An investigation into the relative effects of different manures and different cultural treatments on the production of tomatoes.

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Observations on the general growth of plants on the different treatments throughout the season.

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Introduction.

Little or no experimental work has been carried out on the production of tomatoes in the tropics. This investigation has been carried out to compare the relative fundamental importance of the different manural constituents - nitrogen, phosphate and potash - on the general growth and vigour of the tomato plant and their ultimate effect on the yield and quality of the fruit produced.

The importance of different cultural treatments has also been studied, as were the costs of production on each treatment, recorded in view of the possibility of Trinidad participating in the recently developed trade in this commodity between West Indian Islands and Canada.
The scope of the manurial section of this experiment is confined to an investigation of the fundamental effects of the different manurial constituents on the yield, size and general quality of the fruit. No attempt has been made to investigate the most profitable rates of manuring, that will have to be done in a separate experiment at some future date. Hence it must be understood that the manurial dressings used in this experiment are more or less arbitrary and may not be at all suited to the conditions.

The fact that no significant differences were obtained between manurial treatments in last year's trial was attributed by the experimenter to too high a basal dressing of farm yard manure - 12 tons per acre. Hence it was advised that dressing should be reduced to 2 tons per acre this year. In the author's opinion this was unsound as it is well known that wherever tomatoes are grown extensively they are heavily manured with organic material. By carrying out the experiment on a soil essentially low in organic matter the crop is being grown under abnormal conditions and the manures are not given a chance to show their full effect as other limiting factors such as soil texture and soil moisture relationships come into play which in themselves profoundly affect the crop and tend to inhibit normal growth. Rather than reduce the application of organic matter the artificial dressings should be increased and so make any manurial ingredients in the former relatively unimportant.

Last year the manures were applied singly thus getting the effect of that one manure in the absence or relative deficiency of the others. This year the problem is being tackled from another aspect. The manures have been applied in pairs so that in each case one manurial constituent is lacking thus any effect that is shown will be due to the absence or relative deficiency of the constituent not applied. In the former case a no manure treatment, but in the latter a complete manurial treatment was taken as the control. By using this "deficiency method" it is believed by the author that a more accurate and fair representation of the effect of any one manure will be
obtained by considering the differences in yield etc. of the treatment lacking that manure and from the complete manurnal treatment. For example the effect of Nitrogen will be obtained by comparing results from the Phosphate plus Potash plots and those from the Nitrogen plus Phosphate and Potash plots i.e. \( N = N \cdot P \cdot K - P \cdot K \). Similarly \( P = N \cdot P \cdot K - N \cdot K \) and \( K = N \cdot P \cdot K - N \cdot P \).

Cultural Treatments.

Modifications in the cultural treatments have been made as a result of experience gained last year. As before, staking and pruning to a single stem is being tried against not staking and not pruning, but the former are being planted closer this year as last year there was a significantly higher yield from not staking which might well be explained by the pruned plants not being able to make full use of the soil at the wide spacing. The planting distance adopted for both treatments last year appears, from a brief survey of available literature, to be about normal for unstaked plants hence it has been repeated for that treatment this year but the staked plants have been closed in to 2 feet by 3 feet instead of 3 feet by 3 feet. This spacing was decided upon quite arbitrarily but it is hoped that from the results of a spacing trial being run concurrently with this experiment that in future work the optimum spacing for staked plants will be used.

Specification of Plot treatments.

The plot treatments were as follows:

Manural plots - four manural treatments

- N P K - 14 cwts. per acre of a mixture of
  - 4 cwts. Sulphate of Ammonia.
  - 5 cwts. Sulphate of Potash.
  - 11 cwts. Superphosphate.

- N K - 6 \( \frac{1}{2} \) cwts. per acre of a mixture of
  - 4 cwts. Sulphate of Ammonia.
  - 11 cwts. Superphosphate.

- P K - 11 \( \frac{1}{2} \) cwts. per acre of a mixture of
  - 5 cwts. Sulphate of Potash.
  - 11 cwts. Superphosphate.
These dressings were given at planting. Each treatment was given a
top dressing, on January 22nd, of 1/3 of the original amount.
This ratio of manures is a slight modification of what seems to be
about the usual for tomatoes. Dyke (A B C of Tomato production
Lockwood Press) recommends 2 1/2 parts Sulphate of Ammonia, 6 1/2 parts
Superphosphate and 1 1/2 parts Sulphate of Potash. As the soil here is
said to be deficient in Potash the proportion of that manure has been
increased in the above mixture.

Cultural plots - two cultural treatments.
S - The plants were pruned to a single stem and tied to a bamboo
stake. The planting distance was 2 feet apart in the rows
and 3 feet between rows.
U - The plants were neither pruned or staked. No form of
support was supplied at all (last year the the unstaked
plants were supported on brushwood laid across the furrows).

Experimental Layout of the Experiment.

Last year owing to an insufficient number of plants having
been raised in the nursery the experiment on a whole was on too small
a scale - each plot was only 1/227 of an acre. This year sufficient
plants were raised to allow the plot size to be increased to 1/38 of
an acre for manural treatments and 1/76 of an acre for cultural
treatments and also to increase the number of replications from five
to six. Plot discards were left vacant in the previous trial but in
this they have been planted thus avoiding border effects which might
be quite considerable on the cultural treatments when discards are
not planted.

The experiment has been laid down in the form of six
randomised blocks of four main (manural) plots each of which is
divided into two sub (cultural) plots giving in all 24 main plots or
48 sub plots.

Specification of plots.

Staked sub plot - 9 rows, each 30 feet long having 15
plants per row. Of that 1 complete row and 1 plant at one end and
2 plants at the other end of each remaining row were discarded,
leaving in all 8 rows of 12 plants each for the actual experimental plot from which records were kept i.e. 96 plants per plot.

Unstaked sub plot - 9 rows, each 30 feet long and having 10 plants per row. Of that 1 complete row and 1 plant at each end of the remaining rows were discarded leaving in all 8 rows of 8 plants each i.e. 64 plants per plot.

It was necessary to arrange the discards as above so that the plot area from which the records were kept would be the same in each case. Each bed was about 30 yards long by 1 yard wide and was surrounded by Manorial main plots - consisted of one staked sub plot and one unstaked sub plot their relative positions having been randomised throughout for each main plot i.e. there were in all 16 rows and 160 plants per main plot.

The plot took place on October 26th but owing to your germination a further bed had to be sown on November 2nd. Altogether about 4 ounces of seed were sown. This is of course on appearance a ridiculously high seeding to provide plants for one area (theoretically was ounce of seed should have been sufficient). It was expected that more plants than were necessary would be obtained and that the surplus would be sold locally but, owing to various causes noted below, there was only a comparatively small surplus all of which was used in the variety and spacing trial. After sowing, the seeds were covered with a thin sprinkling of sterilised soil and then watered carefully with a lime spray to prevent washing them to the surface. Shade was supplied by erecting cheese cloth covers in the form of a tent over the beds thus providing protection against heavy rain as well as against strong sunlight. This cover was removed for an increasing length of time each day after germination until a week after sowing when the seedlings were quite hardened. It was permanently removed. A considerable number of seedlings was lost with damping off due to the fungus spreading rapidly under the cover during a spell of a few days when it was impossible to remove the cover owing to extremely heavy rain.

The seedlings were about a week old appeared rather yellow in colour so a small quantity (1 & cigarette tin full) of Sulphate of Ammonia was added to each watering can of water twice a day. This addition of Sulphate of Ammonia was continued all the time the seedlings were in the nursery.
Field Operations.

1. Raising seedlings in the nursery.

Seed beds and sowing.

The variety used in this experiment was Bonny Best, one of the varieties commonly grown in the West Indies. The seed was obtained direct from a seed merchant of good repute in New York. Seed beds were prepared in the usual way for tomatoes or tobacco. Each bed was about 20 yards long by 1 yard wide and was surrounded by a wooden edging to prevent the sides crumbling. The top inch of soil was sterilised by heating before being spread on the bed. Seed beds and sowing.

The first sowing took place on October 26th but owing to poor germination a further bed had to be sown on November 2nd. Altogether about 8 ounces of seed were sown. This is of course on appearance a ridiculously high seeding to provide plants for one acre (theoretically one ounce of seed should have been sufficient). It was expected that more plants than were necessary would be obtained and that the surplus would be sold locally but, owing to various causes noted below, there was only a comparatively small surplus all of which was used in the variety and spacing trial. After sowing, the seeds were covered with a thin sprinkling of sterilised soil and then watered carefully with a fine spray to prevent washing them to the surface. Shade was supplied by erecting cheese cloth covers in the form of a tent over the beds thus providing protection against heavy rain as well as against strong sunlight. This cover was removed for an increasing length of time each day after germination until a week after sowing and then the artificial shade which had previously been mixed after sowing when the seedlings were quite hardened it was permanently removed. A considerable number of seedlings was lost with damping off due to the fungus spreading rapidly under the cover during a spell of a few days when it was impossible to remove the cover owing to the wet soil especially in Blocks 1 and 2 which was to extremely heavy rain.

The seedlings when about a week old appeared rather yellow in colour so a small quantity (1/2 a cigarette tin lid full) of Sulphate of Ammonia was added to each watering-can of water twice a day. This addition of Sulphate of Ammonia was continued all the time the seedlings were in the nursery.
Pricking out.
The pricking out beds were prepared in the same way as the seed beds except that no sterilised soil was added.

The seedlings were lifted from the seed beds when about 3 inches high - 14 days after sowing. They were pricked out 3 inches apart in rows 4 inches apart. Mole crickets destroyed a number of plants in these beds but the most serious loss was caused by a small flea beetle which ate holes in the leaves causing them to shrivel up and die. This damage was checked when it was possible to get a dry day and the plants were dusted with Paris Green diluted 1 to 8 with flour. This treatment was completely successful being quite harmless to the plants and fatal for the insects. Almost all the plants in one half of the bed of younger plants were lost before treatment could be applied.

2. Preparation of the field before planting.

The field was ploughed to a depth of 8 inches with a Gallows plough on November 29th. The openings and furrows were so arranged that they would come on the discards between plots. A series of very wet days followed the ploughing of the field and planting had to be postponed from day to day until eventually the plants were getting so big that planting had to be commenced in spite of the weather. On December 6th the ridges were roughly drawn out with a Victory plough but the soil was much too wet and a very rough job was made of it. The ridges were afterwards dressed off with hand hoes.

3. Application of manures.

The dressing of Synthetic Manure was applied on the flat before ridging. The artificial manures which had previously been mixed and weighed out for each plot were applied on top of the ridges as left by the plough and covered by the dressing of the ridges with hoes. This hand hoeing of the ridges was very necessary but resulted in much puddling of the wet soil especially in Blocks I to IV where the soil was of a more clayey texture and much water was standing in the furrows.

The top dressing of artificials was applied on January 24th in good weather conditions. This was also applied on top of the ridges and covered by hoeing.
4. **Planting, Pruning and Tying.**

Planting was done by making holes with a cutlass on top of the ridge and inserting the plants. This operation was finished on December 8th in heavy rain. The conditions were in every way deplorable - the soil was flooded and badly puddled by the workers tramping about, and the plants had grown much too tall and straggly the majority of them being more than 12 inches high. Hence it is not surprising that very little growth took place for some time after planting and that large numbers of plants had to be replaced.

5. **Supplying.**

About 30% of the plants had to be replaced by supplies. The first supplying was done on December 11th and the second a week later. In the first case the majority of the deaths was undoubtedly due to bad planting in the water logged soil and in the second many of the plants that had been supplied the week before had been too big and never took root again. In the first supplying an effort was made to use up the large plants so as to avoid their loss if possible but as noted they failed to root so in the second supplying only plants likely to be successful were used. Mole crickets caused an additional loss of plants in the early stages in the field. Blocks V and VI i.e. the area at the north end of the field required very few supplies due presumably to the fact that the soil there has a much better texture and there was not the same trouble with water. On December 29th a plant count was made the results of which are discussed in a later section of this report.

6. **Draining.**

Owing to excessive amounts of water having accumulated on the plots a complete system of drains had to be laid down to alleviate the situation. Cross drains were cut between the blocks and the water was taken off from these by three main drains running the length of the experiment - one down each side and one down the centre. In addition the bottoms of many of the furrows had to be cleared out and levelled to drain off pools of water which in places were up to 12 inches deep completely covering the ridges so that the plants were standing in water. Since the reason for draining down from furrows was sometimes fixed at a time so that even certain of plots can done independently.
7. **Staking, Pruning and Tying.**

A light bamboo stake about 6 feet long and up to about 2 inches in diameter was put in with a crowbar beside each plant on the appropriate plots. As recommended as a result of last year's experience the side shoots were trimmed off close to the stake thus facilitating moving about amongst the plants whilst picking. These plants as they grew were periodically pruned to a single stem and tied to the stakes with banana fibre. This material was found quite satisfactory provided it was not allowed to dry out before use and by providing a broad enough strip of it was used. A strip about 1 - $\frac{3}{4}$" wide if twisted into a crude cord was found to be best.

8. **Weeding and Cultivating.**

The crop was hand hoed three times during the season. The first hoeing was given in December to try to break up the clods formed as a result of the drying out of the puddled soil. This was not so successful as it might have been if a differently shaped hoe had been available. Inter-row cultivation was carried out with a mule and a thirteen tine cultivator in December before staking was commenced. This did break up the surface quite a bit but it was impossible to go deep enough to do much permanent good.

The other hand hoeings - one early and the other late in January - were given to keep down weeds.

During the first week in March some of the larger weeds were pulled up by hand and laid on top of the ridges so that they would not obstruct the flow of water during irrigation.

9. **Irrigation.**

The field was irrigated on March 6th and 7th. The soil had been very dry for some time - in fact irrigation had been considered from early in February but had to be postponed as long as possible as there was only a limited supply of water. As the gradient down the furrows was rather steep the water was allowed to run down four or five furrows at a time thus decreasing the rate of flow and increasing the amount of water absorbed by the soil. There are nine furrows per sub plot hence the reason for sometimes doing four furrows and sometimes five at a time so that each column of plots was done independently.
The pump delivered water at the rate of about 0.3 cusecs giving a watering of about 2.7" over the whole area. Considerable trouble was experienced during the operation due to the presence of large cracks in the hard soil resulting in the water from one furrow escaping into the next. Continual supervision of the labour was necessary to get them to stop such inter-furrow leakage. Also a considerable amount of water must have escaped down the cracks beyond the roots of the plants. The unstaked plants at the north end of the field where they were well grown and lying in the bottom of the furrows gave trouble by obstructing the flow of the water.


Picking in the Field.

This was done entirely by native labour after they had been instructed at what stage of ripeness to pick the fruit and what discards to leave. Only the more intelligent labourers could be trusted to do this however. The discard plants were left unpicked until all the experimental plots had been finished and then they were all picked and weighed in bulk without grading, simply to give a figure for total production from the area.

Generally a man and a woman picked and two women or boys carried the baskets from each plot as it was finished to the sorting room. The first pick was made on January 19th and the last on April 17th.

Grading in the Sorting Room.

The tomatoes from each plot were carefully sorted and graded by the author and his co-worker personally. The weight of each grade was recorded in ounces.

On receiving the fruit all that was diseased or damaged and generally unfit for sale was first removed, weighed and then discarded.

Then the fruit was graded through a grading board into four grades according to its diameter. Each of the four grades was then sub-divided according to whether growth cracks were present or not. It was found that none of the smallest grade fruit was cracked hence records were kept of the following classes and grades:

1. Diseased fruit - all fruit attacked by insects or fungi and generally unfit for sale.
2. Cracked fruit class - all fruit exhibiting growth cracks no matter how small these might be. This class was divided into three size grades as it was believed that in future something might be done to reduce the percentage of cracked fruit and that grading into sizes might help and also there was the possibility of a correlation between treatments and the size of fruit which cracked most.

The three grades were:

- a. more than 2 1/4" in diameter
- b. between 2 1/4" and 2 3/4" in diameter
- c. below 2 1/4" in diameter

3. Good fruit - all fruit free from any blemishes but irrespective of stage of ripeness. This class was graded into four grades:

- a. more than 2 1/2" in diameter
- b. between 2 1/2" and 2 3/4" in diameter
- c. between 2 1/4" and 2 3/4" in diameter
- d. below 2 1/2" in diameter

These grade sizes are used throughout the West Indies in exporting fruit to Canada. They were formerly given different names such as "Select", Grade I and II or "Fancy", "Choice" and "Gem" but Shill in his "Report on a visit to Canada" states that the use of such nomenclature must be discontinued as under the Canadian Fruit Act these are essentially quality grades. He says that the crates must be marked "Large", "Medium" or "Small" or simply "over 2 1/4 inches", "2 1/2 to 2 3/4 inches" or "1 1/4 to 2 1/4 inches", as the case may be to make it quite plain that they are merely size grades. All the fruit exported conforms to the quality grade "Select" so this term might be added on the crates of all sizes.

To return to Block 1 - if the relative positions of the treatments in the above table might be explained by the fact that where nitrogen was lacking the plants had no stimulus to grow under the poor...
Experimental. Observations on the general growth of plants on the different treatments throughout the season.

1. Vegetative growth - Manurial treatments.

From planting the plants on all plots in blocks V and VI grew much more rapidly than on the remainder of the field.

Apart from that difference between the north and south of the field there was a marked treatment difference to be seen as early as ten days after planting. In each block the "no Nitrogen" plots could be picked out by eye without the slightest difficulty. The plants on those plots did not grow at all until the end of December almost a month after planting. On December 27th the plots in each block were examined and placed in order of the density of foliage and amount of growth they had put on. The results were as follows:

<table>
<thead>
<tr>
<th>Block No.</th>
<th>Best growth</th>
<th>2nd best</th>
<th>3rd best</th>
<th>Poorest</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>NPK</td>
<td>NP</td>
<td>NK</td>
<td>P</td>
</tr>
<tr>
<td>II</td>
<td>NPK</td>
<td>NP</td>
<td>NK</td>
<td>P</td>
</tr>
<tr>
<td>III</td>
<td>NP</td>
<td>NPK</td>
<td>NK</td>
<td>P</td>
</tr>
<tr>
<td>IV</td>
<td>NPK</td>
<td>NP</td>
<td>NK</td>
<td>P</td>
</tr>
<tr>
<td>V</td>
<td>NP</td>
<td>NK</td>
<td>NPK</td>
<td>P</td>
</tr>
<tr>
<td>VI</td>
<td>NP</td>
<td>NK</td>
<td>NPK</td>
<td>P</td>
</tr>
</tbody>
</table>

From the above table it will be seen that in each block the P K treatment (no Nitrogen) had the poorest growth and not only that but actually they were very much worse than any of the other treatments. Then except for Blocks V and VI the no Potash plots were the next poorest. As regards the N P and N P K plots any difference there was was only slight and as shown in the table sometimes one was better and sometimes the other. Blocks V and VI behaved differently from the rest of the field - from the really more typical part of the field as the nitrogen status of the soil in that area was entirely different due to different treatment in the past and to the better soil texture enabling the green manures to grow much better.

To return to Blocks I - IV the relative positions of the treatments in the above table might be explained by the fact that where nitrogen was lacking the plants had no stimulus to grow under the poor
soil conditions during December. With nitrogen and phosphate the nitrogen provided the stimulus to produce new foliage and this was backed by the phosphate aiding root development thus causing the plants on both the NP and NPK plots to outgrow those on the other plots. That this difference in growth in the early stages had a lasting effect can be seen by reference to Figure I which is a graphical illustration of the yields from the different treatments throughout the season. Potash does not seem to have much effect at all. Nitrogen and Phosphate in combination seem more important than Nitrogen in absence of Phosphate and than Phosphate in absence of Nitrogen.

Observations on the plants at the end of the season - in April showed that the complete manural treatments (NPK) in each block were continuing to grow much better and longer than the others and that the nitrogen plus phosphate (NP) plots were next best. From this it would appear that Potash had some effect in lengthening the life of the plants. This continued growth and production is brought out quite clearly in the production figures (see Figure I). The phosphate plus potash (PK) treatments produced much better than one would have expected from an examination of the plots as right through the season they had very poor bad coloured foliage.

Cultural treatments.

There was one very noticeable feature about the foliage on the two cultural treatments. The lower leaves on the staked and pruned plants died off as new growth was produced on top whereas the unpruned plants retained practically all their leaves until the whole plant died at the end of the season. This was probably due to the drying effect of the wind on the older leaves on the more exposed staked plants as against the unstaked plants which were sheltered by the ridges and any new growth produced. This, one would have thought would have seriously reduced the producing power of the staked plants but if that was so it was probably more than balanced by the wastage of energy on the unstaked plants in producing numerous side shoots which never produced any fruit.

2. Plant numbers count.

On December 29th the number of plants that had died on each manural plot were counted. The total number of blanks for each
treatment was as follows:

\[ \text{NPK 27; NP 25; NK 50; PK 40.} \]

Statistical analysis showed that there was a significant difference (at the 5% point only) between the number of blanks on the NK plots as against the NPK and NP plots. It is doubtful whether any stress can be put on this as the plots had already been supplied twice. The general tendency however is practically the same as was observed on the vegetative growth on the different treatments and this count does help to bear out the importance of Nitrogen and Phosphate.

**Discussion of Experimental Yield Data.**

**Manurial Treatments.**

### Total yield of fruit of all classes and grades.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>lbs per plot</th>
<th>lbs per acre</th>
<th>as % of control treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK</td>
<td>151</td>
<td>11,476</td>
<td>100</td>
</tr>
<tr>
<td>NP</td>
<td>127</td>
<td>9,652</td>
<td>84</td>
</tr>
<tr>
<td>NK</td>
<td>115</td>
<td>8,740</td>
<td>76.2</td>
</tr>
<tr>
<td>PK</td>
<td>117</td>
<td>8,892</td>
<td>77.5</td>
</tr>
<tr>
<td>S</td>
<td>136</td>
<td>10,336</td>
<td>114.3</td>
</tr>
<tr>
<td>U</td>
<td>119</td>
<td>9,044</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>128</td>
<td>9,728</td>
<td>-</td>
</tr>
</tbody>
</table>

NPK has given the highest yield but although NP, the next best, is 15.9% and NK, the lowest, 22.5% lower no statistical difference could be proved on analyses. This is of course due to the immense variation over the field in combination with irregular growth of plants caused by the poor growth conditions. The PK treatment on the average gave almost the lowest yield but there was one plot of that treatment in Block VI which actually gave the highest yield of any single plot in the whole experiment. There must have been some supply of nitrogen available to the plants in that plot not present in the others. This supply was probably cumulative from the better growth of the two green manure crops on the better soil of that patch.
As with luxuriance of foliage and plant numbers here again the combination of nitrogen and phosphate appears of most importance and has brought out on top the two treatments containing that combination. Apart from the increase in yield of N P K over N P, presumably due to potash, that manure does not seem to have had much effect with either nitrogen or phosphate alone. To have made the comparison more complete and absolute it would have been better if a "no manure" treatment had been included in the experiment. This could have been done by having a five by five latin square layout.

Production throughout the season.

Figure I shows the rate of production on the different manurial treatments throughout the season. In each case it has been fairly uniform except for the period between the 29th January and the 5th February. This dip in the curves of all treatments may be partly explained by the fact that the pick made on the latter date was not what might be called a normal pick, as only the ripest fruit was picked in response to a sudden demand for fruit from a tourist ship. This would of course cause a slight dip in the apparent rate of production but if it were the whole explanation there should be a corresponding increase at the next pick. As can be seen from the figure this is not so as the lines of rate of production are markedly straight for some time immediately after the dip. It may be that the application of the manurial top dressings had some effect in depressing the yield for a day or two but in the absence of a "no manure" treatment that cannot be proved. No outstanding environmental conditions that might have affected setting of fruit could be discovered as an explanation.

Another very slight depression in the lines of production occurs just about the time when the crop was irrigated indicating that the yields were tending to fall off at that time but that on moisture being supplied they increased again to the normal rate. N P seems to have been an exception - the rate of production in that treatment did not increase again after irrigation but continued as before. A possible explanation is that the N P treated plants having better root systems were not affected by shortage of moisture and that the decrease in rate of production on that treatment was due to some other cause.
So far as profit per acre is concerned it pays to give the complete manuring as the increase in returns from N P K manuring over any of the others is more than sufficient to pay for the extra cost of the extra manure.

Separating out the effect of each individual manure in presence of reasonable amounts of the other two as is done in Table II it is seen that potash is less than half as effective in increasing the yield as either nitrogen or phosphate. This of course may only apply for the quantities of manures used in this experiment but as the proportion of potash was made higher than normal and as the difference is so marked right throughout the experiment it must be concluded that of the three manures potash is of least importance so far as total yield of fruit is concerned.

2. Good Fruit - Yields of each size grade. (Table III).

On the average only 6% of the total yield of fruit was over 2¾" in diameter and free from blemish. There was little difference in the amount on the different treatments except that N K was lowest with only 3.7% of its total yield in this class which might be taken as an indication that where phosphate was omitted the proportion of larger fruit was decreased.

In the next grade (from 2¼" to 2¾" in diameter) again there is little difference between any of the treatments - N P having only a slightly higher proportion of its total yield in this grade.

But by combining these two grades as is done in column IV of Table III it is seen that N P has about 5% more of its total yield as fruit over 2¼" in diameter. Shill (Marketing Officer for the British West Indies) states that it is most important to keep the proportion of larger fruit as high as possible as in many shipments of fruit to Canada it has been too low and has seriously affected the price obtained. He explains by saying that the merchants will take the smaller fruit without any trouble so long as they also get sufficient large fruit. Again referring to Table II it is seen that phosphate has almost three times the effect of potash in increasing the proportion of fruit over 2¼" in diameter.

Column III of Table III shows that the proportion of good fruit between 1¾" and 2¼" in diameter is practically the same for all treatments.
Columns IV and V have been included in Table III to show the proportion of the total yields of fruit that would be exportable under different conditions of the Canadian market. When prices are low it would not be profitable to pay package and freight charges on the small fruit i.e. only the fruit represented in Column IV would be exported but if prices were higher all fruit down to 1\(\text{in}\) in diameter as represented in Column V would be exported. Shill gives the reasons for this very clearly in his "Report on a brief visit to Canada". He says that the preference for different sizes is largely a question of market price. The consumer usually spends a fixed sum on tomatoes and if the price is high the smaller sizes are preferred since otherwise only a small number of fruit is obtained, but with low prices the larger sizes are required.

3. Cracked Fruit.

Table IV shows the amounts and the proportions of the total yield, of each size of fruit for each treatment. If, as seems possible from observations and experience, sufficiently frequent picking could reduce the amount of cracked fruits to a negligible proportion the last column would represent the fruit that would be exported under normal conditions of the Canadian market (reasonably high price). This of course would increase the possibilities of an export trade enormously as instead of having from 77% to 83%, according to the treatment, about 95% of the crop from all treatments would be exportable.

There is little difference in the proportion of total cracked fruit between any of the manurial treatments (Table V page 27) is a rather higher proportion of the larger fruit cracked, on the higher yielding treatments. This is what one would expect in view of the fact that cracking is supposed to take place under conditions of rapid growth.

Reference has been made above to the possibility of reducing the proportion of cracked fruit. It was observed during sorting that only fruit which had definitely changed colour in the field exhibited growth cracks and that no further cracking took place in the ripening room. Hence if the fruit were picked sufficiently frequently
so that they had not reached the stage when cracking takes place it would be possible to reduce the amount of cracked fruit to a very small percentage of the total yield. For such to be the case picking would have to be done about every second day. This frequent picking would be necessary in any case if the fruit was intended for export. It has been shown that only fruit that is fully grown but still green can be kept in cold storage for the necessary number of days that it takes a ship to go to Canada plus the number of days that the fruit picked after one shipment has gone has to be kept before the next goes. Considerable skill is required to be able to pick the fruit at just the right stage of development but with experience and by handling the fruit it can be done.

4. Diseased Fruit.

The amount of diseased fruit (Table V) on the two higher yielding treatments is the same but N P K giving a high total yield has a lower percentage than N P. N K has the lowest amount of diseased fruit and also the lowest total yield hence the percentage for that treatment is lower than for any of the others. The proportion does not differ much on any of the treatments but potash (Table II, page 24) has had some effect in reducing the amount of disease.

As the total amount of diseased fruit is extremely small in all cases it can be ignored.

The chief damage was caused by Bacillus arcoideae which causes a soft foul smelling rot. Blossom End Rot increased in importance towards the end of the season. Sun scald was never serious or of any consequence at all and was never found on any fruit from staked plants. Birds caused considerable damage to any fruit that was left on the plants until it was ripe.

Cultural Treatments.

1. Total Yield of all classes of fruit.

Table I (page 14) shows the yields from the two cultural treatments. Staked plots gave 14.3% higher yield than the unstaked but this difference was not statistically significant.
Yield in lbs. less 10% wastage | Staked | Unstaked |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>32641b</td>
<td>28561b</td>
</tr>
</tbody>
</table>

Value of produce per acre $5.00 | $465.00 | $407.00 |

Cost of production per acre $246.20 | $159.00 |

Profit per acre $218.80 | $248.00 |

Hence although the staked plots produced 14.3% more fruit than the unstaked plots the profit per acre was greatest on the latter.

This is due to the great expense involved in providing and erecting bamboo stakes. If this expense could be reduced by adopting some other means of supporting the plant, such as the use of string attached to an overhead wire, there might be some possibility of increasing the profit per acre on the staked treatment but it is doubtful if it could be brought to the same high level as the unstaked plots.

2. Amount of cracking.

There was considerably more cracked fruit on the staked plots than on the unstaked (Table V page 27). However, in view of what has been said of the possibility of reducing incidence of cracking, too much consideration should not be given to this difference between the treatments. Presumably the greater amount of cracking on the staked plots may have some correlation with the greater exposure of the fruit on those plants to the drying action of the wind on the ripening fruit - compare effect of wind on foliage previously discussed.

3. Diseased fruit.

The proportion of diseased fruit (Table V page 27) was slightly higher on the unstaked than on the staked plots. That was probably due to the fact that the fruit on the unstaked plants was nearer, or actually on, the soil and was therefore more liable to be damaged by hoeing and weeding. Also infection with Bacillus arcidea would be more likely to take place on those fruit.
4. Comparison of Costs of Production on Staked and Unstaked Treatments.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unstaked</th>
<th>Staked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of growing two green manure crops.</td>
<td>$12.50</td>
<td>$12.50</td>
</tr>
<tr>
<td>Ploughing for tomatoes</td>
<td>$1.00</td>
<td>$1.00</td>
</tr>
<tr>
<td>Ridging and planting (mule &amp; hand labour)</td>
<td>$5.85</td>
<td>$5.85</td>
</tr>
<tr>
<td>Synthetic Manure - 6 loads @ 60g</td>
<td>$1.80</td>
<td>$1.80</td>
</tr>
<tr>
<td>Applying synthetic manure</td>
<td>$.33</td>
<td>$.33</td>
</tr>
<tr>
<td>Plants at 8 for 1 cent (Total nursery expenses)</td>
<td>$6.20</td>
<td>$3.60</td>
</tr>
<tr>
<td>Artificial manures</td>
<td>$14.75</td>
<td>$14.75</td>
</tr>
<tr>
<td>Stakes @ $ each</td>
<td></td>
<td>$16.25</td>
</tr>
<tr>
<td>Cutting &amp; Carting stakes</td>
<td></td>
<td>$8.66</td>
</tr>
<tr>
<td>Erecting stakes</td>
<td></td>
<td>$15.29</td>
</tr>
<tr>
<td>Pruning &amp; fastening plants to stakes</td>
<td></td>
<td>$11.48</td>
</tr>
<tr>
<td>Weeding and hoeing</td>
<td>$9.43</td>
<td>$9.43</td>
</tr>
<tr>
<td>Cultivating - mule and 13 tine cultivator</td>
<td>$.19</td>
<td>$.19</td>
</tr>
<tr>
<td>Irrigating - labour</td>
<td>$1.00</td>
<td>$1.00</td>
</tr>
<tr>
<td>- Petrol @ 36g per gallon</td>
<td>$.36</td>
<td>$.36</td>
</tr>
<tr>
<td>Supplying</td>
<td>$.67</td>
<td>$.67</td>
</tr>
<tr>
<td>Picking</td>
<td>$7.30</td>
<td>$6.00</td>
</tr>
<tr>
<td>Overhead charge @ $30 per acre</td>
<td>$13.50</td>
<td>$13.50</td>
</tr>
<tr>
<td></td>
<td>$70.81</td>
<td>159.07</td>
</tr>
</tbody>
</table>

Comparison of costs of increase in production by application of individual manures.

<table>
<thead>
<tr>
<th>Manure</th>
<th>lbs. increase per acre</th>
<th>Cost per $ expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of Ammonia</td>
<td>2,584</td>
<td>$10.00</td>
</tr>
<tr>
<td>Sulphate of Potash</td>
<td>1,824</td>
<td>$22.60</td>
</tr>
<tr>
<td>Superphosphate</td>
<td>2,736</td>
<td>$20.50</td>
</tr>
</tbody>
</table>
Root Studies.

Some brief observations, on the roots of plants on the different treatments, were made at the end of the crop season.

1. Manurial treatments.

The N P K and N F treated plants had much better developed roots, both as regards depth of rooting and number of fibrous roots, than the plants on the other two treatments. It is known to be more important that two measures - in reducing the occurrence of root disease.

2. Cultural treatments.

The tap root of the plants on the staked plants were, no matter what the manurial treatment, always deeper and better developed than those of the unstaked plants. This is the result of the closer planting of the staked plants.

3. Root diseases.

Every plant examined no matter how healthy its foliage appeared had galls caused by a nematode worm (Heteroda radicicola). This nematode was the cause of the earlier death of many plants especially on N K and P K treatments. These plants died because they had been unable to outgrow the effect of the galls on their roots whilst the plants on the N P K and P K treatments although having just as high an infection did succeed to produce new roots or at least to keep the worm from gaining the upper hand.

The actual amount of infection appeared to be much the same on staked and unstaked plants but the effect is more serious on the former especially if those plants were also N K or P K plants. They had only a few roots which ran deeply into the soil whereas the unstaked plants had more numerous roots nearer the surface which had to be infected individually and which could be replaced more easily by new side roots.
Summary of Results.

Manural Treatments.

1. Yields.

In all respects phosphate appears to be the manural constituent most beneficial in the production of tomatoes. Nitrogen is almost, but not quite, as important and potash is least important of all. In only one instance has potash been shown to be more important than either of the other two manures - in reducing the proportion of diseased fruit; but as the total amount of such fruit was never high, this beneficial effect of potash is of little account.

The effects of phosphate and nitrogen are specially marked in increasing the proportion of large fruit.

2. Costs.

Nitrogen manuring has given much the highest return per unit expenditure. Phosphate also gave a profitable return. The return from potash manuring was only just sufficient to cover the cost of the manure itself.

Cultural Treatments.

Staking has been effective in increasing the total yield and also the yield of large good fruit. However in view of the much greater cost of production on staking it appears that it is more profitable neither to stake nor to prune tomato plants.
Suggestions for future work.

A similar experiment might be carried out with a much higher basal dressing of organic material than was given in this experiment. Under the improved soil conditions which would result from an increased application of organic material the relative importance of the different manural constituents would, in all probability, be different from that shown in this paper.

A "no manure" treatment might be included in the experiment so that the comparison of the effects of individual manures and combinations of two manures could be more closely studied.

An enormous amount of data has been collected from the experiment, all of which has not been thoroughly dealt with in this paper. A complete file of that data has been left with Professor Wood as it is possible that in future work on this subject it may be useful for comparative purposes should any aspect not dealt with in this paper prove to be of importance.
Table II. Effect of individual manurial ingredients.

<table>
<thead>
<tr>
<th></th>
<th>Total Fruit</th>
<th>All good Fruit over 2 1/4&quot;</th>
<th>All good Fruit over 1 3/4&quot;</th>
<th>All cracked Fruit</th>
<th>All Diseased Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs. per acre</td>
<td>% of N P K</td>
<td>lbs. per acre</td>
<td>% of N P K</td>
<td>lbs. per acre</td>
</tr>
<tr>
<td>N</td>
<td>2584</td>
<td>22.5</td>
<td>1148</td>
<td>23.0</td>
<td>2713</td>
</tr>
<tr>
<td>P</td>
<td>2736</td>
<td>23.8</td>
<td>1284</td>
<td>25.7</td>
<td>2508</td>
</tr>
<tr>
<td>K</td>
<td>1824</td>
<td>15.9</td>
<td>448</td>
<td>9.0</td>
<td>1824</td>
</tr>
</tbody>
</table>
### Table III. Yield of Good Fruit of different size grades.

<table>
<thead>
<tr>
<th></th>
<th>I over 2½&quot; in diam.</th>
<th>II from 2¼&quot; to 2½&quot;</th>
<th>III from 1¾&quot; to 2¼&quot;</th>
<th>IV I plus II i.e. Fruit exportable when prices high</th>
<th>V IV plus III i.e. Fruit exportable when prices low</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK</td>
<td>8.8</td>
<td>5.8</td>
<td>56.9</td>
<td>37.7</td>
<td>65.7</td>
</tr>
<tr>
<td>NP</td>
<td>7.7</td>
<td>6.1</td>
<td>52.1</td>
<td>41.1</td>
<td>59.8</td>
</tr>
<tr>
<td>NK</td>
<td>4.3</td>
<td>3.7</td>
<td>44.5</td>
<td>38.7</td>
<td>48.8</td>
</tr>
<tr>
<td>PK</td>
<td>6.7</td>
<td>5.7</td>
<td>43.9</td>
<td>37.5</td>
<td>50.6</td>
</tr>
<tr>
<td>S</td>
<td>8.0</td>
<td>5.9</td>
<td>49.4</td>
<td>36.4</td>
<td>57.4</td>
</tr>
<tr>
<td>U</td>
<td>7.2</td>
<td>6.1</td>
<td>45.4</td>
<td>36.7</td>
<td>51.5</td>
</tr>
<tr>
<td>Mean</td>
<td>7.6</td>
<td>6.0</td>
<td>47.4</td>
<td>36.6</td>
<td>54.5</td>
</tr>
</tbody>
</table>
Table IV. Yield of fruit of different sizes (irrespective of cracking).

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs per plot</td>
<td>% of total</td>
<td>lbs per plot</td>
<td>% of total</td>
<td>lbs per plot</td>
</tr>
<tr>
<td>I 2(\frac{3}{4})&quot; diam &amp; over</td>
<td>13.4</td>
<td>8.9</td>
<td>72.0</td>
<td>47.5</td>
<td>59.5</td>
</tr>
<tr>
<td>N P K</td>
<td>11.5</td>
<td>9.1</td>
<td>56.5</td>
<td>44.5</td>
<td>53.1</td>
</tr>
<tr>
<td>N P</td>
<td>10.1</td>
<td>8.8</td>
<td>52.7</td>
<td>46.0</td>
<td>46.7</td>
</tr>
<tr>
<td>N K</td>
<td>9.6</td>
<td>8.2</td>
<td>54.8</td>
<td>46.9</td>
<td>46.1</td>
</tr>
<tr>
<td>P K</td>
<td>12</td>
<td>8.9</td>
<td>65.2</td>
<td>46.0</td>
<td>52.8</td>
</tr>
<tr>
<td>S</td>
<td>10.2</td>
<td>8.5</td>
<td>52.4</td>
<td>43.9</td>
<td>50.3</td>
</tr>
<tr>
<td>Mean</td>
<td>11.1</td>
<td>8.7</td>
<td>58.8</td>
<td>46.1</td>
<td>51.6</td>
</tr>
</tbody>
</table>
Table V. Amount of cracking on different sizes on each Treatment and amount of diseased fruit.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total cracked fruit per plot</th>
<th>% of Total yield</th>
<th>Diameter over 2(\frac{1}{2})&quot; per plot</th>
<th>% of Total yield</th>
<th>2(\frac{1}{4})&quot; to 2(\frac{3}{4})&quot; per plot</th>
<th>% of Total yield</th>
<th>1(\frac{1}{2})&quot; to 2(\frac{3}{4})&quot; per plot</th>
<th>% of Total yield</th>
<th>Diseased fruit per plot</th>
<th>% of Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK</td>
<td>27.1</td>
<td>17.9</td>
<td>4.7</td>
<td>3.1</td>
<td>14.2</td>
<td>9.4</td>
<td>8.2</td>
<td>5.4</td>
<td>7.3</td>
<td>4.8</td>
</tr>
<tr>
<td>NP</td>
<td>23.3</td>
<td>18.5</td>
<td>3.8</td>
<td>3.0</td>
<td>14.3</td>
<td>11.3</td>
<td>5.2</td>
<td>4.1</td>
<td>7.4</td>
<td>5.8</td>
</tr>
<tr>
<td>NK</td>
<td>18.0</td>
<td>16.8</td>
<td>3.0</td>
<td>2.6</td>
<td>10.6</td>
<td>9.2</td>
<td>6.4</td>
<td>5.6</td>
<td>4.8</td>
<td>4.2</td>
</tr>
<tr>
<td>PK</td>
<td>13.0</td>
<td>17.0</td>
<td>2.8</td>
<td>2.4</td>
<td>11.0</td>
<td>9.4</td>
<td>4.2</td>
<td>3.6</td>
<td>6.2</td>
<td>5.3</td>
</tr>
<tr>
<td>S</td>
<td>26.5</td>
<td>20.8</td>
<td>4.2</td>
<td>3.1</td>
<td>15.8</td>
<td>11.6</td>
<td>6.5</td>
<td>4.8</td>
<td>6.3</td>
<td>4.6</td>
</tr>
<tr>
<td>U</td>
<td>16.7</td>
<td>14.0</td>
<td>3.0</td>
<td>2.5</td>
<td>8.5</td>
<td>7.2</td>
<td>5.2</td>
<td>4.4</td>
<td>6.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Mean</td>
<td>21.6</td>
<td>17.4</td>
<td>3.6</td>
<td>2.8</td>
<td>12.2</td>
<td>9.5</td>
<td>5.9</td>
<td>4.6</td>
<td>6.4</td>
<td>5.0</td>
</tr>
</tbody>
</table>
FIGURE I - RATES OF PRODUCTION THROUGHOUT THE SEASON.

- NPK
- NP
- NK
- PK

Total Production to date - LBS per Treatment

TOP-DRESSED with MANURES

IRRIGATED

JANUARY
FEBRUARY
MARCH
APRIL
1. Nursery beds - showing the method of shading the young seedlings.

2. Showing the condition of the field on December 18th when supplying. Note in the foreground how the soil in the ridges is beginning to crack.

3. A general view of the field on December 27th. Note how certain treatments (P K) can be readily picked out by eye.

4. A view of two adjacent plots on 27th December. The P K plot has not put on any growth since planting.