A Survey of the Vegetable Diseases occurring on the Aranguez Estate and New Farm areas, together with certain experiments carried out in conjunction with the survey.

WALTER HIRST, B.Sc. (Manchester) Dip.Ag.Sci.(Cantab)

D.T.A. Report

1951-52

Report submitted in part requirement for the Diploma in Tropical Agriculture of the Imperial College of Tropical Agriculture, Trinidad, B.W.I.
## Contents

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CROPS.</strong></td>
<td></td>
</tr>
<tr>
<td>Beans</td>
<td>2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>7</td>
</tr>
<tr>
<td>Melengens</td>
<td>12</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>22</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>33</td>
</tr>
<tr>
<td>Bahji Spinach</td>
<td>37</td>
</tr>
<tr>
<td>Lettuce</td>
<td>37</td>
</tr>
<tr>
<td>Celery</td>
<td>37</td>
</tr>
<tr>
<td>Chinese Cabbage</td>
<td>38</td>
</tr>
<tr>
<td>Sweet Potato</td>
<td>38</td>
</tr>
<tr>
<td>Carrots</td>
<td>38</td>
</tr>
<tr>
<td>Okra</td>
<td>39</td>
</tr>
<tr>
<td>Peppers</td>
<td>40</td>
</tr>
</tbody>
</table>

### GENERAL CONSIDERATIONS

| Economics of Peasant Vegetable Production | 41 |
| Details of Cultivation                  | 41 |
| Rotation                                | 42 |
| Suggestions for New Farm Area           | 43 |
| The Present state of Knowledge of the Peasants | 45 |
| Work Required in the Future             | 46 |
| Extension Work                          | 46 |
| Conclusions                             | 48 |
| Plates I - IV                           | 49 |
| References                              | 53 |
This survey was carried out from October 1951 to May 1952. The climate during this period was considered normal for Trinidad; the wet season gradually came to an end in January and a marked dry period continued up to the time when the survey was concluded. All statements given and all deductions drawn refer almost wholly to this period. Records for previous years are very scanty. This is a serious drawback to the work.

The one aim of the work is to assist whosoever is engaged in vegetable production in Trinidad. With this end in view only field descriptions of the various diseases are given. General facts relating to cultivation have also been included.

In the first part of the work the crops have been discussed individually under the following headings:-

Crop.

General.

Diseases discussed separately under:-

Incidence
Symptoms
Discussion
Control
Experiments

Pests.

The second part deals with general aspects of disease control as outlined in the index. This is followed by a summary and conclusions.
Beans.

General.

Several species of bean are commonly grown at Aranguez and in this paper all are considered together. Only dwarf forms are grown. Experiments with dwarf and climbing varieties at the New Farm should soon give information on the comparative values of the two. They are grown on the flat, in rows, and are more popular during the wet season, when so many other crops will not yield satisfactorily.

Diseases.

Sclerotial Disease - Sclerotium rolfsii Sacc.
Cercospora Leaf Spot - Cercospora spp.
Web Blight - Corticium microsclerotium (Matz) Weber
Rust - Uromyces appendiculatus (Pers.) Fr.
Powdery Mildew - Erysiphe sp.
Cowpea Mosaic

Sclerotial Disease - Sclerotium rolfsii Sacc.

Incidence. Attacks are common only in the early stages of growth until the plants are about eight inches high. Cases of twenty-five percent mortality have been seen but these are rare; it is usually well below ten percent. The crop is planted sufficiently thickly to allow of this loss and, as the attack is characteristically evenly distributed throughout the plot, the result is not serious.

The disease tends to be more common on the damper soils and during the wet season.

Symptoms. The plants begin to wilt gradually, at first only during the heat of the day. Finally the wilt becomes very severe and death occurs within four days. The leaves may become slightly yellow prior to death.

The plant is easily removed from the ground as most of the lateral roots have rotted away. On the main tap root a vigorous, coarse, white, mycelium can be seen and usually attached to this, especially near the soil surface, are small, light brown, round, smooth sclerotia, about 1/15 inch in diameter and
reselling mustard seeds.

**Discussion.** This can become a troublesome disease on some soils possibly as the result of a series of susceptible crops allowing the number of sclerotia in the soil to increase.

The fungus also attacks Bhagi Spinach, peppers, tomatoes, eggplants, and probably many other hosts. On these the general symptoms are similar to those described. If however the plants are attacked in the seedbed this strongly growing fungus usually kills the seedlings in groups.

It is probable that a build up of this disease will occur at the New Farm. As *Crotalaria juncea* is being considered as a wet season cover crop for part of the area it is important to know whether it is susceptible to the disease. Therefore, four pots of *Crotalaria* and four of Kentucky Wonder French Bean were planted and inoculated with sclerotia previously produced in pure culture. Within fourteen days all the beans were dead and showed the presence of the fungus. The *Crotalaria* however remained healthy and further addition of sclerotia had no effect. It was therefore concluded that *Crotalaria juncea* is immune to the disease and will not assist in the build up of sclerotia in the soil.

**Control.** This is only necessary if the disease becomes really troublesome. A high seed rate and efficient roguing of diseased material will assist in control. A suitable rotation may be considered necessary and in this connection Bhagi Spinach, Peppers and Beans should be considered as highly susceptible, Eggplant and tomato as fairly resistant and Lettuce and Cabbage as immune. (Eggplant and Tomato are usually attacked only in the seedbed or under very unfavourable soil conditions during the wet season.)

More efficient drainage should also help.

**Cercospora Leaf Spot. Cercospora spp.**

**Incidence.** Symptoms are seen on almost all bean plants, being most common on mature or dying leaves.

**Symptoms.** This fungus causes red-brown spots of very variable size and shape on the leaves. Often the central area of the spot is lighter in colour than the border.

The spores can be obtained easily by scraping the infected areas
and epidermal strips show groups of sporangiophores emerging through the stomata.

**Discussion.** Descriptions of the different species of *Cercospora* in Trinidad are given by Steven. (2)

**Control.** Unnecessary. Spraying with 4-4-50 bordeaux mixture has been recommended to prevent the organism from becoming established (1).


**Incidence.** Serious attacks were seen on the Old Farm in December and several crops of both dwarf and climbing beans were ruined. The disease was also seen at the New Farm at the beginning of January where the incidence was lower. A few infected plants were found on one plot at Aranguez. The fungus needs humid conditions for its external development and therefore was not seen during the dry season.

**Symptoms.** The first symptoms of the disease are seen as small water-soaked spots on the leaves. These increase in size to cover the whole leaf which then has a scalded, or limp, wet brown-green appearance.

At a later stage external hyphae are seen which grow freely over the bean plant, killing any leaves which they contact. Gradually the drooping leaves become fastened together by a mat of mycelial strands. At this stage small irregular sclerotia are found. These are very lightly attached to the mycelial mat on the surface of the plant and are easily detached. They are at first white but later turn brown and resemble a scattering of small granules of soil.

Finally the bean plant is stripped of its lower leaves, but the stem, although covered with mycelium, is unaffected. In climbing forms the upper part of the plant may remain healthy in its less humid micro-environment.

From Florida (3) it is reported that the fruit may also be attacked either on the plant or in transit. On the Old Farm the disease was so severe however that little fruit was produced and the symptoms were not seen.
The description of *Batata* is as follows (1):

Sclerotia superficial, small 0.2 - 0.5 mm. in diameter. White when young, brown to dark brown at maturity, nearly homogeneous in structure and colour, sub-globose, free from tufted mycelium, not smooth, usually single, sometimes conglomerated. Vegetative hyphae 6 - 9 μ wide, first hyaline and granular, brown and more or less empty at maturity, septate.

**Discussion.** This fungus has a wide host range and under suitable conditions will attack most of the cultivated vegetables (1). It has even been recorded upon rice (4). In Trinidad it was found on *Commelina diffusa* Burm. F. growing near infected beans.

It has not been previously recorded in Trinidad and may become serious if it is a recent introduction. Thus a suggested control is that "in the tropics, beans should be planted so that they may complete their growth before the beginning of the rainy season" (1).

**Control.** Harter and Zaumeyer (1) suggest, in addition to the growing of beans only in the dry season:

1. Plantings should be well aerated.
2. Rotation.
3. 3-3-50 Bordeaux mixture should help to reduce the loss.
4. To prevent the accumulation of sclerotia in the soil, infected plants should be destroyed as soon as possible after the crop has been harvested or abandoned.

**Experiments with the fungus.**

The causal organism was obtained in pure culture and sclerotia up to 1 mm. in diameter were produced. Kentucky Wonder French Bean seedlings were grown in pots and the sclerotia placed between the stem and one cotyledon. The pots were kept at a high humidity and the fungus was observed to be growing out along the stems within 24 hours. After three days large brown water-soaked lesions had formed on the stems and within four days the plants were almost dead. Death occurred before any sclerotia had formed on the leaves.

The fungus was reisolated from the plants. All inoculated plants behaved uniformly: uninoculated controls remained healthy.
Rust. Uromyces appendiculatus. (Pers.) Fr.

Occurrence. This disease was only seen during the dry season but apparently it is fairly common throughout the year. In California it is regarded as a disease of humid conditions (1).

Symptoms. Rust coloured pustules about 1 mm. in diameter develop on either side of the leaf. As in the case of most rusts the area of leaf around the pustule is not at first discoloured, but later a small dead area may encircle it. Then the pustule appears much like a miniature coffee cup with the dead area as the saucer.

Discussion. In variety trials at the New Farm the resistance to the strain of rust present, differed greatly.

Control. Usually unnecessary. 4-4-50 Bordeaux mixture could be used (1).

Powdery Mildew. Erysiphe sp.

This was seen occasionally during the wet season on many species of bean.

Cowpea Mosaic.

Incidence. This disease is very common at Aranguez. Possibly 50% of the plants are infected.

Symptoms. Severe mosaic and distortion.

Discussion. "The virus is seed-borne in asparagus bean, but apparently not in tested cowpea varieties. The leaf beetle Ceratoma ruficornis is a vector, and is probably largely responsible for spread in the field" (5).

Pests.

Insect attacks on Cowpea are often severe, large round holes are eaten from the middle of the leaves. On the New Farm dwarf beans sometimes suffer severely from an underground stem borer which causes the plants to wilt and die much as in attacks by Sclerotium rolfsii. On some plots red spiders are very serious; the leaves become a mottle of green and white, between the green veins; the plots have a white appearance from a distance.
Cabbages

General. Cabbages are regarded as a high value crop. They are grown on the flat after the ground has been well hoed or rotatilled. They are transplanted from raised seedling-beds, where they are usually very crowded, and are often planted at what appears to be too late a stage. The high seed rate does however appear to protect the seedlings against the ravages of odd insects.

Cabbages are little grown during the wet season and may be described as a dry season crop. The seeds are usually sown from the beginning of December onwards. However, some seedlings which were planted out in early December gave a very good early yield on one plot and earlier growing of the crop is worth consideration.

Diseases (5).

Downy Mildew - Peronospora parasitica (Fr.) Tul.
Black Rot - Xanthomonas campestris (Fam.) Dows.
Alternaria Leaf Spot - Alternaria brassicae (Berk.) Sacc.

Downy Mildew Peronospora parasitica (Fr.) Tul.

Incidence. This disease is only serious in the seed-beds, which are planted in increasing numbers from the beginning of December. Most of the earlier beds are entirely free from the disease but those which are attacked are almost completely destroyed. Towards the end of December the trouble becomes more widespread and by the beginning of January when the weather is dryer, the disease is seen on all seed-beds. By the beginning of February most cabbages have been transplanted and the disease is no longer serious. Even in March traces can be seen on maturing cabbages.

One uninfected seedbed of Cauliflower was seen in January at Aranguez. At the same time the cauliflower seedlings under shade at the New Farm were severely attacked although cabbages there, under the same conditions, showed little disease.

Symptoms. In the seedbed this disease appears as a white down on the lower surface of the cotyledons. This is most obvious in the early morning but it is present throughout the day. Some seedlings are killed at this stage; the cotyledons turn yellow
and die and the seedling has insufficient photosynthetic area left to survive. Usually the seedlings are past the cotyledon stage when the attacks on the cotyledons become serious and these seedlings survive. The older leaves are then attacked, but sporulating on these is not so plentiful. The diseased parts of the leaves turn pale green, then yellow, and finally brown. Often only one half shows the symptoms and the other half outgrows it to produce an asymmetrical leaf. A seedbed at this stage has a most unhealthy appearance.

The seedlings, if sufficiently vigorous when planted out, appear to outgrow the disease and no permanent injury results. (In Florida (7) the mildew is said never to disappear from once infected plants and may even spoil the appearance of the final head.) On some older leaves it may be seen as very thin irregular purple coloured lines, in the region of which a few sporangiophores may be produced. (In Florida (7) light green spots occur and these go yellow and then brown.)

Discussion. The localised nature of the disease when it first appears, suggests a carry over of oospores in the soil in certain places. The spores produced from these first infections then distribute it very effectively. Alternately diseased cabbages may occur somewhere in the area throughout the year.

The difference in the severity of the symptoms on cauliflower and cabbage at the New Farm may be due to the particular strain of the fungus present, as several strains have been demonstrated elsewhere (8).

The difference between infections at Aranguez and the New Farm may be due to the effect of shading at the latter place, for susceptibility of this disease is connected with light intensity and the resulting condition of chlorophyll in the host cells (8).

This disease causes great concern to the peasants where it occurs.

Control. In Florida the fungicide Spergon, applied as a dust or a spray, gives a very good control (7). The cost of three applications per week for three weeks is less than one penny per
square yard of seedbed. (This figure was obtained by arithmetically reducing the costs per acre to those per yard). Attempts should be made to obtain and test this material. If it gives a good control of the disease it will be a very suitable chemical to use in introducing the peasant to the use of fungicides.

At Aranguez (when the attack appeared early in the growth of the seedlings) timely applications of sulphate of Ammonia solution were seen to give good results. The fertiliser assisted the young plants to grow away from the disease.

**Incidence.** This disease was seen at Aranguez from February onwards, as the cabbages began to heart. It was present on all plots inspected and was very serious on some.

It was not seen at the New Farm where few cabbages were grown.

**Symptoms.** This disease is excellently illustrated and described by Eddins and Tisdale (9) and only a brief description is given here. The plants are stunted. Large brown or yellow patches appear on the outer leaves and the veins in these areas become blackened. These leaves are eventually abscissed. The vasculars of the stem are discoloured.

**Discussion.** This bacterium may be carried in or on the seed and thus could be coming into the area annually. However if this is occurring on a serious scale the disease would be seen more abundantly in the seedbeds.

The bacterium can live in the soil for up to two years in the United States (9) and it may do so at Aranguez, the plants being infected after transplanting. This would account for the comparatively late stage in the growth of the plants at which the disease is seen.

Once the disease is established on a few plants in a field spread can readily occur by wind blown dust, rainsplash, or cultivation implements. (9).

Entry usually occurs via the hydathodes at the margins of the leaves (9a).

This disease is serious and further work on its distribution
and means of spread would be of value.

Control. Before adequate control can be envisaged more knowledge of the disease under Trinidad conditions is needed. General control measures suggested for Florida, where infection usually occurs in the seedbed, include:

- Use of disease free seed.
- Seed treatment.
- Crop rotation.
- Fresh soil for seedbed, and avoidance of excess overhead watering.

**Alternaria Leaf Spot.** *Alternaria brassicae* (Berk) Sacc.

**Incidence.** This disease is very common on the outer leaves of cabbage plants from February onwards. If seedlings were planted at this time it is possible that they also would be attacked as the woody seedlings in discarded seedbeds were severely infected.

**Symptoms.** Walker (6) gives an excellent illustration of this disease. It first appears as very small dark irregular spots on the leaves. These enlarge up to 1 inch in diameter and become circular and light brown in colour. Frequently concentric zonation is seen. At a later stage and especially in damp weather the spots become covered with a black coating of *Alternaria* spores which are easily rubbed off with the hand.

**Discussion.** This disease is not serious as only the older and outer leaves are attacked.

**Control.** Unnecessary.

**Pests.**

The most serious trouble which besets the cabbage growers in Trinidad is 'the worm', i.e. the larva of *Hallula phidilealis*. Without control measures, probably the whole of the cabbages at Aranguez would be ruined. With the present laborious methods of control many plants occur in which the results of the pest can not be found. One experimental plot at the New Farm had about 95% loss of useful plants due to this insect inspite of alleged control measures.

The moth lays its eggs on the surface of the leaf. The larva
burrows through the petiole into the stem below the growing point; many seedlings are thus killed. Fennah (10) recommends the following control; "Regular dusting of the young plants with lead arsenate will give a good measure of control; it is likely that better results can be obtained with a dust or spray of D.D.T."

In practice at Aranguez, lead arsenate is used as a spray, often more frequently than once a week. Small boys are also sent round with pins to pick out the little larvae before they do serious damage.

Further work on this subject is urgently required. The thesis of Kennard is available for study on this subject (11).
General. Ihlengens are grown throughout the year. They are often planted in small holes in the furrows left from the previous crop. In such cases the weeds are first hoed off the ground and left in the furrows. As the melengens are hoed up the weeds are covered. If manure is added it is placed around the individual plants before hoing up. The practice of planting in the hollows is very unsatisfactory during the wet season as the plants are thus placed in the wettest positions. Even in the dry season it is not a good practice for the layer of soil into which the plants are set is apparently never cultivated, as the diagrams below show.

Profile view of soil.

Shading indicates uncultivated soil; dotting indicates cultivated soil.

These remarks apply equally to tomato culture but in this case the production of adventitious roots into the ridge helps to overcome the faults. Fortunately the practice is now disappearing as the peasants are taking advantage of the rototillers recently acquired by several contractors. These till the earth to a depth of about five inches.

Diseases.

Damping Off - *Rhizoctonia* sp.

Bacterial Wilt - *Xanthomonas axonopodis* var. *solanacearum* (E.F. Smith) Dowson.

Sclerotial Wilt - *Sclerotium rolfsii* Sacc.

Witches Broom Disease.

Mosaic

Damping Off *Rhizoctonia* sp.

Incidence. A seedbed was severely attacked at the New Farm.

Symptoms. A typical damping off with a wet rot in the
hypocotyl region was seen. Microscopic examination showed the presence of abundant mycelium of *Rhizoctonia* sp. This may be recognised by characteristic constrictions at points of branching. A pure culture was obtained.

**Discussion.** The bed was severely attacked and most of the seedlings last. Bad environmental conditions were probably the reason for the trouble; shading was heavy and the soil very damp.

**Control.** Under suitable conditions control should be unnecessary. However if the disease should become troublesome routine applications of Cheshunt Mixture could be used as a preventative. Soil sterilization will also be effective.

**Bacterial Wilt.** *Xanthomonas solonacearum.*

**Incidence.** A careful distinction must be drawn between the wilt due to insect damage and that due to the bacterium.

During the wet season especially, a large number of plants wilt due to insects eating away the extra-cambial tissues of the stem, at or below ground level. This is probably far more serious than the bacterial disease. Perhaps 10% die as a result of the bacterium; insect damage may cause 50% loss.

During the dry season the plants are more vigorous and neither insect damage nor the bacterial wilt is serious.

It is suspected that some other pathogen may cause a footrot and wilting of the plants both during the wet and dry seasons.

**Symptoms.** Attention is first drawn to the plant when it begins to wilt and later the leaves may lose their colour. Scrapings of the stem to bare the wood show discolouration in at least some of the branches, while the base of the plant is always discoloured. (Microscopic sections show the presence of many bacteria in the discoloured vessels.)

If this discolouration is not seen the wilting plants will usually show severe insect damage. However, during the dry season a dry foot rot has been observed which may be the result of some fungal pathogen.

During the wet season a study of the disease is seriously complicated by the presence of many secondary bacteria and fungi
at the base of the plant following upon insect attacks.

**Discussion.** The varieties of eggplant grown here are highly resistant to this disease and few losses are seen although the soil is badly contaminated with the bacterium as is shown by the high incidence of the disease on tomatoes.

Isolations were made of the bacterium from both melengens and tomatoes. Cross inoculations may prove of interest.

**Control.** Unnecessary.

**Sclerotial Wilt. Sclerotium rolfsii**

**Incidence.** Very rare. Seen occasionally during the wet season.

**Symptoms.** As given under beans. Sclerotia however are not commonly formed.

**Discussion.** Of no importance.

**Control.** Unnecessary.

**Witches Broom Disease.**

**Incidence.** The incidence of this disease is very odd. Most plants produce few or no brooms, but some plots occur in which almost every plant has produced several brooms. Two such contrasting plots may lie adjacent to each other.

**Symptoms.** Brooms do not normally form on a plant until it is at least three feet high when it may be considered as a mature plant.

One broom is considered here as the product of but one primary broom producing bud. This develops into a branch with short inter nodes and all the lateral buds upon it develop precociously to form similar branches. By a repetition of this process the broom is formed.

The point on the plant at which an apparently normal bud develops into a broom is very variable and is given below:

- **Broom formed more than three feet above the ground level.**
- **Broom formed at the tip of a branch from an apical bud.**
- **Broom formed from a bud near the tip of a branch.**

This is rarely seen. The broom appears much as in Fig. D (which is however the result of a graft).
This is a common place for broom formation. The tip of the branch often dies or at least ceases active growth.

**Broom not formed near tip.**

This is commonly seen, several brooms often forming at intervals along the branch. This is seen in Figs. A, B, and C.

In Fig. A only one broom has formed. It can be seen that the first branch of the broom has produced other branches very near its base—this is characteristic of all brooms.

In Fig. B the condition is much as in Fig. A but a second broom has formed to the right of the main broom. This has however died.

In Fig. C brooms are seen developing at three points and one large composite broom is being formed.

**Broom formed less than 18 inches above the ground.**

This is an uncommon place for broom formation. The brooms here develop from buds at the base of one or more of the main branches of the plant. Usually only a single broom develops but a composite broom may occasionally form from the activity of several initial buds upon one main branch.

These brooms tend to be more elongate due possibly to positive phototropism. In some cases one or more of the branches of a broom appear to assume normal growth but the broom usually dies before growth can proceed very far.

One plot was very notable for its abundant production of brooms which were all near ground level.

The reason for the above categories may require some explanation:-

After observing many cases of the disease a natural distinction seems to occur between the brooms at the base of the plant and those high up. Brooms between 1½ and 3 feet from the ground were very rare. The two distinct forms sometimes occur in the same plot but they are usually on different plots. A knowledge of the actual positions of the buds on the stem may be useful at a later stage in the investigation of the nature of the disease and at least the tabular form allows of an easy description of the
The brooms usually form on plants which have passed their period of maximum production but this is not invariably the case. In spite of the late stage at which the brooms develop they usually die before the rest of the plant.

**Discussion.** The cause of this disease is unknown and there is no reference to it in the literature. Speculations upon its cause include mites, genetical abnormalities, and virus infection. Experiments upon the disease were therefore carried out.

**Control.** This is a difficult subject when the cause is unknown. Fortunately the disease is not serious and flowering and fruiting can occur on the brooms. It is usually seen when the plants are becoming less productive. Many peasants break off the brooms which come off easily for they are somewhat constricted at their point of origin.

**Experiments.**

**Expt. I.**

**Work Carried Out.**

Brooms were examined microscopically and material was plated.

**Result** No difference between healthy and diseased tissue was seen.

**Expt. II.**

**General.** Examination of brooms and their points of formation suggest that the stimulus for their development may be physiological.

**Purpose.** To induce broom formation by alteration of the physiological condition of the plants by various forms of pruning.

**Work Done.** The following pruning operations were carried out, each on two young healthy plants about 2½ feet high.

a) All apical buds removed.

b) All tips of branches cut off and the last inch of stem scraped bare of bark.

c) All buds removed except apical buds, and another lower down on each stem.

d) All buds removed from each branch except for the apical bud and the two next to it.

e) As(d) but apical bud removed also.
f) All buds more than one foot above ground removed.

Result. Although the pruning had interesting effects on the growth form of the plants, no brooms were produced.

Expt. III

Work Carried Out.

Scions from brooms were grafted onto healthy plants.

Results. There was no difficulty in obtaining successful unions but after a little growth the scions usually died. All scions which grew before death, began to form brooms. Three grafts grew vigorously and gave large brooms. (Fig. D). Healthy scions were grafted onto these and unions were established. However, very shortly after this all three brooms died, in much the same way as when occurring on plants naturally. Death occurred up to but not beyond the point of grafting.

Bottle grafts were the most successful, especially, when put onto the beheaded apices of branches. In bud grafts the tissue around the bud readily survived for some time but all the buds, being well-developed at the time of grafting, died before forming a branch. Bottle grafts onto the side of a stem readily took but later died, sometimes after living and growing for six weeks. Many of these two later types of grafts were made in the hope that if the disease were due to virus infection, the virus would pass up the stem to the healthy growing point above.

No brooms were induced on any plants.

Conclusions. 1) The disease is not due to the permanent presence of virus, fungus, or mites, for it would then be transmitted by the grafts.

2) Brooming tissue continues to form brooms even when its environment is changed by transferring it to another plant.

3) Early death of the brooms confirmed field observations.

4) The death of the broom up to and no further than the point of grafting suggests an inherent difference between the broom and healthy material or possibly a failure at the point of grafting.
When natural brooms die the main branches upon which they developed, from lateral buds, are unaffected; there is no obvious reason why the physiology of this lateral branch system should upset the main branch, i.e.

but in the graft the part of the stock immediately below the point of grafting would be expected to react in exactly the same way as the scion alone. It does not react in the same way.

It has been stated previously that brooms do occasionally form from apical buds. It would be of great interest to follow the death of such a broom and determine the final limit of the dead tissue.

**General Conclusions** on the cause of broom formation as a result of observation and experiments.

Grafting shows that this disease is not caused by fungi, virus or mites, unless these first cause the stimulus for abnormal growth and this then continues in the absence of the original cause. This being the case, death of the brooms could only be considered as a breakdown in the physiological balance brought about by abnormal growth, and in a graft the stem below the graft would be expected to die when the stem above the graft died, for both pieces of stem are functioning in harmony. This however does not occur.
One explanation which covers the facts is that brooms are formed as the results of bud mutations, for:-

1) They cannot be transmitted in grafts.
2) They continue to grow abnormally even when grafted onto other plants.
3) When grafted they are fundamentally different from the stock (for stock does not die when scion dies).

Alternatively, the difference suggested in (3) may be due to normal genetical differences in stock and scion material and not due to previous bud mutation. If this is true, the initial reason for the bud to form the broom is more obscure than ever. This hypothesis could be tested by grafting a piece of broom onto another healthy branch of the same plant. If death is then halted at the point of grafting this will tend to support the mutation theory.

The peculiar distribution of the disease suggests very different broom-forming-potentialities in different plots; these are often distinct in that each is often the product of but one fruit. In this connection the following quotation from Butler and Jones (8) (p.207) is of interest:-

"Mites and insects sometimes cause similar growths, and some brooms on pine and spruce are not caused by parasites but appear to be due to an innate heritable tendency of the tree".

Suggestions for Future Work.

1) Collect seeds from diseased plants, and from plots of healthy plants. Grow seedlings under identical conditions and see if there is any difference in the amount of broom formation on plants from the different sources.
2) Graft brooming material onto brooming plants as suggested above.
3) Graft healthy material onto brooms.
4) Make various double grafts.

Mosaic

Slight mosaic symptoms are seen on at least half the plants. There is no evidence of any reduction in yield. The virus is however occasionally seen on tomatoes and produces a severe yellow spotting.
A d e n d u m.

After the conclusion of this thesis a broom developed very near to a piece of grafted broom material as can be seen in the photograph and explanatory diagram.

The graft was made on 17.2.52. It died about 3 months later. During that period the buds on the scion developed very slowly but did not produce branches.

Small branches developed on two other plants just below the points where side grafts had been attempted earlier. Their general form and basal constriction suggested that they were former brooms. However, I now think that these brooms were not formed as a result of grafting of abnormal tissue but as a result of the general lode of vitality of the branch in that region due to the wounding and unsuccessful grafting. I think that broom production occurs when buds on normal tissue begin to develop and grow due to some growth stimulus, such as in this case, the coming of the rains, after a very dry period. The broom develops with a constriction.
at the point of its attachment to the main stem due to the inability of the cells of the latter to become meristematic. This I believe is the stimulus to broom formation referred to previously. Due to these circumstances an irreversible change occurs in the aforesaid meristem of the young broom-forming branch. The nature of this change is unknown. The whole subject is most intriguing and the possibility of means the cannot now be forgotten.
Pests.

Melengens present more problems for the entomologist than for the botanist. There are five major pests and these are discussed below:

**Flea Beetles.** At least two species of *Epitrix* are invariably present on melengens and are responsible for the shot-hole effect on the leaves. They are also the inefficient field vectors of eggplant mosaic.

Large numbers may appear very quickly. They feed mostly on the young foliage which is exposed to the sun and always upon the upper surface.

These Flea Beetles are easily controlled with Gammexane or Lead Arsenate. Control experiments showed that Gammexane dust gave a 95% kill within 48 hours; Lead Arsenate gave an 80% kill after four days but the effect lasted longer than that of the Gammexane especially when it was applied as a spray and this method gives the best control. Only the upper surfaces of young leaves, which are fully exposed to the sun need be sprayed. Spraying should be carried out when ever the pest is seen to be troublesome.

Many peasants regularly apply Lead Arsenate spray and the plants then have a whitish appearance.

Work on this subject was carried out by Kennard (11).

**Lace Bugs.** These occur on the lower sides of older leaves. They build up in numbers slowly and are rarely serious before the first fruits have been harvested.

The recommended control is gammexane dust which must, of course, reach the under sides of the leaves. This will also control flea beetles whereas the Lead Arsenate will not control Lace Bugs, which are sucking and not biting insects. If therefore both pests are troublesome gammexane is the best insecticide to use.

**Ants.** These are usually troublesome especially at the bases of the plants.

**Mole Crickets.** These are very serious on young plants. Older plants are sometimes attacked during the wet season.

No control is ever practised. Gammexane is generally recommended but experiments are urgently needed here. In any field experiments full co-operation will be obtained from the peasants as this pest
Tomatoes.

General. Tomatoes are grown at Aranguez throughout the year. In the past they were considered the most profitable crop in the area during the dry season.

In the wet season rooting conditions are bad the plants grow very slowly in the waterlogged soil. Insect attacks at the root are common and partly as a result of these various rots occur at the base of the stem. The seedlings are often planted in the wettest places in the field as mentioned under 'Melengens', they are later hoed up into ridges and most of the functional roots are produced adventitiously into this dryer soil. The plants appear very sickly and little crop is produced.

During the dry season growth conditions are almost optimal, cultivations are carried out as in the wet season and, as then, many replacements are necessary due to mole cricket damage, the young stems being eaten through below ground level. A few weeks after planting out these attacks are no longer troublesome. Good climate and soil conditions allow beds of plants to be produced which show promise of a good yield. Due however to the diseases mentioned below this is not attained and tomato growing even in the dry season is not profitable.

Diseases. (See paper by Young (12) and Doolittle (13) for excellent illustrations).

Bacterial Wilt - Xanthomonas solanacearum
Fusarium Wilt - Fusarium lycopersici Sacc.
Sclerotium Wilt - Sclerotium rolfsii Sacc.
Alternaria Leaf Spot - Alternaria solani Sacc.
Leaf Mould - Cladosporium fulvum Cooke.
Viruses

Bacterial Wilt. Xanthomonas solanacearum (E.F. Smith) Dowson.

Incidence. This is the worst disease of tomatoes and is very widespread. It occurs on every bed of tomatoes throughout the wet and dry season.

During the wet season the plants are so unhealthy due to unfavourable soil conditions that the disease need cause little concern.

In the dry season, however, conditions for growth are excellent and until this disease manifests itself the crop appears in excellent heart.
The disease can first be seen attacking scattered plants in the seedbed but the few wilting plants are not conspicuous. If a large group of wilting plants is seen it is usually caused by *Sclerotium rolfsii* (See under 'Beans')

When the seedlings are planted out a healthy bed is at first produced. The progress of the disease is different in different cases. In one particular bed the course of the disease was carefully followed:

**Permanent Vegetable Land.**

1800 seedlings were planted out onto rotatilled land on 1.4.52. The plot was very carefully tended and many replacements were added both as a result of mole cricket damage and bacterial wilt.

<table>
<thead>
<tr>
<th>Date inspected</th>
<th>Av. height of plants in inches</th>
<th>Number missing</th>
<th>% Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 7th.</td>
<td>12</td>
<td>240</td>
<td>13</td>
</tr>
<tr>
<td>May 2nd.</td>
<td>21</td>
<td>649</td>
<td>36</td>
</tr>
</tbody>
</table>

Due to the large number of replacements added during the first few weeks after planting out, the number of plants given as missing may be taken as a very conservative estimate of the number of plants actually killed by the bacterium.

In the example above the disease appeared at a very early stage. On other plots the plants may be starting to set fruit before the disease is seen. This is often the case on rice land and the diseased plants may produce a few small fruit if they are hard and woody at the time of infection.

This disease is probably just as serious on rice as on permanent vegetable land. It appears to be worst however on a few plots of permanent vegetable land where tomatoes have been growing very frequently. In this connection it may be mentioned that peasants tend to specialise in certain crops and so some land grows more tomato crops than other land. This is due to differences in the peasants rather than in the land.

A more careful survey of the incidence of this disease would possibly prove very useful.

**Symptoms.** The descriptions of this disease given in the literature are not wholly adequate for the conditions found in Trinidad. The symptoms recorded are as follows:-
The first signs of the disease appear as a sudden wilt. This is not preceded by any discolouration of the foliage. In a short time the plant is dead. The vessels of the plant are brown in colour. Usually all are discoloured at the base but higher up some only may be diseased. After the discolouration reaches the petioles, pedicels and apex of the plant. The petioles of the lower leaves may be actively downturned. If the stem is cut a glistening grey bacterial ooze may be produced. The infected plants are often stunted but normally this symptom is not seen until the wilt has drawn attention to the plant.

In Trinidad the above description is correct for vigorous succulent plants. In the case of less vigorous woody plants, which are so common here, it is not true. In these plants the disease is seen as a gradual defoliation from the base upwards so that eventually only two or three apical leaves are left. These finally show a slight wilt and the plant dies. Discolouration of the vascular occurs in much the same way as in the succulent plants. (For verification of these symptoms see Expt(I) in which inoculations of the isolated bacteria were carried out).

In many descriptions the bacterial ooze is regarded as an important symptom. In Trinidad even with succulent plants it is rarely seen. It appears more commonly if the plant is well supplied with water at the time of the investigation. Its presence is an excellent diagnostic character; its absence is of no significance.

The roots are not rotted and the dead plants have a firm hold on the ground. This condition allows easy separation of the disease from the attacks of mole crickets on young plants, or the attack of Sclerotium rolfsii when the lateral roots are rotted away;

In the field the outer tissues of the stem may be easily scraped away with the nail and the colour of the vasculars seen. Even on succulent plants little reliance should be placed on the stunting effect of the disease. In inoculation experiments the bacterium can cause death in one week and if this occurs in the field there is little time for the disease to cause stunting.

Discussion. It is this disease which makes tomato production at Aranguez uneconomical. An example of the yield obtained is 100 lbs. of poor quality fruit per acre per fortnight. The plants may produce
for two months giving therefore about 400 lbs of fruit per acre. If the plants are spaced at two foot intervals this makes the average yield per plant slightly over half an ounce. (These figures for yield are not very accurate but they are of the correct order).

At the New Farm a yield of 11,000 lbs per acre is quoted but it would also be well to mention that this disease has now appeared there.

On the lagoon land near San Fernando tomatoes were produced so plentifully fifteen years ago that often there was a glut in March and April. Now no tomatoes are grown there. This is believed to be due to this bacterial disease.

In the past the peasant at Aranguez has placed great reliance on tomatoes as an important cash crop. Inspite of the poor production this year large scale attempts to grow the crop will probably be made for some years to come. If the present bacterial position remains the same he will be compelled eventually to cease growing the crop altogether. Emphasis will be placed more and more on cabbages and melengens. Then after a few years cabbages will probably become uneconomical due to a build up of Black Rot or other diseases. It is hoped that by then the land may once again produce reasonable crops of tomatoes after its long rest from the crop.

Control. It may be argued that the above is a very apathetic approach but this appears to be the only solution so far offered.

As it appears impossible to bring about a long rotation due to economic necessities it is obvious that the matter will either have to be left to the strong arm of nature or active measures must be taken by pathologists. To this end experiments have been carried out at Aranguez into the possibilities of soil sterilisation. Some promising results have so far been obtained and it is hoped to add a short account of these to this thesis.

The problem may be approached by the use of resistant varieties. Many claims of partial resistance have been made in the literature but these are somewhat conflicting and the degree of resistance shown by any variety varies greatly under different conditions. It is probable that no resistant variety exists for Aranguez conditions but a large scale trial of the 'more resistant varieties' might prove
useful. One of these varieties, Louisiana Pink, in trial at Aranguez, proved highly susceptible. It is nevertheless a strongly growing vigorous plant under these conditions if the soil can once be freed from the bacterium.

The question of rotation is discussed later in this work under that heading and under 'Suggestions for the New Farm Area'. A paper on rotation in relation to this disease, giving an account of some work done at the St. Augustine Nurseries, by Thorald (14), is available. However, his ideas on the length of rotation needed are peculiar to himself and are in disagreement with the views of other workers. He experimented with several three-crop-rotations of a total duration of 18 months whereas Bright suggests one of five years (15). Young (12) of the Tomato Disease Investigations Laboratory, Texas, says:-

"Fields in which diseased plants have grown remain infested with the wilt bacterium during the next several years, making them unsuitable for susceptible crops".

Doolittle (15) says:-

"When the disease occurs, tomatoes should not be planted again for 4 or 5 years ...."

Many other similar references could also be given. The size of Thorold's experimental plots was surprisingly small and as he himself states, his results are surprising.

Expt.1.

Inoculation of Tomato Plants with Cultures of \textit{X. solani} obtained from Wilting Tomato Plants at Aranguez.

Five district cultures of \textit{X. solani} were used. They were labelled 64, 69, 70, 71 and 72. For inoculation purposes broth cultures of these isolations were prepared.

Each potted plant was inoculated with five needle stabs into the stem, at from one to two and a half inches above the soil level. The wounds were then covered with vaseline. The plants were kept in a high humidity chamber for 24 hours before and after inoculation. The usual precautions were taken to ensure that the inoculations of one culture were not contaminated by another. Each culture was inoculated into five tomato plants. These plants varied
having come from two sources. Some were small and woody, others were large and succulent. The course of the disease is recorded in the table below where the two types of plant are treated separately.

It can be seen that in the case of the succulent plants a severe wilt was often the first symptom. In some cases this was, however, preceded by a slight wilt. An active downturnning of the petioles was also characteristic.

The woody plants responded by a loss of the lower leaves which was sometimes accompanied by wilting.

This difference in reaction between the two types of plants was not known until the experiment was well advanced. If the experiment were repeated it would be better to have some measure of the succulence of the plant and a record of the number of leaves on the plant at each inspection.

Adequate controls were kept but none of the above symptoms developed on these.
**Large Succulent Plants. - Inoculated 1.3.52.**

<table>
<thead>
<tr>
<th>Culture No.</th>
<th>Dates inspected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2/3</td>
</tr>
<tr>
<td>64</td>
<td>H</td>
</tr>
<tr>
<td>64</td>
<td>H</td>
</tr>
<tr>
<td>69</td>
<td>H</td>
</tr>
<tr>
<td>69</td>
<td>H</td>
</tr>
<tr>
<td>70</td>
<td>H</td>
</tr>
<tr>
<td>70</td>
<td>H</td>
</tr>
<tr>
<td>71</td>
<td>H</td>
</tr>
<tr>
<td>71</td>
<td>H</td>
</tr>
<tr>
<td>72</td>
<td>H</td>
</tr>
</tbody>
</table>

**Small Woody Plants (Controls with about 10 leaves).**

<table>
<thead>
<tr>
<th>Culture No.</th>
<th>Dates inspected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>H</td>
</tr>
</tbody>
</table>

**Key:**
- H Apparently healthy.
- S Slight Wilting seen.
- B Severe Wilting seen.
- D Dead.
- 1, 2, 3 Number of leaves remaining on plant.
- d or p. Petioles actively downturned.
Fusarium lycopersici Sacc.

Incidence. This disease was not seen at Aranguez or the New Farm. It did occur however in some College gardens.

Symptoms. The wilt produced by this fungus is not so rapid as that caused by the bacterial pathogen. Yellowing and death of the lower leaves and a slight wilting are seen for several weeks prior to death. Often the wilting occurs first on one side of the plant only, or even on one half of a leaf. Sections of the stem readily show the fungus in the vessels which are discoloured.

Discussion. Most American tomato varieties are highly resistant to most strains of this fungus and so the disease is not common. It has been described here because the Bacterial Tomato Wilt of Trinidad is so often confused with the wilt caused by this fungus. In the case of the wilting plants found in one College garden, individual plants were found which were suffering from both diseases.

Control. Unnecessary. If the disease is troublesome in any particular area other varieties of tomato should be tried.

Experiments. Many isolates of the fungus were obtained but lengthy reinoculations were not attempted.

Sclerotium rolfsii. Sacc.

Incidence. Rare on older plants, but occasionally seen during the wet season. More common in seed beds.

Symptoms. See under Beans.

Alternaria solani (E. & M. ) Jones & Grout.

Incidence. This fungus is very abundant during the dry season and causes a large amount of damage. At Aranguez serious defoliation and stem lesions were caused on seedlings being used in experiments, and weekly sprayings of Perenox were needed.

Symptoms. This disease is first seen as small irregular brown or black spots on the leaves or stem. Those on the leaves enlarge to form dark brown circular areas up to \( \frac{3}{8} \) inch in diameter. Concentric rings are clearly visible. The enlarging spots may fuse and large areas of affected leaves may become yellow and die. The spots on the stem elongate rapidly usually up to \( \frac{3}{8} \) inch.
The damage is most serious on very young plants. The older leaves are attacked and defoliation from the base up occurs. (cf. Bacterial Wilt.)

Discussion. In recent work by Brian (16) a phytocidal extract was obtained from media upon which the fungus had been grown. Pound and Stahman (17) have shown that this is readily carried in the vascular elements of the plant and is able to cause lesions at a distance. Thus lesions on the stem may cause secondary non-infected lesions in the leaves and may also cause defoliation.

This disease is not mentioned by Bright (13) in his two papers on the diseases of tomatoes in Trinidad. He describes leaf spots caused by Septoria and Phoma which however I have not seen.

Control. Bordeaux will control this and any other leaf spots. An excellent paper on the subject by Horsfall and Heuberger (18) is available.

Cladosporium Fulvum Cke.

Incidence. Very common especially during the dry season when a serious build up occurs.

Symptoms. In its early stages this disease may be recognised, at a distance, by the yellowing of infected leaves. Closer examination reveals patches of greenish-grey powdery mould mostly on the undersides of the leaves. Later the leaves die and become brown and shrivelled.

Control. See under Alternaria solani.

Viruses.

Several viruses attack tomatoes in Trinidad; a curly leaf top form is occasionally seen. Cucumber mosaic virus causing a mild mosaic is common.
Pests.

Mole crickets do serious damage to young seedlings when planted out. Kennard (11) deals with the subject at length, before the advent of the chlorinated hydrocarbons. The control of this and other soil-inhabiting insect pests by the use of Aldrin and Dieldrin will probably be investigated at the New Farm.

Flea beetles are occasionally troublesome on the foliage. Small larvae are sometimes common in the flowers at fruit set and cause the young fruits to drop off the plant.

Several large lepidopterous larvae bore into the fruit. A good control of these was obtained at the New Farm with the frequent dustings of Agrocide. Putter wasps also help in control.

Root Knot Eelworms are often serious; they may also do much indirect damage by providing a means of entry for *Xanthomonas solanacearum* into the plants.
Cucumbers.

General. Cucumbers are a very common peasant crop. They are normally grown on the flat, planted about four feet apart at 3-5 seeds per hole. Often the ground has been prepared for only a few inches around the seeds. They may be grown as the only crop on the land or they may be planted between old Melengens. Cucumbers and Okra are frequently sown together on rice land in January. The seeds may be planted amongst the stubble or the land may have been hoed or rotatilled first. The cucumbers yield the first crop followed by the Okras which remain on the land until rice planting time.

Under the catch-cropping system each plant produces three or four fruits at one time and then yields no more due to diseases and pests. If the crop were intensively cultivated yields of an entirely different order could be produced but many problems would first require attention:

1) Fungal diseases would have to be controlled as they soon become serious and are the chief reason for the low yields of the peasant's crop.

2) By prolonging the life of the crop the build-up in the numbers of insect fruit and stem borers would become very serious.

3) Aphids and weeds would also become troublesome.

However intensive cultivation would produce very high yields especially if the plants were grown up supports to assist in disease and pest control.

Diseases.

Angular Leaf Spot or Clinton's Downy Mildew. - Pseudoperonospora cubensis B.&C.

Powdery Mildew - Erysiphe cichoracearum DC.

Anthracnose - Colletotrichum lagenarium (Pass.) Ell. & Halst.

Cucumber Mosaic.

Angular Leaf Spot Pseudoperonospora cubensis B. & C.

Incidence. This downy mildew is seen on almost all cucumbers throughout the year.

Symptoms. This disease is easily recognised by the conspicuous angular yellow leaf spots. The extent of any one infection is restricted by the larger veins so that only certain inter-veinal areas about one centimetre across are affected. If is severe
small brown dead spots may occur in the centres of the yellow areas and the symptoms may be reminiscent of insect damage. A large area of a heavily infected leaf may die and turn brown in colour. A poor coloured photograph of the disease is given by Ellis and Cox. (19).

The fungus spores on the lower surface of the leaf. The sporing stage is not commonly seen: it is said that it can be found early in the morning while there is still dew on the leaves (19). In the case of an experimental plot of cucumbers mentioned below, the dark powdery spores could be seen without difficulty throughout the day; this is most exceptional. The sporangiophores appear much as those of Phytophthora spp. but the angle of branching is greater. The spores are oval and almost black in colour.

Discussion. This is troublesome in the S.E. of the U.S.A., where it is considered to be a disease of wet weather and it is held in check by dry weather. The spores are said to germinate only in the presence of free water (19). Here dry weather does not control the disease.

Control. In North Carolina control is carried out by dusting with tribasic copper sulphate but this is expensive (See also ref. 20 for control in Florida).

An experiment on control at the College is given below. Later it was discovered that resistant varieties of cucumber had been bred in Puerto Rico (21). These resistant strains labelled No. 39 and No. 40 have shown themselves superior to the normal commercial varieties in Puerto Rico, although the latter received Bordeaux Mixture to control the disease. It is hoped that seed of these varieties will be imported and tested here.

Experiment. P.T.O.
The Control of Angular Leaf Spot of Cucumber (*Pseudo
peronospora cubensis*. B. & C.) by the Use of Certain
Sprays, and the Effect of Mosaic Virus on Yield.

By

A.D.S. DUFF and W. HIRST.

**Layout.**

The experiment was laid out on a statistical
basis, using a randomised block with split plots design,
the plots being split for virus free plants, and plants
inoculated with virus. Analysis was to have been carried
out on the yields of fruit produced.

There were five blocks. Growth of the plants
on three of them was so poor that they were abandoned
before the experiment was completed. The results obtained
from the two remaining blocks cannot be analysed statisti-
cally.

Each block was laid out as below, with the treat-
ments applied at random.

<table>
<thead>
<tr>
<th>Spray I</th>
<th>Spray II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virus *</td>
<td>No Virus *</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Virus No Virus Virus No Virus

Spray III No spray

* plants
Cultivation.

Seeds were set on the flat at 3 per hole on 7:3:52. Later the plants were thinned to 2 per hole, and the plants were ridged.

The plants on 3 of the blocks made little growth because of:

1. Insufficient watering during a very dry period.
2. Strawy manure having been placed in a hole beneath the site of each plant. This rotted quickly and left a large air space in the ground beneath each seedling. This added to the conditions of drought.
3. Attacks by millipedes.
4. Attacks by aphids (Controlled by a Nicotine Sulphate spray. 1:500).

The two remaining blocks grew well, being in a damper area of the field.

Treatments.

Fungus. - Natural infection occurred. The fungicides used were:

- Perenox 17 gms/gallon (6 ozs/10 gals.)
- Blitox 13.6 gms/gallon (3 lbs/100 gals.)
- Shirlan 10.6 gms/gallon (1 1/2 ozs/4 gals.)

These were applied weekly from 12.4.52. The amount required varied with the foliage present at the time of each application, the range being 70 - 160 gallons/acre. Spraying was carried out to give 100% cover, particular attention being given to the under surfaces of the leaves.

Virus. - Virus was applied to the plants by leaf inoculation at the cotyledon stage. 80% infection was obtained. The strain of the cucumber mosaic virus used was T1 (Dale). A little spread due to greenfly occurred but this was controlled by Nicotine Sulphate sprays.
Results.

Although the results cannot be analysed statistically, some useful information has been gained.

Appearance - Before the three blocks were abandoned on 26.4.52, after two sprayings, each plot was scored by eye for the severity of leaf spotting. Blocks were considered separately and the values 1, 2, 3 or 4 were allocated, one to each plot. 1 donated the plot which was least infected, 4 the most. Summation of the scores for each treatment gave:-

Perenox - 6
Blitox - 10
Shirlan - 17
Control - 17

Yields.

The weights of fruit, in ounces obtained from the two blocks were:-

Blitox - 393
Perenox - 276
Shirlan - 264
Control - 194

With respect to virus treatment, the yields were:-

Non Virus - 691
Virus - 436

There was a continuous heavy source of fungus infection within the bed. These conditions give fungicides a severe test. Until damp weather set in about 1.5.52, the Perenox treatment was definitely superior to the others, as judged by size, vigour, fruit set and absence of excessive leaf spotting. All the other plots were seriously affected
by the disease. Blitox was better than control but much worse than Perenox. Shirlan was no better than control.

After the damper weather appeared, all blocks became severely infected, and fruit development ceased.

The yields of fruit obtained suggest that Blitox is the best spray, but too much significance should not be placed on these figures: at the onset of wet weather, "Blitox", "Shirlan" and "Control" had almost finished their productive life, whereas the "Perenox" was apparently only then coming into full production.

The virus treated plants were in all cases very much smaller and less vigorous than their neighbours; this is reflected in the yields obtained.

**Conclusions**

1. Of the fungicides tested, Perenox appeared the most satisfactory. It will control *Pseudoperonospora cubensis* in dry weather, in spite of abundance of inoculum.

2. Cucumber mosaic virus seriously reduces the yield of infected plants.

This problem merits further work, but the question of resistant varieties ought to receive attention first. (See discussion).
Powdery Mildew *Erysiphe cichoracearum* DC.

**Incidence.** Normally this disease is seen only during the wet season, it is then worst during very damp weather. Under such conditions all plants are infected. After a few dry days the trouble seems to disappear but after a further 24 hours of wet conditions the sporing mycelium reappears and is as abundant as ever.

One severe case of the disease was reported during the dry season at the College. This was caused by the gardening boy indulging in excessive spraying of the foliage.

**Symptoms.** The fungus is seen as a powdery grey coating on either surface of the leaves, occurring most abundantly on those which are in the damper positions.

**Discussion.** This disease is serious during the wet season.

**Control.** If the plants could be grown up supports the disease would be less severe for the conditions would be dryer, but this method is probably only possible on a garden scale.

Spraying with such sulphur sprays as Shirlan is probably worthwhile if the crop is otherwise healthy and vigorous.

Experiments on control in Egypt by Fikry are given in ref. 22.

**Anthracnose.** *Colletotrichum lagenarium* (Pass.) Ell. and Holst

**Incidence.** This disease is not common and was only seen during the wet season.

**Symptoms.** Round brown dead spots 1-2 cm. in diameter are formed on the leaves. The edge of the spot is not so irregular as in the case of a severe attack of downy mildew. The fungus was not found sporing.

**Discussion.** The pathogen was readily isolated. Few spores were produced in culture and reinfections were not attempted.

**Control.** Unnecessary. The disease is not serious.

**Cucumber Mosaic.** (23)

**General.** Widespread in Trinidad. At Aranguez possibly 5% of the plants are infected.

**Symptoms.** Infected plants are usually much smaller than healthy ones and are of reduced vigour. The very young opening leaves, when about \(\frac{3}{4}\) inch across, show one or two small light spots and at a later stage, a more or less distinct mosaic. The older leaves are usually distinctly mottled but in some cases this is not obvious.
Discussion. This virus is transmitted by Aphids. The vector in question is *Aphis gossypii* Glov. (Ref 24) An Aphid believed to be the latter is common in the area and has been shown to transmit the disease freely (Ref. 25). In the experiment on the control of Angular Leaf Spot an attempt was made to discover the diminution in yield caused by one strain of this virus.

Control. There is no practicable control for this virus. It has also been shown to occur on *Commelina diffusa* Burm.F., *C. elegans* H.B.K. (Ref 25) and *Alternanthra ficoidea* L. These are very common weeds and so there may be a source of virus close at hand to new plots. Alternatively the Aphids can travel large distances by wind. See ref. (21) for resistant varieties.

Pests.

Greenfly are often troublesome but satisfactory control is easily obtained by using a nicotine sulphate spray. Possibly the major damage done by the Aphids is the transmission of mosaic virus. Millepedes sometimes do damage to young plants.

A lepidopterous caterpillar burrows into the fruit and causes rots to begin. If spraying of this crop, for any pest or disease, is carried out, then spraying for this pest must also be considered.
Baji or Bañal Spinach. *Amaranthus viridis*.

**General.** This crop is usually planted in odd places such as at the ends of beds.

**Diseases.** *Sclerotium rolfsii* Sacc.  
*Cercospora* sp.

**Sclerotial Diseases.** *Sclerotium rolfsii* Sacc.

- **Incidence.** Up to 20% of the crop may be killed in the early stages.
- **Symptoms.** See under Beans.

*Cercospora Leaf Spot. Cercospora* sp.

One brown leaf spot was once seen and this yielded *Cercospora* spores in scrapings.

---

**Lettuce.**

**General.** This crop is grown on raised beds about three feet wide resembling seed beds. The crop is transplanted and a little manure is added to each hole. No diseases were ever seen on it and any good soil will produce good lettuce, although these will not heart. This is apparently due to the wrong day length and breeding might here prove useful.

---

**Celery.**

**General.** Celery is only grown on the peat soil at the west end of the Aranguez estate. It is grown for its leaves and not its stem.

**Diseases.** *Cercospora Leaf Spot. Cercospora* apii Fr.

- **Incidence.** This disease is seen throughout the year.
- **Symptoms.** Somewhat irregular light brown spots occur on the leaves and are usually surrounded by a chlorotic zone. Only the older leaves are attacked unless the disease becomes more serious when all the leaves are infected.

**Discussion.** This fungus is probably seed-borne for it usually occurs on celery wherever it is planted and yet there are few available alternative Umbelliferous hosts.

**Control.** With such a high value crop spraying should be
worthwhile whenever the disease appears to be increasing. Bordeaux or any other copper spray should be effective.

---

Chinese Cabbage.

Little attention was given to this crop and no diseases were seen upon it.

---

Sweet Potato.

General. This crop is planted as cuttings on very high ridges in the belief that these reduce the amount of insect damage. After planting, the crop is usually forgotten until harvest time. Little is grown and the crop is not very remunerative.


Incidence. Very common throughout the year.

Symptoms. This disease is seen as white waxy raised pustules on the lower surfaces of the leaves. The spores appear to be eaten by some insect.

Discussion. Not serious.

Control. Unnecessary.

Pests. Numerous leaf feeders exist and many holes are always seen in the leaves; borers in the tubers cause serious trouble. Economical control is impossible.

---

Carrots.

General. These are very little grown although the soil appears very suitable during the dry season.

Diseases. Alternaria sp.

Incidence. This disease often kills whole crops of carrots during the wet season. It is less common during the dry season and did not occur at the New Farm.
Symptoms. Small brown spots first appear on the leaves but usually the disease is not detected until some leaves are completely shrivelled brown and dead. The spread may then be very rapid, especially during wet weather.

Discussion. Possibly seed borne - see under Celery.

Control. Spraying for this disease would be worthwhile (Bordeaux or other copper fungicide.) Early application of the spray would be essential.

Pests. Very rare.

---

Okra. Hibiscus esculentus Linn.

General. Okra is mostly planted on rice land, with cucumber, at the beginning of the dry season. (See under cucumbers). However, it may be planted at any time of the year on permanent vegetable land. It is not regarded as a highly profitable crop but rather as a crop which requires little attention once it is established, beyond picking the fruit.

Diseases. Cercospora Leaf Spot - Cercospora hibisci Tr. & E.
Okra Wilt - Fusarium vasinfectum Atk.
Okra Mosaic.

Cercospora Leaf Spot. Cercospora hibisci Tr. & E.

Incidence. Not common, seen mostly during the wet season.

Symptoms. Different varieties of Okra show different symptoms. This was clearly demonstrated on one occasion when two varieties were growing together.

The variety with a red petiole showed the presence of the fungus over most of the under surface of the leaves. It occurred in patches about \( \frac{1}{2} \) cm. in diameter and many lesions were touching. They were at first dirty yellow, and later turned grey from the centre outwards due to the presence of mycelium on the surface. The appearance was that of a Powdery Mildew. At a late stage the central areas died.

The other plants had green petioles. On the lower surface the yellow areas were seen as before but these soon turned black in patches due to the death of the tissue. The grey stage did not
develop. This appears to be a case of hyper-sensitivity.

**Discussion.** The symptoms are not those usually associated with a Cercospora Leaf Spot.

**Control.** Unnecessary. If the disease should become troublesome variety trials should be tried.

**Okra Wilt.**

Although this disease was said by Todd (26) to be widespread and serious in Trinidad, it was not seen during the present survey; a few wilting plants may have escaped attention during the wet season when many Okras are old and unhealthy.

**Okra Mosaic.**

**Incidence.** Very common, most plants are infected.

**Symptoms.** A severe mosaic and yellowing of the leaves.

**General.** Little is known about this disease; its effect does not appear very serious and its vector is unknown.

**Peppers.**

**General.** These are a common crop especially during the wet season.

**Diseases.** Sclerotial disease is often serious (See under Beans) and an Anthracnose occurs on the fruit. Full details of these and other diseases are given by Weber (27). A mosaic virus is occasionally seen.
Part I

General Considerations.

The Economics of Peasant Vegetable Production.

The economics of vegetable production at Aranguez is dealt with at length by Bell (28). He gives many interesting statistics, but, as he himself suggests, the accuracy of his original data may be questioned. Of the 20 peasants he studied the average "Net Agricultural Income per Man-day Available" was $1.70. Of course, figures are not available for income per hour actually worked. There are many very different ideas as to the amount of profit to be derived from market gardening but the above figure suggests to the economist that the Aranguez peasant is better off than many. It appears that the peasant has to work hard for what (to him) is a reasonable income, and for the privileges of an independent existence. Undoubtedly there is much unused time and more planning of time and crop is needed. The college experimental holdings are producing much information on this subject.

Details of Cultivation.

Cultivation methods have been briefly given for each crop under the individual headings. A more general account is given by Kong (29). He gives a good picture of vegetable growing at Aranguez. Disagreements on certain points and certain changes due to time are however recorded below (in the order in which they occur in the above thesis).

1. The essential drawback to split-ridging, as practised by the peasants, is not given. In the present paper the matter is discussed under 'Welengens'. (Kong P 10).

2. Weeds in seedbeds are not serious (Kong P.11)

3. Only ammonium sulphate appears to be used as a fertiliser. Kong speaks of the indiscriminate use of any of the three major fertilisers (P.14).

4. The Cabbage White butterfly was not serious during the period under study. (Kong p.17).

5. The statement that much disease occurred in overwatered seedbeds was not true for the period of the present study. Very liberal watering was practised. (Kong P.18)
6. Tomatoes are now planted at 2-3 per hole rather than 4-6 (Kong P. 19).

7. Kong suggests that tomato seed is stored by the peasants year after year. (P. 20 & 22) This is not now generally true; fresh seed is bought about every three years and home produced seed is used for the intervening periods: the peasant is a strong believer in the theory of 'running out'.

8. Witches Brooms on Melengens readily set fruit (Kong P. 20) these however rarely mature due to the early death of the broom.

9. Lacebugs do not produce the shot-hole-effect on Melengens (Kong P. 20.)

10. There is no estate mechanisation. (Kong P. 27). The Company owning the estate wishes to have as little to do with vegetable production as possible. The two rototillers, at present operating, belong to peasant contractors.

11. The Cooperative Scheme soon came to an end due to the inability of the peasants to agree amongst themselves.

It is hoped that these facts will add to the usefulness of the account by Kong. Several other similar theses are available, but it is remarkable that although diseases play so great a part in the production or destruction of vegetables, no mention is made of them.

Rotation.

The amount of labour put into the production of crops at Arancuez is large and for this reason only high value crops are a commercial proposition. These crops are tomato, melengen and cabbage. Rice is also grown for home use. Ochroes and beans are not very profitable. Cucumbers are usually grown as a catch crop: the soil is not sufficiently fertile for water-melons. Bahgi spinach is planted in odd places as a vegetable of little account. Seet potatoes are the only root crop grown and they are not very valuable. Small quantities of other plants are grown including odd herbs for the different racial people.

Cabbages, tomatoes, eggplant and rice therefore form the main basis of the economy of the peasants and any rotation must be built around these crops. This year tomatoes have yielded little profit due to bacterial wilt. The only possible control at the moment is a five year rotation with tomatoes occurring only once in that time.
Melengens are also slightly susceptible to the disease. These can be included in the rotation and if diseased plants were carefully removed they would not add to the build up of the bacterium in the soil. If they are grown immediately following tomatoes they would do least damage in this respect. We have therefore this tentative rotation for rice land during the dry season:—

1. Tomato
2. Melengen
3. 
4. 
5. 

Cabbages are the other profitable crop and in this respect Black Rot control must be considered; investigations are required to find how the disease is spread. They can at present be placed at 3 and 5 in the rotation to give:—

1. Tomato
2. Melengen
3. Cabbage
4. 
5. Cabbage

This leaves one place in the rotation for other crops. Some scheme along these lines can easily be devised. This rotation is however very tentative and more knowledge of the incidence and means of spread of bacterial wilt disease is needed before it can be advised with confidence (See p. 9)

Suggestions for the New Farm Area.

The New Farm Vegetable Area only came into production at the beginning of 1952. At the time of writing wonderful progress has been made and work has gone well ahead with variety trials and other cultural experiments.

From the disease aspect it is most fortunate that the prevailing wind blows from the New Farm towards Aranguez and so the area will rarely be inundated with clouds of spores from the peasant holdings; probably with wind borne spores the main danger will be due to a build up within the area itself.

The diseases of this type which will become troublesome are;
Soil borne diseases must also receive attention. *Sclerotium rolfsii* may build up in the soil to serious proportions and, if this occurs a rotation of susceptible and non-susceptible crops must be devised. Bacterial wilt of tomatoes already occurs in the area and its damage at the moment is noticeable but not severe. Recommended control measures are:

1. Never grow tomatoes on the same spot more than once in five years. Whether this is practicable or not is of no concern; it is a necessity.

2. Great care must be taken to level the beds so that damper areas do not exist for disease appeared worst in such places.

3. The ability to recognise the disease in the field is necessary and all plants showing symptoms should be pulled up with as many roots as possible and burnt or left to dry in the sun on waste ground.

4. A drying and thorough aeration of the soil, when the crop is removed, might be beneficial and is worth carrying out by frequent ploughings, in dry weather, if time permits.

5. Posts used on one tomato crop should be left to dry out thoroughly before being used again for tomatoes.

Black rot of cabbage has not yet been seen on the area but may appear at any time and it is hoped that further research on this problem will suggest a control.
Pests and diseases are not given the consideration which they merit. Any reasonable methods of cultivation will produce large crops of vegetables under Trinidad conditions if the crops are not attacked by pests and diseases. The problems which these present should be the primary concern of the vegetable grower. If investigations into cultural techniques are not approached from this angle they will be a waste of time. This however is not the view of the agriculturalist and time alone will be the arbitrator.

The Present State of Knowledge of the Peasants.

The simple principles concerning diseases are very imperfectly understood by the peasants and others. Whereas in England in the past most diseases were blamed directly on the weather, here in Trinidad they are almost entirely blamed upon the 'Control Board'. This is for the most part a false accusation and appears to be a relict of the war years when apparently some very poor seed was imported. Alternatively, diseases which are obvious to those interested in Pathology are accepted by the peasants as 'just the way the plant is'. For example the very obvious and common Mosaic Disease of Ochroe is regarded as a natural phenomenon; Cercospora Leaf Spot of Beans or Celery is thought to be 'just a dying of the older leaves'; Cucumbers suffering from severe attacks of Psuedoperonospora are considered to be 'just dying off' (having finished their natural growth cycle, and incidentally having given a very poor yield); Cabbage seedlings severely attacked by Peronospora parasitica are simply 'beaten down by the rain'.

With the limited time at my disposal I found it almost impossible to explain the fundamental concepts of plant pathology to the peasants. Demonstrations are first needed and for this the control of mildew on cabbage seedbeds offers an excellent opportunity.

Pests, due to their larger size, are better understood but even here much work is needed in evolving control measures and explaining them to the peasants, who will readily listen on the subject of insects.

The peasant knows very little about suitable varieties: the principles which should govern the application of fertilisers are totally unknown to him. The only fertiliser in common use is
sulphate of ammonia, which is commonly called salt.

Work Required in the Future.

Work is urgently required on four major aspects of vegetable production:

1. Pests
2. Diseases
3. Varieties
4. Fertilisers

The problems of pests and diseases have been discussed above. The question of suitable varieties requires much attention. Variety tests are needed in the field under peasant conditions and every possible help may be expected in this direction from the peasants themselves. For example, tests of tomato varieties in the dry season with overhead irrigation are of little value to the small holder who is often faced with a water shortage.

The principles governing the application of different fertilisers should be explained to the peasants; suitable mixtures should be compounded and they should be encouraged to try them.

Extension Work.

None of the facts given above will be of any value, nor will any work which may be done in the future, unless the information is taken to the peasants. The Indian peasant cultivators at Aranguez are genuinely ready to listen to, and act upon, advice given to them. They have cooperated with me to a most remarkable extent and here are a set of people who are very suitable for extension work. Statements that they will not accept sound advice, and will not act upon it, are totally false. The question may well be asked as to what sound advice we have to offer them at the moment. More field research is first needed. (I have found several peasants who are happy for field experiments to be carried out upon their own land). The research must be followed up by extension work.

It is here relevant to state that my questioning has not yet revealed a peasant who knows the meaning of 'Agricultural Officer', let alone the name of the person in charge of his district.

Any Agricultural Department Adviser for the area should live on the area and cultivate a plot of ground there himself and so
help the peasants by demonstration. If his crops are better than those of the surrounding peasants they will eagerly come to him for his advice; if his crops are no better, or worse, there is but one alternative.

It is possible that in the future the New Farm will have an important function as a demonstration area. It is hoped that cordial relations will be established with the peasants.

Most people are very specific about the whole situation. The Department of Agriculture has attempted to increase production by the cultivation and raising plants at the New Farm, by the publication of elementary books, and by the establishment of demonstration areas. No effort has been made to increase production by giving technical assistance to the peasants. The present method is having little success at fertilization by the conventional means of vegetables.

If the present work is urgent, the urgent need of the peasant student for technical assistance has been shown many times. The general standard of cultivation of the peasant is very high and can be bettered only by knowledge of the following subjects:

1. The use of disease and disease control.
2. The best crops and best culture.
3. The best varieties to grow.
4. The exact use of fertilizers.

If the small available efforts of the Department of Agriculture are not directed toward the accumulation and dissemination of knowledge on the above subjects, instead of producing individual results, fundamental data based on the vegetable situation in Trinidad would appear more healthy.

It must, however, be realized that without such careful experimentation and study of peasant conditions, the actual advice to offer will be very scanty.
Conclusions.

The facts given in this thesis do not present a bright picture. In any large area, where vegetables are cultivated intensively, many problems of pests and diseases are sure to occur. This is especially true when no attention is given to them. If vegetable production is to be a profitable concern, then either a plentiful supply of good new land must be made available or modern methods of pest and disease control must be applied. In Trinidad the former alternative is impossible, and the latter appears improbable.

Most people are very apathetic about the whole situation. The Department of Agriculture has attempted to increase production on the 'Back garden scale' by raising plants at the St. Augustine Nurseries and by the publication of elementary 'Grow More Food leaflets' intended for the novice. No effort has been made to increase production by giving technical assistance to the peasant vegetable producer. The present policy is having little success as is evidenced by the phenomenal prices of vegetables.

In this present work the urgent need of the peasant gardener for technical assistance has been shown many times. The general standard of cultivation of the peasant is very high but he badly lacks knowledge on the following subjects;

1. The facts about diseases and disease control.
2. The facts about pests and pest control.
3. The best varieties to grow.
4. The correct use of fertilisers.

If the small available efforts of the Department of Agriculture were directed towards the accumulation and dissemination of knowledge on the above subjects, instead of producing subsidised seedlings for 'gentlemen in cars' the vegetable situation in Trinidad would appear more healthy.

It must however be realised that without much more experimentation, and study of peasant conditions, the actual advice to offer will be very scanty.
References.

Beans.

Cabbage

Tomato


Cucumbers.


Okra.


Peppers.


Economics of Vegetable Production.


Vegetable cultivation.