SOIL CONDITIONS AND ROOT DISEASES

V. Symptomatology of Wilted Cotton and Red Gram

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Introduction

Although wilts of cotton (*Gossypium* spp.) and red gram (*Cajanus cajan*) have been studied in this country and elsewhere (Butler, 1906; Fulton, 1907; Dastur, 1924, 1926 and 1931; Fikry, 1932; Kulkarni, 1934; Subramanian, 1950; and Sarojini, 1950) produced by the soil-borne fungi *Fusarium vasinfectum* and *Fusarium udum*, no serious attempt has been made to precisely indicate wilt symptoms as seen in the aerial parts of the affected plants. Both wilts are known to be vascular in their mode of attack, the progress of wilt being conditioned to some extent, by a toxemic state of the plant.

In recent years much interest has centred round the discovery of antibiotics being formed in soils *in situ* and absorbed by plants detectable in the guttation fluid indicating systemic nature of fungal toxins (Waksman, 1947; Brian, *et al.*, 1951).

The following observations were made in this laboratory during the conduct of experiments on several aspects of the mechanism of wilts in plants and are of considerable fundamental and practical importance in detecting soil-borne fungal wilts of these two crop plants and are, therefore, described here.

Materials and Methods

Plants were grown in sterilised garden soil contained in earthenware pots. Two varieties of cotton, *Gossypium arboreum*, commonly called the Karunganni (K. 2) strain (Madras State) and the Malvi (M. 9) strain (Bombay State), and only one variety of red gram, *Cajanus cajan* (susceptible variety No. 1723 obtained from Kovilpatti) were used. Isolates of *Fusarium vasinfectum* (obtained from Centraalbureau voor Schimmelcultures, Baarn, Holland) and *Fusarium udum* (isolated from the rhizosphere of wilting red gram plant, grown in this Laboratory garden by Mr. V. Agnihothrudu) grown in soil oat (9 : 1) (Padwick, 1935) for a period of three weeks were the sources of inocula. Photographs were taken with "Contax" camera

(F 2; 5 cm. lens) using Ilford F.P. 3, 35 mm. film, the filter used being tri-colour red (filter factor 5–6).

Experimental

Delinted seeds of cotton and surface sterilised seeds of red gram were sown separately in pots, the soils being previously inoculated (3 days) with the pathogens *F. vasinfectum* and *F. udum* respectively. The uninoculated pots of both the series served as control.

Germination was complete by the fourth day in the case of cotton and by the fifth day in the case of red gram. The first external symptom of wilt in the case of cotton was the yellowing of the veins of cotyledonary leaves (Plate II, Figs. 1 and 4) and also second leaves (Plate II, Fig. 1) and in the case of M. 9 and K. 2 varieties the first wilt symptom begins to appear on the seventh and thirteenth days respectively after germination. The intensity of yellow colour of the veins increased in about 24 hours and the leaves showed general dechlorophyllation and assumed a drooping condition. The time interval between the first sign of vein clearing (Plate II, Fig. 4) to the death of the plant was three days. In general, the severity of wilt symptom resulting in a quick death of the plants was greater in cotton than in red gram.

The external symptom of wilt in the case of red gram was general dechlorophyllation of all the leaves (Plate II, Fig. 5) except the cotyledonary leaves, which are not seen to develop above soil level, since the type of germination is hypogeal as opposed to the epigeal germination of cotton. In red gram, from the initial dechlorophyllation complete wilting was encountered in six or seven days, the first typical symptom being observable on or after the eighteenth day from the date of germination. The wilting of red gram plants in *F. udum* infected soils was more gradual when compared to the abrupt wilt production in the case of cotton in *F. vasinfectum* infected soils.

Discussion

Symptomatology of plants as a diagnostic method of soil-borne fungal root diseases, particularly in the case of wilts, has not kept pace with causative agents like viruses and deficiency diseases. This is largely because many of the symptoms that appear in plants following the entry of fungal wilt organisms through roots, result in either too sudden a yellowing followed closely by a drying up of the leaves, and indeed all the aerial parts, or there is an incipient derangement of normal metabolism not so easily discernible to the unaided eye. Nevertheless, considerable changes in the chlorophyll pigmentation resulting in what is called as " yellowing " have been reported

in most wilt diseases (Keyworth, 1938; Foster, 1946). We have presented in this paper photographs of the leaves of two wilted plants artificially inoculated with two distinct species of *Fusarium*. In the case of *F. vasinfectum* on cotton (Plate II, Figs. 1 and 4) there is a well-defined vein clearing in the cotyledonary leaves and less pronounced vein clearing in the second leaf (Plate II, Fig. 1) and this is clearly seen in the photograph although it is not easily noticeable to the naked eye. The other symptoms produced are more of the type of yellowing clearly seen by photographing on panchromatic films with tricolour red filter (Plate II, Fig. 5). Indeed, the yellowing is apparent in photographs even in the cases of cotton seedlings commonly termed 'disease escapes' (Plate II, Fig. 3) in infected soils although this dechlorophyllation is not perceptible to the eye as a clear symptom of incipient disease production. One of us (R. K.) has recently shown that the typically yellowed leaves of the seedlings of cotton and red gram following infection by *F. vasinfectum* and *F. udum* respectively indicate a deranged ascorbic acid build up over their usual undiseased counterparts and also register an increase in reducing sugar (glucose) content (these results will be discussed in full elsewhere). It would suffice for the subject under consideration here to state that both wilts discussed are vascular in origin (Plate II, Figs. 6 and 7) although symptoms of wilt in cotton appear sooner than in red gram. There is every indication of toxin movement in *F. vasinfectum* infected cotton resulting in a more apparent vein clearing symptom than in *F. udum* infected red gram which shows a gradual yellowing of the leaves and no vein clearing probably due to a mechanical plugging of the vessels resulting in a general loss of chlorophyll although the possibility of a toxemic condition cannot be completely overruled. Earlier work in this laboratory (Yogeswari, 1948; Sarojini, 1950; and Sulochana, 1952) indicated very distinct growth response by *F. vasinfectum* and *F. udum* in the presence of trace elements. This enables us to hypothesise the possible role of these trace elements in wilts in that the invading fungus may deprive the plant during their progress in the root system some of the essential chlorophyll forming elements (Hewitt, *et al.*, 1950). It may then follow that the dechlorophylled condition in the red gram without any vein clearing may be due to a certain amount of local deficiency of heavy metals.

SUMMARY

1. Wilt symptoms in cotton and red gram caused by the soil-borne pathogens *F. vasinfectum* and *F. udum* as seen by the naked eye and clearly made out by photographing with tricolour red filter on panchromatic film are recorded.

2. Wilt symptoms in cotton when sown in *F. vasinfectum* infected soils appear on the seventh day in variety M. 9 and thirteenth day in variety K. 2 after germination of the seeds as very distinct vein clearing discernible to the eye in cotyledonary leaves. Later, the first leaves also show vein clearing not clear to the eye but detectable by photographing with tricolour red filter.

3. Wilt symptoms in red gram by *F. udum* do not culminate in vein clearing as in cotton although there is a general and well-marked dechlorophyllation presenting almost a toxemic condition. This is first seen on the eighteenth day after germination.

4. The possibility of these vascular wilts interfering with the normal uptake of some of the essential chlorophyll forming heavy metals is discussed.

Acknowledgments

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EXPLANATION OF PLATE

PLATE II

FIG. 1. Protograph of *F. vasinfectum* infected cotton (*Gossypium arboreum* variety K. 2) showing distinct vein clearing in cotyledonary and first leaf. $\times Ca.\ 1\frac{1}{4}$.

FIG. 2. Photograph of control cotton plant (uninfected) of the same age and variety as above with no vein clearing symptoms. $\times Ca.\ 1\frac{1}{2}$.

FIG. 3. (*a*) Healthy control cotton (variety K. 2) seedling.

(*b*) Wilted plant completely shrivelled.

(*c*) 'Escape' plant in wilt sick soil showing slight dechlorophyllation and tendency of wilt. $\times Ca.\ \frac{3}{5}$.

FIG. 4. (*a*) Cotton seedling (variety K. 2) in infected soil showing distinct early vein clearing in the cotyledonary stage 13 days after germination.

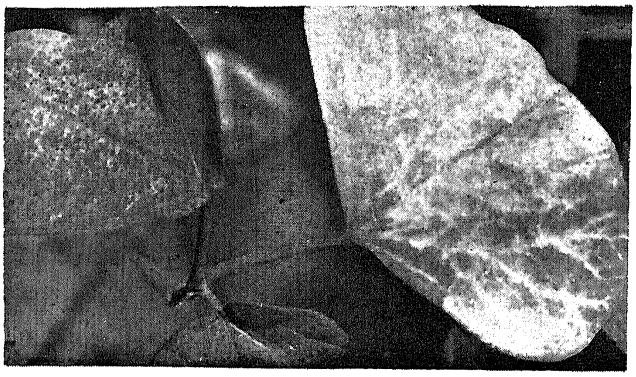
(*b*) Apparently healthy seedling ("escape") in the same pot $\times Ca.\ \frac{3}{4}$.

FIG. 5. (*a*) Completely dechlorophylled diseased red gram (*Cajanus cajan* susceptible variety) plant with no vein clearing as seen in cotton. Tips of leaflets are markedly paler than the rest of the lamina.

(*b*) Healthy control with characteristic dark chlorophyll pigmentation. $\times Ca.\ \frac{2}{3}$.

FIG. 6. T.S. of cotton root showing vascular invasion of *Fusarium vasinfectum*. $\times 600$.

FIG. 7. L.S. of red gram root showing vascular invasion of *Fusarium udum*. $\times 350$.



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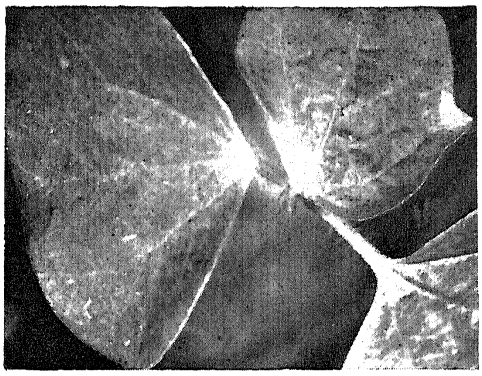

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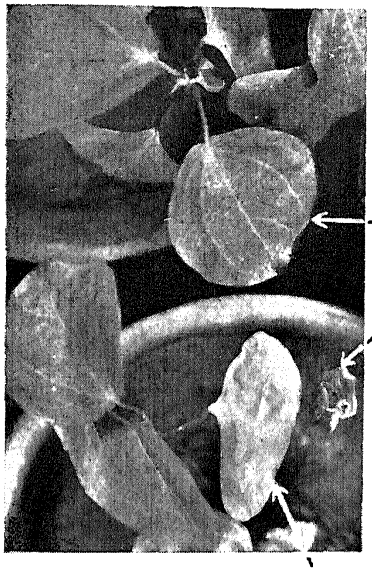

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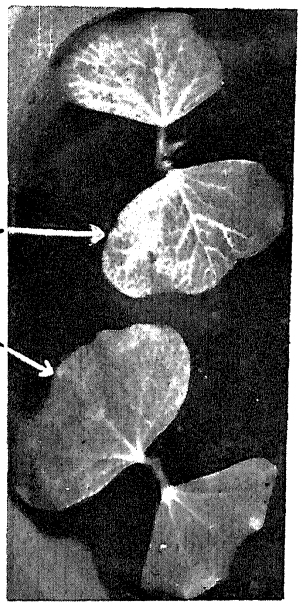

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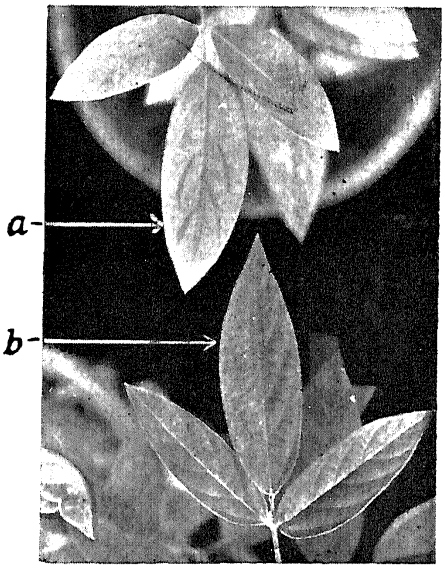

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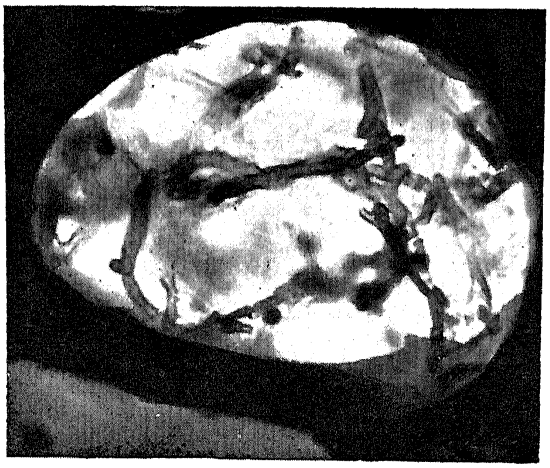

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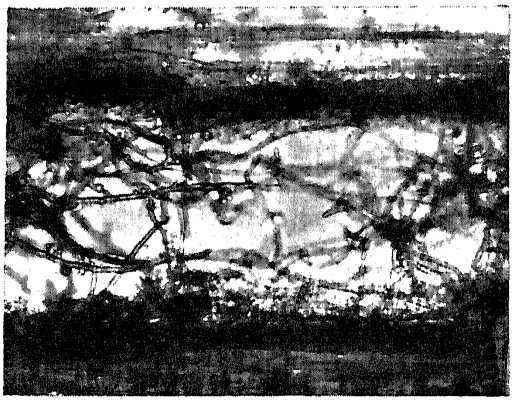

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