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Review article

BANDED LEAF AND SHEATH BLIGHT OF MAIZE INCITED BY *Rhizoctonia solani*f.sp*sasakii* AND ITS MANAGEMENT. A REVIEW

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Globally maize (*Zea mays* L.) is the first and most important cereal crop grown under diverse environments unmatched by any other crop, as expansion of maize to new areas and environment still continues due to its range of plasticity.Maize has a wide adaptability to diverse agro-climatic conditions around the world. Maize was introduced to India in the beginning of 17th century. It is now one of the important crops in India occupying fifth place in area and third place in production. In India, maize is cultivated in an area of about 8.26 m.ha with the production of 19.73 million tonnes and productivity of 2295 kg ha^{-1} (Centre for monitoring Indian economy report, 2009). Maize crop is attacked by number of fungal, bacterial and viral diseases out of which banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani* f. sp*sasakii*(*Thanatephoruscucumeris*) is considered as one of the most important disease and major constraint for low yields. In India the disease was first recorded in the Tarai (foot hill plain areas) region of Uttar Pradesh (Payak and Renfro, 1966). In early sixties, the disease was considered only as a disease of minor importance till it appeared in the epidemic form in the foot hill regions of Himalayas especially in the district of Mandi in Himachal Pradesh. Now banded leaf and sheath blight is considered as one of the major diseases of Maize (Payak and Sharma, 1985). In India it is known to be present in the states of Himachal Pradesh, Uttar Pradesh, Bihar, Haryana, Punjab, Madhya Pradesh, Rajasthan, West Bengal, Meghalaya, Assam, Nagaland, Andhra Pradesh and Orissa. Yield losses vary from 11 to 40 per cent (Singh and Sharma, 1976).

BLSB Pathogen:

Banded leaf and sheath blight disease is caused by *R. solani = Hypochonussasakii* (*Thanatephoruscucumeris* (Frank) Donk) is one of the most widespread, destructive, and versatile pathogen found in most parts of the world and is capable of attacking a wide range of host plants, including maize causing seed decay, damping-off, stem canker, root rot, aerial blight, and seed or cob decay. It is the combination of its competitive saprophytic ability and high pathogenic potential that makes *R. solani* persistent and destructive plant pathogen (Saxena, 1997). The colonies produced by the fungus were fast growing, and formed silky white colonies on PDA medium at 28 $\pm$ 1^{o}C, which gradually lost their luster and became dull in appearance. The mycelium was colorless when young, but assumes brown color as it matures. Microscopic examination of hyphae revealed it as multinucleate, septate and branching at right angles. Hyphae are septate and typically constricted at the point of branching and contain dough nut shaped pore that enables nuclei, mitochondria to migrate between cells. Sclerotia were produced abundantly in culture. Sclerotia typically 1-5 µm diameter spherical and dark brown to black in color. (Duggar, 1915., Reyes, 1941., Sohi*et al*., 1965., Singh and Sharma, 1976., Maiti, 1978 and Akhtar*et al*., 2009).

Symtomatology

The symptoms of the banded leaf and sheath blight were observed on all aerial parts of the maize plant except tassel. The disease manifests itself on leaf, leaf sheaths, stalks and ears as leaf and sheath blight. Under natural conditions, disease appears at pre- flowering stage on 30 to 40 day old plants but infection can also occur on young plants which may subsequently result in severe blighting and death of apical region of growing plants.Ahuja and Payak, 1982) recorded the disease symptoms on leaves as irregularly globular to elongated lesions (1-3 mm diameter) which appear as water-soaked areas. The affected areas appear bleached, soon they become straw colored and necrotic. The spread of the disease on leaves is more rapid and extensive than on sheaths. The lesions and blotches cover greater areas and the alternating narrow purple or brown zones become more prominent, resulting in the characteristic symptoms of banded leaf and sheathblight. In general, the symptoms on leaf sheaths resemble those described for leaves.

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The disease appears on basal leaf sheaths as water-soaked, straw-colored roundish spots on both the surfaces. It spreads from the lower to upper sheaths which are rather rapid under favorable conditions but in dry weather it remains restricted.The pathogen also causes spots or lesions on the rind of the stalk under the affected sheaths.

Dark brown to black, sometimes off-white, superficial to depressed lesions extend on the lower four or five internodes. The disease reaches the ear shoot in favourable weather within 15-20 days of sheath infection. The source of infection of the ears is the lower adjacent affected sheaths.

Hirrel*et al*. (1988) noted the symptoms as reddish eye spot lesions with dark red to purple margin on stalks near the soil line. Prolific sclerotial and hyphal development was also recorded on older sheaths which appeared as yellow green discoloration with a thin black border.

Sharma *et al*. (2004) reported the pathogen affects all the aerial plant parts of maize except the tassel. The symptoms appeared within 4-5 days after inoculation, which were irregular, water-soaked, straw-coloured lesions on leaf bases and sheaths. The lesions enlarged rapidly resulting in discoloured areas alternating with dark bands, apparent on lower leaves after 7 to 8 days.

The symptoms appeared on inoculated plants as irregular shaped spots. Typical banded leaf and sheath blight symptoms were observed as small purplish brown lesions or greenish olive brown large continuous patches on leaf sheath and pale olive brown lesions on stalk as well as rotting of ears (Akthar*et al*., 2009). The symptoms and morphological characters observed in the present investigations have also been recorded and described by several workers (Duggar, 1915, Reyes, 1941, Sohi*et al*., 1965, Singh and Sharma, 1976 and Maiti, Isolation and maintenance of the Pathogen
Diseased specimens along with sclerotial mass were thoroughly washed in tap water. Specimens were cut into pieces measuring about 5 mm with healthy portion as well using sterilized blade after washing. Leaf pieces and sclerotia were surface sterilized in 0.1 per cent mercuric chloride solution for about 30-60 sec followed by 3 rinsing in sterilized distilled water. The sclerotia and leaf pieces were placed in between two layers of sterilized blotting sheets to remove moisture and then leaf pieces and sclerotia were transferred asceptically to PDA plates and incubated at 28±1ºC temperature. Inoculated Petriplates were obseved to record mycelial growth of pathogen after every 24 hours. Pure cultures of the pathogen isolates were obtained using hyphal tip culture technique Pure culture of the pathogen was maintained on PDA by periodical transfers.(Akhtar*et al*., 2009).

Pathogenicity tests

Ahuja and Payak (1978) proved pathogenicity of *R. solani* by inoculating 40 day old maize plants of var. BVM 5 by inserting 2 to 3 grains covered with mycelial growth of each isolate, separately, between the rind and the leaf sheath of test plants. High humidity was maintained during disease development by frequent watering. The inoculated plants were regularly observed for development of symptoms. Re-isolations were made from infected plant parts and compared with previous cultures. Pathogenicity and host range tests were conducted under field, glass house and laboratory conditions by Ahuja and Payak, (1985). Plants were inoculated during wet weather by inserting four barley grains culture in between sheath and culm. In laboratory tests, five replications of one leaf in each dish were maintained for each test species and these leaf pieces were inoculated by placing single grain culture on midrib of adaxial surface. Observations on disease development were recorded at crop maturity, disease severity was recorded using 1-5 disease rating scale given by Vimla and Mukherjee (1987). Baraka *et al*. (1998) proved the pathogenicity of *R. solani*, on fababean*cv*. Giza using the soil infestation method. Emerging faba bean seedling produced post emergence damping off and root rot. A susceptible maize inbred, CM-119, was subjected to different inoculation methods to test their corresponding performance and efficacy with respect to number and percentage of plants affected and comparative disease severity. Results revealed that the inoculation method *i.e*., inoculating the leaf and sheath with mass culture multiplied on sorghum grains exhibited the most efficacious performance among all methods tested (Kumar *et al*., 2008).

The pathogenicity of Yunnan isolates of *R. solani* was evaluated on maize seedlings. Isolates were cultured on PDA in a 9 cm petridish for 3-4 days at 25 ^{o}C and then covered with about 20 g autoclaved soil (121 ^{o}C, 15 min), and maintained at 25 ^{o}C for 3-4 days, this was used as the inoculums source. Maize seedlings of *cv*. Huidan-1, about 5 cm high, were planted in potting soil, one per vinyl pot (15 cm diameter, 20 cm height). Each seedling was inoculated in the root zone with about 7 g of infested soil. Control plants inoculated with autoclaved soil. After 7 days the disease severity was recorded based on 0-4 disease rating scale (Yang *et al*., 2008).

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Biological Control of BLSB

Biocontrol agents are applied to soil as inoculated oil cake, FYM, granules, tablets, talc based formulations and crude spore suspensions. It has been known about 70 years that *Trichoderma* spp. produces a wide range of antibiotic substances that affects other microbes, and act as biocontrol agents (Weindling, 1934). Dennis and Webster (1971) reported production of volatile and non volatile antibiotics by *Trichoderma* sp. effective in controlling *R. solani.*

***In vitro* studies**

Antagonistic activities of fungal isolates were tested by employing dual culture techniques by Morton and Strouble (1995) on PDA. Extensive coiling of biocontrol agents along with the hyphae of *R. solani* was observed by Das *et al*. (1996). Siva Kumar *et al*. (2000) reported that among seven isolates of *P. fluorescens* isolated from various crops two isolates PF-1 and PF-6 showed high degree of efficacy in inhibiting *R. solani* f. sp. *sasakiiin vitro,* exhibiting the inhibition zone of 23.7 mm and 20.3 mm, respectively. Mycelial growth of pathogen decreases with the increase in the concentration of the culture filtrate produced by fungal antagonists from 10 to 40 per cent and no growth at 50 per cent Seshagiri and Eshwaran (2002). Volatile chemicals released by the *T. harzianum* were effective in suppression of both growth and sclerotial formation of *R. solani* f.sp. *sasakii*. *T. harzianum* inhibited more than 80 per cent growth after 72 hours of incubation and 33.5 per cent inhibition of sclerotial formation after 10 days of incubation followed by *T. viride* which caused above 70 per cent inhibition of growth and 25.9 per cent inhibition of sclerotial formation by *R. solani* f.sp. *sasakii* Meena *et al*. (2003a). Ultra structural studies conducted by Yobo*et al*. (2004) demonstrated that the *Trichoderma* isolates coiled around the *R. solani* hyphae and subsequently caused the cell wall lysis. Under *in vitro* condition *Trichoderma* species exhibited a distinct antagonism against *R.solani* causing sheath blight of rice Tang *et al*. (2002). Antagonistic fungi *T.harzianum, T. viride* and *Gliocladiumvirens* inhibited the growth of *R. solani*. (Kazempour, 2003 and Gogoi and Ali, 2005). Among the several antagonists tested by various scientists, species of *Trichoderma,Gliocladium*and *Aspergillus* etc. have been found effective in reducing the sheath blight of rice and extensively explored for the control of soil borne plant pathogens (Khan and Sinha, 2005). Laboratory studies were conducted by Zhang Guang*et al*. (2005) in China to determine efficacy of *Trichoderma* sp. against maize sheath blight caused by *Rhizoctonia solani*. A total of 18 *Trichoderma* isolates were obtained from maize rhizosphere in Yaan, Sichuan Province, China, and tested. The suppression rates of the mycelial growth of *R. solani* by the *Trichoderma* isolates by dual culture were 39.44-84.98 per cent whereas with ferment filtrates it was 13.48-85.81 per cent on PDA plates. But when the filtrates were autoclaved, inhibition activities against *R. solani* were decreased. Five isolates of *Trichoderma* spp. exhibited antagonistic potential against *R. solani* by inhibiting the mycelial growth. With the increase in the concentration of culture filtrates of the bioagent, the radial growth of the test pathogen was proportionally decreased, in general. Maximum inhibition (76.3 %) of the mycelial growth of *R.solani* was observed with the culture filtrate of *T.harzianum* at 50 per cent concentration. Whereas the culture filtrates of *T. virens, Trichoderma* sp. (Isolate 107), *T. hamatum* and *Trichoderma* sp. (Isolate 87) inhibited radial growth of *R. solani* by 70.0, 65.0, 63.7 and 59.6 percent respectively at 50 per cent concentration (Ashraf Ali Khan and Sinha, 2007). Biswas*et al*. (2008) evaluated bio-agents such as *T. harzianum, T. viride,* bio formulation of *P. fluorescens* and *T. harzianum* and botanicals such as garlic extract and Achook (Azadiractin) against sheath blightpathogen of rice (*R. solani*) under *in vitro* . In dual culture test, *T. harzianum* and commercial bio formulation reduced mycelial growth by 42.7 per cent and 43.0 per cent of *R. solani.* Sahar*et al*. (2009) reported that *T. hamatum* showed the highest reduction in the growth of *R. solani* where as *B.subtilis* isolate reduced *R. solani* growth by 89.4 per cent, while it was less effective against *M. phaseolina* and *F. solani*. It was also observed that mycelia of *T. hamatum* mainly grew over the mycelium of test pathogens in soybean.

***In vivo* studies**

Antagonists when applied to seeds were found to colonize the rhizosphere and offer protection against several soil borne pathogens (Turner and Backman, 1971). Several research workers tested the different species of *Trichoderma, Gliocladium* against *R.solani* on crops other than maize (Elad*et al*., 1983., Chet *et al*., 1981 and Howell, 1987). Isolates of *P. fluorescens* were used as biocontrol agents as the bacterium was reported to suppress soil borne diseases caused by fungal pathogens (Weller, 1988). In both green house and field experiments the antagonist *P. fluorescens* survived well in the rhizosphere of maize crop. When applied to seeds the antagonist multiplied and survived well in the rhizosphere, even 75 days after sowing and considerable bacterial population even 90 days after sowing. There was an increase in rhizosphere bacterial population when seed treatment was combined with soil application. Seed treatment followed by root zone application of *P. fluorescens* recorded better rhizosphere bacterial population. Rhizosphere population ranged 15.6 to 22.6X 10^8 and 18.4 to 27X$10^{4,}$ respectively both under green house and field conditions as compared to untreated plants where it was 1X10^8 and 8X10^4 respectively. Good establishment of bacteria in the rhizosphere of plants may be due to an improved capacity of it to complete for root exudates (Loper*et al*., 1985 and Gamliel and Katan,1992).

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Larkin *et al*. (1997) reported that reduction in saprophytic growth of *R. solani* and an increase in population of various *Trichoderma* spp. Was 10^3 to 10^4 fold in soil less mix when they were applied as rice flour based formulation. Similar increase in bioagents population in granule amended plots was recorded. The granular formulation probably helps in better survival of *Trichoderma* in the changed environment. Hazarica and Das (1999) had reported the successful management of root-rot of French bean caused by *R. solani* using biocontrol agents including *Trichoderma.* In wheat seed treatment with *B. subtilis*significantly reduced the *Rhizoctonia* disease (*R. solani*) and increased grain yield and dry matter of wheat (Merriman *et al*.,1974). According to McMullen and Lamey (2000), *B. subtilis*used as seed treatment colonize the developing root system, suppressing disease organismssuch as *Fusarium*and *Rhizoctonia*. As the root system develops, the bacteria grow with the rootsextending the protection throughout the growing season. As a result, a vigorous root system isestablished by the plant, which often results in more uniform stands and greater yields. Sivakumar*et al*. (2000) reported that the efficacy of peat formulation as a seed treatment in BLSB management increased as a dosage of the formulation increased. Seed treatment at 16 and 20 g $ha^{-1}$of seed effectively controlled the disease, as disease ratings were noted 2. 1 and 2.0, respectively, against check (4.3). Soil application (2.5 kg ha^{-1}) of peat based formulation also controlled the disease effectively. Increased dosage (3.0 kg ha^{-1}) of the peat based formulation to the soil resulted in equally effective control of the disease. Application of *P. fluorescens* and *T. viride* resulted in a significant reduction of sheath blight incidence caused by *R. solani*and was comparable to the systemic fungicide, carbendazim. The number of productive tillers, grains per panicle and 1000-weight, straw and grain yields were also significantly increased when compared with control (Wang *et al*., 2000., Tang *et al*., 2002., Kazempour*et al*., 2003 and Mathivanan*et al*., 2005).

Compatibility of bio control agents with commonly used fungicides and herbicides

Compatibility of living organisms with modern inputs of plant protection like fungicides and herbicides is a prerequisite now a day for developing integrated disease management strategies. A biocontrol agent must be effective and compatible with commonly used fungicides, biopesticides and herbicides in a particular crop, so that it can be integrated in managing the disease. In such an approach biocontrol agents were used along with fungicides and herbicides should not have any toxic effect on antagonists. Papavizas (1985) reported that biological approach can be successful only if antagonists are compatible with fungicides and other agrochemicals. *In vitro* compatibility studies of biocontrol agent *T. harzianum* C-52 with the fungicides for the control of onion white rot caused by *Sclerotium cepivorum* confirmed that, antagonist was least sensitive towards procymidone and captan and most sensitive to mancozeb, tebuconazole and thiram which inhibited the growth of *T. harzianum* 100 per cent (Mc Lean *et al*., 2001). Mancozeb (75 % WP) and copper oxy chloride (88%w/w) at 100 ppm and 500 ppm concentrations did not inhibit the growth of *T. viride* significantly. However, at a concentration of 1000 ppm, copper oxy chloride completely inhibited the growth of *T. viride*. Fungicides like carbendazim (50 % WP), hexaconazole (5 % EC), propiconazole (25 % WP) completely inhibited the growth of *T. viride* even at 100 ppm concentration under *in vitro* condition (Ramarethinam*et al*., 2001). Bhat and Srivasthava (2003) reported that mancozeb (Indofil M-45) was fungistatic against *T. viride* at 500 ppm, whereas copper oxychloride (Blitox 50 % WP) inhibited the growth of *Trichoderma* sp. at 1000 ppm and hexaconazole (Contaf 5 % EC) is highly inhibitory to *Trichoderma* sp. even from 250 ppm concentration. Complete inhibition of all the four species of *Trichoderma* (*T. viride, T. koningii*, *T. harzianum* and *T.virens*) by tebuconazole and hexaconazole showing extremely toxic nature, while captan and propineb showed tolerable growth up to 200 µg ml^{-1} and azoxystrobin at 400 µg ml^{-1}. Among these fungicides azoxystrobin is less toxic and compatible upto 400 µg ml^{-1} and captan is fungistatic to *T.harzianum* and can be applied by keeping 2-3 days gap between the fungicide and bioagent integration. *Trichoderma* was most sensitive to benomyl, tebuconazole, carboxin 37.5 % + thiram 37.5 %, propiconazole, chlorothalonil and hexaconazole. These seven fungicides effectively suppressed 100% growth of both species of *Trichoderma*Pandey*et al.* (2006). In a laboratory study conducted by Bhattiprolu (2007) to determine the compatibility of *T. viride* isolate with carbendazim 0.1 %, mancozeb 0.25 %, thiram 0.3 %, copper oxychloride 0.3 %, thiophanate-methyl 0.1 % and hexaconazole 0.2 % by poisoned food technique, reported that *T. viride* was compatible with dithane M-45 and thiram, while it was not compatible with carbendazim, hexaconazole and thiophanate-methyl.

Among the seven different isolates of *T. viride* (Native 1 Tv) was the potential isolate in dual culture studies, tested for its *in vitro* compatibility with eight fungicides at recommended and half recommended dosages. Among the fungicides tested, validamycin found to be compatible with *T. viride* (Native 1 Tv), carbendazim with *T. harzianum* (DOR Th) while, thiophanate methyl was found compatible with *P. fluorescens* (ANGRAU *Pf*1) and *Bacillus subtilis* (PDBC Bs) was compatible with Quintal (iprodione+carbendazim) at recommended and half recommended dosages. (KiranBabu, 2007).

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Compatibility of *T. viride* was tested with commonly used fungicides like mancozeb 75 % WP, copper oxy chloride 88 % WP, carbendazim 50 % WP, hexaconazole 5% EC, propiconazole 25 % EC and a herbicide, metalachlor 50 % EC by Latha (2008). The results revealed that fungicides carbendazim, propiconazole, hexaconazole and herbicide metalachlor, irrespective of the concentrations, had a very significant effect on growth of *T. viride*, so as to exhibit a complete noticeable inhibition where as mancozeb and copper oxychloride at 100 and 500 ppm did not show statistically significant inhibition in the growth of *T. viride*. However, at 1000 ppm mancozeb and copper oxychloride affected the growth of *T. viride*. Sarkar*et al*. (2008) reported that among the systemic fungicides tested, hexaconazole was the most toxic to the growth of *T. harzianum*, followed by propiconazole and triflumizole (Procure 30 WP) at 5 ppm with 87.7, 56.4, and 36.2 per cent inhibition in the growth respectively. Growth was not observed at 10 ppm with hexaconazole, propiconazole at 25 ppm, and at 50 ppm with triflumizole. Herbicide alachlor showed complete inhibition of hyphal growth of *Trichoderma harzianum* Abdel-Malle*et al*. (1994).

Sharma and Mishra (1995) observed better tolerance of a strain of *T. harzianum* to 2, 4-D as compared to fluchloralin and pendimethalin. The tolerance of *Trichoderma* to certain herbicides might be attributed to gradual utilization of herbicides as a source of C and N by the organism. Ciraj (1996) stated that herbicide, atrazine inhibited the growth of the genus *Trichoderma*. However sulfonylurea based herbicides had no statistically significant negative effect on *Trichoderma* and in some conditions they stimulated the growth of the fungus. Jayraj and Radhakrishnan (2000) reported that five herbicides namely alachlor, butachlor, 2, 4-D, oxyfluorfen and pendimethalin were tested at 1,5, 10 and 20 ppm concentrations for their *in vitro* influence on the growth, sporulation and cellulose production by *T. harzianum*. The results revealed that all the herbicides significantly reduced the sporulating and cellulose producing ability of *Trichoderma harzianum*, especially at higher concentrations.

Metalachlor (50% EC) completely inhibited the growth of *T. viride* even at 100 ppm concentration under *in vitro* condition (Ramarethinam*et al*., 2001). Jaworska and Dluzniewaska (2002) reported the effect of herbicides Afalon 45 % SC (linuron), Pyramin Turbo 52 % SC (chloridazon) and Stomp 33 % EC (pendimethalin) on the growth and biological activity of *T. harzianum* and *T. viride*. Though pendimethalin strongly inhibited the growth rate of tested antagonistic fungi *T. viride* was found to be more sensitive to herbicides than *T. harzianum*. Desai and Srikant (2004) evaluated thirteen agrochemicals involving six weedicides, five fungicides and two insecticides at 500, 1000 and 2000 ppm concentrations to assess their effect on native *T. harzianum* a biocontrol agent. All the tested agrochemicals were highly inhibitory to *T. harzianum*. Cent per cent inhibition of hyphae was recorded in alachlor, carbendazim, chlorpyriphos, glyphosate and thiram. Significantly lowest inhibition was recorded in acephate (8.45) followed by atrazine (27.50), captan (32.45) and metalaxyl MZ (33.13) which differed significantly. Two stable mutants, one each of *T. viride* (TvM_1) and *T. harzianum* (ThM_1), obtained through gamma radiation were tested for their compatibility with different pesticides in order to fit them in integrated disease management for the control of fusarial wilt of chilli. Both the fungal mutants showed high compatibility with carbendazim (0.1 %), fipronil (0.2 %), imidacloprid (0.025 %) and fluchloralin (0.33 %). TvM_1 showed compatibility with captan (0.25 %), copper oxy chloride (0.15%), phosalone (0.1 %) and butachlor (0.2 %) whereas ThM_1 was compatible with mancozeb (0.125%) and phosalone (0.1 %). However mancozeb (0.25 %), copper oxy chloride (0.3 %), dicofol (0.5 %), pendimethalin (0.66 %) and alachlor (0.4 %) were found to be highly inhibitory to the radial growth of the mutants TvM_1 and ThM_1. (Madhavi*et al*., 2006).

The effect of some commonly used herbicides, viz. alachlor 50 % w/w, butachlor50 % w/w, pendimethalin 50 % w/w and glyphosate 50% w/w on the growth and sporulation of *Trichoderma* and *Gliocladium* spp. was studied by Subhalakshmi*et al*. (2006). The results revealed a significant variation in the effect of these chemicals on the radial growth in terms of per cent reduction in growth of the antagonists. It was further observed that all the herbicides were more or less compatible with the antagonists up to certain concentrations with glyphosate showing more promising effects. Laboratory experiments were conducted by SurajitKhalko*et al*. (2006) to study the compatibility of alachlor, butachlor, pendimethalin and glyphosate, at 5 different concentrations, with *Trichoderma harzianum* and *T. viride*. Both antagonist were highly effective against *Sclerotium rolfsii* inhibiting 83.72 and 70.54% mycelial growth, respectively, while the least inhibition was recorded against *Fusariumoxysporum*f.sp. *ciceri*. *T. harzianum* showed high tolerance against butachlor, whereas *T. viride* showed high tolerance against glyphosate. Alachlor at 500 ppm was sensitive to *T. harzianum* and *T. viride* causing 80.7 and 75.9 per cent inhibition of radial mycelial growth, respectively. Sporulation of these antagonistic fungi was less affected by glyphosate at 500 ppm causing 66.7 and 65.2 per cent inhibition in *T. harzianum* and *T. viride*, respectively.

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Chemical control of BLSB

Due to ambiguity in understanding of inheritance of resistance and non-availability of widely adapted and stable source of resistance to BLSB, control of disease by chemical procedures is extremely important to minimize the destruction of crop and to prevent economically crop losses. Saxena (2002) tested efficacy of chemicals (*viz*, Propiconazole, 0.1%, and Carbendazim, 0.05%), by applying as foliar sprays at 30, 40 and 50th day of planting, alone or in combinations. Effectiveness of Propaconazole was markedly observed when the chemical was applied at initial stages at 30th or 40^{th} day after planting and the second spray at 10 days after first. Foliar sprays of Carbendazim showed the ineffectiveness against BLSB. On *in vitro* evaluation, three often used fungicides, namely Bavistin, Rhizolex, and Thiophenate Methyl, have shown absolute control of mycelial growth with 100% inhibition. It is, therefore, envisaged that under field conditions a high level of control of BLSB could be achieved using these three fungicides (Sharma *et al*, 2002). Meena *et al*. (2003) evaluated fungicides and plant extracts against banded leaf and sheath blight of maize. These fungicides and plant extracts applied as drench reduced disease severity index significantly over control. Soil drenching of carbendazim (0.1 %) @ 500 ml pot^{-1} resulted in 51.3 per cent disease reduction over control. Kitazin (0.05 %) also showed effectiveness, resulting in disease reduction of 34.1 and 43.5 per cent over control. Devlash Rakesh*et al*., 2011evaluated some seed dressing fungicides for the management of Banded leaf and sheath blight by using maize variety Early Composite and three seed dressing fungicides applied before sowing viz. Bavistin (2.5 gm/kg of seed), Vitavax Power(2.5 gm/kg of seed) and Thiram(2.5 gm/kg of seed). The results revealed that all the fungicides improved the seed germination, reduced lodging and Banded leaf and sheath blight along with significant increase in grain yield as compared to control (no seed treatment). Bavistin were found highly effective with 48.7% disease control and highest yield of 64.7q/ha over control.

Integrated management of banded leaf and sheath blight

Dalmacio*et al*., 1990 were conductedthree experiments on the mechanical, biological, and chemical control of banded leaf and sheath blight in corn caused by *Rhizoctonia solani*. In case of mechanical control the deleafing of corn plants proved to be effective in controlling the upward spread of lesion. Among the chemicals and biocontrol agents validamycin gave the best control, followed by *T. harzianum*. Validamycin afforded the best control in terms of reduction in lesion spread.

Singh Akhilesh and Singh Dhanbir, 2011 was conducted a field trial using cultural practices, bioagents and fungicides. Out of 11 treatments, minimum disease intensity (1.36 on 1–5 scale) and maximum yield(42.28 q/ha) was found in case of foliar spray of validamycin (0.25%) followed by Tilt (0.1%) and bavistin (0.1%). Foliar spray of Indofil M-45 (0.25%) was found to be least effective among all chemicals,but showed significantly lower disease severity and higher grain yield over check. Use of bioagents given as foliar spray showed more effective response against the disease when compared with seed treatment. *Trichoderma viride* was found more effective than *Pseudomonas fluorescens.*In all the treatments,there were significant increase in yield over check.

Carbendazim, neem oil and *Trichoderma harzianum* were evaluated as seed treatment (ST) and also as ST plus spray in various combinations for manageing the banded leaf and sheath blight of maize. Treatments with combination of ST and spray application were more effective than ST alone. The maximum grain yield (52.0 q ha^{-1}) with significantly reduced disease (46.8%) and increased grain yield (51.6%) were recorded in the ST+spray of carbendazim (0.1%), followed by treatment with neem oil (0.2%), over other treatments and control. Use of neem oil as seed treatment and spray could be a cost effective and eco-friendly strategy in managing the BLSB. (Bunker *et al*., 2012)

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