Universal Journal of Agricultural Research 3(2): 59-67, 2015 http://www.hrpub.org
DOI: 10.13189/ujar.2015.030205

Seed Priming and *Trichoderma* Application: A Method for Improving Seedling Establishment and Yield of Dry Direct Seeded *Boro* (Winter) Rice in Bangladesh

Moshiur Rahman*, Julfikar Ali , Mehedi Masood

Department of Agronomy, Bangladesh Agricultural University, Bangladesh

Copyright © 2015 Horizon Research Publishing All rights reserved.

Abstract Seedling mortality is the major barrier to optimum stand establishment in dry direct seeded boro (winter) rice. Two experiments were carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh during January to June 2012 and 2013 to study the effect of seed priming, *Trichoderma* and fungicide application on seedling establishment and yield performance of dry direct seeded *Boro* rice. First experiment comprised three seed priming treatments, osmopriming with 3% $ZnSO_4$ solution, hydropriming and no priming. There were five treatment combinations of *Trichoderma* and fungicides. These were seed treatment with *Trichoderma* (T_1), spraying of rice seedling with sulphur fungicide (Thiovit) (T_2); propiconazole fungicide (Potent) (T_3), and combination of Thiovit and Potent (T_4) and a control treatment (T_5) where no fungicide or *Trichoderma* was applied. The treatment was applied at 20 days after sowing (DAS). In year 2013, the experiment comprised ten treatment combinations of *Trichoderma* and fungicides viz.seed treatment with *Trichoderma* (T_1), seed treatment with *Trichoderma* + spraying of Thiovit (T_2), seed treatment with *Trichoderma* + spraying of Potent (T_3), seed treatment with *Trichoderma* + spraying of Thiovit and Potent (T_4), spraying of Thiovit (T_5), spraying of Potent (T_6), seed treatment with Thiovit + spraying of Potent (T_7), seed treatment with Potent + spraying of Thiovit (T_8), spraying of mixture of Thiovit and Potent (T_9), and control (no fungicide or *Trichoderma*) (T_{10}). Both the experiments used Randomized Complete Block Design (RCBD) with three replications. Results showed that osmopriming gave higher number of seedling, length and dry matter of shoot and root and yield than hydropriming. All these attributes were highest with seed treatment by Trichoderma. Experiment 2 revealed that seed treatment with *Trichoderma harzianum* followed by spraying of Thiovit gave the highest yield of rice. The study concludes that sowing of seed after osmopriming with 3% $ZnSO_4$ and biopriming with *Trichoderma* and then application of sulphur fungicide at 20 days after sowing could be practiced for ensuring high seedling establishment and yield of rice under dry direct seeded system in boro season.

Keywords Rice, Boro Season, Dry Direct Seeding, Priming, Fungicide Application

1. Introduction

Rice (*Oryza sativa L.*) is the staple food for nearly half of the world's population.The global rice requirement has been increased by more than two folds (e.g. 150 million tones in 1961 and 350 million tones in 2011) during the last five decades [23]. In 2011-12, 33.541 million tons of rice is produced from 11.527 million hectares of land in Bangladesh [5]. Among the three rice seasons viz. *Aus, Aman* and *Boro,* rice yield is the highest in *Boro* season. *Boro* rice contributes about 56% of the total rice production in Bangladesh. Therefore, *Boro* rice is the main contributor to the food production and security in the country.

Rainfall is practically nil during Boro season (December – March) and therefore, rice production in this season is fully dependant on irrigation. Rice is mainly cultivated in puddle transplanted flood irrigation (PTR-CI) system requiring 3000-5000 litres of water to produce one kilogram of rice. Very recently, scarcity of irrigation water is evident in many parts of the country that threatens the sustainability of boro rice production. Under this water scarce situation, farmers may be forced to shift their rice land to other crops which would cause severe food shortage in the country.

Rice production could be sustained in water shortage areas by adopting technologies that ensures rice production with less water. Recent research shows that boro rice could be produced using 50-70% less water by adopting the dry direct seeded rice production technology [28, 32]. In this system rice seed is directly sown on dry cultivated land during December to January. This sowing period coincides with very low temperature which causes poor seedling establishment owing to seedling mortality. The poor seedling establishment due seedling mortality poses a serious hindrance to the rice production in this new system.

Application of chemical fungicides (e.g. sulphur or propiconazole) helps improve field emergence and percent survival of seedlings and thus contributes to stand establishment [33]. Research reports reveal that seed priming helps improve germination rate, reduces the germination time, improves synchronized germination and increases stand establishment in rice [3, 13]. Other reports indicate that *Trichoderma harzanium*, a plant growth promoting fungi (PGPF) can be used for improving germination and seedling establishment [10, 20]. The present study sought to investigate the effect of seed priming, *Trichoderma* and fungicide application on seedling establishment and yield performance of dry direct seeded *Boro* rice.

2. Materials and Methods

2.1. Study Site

Field experiments were conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh during *Boro* season (January to June) 2012 and 2013.The experimental site is a medium high land belonging to the Sonatala series of Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) having non-calcareous dark grey floodplain soils. The site is located at 24º75´N latitude and 90º50´E longitude having an altitude of 18 m. The soil was silt loam with pH 6.5. Soil contained 1.78% organic matter, 0.14% total N, 1.98 μg g^{-1} available P, 0.10 meq $100g^{-1}$ exchangeable K and 4.56 μg g^{-1} available S. The crop experienced very low rainfall (0-15 mm) during January – March which coincided with the vegetative stage. However, high rainfall was experienced in the later phase of plant growth. The average minimum temperatures of the area are below 15 ^{o}C during mid December and mid February and rises to more than 20 ^{o}C in last week of February.

2.2. Treatments and Experimental Design

In 2012, the experiment comprised three seed priming treatments viz. osmo-priming, hydro-priming and no priming and five *Trichoderma* and chemical fungicide treatment combinations viz. *Trichoderma harzanium* (T_1),sulphur fungicide (T_2), propiconazole fungicide (T_3), sulphur fungicide + propiconazole fungicide (T_4), and control (no fungicide or *Trichoderma*) (T_5) treatment. In 2013, the experiment comprised ten treatment combinations viz. seed treatment with *Trichoderma*(T_1), seed treatment with *Trichoderma* + spraying of sulphur fungicide (T_2), seed treatment with *Trichoderma* + spraying of propiconazole fungicide (T_3), seed treatment with *Trichoderma* + spraying of sulphur fungicide and propiconazole fungicide (T_4), spraying of sulphur fungicide (T_5), spraying of propiconazole fungicide (T_6), seed treatment with sulphur fungicide + spraying of propiconazole fungicide (T_7), seed treatment with propiconazole fungicide + spraying of sulphur fungicide (T_8), spraying of mixture of sulphur fungicide and propiconazole fungicide (T_9) and control (no fungicide or *Trichoderma*) treatment (T_{10}). Both the experiments used Randomized Complete Block Design (RCBD) and three replications. The plot size was 4.0 m × 2.5 m with 1 meter drain in between two plots to manage the irrigation easily.

2.3. Husbandry

BRRI dhan28 was used as test crop and seed was sown at 25 cm × 15 cm spacing allocating 4 seeds $hill^{-1}$. The sowing was done on 5 and 16 January 2012 and 2013, respectively. Hydro-priming and osmo-priming were done by soaking seeds in tap water and in 3% $ZnSO_4$ solution, respectively for 24 hours followed by incubation at 35 ºC for 30 hours. *T.harzianum* inoculum was mixed with seed at the rate of 4% of seed weight before 4 hours of sowing. Sulphur fungicide and propiconazole fungicide were mixed with seed @ 3% of seed weight. The land was fertilized with N, P, K, S and Zn @ 120, 14, 58, 8 and 1 kg ha^{-1} as urea, triple supper phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively. All the fertilizers were applied at final land preparation while urea was top dressed in three equal splits at 30, 45, and 65 days after sowing (DAS). Sulphur and propiconazole fungicide were applied at 20 DAS @ 2.5 kg ha^{-1} and 0.5 litre per hectare, respectively. A pre-emergence herbicide Panida (Pendimethalin) was applied at 2 DAS @ 2 litre ha^{-1}. In addition, four hand weedings were done at 30, 45, 60 and 75 DAS. Land preparation was done with residual moisture and therefore, no irrigation was required during land preparation. Then five irrigations were done at 40, 55, 70, 85 and 90 DAS. Standing water of 3-4 cm was maintained during irrigation at 85 and 90 DAS. Crop management was done following standard agronomic practices when necessary. The crop was harvested on 19 and 31 May, respectively in 2012 and 2013 crop seasons.

2.4. Recording of Data

Number of seedlings were counted at 7, 15 and 30 DAS from the central 1.5 m^2 (1.5 m length of four central rows) of each plot. Randomly selected ten seedlings were uprooted from each plot at 30 DAS to measure shoot and root length and their dry matter. Dry matter was recorded after oven drying of the plants at 70 ºC for 72 hours in force draft oven and was expressed in g $plant^{-1}$. The crop was harvested at maturity (when 80% grains become golden yellow in colour) from the central 3.6 m^2 area of each plot. The number of tillers and panicle m^{-2} were counted from the harvest area. The plant height was recorded from randomly selected five hills. The number of grains and unfilled spikelets $panicle^{-1}$ were counted from the randomly selected 10 panicles of the harvested crops. Grain and straw yields were recorded after sun drying. Grain yield was adjusted to 14% moisture content. Harvest index was calculated as percentage of grain yield to total above ground biomass. The weight of 1000 grain was also recorded from the collected grains of each plot.

2.5. Statistical Analysis

All data were subjected to statistical analysis following analysis of variance (ANOVA) technique with the help of computer package programme MSTAT-C and Duncan's Multiple Range Test (DMRT) was used for mean comparison [15].

3. Results

The number of seedling at 7, 15 and 30 days after sowing (DAS), seedling shoot and root length, shoot and root dry matter at 30 DAS, plant height, number of tillers and panicle m^{-2} at harvest, panicle length, number of filled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield and harvest index were affected significantly by seed priming, *Trichoderma* and fungicide application treatments but not by their interactions (experiment 1). In 2013, the effects of *Trichoderma* and fungicide application treatments showed significant effects on these characters (experiment 2). The results obtained for these experiments are presented here.

3.1. Seed priming

The highest numbers of seedling m^{-2} at 7, 15 and 30 DAS were found in osmopriming treated plots and the values were 58, 112 and 110, respectively while the values for hydropriming treatments were 53, 104 and 101, respectively. The corresponding values for crops with no priming treatment were only 7, 88 and 84, respectively (Table 1). The number of seedlings at 7 days after sowing did not significantly differ for osmopriming and hydropriming but this became significant at later stages at 15 and 30 DAS. Osmopriming produced the highest shoot and root lengths and shoot and root dry matters of seedlings at 30 DAS than the hydropriming plots. The shoot and root lengths for osmopriming were 20.06 and 7.38 cm while those for hydropriming were 18.10 and 6.66 cm respectively. The shoot and root dry matter for osmopriming were 2.149 and 0.862 g $plant^{-1}$ while those for hydropriming were 1.970 and 0.753 g $plant^{-1}$ (Table 3). The yield obtained from hydropriming treatment was statistically lower than the osmopriming treatment. Seed priming had significant effect on plant height, number of panicle m^{-2}, panicle length, numbers of grains $panicle^{-1}$, 1000-grain weight, grain and straw yield (Table 5 and 6). For all these parameters, the highest values were found with osmopriming which was significantly higher than those of hydropriming treated crops. The lowest values for all these characters were found with no priming control treatment.

3.2. Trichoderma and fungicide treatment

Trichoderma and fungicide treatment had significant effects on seedling establishment in both the years. In 2012, the number of seedlings at 7, 15 and 30 DAS were 65.56, 113.40 and 112.00 for *Trichoderma* treatment while the corresponding values for control plots were 36.56, 97.11 and 84.33, respectively (Table 2). The highest number of tillers (339 tillers m^{-2}) was obtained for *Trichoderma* treatment. This value was statistically similar to those obtained for other fungicide treatments but significantly higher than control plots (Table 2). The lengths of root and shoot as well as the dry matter of root and shoot were significantly affected by *Trichoderma* and fungicide treatments. The highest values were found with *Trichoderma* treatment for all these parameters (Table 4). In 2013, the numbers of seedling at 10, 18 and 30 DAS as well as number of tiller m-2 at harvest were affected significantly by *Trichoderma* and fungicide treatment. The highest number of seedling (86.66, 113.00) were found with M_1 treatmentat 10 and 18 DAS which were statistically similar to M_2, M_3, M_4, M_7 andM_8 treatments. At 30 DAS the highest number of seedlings (112.33) was found with M_2 treatment which was statistically similar to M_1, M_3, M_4, M_7 andM_8 treatment. The lowest number of seedling (45.00, 71.66 and 65.00) was found with M_9 treatment at 10, 18 and 30 DAS which was statistically similar to M_5, M_6 andM_{10} treatment (Table 9). The highest shoot and root length (20.19 cm and 8.25 cm) were recorded from M_1 treatment at 30 DAS, which was statistically similar to M_2 and M_4 treatments whereas the lowest shoot and root length (16.10 cm and 5.82 cm) were recorded from M_{10} treatment. The highest shoot dry matter was found with M_2 treatment which was statistically similar to M_1, M_3 and M_4 treatments (Table 10). The highest root dry matter was found with M_1 treatment which was statistically similar to M_2, M_3, and M_8 treatment. The lowest shoot and root dry matter were found with M_{10} treatment at 30 DAS (Table 10).

Number of panicle m^{-2}, filled grains $panicle^{-1}$, grain yield and straw yields were affected significantly by *Trichoderma* and fungicide treatments but plant height, 1000-grain weight and harvest index remained unaffected.The highest number of panicle m^{-2} (380.33 m^{-2}), filled grain $panicle^{-1}$ (98), grain yield (6.28 tha^{-1}) and straw yield (7.45 t ha^{-1}) were found with the plot sown with Trichoderma treated seeds followed by spraying of sulphur fungicide at 20 DAS.The highest number of tiller and panicle (426.00 and 380.33) were observed with M_2 treatment which was statistically similar to M_1 treatment. The lowest number of tiller and panicle (287.33 and 237.66) were observed with M_9 and M_{10} treatment, respectively. No. of filled grains $panicle^{-1}$ (98.00) was found significantly highest with M_2 treatment and the lowest no. of filled grains $panicle^{-1}$ (75.66) was found with M_{10} treatment (Table 11). The highest grain yield (6.28 t ha^{-1}) was recorded from M_2 treatment and the highest straw yield (7.54 t ha^{-1}) was recorded from M_1 treatment which was statistically similar to M_1 and M_2 treatments, respectively whereas the lowest grain (3.41 t ha^{-1}) and straw yield (4.12 t ha^{-1}) were recorded from M_{10} treatment. Plant height and 1000-grain weight were not affected significantly by any of the Trichoderma and fungicide treatment (Table 12).

Table 1. Effect of seed priming onnumber of seedlings and tillers of dry direct seeded *Boro* rice in 2012

Seed priming	No. of seedling m^{-2}			No. of tiller m^{-2} at harvest
	7 DAS	15 DAS	30 DAS	
P_1	58.33a	111.6a	109.7 a	339a
P_2	52.53a	103.6b	100.8b	328b
P_3	16.66b	88.13c	83.47c	320b
$S\bar{x}$	2.017	2.083	2.114	3.407
CV (%)	18.52	7.93	8.38	4.01
Level of significance	**	**	**	**

Table 2. Effect of *Trichoderma* and fungicide onnumber of seedlings and tillers of dry direct seeded *Boro* rice in 2012

Trichoderma and fungicide	No. of seedling m^{-2}			No. of tiller m^{-2} at harvest
	7 DAS	15 DAS	30 DAS	
T_1	65.56a	113.4a	112.00a	339a
T_2	35.89b	95.44b	94.11b	333a
T_3	37.56b	99.66b	98.88b	333a
T_4	37.00b	99.88b	99.66b	330a
T_5	36.56b	97.11b	84.33c	310b
$S\bar{x}$	2.604	2.689	2.729	4.398
CV (%)	18.37	7.98	8.37	4.01
Level of significance	**	**	**	**

Table 3. Effect of seed priming on shoot and root length and dry matter of dry direct seeded *Boro* rice in 2012

Seed priming	At 30 DAS			
	Shoot length (cm)	Root length (cm)	Shoot dry matter (g $plant^{-1}$)	Root dry matter (g $plant^{-1}$)
P_1	20.06a	7.38a	2.149a	0.862a
P_2	18.10b	6.66b	1.970b	0.753b
P_3	15.71c	5.99c	1.790c	0.659c
$S\bar{x}$	0.4443	0.1590	0.3782	0.2422
CV (%)	9.58	9.21	7.44	12.38
Level of significance	**	**	**	**

In a column, figures having common letter(s) do not differ significantly whereas mean values with dissimilar letter(s) differ significantly as per DMRT.

LS= Level of Significance, CV= Coefficient of Variance, **= Significant at 1% level P_1= Osmo-priming, P_2= Hydro-priming, P_3= No priming, T_1 = Trichoderma, T_2 = Sulfur Fungicide, T_3 = Propiconazole fungicide, T_4 = Sulfur fungicide+ propiconazole fungicide, T_5 = Control

Table 4. Effect of *Trichoderma* and fungicide on shoot and root length and dry matter of dry direct seeded *Boro* rice in 2012

Trichoderma & fungicide	At 30 DAS			
	Shoot length (cm)	Root length (cm)	Shoot dry matter (g $plant^{-1}$)	Root dry matter (g $plant^{-1}$)
T_1	19.7a	7.61a	2.191a	0.888a
T_2	18.70ab	6.76bc	1.993b	0.762bc
T_3	17.72b	6.27c	1.997b	0.695cd
T_4	19.07ab	7.18ab	2.137ab	0.836ab
T_5	14.57c	5.57d	1.531c	0.610d
$S\bar{x}$	0.5736	0.2052	0.4883	0.3127
CV (%)	9.58	9.21	7.44	12.38
Level of significance	**	**	**	**

Table 5. Effect of seed priming on the yield components and yield of dry direct seeded *Boro* rice in 2012

Seed priming	Plant height (cm)	No. of panicle m^{-2}	Panicle length (cm)	No. of filled grain $panicle^{-1}$
P_1	102.72a	310a	23.35a	98.40a
P_2	99.39b	305ab	22.98a	93.67a
P_3	98.27b	299b	22.07b	86.20b
$S\bar{x}$	0.7504	3.407	0.2798	1.728
CV (%)	2.90	3.37	4.75	7.22
Level of significance	**	*	**	**

Table 6. Effect of seed priming on the yield components and yield of dry direct seeded *Boro* rice in 2012

Seed priming	1000 - grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
P_1	22.43a	6.75a	7.87a	46.16a
P_2	22.12ab	6.27b	7.47b	45.59a
P_3	21.88b	5.61c	6.92c	44.78b
$S\bar{x}$	0.1225	0.0509	0.0627	0.2249
CV (%)	2.14	3.16	3.28	1.91
Level of significance	*	**	**	**

In a column, figures having common letters do not differ significantly whereas mean values with dissimilar letters differ significantly as per DMRT.LS= Level of Significance, CV= Coefficient of Variance, *= Significant at 5% level, **= Significant at 1% level P_1= Osmo-priming, P_2= Hydro-priming, P_3= No priming, T_1 = Trichoderma,T_2 = Sulfur Fungicide, T_3 = Propiconazole fungicide, T_4 = Sulfur fungicide+ propiconazole fungicide,T_5 = Control

Table 7. Effect of *Trichoderma* and fungicide on the yield and yield components of drydirect seeded *Boro* rice in 2012

Trichoderma and fungicide	Plant height (cm)	No. of panicle m^{-2}	Panicle length (cm)	No. of filled grain $panicle^{-1}$
T_1	101.73	318a	23.76a	99.22a
T_2	100.7	301b	22.03b	96.56a
T_3	98.31	306ab	23.30a	95.11a
T_4	100.16	314ab	23.63a	92.67a
T_5	99.74	285c	21.29b	80.22b
$S\bar{x}$	0.9687	4.398	0.3612	2.231
CV (%)	2.90	3.37	4.75	7.22
Level of significance	NS	**	**	**

Table 8. Effect of *Trichoderma* and fungicide on the yield and yield components of dry direct seeded *Boro* rice in 2012

Trichoderma and fungicide	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	22.26	6.64a	7.80a	45.95ab
T_2	22.04	6.36b	7.72a	45.12bc
T_3	22.30	6.38b	7.47b	46.05a
T_4	22.21	6.35b	7.58ab	45.53ab
T_5	21.92	5.32c	6.45c	44.89c
$S\bar{x}$	0.1581	0.0658	0.0809	0.2904
CV (%)	2.14	3.16	3.07	1.91
Level of significance	NS	**	**	*

In a column, figures having common letter(s) do not differ significantly whereas mean values with dissimilar letter(s) differ significantly as per DMRT. LS= Level of Significance, CV= Coefficient of Variance, **= Significant at 1% level P_1= Osmo-priming, P_2= Hydro-priming, P_3= No priming, T_1 = Trichoderma,T_2 = Sulfur Fungicide, T_3 = Fungicide, T_4 = Sulfur fungicide+ Fungicide,T_5 = Control,

Table 9. Effect of *Trichoderma* and fungicide on number of seedlings of dry direct seeded *boro* rice in 2013

Treatment	No. of seedlingsm^{-2}			No. of tiller m^{-2} at harvest
	10 DAS	18 DAS	30 DAS	
M_1	86.66a	113.00a	111.66a	411.33a
M_2	85.33a	112.66a	112.33a	426.00a
M_3	83.33a	111.33a	109.66a	320.66bc
M_4	85.00a	109.66a	107.66a	319.33bc
M_5	51.33b	79.33b	73.33b	340.33b
M_6	52.00b	78.00b	69.66b	337.66bc
M_7	83.00a	107.66a	106.00a	324.00bc
M_8	77.00a	106.33a	105.00a	326.00bc
M_9	45.00b	71.66b	65.00b	287.33d
M_{10}	48.66b	74.00b	65.00b	302.66cd
$S\bar{x}$	3.476	3.540	3.235	10.62
CV (%)	8.63	6.36	6.06	5.42
Level of significance	**	**	**	**

Table 10. Effect of *Trichoderma* and fungicide on shoot and root of dry direct seeded boro rice in 2013

Treatment	At 30 DAS			
	Shoot length (cm)	Root length (cm)	Shoot dry matter (g $plant^{-1}$)	Root dry matter (g $plant^{-1}$)
M_1	20.19a	8.25a	2.198ab	0.995a
M_2	19.12ab	7.15ab	2.242a	0.875ab
M_3	19.73ab	6.32bc	2.259a	0.830ab
M_4	18.38ab	7.32ab	2.131ab	0.782b
M_5	17.71bc	6.26bc	1.894c	0.700b
M_6	17.60bc	6.11bc	1.870c	0.754b
M_7	18.73ab	6.83bc	2.095ab	0.813b
M_8	18.41ab	6.73bc	1.977ab	0.875ab
M_9	16.78cd	6.03cd	1.924bc	0.702b
M_{10}	16.10d	5.82d	1.854c	0.698b
$S\bar{x}$	0.7125	0.3737	0.856	0.5486
CV (%)	6.75	9.68	7.25	11.84
Level of significance	*	**	*	*

In a column, figures having common letter(s) do not differ significantly whereas mean values with dissimilar letter(s) differ significantly as per DMRT.

M1= seed treatment with Trichoderma
M2 = seed treatment with Trichoderma + spraying of sulphur fungicide at 20 (DAS)
M3 = seed treatment with Trichoderma + spraying of propiconazole fungicide at 20 DAS
M4 = seed treatment with Trichoderma + spraying of sulphur and propiconazole fungicide at 20 DAS
M5=spraying of sulphur fungicide at 20 DAS
M6 = spraying of propiconazole fungicide at 20 DAS
M7 = seed treatment with sulphur fungicide + spraying of propiconazole fungicide at 20 DAS
M8 = seed treatment with propiconazole fungicide + spraying of sulphur fungicide at 20 DAS
M9 = spraying of mixture of sulphur fungicide and propiconazole fungicide at 20 DAS and
M_{10} = control treatment

Table 11. Effect of *Trichoderma* and fungicide on yield contributing characters of dry direct seeded boro rice in 2013

Treatment	Plant height (cm)	No. of panicle m^{-2}	No. of filled grain pan^{-1}
M_1	98.06	364.00a	92.66c
M_2	100.00	380.33a	98.00a
M_3	97.93	300.33b	93.00c
M_4	98.73	276.66bc	90.00d
M_5	98.20	267.00bc	78.66h
M_6	96.80	288.33b	87.33f
M_7	96.66	270.00bc	88.66e
M_8	99.00	276.33bc	96.00b
M_9	97.13	251.00cd	83.33g
M_{10}	97.00	237.66d	75.66i
$S\bar{x}$	1.381	10.42	0.164
CV (%)	2.44	6.20	8.23
Level of significance	NS	**	*

Table 12. Effect of *Trichoderma* and fungicide on yield contributing characters and yieldof dry direct seeded boro rice in 2013

Treatment	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield(t ha^{-1})	Harvest index (%)
M_1	22.09	6.08ab	7.54a	44.64
M_2	21.72	6.28a	7.45a	45.72
M_3	21.68	5.65bc	6.75b	45.55
M_4	22.31	5.29c	6.38b	45.32
M_5	22.04	4.42d	5.47c	44.68
M_6	22.13	4.69d	5.53c	45.83
M_7	22.10	5.36c	6.62b	44.80
M_8	22.02	5.30c	6.33b	45.54
M_9	21.89	4.63d	5.68c	44.93
M_{10}	21.74	3.41e	4.12d	45.28
$S\bar{x}$	0.248	0.164	0.173	0.459
CV (%)	1.95	5.57	4.85	1.76
Level of significance	NS	**	**	NS

In a column, figures having common letters do not differ significantly whereas mean values with dissimilar letters differ significantly as per DMRT.
M_1= seed treatment with *Trichoderma*
M_2 = seed treatment with *Trichoderma* + spraying of sulphur fungicide at 20 (DAS)
M_3 = seed treatment with *Trichoderma* + spraying of propiconazole fungicide at 20 DAS
M_4 = seed treatment with *Trichoderma* + spraying of sulphur and propiconazole fungicide at 20 DAS
M_5=spraying of sulphur fungicide at 20 DAS
M_6 = spraying of propiconazole fungicide at 20 DAS
M_7 = seed treatment with sulphur fungicide + spraying of propiconazole fungicide at 20 DAS
M_8 = seed treatment with propiconazole fungicide + spraying of sulphur fungicide at 20 DAS
M_9 = spraying of mixture of sulphur fungicide and propiconazole fungicide at 20 DAS and
M_{10} = control treatment

4. Discussion

Establishment of optimal number of seedling in dry direct seeded rice in boro (winter) season is very difficult mainly because of seedling mortality due to cold injury. The seed sowing is done during early January when the minimum temperature generally goes below (15 ^oC) that delayed seedling emergence, reduced seedling early growth and causes seedling mortality.

Seed priming allows the early DNA transcription and RNA and protein synthesis which repair the damaged parts of the seed and reduce metabolic exudation and ultimately improve seed germination characteristics and the seedling emergence [14, 22]. In the present study it was found that seedling emergence and seedling growth was higher in osmoprimed seed than the hydroprimed seed. Osmopriming helped not only improving seedling establishment but also helped increase yield of dry direct seeded rice by improving the yield attributes such as number of panicle m^{-2} and grains $panicle^{-1}$. Similar result was reported by Islam *et al*. [25] and Takhti and Shekafandeh [37] who reported that osmo-priming increased the shoot length, root length, shoot dry matter and root dry matter. Farooq *et al.* [12, 13] reported that the seedling establishment, grain and straw yield were improved by priming. The osmopriming with 3% $ZnSO_4$ solution in this study significantly improved number of seedling, early growth and yield significantly over hydropriming. This was probably because of the supply of Zn in the seed which is an essential component for the plant growth required for chlorophyll synthesis, pollination, fertilization and germination [7, 19]. Khan and Sinha [27] reported that seed priming improved the physiological responses under the environmental stress conditions and increased seeds tolerance to the environmental stress.

In the present study *Trichoderma harzianum* seed treatment significantly contributed to the improvement in establishment of plant stand and yield of dry direct seeded boro rice. The yield increase by *T. harzanium* application was probably related to increased plant stand establishment and crop growth [9, 21]. Entesari *et al.* [11] reported that *Trichoderma harzanium* application induced profound changes in plant characteristics and encouraged more uniform seed germination and plant growth in soybean. *Trichoderma harzanium* has the ability to solubilize P, Mn and Zn and extract insoluble nutrients from soil which contributed to the growth promoting effects on crops [39]. Altomare *et al.* [2] reported that *T. harzanium* stimulated root growth [18, 38], enhances biomass production [35], increases rates of germination of seeds [6, 8], increases disease tolerance in the seedlings [17, 26, 29, 36]. *Trichoderma* inoculation increased levels of SOD, increasing ROS scavenging abilities peroxidase, glutathione reductase, glutathione-s-transferas (GST) and other detoxifing enzyme in leaves [1, 30, 34].

Trichoderma seed treatment followed by application of sulphur fungicide significantly improved seedling population, root and shoot growth and yield in the present study. Similar improvement was reported by Hamed *et al*. [16], Azarmi *et al*. [4] and Nzanza *et al*. [31]. So, seed treatment with *Trichoderma* and seed treatment with *Trichoderma* + spraying of sulphur fungicide at 20 DAS treatments can be used to improve seedling establishment and increase yield of dry direct seeded *Boro* rice.

5. Conclusions

Osmopriming with 3% ZnSO4 followed by *Trichoderma* seed treatment (biopriming) improved seedling establishment and yield in dry direct seeded rice in boro season. *Trichoderma* application alone or application of *Trichoderma* followed by spraying of sulphur fungicide at 20 DAS gave similar yield in dry direct seeded boro rice. Therefore, osmopriming of seed with 3% Zn SO_4 solution followed by seed treatment with *Trichoderma* inoculum could be used for improving seedling establishment and increase grain yield of dry direct seeded boro rice.

Acknowledgements

We thank the Program for Agriculture and Life Science (PALS) of Bangladesh Academy of Sciences (BAS) and the United States Department of Agriculture (USDA) for providing fund for this research under the project CR#21.

REFERENCES

[1] Abd-El-Khair, H., Khalifa, R. M.and Haggag, K. H. E. 2011. Effect of Trichoderma species on damping off diseases incidence, some plant enzymes activity and nutritional status of bean plants. J. Am. Sci. 6(9) : 486-497.

[2] Altomare, C. Norvell, W. A., Bjorkman, T. and Harman, G. A. 1999. Solubilization of phosphate and micronutrients by the plant-growth promoting and biocontrol fungus Trichoderma harzanium Rifai. Appl. Env. Microbiol. 65 : 2926-2933.

[3] Anwar, S., Iqbal, M., Raza, S. H. and Iqbal, N. 2013. Efficacy of seed preconditioning with salicylic and ascorbic acid in increasing vigour of rice (Oryza sativa L.) seedling. Pak. J. Bot. 45(1) : 157-162.

[4] Azarmi, R., Hajieghrari, B. and Giglou, A. 2011. Effect of Trichoderma isolates on tomato seedling growth response and nutrient uptake. African J. Biotech. 10(31): 5850-5855.

[5] BBS (Bangladesh Bureau of Statistics}. 2011. Bangladesh Bureau of Statistics, Stat. Div. Minist. Plann. Govt. Peoples Repub. Bangladesh, Dhaka. pp. 123 - 127.

[6] Bjokman, T., Blanchard, L. M. and Harman, G. E. 1998. Growth enhancement of shrunken-2 (sh2) sweet corn by Trichoderma harzianum 1295-22: effect of environment stress. J. Am. Soc. Hortic. Sci. 123 : 35-40.

[7] Cakmak, I. 2008. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? Plant Soil. 302 : 1-17.

[8] Chang, Y. C., Chang, Y. C., Baker, R., Kleifeld, O. and Chet, I. 1986. Increased growth of plants in the presence of the biological control agent Trichoderma harzainum. Plant Dis. 70:145-148.

[9] Cuvas, V. C. 2006. Soil inoculation with Trichoderma pseudokoningiienhances yield of rice. Philippine J. Sci. 135 (1) : 31-37.

[10] Doni, F., Anizan, I., Che Radziah, C. M. Z., Salam, A. H., Rodzihan, M. H., and Yusoff, W. M. W. 2014. Enhancement of rice seed germinatino and vigour by Trichoderma spp. Res. J. Appl. Sci. Eng. Tech. 7(21) : 4547-4552.

[11] Entesari, M., Sharifzadeh, F., Ahmadzadesh, M. and Farhangfar, M. 2013. Seed biopriming with Trichoderma species and Pseudomonas fluorescent on growth parameters, enzyme activity and nutritional status of soybean. Intern. J. Agron. Plant Product. 4: 610-619.

[12] Farooq, M., Basra, S. M. A. and Ahmad, N. 2007. Improving the performance of transplanted rice by seed priming. Plant Growth Reg. 51(2): 129-137.

[13] Farooq, M., Basra, S. M. A., Rehman, H. U. and Hussain, M. 2008. Seed priming with polyamines improves the germination and early seedling growth in fine rice. J. New

Seeds. 9(2): 145-155.

[14] Ghassemi-Golezani, K., Sheikhzadeh, M. P. andValizadeh, M. 2008. Effect of hydropriming duration and limited irrigation on field performance of chickpea. Res. J. Seed Sci. 1 : 34-40.

[15] Gomez, K. A., and Gomez. A. A. 1984. Statistical Procedures for Agricultural Research. A Wiley Int. Sci. Pub. John Wiley and Sons, New York, Brisbane, Singapore. pp.139 - 240.

[16] Hamed, K., Jartoodeh, S. V., Aruee, H. and Mazhabi, M. 2011. Would Trichoderma Affect Seed Germination and Seedling Quality of Two Muskmelon Cultivars, Khatooni and Qasri and Increase Their Transplanting Success. J. Biol. Environ. Sci. 5(15): 169-175.

[17] Harman, G. E. 2000. Myths and dogmas of biocontrol: Changes in perceptions derived from research on Trichoderma harzanium T 22. Plant Dis. 84 : 377-393.

[18] Harman, G. E., Petzoldt, R. Comis, A. and Chen, J. 2004. Interactions between Trichoderma harzianum strain T22 and maize inbreed line Mo 17 and effect of this interaction on diseases caused by Pythium ultimum and Colletotrichum graminicola. Phytopathol. 94 : 147-153.

[19] Harris, D., Rashid, A., Miraj, G., Arif, M. and Yunas, M. 2008. On-farm seed priming with zinc in Chickpea and Wheat in Pakistan. Plant and soil. 306: 1-10.

[20] Hossain, I. 2011. BAU-Biofungicide: Unique Eco-friendly Means and New Dimension of Plant Disease Control in Bangladesh. Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. pp. 8-10.

[21] Hossain, I., Yeasmin, R. and Hossain, M. M. 2009. Management of seedling diseaaes of blackgram, mungbean and lentil using BAU- Biofungicide, Biofertilizer and cowdung. Eco-friendly Agril. J. 2(11): 905-910.

[22] Hu, J., Zhu, Z. Y., Song, W. J., Wang, J. C. and Hu, W. M. 2005. Effect of sand priming on germination and field performance in direct sown rice (Oryza sativa L.). Seed science and technology. 33(1): 243-248.

[23] IRRI (International Rice Research Institute). 2013. Rice today. International Rice Research Institute. Metro Manila, Philippines. Vol. 12(1): pp. 8- 44.

[24] Islam, M.S., Rahman, M. A., Bulbul, S. H. and Alam, M. F. 2011.Effect of Trichoderma on seed germination and seedling parameters in chili. Int. J. Expt. Agric. 2(1):21-26.

[25] Islam, R., Mukherjee, A. and Hossain, M. 2012. Effect of osmo-priming on rice seed germination and seedling growth. J. Bangladesh Agric. Univ. 10(1): 15–20.

[26] Islam, S. 2009. Comparative efficacy of BAU- Biofungicide and Tilt in controlling diseases of rice. An M. S. Thesis submitted to the Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh.

[27] Khan, A. A. and Sinha, A. P. 2007. Biocontrol potential of Trichoderma species against sheath blight of rice. Ind. Phytopathol. 60 : 208-213.

[28] Mandal, S. N., Regmi, A. P., Ladha, J. K. and Tuong, T. P.2009. Crop establishment, tillage and water management effects on crop and water productivity in rice-wheat rotation in Nepal. In Ladha, Yadvinder-Singh, J. K.,Erestein, O., Hardy, b. 9Eds.). Integrated Crop and Resource Management in the rice-wheat system of south Asia. Los Banos, Philippines: International Rice Research Institute. pp. 133-150.

[29] Marschner, H. 1995. Mineral Nutrition of Higher Plants. 2nd Ed. London: Academic Press. 889p.

[30] Mastouri, F., Bjorkman, T. and Harman, G. E. 2012. Trichoderma harzanum enhances antioxidant defense of tomato seedlings and resistance to water deficit. Molecular Plant – Microbe Interactions. 25 : 1264-1271.

[31] Nzanza, B., Marais, D. and Soundy, P. 2011. Tomato (Solanum lycopersicum L.) seedling growth and development as influenced by Trichoderma harzianum and arbuscular mycorrhizal fungi. African J. Microbiol. Res.. 5(4): 425-431.

[32] Rahman, M. M., Uddin, M. A. and Masood, M. M. 2012. Irrigation water saving, yield performance and cost effectiveness of different rice cultivation systems in boro season. Banglasdesh Agron. J. 15(1): 99-106.

[33] Sarkar, S. K. and Saxena, S. C. 2005. Field efficacy of seed dressing fungicides on emergence, survival and seedling vigour of sunhemp (Crotalaria juncea L.). Seed Res. 33(1): 100-102.

[34] Shoresh, M. and Harman, G. 2008. The molecular basis of shoot responses of maize seedlings to Trichoderma harzianum t22 inoculation of the root : A proteomic approach. Plant Physiol. 147: 2147-2163.

[35] Shoresh, M., Harman, G. E. and Mastouri, F. 2010. Induced systemic resistance and plant responses to fungal biocontrol agents. Annu. Rev. Phytopathol. 48 : 21-43.

[36] Shultana, R., Hossain, I., Ahmed, S. and Mamun, M. A. A. 2009. Efficacy of BAU-Biofungicide in controlling leaf spot of wheat (Triticum aestivum). Eco-friendly Agril. J. 2(2): 392-395.

[37] Takhti, S. and Shekafandeh, A. 2012. Effect of different seed priming on germination rate and seedling growth of Ziziphus Spina-Christi. Advances in Environmental Biology. 6(1): 159-164.

[38] Vinale, F., Sivasithamparam, K.,Ghisalberti, E. L., Marra, R., Barbetti, M. J. Li, H., Woo, S. L. and Lorito, M. 2008. Trichoderma- Plant – Pathogen interactions. Soil Biol. Biochem. 40 : 1-10. African J. Biotechnol. 9(28) : 4342-4347.

[39] Yedidia, I., Srivastava, A. K., Kapulnik, Y. and Chet, I. 2001. Effect of Trichoderma harzianum on micronutrient concentrations and increased growth of cucumber plants. Plant Soil. 235: 235-242.