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Short communication

Evaluation of fungicides for the management of pearl millet [*Pennisetum glaucum* (L.)] blast caused by *Magnaporthe grisea*

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ABSTRACT

Blast disease caused by *Magnaporthe grisea* has emerged as a serious threat to pearl millet cultivation in India. Most of the hybrids being grown in India are susceptible to blast as not much efforts have been made to breed for blast resistance in pearl millet. In the absence of host plant resistance, the disease can be effectively managed with chemical fungicides. Therefore, nine fungicides, chlorothalonil, tricyclazole, hexaconazole, kasugamycin, benomyl, carbendazim, tebuconazole + trifloxystrobin, propiconazole and metalaxyl + mancozeb were tested for their efficacy to manage blast disease on a blast susceptible pearl millet line ICMB 95444. Different combinations of seed treatment and foliar sprays were tested: seed treatment alone, seed treatment + one spray, seed treatment + two sprays, seed treatment + three sprays. None of the fungicides was found effective when used as seed treatment. Results of this study clearly demonstrated that the disease can be effectively managed with three sprays of tebuconazole + trifloxystrobin (Nativo) or propiconazole (Tilt).

1. Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an important cereal crop grown on a 30 million ha area in the arid and semi-arid tropics (SAT) of Asia and Africa (Yadav and Rai, 2013). Due to the tolerance to drought, it is cultivated as a major crop in most countries of the world (Bidinger et al., 1987). In India, pearl millet is the third most important rainfed cereal crop grown over 9 million ha with an annual production of 9.5 million tonnes, mainly in the states of Haryana, Gujarat, Maharashtra, Rajasthan and Uttar Pradesh (Yadav and Rai, 2013; Yadav et al., 2012). The grains are highly nutritious with high levels of energy and protein, and high densities of iron and zinc (Rai et al., 2008).

Among the diseases of pearl millet, blast caused by *Pyricularia grisea* (Cooke) Sacc. [Teleomorph: *Magnaporthe grisea* (Herbert) Barr], a disease of minor importance in past years, has gained status of major constraint to pearl millet production in India (Lukose et al., 2007). *Magnaporthe grisea* is externally seed borne and also survives as chlamydospores or as free saprophytic mycelium in the soil/leaf debris which serves as a source of primary inoculum (Singh and Pavgi, 1977). The disease also appears in several countries in west and central Africa such as Senegal, Mali, Burkina Faso, Niger, Nigeria and Chad. The disease appears in severe form in forage crops in the southern coastal plains of the USA (Wilson and Gates, 1993). It has been observed on various hybrids and local cultivars being grown in the major pearl millet growing states, Rajasthan, Gujarat, Uttar Pradesh, Haryana and Maharashtra in India with various levels of disease severity (AICPMIP, 2011–12).

Deployment of resistant varieties is considered as the most economical and ecofriendly method of management of plant diseases. Efforts are being made to understand inheritance of resistance to *M. grisea* and pathogenic variation in the pathogen so as to develop pearl millet parental lines and hybrids resistant to blast (Gupta et al., 2012; Sharma et al., 2013). Although blast disease in rice (*Oryza sativa*) is primarily managed through host plant resistance, the pathogen has the ability to develop new pathogenic races leading to breakdown of resistance within few years (Ahn, 1994). Hence, attempts have been made to manage blast disease in different crops using fungicides (Varier et al., 1993; Lukose et al., 2007; Narayana Swamy et al., 2009; Netam et al., 2014; Pagani et al., 2014). Though host plant resistance is the most economical and viable disease management strategy to control pearl millet blast, most of the commercial hybrids being grown in India are susceptible to blast. In the absence of blast-resistant cultivars, the disease can be best managed with chemical fungicides. *In vitro* studies have shown the inhibition of radial growth of pearl millet isolate of *M. grisea* with fungicides such as chlorothalonil, tricyclazole, hexaconazole, carbendazim and propiconazole (Kumar and Singh, 1995; Bhojya Naik and Jamadar, 2014). These fungicides have also been found to be effective in providing protection to the rice crop against blast disease (Sood and Kapoor, 1997; Prajapati et al., 2004; Dutta et al., 2012). Carbendazim and tricyclazole have been reported to be effective against

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pearl millet blast under field conditions (Lukose et al., 2007; Joshi and Gohel, 2015). However, differential sensitivity of the pathogen isolates from rice to tricyclazole and carbendazim has also been reported (Yuan and Yang, 2003; Mohammad et al., 2011). In addition, benomyl, kasugamycin and Nativo (a combination fungicide containing tebuconazole and trifloxystrobin) have also been reported to be effective against rice blast (Narayana Swamy et al., 2009; Ganesh Naik et al., 2012). The present study was planned to evaluate these eight fungicides against pearl millet blast under field conditions to identify promising fungicides for the management of this disease. As major efforts in pearl millet pathology have always been focused on the management of downy mildew, the most important disease of pearl millet, seed treatment with metalaxyl and foliar spray of Ridomil (metalaxyl 8% + mancozeb 64% WP) which is most effective against downy mildew was also included in the present study (Singh et al., 1984; Thakur et al., 2011).

2. Materials and methods

2.1. Field preparation and experiment layout

The field trials were conducted during the rainy seasons of 2012 and 2013 in a research farm at ICRISAT, Patancheru, Hyderabad, India. The trials were laid out in a split plot design with 10 treatments and three replications. Each plot size was 4 m × 2.25 m, and consisted of three rows 0.75 m apart. Main plots and subplots were separated by 1.5 m and 1.0 m, respectively, on each side. The blast susceptible pearl millet hybrid parent line, ICMB 95444 was used in the field trials. Seeds were sown in the plot with a spacing of 75 × 10 cm and uniform number of plants in each plot was maintained by removing the extra seedlings at 15 days after sowing (DAS). The recommended package of practices for pearl millet cultivation was followed (Yadav et al., 2015).

2.2. Fungicides treatment and spray schedule

Nine fungicides (subplot factor), chlorothalonil, tricyclazole, hexaconazole, kasugamycin, benomyl, carbendazim, tebuconazole + trifloxystrobin, propiconazole and metalaxyl [metalaxyl as seed treatment and Ridomil (metalaxyl 8% + mancozeb 64% WP) as foliar spray] were tested for their efficacy against blast disease on the susceptible line, ICMB 95444 (Table 1). Four combinations of seed treatment and foliar sprays (main plot factor) were tested: seed treatment alone (set 0), seed treatment + one spray (set 1), seed treatment + two sprays (set 2), seed treatment + three sprays (set 3). For seed treatment, seeds were treated separately with each fungicide with the dose as described in Table 1. The doses of the fungicides found to be effective against blast disease in other crops were selected for this study. The first spray of fungicides was scheduled at seven days before inoculation with *M. grisea* spore suspension. The second spray was applied seven days after inoculation in sets 2 and 3, and the third spray in set 3 was applied 15 days after the second spray.

Table 1
Fungicides evaluated against *Magnaporthe grisea* under field conditions during 2012–13.

Treatment	Fungicide	Trade Name	Dose	
			Seed treatment (/Kg)	Spray (/L)
T1	Chlorothalonil 75% WP	Kavach	2.5 g	2.5 g
T2	Tricyclazole 75% WP	Baan	0.6 g	0.6 g
T3	Hexaconazole 5% EC	Contaf 5E	0.5 mL	0.5 mL
T4	Kasugamycin 3% SL	KASU-B	2.5 mL	2.5 mL
T5	Benomyl 50% WP	Benofit	2.0 g	1.0 g
T6	Carbendazim 50% WP	Bavistin	2.0 g	0.5 g
T7	Tebuconazole 50% + trifloxystrobin 25% WG	Nativo	0.4 g	0.4 g
T8	Propiconazole 25% EC	Tilt	1.0 mL	1.0 mL
T9	(Metalaxyl 8% + mancozeb 64% WP) for spray/ metalaxyl 35 WS for seed treatment	Ridomil/ Metal	6.0 g	2.5 g
T10	Control			

2.3. Inoculum preparation and inoculation

Magnaporthe grisea isolate Pg 45, collected from pearl millet fields at ICRISAT, Patancheru, India was used in this study. Inoculum of the isolate Pg 45 was prepared according to the procedure described by Sharma et al. (2013). The spore suspension was prepared using sterilised distilled water, adjusted to a desired concentration (1×10^5 spores mL^{-1}) using a haemocytometer (Fisher Scientific) and a drop of surfactant Tween 20 (HiMedia) was added to ensure the uniform dispersal of spores. The crop (30 days old seedlings) was spray inoculated with an aqueous conidial suspension using a hand operated Knapsack sprayer. Perfo-irrigation was provided to the crop twice a day 30 min each in the morning (between 10 and 11 a.m.) and in the afternoon (between 5 and 6 p.m.) on rain-free days to maintain high relative humidity and leaf wetness to facilitate fungal infection and disease development. Weather data during the crop growth (standard meteorological weeks 31–42) in 2012 and 2013 is given in Fig. 1.

2.4. Disease assessment and analysis

The blast severity was measured visually as percent infected foliage at seven days after inoculation, and further measurement was done up to 35 days at seven days intervals. The disease severity values at each recording were used to calculate the area under the disease progress curve (AUDPC). The AUDPC was calculated using the formula:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

where "t" is the time of each reading, "y" is percent disease severity at each reading and "n" is the number of readings.

Disease severity recorded at 35 days after inoculation was used to calculate percent disease reduction (PDR) in the fungicide treatments over control using the formula:

$$\text{PDR} = \frac{\text{Disease severity in control} - \text{disease severity in treatment}}{\text{Disease severity in control}} \times 100$$

GENSTAT statistical package version 10.1 (Rothamsted Experiment Station, Herpenden, Herts AL52JQ, UK) was used for randomization of treatments and analysis of variance (ANOVA) for the arcsine transformed values of percent disease reduction over control for the comparison of treatments.

3. Results

The disease symptoms were clearly visible seven days after inoculation in the untreated control. Hence, the first observation was made at seven days after inoculation. Significant differences ($P < 0.05$) for percent disease reduction over the control were observed among fungicides and different sets of treatments (Table 2). This indicated differences in the effectiveness of fungicides against blast. None of the fungicides provided an adequate level of disease control through seed treatment alone (Set 0) and the fungicide treatments were comparable to the untreated control (Table 3). AUDPC values were also high in Set 0 and were comparable to untreated control (Fig. 2).

Disease severity increased substantially 14 days after inoculation both during 2012 and 2013 in the untreated control and other treatment plots except propiconazole and tebuconazole + trifloxystrobin