ON THE ROOT ROT OF KOCHIA INDICA WIGHT

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INTRODUCTION

Kochia indica Wight (Chenopodiaceae), ornamental plants of the summers suffer regularly from a 'root rot' disease which is found to occur in almost all the Lucknow gardens. The diseased parts of the plants yielded only two fungi: a species of Fusarium sp. and Rhizoctonia solani Kuhn. Of these the latter has been found to be dominantly associated with the affected parts showing different stages of the disease while the former only with the root and the stem base of plants exhibiting advanced symptoms.

The preliminary experiments showed that only R. solani was responsible for the causing of the root rot in Kochia indica while Fusarium sp. is associated only as a secondary fungus being a soil dweller. The present paper gives a brief account of the various pathological aspects of this disease.

SYMPTOMS

The earliest symptom of the root rot in young plants is the etiolation of the stem base which gradually turns brown and at the ground level becomes black while at the top it merges into the healthy green colour of the stem. Some scattered white spots appear in the etiolated portions and later the foliage dries up (Text-Fig. 1, a).

When the infection occurs in older plants, the withering of the foliage starts from the lowermost branches where the leaves at the base are completely dried up while those at the top exhibit only initial signs of drying. The withered leaves show a downward curl from their apices and after the shoot has dried up, they fall off within a fortnight. The main axis gradually turns reddish-brown, becomes hard and remains erect even in the fully withered plants. The basal portion of the stem develops several irregular longitudinal folds (Text-Fig. 1, b); which at the ground level assumes dark colour, increases in diameter and starts rotting emanating a characteristic odour. The rotting also involves the upper portion of the roots. The cortical layers
TEXT-FIG. 1. A, B—Diagrammatic presentation of the disease in Kochia plants. (A) Showing early stage in the development of disease. (B) Showing advanced stage of the disease. (C to G) Camera lucida sketch to illustrate the different stages in the formation of the selerotium.
including the bast of the rotted portions can easily be peeled off. Some of the roots, in advanced stages of the disease, are found to have irregular wavy outlines.

In the completely dried up plants, towards the final stage of the disease, a large number of tiny black sclerotia appear all over the outer surface of the branches, which gradually involves the main axis and also some of the roots (Text-Fig. 1, b).

No galls or tumours are developed on the root or the shoot of the affected plants at any stage of the development of the disease. The internal symptoms have been described elsewhere (Histopathology).

**Pathogenicity**

A large number of seedlings, raised from healthy *Kochia* seeds, were transplanted in pots containing sterilised soil. Plants between 1 to 4 months of age were normally employed for the experiments, and the inoculum was taken from 6 to 8-day old bacteria free monohyphal culture of *R. solani*. The method of experiment consisted in the inoculation of the root and the hypocotyl region of the seedlings. In the former the seedling root was either directly inoculated with and without wound, or, the inoculum was mixed with the soil of the rhizosphere; while in the latter the inoculum was applied on the hypocotyl region.

The infection attempted through the wounded and unwounded hypocotyl proved unsuccessful for *Kochia* plants of any age, whereas the root inoculation gave successful results.

In direct inoculations on the root, the one-month old seedlings succumb readily in three days after the experiment (90%). The top portion of the shoot becomes flaccid, collapses down forming an arch and dries up within a week (Plate VII, Fig. 1). The older seedlings, however, show a gradual withering of the foliage. In the experimented plants of 2-3 months age, the first visual sign of infection is noted after three weeks of the experiment and complete withering within a fortnight from this in 40–60% cases (Plate VII, Fig. 2). The injury did not in any way seem to favour the infection as the inoculations on the experimentally injured roots yielded infection in not more than 50% plants.

In the rhizosphere inoculation the disease symptoms were visible generally in the third week after the inoculation and 30% plants dried up completely after six weeks, except in the case of one-month old seedlings where the percentage of the rot produced was 60%.
The fungus employed for the artificial inoculation of the plants was reisolated from the experimentally diseased plants in the usual manner.

**Morphology of the Pathogen in Culture**

Hyphae form a hallow round the inoculum when young, are 2.5 to 3.0 \( \mu \) wide. With age turn reddish-brown, branches arising at right angles to parent hypha and bending after a short length becoming nearly parallel to it, 9.3 to 12.0 \( \mu \) wide and the septa being 13.8 to 24.8 \( \mu \) apart. In old cultures a white hyphal tangle is developed aerially but the sclerotia are not produced in this aerial mass.

The sclerotia are formed after the fourth day of inoculation on thick brown hyphae which divide into rectangular cells measuring 9.0 to 9.3 \( \mu \) \( \times \) 12.4 to 18.6 \( \mu \). Some cells branch outwards, are barrel-shaped and measure 15.5 \( \mu \) \( \times \) 30.0 \( \mu \). The hyphae are attached as fibrils all round the sclerotium, the average dimension being 56.0 to 63.0 \( \mu \) \( \times \) 84.0 to 85.0 \( \mu \) and 112.0 \( \mu \) \( \times \) 182.0 \( \mu \). Some are roundish in structure and measure 154.0 \( \mu \) \( \times \) 154.0 \( \mu \) (Text-Fig. 1, C to G).

The cardinal temperatures for this strain of *R. solani* have been determined as: minimum 10°C, maximum 40°C, and optimum 25 to 30°C.

**Histopathology**

A study of the histopathology of the various parts of the diseased plants, collected from nature as well as those produced experimentally, using the usual technique, gives a complete picture of the host invasion by the fungus from the root through the hypocotyl region into the stem and branches of the host tissue.

As the pathogen penetrates through the epidermis in the seedling root or in younger roots of the more mature plants, the hyphae remain restricted to the epidermal and subepidermal regions. The sclerotia if formed are lodged in the epidermis. The fungus gradually encroaches upon the xylem vessels and as the disease progresses and more sclerotia are developed in the vascular zone, the central cylinder which was intact in the early stages, breaks up into 3 to 4 concentric incomplete rings. The sclerotia fill up these gaps of the separated vascular rings and the accompanying dark hyphal tangle spreads over the vessels of either side (Plate VII, Fig. 3). Relatively only a few vessels are found to enclose the sclerotia which measure 42 \( \mu \) \( \times \) 28 \( \mu \) to 84 \( \mu \) \( \times \) 42 \( \mu \). The hyphae present in the xylem vessels of the innermost ring are lighter in colour than those distributed towards the periphery where they are
arranged in a radial manner between the vessels. This radial arrangement of
the hyphae is more pronounced in the upper regions of the infected plants.

From the root, with the advance of the disease, the pathogen enters the
hypocotyl and the stem base region, spreading copiously in the cortical as
well as in the central cylinder. The peripheral ground tissue becomes rotted and
forms a weak covering over the stele in which the hyphae are arranged radially
between the vessels. Generally a few sclerotia and hyphae fill these vessels
and also the small cavities developed in between the xylem rings of the stele
which are not as completely separated as in the mature root.

Further up in the region of the central axis below the level of lateral
branches, the fungus spreads all over the general tissue but more towards
the centre even involving a few cells of the pith. There is no marked breaking
of the stele in this region, but few sclerotia are found lodged in between the
xylem rings and the hyphae are conspicuously arranged in the characteristic
radial manner over the stele (Plate VII, Fig. 4).

The pathogen, while entering into the branches, ramifies profusely all
over the cortical and subepidermal regions mainly as inter- but also as intra-
cellular hyphae which are 3·5 to 6·2 μ wide and form a thick mat between the
cortex and the stele. In contradistinction with other parts the hyphal distri-
bution over the vascular cylinder here is scattered. The rounded or elongate
sclerotia are developed only in the extrastelar tissue, their average dimensions
being, 98 μ×112 μ to 140 μ×175 μ, whereas a few measure 126 μ×126 μ to
140 μ×140 μ (Plate VII, Fig. 5).

DISCUSSION

Rhizoctonia is known as the sterile mycelial condition of a basidiomycetous
fungus allied to Corticium or Hypochamus. Both these fungi are soil dwellers.
The unusually wide range of hosts attacked by Rhizoctonia, includes along
with a number of conifers and cucurbits, jute, cotton, tobacco, citrus, straw-
berry, wheat, oat and several others. R. solani alone, has been reported on
about 230 susceptible hosts belonging to 66 different families (Braun, 1930).
The fungus has been described to produce a variety of symptoms on various
hosts.

Among the species of Kochia, only K. scoparia L. is known to be affected
from a few virus diseases and a damping-off caused by Pythium debaryanum
(Erickson, 1947). Recently Bruehl (1951), while studying the nature of the
crown rot disease in the wheat seedlings by R. solani, also tested a number
of grass and non-grass hosts for their susceptibility to this pathogen. The
list included K. scoparia as well, in which the infected plants were marked by
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the general stunting and the brownish lesions at their collar region. This root-rot of *K. indica* Wight caused by *Rhizoctonia solani* Kuhn is, however, recorded for the first time.

Two fungi have been found associated with the diseased plants, of which *R. solani* has been proved to be pathogenic while the *Fusarium* sp. has been concluded to be a secondary fungus. The pathogen is able to infect through the roots and is unable to attack the hypocotyl. This is in contrast to its nature on potatoes, cotton and a few others, where the infection may be secured at the ground level also. The young *Kochia* seedlings succumb to infection within three days, become flaccid, lose turgidity and dry up within a week resembling the ‘damping-off’. *R. solani* is also known to cause the ‘damping-off’ in seedlings in a wide number of plants. The older plants of *K. indica* react after three weeks of the inoculation. The general characters of the disease closely agree with those described by Samuel and Garrett (1932) for the root-rot of wheat and oats caused by *R. solani*. The decortication of the affected roots of *Kochia* is similar to that produced by the infection of *R. solani* through the first internode of corn seedlings (Ho and Melhus, 1940).

*Rhizoctonia* is known to be most active as a parasite at low temperatures and in nature the plants which are not killed usually recover from the infection at a little higher temperatures (Richards, 1921 and Walker, 1928). Also the temperature requirements for the different species of *Rhizoctonia* and also for the same species on different hosts vary greatly (Leclerg, 1939 and Samuel and Garrett, 1932). The optimum temperature for this strain of *R. solani* has been found to be 25°C. on potato dextrose agar and 30°C. on other media. Thus the one-month old *Kochia* seedlings are subjected to optimum growth temperature during the months of February and March and succumb readily, while the older plants survive for a longer period because of the higher range in temperature during May and June and therefore consequent slow growth and development of the pathogen in the host. The fact that diseased plants have been observed even in the late season, is suggestive of the fact that once the plants become infected earlier or later, they are unable to recover.

**Summary**

The paper deals with the root-rot of *Kochia indica* Wight caused by *Rhizoctonia solani* Kuhn which secures successful infection through the root of the host. The disease is described for the first time.

The external and internal symptomatology of the diseased plants has been described. The distribution of the fungus in different parts of the host has been studied in detail. In the seedling stage of the plant the disease symptoms resemble the ‘damping-off’.
The morphology of the pathogen in culture and its temperature requirements have been determined.

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EXPLANATION OF PLATE VII

Fig. 1. (a) One-month old seedling showing the drooping of the shoot in the form of an arch.

(b) A healthy seedling of the same age.

Fig. 2. (a) Completely healthy plant which is short and erect with bushy foliage.

(b) Plant showing gradual withering of foliage. The branches towards the top are affected partially.

(c) Completely withered plant about a fortnight after the first visual symptom.

Fig. 3. Microphotograph of a portion of the central cylinder of the matured root to show the presence of sclerotia in the 'gap' while the hyphae spread over the vessels on either side of the separated vascular rings, × 160.

Fig. 4. Microphotograph of the cross-section of the main central axis to show the radial distribution of the hyphae over the vascular tissue, × 160.

Fig. 5. Microphotograph of the infected lateral branch showing the inter-cellular distribution of the hyphae in the extrastelar tissue and the development of sclerotia towards the periphery. The hyphae are thick, dark-brown and profusely branched, the branches arising at right angles, × 240.

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FIGS. 1-5