Discussion
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The salient findings of the experiment entitled "Studies on pathogenicity and survival of Rhizoctonia solani (Kuün), the cause of sheath blight of rice" have been presented in the preceding chapter in details. On reviewing the data on various aspects several points of interest have emerged which are discussed here in terms of cause and effect relationship conjugated with the findings of other workers as far as possible.

5.1 Symptoms of the disease

The pathogen Rhizoctonia solani was found to be associated with sheath blight disease of rice. Distinct symptoms on different plant parts have been observed. The symptoms on seedling i.e., seedling mortality was more severe under glass house conditions. Fluffy mycelial growth of pathogen appeared at the base of seedlings. Due to which the seedlings showed rotting at the base. As the disease advances, seedlings became yellowish
and finally died. The most common and distinctive symptoms appeared on the leaf sheath as water soaked, circular to oblong ellipsoid, or ovoid, even irregularly elongated discolourations. They finally turn into distinct lesions with narrow blackish to dark brown margins. Several such lesions can encircle the whole leaf on culm and cause death of the plants. In the vertical spread of disease, symptoms were clearly visible with ovoid 5 to 10 cm long greenish grey spots on the upper leaf sheaths and leaf blades and also on flag leaf. Outer leaf sheaths were first affected, symptoms gradually extended towards the inner sheath. Sclerotia initially white but turn brown at maturity on or near the infected plant parts, after about 6 days. Sclerotia were loosely attached and easily dislodged from the plant at maturity. In the severe infection the whole panicle of the plants were covered with mycelial growth of the pathogen and several white and brownish coloured sclerotal bodies were seen on the seeds. The infected seeds show greyish brown discolourations.
Infected plant parts confirmed the involvement of *R. solani* after isolation, identification and upon inoculation in glass house. They produced similar symptoms as observed in the field. Several workers have described the symptoms of the disease. (Gangopadhyay and Chakrabarti; 1982; Ou, 1985; Dasgupta, 1992 and Misra, 1998). The symptoms observed in the course of present study were not at all different from the descriptions given by authors already cited.

5.2 **Mycelial growth and sclerotial production of *R. solani***

In order to find out the most suitable medium for mycelial growth and sclerotial production, 11 different media were tested. Maximum colony diameter of the fungus was recorded on Potato Dextrose Agar medium followed by PDA + Rice leaf extract Agar and Rice Polish Agar and Water Agar. Richard's Agar and Water Agar supported poor growth of *R. solani*. Maximum sclerotial formation was recorded on PDA medium, Richard's Agar followed by Soybean Decoction Sucrose
Agar, PDA + Rice leaf extract Agar. Sclerotia were not produced on v-8 juice and Water Agar. It was interesting to note that PDA + Rice leaf extract Agar medium produced mycelial growth at par with the PDA, but sclerotial production was drastically reduced. Although v-8 juice supported good mycelial growth of the fungus but without any sclerotial formation. Sharma and Teng (1990) observed better mycelial growth of R. solani on PDA.

Thus on the basis of the maximum colony size, uniform compact growth, highest growth rate, maximum sclerotial production and easier viability, Potato Dextrose Agar medium was identified as the basal medium for various studies.

5.3 Studies on survivability of fungus

Reports of epidemics of rice sheath blight in different parts of the world indicates existence of definite and efficient mechanism for the survival of the pathogen from one season to another. The causal organism of rice sheath blight R. solani survives mainly in diseased plant debris in the soil, on seeds and
collateral hosts. There are reports that the mycelium in straw can remain viable as long as sclerotia under upland conditions. Dormant mycelium in crop refuse may remain active, alive in soil for almost a year (Kannaiyan and Prasad, 1978). Viability of sclerotia is affected by temperature and nutrients. There is considerable disagreement among various workers regarding the viability of sclerotia from 14 days to 2 year under varying influence of the micro-environment surface or under-ground, moisture, temperatures, soil textures, organic amendments, green manuring, nutrient status etc. Keeping above facts in mind and considering the serious nature of the disease, the present investigations were undertaken to study the role of infected plant debris having mycelium/sclerotia in the survivability of the pathogen.

5.3.1 Survival of *R. solani* in infected crop debris having mycelium and in the form of sclerotia in soil stored at room temperature
Survival of the fungus declined over a period of time. An initial recovery of 100 percent dropped down to 53.5 percent after 5 months in plant debris and 16 percent after 10 months in the form of sclerotia. It appears that high temperature during the months of April to June did reduce the survival of the fungus, but it was not altogether eliminated as the recovery of the colonies continued up to July. Steady, gradual or sharp decline in the recovery of the fungus from infected plant debris and sclerotia have been observed. Richard's (1923) also observed that R. solani remains in active state much longer at lower temperature than at higher. Park and Berteus (1932) had found that the sclerotia remained viable for 130 days in air dried soil kept at room temperature, (30°C). Reports are also on hand indicating viability of sclerotia up to 10 months (Misra et al., 1966) and 12 months (Kim, 1988).
5.3.2 Survival of *R. solani* in infected crop debris having mycelium and in the form of sclerotia buried in soil at different temperatures

Exposure to a particular temperature did effect the length of survival of *R. solani* in infected crop debris and in the form of sclerotia. It was also observed that as the period of incubation increased, there was corresponding reduction in the survivability of the fungus. Mycelium of *R. solani* survived for 150 days in infected crop debris incubated at 10-40°C and for 120 days at 0°C temperature, whereas survivability of sclerotia buried in soil at 0, 10 and 28°C was reduced to 10, 13.3 and 36.7 percent, respectively after a period of 330 days. Sclerotia placed in soil at 40°C survived only for 270 days.

Survival of the fungus at 28°C is practically good enough for the transmission of primary inoculum. Basu and Gupta (1995), demonstrated that sclerotia were more resistant to heat than mycelia. In the present study also viability of sclerotia
was up to 270 days, whereas survivability of the mycelium in crop debris was observed till 150 days only.

5.3.3 Survival of *R. solani* in infected crop debris having mycelium and in the form of sclerotia buried in soil of different textures

Studies on the survival of *R. solani* in diseased crop debris and in the form of sclerotia, placed in different types of soil revealed that the fungus survived for longer duration in light soil like sandy loam than the soil having higher proportions of clay or silt. The initial recovery of 100 percent of the fungus in plant debris declined and reached up to 33.3 and 40.0 percent in clay loam and sandy loam soil, respectively in 150 days. In *Tarai* / local soil, the recovery was observed as 36.6 percent after 150 days of incubation. The sclerotia placed in sandy loam, clay loam and soils, survived up to 36.7, 33.7 and 30.0 percent respectively, after 330 days. The results of the experiments supports the findings of *Lewis (1979)*, that *R. solani* survived longer in a sandy loam soil
than in silty clay loam. Similarly, Papavizas (1968), observed greatest saprophytic activity of *R. solani* in the medium and coarse sand fractions of a naturally infested sandy loam or loamy sand, whereas little activity occurred in the fine sand, silt or clay fractions. *R. solani* was isolated more frequently from a fine sandy loam than from either a heavier loam or a silty loam (Johnson et al., 1978).

Stotzkey (1974), emphasized that a single soil environmental factor such as type of clay minerals could greatly influence microbial life in soil. The present observation suggested that sandy loam soil that allowed good survival of *R. solani* could be rendered suppressive to the pathogen by addition of different clay suggested the importance of soil texture. Lewis (1979) was of the opinion that a single factor probably can not account for the population dynamics of a pathogen in a complex natural soil. Chemical and biological properties of soil are more important than soil texture in influencing the differential survival of *R. solani* in
various soils. It may be possible that, clays may influence microbial activity which in turn affects *R. solani*.

5.3.4 **Survival of *R. solani* in infected crop debris having mycelium and in the form of sclerotia placed in soil at different depths**

The survivability of the fungus declined sharply over a period of time and also with increase in depth of placement. The infected leaf sheath pieces placed at 15.0 and 10.0 cm depth in soil, showed significant reduction upto 23.3 and 6.6 percent, respectively, after 150 days. From the sclerotia buried at 2.5 and 20.0 cm depths, the survivability of the fungus continued for 210 and 300 days, respectively. However, the survival of the fungus in the samples buried at 5.0 and 10.0 cm depths was not much different. The survivability of the fungus was minimum from the sclerotia placed at 20.0 cm

**Park and Berteus (1932)**, reported that the sclerotia of *R. solani* were viable only for 180 days, whereas **Ou (1973)**, found
that the sclerotia of sheath blight fungus survived in soil for one or two years. The present findings shows that the sclerotia lost viability after 240 days, when they were placed at the depth of 2.5 cm. The rapid loss in the viability of sclerotia when placed at the depth of 2.5 cm might be due to the desiccation of sclerotia. Misra et al. (1966), found that the viability of sclerotia of S. oryzae decreased with increase in depth. In the present investigation also percent viability of sclerotia was reduced when they were buried in soil at 20.0 cm depth. After 6 months, the buried samples (plant debris) were thoroughly decomposed and saprophytic fungi like Aspergillus, Penicillium, Mucor, Alternaria etc were invariably isolated from them. Leakage of nutrients in addition to exhausting food reserves, favours the growth of antagonistic microorganisms. The role of environmental factors are more complex with soil borne diseases. Apart from the direct effect of moisture and temperature on the germination, dissemination and pathogenicity of organisms, the complexity of soil itself is highly significant as soil environment present a physical, chemical and biological
barrier for survival. The biological component of soil environment is so variable as to produce effects that defy resolution obviously all these factors interact, as has been hypothesized as an explanation for the survivability of the pathogen (Sewell, 1970).

5.3.5 **Survival of R. solani in infected crop debris having mycelium and in the form of sclerotia placed in soil at different moisture regimes**

It has been observed that as the level of moisture increased in soil, there was corresponding decrease in the recovery of the fungus from infected plant debris. In soil having submerged condition, the mycelium of the pathogen survived for 120 days, whereas, in soil of dry and field condition, the fungus survived for 150 days. When sclerotia were placed at field condition, the length of survival was maximum i.e., 330 days along with 43.3 percent viability of sclerolia. Under dry condition, viability of sclerotia was 10 percent after 300 days. But in soil having submerged
condition, the length of survivability of sclerotia was drastically reduced to 240 days.

These results clearly indicate that under high soil moisture level either as mycelium or sclerotia, the rice sheath blight pathogen can survive only for a short period as compared to dry condition or field conditions. It has been reported that the sclerotia of the organism can survive for a longer period under dry condition. Park and Berteus (1932), noted that the sclerotia remained viable for 130 days in air dried soil kept at room temperature. Mahendra and Prabhath (1971) found that the sclerotia buried in soil and also those stored in the laboratory under dry condition, remained viable for very long period, but he reported the loss in viability of sclerotia stored under flooded condition, within 60-80 days. The present observations also agrees with the earlier reports on the survival of the pathogen. The sudden loss in viability of the pathogen under flooded condition may be due to the presence of the antagonistic organisms as well
as poor aeration. According to Papavizas and Devey (1961), high soil moisture content could stimulate bacterial activity, which in turn will affect the *R. solani*. Radha and Menon (1957), also reported stimulation in the activity of antagonistic microorganisms at high soil moisture. Sarkar and Gupta (2002) observed very less incidence of disease in submerged soil.

The longer viability of the sclerotia under dry condition may be due to the formation of thick and hard wall which resist the adverse effect of environment as pointed out by Butler (1966). In the present investigation, after 6 months the buried plant samples were thoroughly decomposed due to saprophytic fungi. According to Mesroson and Sagay (1975), the infectivity several ways to control soil borne plant pathogens such as stimulation of general microbial activities in soil with increased competition for the pathogen, changes in pH of the soil with resultant effect on the microbial population, toxicity of chemicals produced in the soils during decomposition of plant residues, alternation of water
holding capacity of soil, inhibition or depression of speculation by the pathogen. Organic substrate as amendments after the physical, chemical and biological characteristics of the soil. Lakashmanan and Nair (1984) observed that more than 50 percent loss in viability of sclerotia in soil amended with Neem cake and groundnut cake on 20th day of incubation. Sarkar and Gupta (2002) and Khan and Sinha (2006) observed inhibitory effect of organic amendments on fungal survival after 20th day of incubation.

It is likely that one or more of these possibilities discussed above were in operation in the present case also. It is clearly evident that application of Neem cake, Castor cake Mustard cake, Rice husk, the sclerotia of the fungus in soil can be reduced considerably. This bringing about almost a reduction in the source of primary inoculum. Addition of green leaves to the paddy field also has get beneficial influence in reducing the viability of sclerotia.
5.3.7 Survival of *R. solani* in infected crop debris having mycelium and in the form of sclerotia placed in soil amended with Nitrogen, Phosphorus and Potash

K either alone or in combination with N or P have reduced the survivability of the mycelium of the pathogen in plant debris. Maximum inhibition was observed in K amended soil which is followed by PK and NK. Survivability of sclerotia was reduced in P, K and PK amended soil. Similar results were recorded by *Kannaiyan and Prasad* (1983), who observed that K and PK reduced the survival of the pathogen. Application of inorganic fertilizers discouraged the survival of the certain soil borne plant pathogens (*Sadasivan, 1970 and Garett, 1971*). Application of K in soil was found to be unfavourable for the multiplication of the pathogen in contrast to P and N. The depressing effect of K might be in the formation and existence of resistant propagules of the pathogen in soil. *Wensley and Mekeen* (1964), noticed a reduction in the population of musk
melon wilt fungus in calcium and Potassium amended soil. Kannaiyan and Prasad (1973), found that soils amended with Potassium chloride suppressed the survival of musk melon wilt fungus. Alagappan (1976), demonstrated that soils amended with Potassium chloride, Potassium sulphate and Potassium nitrate inhibited the survival of R. bataticola.

The application of inorganic fertilizers after the soil micro flora, which in turn may influence the survival of the pathogen (Emmimath and Rangaswami, 1971). The possible role of soil microorganism in the survival of soil borne plant pathogens was reported by several workers. Kannaiyan (1977) reported that actinomycetes and bacterial population was enhanced with simultaneous decrease in the pathogenic population due to Potassium application.

It is worthwhile to presume that depressing effect of Potassium might be due to an increase in the antagonistic microorganisms. Alagappan (1976), has reported that the
application of Potassium enhanced the actinomycetes population.

The results obtained from the present investigation clearly indicate that K reduced the survival of *R. solani*. 