Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 1684-1687
Received: 01-07-2019
Accepted: 03-08-2019

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Evaluation of fungicides and bio-control agents against stripe disease of barley caused by *Drechslera graminea*

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Abstract
The stripe disease caused by *Drechslera graminea* (Telomorph- *Pyrenophora graminea*) is most devastating barley disease which constantly increasing in all major barley growing countries and causing mild to severe damage. The present experiment was carried out to evaluate the chemical as well as biological seed dressers to find out the most effective seed dresser to manage the stripe disease of barley. Among the chemical seed dressers tebuconazole 2% Ds @ 0.2% was found best with minimum disease incidence (7.42%) and maximum grain (55.01q) as well as fodder (65.67q) yield. It was closely followed by seed treatment with combination of carboxin + thiram (1:1)75%WP @ 0.2 per cent (10.37,52.66 & 62.65) and lower dose of tebuconazole 2% Ds @ 0.1% (11.53,51.29 &61.59) with per cent disease incidence, grain & fodder yield respectively. The bio-agents were found less effective as compared to chemicals, however, *Trichoderma viride* and *T. harzianum* proved good in efficacy as compared to other bio-agents.The cost benefit ratio was also recorded maximum in the best treatment tebuconazole 2% Ds @ 0.2% (1:2.63) followed by carboxin + thiram (1:1)75%WP @ 0.2 per cent (1: 2.53).

Keywords: *Drechslera graminea, Pyrenophora graminea,* tebuconazole, *Trichoderma viride,* disease incidence

1. Introduction
Barley (*Hordeum vulgare* L.) is fourth largest cereal crop in the world with a share of 7% of the global cereal production (Pal *et al.*, 2012) [17] and it has capability to grow in marginal and stress-affected environment and is a source of malt and other products (Devlash *et al*., 2015) [5]. In India, barley is cultivated on about 6.7 lakh ha area with the production of 1.75 million tons in 2016-2017 (www.agricoop. gov. in). In Rajasthan, it covers 2.8 lakh ha area with the production of 9.0 lakh tons in 2016-17 (www.agriculture.rajasthhan.gov.in). Barley is subject to various fungal, bacterial, viral and noninfectious diseases. Among the barley diseases, the stripe disease caused by *Drechslera graminea* (Telomorph- *Pyrenophora graminea*) is most devastating disease in the world (Benbelkacem *et al.*, 2000) [2]. The disease is seed borne in nature and pathogen survives exclusively as mycelium on pericarp or hull and easily transported through infected seed from infested area to healthy crop growing area (Platenkamp, 1976) [18]. Yaduman *et al.* (2013) [22] reported barley leaf stripe disease caused more loss as 70 to 72% under epiphytotic conditions. In India, the disease was first time reported by Butler in 1918 and Mathur and Bhatnagar (1991) [14] reported up to 31.9 per cent loss occurred due to barley stripe. But in recent years, the disease incidence of stripe disease is gradually increasing in all major growing areas in world as well as in India due to intensive use of susceptible cultivars, favourable environmental conditions, unawareness of farmers from the spread of disease. Therefore, the present investigation was formulated to know the best management strategy for disease management through fungicides and bio-control agents either alone or with combinations.

2. Material and methods
The field experiments were conducted during consecutive two *rabi* seasons (2016-17 and 2017-18) at Rajasthan Agricultural Research Institute, Durgapura. Sowing was done by using susceptible variety RD 2035 in 3x2m plot with three replications. The seven chemical seed dressers *viz*. Thiram, Captan, Carbendazim, Tebuconazole, Propiconazole, Mancozeb and Carboxin 37.5% + thiram 37.5% (Vitavax power) and four bio-control agents *viz*. *Trichoderma harzianum, Trichoderma viride, Pseudomonas fluorescens* and *Bacillus subtilis* were tested against this disease.

The data on disease incidence were recorded at the maturity of crop. Total number of healthy and diseases plants were counted individually and per cent disease incidence was calculated. The grain and fodder yield were recorded after harvest.

The disease is seed and soil borne in nature. Therefore, inoculum was applied through seed and soil to getting maximum disease pressure. Seeds were surface sterilized with sodium hypochlorite (1.0%) and washed thoroughly before inoculation. The seeds were soaked in water and left overnight. These soaked seeds were inoculated by plunging in an active mycelial suspension of the highly virulent isolate Dg-03. Soil inoculation was done by adding mass inoculum @ 1g/10 g soil and applied in furrow after thoroughly mixing, at the time of sowing. The benefit: cost ratio (B: C ratio) was calculated by using existing price of inputs and outputs on the basis of minimum support price (MSP).

$$\text{Benefit: cost ration} = \frac{\text{Gross returns } (₹ ha^{-1})}{\text{Cost of cultivation } (₹ ha^{-1})}$$

List of fungicides and bio-control agents for seed treatment

Fungicides	Concentration
Carboxin+thiram	0.1%, 0.2%
Carbendazim	0.1%, 0.2%
Tebuconazole	0.1%, 0.2%
Mancozeb	0.2%, 0.3%
Thiram	0.2%, 0.3%
Captan	0.2%, 0.3%
Trichoderma harzianum	0.5%
Trichoderma viride	0.5%
Pseudomonas fluorescens	0.5%
Bacillus subtilis	0.5%

3. Result and discussion

The two years pooled data depicted in table-1 revealed that all the seed dressers were found significantly superior over the control. However, the seed treatment with tebuconazole 2%DS @ 0.2% was found best with minimum percent disease incidence (7.42) and it was closely followed by carboxin + thiram (1:1) 75% WP @ 0.2% with 10.37 per cent disease incidence. These treatments were at par in efficacy and these were followed by seed treatment with lower dose of tebuconazole 2%DS & carboxin + thiram (1:1) 75% WP, mancozeb 75% WP @ 0.3% and thiram @0.3% with 11.53, 15.78, 17.33 and 17.48 per cent disease incidence respectively. The bio-agents were found less effective as compared to chemical seed dressers, however, *Trichoderma viride* (33.41PDI) and *T. harzianum* (36.9PDI) showed good efficacy as compared to other bio-agents tested against this disease.

3.1 Yield: The maximum grain and fodder yield was also obtained in seed treatment with tebuconazole 2%DS @ 0.2% (55.01& 65.67q) followed by carboxin + thiram (1:1) 75% WP @ 0.2% (52.66&62.55 q) & tebuconazole 2%DS @ 0.1% (51.29&61.59q). These treatments were at par in performance of both grain as well as fodder yield.

3.2 Cost Benefit ratio: The cost benefit ratio was highest in case of tebuconazole 2%DS @ 0.2% (1:2.63) followed by carboxin + thiram (1:1) 75% WP @ 0.2% (1:2.53) and in lower dose of tebuconazole 2%DS (1:2.47).

Table 1: Effect of seed treatment on stripe disease of barley during 2016-17 and 2017-18 (Two year pooled data)

Treatments	PDI (%)	Yield q/ha	Fodder yield q/ha	C : B Ratio
T_1Carboxin+thiram (V.P) 0.1%	*15.78 **(23.41)	47.81	54.23	1: 2.30
T_2 Carboxin+thiram (V.P) 0.2%	10.37 (18.79)	52.66	62.65	1 :2.53
T_3 Thiram 0.2%	20.69 (27.06)	45.69	52.59	1 : 2.21
T_4Thiram 0.3%	17.48 (24.71)	46.03	55.64	1 : 2.22
T_5Mancozeb 0.2%	22.60 (28.39)	40.75	49.13	1 : 1.97
T_6Mancozeb 0.3%	17.33 (24.60)	47.25	55.31	1 : 2.28
T_7Carbendazium 0.1%	28.16 (32.05)	36.65	43.95	1 : 1.77
T_8Carbendazium 0.2%	26.47 (30.96)	37.87	45.10	1 : 1.82
T_9Tebuconazole 0.1%	11.53 (19.85)	51.29	61.59	1 : 2.47
T_{10}Tebuconazole 0.2%	7.42 (15.81)	55.01	65.67	1 : 2.63
T_{11}Captan 0.2%	24.69 (29.79)	40.20	48.42	1 : 1.94
T_{12}Captan 0.3%	20.91 (27.21)	44.09	52.06	1 : 2.12
T_{13}*Trichoderma viride*	33.41 (35.31)	31.21	37.31	1 : 1.50
T_{14}*Trichoderma harzianum*	36.90 (37.41)	29.37	35.10	1 : 1.41
T_{15}*Pseudomonas fluorescens*	44.53 (41.86)	25.81	30.71	1 : 1.24
T_{16}*Bacillus subtilis*	47.01 (43.29)	24.53	28.58	1 : 1.18
T_{17}Control	51.96 (46.12)	20.18	25.81	1 : 0.99
SEm ±	1.09	1.76	1.89	
CD at 5%	3.15	5.08	5.46	
C.V	7.37	7.68	6.91	

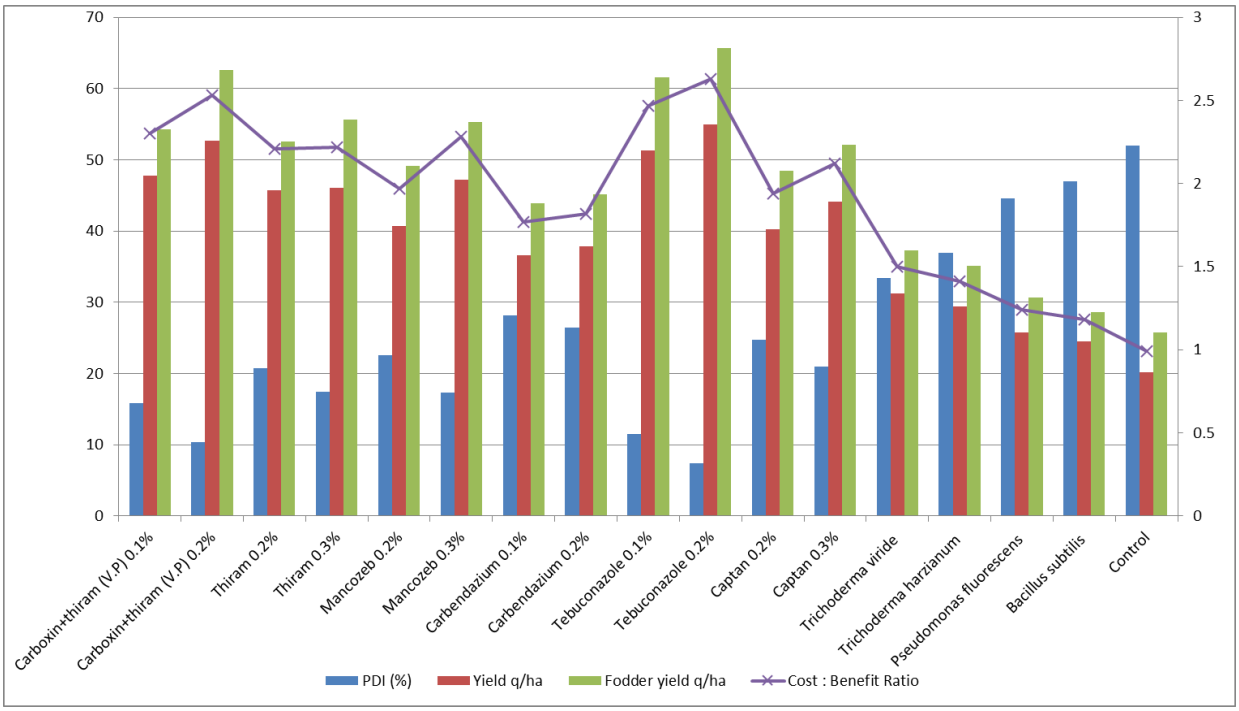

Fig 1: Effect of seed treatment on stripe disease of barley (Pooled)

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