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REVIEW ARTICLE Agricultural Reviews, Volume Issue : ()

Rhizoctonia Aerial Blight of Soybean, its Prevalence and Epidemiology: A Review

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10.18805/ag.R-2311

Abstract

Soybean [*Glycine max* (L.) Merrill] is high value oilseed crop grown throughout the world as well as in few soybean growing pockets in India. The hot and humid weather conditions during the soybean cropping season favours the attack by various fungal, bacterial and viral diseases, thereby lowering the crop productivity. Rhizoctonia aerial blight or web blight disease, caused by *Rhizoctonia solani* is considered one of the most economically important disease of soybean in India. It causes yields losses ranging from 35-60% which might reach a devastating level of 80% under favourable environmental conditions. In India, the disease has been reported from most of the soybean growing states of Uttrakhand, Rajasthan, Sikkim, Haryana, Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Chhattisgarh and Assam. Epidemiological studies prove to be very important in managing the disease as the disease severity highly depends on the weather variables prevailing in the growing season. The present review has attempted to compile findings on this devastating disease of soybean crops, its prevalence in the country, epidemiological studies and strategies on integrated disease management.

Key words: Epidemiology, Rhizoctonia aerial blight, *Rhizoctonia solani*, Soybean.

Soybean [*Glycine max* (L.) Merrill] is one of the most important oilseed crop grown throughout the world. It is a high value crop with multiple food, feed and industrial uses and plays a vital role in agricultural economy of India. It contains 40-42% protein and 20-22% edible oil on dry weight basis. In India, soybean is mostly grown during kharif season when the weather is hot and humid making the crop more susceptible to disease and insect pest attack. Losses due to various diseases are one of the major causes for low productivity of the soybean. Major diseases of soybean reported from different parts of India are hizoctonia aerial blight, pod blight, charcoal rot, myrothecium leaf spot, brown spot, target leaf spot, powdery mildew, alternaria leaf spot, curvularia leaf spot, soybean rust, bacterial pustule, Bacterial leaf blight and viral diseases such as Soybean mosaic virus, soybean yellow mosaic virus and Leaf crinkle virus. One of the most destructive disease is aerial blight caused by the fungus *Rhizoctonia solani* Kuhn (teleomorph: *Thanatephorus cucumeris* (Frank) Donk). It causes yield losses ranging from 35-60%, depending on the prevailing environmental conditions *viz.,* temperature, relative humidity, bright sunshine hours and rainfall. (Rai *et al.* 2007; Yang *et al.* 1990a).

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How to cite this article: Bhamra, G.K., Borah, M. and Borah, P.K. (2022). Rhizoctonia Aerial Blight of Soybean, its Prevalence and Epidemiology: A Review. Agricultural Reviews. DOI: 10.18805/ag.R-2311.

Submitted: 19-01-2021 **Accepted:** 24-08-2022 **Online:** 05-09-2022

Pathogen

Rhizoctonia solani Kuhn. is the asexual, imperfect or anamorphic stage, whereas *Thanatephorus cucumeris* (Frank) Donk. is the sexual, perfect or teleomorphic stage of the pathogen causing aerial blight of soybean. The detailed classification of the fungus is as follows:

Anamorphic stage

Subdivision: Deuteromycotina
Form class: Deuteromycetes
Form subclass: Hyphomycetidae
Form order: Aganomycetales
Genus: *Rhizoctonia*
Species: *solani*

Teleomorph stage

Subdivision: Basidiomycotina
Class: Basidiomycetes
Sub class: Holobasidiomycetidae
Order: Tulasnellales
Family: Caratobasidiaceae
Genus: *Thanatephorus*
Species: *cucumeris*

Rhizoctonia solani is a cosmopolitian soilborne fungus with a very wide host range. It has been reported to attack a large number of plants and weeds (Ou, 1985). In India, it was first reported from Pantnagar, Uttrakhand in 1967 (Mukhopadyay and Singh, 1984). The pathogen have a very wide host range and it was once claimed that there is hardly any plant which the fungus, *R. solani* cannot infect

(Singh *et al.* 1999). *R. solani* causes aerial blight on soybean (*Glycine max*), groundnut (*Arachis hypogaea*), black gram (*Vigna mungo*), green gram (*Vigna radiata*), horse gram (*Macrotyloma uniflorum*)and french bean (*Phaseolus vulgaris*) (Srivastava and Gupta, 1989). Sharma and Tripathi (2001) worked on the host range of urd bean isolates of *R. solani* and found the wide host range belongs to family Leguminoceae, Solanacae, Brassicaceae, Malvaceae, Cucurbitaceae *etc*.

Symptoms

Yang *et al.* (1990a) described the rhizoctonia aerial blight of soybean as a destructive foliar disease which causes rapid defoliation of the plants in warm, humid regions. The symptoms of aerial blight of soybean caused by *Rhizoctonia solani* includes leaf and pod spots, leaf blight, defoliation, stem and petiole lesions, cob web like mycelium and sclerotia developed over infected leaves (Atkins and Lewis,1954). Sinclair (1982) categorized the symptoms of rhizoctonia aerial blight on soybean as foliar and aerial blight. Foliar symptoms appears on the leaves, stem and pods. Infection begins from the lower or middle parts of the plant and gradually moves up. Initially, water soaked spots appear on the leaves which soon take on a greenish brown to reddish brown appearance and later become tan, brown or black. Spots are initially small which later coalesce to cover large areas of the leaf. In the aerial blight phase, infected leaves droop and adhere to the pods and stem beneath them, thus becoming sources of infection for the pods and seeds. On the petioles and stem brownish lesions forms. On the pods, lesions may be small, brownish spots or may blight the whole pod. Seed infection is associated with pod infection. High humidity enhance mycelial growth and sclerotia formation in the lesion and blighted areas. Mukhopadhaya and Singh (1984) reported that symptoms of the disease depend on varieties of soybean. They also reported that the brown spot found on petioles and stems. Necrotic brown spot also formed on green leaves or complete leaves may be blighted. Web like mycelium of the pathogen also seen on diseased parts and their adjoining area of leaves. Thapliyal and Dubey (1987) reported that the pathogen produces two type of sclerotia *viz.,* micro and macro sclerotia both can infect six week old plants.

Disease cycle and mode of spread

The aerial blight fungus, *Rhizoctonia solani* overwinters as sclerotia in soil or plant debris from the preceding crop. With the onset of soybean growing season and presence of favourable environmental conditions (high RH and 77 to 90°F), the sclerotia germinates and the mycelium spreads inside the soybean plant. The infected plants show typical disease symptoms *viz.,* development of web like mycelium. The fungus spreads to adjacent plants via rainwater runoff, flood irrigation and direct contact. When the crop is harvested, the fungus survive as sclerotia and dormant mycelium in soil and plant debris respectively (Fig 1).

The pathogen, *Rhizoctonia solani* also known to cause sheath blight disease in rice, soybean fields that follow rice with a history of sheath blight are likely to have high incidence of aerial blight (Belmar *et al.* 1987). According to Russin and Stetina (1999) there are two stages of *R. solani* disease development. The first is the soilborne phase, when disease loci became established and the second is sclerotia structure or mycelia fragments that are splashed onto the plants canopy (aerial plants part) by rain.

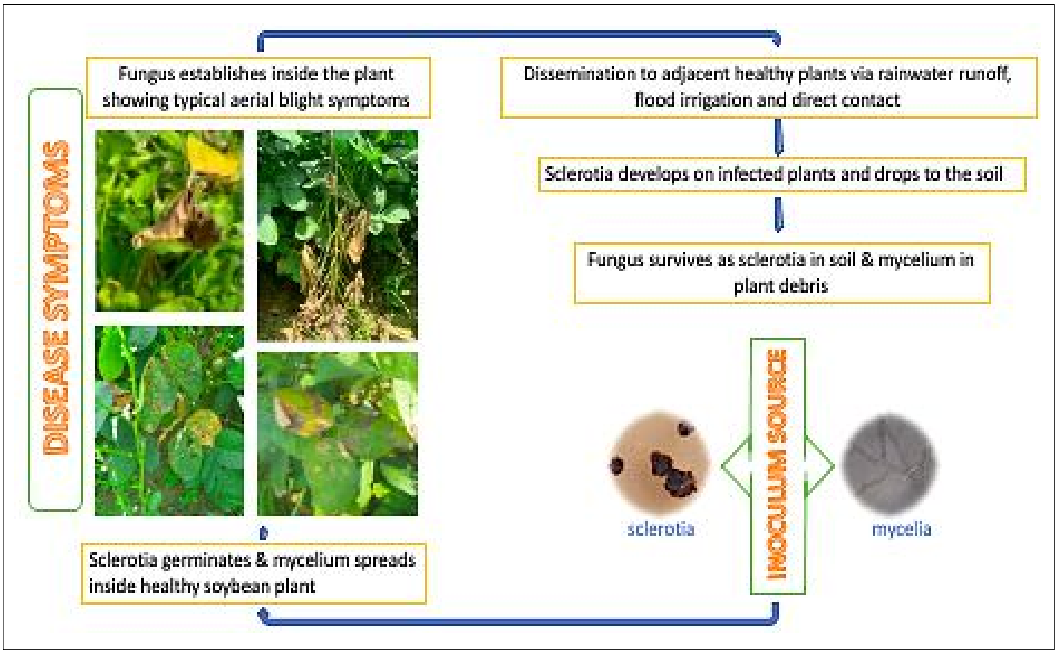

Fig 1: Disease cycle of *Rhizoctonia solani* causing aerial blight on soybean.

Epidemiology

Sinclair (1982) reported that web blight occurs in areas characterized by prolonged periods of high humidity and warm temperature, which enhances mycelial growth and sclerotia formation in the lesion and blighted area. Cultivars with more shorter and more compact growth habit are most severely infected. Thapliyal and Dubey (1987) reported 37°C temperature and pH 6 are congenial for disease development. Joye *et al.* (1990) reported that under field conditions, rhizoctonia aerial blight severity fluctuates with rainfall and relative humidity. Yang *et al.* (1990a) divided the epidemiology of aerial blight into two phases, one before and one after canopy closure. The first phase is soilborne and determines the number of potential disease foci in the crop canopy. The second phase is leafborne and is important to the expansion of disease foci. Yang *et al.* (1990b) also studied the effect of free moisture and plant growth stage on focus expansion of soybean aerial blight, caused by *Rhizoctonia solani* and reported that disease severity increased when free moisture is increased and showed positive correlation between each other. Nelson *et al.* (1996) stated that the epidemics of *R. solani* in field crops was related to a function of environment condition, pathogen density in the soil and as a result of rotation with host crops. Ram and Trikha (1997) stated that maximum temperature of 26-32°C, 70% water holding capacity of soil and pH >6.6 are favourable for disease development. Kucharek (1981) stated that when frequent rains occur, aerial blight disease spread fast and within one week or less an entire field may appear scorched. Small field bordered by trees or poorly drained field are more apt to have severe aerial blight. Teo *et al.* (1988) reported that *R. solan* isolates were more virulent with early seeding and at high soil moisture. Early seeding resulted in significantly greater seedling infection and disease rating. Soil moisture had a significant effect on seedling infection. Patel and Bhargava (1998) analyzed the epidemiology and crop losses of *R. solani* on soybean in Madhya Pradesh. As a result of infection, shoot length, pod and seed production was reduced and there was a significant decline in the total number of seeds and seed weight. Rain was a significant factor in increasing disease development. Application of N, P and K fertilizers and herbicides reduced disease incidence, although application of 20 kg N/ha as urea resulted in the maximum disease incidence. Harikrishnan and Yang (2004) describe the effects of temperature on the growth and sclerotia production among the isolates of *R. solani*. The optimum temperature for growth of the fungus was between 25-30°C and 25°C for sclerotia production. Torres *et al.* (2004) reported higher incidence of death of soybean seedlings (DSS) when the crop was planted in shallow soils and when these soils were originated from basalt. Approximately 70% of the death of soybean seedlings occurred in excess soil moisture. Only 30% of the deaths of soybean seedlings were in “latossols”, which are well developed soils, deep and with good permeability. Sikora *et al.* (2011) reported that prolonged humidity and warm temperature favoured disease progress and which further be limited during an abnormally dry period. Mathpal (2016) reported that aerial blight progression negatively correlated with temperature and relative humidity and positively with rainfall and sunshine hours under north Indian conditions. Kumar *et al.* (2016) reported that high soil moisture (80%) and 25°C temperature were the most favourable for root rot development while web blight was best favoured at >85% relative humidity coupled with 25°C temperature. Continuous leaf wetness for at least 6 hrs was essential for disease initiation, while increase in leaf wetness duration for 6-12 hrs showed corresponding disease incubation period observed with further increase in leaf wetness. Joshi (2018) screened 120 soybean genotypes for resistance to rhizoctonia aerial blight disease and directly corelated disease spread with temperature. When temperature >20°C, disease spread 82% in Tarai region, Uttrakhand.

Integrated disease management

Integrated disease management (IDM) is the practice of using a range of control measures as and when required, alone or in combination, to prevent and manage diseases in crops. The combined use of cultural practices (deep summer ploughing), chemical method (seed treatment with carbendazim @ 2 g/kg seed+foliar spray of carbendazim @0.05% at 30 DAS+P.E. soil application of herbicide *i.e.* pendimethalin @ 1.0 kg a.i. /ha)+Use of organic matter as vermicompost under biosuppression have been proved a good IDM module for reduction of disease intensity of rhizoctonia aerial blight and to increase the yield of soybean (Pushpendra *et al.* 2017).

The use of resistant varieties is the cheapest, easiest, safest and most effective method to manage the aerial blight disease. A few tolerant cultivars such as PK-262, PK- 416, PK-472 and PUSA 16 (Thind, 2005), PS 564, PS 1024 and PS 1042 have been identified against rhizoctonia aerial blight (Anonymous, 2006). Palat *et al.* (2004) screened soybean germplasm for their resistance to web blight. They found 8 cultivars free from the disease, 11 cultivars as resistant and 9 cultivars as moderate resistant. Among these 13 entries were evaluated against the disease of soybean at 7 centers along with checks.

Cultural management practices such as destruction or burning of crop residues, summer ploughing and crop rotation have been recommended against the pathogen, *Rhizoctonia solani* (Lee and Courtney, 1982; Thind, 2005; Prasad, 2005). Incorporation of oil cake and some green manuring crop particularly sunhemp and green gram reduced survivals of *R. solani* (Rajan and Menon, 1975). Sharma and Gupta (2003) reported that mulching with single polyethylene along with soil amendment (mustard cake) for 30 and 50 days eliminates the *R. solani* from 5 and 10 cm soil depth, respectively. The cause of reduction was increased soil temperature lethal to the pathogen.

Control of the disease using fungicides have been reviewed by many researchers. Fungicides have various advantages over the other control measures such as, cheap, easy availability in the market and quick knock down action. But due to its harmful effects on the plants, animals, humans and environment as a whole, these should be applied only as a last resort or in combination with other control measures. Ram and Trikha (1997) recommended Benomyl (0.5 kg/ha) and Mancozeb (2.5 kg/ha) 60 days after sowing for control of aerial blight of soybean. Ray and Kumar (2008) tested the efficacy of six different fungicides *viz.,* carbendazim, mancozeb, hexaconazole, propiconazole, blitox-50 and thiram at different concentrations against the aerial blight pathogen, *R. solani*. Under *in vitro* conditions, Propioconazole was found to be most effective inhibiting complete radial growth of fungus at 5 ppm. Effect of seed treatments and foliar sprays of the fungicides on disease severity and grain yield were also studied under field conditions. Seed treatment and foliar sprays of Tilt at 15 day intervals, showed lowest disease severity (27.56%) with highest grain yield (34.46 q/ha). Rai *et al.* (2007) screened the twelve fungicides/antifungal antibiotics, possessing either systemic or non-systemic activity against *Rhizoctonia solani* pathogen, causing aerial blight of soybean,under *in vitro* conditions. Among these, Contaf Hexathir, Dhanustin and Rovral showed almost complete inhibition of the test fungus at all the concentration tested (*i.e.* 25, 50, 100 and 500 ppm). Sonakar *et al.* (2014a) tested the efficacy of eight different fungicides, *viz.*, Roko, Mancozeb, Indofil Z-78, Acrobat, Vitavax, Taquat, Matco and Antrocol (*i.e.* application @ 0.2 per cent) were tested under *in vitro* conditions against *Rhizoctonia solani*, the causal organism of aerial blight of soybean. Vitavax was found to be most effective inhibiting complete radial growth of fungus.

There is a shift towards the biological control as the degree of disease suppression achieved with biological agents can be comparable to that achieved with chemicals. Sonakar *et al.* (2014b) tested the efficacy of bio agents and botanical extracts against *R. solani,* causing aerial blight of soybean. The efficacy of seven botanical extract *viz.,* Garlic, Madar, Ginger, Aloevera, Neem, Makoy, Datura *i.e.* application @ 5% and six bio-agents *viz., Trichoderma viride*, *T. atroviride, T. harzianum, T. longibrachiatum, T. koningii* and *Aspergillus niger* were tested *in vitro* and *in vivo* conditions were against *Rhizoctonia solani*, the causal organism of aerial blight of soybean. Results revealed that the under *in vitro* conditions, botanical extracts of garlic was found highly effective showed 88.47 per cent inhibition in radial growth of the fungus. *Trichoderma viride* was the most significantly effective 70.42 per cent as it inhibited the mycelial growth of *Rhizoctonia solani* after 7 days of incubation. Kumar *et al.* (2016) tested the antifungal activity of different medicinal plant leaf extracts, oils and *Trichoderma* spp. were studies under *in vitro* condition. The out of fifteen medicinal plants leaf extracts tested, the extract of Butch (*Acorus calamus*) significantly inhibited the mycelial growth of *Rhizoctonia solani* (87.71%) under *in vitro* conditions. Among the medicinal oils, Eucalyptus (100%) and Neem oils (86.78%) were found to significantly inhibit the mycelial growth of *Rhizoctonia solani* at 5% concentrations. Among the antagonists, maximum mycelial growth inhibition was observed by *Trichoderma harzianum* (74.81%) followed by *Trichoderma viride* (67.40%). India is the fifth largest producer of soybean in the world having 10.56 million ha area under cultivation of the crop producing 12.22 million tons of soybean annually with the productivity of 1.5 t/ha (ICAR-IISR, 2018).

In spite of having such a large area under soybean cultivation, India is the fifth largest producer of soybean in the world having 10.56 million ha area under cultivation of the crop producing 12.22 million tons of soybean annually with the productivity of 1.5 t/ha (ICAR-IISR, 2018). In spite of having such a large area under soybean cultivation,India is the fifth largest producer of soybean in the world having 10.56 million ha area under cultivation of the crop producing 12.22 million tons of soybean annually with the productivity of 1.5 t/ha (ICAR-IISR, 2018). In spite of having such a large area under soybean cultivation.

Rhizoctonia aerial blight reports from different parts of India

India is the fifth largest producer of soybean in the world with an annual productivity of 1.5 t/ha which is only about 47 per cent of the world average *i.e.*, 2.74 ton/ha (ICAR-IISR, 2018). Major soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Andhra Pradesh. The low productivity in the country is due to several abiotic and biotic factors such as rainfall pattern, diseases and pests. Aerial blight of soybean caused by *Rhizoctonia solani* has been reported to cause an average yield loss of about (40-50)% which can reach a devastating level of 80% under favourable conditions (Joshi *et al.* 2018; Mathpal and Singh, 2017). In India, it was first reported from Pantnagar (Uttarakhand) in 1967 (Mukhopadhyay and Singh, 1984). Since then it has spread to most of the soybean growing states like Rajasthan (Goyal and Ahmad, 1988), Sikkim (Srivastava and Gupta, 1989), Haryana, Punjab, Uttar Pradesh, Bihar (Sharma and Tripathi, 2001 and Ray *et al.* 2007), Madhya Pradesh, Chhattisgargh (Anonymous, 2007) and Assam (Borah, 2019).

CONCLUSION

Soybean is a high value oilseed crop with multiple food, feed and industrial uses and plays a vital role in agricultural economy of India. Aerial blight or web blight disease is considered one of the most economically important disease of soybean as it causes heavy yield losses. The pathogen, *Rhizoctonia solani* is soilborne and has a very wide host range which is why it is very difficult to control under the field conditions. Therefore, correct identification, early detection and timely control measures are important in managing the aerial blight disease. In this paper, we have made an attempt to review about the aerial blight disease of soybean, the pathogen associated with it, symptoms, mode of survival, epidemiological studies, integrated management practices and its reports from different parts of India.

FUTURE THRUST

Soybean crop has enormous potential to uplift the economic status of famers, improve dietary quality of nation and earn good foreign exchange in India. Among the various abiotic and biotic constraints which reduces the yield potential of soybean, rhizoctonia aerial blight disease holds a very critical place. Research should be directed towards bringing the crop productivity at par with the world average, which is currently double that the nations average. Research related to systematics and epidemiological studies, breeding disease resistant varieties, standardizing effective IDM modules, development of disease forecasting models along with timely advisory system at grass root level will help in improving the crop productivity.

Conflict of interest: None.

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