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Control of Helminthosporium leaf blight of spring wheat using seed treatments and single foliar spray in Indo-Gangetic Plains of Nepal

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ABSTRACT

Four fungicides for seed treatments and one as foliar spray were tested in replicated field experiments in a strip plot design to determine the effect of fungicides on Helminthosporium leaf blight (caused by *Cochliobolus sativus* and *Pyrenophora tritici-repentis*) severity and grain yield of wheat. Wheat seed cv. RR 21 was treated with fungicides, carbendazim (Areestin), triadimenol (Baytan), tebuconazole (Raxil), and carboxin + thiram (Vitavax 200B). Single foliar application of propiconazole (Tilt) was sprayed at flowering stage. Controls were included for both factors and treatments were replicated four times. Triadimenol and carboxin + thiram increased seed germination in both years. Triadimenol, tebuconazole, and carboxin + thiram reduced the number of infected seedlings and seedling root rot severity in both years. Number of tillers was higher in carboxin + thiram treated plots compared to other seed treatments. Compared to the control, carboxin + thiram increased grain yield by 9% and 8% in 2004 and 2005, respectively, and triadimenol by 6% in both years. The foliar spray of propiconazole significantly reduced Helminthosporium leaf blight severity and increased thousand-kernel weights. Propiconazole spray increased grain yield by 15% and 14% in 2004 and 2005, respectively. Therefore, seed treatment either with triadimenol or carboxin + thiram in combination with single post-flowering foliar spray of fungicides should minimize grain yield loss due to wheat foliar blight in South Asia. The findings of this study could be useful in developing strategies to manage Helminthosporium leaf blight in South Asia and other warm wheat growing regions of the world.

1. Introduction

In the Indian subcontinent, Helminthosporium leaf blight (HLB) of wheat (*Triticum aestivum* L.) occurs as a complex of spot blotch [caused by *Cochliobolus sativus* (Ito & Kurib.) Drechsler ex Dastur (anamorph: *Bipolaris sorokiniana* (Sacc.) Shoem.)] and tan spot [caused by *Pyrenophora tritici-repentis* (Died.) Drechsler (anamorph: *Drechslera tritici-repentis* (Died.) Shoem.)] (Duveiller et al., 2005). Helminthosporium leaf blight is an economically important disease especially in Indo-Gangetic Plains of Bangladesh, India, Nepal, and Pakistan as well as in many other wheat producing regions of the world (Acharya et al., 2011). The disease can be devastating with up to 100% severity by causing more than 30% yield loss to susceptible wheat cultivars under favorable weather conditions (Saari, 1998; Sharma and Duveiller, 2004, 2007; Duveiller et al., 2005).

Bipolaris sorokiniana is a seed-borne (Shrestha et al., 1998; Burlakoti et al., 2014), soil-borne (Sarwar et al., 1998; Kumar et al., 2002), and wind-borne pathogen (Duveiller et al., 2005). The pathogen causes black point, seedling blight, common root rot (Kumar et al., 2002; Burlakoti et al., 2014) and leaf blight of wheat (Dubin et al., 1998; Duveiller et al., 2005; Burlakoti et al., 2013). Foliar symptoms caused by *B. sorokiniana* are observed as early as seedling stage whereas those of *P. tritici-repentis* are found at late tillering stage in the warmer wheat growing region of Nepal (Duveiller et al., 2005). However, airborne inoculum of these pathogens can be detected simultaneously at low temperature conditions or early wheat growing stages. As the wheat growing stage advances with increases in temperature, *B. sorokiniana* becomes dominant compared to *P. tritici-repentis* in the HLB complex

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(Duveiller et al., 2005). Concurrence of *P. tritici-repentis* with *B. sorokiniana* signifies the role of *P. tritici-repentis* in HLB complex across the lowland wheat growing regions in Nepal (Sharma et al., 2003). Therefore, HLB complex poses multiple challenges to manage seed-borne, soil-borne, and wind-borne inoculum for effective disease management.

Fungicide seed treatments and foliar spray are in use to manage seed- and wind-borne infections, respectively (Stack and McMullen, 1988; Mehta, 1993; Sharma-Poudyal et al., 2005; Duveiller et al., 2005). Several fungicides such as iprodione + thiram or iminoctadine (Reis, 1991); imazalil (Herrman et al., 1990); imazalil, nuarimol, triadimenol, propiconazole, difenoconazole, and flutriafol (Stack and McMullen, 1991); mancozeb and thiram (Giri et al., 2001); carboxin + thiram, and carbendazim (Sharma-Poudyal et al., 2005) have been reported to be useful in protecting germinating seeds and seedlings from early infection. Foliar spray of fungicides has proven useful and economical to control spot blotch or HLB complex (de Viedma and Kohli, 1998; Duveiller et al., 2005; Sharma-Poudyal et al., 2005). Other fungicides such as epoxiconazole, epoxiconazole + dekresoxim-methyl, tebuconazole, propiconazole (Sharma-Poudyal et al., 2005); epoxiconazole (Sharma et al., 2006); tebuconazole, ciproconazole, fluzilazole, metaconazole and propiconazole (de Viedma and Kohli, 1998); triademefon, fentinacetate-maneb and propiconazole (Hobbs et al., 1998); and propiconazole (Lapis, 1985) are effective to reduce the disease severity. In our previous study, carboxin + thiram is the most promising fungicide for seed treatment (Sharma-Poudyal et al., 2005) in the Indo-Gangetic Plains. Therefore, this study was performed to compare the efficacy of carboxin + thiram with other fungicide seed treatments such as triadimenol (Stack and McMullen, 1991; Mathre et al., 2001) and tebuconazole (Mathre et al., 2001) that were effective to control common root rot as well as other root rots in temperate wheat growing regions (Stack and McMullen, 1991; Mathre et al., 2001), with or without a single spray of propiconazole on HLB development and grain yield under natural disease pressure in subtropical wheat growing region in Nepal.

2. Materials and methods

2.1. Field experiments and fungicide treatments

Field experiments were conducted during spring wheat growing seasons in 2003–2004 and 2004–2005 at Rampur, Nepal [(27°40′N and 84°19′E), 228 m above sea level]. Each experiment consisted of a strip plot design with four replications. Four seed treatments and the control were horizontal factors. Wheat cultivar RR 21 susceptible to HLB was selected for the study (Duveiller et al., 2005). Seeds were treated (either 2 g or 2 ml kg^{-1} of seed) with carbendazim 50% WP (Areestin, Artee Graphite, New Delhi, India), triadimenol 150 ml L^{-1} (Baytan, Bayer CropScience, Durham, NC, USA), tebuconazole 2% (Raxil, Bayer CropScience, Durham, NC, USA), or carboxin 19.5, w/v + thiram 19.5, w/v (Vitavax 200B, Uniroyal Chemical, Middlebury, CT, USA). A vertical factor was single foliar spray of propiconazole 25% EC (Tilt 250EC, Novartis India Ltd., Mumbai, India) and non-spray check. Propiconazole (0.5 l ai ha^{-1} mixed with 300 l ha^{-1} water) was a single foliar sprayed with an electric backpack sprayer (Pulverisateur Pulvelec – piston membrane 5 bar – 1.5 l min^{-1}, Markus Technology, Godewaersvelde, France) at flowering stage (Zadoks' growth stage GS 61, Zadoks et al., 1974).

Wheat was planted on December 6 and 7 in 2003 and 2004, respectively. Recommended dose of fertilizers were applied (120 kg N, 60 kg P_2O_5 and 40 K_2O kg ha^{-1}) as a basal application. Nitrogen 20 kg ha^{-1} was top-dressed at tillering stage. Seeds (120 kg ha^{-1}) were planted manually along rows in each plot (2×2 m^2). Each plot consisted of 8 rows spaced 0.25 m apart. Each plot had a 1 m wide border of wheat planted to reduce inter-plot interference due to fungicide spray. Weeds were pulled out manually from the plots. Plots were irrigated three times as per the recommendation for the test site (Sharma and Duveiller, 2004).

2.2. Disease rating and agronomic traits

Germinated wheat seedlings were counted per m^2 (4 centered rows of 1 m length) at 10 days after seeding (DAS). Similarly, HLB-infected seedlings were counted at 15, 22, and 29 DAS (Sharma-Poudyal et al., 2005). At 29 DAS, seedling height of 10 randomly selected seedlings was measured from ground level to tip of top most leaf in each plot.

Wheat plants were dug out in 1-m length from second row of each plot at flowering stage (GS 69) to assess sub-crown root rot. Common root rot severity was scored from 10 randomly selected roots using 0–3 scale [0 = healthy root, 1 = slight infection (1–25% of the subcrown internode tissue covered by lesions), 2 = moderate infection (26–50% diseased root area), and 3 = severe (>50% diseased root area) (Ledingham et al., 1973)]. Ten primary tillers were randomly selected and tagged at anthesis (GS 69) in each plot for HLB severity assessment. Disease severity was estimated three times on flag (F) and penultimate (F-1) leaves as described by Dubin et al. (1998). First disease scoring was done on 3 March (88 DAS, 73 GS) and on 6 March (89 DAS, 73 GS) in 2004 and 2005, respectively. Second and third HLB severity assessments were made after 7 and 17 days of first scoring in 2004, and 10 and 17 days of first scoring in 2005. Area under the disease progress curve (AUDPC) curve was first calculated for F and F-1 leaves according to Das et al. (1992), and then an average was calculated for two leaf positions. Effective tiller numbers were counted in two center rows of 2-m length (1 m^2). Plants were harvested at maturity from the center rows (1.25×2 m^2). Yield variables measured were total grain weight (adjusted to 12% moisture content), and thousand-kernel weight (TKW).

2.3. Data analysis

Effect of seed treatments on seedling disease variables was computed with analyses of variance (ANOVA). Similarly, individual ANOVA was performed for each agronomic, disease, and yield variable of field experiments to determine the effect of seed treatments, foliar spray, and interactions. Treatments mean comparisons for variables were performed using Fisher's protected LSD ($P \leq 0.05$). A combined ANOVA over years was also computed. All the statistical analyses were performed using Minitab (PA, USA).

3. Results and discussion

The effect of years, seed treatment (horizontal factors), foliar spray (vertical factor), and their interactions on HLB and agronomic traits are presented in Table 1. The effect of year was significant on number of seedlings, AUDPC, TKW, and grain yield. Seed treatment significantly affected germination, infected seedlings number, root rot severity, effective tiller number, and grain yield. Seed treatment and year interaction was significant only for the number seedling germinated and number of infected seedlings at 15 and 22 days of sowing. One spray of propiconazole significantly affected AUDPC, TKW, and grain yield. Interaction between a foliar spray and year was significant only for AUDPC. Difference in weather conditions over the years might have resulted in the significant interaction. Interaction among year, seed treatment, and foliar spray was significant only for grain yield. Interaction between seed treatment