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Sheath blight of rice : some aspects of perennation of the causal fungus*

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INTRODUCTION

Before going to the subject proper, I would like to mention of few words about the changed rice disease situation during the last 30 years or so in India with particular reference to West Bengal. Prior to the mid 60s brown spot of rice caused by *Drechslera oryzae* was the most serious disease of rice in West Bengal and the disease has taken its position in the history of plant pathology after the "great Bengal famine" in 1943. Crop loss in 1942 due to brown spot has been considered as a major factor causing the famine (Padmanabhan, 1973).

Since the introduction of high yielding rice varieties in mid 60s, there has been a significant change in the rice disease situation. While brown spot has been relegated to a more or less unimportant position, blast caused by *Pyricularia oryzae*, which was mainly confined to the cool regions of some northern districts of West Bengal and appeared only sporadically in the major rice growing areas of the plains of West Bengal has made its foothold throughout West Bengal. Several diseases which were so far unknown or insignificant in India have been reported from different parts of India to cause concern. Sheath blight (*Rhizoctonia solani*), sheath rot (*Sarocladium oryzae*), leaf scald (*Gerlachia oryzae*) among fungal diseases, bacterial leaf blight, bacterial leaf streak among bacterial diseases, tungro among virus diseases may be mentioned in this regard.

Several possible reasons may be cited for such a change in disease situation : (i) change in rice cultivation technology with the introduction of high yielding cultivars - such as increased fertilizer application, particularly N fertilizers, reduced plants spacing, increased irrigation etc. All these factors, along with the bushy nature of growth of the dwarf cultivars, tending to increase the temperature and humidity in the microclimate, favour development of many disease including sheath blight (Sarkar *et al*, 1991), (ii) wider exchange of germplasm among different countries with a chance of introduction of new disease from another country, (iii) intensive rice cultivation in many areas with the availability of irrigation water. In many areas now more than one rice crop is grown, allowing the pathogen propagules to survive in their natural host for the better part of the year.

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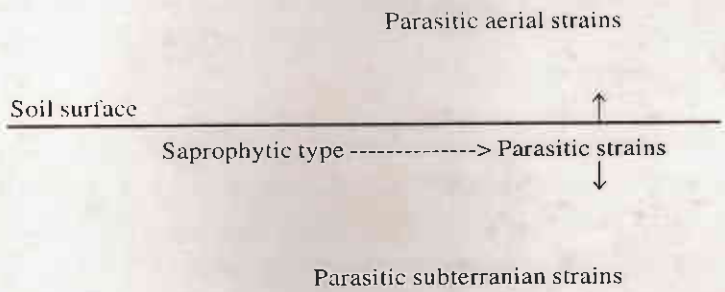
Sheath blight, caused by *R. solani* is regarded as an internationally important disease of rice, second only to and rivals the blast disease in many rice growing countries particularly since the introduction of high yielding varieties (Gangopadhyay and Chakraborti, 1982). In India the disease was reported for the first time by Paracer and Chahal (1963) from Punjab. Since then the disease has become one of the most common and destructive diseases in India (Rao and Kannaiyan, 1973). Due to its more prevalence in the eastern part of the world (Fig. 1) the disease has been referred to as oriental sheath blight.

R. solani is a very ancient soil fungus consisting of a large number of strains and it is suggested that the plant pathogenic strains originated by specialisation from the saprophytic strains residing on the soil surface (Baker, 1970). From the parental material probaly evolved the strains able to successfully establish and persist parasitically in aerial habitat, as in case of sheath blight of rice, and those that were able to develop, survive and parasitize plant parts under the soil surface. The evolutionary sequence might be represented as follows :



Although sheath blight is the most prominent symptom, various other symptoms may also be caused on rice plants due to infection with *R. solani*. Rice plants may be infected with the fungus at any stage of growth, seedling to grain formation, and depending upon the growth stage and source of inoculm different types of symptoms may be produced, such as pre and post emergence seedling blight (from soil or seed borne inoculum), sheath blight, usually found in the mid tillering stage (from sclerotia perennating in soil coming in contact with the host with irrigation water), banded blight of leaves (probably caused by air borne basidiospores of the perfect state of the fungus, *Thanatephorus cucumeris* - as suggested by Saksena, 1973), flag leaf and panicle blight (due to upward vertical spread of the fungus from the lower sheaths), grain infection (caused by contact with infected flag leaves surrounding the panicles during panicle emergence or infection from basidiospores as suggested by Saksena, 1973), symptoms of seedling blight and seed infection (spotted seeds) may be confused with those caused by brown spot of rice caused by *Drechslera oryzae*.

Possible sources of perennation of the rice sheath blight pathogen are discussed here. It may be mentioned that the informations presented are mainly from our own observations in the field and in the laboratory.

Soil borne inoculum is, no doubt, the main source of primary inoculum in most of the *R.solani* disease causing seedling blight, foot rot, collar rot and similar other symptoms in various crops. But in sheath blight of rice, where the aerial parts of the host are also infected, the role and importance of various other sources of perennation from which primary infection of the desease may be initiated have not received proper attention. As sheath blight of rice has been reported from practically all the rice growing countries of the world with various agroclimatic conditions, it is quite probable that different sources may be important in different areas depending upon the climatic condition of the area.

Infected plants parts

It has been confirmed in our studies that in the infected plant parts the pathogen may remain viable for atleast 4 months at a low temperature (10°C) under laboratory condition (Acharya, 1996). Therefore, in low temperature areas crop residues may serve as a major source of primary infection. At 28°C also a small percentage of crop residues yielded the fungus. Perennation of *R. solani* in rice straw has also been reported from IRRI (Anon, 1973).

The depth of soil at which crop residues are present has got considerable effect on the survival of the pathogen. The pathogen could be recovered after 160 days from a depth of 0 - 5 cm. In dipper soil recovery was possible for much shorter period due to decomposition of straw pieces by soil microbial activity (Acharya, 1996).

However, it is quite probable that soil being the habitat of *R. solani*, after decomposition of host plant parts also the pathogen may remain viable in soil, although in smaller population by saprophytic colonization of various organic particles in soil. Papavizas and Davey (1962) observed that the surviving mycelium of *R. solani* in precolonizad substrates was less sensitive to adverse microenvironment than the active saprophytic phase of the fungus.

From the saprophytic perennation in infected straw pieces the pathogen is able to resume parasitic activity, when a fresh rice crop is available. However, seedling or plant infection decreased with increasing depth of soil (Table 1) at which the inoculum (infected plant parts) were kept (Basu and Sen Gupta, 1995). The dicrease in desease incidence when the inoculum is present in greater depth of soil might be due to : (i) the distance over which the pathogen mycelium from original source of inoculum has to spread through soil for parasitizing the newly sown host and (ii) a reduction in pathogen population at increased soil depths.

Blair (1942) earlier observed that closer to the *R. solani* inoculum seeds of radish were placed, the earlier and more extensive was damping off.

Table 1. Perennation of *R. solani* at different soil depths and subsquent infeciton of the rice seedlings (period of incubation : 1 months)[1]

Depth of inoculum in soil	Seed germination (%)	Infected plants (%)	Length (cm)	
		Root	Shoot	
Upper Layer (0.0 cm)	31.50(34.14)[2]	100.00	1.35	3.95
Middle layer (6.0 cm)	48.50(44.14)	100.00	2.70	7.62
Lower Layer (12.0 cm)	70.50(60.47)	70.17	6.00	17.70
Control (uninoculated)	90.00(71.57)	0.00	7.50	18.00
C.D. (P=0.05)	3.35		0.50	1.10

[1] Data recorded 10 days after transplanting
[2] Figures in parenthesis are transformed angular values

Infested soil

Soil is the natural habitat of *R. solani*. Ou (1985) observed that in the field *R. solani* survives mainly as sclerotia in upper 2.5 cm depth of soil. The sclerotia come to soil surface during land preparation, float with irrigation water and when come in contact with rice plants initiate infection. Several workers have reported that sclerotia of rice sheath blight organism can survive several months in soil under various condition (Leu and Yang, 1985; Roy, 1987). In our studies with soil samples collected from different depths of naturally infested field soil (collected from a farmers field at Pandua, Dist. Hooghly) maximum population of *R. solani* was obtained in non-fractionated, residue I and debris particles of the soil (Table 2). The soil fraction that passed through 75 mesh seive (mostly-silt and clay) has a much lower population of *R. solani*. Viable sclerotia could also be recovered by seiving and centrifugation. Maximum number of sclerotia were recovered from a depth of 12 - 15 cm. and none from the depath of - 2.5 cm. Soil samples were collected from a fallow plot after harvesting and the sclerotia appear to have gradually settled to a deeper soil and hence could not be recovered from a depth of O - 2.5 cm.

Table 2. Recovery of *R. solani* in non fractionated soil and various soil fractions at 12 - 15 cm Data recorded in the month of October 1995)

Soil Factions	Colonization (%) of rice straw pieces
Non Fractionated	94.00 (75.23)[1]
Residue I	97.22 (79.56)
Residue II[2]	62.00 (51.64)
Residue III[3]	36.66(36.96)
Debris particles	100.00(85.94)
CD (P=0.05	1.67

[1] Figures in the parenthesis are transformed angular values

In soil *R. solani* has to survive in competition with other soil microorganisms. Soil moisture is an important factor in affecting competitive saprophytic survival. In our study maximum saprophytic survival was recorded at a moderate moisture level of soil. With increase in soil MHC saprophytic survival gradually declined (Table 3). The reduced saprophytic survival of *R. solani* at high moisture level has been attributed by Blair (1943) to a decline in soil moisture on the otherhand undoubtedly stimulates bacterial activity which in term may cause lysis of fungal mycelia. Bacterial colonization of hyphae of *Macrophomina phaseolina* and their lysis on soil with high moisture content has

earlier been reported by Kavoor (1954).

Table 3. Effect of soil moisture on competitive saprophytic survival of *R. solani*

MHC(%) of soil	Percent straw pieces colonization at different intervals (day) 3	15	30	45	60
25	67.73(55.38)[1]	37.81(37.94)	18.79(25.69)	8.45(16.90)	0(4.05)
50	70.23(56.93)	47.43(43.53)	28.10(32.01)	19.03(25.86)	12.66(20.84)
70	40.99(39.81)	15.86(23.47)	8.33(16.77)	2.77(9.58)	0(4.05)
80	23.71(29.14)	11.98(20.25)	5.14(13.10)	0(4.05)	0(4.05)
100	8.33(16.77)	5.55(13.63)	0(4.05)	0(4.05)	0(4.05)
CD (P=0.05)	Soil MHC 0.55		Days 0.55		Soil MHC x Days 1.24

[1] Figures in parenthesis are transformed angular values

Seed

During the last 15 - 16 years many reports on seed borne infection by *R. solani* on several field crops, vegetables and ornamentals have come in quick succession and have been reviewed by Michail (1984). Isolation of *R. solani* from rice seeds has also been reported by several workers (Kannaiyan and Prasad, 1978; Singh *et al.*, 1988; Basu and SenGupta; 1992). In our laboratory also a high percentage (40%) of naturally infested seeds yielded *R. solani* on water agar medium. However, the mode of seed infection in rice sheath blight disease has not yet been properly invesitgated. Marchetti (1983) and Roy (1989) observed that *R. solani* infection in rice reaches the seeds in panicles only when the plants lodged and panicles came in contact with *R. solani* infested soil before grain filling. In our studies, however, seed infection was observed in standing crop which did not lodge. Saksena (1973) suggested that rice panicle infection might be caused by air borne basidiospores produced by *Thanatephorus cucumeris*. However, the perfect state has not been observed in our surveys conducted in the rice fields of the districts of Nadia and Hooghly, although seed infection was observed in some fields. It was observed (Sarkar, Basu and Sen Gupta, 1993) that sheath blight vertically spread upto the flag leaf encircling the panicles in susceptible cultivars. A correlation between seed infection and susceptibility of the cultivars has also been observed (Basu and Sen Gupta, 1992). It is, therefore, presumed that rice seeds may get infected by *R. solani* by contact with infected flag leaves during penicle emergence. Very recently, however, the *Thanatephorus* state of the fungus in rice fields of Coochbehar has been observed (Basu, 1996 - personal communication). However, the role of *T. cucumeris* in initiating seed infection has not been properly established. Infection of seeds resulted in seed spotting. Spotted seeds, as well as nonspotted seeds collected from the same panicles yielded *R. solani* in agar culture. But after surface sterilization the number of seeds yielding *R. solani* was very much reduced in nonspotted seeds. In naturally infested spotted seeds, on the other hand, there was little reduction in *R. solani* isolation by surface sterilization. The fungus, therefore, appears to be both in externally and internally seed borne.

About 10% of the seedlings raised from spotted (*R. solani* infected) seeds showed infection on the lowermost sheaths, ultimately resulting in seedlings blight (Acharya, 1996).

Collateral host

Perennial collateral hosts around the rice fields may also play a very important role in the perennation of the fungus during the off seasons. A number of collateral hosts of rice sheath blight pathogen have been reported (Kannaiyan and Prasad, 1978; Nayek *et al.*, 1980; Acharya, 1996).

A number of vegetable crops of different plant families namely, cabbage, cauliflower, onion, garlic, pea, bean, tomato, brinjal, gram, cucumber and bhendi when grown in *R. solani* infested rice field soil showed symptoms like root rot, collar rot, foliage blight etc. Thus susceptible hosts other than rice may also help to retain the high population level of the pathogen in soil from season to season in absance of rice. Crop rotation is a general advice for management of diseases caused by soilborne pathogens. *R. solani* has a wide host range, but also has a large number of strains. Isolates within an anastmosis group may also vary in pathogenicity towards a crop from highly pathogenic to non-pathogenic (Papavizas *et al*, 1975). One must, therefore, be very selective in choosing crops for rotation with rice for reducing the soil inoculum level of *R. solani* .

The rice sheath blight organism, *R. solani* , has, thus many options left open to it for survival during the off seasons. Thus control of the desease poses a serious problem. The problem is compounded by the absence of satisfactorily resistant cultivars against the disease. An integrated approach should, therefore, be taken to combat the disease.

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