESI and ES5, the Stoner varieties: Money maker, Exhibition, Xlay Vanguard, M.P., Prolific which are characterized by the conspicuous pale-green fruit with very even colouring to a light red. For the out door crop Carter's Sunrise and Devon Surprise are preferred in Jersey but Ibbitts seedling, Money Maker, Harbinger, Market King are widely grown.

Potentate is an excellent variety, which does well under practically all conditions except poor soils. It has a weak root system which limits rank growth. It produces heavy lower trusses of 15 - 20 fruits and may be used for early production. It has, however, the tendency to produce small middle trusses due to much dropping of flowers.

After Potentate, Craig is the most widely grown variety in Britain. Possessing an extensive root system it grows well with good culture under a wide range of soil conditions. It prefers, however, hot well drained soils. Its trusses are elongated, branched and the two-celled fruit is medium in size and colours well. It is not suitable for early work.

South African varieties described by Van Blommestein et al (1954) include Marvel, Rutgers, Hortus 5, San Malzano, Low Veld, Gold Mine, Indiana, Great Baltimore and selections of Pearson.

Marvel combines a relatively high resistance to Fusarium wilt with a high keeping quality and is regarded as the most suitable variety where production on the low veld takes place after August and before April. It is relatively early.

Frazier et al (1950) working in Hawaii have produced seven new varieties of tomatoes all resistant in varying degrees to spotted wilt, fusarium wilt, and gray leaf spot. Of these Nihau is indeterminate and of medium maturity. The remaining six which are Oahu, Lanai, Hawaii, Maui, Molokai, and Kauai are all determinate. Oahu is distinctly early preferring highly fertile soils and low elevations in the Summer while Kauai is a medium - early plant well adapted to staking and pruning. Lanai, Hawaii, Maui, Molokai are all medium early plants well adapted to low elevations in Winter, to medium elevations at all seasons and to high elevations in Summer.

In the U.S.A. the varieties Marglobe, Rutgers, Indiana Baltimore, Greater Baltimore, Pearson, Stone, San Manzano which require a long time to mature, account for a large part of the main crop production of tomatoes, (Thompson & Kelly, 1957).

Marglobe is a thick stemmed determinate variety with a high yielding capacity (Young and Mac Arthur, 1947). It is resistant to fusarium wilt but is susceptible to fruit puffing. Rutgers is similar to Marglobe but is less fruitful. It is the most important variety grown for processing in New Jersey, Delaware, and Maryland and is an important market variety in several regions, including some of the Southern States, (Thompson & Kelly, 1957).

Other important varieties include Earliana Victor and Bounty which were developed for regions having a very short growing season, Pritchard, a determinate and very fruitful variety and Globe which yields smooth, globular, large, pink fruits abundantly.

A new outstanding variety produced and called Manalucie by the Florida Agricultural Experimental Station has been reported by Walter and Kelbert (1953). It is claimed that Manalucie does not only yield outstandingly large crops, but is most pleasingly palatable and is resistant to both concentric and radial cracking, blossom end rot,

Fusarium wilt, *Stemphyllium* wilt, early blight, leaf mould and the root-knot eel worm *Meloidogyne* Spp. It is however not resistant to tobacco mosaic and the soil borne diseases; Southern bacterial wilt (*Pseudomonas Solanacearum* E.F. Sm), Damping-off (*Pythium* Sp. and *Pellicularia filamentosa* (Pat), Rogers) and Southern blight (*Pellicularia rotfsii* (Sacc.) West).

Hybrid Vigour.

First generation hybrids of tomatoes which show qualities beyond those of the parents are gradually coming into use. The process of producing these hybrids is laborious and expensive as successive crops raised from the F_1 hybrids give rise to progressively less desirable types and the crosses must be carried out each season from the same true line parents to obtain fresh first generation seed, (Young and Mac Arthur, 1947).

Diseases and Pests.

Where-ever tomatoes are grown they are subject to diseases and pests which because of their serious effect on yield and market value, are a major factor in crop production. In Hawaii it is estimated that 20% of the yearly value of the crop is lost through foliage diseases alone, (Hendrix et al 1950). In the tropics in general where resistant varieties are rarely used a very great proportion of the crop is lost through diseases.

The diseases affect all parts of the plant-roots, leaves, stems and fruits. The most important diseases are probably *fusarium* wilt, bacterial wilt, bacterial canker, early blight, late blight, *Septoria* leaf spot, *Stemphyllium* or grey leaf spot, leaf mould, anthracnose and virus diseases. Of the pests the red spider mite, caterpillars, root knot eelworms and serpentine miners are the most serious.

Fungal and bacterial diseases.

Fusarium wilt.

Fusarium wilt caused by the fungus *Fusarium Oxysporium*, f. *Lycopersici* (Sacc.) Snyder and Hausen, is by far the most serious wilt disease of tomatoes.

It is most prevalent in tropical and subtropical regions of the world where according to Clayton, (1923) it is favoured by optimum air and soil temperatures of 20°C and 27°C respectively. In Trinidad the disease may lead to a total failure of the crop planted any time of the year, (Briandt, 1932). In Bermuda, a more northerly country, the disease is stated by Russel (1936) to be only serious during the period July to December when the mean daily maximum shade temperature ranges from 74°F to 80°F.

The fungus is capable of living in the soil for a number of years, even in the absence of the host. According to Edgerton and Moreland (1920) it is favoured by acid soils and may be made less serious in such soils by liming.

Symptoms of the disease are fully described by Briandt (1932). In a severe attack the leaves wilt progressively starting with those at the base of the plant. The fungus enters the plant through the roots and quickly invades the wood vessels imparting a brownish-yellow discoloration to them.

The disease may be controlled by sterilizing the soil with formalin or steam where practicable, by employing a rotation which does not permit a susceptible crop e.g. egg plant, tomatoes to be grown on the same land more than once in three or four years, and by observing strict hygiene.

Various varieties resistant to Fusarium wilt are known. These include Marglobe, Rutgers, Indiana Baltimore, Pritchard, which are mentioned by Thompson and Kelly, (1957) and the seven new Hawaiian varieties described by Frazier et al, (1950).

Bacterial Wilt.

This disease is caused by *Pseudomonas Solanacearum* EF. Sm. which lives in the soil and infects the plant through the roots, (Briandt 1932, Thompson and Kelly, 1957). The pathogen occurs in cooler regions but flourishes in warmer climates. Briandt recorded it in 1932 as occurring in Trinidad. Affected plants usually wilt suddenly and completely without preliminary yellowing or browning of the leaves (Briandt 1932).

A method of controlling the disease suggested by Doolittle (1948) is by adopting a rotation in which tomatoes are grown once in 4 or 5 years and in which also such crops as tobacco, potatoes, egg plant or peppers susceptible to the disease are not grown during the interval.

Field sanitation is also important.

Septoria leaf spot or blight.

This disease is caused by *Septoria lycopersici* Speg. An account of it has been given by Briandt (1932), Atkinson et al (1949), Thompson & Kelly, (1957). The disease is widely distributed in tomato growing countries being serious in the Atlantic and Western States of the U.S.A. and the area around Buenos Aires.

The first symptoms of the disease appear on the leaves and consist of numerous small, brown, water soaked spots, the centres of which later turn grayish white surrounded by darker margins. In severe cases the leaves wilt and drop off resulting in serious defoliation. In Trinidad the disease is not serious enough to cause defoliation, (Briandt, 1932).

In America, Pritchard and Porte, (1924) found that the disease is favoured by temperatures between 50°F and 82°F which overlap the optimum range for the growth of the tomato plant during the growing season.

In Hawaii, Hendrix et al (1950) found Ferlate (ferric dimethyldithio carbamate) and Zerlate (Zinc dimethyl-dithio carbamate) more effective than the copper fungicides in controlling the disease. Control may also be effected by burning all crop residues in an infected area. No resistant varieties are available.

Late Blight.

Late blight, known also as downy mildew, is caused by the fungus *Phytophthora infestans* (Mont) de Bary. It is one of the most destructive diseases of tomatoes. In Auckland province in New Zealand the disease has often caused up to 50% loss of the crop, (Atkinson et al 1949).

The disease may attack plants at any stage. It is most prevalent at temperatures 70°F - 80°F under wet conditions, (Doolittle, 1948). It first appears on the leaves and leaf stalks as irregular, greenish black water-soaked areas which rapidly enlarge in wet weather and show on the undersides of the leaves a white downy growth of the fungus, (Atkinson et al, 1949, Hendrix et al, 1950). Infection frequently spreads to stems and fruits.

In Hawaii, Hendrix et al, 1950, obtained successful control of the disease with Fermate and Zerlate. Manzate, a Dupont fungicide containing manganese ethylene - bis - dithiocarbamate, has been claimed by the manufacturers to be effective in controlling the disease.

Stemphylium or Gray leaf Spot.

Gray leaf spot is caused by the fungus *Stemphylium Solani*, Weber. A description of it has been given by Hendrix et al, (1950). Though it may attack young seedlings, normally heaviest infection occurs after the plants have been transplanted into the field, and after the fruits have set.

The fungus does not harm the fruit but confines its attack to the leaves, the older ones being attacked first. The spots which may vary in diameter between $\frac{1}{2}$ inch and $\frac{1}{8}$ inch have a glazed grayish brown appearance and are slightly depressed on the lower surface of the leaf. The affected leaves may turn yellow and die especially if the spots are numerous. The dead leaves later drop off.

The disease has recently assumed great importance in the tropics and sub tropics of the Western Hemisphere. In Hawaii it has become one of the major foliage diseases. In Trinidad it was first recorded in 1954 by Barrett and has since become a serious disease. Hardy and Baker noticed it during their visit to Andros Island in 1952 and surmised that it might have arrived there from Florida where it is a serious disease.

In Hawaii, Zerlate, Fermate, and Tribasic copper sulphate have been used to control the disease (Hendrix et al, 1950). Manzate may also be used in controlling the disease.

Resistant varieties are available. Among those grown in Hawaii are Nihau, Oahu, Lanai (Frazier et al, 1950). In Florida the outstanding one seems to be the new variety Manalucie which combines a high yielding capacity with resistance to the disease (Walter and Kelbert, 1953).

Early Blight.

The disease is caused by *Alternaria Solani*. It occurs in Trinidad, (Tremeer 1956, Fenwick, 1957) and is one of the most common and serious of the leaf spot diseases on the Atlantic Coast and Central States of the U.S.A. (Thompson & Kelly, 1957).

Grayish-brown spots appear on the leaves and later extend to the stem and stalk end of the fruits which may drop. The disease may be controlled with the organic compounds of the di-thio-carbamate group.

Tomato leaf mould.

Leaf mould is caused ^{by} *Cladosporium fulvum*, CKe. It probably occurs in all countries where tomatoes are grown. It was recorded in Trinidad in 1932 by Briandt who has given a description of the disease. In Britain the disease sometimes causes serious damage to the green house crop, (Allerton, 1954).

The disease generally appears as yellowish spots on the upper side of the oldest leaves which are near the ground and therefore are under humid conditions. The under surface of the leaves later develops velvety patches of mould growth corresponding with the spots on the upper surface. The leaves eventually turn brown and die. The upward spread of the disease often proceeds at an alarming rate.

Small (1929) has shown that the seriousness of the disease depends on atmospheric temperature and humidity. At 72°F which was optimum temperature for the various stages of the growth of the fungus, Smith found that primary infection was severe at 80% relative humidity, and decreased as the temperature was reduced. Under optimum conditions of temperature infection was rare at 70% humidity and at 66% humidity progress of the disease was arrested.

The disease may be controlled by growing the plant where the atmospheric humidity is low or by allowing free circulation of air in the glass house. Copper sprays, 'Zineb', 'thiram' have all been used with varying success against the disease, (Allerton 1954).

Virus Diseases.

The tomato suffers from a host of diseases caused by a complex of viruses. These diseases include tomato or tobacco mosaic, cucumber mosaic, tomato spotted wilt, single or tomato streak, double or severe tomato streak, and curly top.

Atkinson et al (1949) and Thompson and Kelly (1957) have given descriptive accounts of the virus diseases.

Went (1945) has shown that the incidence of virus diseases in tomatoes is affected by night temperatures. At 13°C Went noticed no tomato mosaic symptoms; at 16°C disease symptoms were hardly discernible; at 22° and 26°C diseased plants were very apparent and at 30°C night temperature plants having mosaic showed systemic effects and were dwarfed. Spotted wilt also developed only at high night temperatures.

Tomato (tobacco) mosaic.

This is the commonest virus disease of tomatoes occurring both in the field and in the green house. It is probably found in all countries where tomato is grown, and may become serious resulting in considerable losses. Its alternate hosts are tobacco, pepper, eggplant and other solanaceous plants.

The virus causes green and yellow mottling in the leaves which may later turn yellow and die. Plants infected early in the season may be stunted and bear little fruit.

The disease is highly infectious and is readily spread by contact between diseased and healthy plants or by contaminated implements and hands of workmen during transplanting or pruning. The virus persists in dry tobacco leaves and may be introduced into a crop through the fingers of smokers. It may be spread also by aphids.

Cucumber mosaic.

Infection of Cucumber mosaic causes the formation of narrow leaves which in the extreme may consist mainly of midribs. The reduction in total leaf area results in fruits smaller than normal which are inclined to be flattened and light in weight.

The virus has a very wide host range including cucumber, pumpkin, marrow, rock melon, milk weed, poke weed, viola, pansy, polyanthus, violet.

Natural spread of the disease is by green aphids. The disease may also be spread by workmen whose fingers become contaminated when they handle infected plants during pruning, tying and staking operations. The virus is, however, not seedborne.

Tomato Spotted wilt.

This is a disease which can cause severe losses both in the outdoor and glass house crops. The first symptoms on the plants is a branching of growing points and a downward curling of stalks of young leaves, together with the appearance of small dark necrotic spots on younger leaves. Badly affected leaves later turn yellow and wither. Infection often spreads to the fruits which develop numerous red, yellow or almost white circular areas.

Spotted wilt has a very wide host range and affects lettuce, celery, spinach, potatoes, peppers, tobacco, garden pea, and many weeds and ornamentals such as dahlias, petunias, Zinnias, Iceland poppy, chrysanthemum. It is spread by thrips.

Single or Tomato Streak.

Though a disease most commonly found in glass houses, it sometimes occurs in the outdoor crop with serious losses. The virus is a strain of the tomato (tobacco) mosaic virus and has the same host range, methods of transmission and other characteristics. It is however not carried by manufactured tobacco as tobacco is not susceptible under field conditions.

The symptoms are black streaks on stems, leaf stalks and fruits, which may become sunken. A slight mosaic mottling sometimes appears on the leaves. Plants infected when young are stunted, while those developing symptoms at a later stage lose much of their foliage and present an unthrifty appearance.

Double or Severe tomato streak.

Double or severe tomato streak is caused by a combination of tobacco mosaic and potato virus X. Leaves of infected plants are small, mottled and show dark necrotic spots between the veins. Numerous dark streaks appear on the petioles and stems. Infected plants are stunted and set comparatively few fruits which may show small sunken spots. Like tobacco - mosaic spread occurs through handling of plants during cultural operations.

Curly top.

Curly top is caused by the same virus that causes curly top of sugar beets.

It is important in the western states of the U.S.A. On infected old plants the symptoms of the disease take the form of pronounced upward rolling and twisting of leaflets, a general stiffening of the foliage and dull yellowing of the whole plant. Infected seedlings show a yellowing of the foliage which may be accompanied by some curling of the leaves. The disease is also found on other vegetable crops such as beans, table beets, spinach, squashes and peppers. Beet leaf hoppers are thought to transmit the disease.

Control of Virus diseases.

Virus diseases are mainly controlled by taking measures to prevent infection. Clean seed, in cases where the virus can be carried on the seed, should always be sown. Weeds and ornamental host plants growing near tomato fields and plant beds should be destroyed. Infected plants should be removed and destroyed. All remains of infected crops should be burnt. Workers who smoke must wash their hands before handling the plants and every effort should be made to prevent the spread of the disease from infected to healthy plants in transplanting, cultivating, pruning and other cultural practices. Control of insect vectors by use of insecticides should aid in control of those diseases in which the virus is carried by insects.

Fruit rots.

Various fruit rot diseases affect tomatoes in the field and on the market. Many of these are caused by fungi or bacteria which are present on the fruit when harvested and later attack the fruit through minute injuries such as broken glandular hairs, sand scarring, growth scars and other mechanical injuries.

Briandt (1932) and Ramsey et al (1952) have written accounts of the various fungal and bacterial fruit diseases that occur in Trinidad and the U.S.A.

Late Blight rot is caused by *Phytophthora infestans* (Mont), de Bary. Brown water soaked areas first appear on the fruit and as decay advances acquire smooth or rough surfaces.

Phoma destruction plowr. produces on the fruit small depressed areas enlarging later into circular or elliptical lesions.

Fusarium rot is caused by species of *Fusarium* which are most destructive on ripe fruits in the field, producing water-soaked sunken, soft, wrinkled areas.

Cladosporium rot is caused by *Cladosporium herbarum* Fr. It is often the cause of heavy transit and market losses of California tomatoes. It is not serious on tomatoes in the field. On green tomatoes the first visible signs of *Cladosporium* rot are small light-tan spots in the skin without visible surface mould. As the spots enlarge they become slightly sunken and have dark-brown to black centres with light brown margins.

Of the bacterial rots the most important is probably that caused by *Erwinia arceuthae* (Townsend) Holland. Briandt, (1932) noticed it in Trinidad, Nowell (1924) has reported it in St. Vincent and Ramsey (1952) has recorded it as occurring in the U.S.A. The bacterium causes a soft rot in which the whole fruit becomes very soft and watery. Briandt (1932) has demonstrated that the bacterium is essentially a wound parasite and probably enters the fruit through punctures made by the bugs *Leptoglossus* and *Pthia*.

Control of fruit rots.

As most of the pathogens enter the fruit through injuries, it is necessary to handle tomatoes as carefully as possible during picking and packing to avoid skin cuts and punctures. It is advisable to wash and cool tomatoes by ventilation or refrigeration soon after harvesting. This is effective in preventing soft rots and other decays caused by the rapid development of certain pathogens. It also prevents excessive ripening during transit. Tomatoes should however not be chilled as chilled fruits are subject to extensive decay by the slow action of weak pathogens.

All fruits showing disease symptoms should be removed immediately after harvest.

Physiological diseases.

The physiological diseases that affect tomatoes are not caused by pathogens but are the result of unfavourable environmental conditions during growth.

The most important of these diseases are blossom-end rot, growth cracks, puffiness, sun-scald (Briandt, 1932; Ramsey et al, 1952; Atkinson et al 1949; Thompson & Kelly, 1957). Other physiological diseases of minor significance are described by Atkinson et al, (1949). These include catface in which the fruits are distorted and puckered at the blossom-end; hard-core which shows itself as a hardening of the tissues around the stem end of the fruit; fruit splitting which is characterised by wide, shallow deep brown depressions on the side or blossom-end of the fruit; and blotchy-ripening in which yellow patches with a network of vascular bundles develop on the fruit. This latter disease is often serious in New Zealand.

Blossom-end rot.

This is found where ever tomatoes are grown and may cause serious losses during certain seasons. Well defined dark leathery and sunken lesions develop at the blossom end of the fruits.

The disease appears to be induced by a temporary but severe water deficit in the plant causing the cells at the blossom-end of the fruit to break down. This condition may occur during periods of drought especially when they come after periods of abundant moisture. It may also occur during periods of excessive moisture. Under these conditions many roots are killed by lack of air and soil fungi and the plant suffers from physiological drought.

Evidence has been presented by Evans and Troxler (1953) which indicates that calcium deficiency may favour the disease.

The disease may be controlled by ensuring a uniform supply of water. Resistant varieties are available and may be used.

Growth cracks.

Growth cracks occur in all countries where tomatoes are grown. The cracks occur at the stem end of the fruit and either radiate from the stem or develop concentrically around the shoulder of the fruit. On the market growth cracks detract from the appearance of the fruit and predispose it to disease.

Periods of abundant rainfall and high temperatures especially if they follow long dry spells favour the disease. According to Reynard (1951) the severity of radial cracking of susceptible strains is more closely associated with the number of days that rain fell just preceding picking than with the amount of rain in the same period.

The incidence of the disease may be reduced by picking fruits before they become fully ripe. Resistant varieties like Manalucie (Walter and Kelbert, 1953) are available and may be grown.

Puffiness.

Puffy tomatoes are only partially filled with pulp and seed. They feel soft, are light in weight, and their surface is usually flattened or sunken in areas between the internal cross walls. Puffiness seems to be caused by environmental and nutritional factors that affect pollination and fertilization. Results of experiments by Yarnell et al, (1937) indicated that temperature above 100°F increased puffiness in Texas and that there was a general relationship between rainfall and the percentage of puffy fruits. (See also climatic conditions of growth - Rainfall).

Sunscald.

Sunscald of tomatoes usually occurs when tomatoes are exposed to intense sunlight. The damage consists of flattened greyish-white spots with a dry papery surface on the fruits. Any factor that causes shedding of the leaves increases the risk of sunscald. Pruning, it has been reported, tends to increase sunscald.

Pests.

The insect pests of the tomatoes are legion. They include ants, millipedes, caterpillars, cutworms, leather jackets, wire worms, flea beetles, eelworms, the green vegetable bug, the white fly, green aphids, thrips, mites woodlice, leaf hoppers, leaf miners, slugs and snails, midges, crickets.

Ants.

These are usually not very serious pests. Edwards, (1948) has however reported that the Fire Ant, *Solenopsis geminata* sometimes makes it difficult

in Jamaica to establish a nursery by unearthing and carrying away seeds newly sown.

Millipedes.

These attack the stem and lower leaves of young plants.

They are apparently serious in Jamaica where Edwards (1948) advises the drenching of seed boxes or small nurseries infected with them, with Jeyes-Kerosene soap emulsion as a control measure. In Britain the burrowing minute millipede *Scutigrella immaculata* causes very severe damage to the extending roots of the young plant, (Allerton, 1954). Plants can be protected from attack by applying to the root region a solution of DDT., BHC. or parathion.

Caterpillars, cutworms, fruit worms.

Caterpillars and fruit worms are among the most serious and widespread pests of the tomato. In New Zealand looper-caterpillar (*Phisia chalcites* Esp. and the tomato-caterpillar (*Heliothis armiger* IH) attack the foliage and fruits eating large holes in them and making the fruits unmarketable (Atkinson et al, 1949). *Heliothis armiger* also occurs in Jamaica, (Edwards, 1948), in Trinidad and in California and the Southern parts of the U.S.A. In these two latter areas it is known as Tomato fruitworm. Previous to 1940 when DDT. began to be widely used in glass houses the Tomato moth (*Hadena Oleracea*) destroyed many tons of the crop in Britain, (Allerton, 1954).

The tobacco horn worm (*Protoparce sexta*) is a large caterpillar which when present in large numbers may completely defoliate the entire crop. In the U.S.A. it is occasionally serious (Thompson and Kelly 1957). In the Bahamas (Dalgano, 1936), in Jamaica (Edwards, 1948) and in Trinidad (Wright, 1932) it does damage but seldom on a large scale.

Cutworms (*Agrostis* spp.) are occasional pests of the outdoor crop. They usually occur on land left fallow for some time or which has been allowed to be weed-infested.

Cutworms attack the plants during the night by eating away the stem at soil level thus causing complete collapse. Control measures suggested by Edwards, (1948), Atkinson et al, (1949) include destruction of all weeds growing among the tomatoes, thorough ploughing of the soil to expose the pests to adverse conditions, and spraying with D.D.T., or arsenical compounds. The latter compounds may also be used to control other caterpillars.

Eelworms.

Several species of eelworms attack the roots of the tomato causing galls and stunting. The most common occurring in Britain, U.S.A., New Zealand, is the root-knot eelworm (*Heterodera marioni*), (Atkinson et al 1949, Thompson & Kelly 1957, Allerton 1954). Another species mentioned by Allerton 1954 which may become more serious and more difficult to control than root-knot eelworm is the potato eelworm (*Heterodera rostochiensis*). In Hawaii the most common species is *Meloidogyne incognita*, (Gilbert and McGuire, 1956).

Eelworms may be controlled by steam or chemical disinfection of the soil where economical. Since the pest tends to build up where successive crops of a susceptible plant are raised, growing tomatoes on the same land for two successive years should be avoided. If eelworm becomes established tomatoes should be rotated with a grass crop since grasses are the only plants resistant to the pest, (Atkinson et al, 1949).

In Hawaii attempts are being made to produce resistant varieties, (Gilbert and McGuire, 1956).

Mites.

Of the mites that attack tomato the most important are the Red Spider Mite (*Tetranychus telarius*), the Red-legged Earth-mite (*Halotydeus destructor*) and species of *Phyllocoptes*.

In Britain the red spider mite has become the despair of the glass house tomato grower by producing resistant generations to any new pesticide that is produced. The pest lives in large numbers on the underside of the leaves on which it feeds, (Allerton, 1954).

The red-legged earth-mite often causes severe wilting of young transplants by sucking large quantities of sap from the leaf tissues, (Atkinson et al, 1949). Species of Phyllocoptes are of sporadic occurrence but may cause severe damage under glass and in the field. White mould caused by the Mite Eriophyes cladophthirus was noticed on tomato in Montserrat by Campbell (1957). The mite causes outgrowth of epidermal cells giving the appearance of white mould. The disease does not kill the plant but reduces yields.

Mites may be controlled by fumigating glass houses with nicotine sulphate or azobenzene or spraying with D.D.T. or parathion.

Aphids.

Aphids are casual pests on tomatoes but may become serious when they are in large numbers. Plants attacked by these insects remain dwarfed whilst their young leaves curl and do not expand normally. The green aphid Macrosiphum euphorbiae is known to carry cucumber-mosaic, (Atkinson et al, 1949) and should be controlled as soon as it is noticed. The pest is easily controlled with nicotine sulphate or B.H.C. in various formulations.

Leaf miner.

The disease is caused by Liriomyza Solani and is characterised by Serpentine tunnels in the leaf, formed by the maggots of the fly. The disease has recently become a serious problem in Trinidad. Where the attack is heavy the effective leaf area becomes limited, and yields are reduced. The disease can be controlled with BHC or parathion, (Allerton, 1954).

Midge.

Contarinia lycopersici, a small midge has often been reported to occur on tomatoes in the West Indies. In 1911 it was reported in St. Vincent in the Agricultural Department Report of that year. In 1932 Briandt noticed it in Trinidad where it caused considerable damage to tomato flowers. In 1952 Hardy and Baker found it on tomatoes in Andros Island, Bahamas.

The midge lays its eggs in the young flower buds. From these eggs small white larvae emerge which feed inside the anther cone frequently damaging the style and ovary. The flower often abscisses. If it remains on the plant a damaged malformed fruit may develop. The disease is especially serious during the wet season.

Grading.

In many countries where tomatoes are grown the crop is marketed on the basis of grade. A premium price is usually paid for high-grade tomatoes which should consist of large fruits, very few or none of which are green, over ripe, rotten or defective.

In the U.S.A. tomatoes are graded according to specifications laid down by the State Department. As the harvested crop comes to the packing sheds the defective, damaged and rotten fruits are removed by hand and the good, marketable ones are sorted by hand or sizing machines into sizes of which there are usually four, (Spangler & Ide 1955; Thompson & Kelly 1957).

In British West Indian producing countries, mature - green fruits are graded into six sizes namely: 5 x 5, 5 x 6, 6 x 6, 6 x 7, 7 x 7, 7 x 8. The larger sizes 5 x 5 (three tomatoes to the pound) to 6 x 7 (approximately 5 tomatoes to the pound) are usually exported to America. All other sizes are locally marketable.

Packing for the Market.

The packing process and various containers used for shipping tomatoes have been described by Spangler and Ide, 1955. In the U.S.A. the lug box is the most popular package used in shipping by rail or truck tomatoes to the markets. It is a lidded rectangular box designed to hold about 30 lbs. of tomatoes wrapped in paper and place-packed. Other containers which are becoming important as carriers for the mature-green fruit are wire-bound crates, nailed crates, and field boxes. These are larger than the lug box and made to take 60 lbs. of jumble-packed fruits. Wire bound and nailed crates are provided with a lid and cardboard linings. The fruits carried in them are however not wrapped in paper.

Pink and ripe tomatoes are shipped usually in 8-, 12- and 16- quart splint, market, climax and fiber-board baskets, peach boxes and hampers which have handles. These boxes owing to their small size are well adapted to Sales direct to the consumer.

In Jamaica, Cuba, Bahamas and Montserrat, the lug box as described above is used exclusively as package for wrapped tomatoes.

In the Canaries shipment of tomatoes is in wooden boxes holding 14 - 18 lbs. of fruit with about $5\frac{1}{2}$ lb. of packing material including paper, peat and sawdust, (Holmes, 1931).

In Tests on containers for shipping Florida tomatoes, Halsey et al (1955) found that despite the popularity of the lug box, its flimsy lid, rough surfaces and protruding staples, prevented it from being a first class shipping container. They found that wire-bound boxes with heavy paper lining and smooth surfaced fiber-board boxes gave better protection against pressure and box-rubbing injury than lug boxes or unlined field boxes.

Storage.

Shipment of tomatoes to distant markets necessitates storage under cold conditions for some days during which the fruits should be kept sufficiently dormant to allow of distribution at the marketing centres in fresh condition.

Where tomatoes are exported on ships which operate at fairly long intervals provision is often made for pre-cooling the fruits before they are finally put into cold storage on a ship. For Trinidad grown commercial fruit Wardlaw and McGuire (1932) found 47.5° F. to be the optimal temperature for cold storage. At this temperature incidence of fungal and bacterial diseases was at a minimum, and there was also little danger of suitable colouring not developing when the fruits were later removed into a ripening temperature. Wright (1953), however, working with Trinidad tomatoes at this cold storage temperature and a ripening temperature of 70°F, got a high percentage of wastage from *Phoma destructiva* after keeping the fruits for 15 - 17 days in cold storage. The discrepancy in the results was probably due to the fact that Wardlaw and McGuire did their work during the dry season while Wright carried out his experiments in the wet season when conditions favoured disease.

According to Platenius et al (1934), however, tomatoes kept at temperatures below 49° F. for longer than 2 weeks may decay rapidly when allowed to ripen subsequently at 70° F. Craft and Heinze (1954) found that mature-green fruit stored at 32° F for 9 - 14 days failed to ripen properly and showed signs of low-temperature injury when transferred to 65° F. Wright et al (1931) consider 55° F. as the lowest temperature at which tomatoes ripen with good colour and good flavour.

(ii) Different cultural methods.

Experimental details.

Three methods of cultivation were adopted. These were:

- (1) Planting tomato seedlings on the flat and leaving them on flat throughout their growth.
 - (2) Planting tomato seedlings on the flat and raising earthen ridges subsequently.
 - (3) Planting tomato seedlings on ridges made before transplanting.
- There were also three combinations of pruning and staking treatments. These included:
- (a) No pruning and no staking.
 - (b) Staking without pruning.
 - (c) Staking with pruning.

A 3 x 5 randomized factorial design was adopted for the experiment. There were four replications in each of which the nine treatment combinations were randomized using Cochran and Cox's (1957) tables of random permutations. The nine treatment combinations were represented in the plan of the layout as follows. (See Appendix II).

<u>Treatment combinations</u>		<u>Legend.</u>
1.	Planting on the flat; no pruning and no staking	3F
2.	Planting on the flat and raising ridges; no pruning and no staking	3R

INVESTIGATIONS INTO DRY-SEASON TOMATO PRODUCTION IN TRINIDAD.

Object of Experiment.

The object of the experiment was to find the effects on yield and size of fruit and also costings of the following treatments:

- (1) Pruning and staking of tomato stems.
- (ii) Different cultural methods.

Experimental Details.

Three methods of cultivation were adopted. These were:

- (1) Planting tomato seedlings on the flat and leaving them on flat throughout their growth.
- (2) Planting tomato seedlings on the flat and moulding subsequently.

- (3) Planting tomato seedlings on ridges made before transplanting.

There were also three combinations of pruning and staking treatments. These included:

- (1) No pruning and no staking.
- (2) Staking without pruning.
- (3) Staking with pruning.

A 3 x 3 randomised factorial design was adopted for the experiment. There were four replications in each of which the nine treatment combinations were randomised using Cochran and Cox's (1957) tables of random permutations. The nine treatment combinations were represented in the plan of the layout as follows, (See Appendix I).

	<u>Treatment combinations</u>	<u>legend.</u>
1.	Planting on the flat; no pruning and no staking	Q F
2.	Planting on the flat and moulding later; no pruning and no staking	Q M

3.	Planting on ridges; no pruning and no staking	Q R
4.	Planting on the flat; staking without pruning	P F
5.	Planting on the flat and moulding later; staking without pruning	P M
6.	Planting on ridges; staking without pruning.	P R
7.	Planting on the flat; staking with pruning.	S F
8.	Planting on the flat and moulding later; staking with pruning	S M
9.	Planting on ridges; staking with pruning.	S R

Three cambered beds measuring 280' x 24' each and previously planted with maize were used for the experiment. The beds lay together and were orientated east to west. Two replications (2 and 3) were placed on the middle bed, one replication occupying half of the bed. The remaining two replications 1 and 4 were placed on the eastern halves of the other two beds, since fertility was known to deteriorate westwards.

Each plot measured 24' x 15' and had a single row of discard around each of the four margins, giving a net harvest area of 21' x 9'. After discards had been allowed the harvested areas became very much narrower than the gross plots and thus tended towards the ideal of long narrow plots recommended by Christidis (1931).

The plant spacing adopted was 3 ft. between rows and $1\frac{1}{2}$ ft. between plants in the row. One plot thus consisted of 5 rows of 16 plants, giving 80 plants per plot. After discards had been allowed, 42 plants were left to be harvested. This number of plants was just adequate as Strickland (1935) reports 36 as being the least number to give satisfactory coefficient of variation.

SOIL Type.

According to Chenery (1952) the soil of the area of the experiment falls in the Azonal River Estate sand series which consists of alluvial material of micaceous or schisty sand and have dark yellowish brown loamy topsoils merging below into a pale yellow fine sandy loam with black and orange concretions. Vine (1958) is however of the opinion that the soil of the experimental area must be classified in the Washington series owing to its impeded drainage and high water table.

NURSERY OPERATIONS.

Before the nursery beds were made the area allotted to them was ploughed and two weeks later, that is on the 7th of November 1957, levelled with rakes and hoes. Four beds 30' x 4' and 6 ins. high were prepared. A layer of highly humic soil from under a clump of bamboos was spread thinly and evenly over the surface of the beds. On the 11th of December, five days before sowing of the seeds, a mixture of artificial fertilizers containing sulphate of Ammonia, triple super phosphate, and sulphate of potash was applied to the beds at the rate of 9oz/ sq. yard. This was made up of 2oz sulphate of ammonia, 3oz triple super phosphate and 4oz sulphate of potash. The seeds which were of the indeterminate 'Ogier' variety were sown thinly in drills 3" apart. Before sowing, the surfaces of the beds were broken into a fine tilth using a rake and more bamboo soil was lightly sprinkled on them. After sowing the drills were closed using the fingers.

A low shed of palm leaves about 3 ft. from the ground was raised on bamboo uprights to shade the beds. Watering was done morning and afternoon except when it rained.

Germination started five days after sowing. Percentage germination obtained was 55. This was considered poor and was thought to have been caused by the heavy rains which, starting soon

after the seeds were sown, fell continuously for three days.

Four days after germination the seedlings were singled out to a spacing of 3" x 3". The following day they were sprayed with perenox and the shade over them slightly reduced. A second spraying was given two days later and the shade further reduced. 12 days after germination the shade was completely removed. The seedlings were by this time well away and showed every promise of continued satisfactory growth.

FIELD OPERATIONS.

1. Transplanting.

The three experimental beds were cutlassed on the 15th of November. The thrash was removed the next day and the beds ploughed a day after. On the following day the beds were disced and allowed to lie fallow for seven weeks.

On the 13th and 14th of December the beds were again cutlassed of weeds and the blocks and plots marked as described above. Ridges which were spaced 3 ft. apart from crest to crest and lying across the beds were made on the plots which were to receive this treatment.

Holes were dug at a spacing of 3' x 1½' during the mornings of the 16th and 17th of December and the seedlings were planted out in the afternoons. Except the seedlings transplanted on ridges, all seedlings were transplanted on the flat to begin with. No special care was taken to preserve a ball of earth around the roots of the seedling during lifting, but most of the seedlings as they were planted out had bits of soil sticking to their roots. The seedlings at the time of transplanting were about 10 ins. tall, looked robust and had a healthy green colour. They showed no signs of disease except a very slight attack of leaf miner.

Each seedling immediately after transplanting received a $\frac{1}{4}$ pint of a starter solution containing aldrin and a fertilizer mixture made up of two parts of Ammonium phosphate to one part of potassium nitrate, 5 lb. of the mixture of fertilizers being dissolved in 50 gallons of water. This concentration of starter solution was used as it had been shown by many investigators including Fenwich (1957) to give higher yields than lower concentrations. The aldrin was added to prevent mole crickets and other soil pests from attacking the seedlings.

Supplying was carried out until 13 days after transplanting into the field, the final supplying being done on 30th December. The low percentage of supplying (6.3%) obtained for the whole experiment again demonstrated the importance of transplanting during the afternoon.

In 1957 Fenwich obtained for bare root seedlings transplanted after 3 O'clock in the afternoon total percentage replacements varying from 10.3 to 13.2 and for seedlings raised in pots obtained percentage replacements of 6.4 for seedlings raised in pots, Smith (1954) obtained a comparative figure of 6.1% and Tremeer (1956) obtained 8.3%.

S U P P L Y I N G.

BLOCKS	TOTAL NO. SUPPLIED	PERCENT SUPPLYING
I	51	7.1.
II	10	1.3
III	8	1.1
IV	111	15.4
WHOLE EXPT.	180	6.3

Judging from the fact that various workers have found pot raised seedlings to have greater transplanting power than seedlings raised on seedbeds, the seedlings produced in the present experiment could be said to have established very well. Their success was also partly due to the very favourable weather conditions (an overcast sky) prevailing during the time of transplanting, partly to the use of starter solution and partly also to the moist soil conditions produced by rainfall just before transplanting.

2. Moulding, Weeding, fertilizing.

The method of fertilizing was virtually the same as that employed by Tremere (1956) and Fenwich (1957). 500 lb./Acre of a mixture of sulphate of ammonia, superphosphate and potassium sulphate in the ratio of 1: 2: 1 was applied at the time of first moulding up which was a week after transplanting. The fertilizer was "spotted" i.e. it was placed in a small heap near each plant and covered up with soil during moulding up or weeding of the ridges and flats. Each plot received $4 \frac{1}{8}$ lb. of the mixture of fertilizer.

The second and last dressing of fertilizer was applied twenty four days later as Hester (1937) had shown that tomato plants absorb most of their nutrients between the 2nd and 3rd months after transplanting. For the second dressing which was at 600 lb./acre or 5 lb. per plot the potassium content of the mixture was increased and the nitrogen decreased. The mixture used was:

52 lb. Ammonium sulphate.

60 lb. Triple Super phosphate.

68 lb. Potassium sulphate.

The fertilizer was again "spotted" and covered with soil during the second moulding and weeding operations.

Moulding was done with a long handled hoe in the usual peasant manner. The weeds in the flat areas were scraped using the long hoe care being taken not to do any deep cultivation. On the ridged and moulded plots weeding was automatically done as the ridges and moulds were made up.

3. Pruning.

Pruning was started on 2nd January soon after the first blossoms appeared on the plants. Each stem was pruned to a single stem by pinching out the new suckers or shoots as they appeared in the axils of the leaves. Pruning was done as often as was found necessary.

4. Staking.

In all the staking treatments, each plant was tied to a bamboo stake of an average height of 6 ft. Tying of the plants to the stakes was done with wrapping twine. Staking and tying were started on the 8th of January and ended on the 14th of the same month. Many times during the season the tying operation was repeated in order to keep the plants properly tied.

5. Spraying.

Spraying in the field started on the 18th of December a day after transplanting was completed. Alternate weekly spraying with "perenox" and a mixture of "manzate" and "fosferno" (parathion) was adopted. "Perenox" at the rate of $\frac{1}{2}$ oz in a gallon of water containing 12 drops of Dupont spreader sticker was sprayed in the first week. In the following week a mixture of "manzate" and "fosferno", also containing Dupont spreader sticker at the rate of 20 drops per gallon of mixture, was sprayed; and so the spraying was continued. The "manzate" and the "fosferno" were at the rates of $\frac{1}{2}$ oz and $\frac{1}{2}$ fluid oz per gallon respectively.

Manzate is a Dupont proprietary substance containing as the active principle manganese ethylene-bis-dithio carbamate. It has been claimed by the manufacturers to be effective against the fungus diseases, early blight, late blight, septoria leaf spot, grey leaf spot, and anthracnose. Fosferno was used to control leaf miner and caterpillars.

6. Irrigation.

Irrigation was started on the 21st of January and continued at weekly intervals except when there was rainfall in the intervening period. The overhead sprinkler system was used. One inch of water (3 hours irrigation) was delivered by the sprinkler system during the first irrigation. In subsequent irrigations the time of irrigation was increased to $4\frac{1}{2}$ hours which was equivalent to $1\frac{1}{2}$ inches of water. A total of 5 inches of water (15 irrigation hours) was used to irrigate the area during the period of the experiment.

General observations in the field.

Soon after transplanting the seedlings lost their healthy green colour and turned yellowish green. About a week after the first application of fertilizer however, the green colour returned to the seedlings which started to grow vigorously.

The first blossoms were observed on the 30th of December, two weeks after transplanting. On the 6th of January fruiting was also observed.

Weed growth.

Weed growth was found to be most abundant on the flat areas.

Diseases.

Except an attack of leaf miner the plants were free from pests and diseases during the early period of their growth.

The attack of leaf miner which started in the nursery increased with the growth of the plants in the field but was prevented from becoming serious by spraying with "fosferno".

Six weeks after transplanting Grey leaf spot (*Stemphilia solani*) appeared on the bottom leaves of a few plants. These leaves developed brownish spots and later turned yellow and died. Within a month other leaf diseases including *Cladosporium fulvum*, *Septoria lycopersical*, *Alternaria solani* had attacked the plants and with the increase in the incidence of grey leaf spot were causing a steady decline in yields.

The method of alternate weekly spraying with "perenox" and "manzate" adopted to control diseases was not very successful. It would appear that the interval between two successive sprayings with the same fungicide especially in the case of "manzate" was too long for effective control to be achieved. It is also likely that the rates at which the fungicides were used were not high enough to cope with the diseases under the conditions prevailing on the New Farm. It is suggested that "manzate" should be used again in future experiments at higher rates and at shorter intervals.

The incidence of mosaic was very low in all the treatments. This was probably due to the fact that the workers who did the pruning and tying were made to wash their hands with soap before they started on any operation.

The incidence of physiological diseases was negligible for blossom-end rot and fairly high for growth-cracks. The incidence of the latter disease was estimated to be 20%. Its distribution among the different treatments was observed to be fairly uniform. The staking and pruning treatments did not appear to be affected to any greater extent than any of the other treatments.

Harvesting.

Harvesting started on the 4th of February and continued to the 10th of March. Two pickings were made each week, on Tuesdays and Thursdays, to coincide with the opening of the College Vegetable Shop. Fruits were picked when they were at the mature-green stage or just turning colour. The plots were harvested one at a time and the tomatoes were carried to the Shed in paper boxes. At the Shed fruits were graded into two sizes: those with a diameter greater than 2 inches, and those with a diameter below this size.

53.75	53.50	57.00	42.75
Q H	S R	Q R	Q R
53.75	61.75	65.75	35.75
P F	S F	S H	S F
66.50	45.75	72.50	35.75
P R	T R	P R	S H
63.75	56.75	66.75	37.75
Q R	P R	P F	P F
67.0	52.0	76.50	33.50
Q F	S H	S F	S H
52.0	50.5	61.50	30.5
S R	Q R	Q H	Q F
58.75	61.75	62.50	29.5
P H	T H	S H	P H
71.50	61.50	71.75	40.75

R E S U L T S.

TOTAL YIELDS OF INDIVIDUAL PLOTS IN LB.

BLOCK I.	BLOCK II.	BLOCK III.	BLOCK IV.
S F 51.00	P M 43.25	P M 63.75	P R 52.00
S M 53.25	P F 53.50	Q F 57.00	Q M 42.75
Q M 53.75	S R 61.75	Q R 65.75	Q R 35.75
P F 66.50	S F 49.75	S R 72.50	S F 35.75
P R 68.75	Q F 56.75	P R 66.25	S R 37.75
Q R 67.0	P R 68.0	P F 76.50	P F 33.50
Q F 52.0	S M 69.5	S F 64.50	S M 30.5
S R 58.75	Q R 64.75	Q M 62.50	Q F 29.5
P M 71.50	Q M 61.00	S M 71.25	P M 40.75

INDIVIDUAL PLOT YIELD OF FRUIT OVER 2" IN DIAMETER
IN LBS.

BLOCK I.	BLOCK II.	BLOCK III.	BLOCK IV.
S F 30.00	P M 22.25	P M 39.25	P R 27.75
S M 25.00	P F 31.25	Q F 35.25	Q M 21.75
Q.M 33.25	S R 38.25	Q R 41.25	Q R 19.00
P F 39.50	S F 29.25	S R 43.25	S F 18.25
P R 43.50	Q F 29.00	P R 40.00	S R 22.25
Q R 38.50	P R 38.75	P F 47.75	P F 15.00
Q F 35.00	S M 41.25	S F 39.25	S M 16.00
S R 33.00	Q R 38.75	Q M 36.75	Q F 16.50
P M 39.00	Q M 36.50	S M 40.00	P M 23.75

TWO - WAY TABLES.

I. TOTAL YIELD OF FRUIT IN LB.

	FLAT	MOULD	RIDGE	TOTAL	MEAN
STAKING WITH PRUNING	201.00	224.50	230.75	656.25	54.69
STAKING WITHOUT PRUNING	230.00	219.25	255.00	704.25	58.69
NO STAKING; NO PRUNING.	195.25	220.00	233.25	648.50	54.04
TOTAL	626.25	663.75	719.00	2009.00	
MEAN	52.19	55.31	59.92		55.81

II. TOTAL YIELD OF FRUIT OVER 2" IN DIAMETER IN LB.

	FLAT	MOULD	RIDGE	TOTAL	MEAN
STAKING WITH PRUNING	116.75	122.25	136.75	375.75	31.31
STAKING WITHOUT PRUNING.	133.50	124.25	150.00	407.75	33.98
NO STAKING; NO PRUNING.	115.75	128.25	137.50	381.50	31.79
TOTAL	366.00	374.75	424.25	1165.00	
MEAN	30.50	31.23	35.35		32.36

ANALYSIS OF VARIANCE.

(a) TOTAL YIELD.

Source of Variation.	D F	S S	M S	F
Blocks	3	4305.24	1435.08	32.63 * * *
Treatments	8	629.26	78.66	
Cultural	2	362.82	181.41	4.12 *
Training & Pruning	2	152.00	76.00	1.73
Interaction	4	114.44	28.61	0.65
Error	24	1055.51	43.98	
TOTAL	35	5990.01		

S. E. of a single plot yield	= 6.63
Coefficient of variation of single plot yield	= 11.8 %
S. E. of mean of 12 plot yields	= 1.916.

Training and pruning treatments and their interaction with the cultural treatments were not significant. The cultural treatments were significant at the 5% level. The F-ratio for blocks was very highly significant suggesting that there were real fertility or edaphic variations in the area and thus justifying the adoption of the randomised block design for the experiment. This fertility trend in the area was actually observed by its effects throughout the experiment. It appeared soil conditions were least favourable on block IV. which gave the lowest yield and took the greatest number of supplies. On this block also it was observed that the condition of the plants was not as satisfactory as it was on the other blocks in the early stages of growth.

"T" - Test.

Applying the T - test to the cultural treatments it was found that at 24 D - F. ridging gave significantly greater yields at the 1% level than planting on the flat. The increased yield of **ridging** treatment over the moulding treatment was however not significant. The difference in yield between moulding and planting on the flat was also not significant.

Value of t for diff. between means of Ridge and flat = 2.877 **
 " " " " " " " " Ridge and mould = 1.715
 " " " " " " " " Mould and flat = 1.116

(b) FRUIT SIZE.

Source of Variation	D F	S S	M S	F
Blocks	3	2031.06	6 77.02	28.70 ***
Treatments	8	246.52	30.82	
Cultural	2	164.44	82.22	3.48 *
Training & Pruning	2	48.50	24.25	1.03
Interaction	4	33.58	8.39	0.36
Error	24	566.24	23.59	
Total	35	2843.82		

S.E. of a single plot yield = 4.85
 Coefficient of variation of single plot yield = 15.0%
 S.E. of mean of 12 plot yields = 1.4 lbs.

Training and pruning treatments and their interaction with the cultural treatments were not significant and do not seem to affect the size of fruit. The cultural treatments were however just significant at the 5% level. This suggests that fruit size may depend on the type of cultural treatment given to the plants in the field.

"T" Test.

Application of the "T" test to the cultural treatments showed that at 24 D.F. plants grown on ridges yielded significantly at the 5% level larger fruits than either plants grown on the flat or moulded up. There was no significant difference between the flat and the mould as regards fruit size.

Value of "t" for diff. between means of Ridge and flat	-	2.449*
" " " " " " " " Ridge and mould	-	2.081*
" " " " " " " " Mould and flat	-	0.36

The conflicting results may have resulted from the different conditions under which the experiments were done. Most of the experiments had an attack of blight which in the case of Smith's was almost very serious damage, a fact which might well have accounted for the very different results he obtained. In some of the experiments all the plants were staked to facilitate harvesting while in others staking was adopted as a main treatment. Some effects have to be taken into account as interactions have been reported between staking and cultural methods, such as evident elsewhere that staking may increase yield in variety (Gardner 1941) and with spacing (Barnier, 1941).

Discussion.

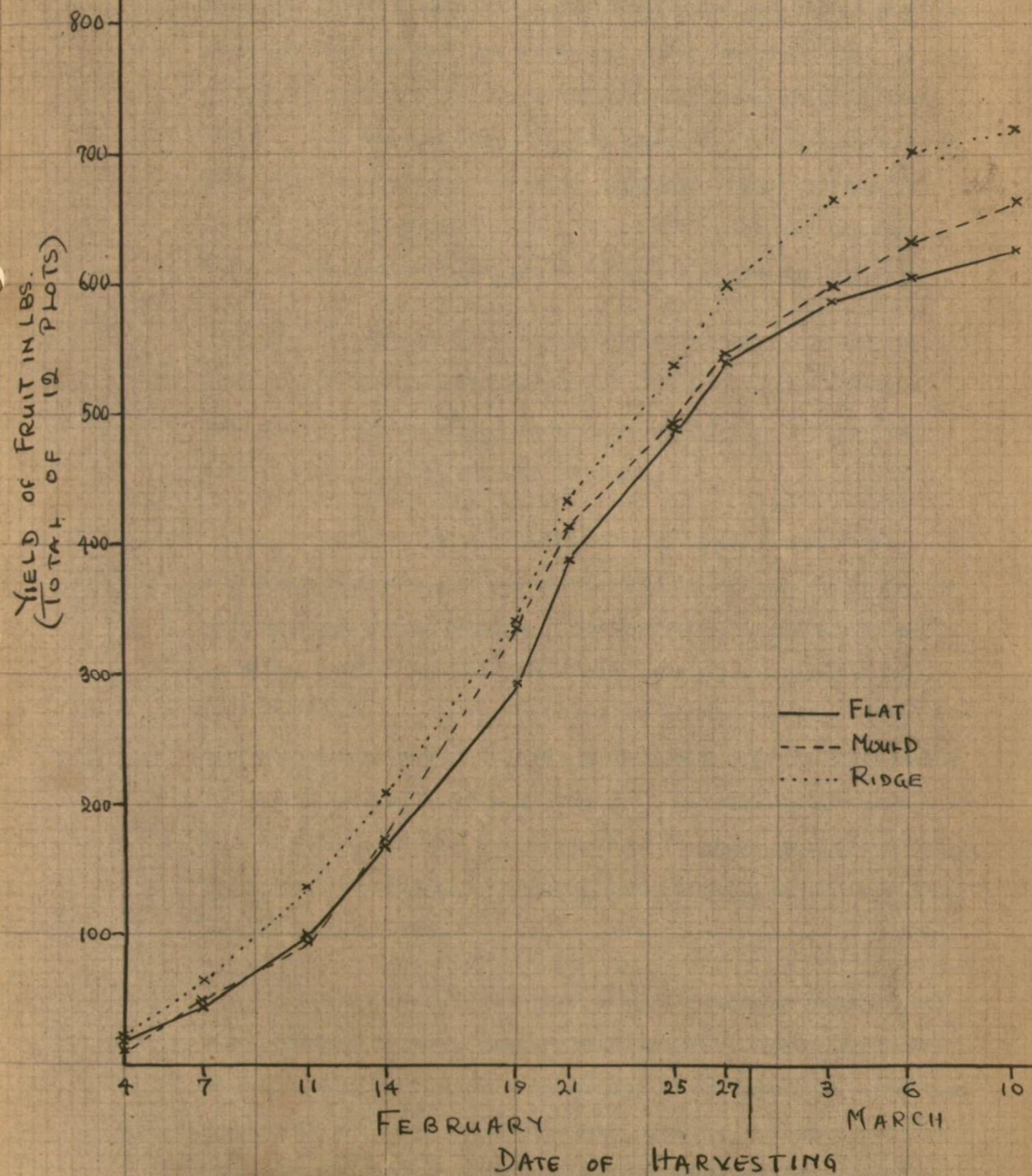
Cultural treatments.

In the experiment plants grown on the ridges very significantly outyielded those planted on the level but showed no measurable difference from those planted on the level and moulded up later. No measurable difference in yield was also found between plants on the level and those on the "mould", though the latter outyielded the former. With the exception of Smith (1954) who reported results in which flat cultivation and moulding significantly produced higher yields than ridging, various investigators at I.C.T.A. have obtained results similar to those obtained in the present experiment, in which plants on ridges and on the mould have outyielded plants on the level.

Opinion is however divided on which of the two methods - ridge planting and planting on the mould - is superior. Fenwich (1957) obtained no significant differences between the two methods but had higher yields from plants on ridges, while Rombulow-Pearse (1953) also obtained no significant differences between the two methods but had higher yields from plants in the mould.

The conflicting results may have resulted from the different conditions under which the experiments were done. Most of the experiments had an attack of diseases which in the case of Smith's work caused very serious damage; a fact which might well have accounted for the very different results he obtained. In some of the experiments also all the plants were staked to facilitate harvesting while in others staking was adopted as a main treatment whose effects were to be found out. Though no interactions have been reported between staking and cultural methods, there is evidence elsewhere that staking may interact with variety (Currence 1941) and with spacing (Deonier, 1944).

GRAPH I
(Showing cumulative yields)
for cultural treatments



In the present experiment it was found that plants on ridges produce larger fruits than those growing on the level or on moulds. This needs further confirmation as the level of significance is rather low.

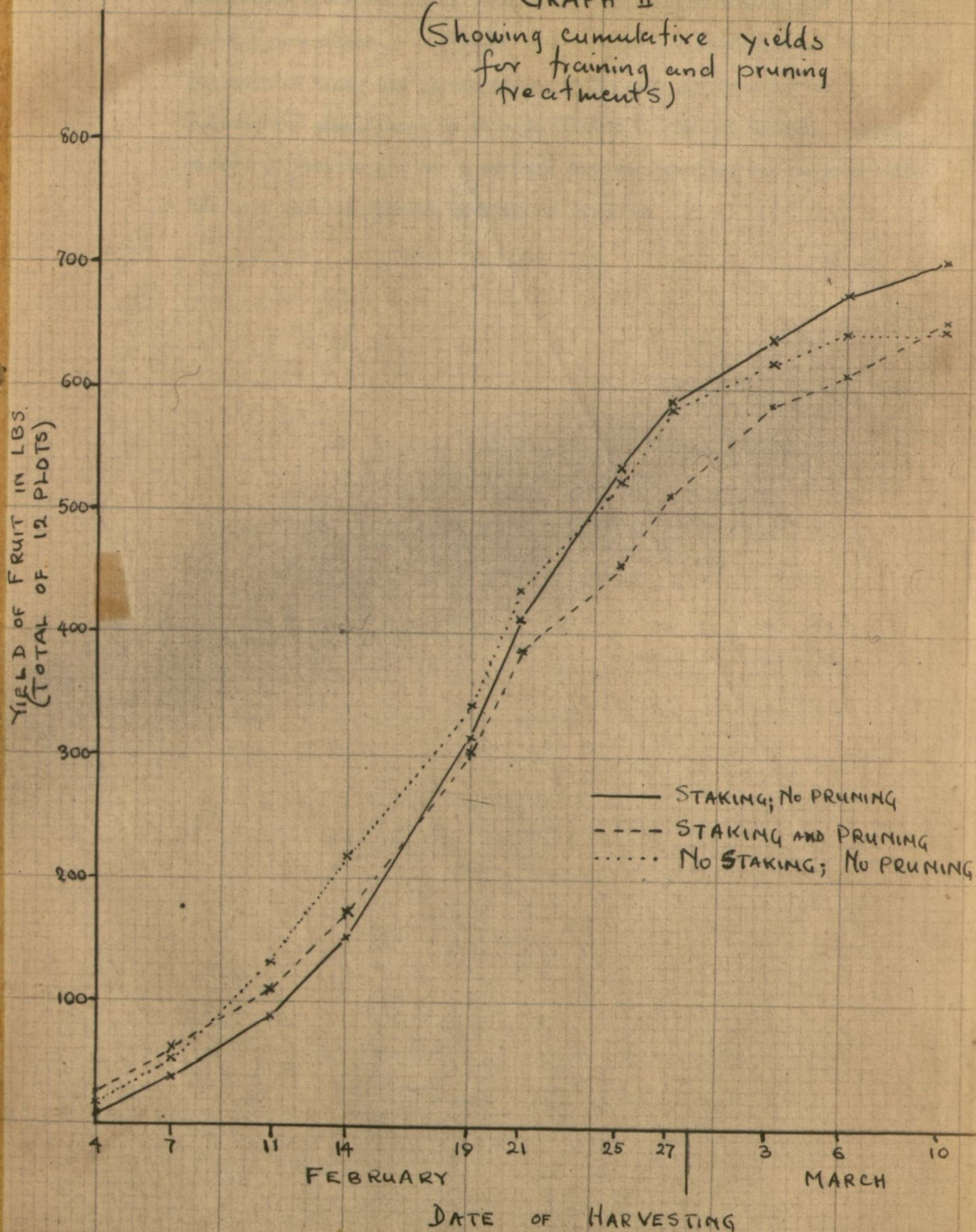
Training and pruning treatments.

Though the Training and pruning treatments showed no significant differences among themselves in yield, the indication would appear to be that staking and pruning do have adverse effects on early though not on total yields. Staking without pruning appears to retard early yields more effectively than the combination of staking and pruning. This increased early yield with staking and pruning is however nothing like as great as the early yields obtained with no staking and no pruning. (See Graph II).

The higher total yields obtained for the two treatments staking with pruning and staking without pruning may be attributed to the increase in the incidence of disease after the first four pickings. After giving unsatisfactory early yields the staking without pruning treatment began to show increasing yields and over the last four pickings actually outyielded the other two treatments. The no-staking and no-pruning treatment was the hardest hit with disease and at the end of the experiment was showing an overall total yield below that of the other two treatments even though it had given the highest early yields. Under disease conditions it would appear staking is more advantageous than no-staking. This advantage may be lessened by pruning staked plants.

The costings show that the most profitable treatment was staking without pruning, the next profitable no-staking and no-pruning and the least profitable staking with pruning (See appendix IV). Under the conditions at the College farm, and from the stand-point of financial gain, staking with pruning is the least desirable of the three treatments. Despite the fact that it resulted in higher total yields than the no-staking and no-pruning treatment, it brought in a lower net income than

GRAPH II
(Showing cumulative yields
for training and pruning
treatments)



the latter treatment owing to the high cost of the staking and pruning operations. Pruning with staking may therefore not be recommended under any circumstances while staking alone may be recommended where there is disease risk or in the wet season. When, however, diseases are not a serious problem, tomatoes may be grown with the best results without staking and pruning.

S U M M A R Y.

The effects on yields of training and pruning and of different cultural treatments are investigated.

Planting on the ridge is found to give significantly higher yields than planting on the level, but to show no measurable difference from planting on the "mould". No measurable difference in yield is also found between planting on the level and planting on the "mould".

No significant differences are found between the training and pruning treatments. There is indication, however, that growing tomatoes without staking and pruning favours early yields, and staking and pruning tend to increase total yields.

The different operations in the experiment are costed for and it is shown that staking and pruning is of the least financial benefit, while staking without pruning brings in the greatest financial returns. It is however suggested that under conditions where disease is not a hazard tomatoes may be grown with maximum benefit without being staked and pruned.

A C K N O W L E D G E M E N T.

The writer wishes to thank Mr. J. S. Campbell for his invaluable advice and guidance throughout the duration of the experiment.

He would also like to express his thanks to Mr. G. E. Hodnett who advised on the statistical design and to Mr. M. Benny who supervised the field work.

GRAPH III

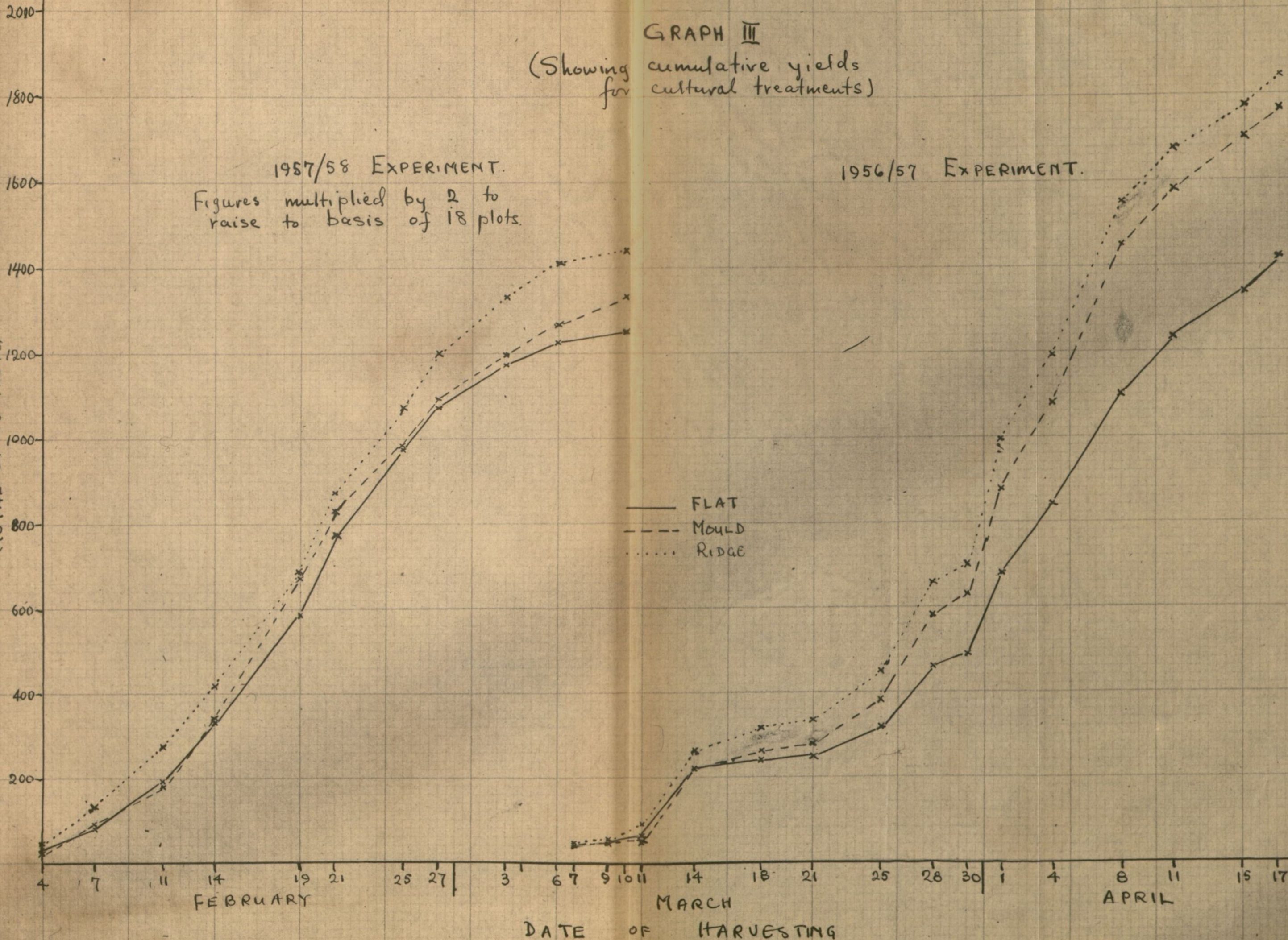
(Showing cumulative yields for cultural treatments)

1957/58 EXPERIMENT.

Figures multiplied by 2 to raise to basis of 18 plots.

1956/57 EXPERIMENT.

YIELD OF FRUIT IN LBS.
(TOTAL OF 18 PLOTS)



APPENDIX I.

Plan and Layout of the Experiment.

Bed 7. Block I.	
1	S F
2	S M
3	Q M
4	P F
5	P R
6	Q R
7	Q F
8	S R
9	P M

Bed 8. Block II.	
10	P M
11	P F
12	S R
13	S F
14	Q F
15	P R
16	S M
17	Q R
18	Q M

Bed 9. Block IV.	
28	P R
29	Q M
30	Q R
31	S F
32	S R
33	P F
34	S M
35	Q F
36	P M

135'

15 ft

24'

LEGEND.

Q F = Planting on the flat; no pruning, no staking.

Q M = Moulding; no pruning, no staking.

Q R = Ridging; no pruning, no staking

P F = Planting on the flat; staking no pruning.

P M = Moulding; staking no pruning.

P R = Ridging; staking no pruning.

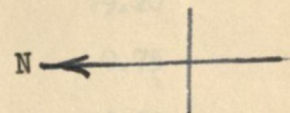
S F = Planting on the flat; staking and pruning.

Block III.

19	P M
20	Q F
21	Q R
22	S R
23	P R
24	P F
25	S F
26	Q M
27	S M

S M = Moulding; staking and pruning.

S R = Ridging; staking and pruning,



APPENDIX II.

COSTS OF PRODUCTION.

Figures are derived from the records of 1/3 of an acre and converted to cost per acre.

<u>Operation.</u>	<u>Cost in Dollars (BWI).</u>	
Raising of Seedlings.		
Preparation of nursery beds	8.43	
Labour - application of fertilizer.	3.06	
Labour - building Shed and sowing.	25.29	
Thinning	27.27	
Labour - spraying perenox	2.52	
Cost of seed - 4 ozs. "Ogier"	14.40	
Cost of art. fertilizer - 30 lbs.	7.20	88.17
Field operations and transplanting.		
Marking blocks and plots	25.02	
Making ridges	16.86	
Ridging Holing and transplanting.	85.53	
Cost of starter solution	7.29	
Cost of aldrin - 1/4 gallon.	5.52	140.22
Operations during growth.		
Labour - spraying with perenox	36.03	
Labour - spraying with manzate	30.06	
Supplying.	9.27	
Application of fertilizer.	25.02	
Weeding and moulding	115.89	
Labour - irrigation	8.37	
Harvesting	185.67	
Cost of Art. fertilizer - 330 lbs.	79.20	
Cost of "perenox"	0.75	
Cost of "manzate" - 2 lbs.	20.04	
Cost of "fosferno" - 150 ec.	5.25	
Cost of Dupont Spreader sticker - 32 ec.	2.40	517.95

Total expenses for cultivated operations

746.34

Staking operations	Cost in Dollars.	
Cutting stakes and transporting	100.02	
Staking	31.20	
Tying	37.71	
Cost of wrapping twine for tying	3.75	172.68
Pruning	35.61	35.61
Total expenses for staking and pruning operations		208.29
Total expenses for whole experiment		954.63

Cutlassing of the experimental beds was not costed for as the operation was given on contract to a local farmer who used the thrash to feed his Stock. Payment for the operation was therefore in kind.

A P P E N D I X I I I .

Value of Produce For Different Treatments.

Figures are derived from 1/19 of an acre and converted to cost per acre.

(A)

Date of harvest- ing.	Price per lb. on day of harvest- ing in cents.	F L A T		M O U L D		R I D G E	
		Yield/Acre in lbs	Total value in \$. BWT.	Yield/Acre in lbs.	Total value in \$. BWT.	Yield/Acre in lbs.	Total value in \$. BWT.
4.2.58	50	361.00	180.50	256.50	128.25	399.00	199.50
7.2.58	45	408.50	183.53	593.75	267.19	864.50	389.03
11.2.58	25	1125.75	281.44	964.25	241.06	1349.00	337.25
14.2.58	25	1277.75	319.44	1410.75	352.69	1363.25	340.81
19.2.58	25	2370.25	592.56	3116.00	779.00	2455.75	613.94
21.2.58	30	1838.25	459.56	1529.50	382.38	1805.00	541.50
25.2.58	25	1890.50	472.63	1439.25	359.81	1985.50	496.38
27.2.58	25	969.00	242.25	1054.50	263.63	1187.50	296.88
3.3.58	26	931.00	242.06	1021.25	265.53	1230.25	319.87
6.3.58	20	346.75	69.35	631.75	126.35	722.00	144.40
10.3.58	20	370.50	74.10	593.75	118.75	308.75	61.75
Total		11889.25	3117.72	12611.25	3284.64	13670.50	3741.31

(B)

Date of harvesting	Price per lb. on day of harvesting in Cents.	STAKING & PRUNING		STAKING NO PRUNING		NO STAKING, NO PRUNING	
		Yield/Acre in lbs.	Total Value in \$ B.W.I.	Yield/Acre in lbs.	Total Value in \$ B.W.I.	Yield/Acre in lbs.	Total value in \$ B.W.I.
4.2.58	50	517.75	258.88	175.75	87.88	323.00	161.50
7.2.58	45	627.00	282.15	574.75	258.64	665.00	299.25
11.2.58	25	945.25	236.31	950.00	237.50	1543.75	385.94
14.2.58	25	1187.50	296.88	1263.50	315.88	1610.25	402.56
19.2.58	25	2479.50	619.88	3073.25	768.31	2389.25	597.31
21.2.58	30	1624.50	487.35	1800.25	540.07	1748.00	524.40
25.2.58	25	1306.25	326.56	2341.75	585.44	1667.25	416.81
27.2.58	25	1040.25	260.06	1021.25	255.31	1149.50	287.38
3.3.58	26	1467.75	381.62	983.25	255.65	722.00	187.72
6.3.58	20	503.50	100.70	722.00	144.40	475.00	95.00
10.3.58	20	769.50	153.90	475.00	95.00	28.50	5.70
Total		12468.75	3404.29	13380.75	3544.08	12321.50	3363.57

Average value of Crop for Different Treatments.

Average price per lb. during season - 29 cents.

Treatment	Average value of crop in \$ B.W.I.
flat	3449.88
Mould	3657.26
Ridge	3964.45
Staking and pruning	3615.94
Staking no pruning	3880.42
No staking, no pruning	3573.24

APPENDIX IV.COST - PROFIT ANALYSIS For Staking and Pruning Treatments.

ITEM	Staking & Pruning	Staking, No Pruning	No Staking, No Pruning.
Total value of early crop (fruit produced per acre during the first 4 pickings) in \$ BWI.	1074.22	899.90	1249.24
Total value of fruit produced during the experiment in \$ BWI.	3516.94	3880.42	3573.24
Total cost of production per acre in \$ BWI.	457.07	421.46	248.78
Net income at end of Season in \$ BWI.	3158.87	3458.96	3324.46

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