A LEAF CURL DISEASE OF TOMATO AND ITS RELATION TO SOME OTHER PLANTS

J. W. L. PEIRIS, B.Sc. (Lond.)
RESEARCH ASSISTANT IN PLANT PATHOLOGY.

Complaints have been received from time to time of a common disease of tomato (*Lycopersicum esculentum Mill.*) which caused a general stunting of the plant, a curling and bronzing of the leaves and which sometimes even brought on a die-back ultimately resulting in the death of the plant. In the early stages, the disease led to a certain amount of speculation as to whether it was caused by a virus (specially as leaf-curl diseases were originally believed to be of the virus complex) or whether it was a nutritional deficiency. Later investigation however, the results of which are outlined in the present communication, revealed that the malformation was due to the injury caused by a species of mites and that the disease is communicable to a number of other plants.

The type of leaf curl caused by mites may affect a tomato plant at any stage in its life history after the first few foliage leaves have expanded. The symptoms manifest themselves conspicuously on the apices of the terminal or axillary shoots. Here the leaflets are curled and distorted and their lower surface presents a ribbed appearance owing to the buckling of the intervenial areas. The rachis on which the leaflets are borne shows a downward curving and the margins of the leaflets themselves show a general tendency to curve downwards or abaxially. When young leaflets are infested, the petiolar end is first involved and the margin of the blade in this region more often curves upwards giving the leaflet a "shovel-shaped" appearance. The abaxial curving is specially characteristic of those leaflets that are attacked when they are more than half grown. These leaflets also present a peculiar shiny or "glossy" appearance on their lower side. This is by far the most characteristic feature of the disease. Subsequently the affected leaflets become "bronzed" or fawn-coloured. This is at first noticeable on the lower surface but may later spread to the upper surface where it can occur in patches or involve the leaflet completely. Generally the part of the stem bearing the malformed leaves is also "bronzed" and the affected stems and leaves are smooth to the touch. At a later stage in the course of this malformation the leaflets are thickened, attenuated and reduced to such brittle, scale-like structures that the plant is only recognised with difficulty. A die-back very often follows and although the plant attempts to survive by throwing out axillary shoots, these are involved in turn and follow the same fate as the main shoot, before they have grown a few centimetres. If the plant has been able to set any fruit in spite of the attack, these also may be attacked. Such fruits develop a russetting instead of the normal shiny, smooth skin

that is characteristic of healthy fruit. The skin becomes more or less corky and rough accompanied by cracking and, though edible, the fruits thus affected are unsightly and have poor marketable value.

To the naked eye there does not appear to be any visible cause which may account for this malformation, but if the lower surface of a diseased leaflet were examined closely with a lens, numerous minute crawling mites may be seen in various stages of their life history. The mites have smooth glistening skins. They are hyaline when young with three pairs of legs but possess a clear light-amber colour and four pairs of legs in the adult stage. Numerous eggs are present firmly attached to the lower surface of infested leaflets and are recognised as whitish rounded-oval objects with a peculiar sculpturing on the wall. The larva comes out through an irregular tear on this wall which persists for some time showing rows of tiny white globules which form the sculpturing on the empty transparent egg case. Careful examination of the affected plants revealed no other organisms, (bacteria or fungi) which may be associated with this malformation and the root systems of these plants were quite normal. The mites are present in sufficient numbers to suggest that the malformation of the plant is due to the mechanical injury caused by them. The mere presence of the mites, however, is not considered enough evidence to incriminate this organism and inoculation experiments were carried out to confirm this observation.

Three weeks old healthy tomato seedlings of the Marglobe variety were transplanted into pots containing garden soil well mixed with cattle manure. Three of these pots were used, each containing five plants. After a week the plants had established themselves they were sprayed with a wash made up of ($\frac{1}{2}$ oz. sulfinette in 1 gallon of water). The pots were then covered with insect proof cloth cages and marked A. B and C respectively. Except for a few minutes in the morning when the plants were watered, they continued to be under insect proof conditions for the duration of the experiment. Three weeks later, when the plants were six weeks old the ten plants in pots A and B were inoculated with mites from tomato leaves showing the symptoms described above. The diseased leaflets were first carefully examined under the binoculars to make sure that they only contained mites and their eggs and these were placed on the apices of the plants to be inoculated. About five or six such leaflets were used on each plant in the pots A and B. Similarly some leaflets from a healthy tomato plant and not containing mites, were placed on the control plants in pot C. The three pots were then returned to their insect proof cages.

At the end of two days all the leaflets used for inoculation, which were by this time dried up, were removed and the plants were examined with a lens. In the case of plants in pots A and B (which were inoculated with material from diseased plants) the mites had migrated to the terminal shoots and had settled down to feed on the young leaflets. Already on the lower surface of these leaflets tiny " water-soaked " or oily spots were visible at the places where the mites had fed. The examination of the control plants in pot C showed no signs of disease.

On the fifth day after inoculation all the plants in pots A and B showed marked symptoms of the malformation. The oily spots had spread into

large patches on the lower surface and a shiny or glossy appearance was observed on most of the affected leaflets. The petiolar end of the infested leaflets were curled upwards. The apex of the terminal shoot had been involved and the growth retarded as compared with the controls. Nine days after inoculation the plants in pots A and B were suffering severely from the infestation. The older leaflets were curved abaxially (downwards) while the younger leaflets were much thickened, brittle and distorted. Of the ten plants, seven showed a die-back of the terminal shoot. The photograph taken at this stage shows the stunting of the plants as compared with the controls (Fig. 2).

At this stage the plants in pot A were sprayed with the sulfinette wash mentioned earlier and returned to the insect-proof cage. The pot B which contained the second set of infected plants was not sprayed and left as control. The next day the sprayed plants in pot A were examined with a lens and it was observed that almost all the mites were dead. These plants were sprayed again after examination. A week later the plants were examined once more. The unsprayed plants in pot B had ceased growing in height. The axillary buds that had attempted to shoot out were attacked by mites, bronzed and attenuated. The sprayed plants in pot A, on the contrary, had considerably recovered. Where the terminal shoots were dead, new axillary shoots had developed and in the less seriously damaged plants of which there were two, the new expanding leaves of the terminal shoots were quite normal. A fortnight after spraying the plants in pot A had all put out fresh bursts of healthy foliage in contrast to the unsprayed plants in pot B. The controls in pot C, however, which had not received any check to growth from the beginning of the experiment, were the best in growth. The comparative growth of plants in pots A, B and C at this stage could be seen from the photograph (Fig. 3). From the foregoing evidence it seems reasonable to conclude that the type of malformation described earlier in this paper is due to the direct injury caused by a species of mites and that the malady could be easily checked by the use of a suitable spray. The possibility that it is caused by a virus of which the mite is the vector and which does not become systemic but is localised in the infected leaves, though not completely precluded, is very remote.

CONTROL

Infestations of mites occur chiefly during the drier months of the year and during these periods they may rapidly spread from small foci of infection till they involve large patches in the field. Heavy showers of rain have been observed to check the spread of mite attack and it seems probable that the mites are washed down by the rain. They are so tiny that they may be inadvertantly carried from diseased to healthy plants on the cultivator's hands while tending the plants. It is also possible that they are carried about on insects, specially ants, which are generally found in association with them. A sulphur spray such as sulfinette has been found to readily control the disease, and probably any sulphur spray or nicotine wash would be just as effective. In the case of badly affected plants it is advisable to nip off the curled leaflets first and the spray should be directed specially on the lower surfaces of the leaves. Two sprays at an interval of about three

days is generally found sufficient. If a careful watch is maintained on the crop from an early stage, and the spray applied at the first appearance of symptoms, the disease is checked with the least trouble. Sulphur dusting is equally effective and would perhaps appeal to owners of garden plots. After the badly curled leaflets have been plucked off, finely ground sulphur tied up loosely in a piece of muslin, is suspended from a stick, and shaken among the foliage. A fine cloud of sulphur dust is thus created which settles on the surface of the leaves and stem.

OTHER HOSTS

Malformations similar in general appearance to that described for tomato have been frequently observed on other plants. One of the more important crops that has been observed to suffer from mite attack rather severely in the dry seasons is Chilli (*Capsicum annum, L.*) In certain cases whole patches of plants in a field may be infested and the crop reduced to less than 50 per cent. The abaxial (downward) curling of the leaf blade is more constant in Chilli than in tomato, even the youngest leaves in the former showing this symptom. The bronzing is chiefly restricted to the lower surface of the leaves which lose their flexibility and become thick and brittle. Cowpea, (*Vigna sinensis*) exhibits symptoms rather similar to tomato. The colour of the infested plants is paler than that of healthy plants and the bronzing and shiny appearance of the leaves are a constant feature. The older leaves as in tomato, are invariably curled downwards while the younger terminal leaves may be ribbed and distorted in various ways.

Cross inoculation experiments were carried out to determine whether the mites causing the leaf-curl of Chilli and Cowpea could induce the same malformation on tomato. Six weeks old tomato plants of the Marglobe variety, planted in pots and maintained under insect-proof conditions as in the earlier experiment, were used. One set of five plants was inoculated with cowpea leaflets showing symptoms of the disease and containing mites, while another set was similarly treated with material from infested chilli plants. A third set of plants was maintained as controls. Within four days all the plants whether inoculated with cowpea or chilli mites showed incipient signs of disease. After ten days the symptoms were very severe and exactly similar to those observed when tomato plants were infested with mites from diseased tomato itself.

It has not been possible to establish whether the mites concerned in the cases of tomato, chilli and cowpea were identical, but it is clear that the organisms from cowpea and chilli could attack tomato and very probably the reverse too is possible. In addition to these, Cape gooseberry (*Physalis Peruviana, L.*) spinach (*Basella alba, L.*) Dambala (*Psophocarpus tetragonolobus, D. C.*) Potato (*Solanum tuberosum, L*) and tobacco (*Nicotiana tabacum, L*) have been observed to harbour mites and show symptoms that are characteristic of mite infestations. It is very probable that the host range is much wider.

DISCUSSION

In 1918 Carpenter described a disease of Irish potatoes from Hawaii. The disease was new to Pathologists and caused the drying up and the death of the affected plants, from the growing point downward. The young leaves

of both terminal and axillary shoots became bronzed on the lower surface and twisted and curled upon the longer axis ; both leaves and shoots became abnormally hirsute and soon withered and died. The disease was associated with a species of mites which were found in sufficient numbers on the infested plants to warrant the conclusion that the disease was due to mite injury. He observed that tomato had also been attacked by mites apparently of the same type. Reddick (1938) also described a disease of potato similar to the above which spread to tomato, Datura stramoniun, Physalis spp : and to Capsicum annum (Chilli).

The symptoms of the mite disease of tomato recorded in this communication correspond with those described by these two workers on potato and tomato. The hirsute conditions of the leaves and shoot described by Carpenter, however, is not a feature of the malformation described in this paper. On the contrary those parts of the plants that are attacked show a smoother appearance than that of normal plants.

A new leaf-curl like disease of Tobacco in Formosa showing similar symptoms to those on tomato described above, was originally thought by Matsumoto (1939) to be due to a new virus, but subsequently the stunting, curling and glossiness of the plants were proved to be due to mites. In India, mites have been known to cause the " Tambera disease " of potato and the " Murda " disease of chilli. Mann et al found the former to be a very serious disease in the summer crop of potato in the whole of the Poona district, while according to Kulkarni, the extensive damage caused by the Murda disease of pepper was caused by the same organism.

A type of leaf-curl of chilli in Ceylon characterised by the abaxial curling of leaf-blades was proved by Park and Fernando (1938) to be the result of direct mechanical injury due to insects. Johnpulle (1939) incriminated a species of thrips as the offending insect in this connection, but no malformation resulted when mites were used for inoculation. The leaf-curl of chilli described here as being communicable to tomato and causing on it the leaf-curl which is the subject of this discussion, is very similar to that described by these three workers in most of the symptoms but differs in that the injury caused by mites is always characterised by the glossiness and bronzing on the lower surface of the affected leaves. Cherian (1936) also reports a leaf-curl disease of chilli in India caused by a species of thrips, *Scirtothrips dorsalis*. Hood. The nature of the damage caused by this insect is different to the mite injury described in this article. From the symtomatic picture as well as in its association with mites, the tomato leaf-curl described in this communication is identical with that of potato and of tomato of Reddick, the " Tambera " disease of potato of Mann et al, and the " Murda " disease of chilli of Kulkarni. It is, not known whether the same arachnid is concerned in all these cases. The identity of the mite, however, is evidently the concern of a specialist and is perhaps only of acadamic interest.

Two types of leaf-curl diseases have been recorded on tomato in Ceylon. In order to control these malformations, it is very necessary to carefully distinguish them from each other. The type that is described in this paper as induced by mites, is characterised by a general abaxial curling of leaflets, bronzing and glossiness of the lower surfaces of these and often

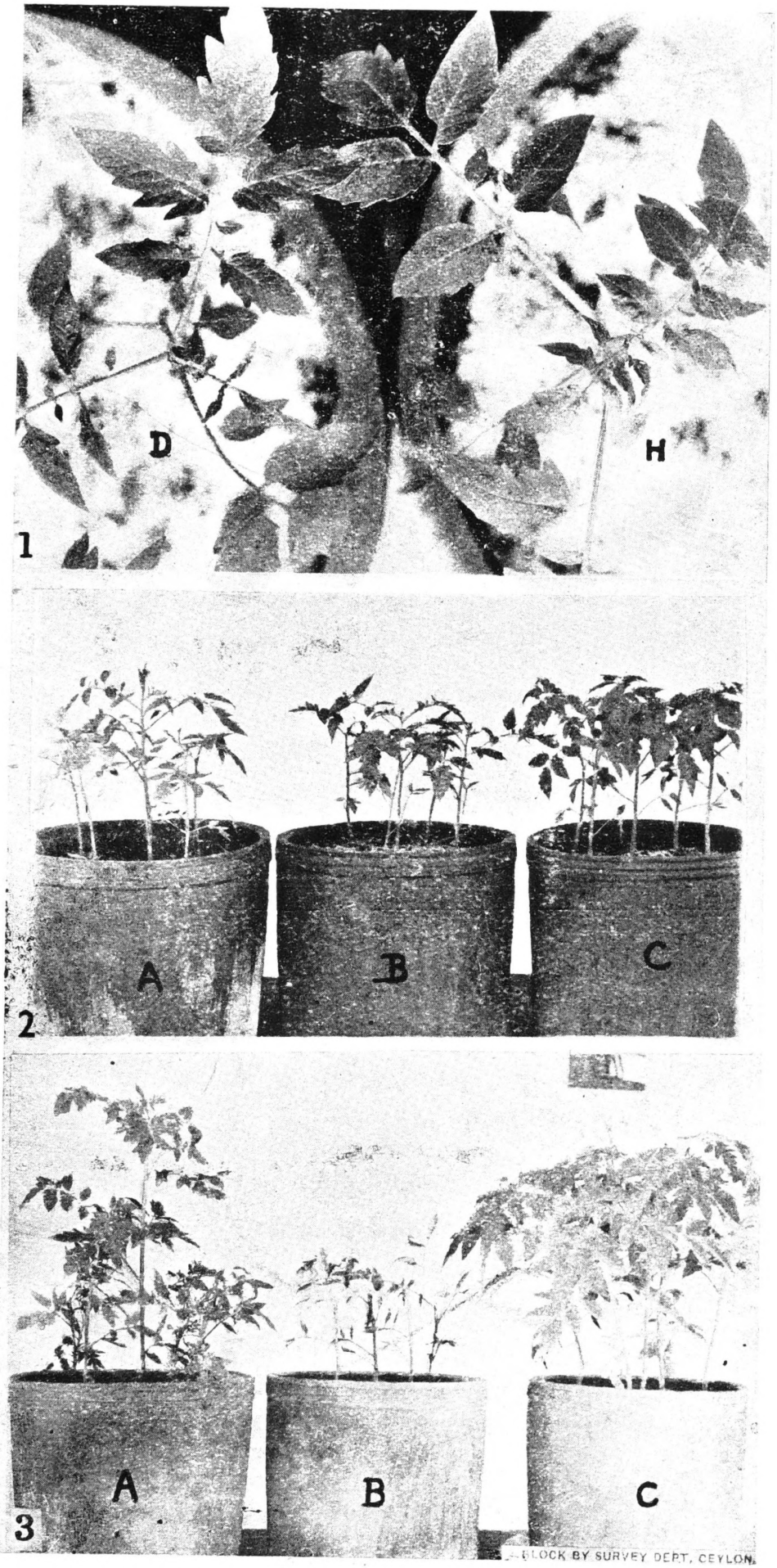

PLATE 1.

Showing leaf curl of tomato caused by mites.

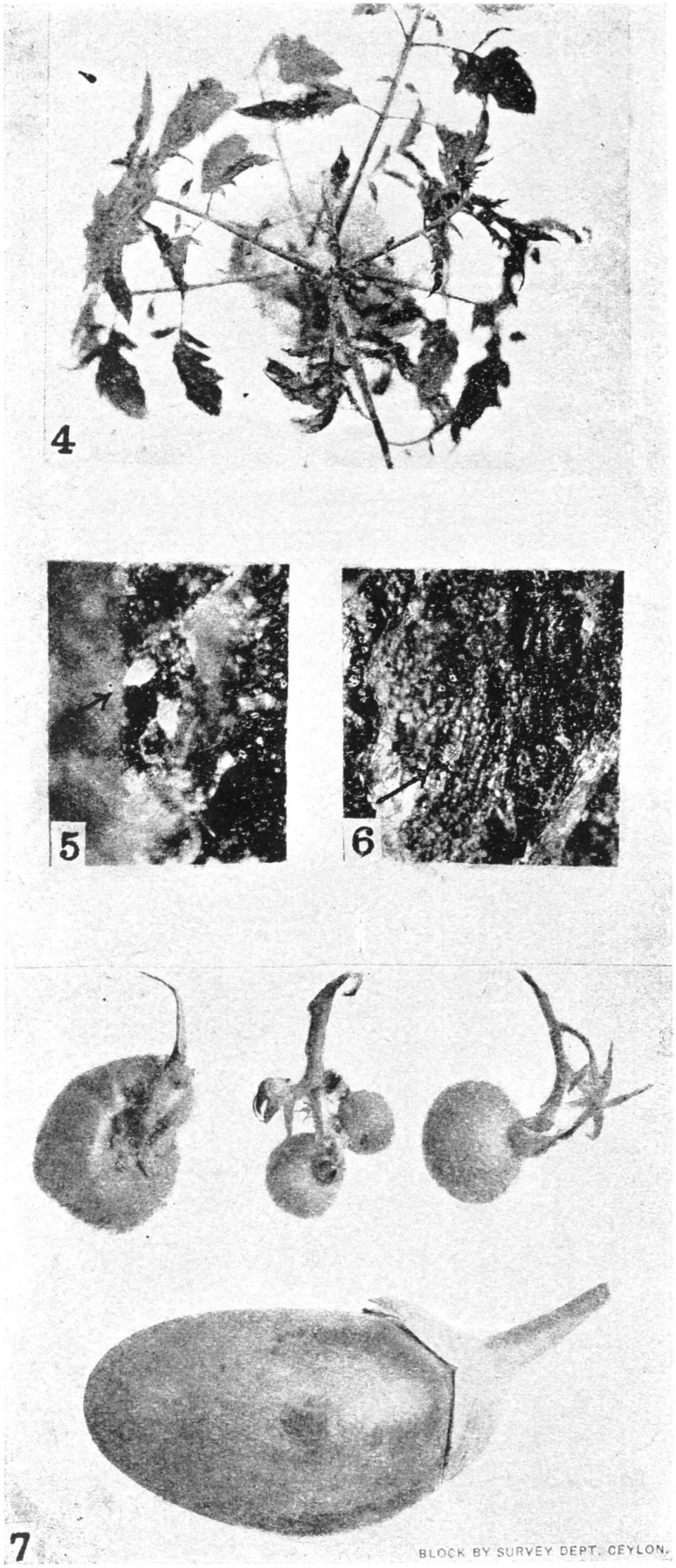

PLATE 2.

Showing leaf curl of tomato caused by mites.

results in the die-back of the plant. This is easily controlled by spraying or dusting with sulphur preparations. The other type is caused by a virus (unpublished) and is distinguished by the abaxial (upward) curling and interveinal yellowing of leaflets and is hardly known to cause the death of the plant. This disease is not amenable to treatment of the affected plants with sprays or dusts and the diseased plants must be rogued out as early as possible lest they become a source of infection to other plants.

SUMMARY

1. A leaf curl disease of tomato characterised by the abaxial curling, bronzing and glossiness of leaflets is described and is found to be associated with a species of mites.
2. Inoculation with mites from diseased to healthy plants resulted in reproducing the malformation.
3. The disease is communicable to other plants.
4. Sulphur dusting or use of a sulphur spray was effective in controlling the disease.

REFERENCES

(1) Carpenter, C. W. .. A new disease of Irish potatoes. Phytopath 8, pp. 286–87. 1918
(2) Reddick Ronald .. Mites on Potatoes. Phytopath 23, pp. 622–24. 1933.
(3) Matsumoto, T. .. Mites in relation to a leaf curl-like tobacco disease. Trans Nat. Hist. Soc. Formasa 29, pp. 90–91. 1939.
(4) Mann Harold H., S. D. Nagpurkar & G. S. Kulkarni The "tambera" disease of potato. *Agr. Jour. India.* 15 pp. 282–288. 1920.
(5) Kulkarni, G. S. .. The "murda" disease of chilli (Capsicum) *Agr. Jour. India, 17* pp. 51–54. 1922.
(6) Park, M. & Fernando,M The nature of chilli leaf-curl. *The Tropical Agriculturist,* Vol XCI, No. 5, pp. 263–265. 1938.
(7) Johnpulle, A. L. .. Chilli leafcurl experiments. *The Tropical Agriculturist,* Vol XCII, pp. 28–30. 1939.
(8) Cherian, M. C. .. The leaf-curl disease of Chilli. Department of Agriculture, Madras, Leaflet No. 73. 1936.

ACKNOWLEDGMENTS

The writer's thanks are due to Dr. B. A. Baptist, Entomologist, and Mr. L. S. Bertus, Acting Plant Pathologist, Department of Agriculture, for valuable suggestions in the preparation of this paper.

EXPLANATION OF PLATES

Fig. 1. Apices from a diseased (D) and healthy (H) tomato plants from pots B and C respectively.
Fig. 2. Pots A, B and C nine days after the inoculation of the plants in A and B with mites. C is the uninoculated control.
Fig. 3. Pots A and B a fortnight after spraying the plants in A with a sulphur spray.
Fig. 4. Apex of shoot of tomato plant naturally infected with leaf curl disease.
Fig. 5. Mites on tomato leaflet (X 29).
Fig. 6. Eggs of mites (X 29).
Fig. 7. Russetting of fruits of tomato and brinjal caused by mites.