INVESTIGATIONS INTO DRY-SEASON TOMATO PRODUCTION IN TRINIDAD

by

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SUMMARY

The paper describes an experiment to investigate the effect of plant raising techniques and the use of a "starter" solution on tomato cultivation under Trinidad dry season conditions.

Following on from work by Smith (1954) and earlier investigations the normal method of tomato plant raising by the peasant grower was compared with an "improvement" of this method and with the seedbox and pot method of temperate regions. At the same time the use of a "starter " solution at transplanting time was also investigated.

A field experiment proved the superiority of the pot-raising method over the peasant seedbed method as judged by fruit yield. It was found that plants from the improved seedbed yielded almost as well as the pot raised plants.

The effects of the "starter" solution on earliness of fruiting, transplanting success and final yield are discussed.

INTRODUCTION

The tomato, a native of Tropical America, is one of the most widely used vegetables produced in the tropics. Macmillan, in his classic "Tropical Planting and Gardening" says that "Tomatoes can be grown with much success in the tropics, especially in rather dry districts and at medium elevations." In Trinidad the crop is widely grown in the dry season by the local people; the chief factor operating against wet season production being the higher prevalence of fungal pathogens and insects. Apart from occasional gluts during the dry season in Trinidad, there is usually a ready sale for the crop; indeed the local people are prepared to pay quite high prices for fruit of often inferior quality. Thus in January 1956 the price to the consumer was often 72¢ per lb. - indicating the esteem in which the fruit is held. Being a crop of high nutritive value, it's cultivation is to be encouraged wherever possible. In Trinidad there is room for improvement in cultural methods and in quality of produce. Investigations into tomato production in Trinidad, such as here described, are therefore justified, even though similar experiments in the past have failed to yield any conclusive results (due mainly to the crop being dessicated by diseases, such as Gray Leaf Spot, caused by Stemphyllium solani). Thus similar trials to the one here described were carried out by Smith in 1954 and Barrett in 1955 after Rombulow - Pearse (1953) had indicated that improvements could be made in the cultivation techniques of the peasant growers. However, it was thought that the effect of different plant raising methods on the establishment and behaviour of the tomato crop would repay further investigation; also, Smith in 1954 suggested that the effect of applying immediately available nutrient solutions ("starter solutions") at the time of transplanting should be studied under Trinidad dry conditions.

This paper describes two experiments laid out at the I.C.T.A. Market Garden in the dry season of 1956 to examine these questions.

EXPERIMENT I

THE EFFECT OF DIFFERENT PLANT RAISING TECHNIQUES AND THE USE OF STARTER SOLUTIONS.

(i) CONSIDERATIONS FOR EXPERIMENT.

The object of this experiment was to establish the relative importance under tropical conditions of the early treatment of the tomato plant up to the time of transplanting as it affects final yield. It was thought that the early treatment of the seedling would have an effect right through the life of the plant, and that by producing a sturdy plant with a good root system at transplanting time, such a plant would be more likely to reflect fully its inherent genetic potential than a poorly raised plant with a weak root system.

In this experiment three methods of raising tomato plants were investigated; these formed the three main treatments, with which were combined two treatments for starter solutions, (i.e. with and without), giving six treatments in all. The experiment was carried out in the dry season of 1956, at the I.C.T.A. Market Garden. The variety was Ogier, an indeterminate variety which has given good yields in Trinidad. However, it might be pointed out that tomato yields in the tropics do not generally approach those of temperate regions (where yields of 10 tons per acre are common), due partly to the night temperatures being too high (Went 1945). Another reason might be that breeding for varieties suited to tropical conditions has not been fully exploited.

(ii) TREATMENTS.

(a) Main Treatments.

The three main treatments were:-

I Seed sown in boxes and the seedlings pricked out into 3" pots under cover (the normal temperate greenhouse method)

II Seed broadcast thickly in the open on a raised seedbed and not thinned (the common peasant method in Trinidad).

III Seed sown in the open in drills on a raised seedbed and later thinned out (an improvement of the peasant method).

When the plants had reached the transplanting stage, the two starter solution treatments were superimposed giving the following six treatments:-

		Legend
1.	Plants raised in boxes and pots; starter solution used.	PW
2.	Plants raised in boxes and pots; no starter solution used.	PO
3.	Plants raised on peasant type seed-bed; starter solution used.	BW
4.	Plants raised on peasant type seed-bed; no solution used.	BO
5.	Plants raised on improved seedbed; starter solution used.	1BW
6.	Plants raised on improved seedbed; no starter solution used.	1BO.

(b) Starter Solution.

Most of the work on the use of nutrient or "starter" solution for tomatoes has been done in the U.S. where mechanical transplanters are often used, which are capable of injecting water into the planting hole at transplanting time. The idea was suggested that by placing soluble nutrients in the water used, the plant might better recover from the shock of transplanting. Accordingly, Baker working in Indiana in 1937, found that on soils low in available phosphorus, the use of phosphoric acid and soluble phosphate at proper dilution at planting time started tomatoes out more readily, reduced the amount of supplying necessary and brought about earlier fruiting. Moreover, the total yield was increased.

The following year Sayre in the U.S. tested the effects of hormones as well as nutrients in the transplanting solutions. While the hormone treatments tried did not increase yields, nor hasten maturity (indeed maturity was delayed), he found that 20 oz. Ammonium phosphate A and 10 oz. Potassium nitrate in 50 gallons water applied at rate of 1 pint per plant, spaced 3' x 5', increased the early yield by 1.44 tons per acre and total yield by 1.85 tons per acre (the composition of the Ammonium phosphate A was 11% N and 48% P_2O_5; and the Potassium nitrate 13% N and 49% K_2O).

Carrying the work further, Sayre in 1939 worked on several differently composed nutrient solutions. He found that 2 parts Ammonium phosphate and 1 part Potassium nitrate proved as effective as any other tried and was the least expensive. The most effective concentrations was 8 lb. mixture in 50 gallons at ¼ pint per plant. In "Commercial Production of Tomatoes" issued by the U.S.D.A. 1952, the concentration recommended was 5 lb. of the above mixture in 100 gallons applied at ½ pint per plant, this being a considerably lower amount of nutrient applied per plant. The solution as applied to the plant thus contains approx:-

0.06% N,

0.16% P_2O_5

0.075% K_2O

Even at the concentration recommended by Sayre, the amount of nutrient applied to each plant is very small. In discussing the pronounced effect these small amounts of nutrient have on transplanting success, early fruiting and total yield, he pointed out that at the time of transplanting the tomato plant is in a very vulnerable condition, and by the application of immediately available nutrients the plant is enabled to get over this stage quickly. Obviously, however much care is taken, there will be some damage to the roots of the plant when it is transplanted; by applying a starter solution, the plant is provided with easily absorbed N,P and K to "keep it going" until it has established a new root system.

(iii) EXPERIMENTAL DESIGN AND LAYOUT

The randomized block layout was adopted. The six treatment combinations were randomized within blocks using Cochran and Cox's Tables of Random Permutations. There were four replications. Two cambered beds measuring 270' x 24' were used for the experiment; there were thus two blocks or replications per bed. Plot size was 12' x 44'. The plant spacing was 2' apart in the rows and 3' between the rows. One plot thus consisted of 4 rows of plants with 22 plants per row, giving 88 plants per plot.

(iv) FIELD OPERATIONS

(a) Prior to transplanting.

In all treatments the seed was sown on December 9th. 1955. The first treatment (I) followed closely that advocated by Smith, 1954. It differed however in that the potting soil used was not sterilized in any way (Smith advised the use of steam). This was due to the fact that steam sterilizing facilities were not available at the time, and moreover the bamboo soil used was thought to be relatively free from harmful organism and weeds. (This was later borne out; there were no losses in the pots from damping off, and very few weeds emerged in the pots) The compost for the seedbox was composed of:

1 part coconut fibre

1 part well rotted pen manure

2 parts bamboo soil.

These ingredients were thoroughly mixed together. About ¼ oz. seed was broadcast in a seed tray, measuring 2' 6" x 1' 6" by 3" deep. The seed was firmed in, and the boxes placed on staging under 50% light. After three days the seed had germinated, and after a further five days were sufficiently large in the cotyledon stage to be pricked out into 3" clay pots. The potting compost was composed of:

2 parts by weight bamboo soil

1 part by weight coarse sand

1 part by weight coconut fibre dust

To 1 bushel of this mixture was added a fertilizer mixture composed of:

¾ oz. hydrated lime

¾ oz. potassium sulphate

1½ oz. superphosphate

1 oz. ammonium sulphate.

Altogether about 1,200 seedlings were potted; the pots were placed in batches of 100 on staging under 50% light. As a precautionary measure, a light copper spray (Perenox) was given. Care was taken in the watering of the pots to avoid both waterlogging and drying out. It was found that in the batches of 100, the pots on the outside dried out more quickly than the others. Plant losses in the pots were negligible : the few that did die had been damaged during the potting-on process. These plants soon commenced growth, and rapidly reached the planting out size, so that by January 6th., 1956 they were at the correct stage for planting out in the field.

The second main treatment was considered to be typical of the peasant method of raising tomato plants in Trinidad. Although there is some variation in detail in the way different peasants produce their seedlings (e.g. some use flat beds, while others use curved beds), they all follow the principle of very thick sowing. Such methods were described by Rombulow - Pearse in 1953, in a Survey of the Aranguez Area.

A raised seedbed was prepared in the open measuring 29' x 4'. The bed was levelled, and a thin layer of well rotted pen manure was applied. On this the seed was scattered thickly, at the rate of about ½ oz. per 16 sq. ft. A layer of bamboo leaves was placed over the seed, this operation being termed "blinding" the seed. The seed had germinated in four days and then the bamboo leaves were removed. The seedlings grew slowly, due to the intense competition, and were very spindly and weak. Although the bed had been sprayed with Perenox, about 10% of the seedlings were lost due to damping off organisms. It is possible that the pen manure had pre-disposed the seedlings to fungal attack, for in the other two treatments where pen manure was not used, there were no damping-off losses. The plants were planted in the field on January 10th.

The third main treatment was essentially a modification of the one just described. It was thought that even if the pot method was found to be superior to the peasant method, the cost of pots and so on would generally be too great for the adoption of the method by the peasant growers. But if it could be demonstrated that better crops could be obtained by improvements in the seedbed itself, then the extra cost would be small and the peasant would be in a position to adopt the new method.

A seedbed was prepared as before, except that a thin layer of bamboo soil, and not pen manure, was applied to the surface. Shallow drills were drawn out in the bamboo soil, 3" apart and at right angles to the length of the bed. Seed was sown thinly in these rows, and then lightly covered over. After 5 days the seedlings had emerged, and after a few more days they were thinned in the rows to 3" apart. Thus each plant had approximately the same amount of room as if it were in a 3" pot. The seedlings grew slowly at first, due to heavy rains, but later grew quickly and formed sturdy plants with a good root system. On January 10th. they were put out in the field.

(b) After transplanting.

There was a marked difference in the rate of growth of the plants in the three treatments; those in the pots grew fastest, next came the thinned plants on the open bed and lastly those raised by the common peasant method. By January 6th. the pot plants were at the correct stage for planting in the field - i.e. about 6 - 8" tall, with a well developed root system. The plants from the other two treatments were by no means ready. It was therefore decided to plant out the pot plants first in the randomized blocks.

On January 5th. two cambered beds measuring 270' x 24' on the College Market Garden area were cutlassed of weeds and the growth removed. At the time the ground was extremely water-saturated after heavy rains, so that any cultivation of the ground was not possible. It was therefore decided to plant out the tomatoes direct into the beds. In temperate countries it is considered essential for tomato cultivators to carefully prepare the soil by ploughing and cultivating so as to produce a good tilth before setting out the plants. Quite often large amounts of organic manures are ploughed in before planting. These methods however do not necessarily apply to tropical conditions. Indeed, it is considered that thorough cultivation of the soil here is undesirable, because the frequent heavy rains soon "pan down" the surface of the soil, destroy its structure and cause erosion. By leaving the vegetative cover, the harmful effects of beating rain on the soil are minimised. Moreover, the vegetative cover behaves as an "upward drain" system, whereby excess soil water is removed.

Although pen manure is often used by peasant growers for the tomato crop in Trinidad, it was decided not to use it for the purposes of this experiment. Experience in past years has indicated that the use of pen manure predisposes the crop to disease. As several trials have yielded indecisive results in past years due to the incidence of disease, measures which would minimise the danger of disease were considered worth while adopting.

On the 6th. January the pot raised plants were set out. Apart from cutlassing and removing the weeds the only other preparation was the digging of the holes for the plants. The ground was still very wet, and in some of the holes there was standing water. To those plots due to receive starter solution, half pint was applied to each plant after transplanting of a solution composed of 2 parts Ammonium phosphate and 1 part potassium nitrate = 12% N, 32% P_2O_5 and 15% K_2O. 5 lb in 100 gallons. At the time the soil was still saturated, so that any beneficial effect of the starter solution could not have been due to an increased water supply. Had the soil not been water-saturated, the plants not receiving starter solution would have been given an equivalent volume of water per plant. As a precaution against insect and other soil pests, the holes were sprayed with Dieldrex before planting. There was very little wilting of these plants.

On January 10th. the plants from the improved seedbed were considered to be at the correct stage for planting out. They were about 8" high, and looked quite sturdy. As they were lifted from the bed care was taken to preserve a ball of roots around each plant. The plants were put out into prepared holes, sprayed with Dieldrex. The 1 B W plots were given starter solution as before. Although the ground was very wet, there was severe wilting and the tips of many of the leaves withered and died.

The seedlings from the peasant type seedbed were very drawn and spindly and were yellowish, and compared with the other types of seedlings looked very unpromising planting material. They were planted out on the same day as the improved seedbed type, and the B W plots were treated with starter solution as before. These seedlings lifted from the seedbed with practically no roots or soil adhering to them. This is the normal type of transplanting material used by the peasant growers. Wilting was not as severe as with the 1 B seedlings however.

The above photograph illustrates the three types of plants as they appeared at transplanting time. The two on the extreme left are from the peasant seedbed; the central one from the improved seedbed, while the plant on the right has been raised by the seed box and pot method. All plants are the same age.

In all cases Dieldrex was sprayed in the planting holes, as a precaution against molecrickets and other pests.

All the plants were put out on the flat, and were later moulded up. This was found by Smith 1953 to be the best way of growing tomatoes under Trinidad dry season conditions.

(c) Supplying.

In each case, supplying was carried out until 10 days after transplanting into the field. Thus the final supplying was on the 20th. January.

(d) Irrigation.

The area was first irrigated by the overhead sprinkler system on January 27th. Because of wet weather it was not needed again until March 5th.

(e) Fertilizing.

Patterson in his suggestions for experiments on tomatoes in the West Indies advised that where farm yard manure is not used, 500 lbs per acre of a mixture of nitrate of soda, superphosphate and potassium chloride in the ratio 1: 2: 1 should be applied at the time of ridging up and a further 600 lbs per acre as a side-dressing later. Many experiments on the manurial requirements of the tomato have in general failed to produce any definite information - thus a manurial trial by Cockburn in 1954 at I.C.T.A. threw little or no light on the subject. Results of similar experiments in other parts of the world have been conflicting - it appears that the manurial requirements of the tomato are very closely bound up with the soil type. The soil for this experiment was poor, having lost its original top bamboo soil during levelling operations. The remaining soil is a silty loam, which pans down after heavy rain.

Patterson's suggestions were largely followed, except that ammonium sulphate was used instead of sodium nitrate.

Hester and Hall (1942) in the U.S. showed that there was no great difference in fruit quality whether ammonium sulphate or sodium nitrate is used. On January 18th. the first application of fertilizer was followed by the first ridging up. Patterson's mixture was used, and 6¼ lb. was applied per plot - 600 lbs. per acre. For the second application on 21st. February the potassium was stepped up and the nitrogen decreased. The mixture used was:

75 lb. triple superphosphate
65 lb. ammonium sulphate
85 lb. potassium sulphate.

This mixture was again applied along the ridge at the rate of 6¼ lb. per plot at the final ridging up. The ridging up was done with a long handled hoe in the usual peasant manner. During the first moulding up, some fertilizer was drawn onto the lower leaves of some of the plants, and some of the smaller plants were killed.

This method of fertilizing tomatoes, i.e. after transplanting, has some experimental backing. Thus Hester (1937) in the U.S. showed by chemical analysis of tomato plants at monthly intervals that a large proportion of the nutrients were absorbed by the plant between the second and third month after transplanting in the field. This indicates that sidedressing with N,P and K after transplanting is a sound practice.

(f) Staking and pruning.

The normal practice in temperate regions when growing an indeterminate variety of tomato such as the one used for this trial is to prune each plant. By this is meant the removal of side shoots so that the plant is kept to one or two main stems which have to be tied to a stake. Experimental evidence favours this practise in such regions, but the practise is of doubtful application in the tropics. Styrdom, 1955, at the Horticultural Research Station in Pretoria, found that pruning definitely reduced yields. In Puerto Rico in 1943,

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Riollano found that pruning and staking tomato plants reduced yields considerably. Thompson (1943) presented similar evidence from New York State, and Strickland in Australia.

Because of this, and also because of a disease control measure (discussed later) it was decided not to prune the plants in this experiment, but in order to facilitate harvesting the plots, the plants were staked. Bamboo canes were used, about 6' long. The plants were tied at fortnightly intervals.

(g) Disease and pest control.

The tomato is prone to a large number of diseases and a few insect pests. It has already been mentioned that trials in the past have often yielded little reliable information because of disease. Not only can losses occur through infection by bacteria, fungi and viruses, but also through physiological and nutritional disorders. The symptoms thus formed can be classified into wilts, leaf spots, fruit spots or rots, and abnormalities of the growth of the foliage or fruit. Of the wilts Fusarium oxysporum is especially serious here as it is most active at temperatures of 80 - 90°F, and the fungus can persist in the soil for many years.

Of the leaf spots, the following are encountered: Cladosporium fulvum, Septoria lycopersicae, Alternaria solani and Stemphyllium solani. A number of fruit rots caused by bacteria and fungi cause no other significant injuries to the plant, e.g. Anthracnose - Colletotrichum phomoides

Of the virus diseases, the tobacco mozaic is perhaps the most serious and most common virus attacking the tomato. The non-parasitic disorders include surface injuries (e.g. birds were found to attack ripe fruits) malformations, blossom end rots etc. The latter is said to be more common on plants which are staked and pruned, possibly because pruning restricts the root system. (S.P. Doolittle, U.S.D.A.

Year book :"Plant Diseases", (1953 pg459)

Control and preventative measures are therefore essential if the crop is to be grown successfully. In this experiment the following disease and insect control measures were taken:-

1. the exculsion of pen manure.
2. the avoidance of pruning. It was considered that pruning would rapidly transmit the virus from plant to plant.
3. Weekly spraying of the crop with a neutral copper spray (Perenox) (which is 50% cuprous oxide plus a filler) was used. Bordeaux mixture cannot safely be used on young tomato seedlings, and there is some evidence that it delays fruiting (Henderson 1944 and Horsfall, 1953).
4. The removal of the lower leaves as soon as they became infected (Butler and Jones 1949). However, when later Cladosporium fulvum became very prevalent, this was not possible.

(h) Harvesting.

Harvesting was commenced on 28th. February, when some fruits, especially on the PW and PO plots were becoming red. The aim was to pick just as the fruits were turning colour. Whole plots were harvested one at a time. There were two pickings per week, on Tuesdays and Thursdays, to coincide with College vegetable shop opening days. Harvesting was continued until April 5th.

TABLE 1.

PERCENTAGE OF REPLACEMENTS FOR TRANSPLANTED PLANTS

TREATMENT		% REPLACEMENTS	TOTAL %
Pot raised (P)	With starter solution	6.3	8.3
	Without starter solution.	10.2	
Improved seedbed (1B)	With starter solution	13.1	12.5
	Without starter solution.	11.9	
"Peasant" seedbed (B)	With starter solution	10.5	16.5
	Without starter solution.	22.4	

Of total plants receiving starter solution, 9.8% were supplied
" " " not receiving " " 14.9% were

From these figures it would appear that transplanting success bears a direct relationship to the quality of the transplanting material. This is to be expected, and bears out work by Smith (1954), who compared pot raised plants with those raised in a seedbed. The chief factor governing transplanting success is the root system of the plant. The pot raised plants (P) were furnished with the best root system. Moreover, for these plants, there was very little damage done to the roots during the actual process of transplanting. The improved seedbed type plants (1B) also had a good root system, which differed from that of the pot raised plants in being more spreading. Inevitably, however, there was considerable damage to these roots in lifting the plants from the seedbed and in transporting them to the field, despite the fact that great care was taken. The plants raised in the peasant type seedbed (B) were transplanted with very little root at all. It is not surprising that these plants required more supplying than the others; what is surpising is that plants with so few roots transplanted so well (16.5% of supplies is not an unduly high figure).

It is important to realize that the three types of plants were of different sizes when transplanted (as illustrated in the photograph on page 11). There is probably an optimum plant size for transplanting success, and while the pot raised plants possibly exceeded this optimum size, it is likely that the peasant seedbed (B) plants were below it.

It must be remembered that the pot raised plants were put out in the field a few days before the other two types. The field conditions were most unfavourable for the pot raised plants, the soil being water saturated at the time they were transplanted. When the two types of seedbed raised plants were transplanted, the soil had dried out somewhat. Wilting was most severe on the peasant seedbed plants (B).

The starter solution would appear to have helped transplanting success in the case of the pot and the peasant seedbed raised plants, but not in the case of the improved seedbed plants. The beneficial effect of the starter solution is most pronounced on the peasant seedbed plants. These plants, having received the most unfavourable treatment, would be expected to benefit most from a nutrient solution at the critical transplanting stage.

TABLE 2.

EARLINESS OF FLOWERING.

TREATMENT		Number of plants flowering on January 27th.	%
Pot raised (P)	With starter solution	337	95.7
	Without starter solution	307	87.9
Improved seedbed (1B)	With starter solution	241	68.5
	Without starter solution	104	29.5
Peasant seedbed (B)	With starter solution	40	11.0
	Without starter solution	10	2.8

The above figures are of limited value because measurements were only made on one arbitrarily chosen date. Nevertheless, the earlier flowering of the pot and improved seedbed raised plants is clearly illustrated. These plants very quickly started growing after transplanting, whereas the peasant seedbed plants "stood still" for several weeks before any growth was apparent at all. Obviously, before active aerial growth could commence, an adequate root system had to be built up.

There is a strong indication that the use of a nutrient solution at planting time enhances the rate of growth and hence the earliness of flowering of all types of plant.

YIELD TABLE (Yields expressed in pounds to nearest ¼ lb.)

	P		B		1B		
Blocks	O	W	O	W	O	W	TOTALS
I	222.25	253.75	130.75	228.25	249.50	232.00	1316.50
II	190.50	281.00	75.50	76.25	238.50	142.50	1004.25
III	203.00	237.25	53.00	126.75	111.50	113.50	845.00
IV	164.00	193.50	136.25	141.75	119.25	221.75	976.50
totals	779.75	965.50	395.50	573.00	718.75	709.75	
	1745.25		968.50		1428.50		4142.25

<u>Legend</u> P= pot raised plants

B= peasant seed bed raised plants

1B= improved seedbed raised plants

W= receiving Starter solution

O= not receiving Starter Solution.

<u>TWO-WAY TABLE</u>

	P	B	1B	TOTALS
O	779.75	395.50	718.75	1894.00
W	965.50	573.00	709.75	2248.25
TOTALS	1745.25	968.50	1428.50	4142.25

ANALYSIS OF VARIANCE TABLE (in pounds)

Sources of Variation	D.F		S.S	M.S.	"F"
Blocks		3	19951.46	6650.48	
Treatments		5	46397.58	9279.51	
)Methods	2		38136.29	19068.14	4.07*
)Starter Solution	1		5230.91	5230.91	
)Methods x Starter sol.	2		3032.32	1516.16	
Error		15	70194.81	4679.65	
Total		23	96154.23		

Thus the F-ratio for the main treatments (the three methods of raising the plants) is significant at the 5% level with 2 and 15 d.f. The F-ratio for Starter Solution/no Starter Solution is not significant at the 5% level, neither is the interaction.

"T" test on methods.

From tables, the value of 't' at the 5% level for 15 d.f. is 2.131. Therefore differences greater than 357.2 are significant.

Hence, from above , both the pot raised plants and the improved seedbed raised plants yielded significantly greater than the peasant seedbed raised plants at the 5% level, but there was no significant difference between the pot raised and the improved seedbed plants.

YIELD OF TOMATOES PER ACRE BY PICKINGS.

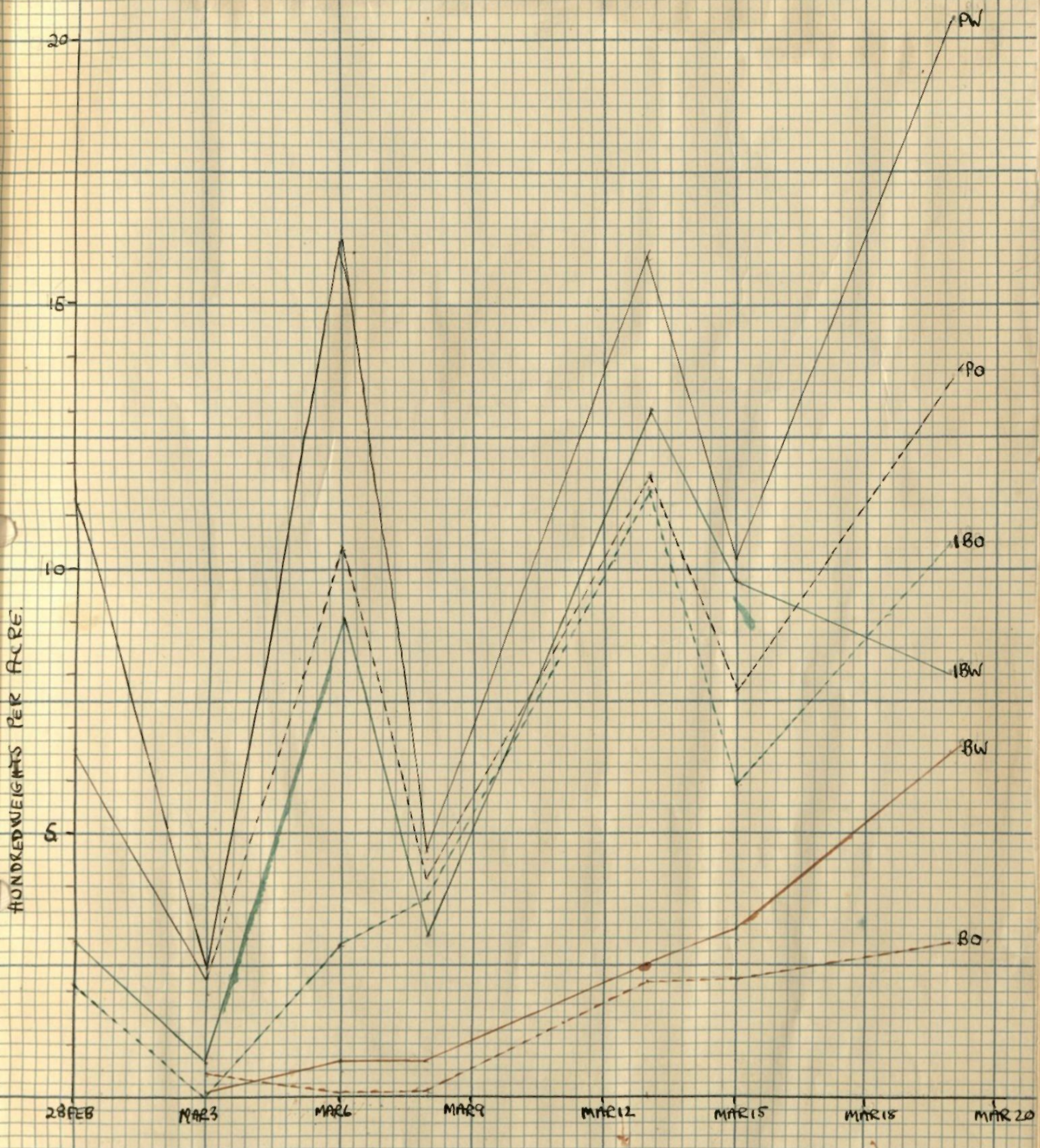

Fig.1 THE EFFECT OF TREATMENTS ON EARLINESS OF FRUITING.

DISCUSSION AND RECOMMENDATIONS

(a) Main Treatments.

The importance of the early treatment of the tomato plant before planting out in the field has been proved. Both the plants raised in pots and those raised in an open but improved seedbed yielded significantly better than the plants raised by the normal peasant method in Trinidad.

Although the higher yield of the pot raised over improved seedbed raised plants was not statistically significant, the earliness of fruiting of the pot raised plants is a factor of considerable commercial importance. For this reason alone, there is a case for the production of pot raised tomato plants where the facilities are available. The apparent higher transplanting success of the pot raised plants is a factor of some importance, especially where tomatoes are grown on a large scale.

The "improvements" in the improved seedbed over the normal peasant seedbed were very simple, and consisted essentially in the sowing of the seed in drills and later thinning out the seedlings to allow them room to develop. The disadvantages of these improvements from the peasant point of view is that more time, labour and space is required for the seedbed than he normally gives. However, it would seem that by the adoption of certain modifications in the seedbed, the Trinidad peasant grower could increase his tomato yields. To give full expression to the better quality plants, the crop has to be carefully protected from fungal diseases (in this case by weekly 'Perenox' spraying). To produce good tomato plants and not to spray them regularly would be largely a waste of time. The writer believes that if the beneficial effect of improved plant raising methods coupled with a regular spraying programme could be demonstrated to the peasant grower, he would readily adopt them. Further work on the production of plants from open seedbeds might concern the adoption of other improvements, such as the use of sterilized soil, for example by using methylbromide. The effects of protecting the seedbed from heavy rain and the use of some shade might be examined.

(b) Starter Solution.

Although the starter solution used did not have a significant effect on final yield, the beneficial effect on earliness of fruiting and transplanting success would probably justify the adoption of the practice more widely. Certainly the effect of starter solutions in Trinidad would repay further investigation. In this experiment the effects of the starter solution were probably minimised by the heavy rains which fell at the time of transplanting.

(c) Cultural

The yield of tomatoes from this experiment was high for Trinidad conditions, despite the fact that the cultural practices adopted were in some respects unorthodox. Thus, there was no preparation of the soil before transplanting (because the water saturated conditions of the soil precluded any cultivations). It is normally considered essential to thoroughly cultivate the soil for tomatoes. No organic manure was used on the crop, whereas in normal practice organic manure is invariably used. It would appear that the merits of thorough soil cultivation and the use of organic manure for tomato growing in the tropics would warrant investigation.

Work in various countries has shown the detrimental effect of pruning indeterminate tomato varieties in the tropics. In this experiment the plants were not pruned. Apart from the obvious saving in labour, the risks of transmitting virus diseases from plant to plant are minimised. Certainly in this experiment the incidence of virus diseases was very low.

Riollano (1943) found in Puerto Rico that staking consistently and significantly reduced yields. In the present experiment, however, with a spacing of 3' x 2', harvesting would have been extremely difficult if the plants had not been staked.

Although there is little information on the fertilizer requirements of tomatoes in Trinidad, the amount used in this experiment would seem to have been approximately correct. There were no obvious deficiencies shown by the crop, and the yield was high.

The measures taken to prevent and control diseases were largely successful, although towards the end of the experiment it proved impossible to control Cladosporium fulvum on the lower leaves.

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APPENDIX I

SOIL ANALYSIS OF EXPERIMENTAL BEDS ON THE COLLEGE MARKET GARDEN.

	Fine Sand	I.T.	pH	O.M.%	Total N%	C/N	Avail K_2O p.p.m	Avail P_2O_5 p.p.m.
Top 6"	48	25	5.7	2.0	0.13	9.0	41	40
Next 6"		24		1.6	0.11	8.6	47	36

****

NUTRITIVE VALUE OF TOMATO

% Composition of 100 Grams uncooked edible portion

(from the Malayan Food Composition Table)

Edible Portion	100	Calcium	11mg/100G
Water	94.1	Phosphorus	27mg/100G
Protein	1.0	Iron	0.6mg/100G
Fat	0.3		
Total Carbohydrate	4.0	Vit. A 1.U/100G	1,100.0
Calories	21.0	Thiamin mg/100G	0.06
		Riboflavin mg/100G	0.04
		Miacin mg/100G	0.60
		Ascorbic Acid mg/100G	23.0

APPENDIX II

LAY-OUT OF TOMATO EXPERIMENT SHOWING YIELDS 1955 - 1956

	BED A			BED B		
	PO 190.5 lb	BW 76.25 lb		1BW 113.50 lb.	1BO 111.5 lb	
II	1BW 150.5 lb	BO 75.5 lb		PO 203.00 lb	BO 53.0 lb	III
	1BO 238.5 lb	PW 281.00 lb	OPEN DRAIN	PW 237.25 lb	BW 126.75 lb.	
	1BW 232.0 lb	PO 238.25 lb		1BW 221.75 lb	BO 136.25 lb	
I	1BO 249.05 lb	PW 235.75 lb		BW 123.75 lb	PW 184.50 lb	IV
	BW 92.25 lb	BO 139.5 lb		1BO 119.25 lb	PO 164.00 lb	

TRACE — To Shed →

BAMBOO THICKET

→ N.

APPENDIX III
PHOTOGRAPHS

1. Illustrating Staking of Plants

2. The method of irrigation. Note portable nature of equipment.

3. The First Fruit. Note type of trays used to harvest the crop. The cracking of some fruit due to swelling after heavy rain.

ACKNOWLEDGEMENTS

The writer wishes to thank Mr. J. S. Campbell for his advice, criticism and encouragement at all stages of the experiment.

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A SPACING TRIAL ON THE EGGPLANT

(<u>Solanum melongena</u>)

R.E. TREMEER, B.Sc.(Hort.)

1956

D.T.A. ~~Thesis~~ Report

In part fulfilment for the Diploma of Tropical Agriculture of the Imperial College of Tropical Agriculture, Trinidad, B.W.I.

C O N T E N T S

SUMMARY

Results from a spacing trial on the eggplant are thought to be of only limited application because an attack of flea beetles severely defoliated the crop before a full expression of yield had been obtained for the various spacings.

However, certain trends are observable. With increasing spacing there is a trend of increase in yield per plant, while yield per unit area decreases significantly. There would appear, therefore, to be a case for adopting a closer spacing for eggplants than is normally given. Thus, for example, 2 feet by 2 feet might be considered a suitable spacing for eggplants under local conditions.

From the early growth of the seedlings in the seedboxes the importance of sufficient drainage in the bottom of the boxes was illustrated.

INTRODUCTION

The eggplant, (Solanum melongena), is one of the commonest of vegetables grown in tropical countries. A variety of names is ascribed to it, depending on the country in which it is grown. In England the vegetable is usually called the eggplant or aubergine, in the United States it is the Guinea Squash, in the East the Bringal, while in Trinidad the name usually given is the melongene.

The crop is an old-established one, having been grown in the East since early times. Thus it is mentioned in Chinese writings of 1500 years ago. Shoemaker (1949) considers that it is probably a native of India, where it is closely related to the common Solanum insanum. He suggests that there might have been two centres of origin, however, in tropical or sub-tropical India and in China.

The immature fruits, which are eaten as a vegetable, are borne on bushy plants, 2 feet to 4 feet high. The fruits show considerable varietal differences in both shape and colour. In Trinidad the only types grown have oblong fruits of a dark purple to black colour. Although most peasant growers cultivate the crop, it is not grown on a very large scale commercially in Trinidad. Nevertheless it is an important and esteemed vegetable, especially among the East Indian population. It is one of the few vegetables which can be grown successfully in Trinidad during the wet season. Moreover, it is a comparatively easy crop to grow.

It is perhaps because the cultivation of the eggplant presents so few difficulties that little experimental work has been done on it. In Trinidad, cultural methods vary widely concerning the eggplant; in particular there seems to be much variation in the spacings given. Work in temperate countries has shown that the spacing of vegetables

/is important if

is important if optimum yields are to be obtained. However, very little work on the spacing of vegetables has been done in the Tropics. It was decided, therefore, to lay out an experiment at the Imperial College of Tropical Agriculture Market Garden with a view to obtaining some information on the effect of different plant densities on the growth of the eggplant.

REVIEW OF LITERATURE

On the general subject of vegetable spacing, Knott (1949) states that:

> "The space allotted to each plant in the ground varies with the crop, the method of cultivation and the fertility of the soil. Crops of spreading growth need more room than those more upright in their development..... Maturity is delayed when plants are crowded."

It is very difficult, therefore, to lay down precise spacings for any one crop, and it is not surprising that spacings recommended by different authorities are often at variance with one another. Obviously, it is valueless to recommend a spacing for any crop unless the variety and the conditions under which the crop is grown are given at the same time.

For the eggplant, with its wide variation in growth habit (depending on the variety), it is especially difficult to stipulate plant spacings. Milsum and Grist (1941) recommend for Malayan conditions a spacing of rows 3 feet to 4 feet apart with plants 2 feet to 3 feet apart in the rows, depending on the variety. Ochse (1931) suggests rows 2 feet to 3 feet apart and plants 2 feet apart for the Dutch East Indies. Saunders (1940) recommends a close spacing of 18 inches by 18 inches. Shoemaker (1947) gives a spacing of 15 inches to 18 inches in the rows, with rows 3 feet to 4 feet apart. In the Agricultural Society Journal of Trinidad and Tobago (September 1954), a spacing of 3 feet by 5 feet is given. Guadeignin (1944) described a spacing for eggplants adopted in Brazil, where the plants are put out in double rows. The two rows forming a double row are 50 cm. apart, with plants in the rows 50 cm. apart, while each double row is separated from the next by 80 cm.

EXPERIMENTAL

(1) TREATMENTS AND LAYOUT

For the present experiment it was decided to investigate a wide range of spacings, from 18 inches by 18 inches at one extreme to 4 feet by 4 feet on the other.

The treatments, which consisted of six different plant spacings, were:-

(i) 4' x 4'
(ii) 3½' x 3½'
(iii) 3' x 3'
(iv) 2½' x 2½'
(v) 2' x 2'
(vi) 1½' x 1½'

These were randomized and there were four blocks or replications. The plots were arranged so that there were an equal number of plants per plot. This number was forty-nine, which includes the outer twenty-four plants of the square which were guard rows. The inside twenty-five plants formed the actual harvested plot.

(2) FIELD OPERATIONS

(a) Prior to Transplanting

The seed, of a locally-selected variety, was sown on 7th October 1955 in wooden trays measuring 2'6" x 1'6" x 3". The compost used was composed of:-

2 parts bamboo soil
1 part well-rotted pen manure
1 part well-rotted coconut fibre

Dead Savanna grass was placed over the drainage slits in the bottom of the trays, which were then filled to within half-an-inch of the top with compost. The seed was thinly broadcast on the top, and was lightly covered with a sprinkling of dry soil. After watering, the trays were placed on staging under 50% light. Within four days the seed had germinated, and on 17th October they were pricked out 2 inches apart each way into boxes of the same size, using the same compost as before. Each box held sixty-six plants. By the 26th October there was some caterpillar damage apparent; a lead arsenate spray was applied to counteract this. By the 3rd November there was a noticeable variation in the rate of growth from box to box. This variation became more and more pronounced, so that by the 14th November the plants in some boxes were about three times the size of others. Within boxes, however, growth was fairly even.

In an endeavour to find the reason for this variation from box to box, each box was carefully examined. They were found not to be identical, but to differ widely in the size, number and arrangement of slats forming the bottom of each box. By measuring the amount of free drainage area in each box, it was established beyond reasonable doubt that the size variation was due to impeded drainage in some boxes. The largest seedlings came from boxes which had about 20%

/open area of

open area of drainage slits, whilst the smallest came from boxes with only 10% open area. This is a matter of practical importance, and it would appear that some of the boxes now used for seedling raising should be modified to provide freer drainage.

Picture illustrating variation in seed boxes used. The one on the left allows insufficient drainage while the one on the right allows adequate drainage.

By 22nd November the plants were considered to be ready for planting out in the field.

(b) After Transplanting

On 21st November two beds at the College Market Garden were cultivated with a Howard Rotary Cultivator. In drying conditions, after two days without rain, a good tilth was fairly easily obtained. On the same day the randomised blocks were measured out and the holes dug. A solution of "Aldrex" was sprayed into each hole as a precaution against mole crickets. On the 22nd and 23rd November the transplanting was completed. The plants were watered in because of the dry conditions. There were some losses, due mainly to mole cricket damage, and some due to severe wilting. Plants were

/supplied, as necessary,

supplied, as necessary, until 21st December. A period of very heavy rain followed the transplanting; this favoured weed growth, which was profuse, but the eggplants showed no signs of growing at all. On 9th December the plants were weeded and banked up, and at the same time a fertilizer mixture composed of:-

125 lb. ammonium sulphate
300 lb. superphosphate
75 lb. potassium chloride

was applied at the rate of 1 ounce per plant.

By the 31st December both beds were again profusely covered with weeds. After one bed was weeded, a period of very wet weather prevented the other from being weeded until 7th January. This was unfortunate, for the plants in this second bed suffered badly from the competition with the weeds. They were visibly smaller and more yellow than those in the bed hoed a week earlier. This experience indicates the importance of keeping weeds under control before they compete too severely with the growing crop.

On 10th January insect damage was noticed on the leaves, caused by a flea beetle, Epitrix fuscula. B.H.C. dust was applied; this at first controlled the pest, but later applications failed to do so. D.D.T. dust was also found to be ineffective as a control measure. On 17th February the infestation was so bad that it was decided to spray the plants with malathion at the rate of 6 ounces to 2½ gallons of water. This afforded a measure of control initially, but despite regular spraying the flea beetle infestation later became serious.

The hoeing-up and fertilizing was given on 26th January. The fertilizer mixture was the same as before and was applied at the same rate.

/The fruits were

The fruits were harvested when of a good colour, that is, nearly black, but when still soft to the touch. The first harvesting was on 27th January and afterwards twice weekly until 27th March. From the twenty-five plants comprising each plot, each individual fruit was weighed.

Overhead irrigation was first applied on 28th January and thereafter whenever necessary. The method was to irrigate thoroughly for three hours at each application.

RESULTS

TABLE I MEAN YIELDS PER PLANT (OZ.)

	BLOCKS					
Treat-ments	I	II	III	IV	Means	Totals
1½'	23.36	15.88	20.52	14.56	18.58	74.32
2 '	31.96	38.44	20.36	21.40	28.08	112.16
2½'	47.12	26.00	18.60	14.04	26.44	105.76
3 '	21.44	50.84	16.24	31.84	30.09	120.36
3½'	63.52	18.56	36.20	20.12	34.60	138.40
4 '	50.64	21.92	32.28	27.88	33.18	132.72
Totals	238.04	171.64	144.20	129.84	G.T.	683.72
					G.M.	28.5

ANALYSIS OF VARIANCE

VARIATION DUE TO	D.F.	S.S.	M.S.	V.R.
Blocks	3	1151	383	2.7
Treatments	5	758	152	1.1
Error	15	2135	142	
Total	23	4044		
Treatments				
(Linear regression	1	530		3.73
(Remainder	4	228		

Estimated s.d. = $\sqrt{142}$ = 11.9

As a percentage of general mean = $\frac{11.9}{28.5}$ = 42%

S.E. oz. per plot = 4.9

The linear regression value is only just below the significant value at 5%. There is, therefore, a strong indication that the trend of yield per plant against spacing is linear.

TABLE II YIELD PER SQ.FT. (IN OZ.)

	BLOCKS				
Treatments	I	II	III	IV	Totals
$1\frac{1}{2}$'	10.40	7.06	9.12	6.47	33.05
2 '	7.99	9.61	5.09	5.33	28.02
$2\frac{1}{2}$'	7.54	4.16	2.97	2.25	16.92
3 '	5.56	2.38	1.80	3.54	13.28
$3\frac{1}{2}$'	5.19	1.52	2.96	1.64	11.31
4 '	3.14	1.37	2.02	1.74	8.27
Totals	39.82	26.10	23.96	20.97	110.85
					G.M. 4.62

ANALYSIS OF VARIANCE

VARIATION DUE TO	D.F.	S.S.	M.S.	V.R.
Blocks	3	37	12.3	36
Treatments	5	137	27.4	71
Error	15	5	.33	
Total	23	179		

Thus treatments are significant on the yield per unit area basis. The yields indicate a trend of increasing yield per unit area with decreasing plant spacing.

TABLE III COMBINED RESULTS

Treatments	Total Yield (oz.)	Total Yield cwt.per acre	Total Yield oz.per sq.ft.	Number of Fruits	Average weight per fruit (oz.)	Yield per plant (oz.)
$1\frac{1}{2}$'	1858	201.2	33.1	178	10.4	18.6
2 '	2808	170.4	28.0	262	10.7	28.1
$2\frac{1}{2}$'	2644	101.9	16.9	241	10.7	26.4
3 '	3009	81.3	13.3	271	11.2	30.1
$3\frac{1}{2}$'	3460	68.7	11.3	307	11.1	34.6
4 '	3318	53.5	8.3	274	12.1	33.2

TABLE IV PLAN OF LAYOUT SHOWING YIELDS

N.B. Diagrammatic plan only. Plot size varied according to the treatment.

BED A	BED B
BLOCK II	**BLOCK III**
2½' x 2½' 650 oz. 66 fruits	1½' x 1½' 513 oz. 48 fruits
3' x 3' 536 oz. 53 fruits	2' x 2' 509 oz. 55 fruits
3½' x 3½' 464 oz. 40 fruits	3' x 3' 406 oz. 36 fruits
4' x 4' 548 oz. 50 fruits	3½' x 3½' 905 oz. 83 fruits
1½' x 1½' 397 oz. 40 fruits	4' x 4' 807 oz. 68 fruits
2' x 2' 799 oz. 74 fruits	2½' x 2½' 465 oz. 43 fruits
BLOCK I	**BLOCK IV**
1½' x 1½' 584 oz. 56 fruits	1½' x 1½' 364 oz. 34 fruits
3' x 3' 1271 oz. 120 fruits	4' x 4' 697 oz. 53 fruits
4' x 4' 1266 oz. 103 fruits	2½' x 2½' 351 oz. 34 fruits
2' x 2' 961 oz. 87 fruits	3½' x 3½' 503 oz. 50 fruits
2½' x 2½' 1178 oz. 98 fruits	2' x 2' 533 oz. 46 fruits
3½' x 3½' 1588 oz. 134 fruits	3' x 3' 796 oz. 62 fruits

Fig. EFFECT OF SPACING ON TREATMENT YIELDS

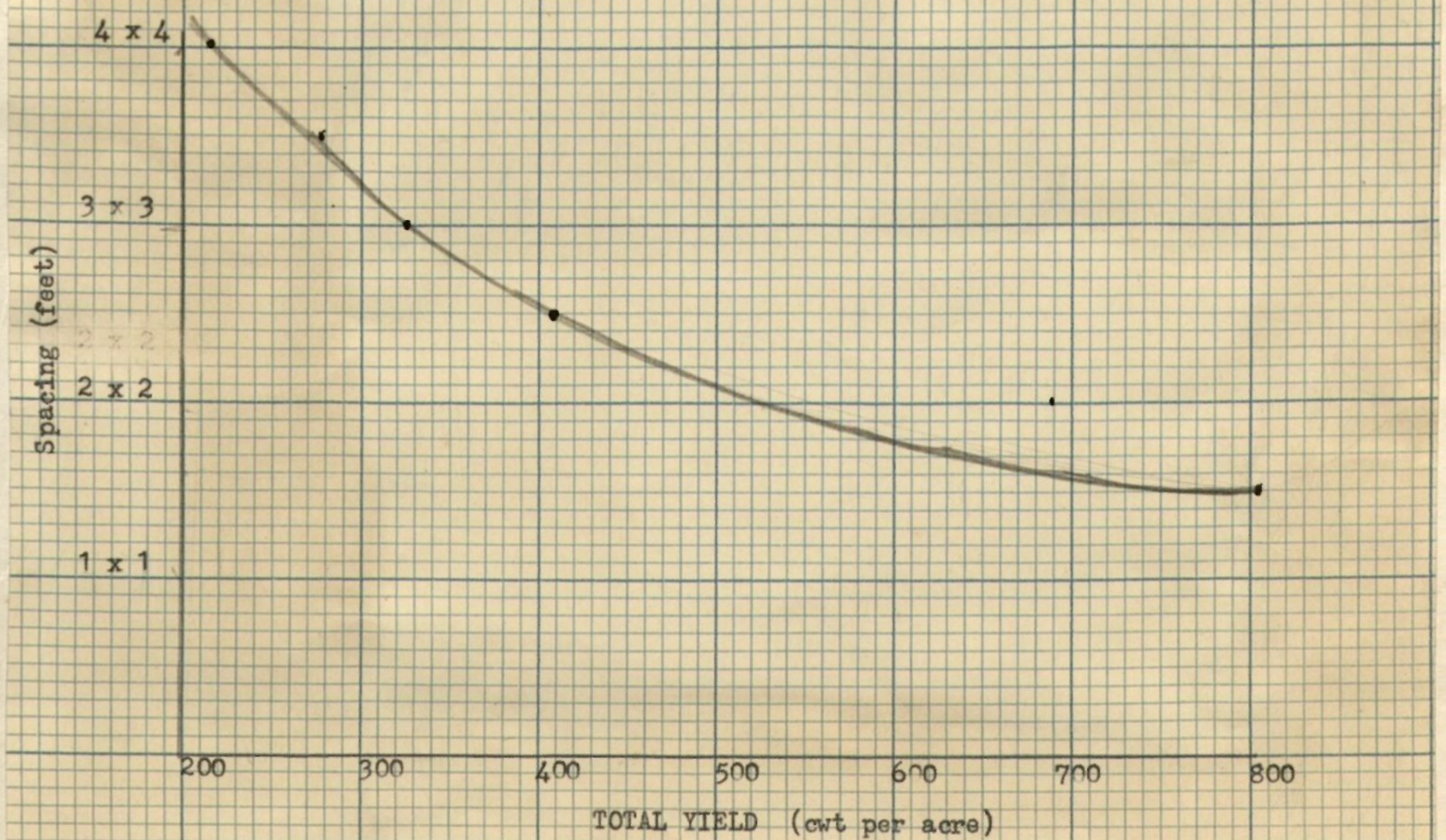
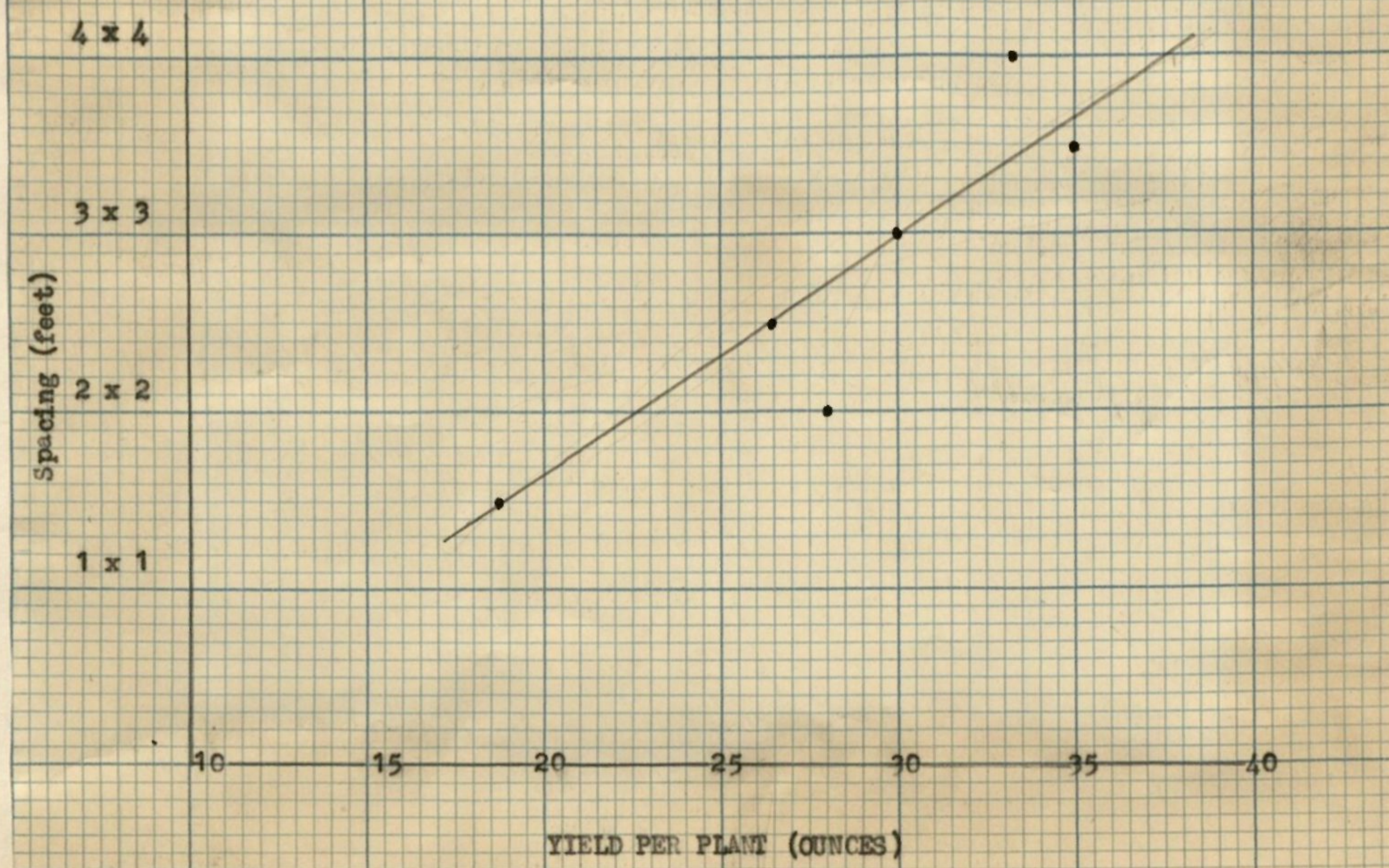


Fig. EFFECT OF SPACING ON YIELD PER PLANT



(2) DISCUSSION

Because the plants in this experiment were heavily infested with flea beetles, the yields were considerably depressed. Normally the plants would have gone on bearing fruit much longer. It is thought, therefore, that the results from this experiment are of only limited application. Nevertheless, definite trends can be observed.

The effect of the treatments on the yield per unit area was found to be significant. The lowest yield per acre was for the 4 feet by 4 feet spacing, while the highest yield per acre was for the 1½ feet by 1½ feet spacing. Planting at the closer spacing involves more plants per acre, but eggplants are easy to produce and this is, therefore, no great disadvantage. It would seem, therefore, that at least for conditions similar to those at the College Market Garden, a closer spacing than is normally used could be adopted (say 2 feet by 2 feet). However, it is possible that at the closer spacing the eggplant would not go on fruiting for as long as those given more space. On this point the present experiment yields no information.

There is a strong indication that the yield per plant increases in a linear relationship with increased spacing, although due to the high errors this was not proved significant statistically.

From Table III it would appear that the number of fruits per plant goes up with increasing spacing, as does also the size of fruit. However, as the consumer prefers fruits of average size, the small decrease in size of fruit at the closer spacing is not important commercially. On the other hand, yield per acre is very important from the producer's point of view.

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APPENDICES

(1) SOIL ANALYSIS OF EXPERIMENTAL BEDS ON THE COLLEGE MARKET GARDEN

	Fine Sand	I.T.	p^H	O.M.%	Total N%	C/N	Avail. K_2O p.p.m.	Avail. P_2O_5 p.p.m.
Top 6"	48	25	5.7	2.0	0.13	9.0	41	40
Next 6"		24		1.6	0.11	8.6	47	36

(2) FOOD VALUE OF THE EGGPLANT

From the Malayan Food Composition Table

Edible Portion	87%	Calcium	13	mg. per 100 G
Water	92.7%	Phosphorus	27	mg. per 100 G
Protein	1.1%	Iron	0.5	mg. per 100 G
Fat	0.2%			
Total Carbohydrate	5.5%	VIT.A.	I.U. per 100 G	120
Calories	27	THIAMIN	mg. per 100G	0.05
		NIACIN	mg. per 100G	0.8
		ASCORBIC ACID	mg. per 100G	5
		RIBOFLAVIN	mg. per 100G	0.03

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