Available at: https://dergipark.org.tr/tjws

Turkish Journal of Weed Science

Araştırma Makalesi / Research Article

Improvement of Weed Competitiveness and Yield Performance of Dry Direct Seeded Rice through Seed Priming

Md. Parvez Anwar[1,2*], Md. Kawser Ahmed[1], A.K.M. Mominul Islam[1,2], Md. Delwar Hossain[1] and F.M. Jamil Uddin[1]

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[2]Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

*****Corresponding Author: parvezanwar@bau.edu.bd

ABSTRACT

The study was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University during January to May 2019 to investigate the seed priming influence on the growth, weed suppression ability and yield of BRRI dhan29 and weed growth under dry direct seeded (DDS) condition. Seed priming agents included NaCl (20000 and 30000 ppm), KCl (20000 and 30000 ppm), $CaCl_2$ (20000 and 30000 ppm), $CuSO_4$ (50 and 75 ppm), $ZnSO_4$ (10000 and 15000 ppm), Na_2MoO_4 (2 and 3 ppm), PEG (100 and 150 ppm) and control (no priming). The experiment was laid out in a randomized complete block design with three replications. Data were collected on growth, yield parameters, yield of rice and weed growth in terms of weed density and dry matter. Rice plant height and tillering ability were significantly enhanced due to seed priming. Among yield parameters, number of effective tillers hill^{-1} and number of grains panicle^{-1} were positively influenced due to seed priming resulting yield enhancement up to 18% compared to control. But, seed priming failed to enhance the weed competitiveness of rice resulting similar weed growth for primed and control treatments. Therefore, seed priming with 20000 ppm KCl or 20000 ppm $CaCl_2$ may be practiced for enhancing yield of BRRI dhan29 under DDS condition.

Key Words: Aerobic rice, seed invigoration, weed suppression, winter rice, grain yield

INTRODUCTION

Dry direct seeded (DDSR) rice is considered to be a potential water-wise technology which requires 50-60% less water compared to puddled transplanted rice (Anwar et al., 2010; Rabeya et al., 2018; Rahman, 2019). Direct seeding rice refers to the process of establishing rice crop from seeds directly sown in the field rather than by transplanting seedlings obtained from nursery bed (Farooq et al., 2011). Direct seeding avoids three basic operations, namely, puddling (soil compaction for reducing water seepage), transplanting and maintaining standing water. Direct seeded rice is however highly vulnerable to weeds (Anwar et al., 2010) as direct seeded rice germinates concurrently with weeds without any 'head start' over weeds and lacks standing water to suppress weeds (Moody, 1983; Sunyob et al., 2012) and therefore, weed management is a great challenge for direct seeded rice.

Seed priming is an approach to add moisture to seeds allowing seeds to be hydrated partially without radicle emergence (Farooq et al., 2007). Seed priming involves partial hydration to a point where germination-related metabolic processes begin but radical emergence does not occur (Farooq et al., 2006a). It is an effective pre germination physiological method that mends seed performance and delivers quicker and synchronized seed germination (Matsushima and Sakagami, 2013) by prior exposure of seed to a stress situation, which endows plant to better withstand the future stress imposition (Yadav et al., 2011). Different types of priming techniques include hydro-priming (soaked seed in water), halo- priming (soaking of seed in inorganic salt solutions), osmo-priming (soaked of seed in organic osmotic solution), thermo-priming (treated the seed with low or high temperature), solid matrix priming (treated the seed solid matrices) and bio-priming (seeds treated by biological compounds) (Ashraf and Foolad, 2005). Seed priming involves soaking of seeds in water (hydropriming) or solutions of lower water potential (osmotic solutions) composed of polyethylene glycol (PEG) (osmopriming) or salts ($CaCl_2$, $CaSO_4$, KH_2PO_4, KCl, NaCl, etc.) (halopriming) prior to germination (Jisha et al., 2013). As stated by Farooq et al. (2006b), seed priming is the most pragmatic approaches to overcome the drought stress effects (Farooq et al., 2006b). Seed priming tools have the potential to improve emergence and stand establishment under a wide range of field conditions (Phill, 1995). These techniques can also enhance rice performance in DDSR culture (Farooq et al., 2007).

Primed seeds usually exhibit increased germination rate, uniform and faster seedlings growth, greater germination uniformity, greater growth, dry matter accumulation, plant height, root weight, dry matter production and increased yield by 2.1 t ha^{-1} compared to control (Farooq et al., 2011). Apart from higher germination rate, synchronized germination and vigorous seedlings were found in seed priming (Basra et al., 2005; Kaya et al., 2006). Therefore, seed priming technique should be explored to mitigate drought stress and improve weed competitiveness of direct seeded rice. Many researchers have reported the improved performance of direct seeded rice by seed priming (Du and Tuong, 2002; Harris et al., 2002; Farooq et al., 2006a; Juraimi et al., 2012) but most of these studies involve either development and optimization of seed priming techniques or monitor the physiological and biochemical basis of priming-induced benefits (Basra et al., 2005). However, quite a few studies report the role of seed priming in improving crop yield and quality (Farooq et al., 2006b, 2006c).Although seed priming techniques have been found effective for better germination and seedling establishment in rice under controlled conditions (Basra et al., 2005; Farooq et al., 2006b) and although some success in enhancing the performance of direct-seeded rice has been reported (Du and Tuong, 2002), no comprehensive study has yet been done to evaluate the response to a wide range of seed invigoration techniques to enhance germination and yield of direct seeded rice especially under Bangladesh condition. With these end in view, an experiment was undertaken to examine the influence of some seed priming approaches on growth, yield and weed competitiveness of winter rice under dry direct seeded condition.

MATERIALS and METHODS

Experimental site

The experiment was conducted at the Agronomy Field Laboratory and Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh (24°25' N N latitude and 90°50' E longitude with the altitude of 18.6 meter above sea level) during January-May 2019. The experimental site belongs to the Sonatala series of non-calcareous dark grey flood plain soil under the agro-ecological region (AEZ-9) of the Old Brahmaputra Floodplain. The field was medium high land having well-drained silty loam soil with pH 6.75. The experimental area was located under the sub-tropical climate which is specialized with hot-humid-rainy *kharif* season (April to September) and cool-dry *rabi* season (October to March). Monthly average air temperature, total rainfall, average relative humidity and total sunshine hours during the experimental period ranged from 21.8-27.9 °C, 0.25–434.6 mm, 74.3–85.7% and 98.3–187.7 hr, respectively.

Experimental treatment and design

The experiment comprised fourteen different seed priming agents such as control (no priming), 20000 ppm NaCl , 30000 ppm NaCl , 20000 ppm KCl , 30000 ppm KCl , 20000 ppm $CaCl_2$, 30000 ppm $CaCl_2$, 50 ppm $CuSO_4$, 75 ppm $CuSO_4$, 10000 ppm $ZnSO_4$, 15000 ppm $ZnSO_4$, 2 ppm Na_2MoO_4 , 3 ppm Na_2MoO_4 , 100 ppm PEG and 150 ppm PEG. The experiment was laid out in a randomized complete block design with three replications. The distance between blocks was 1.0 m and between plots was 0.5 m. Individual plot size was 2.5 m × 2.0 m. All the priming agents used in the experiment were laboratory grade. Details of the priming agents are presented in Table 1.

Table 1. Description of the priming agents

Sl. No.	Priming agent	Chemical formula	Manufacturer	Country of origin
1.	Sodium chloride	NaCl	MERCK	India
2.	Potassium chloride	KCl	MERCK	India
3.	Calcium chloride	$CaCl_2$	MERCK	India
4.	Copper sulphate	$CuSO_4.5H_2O$	MERCK	India
5.	Zinc sulphate	$ZnSO_4.7H_2O$	MERCK	India
6.	Sodium molybdate	Na_2MoO_4. $2H_2O$	MERCK	India
7.	Polyethylene glycol 4000	PEG 4000	LOBAL Chemie	India

Planting material used

A high yielding popular winter rice (locally called boro rice) variety BRRI dhan29 was used as planting material in this study. This variety was developed by the Bangladesh Rice Research Institute (BRRI) in 1980 from crossing between BG 90-2 and BR15-46-5 lines. It is characterized by weakly photoperiod sensitivity and takes about 160 days to complete its life cycle with an average yield of 7-8 t ha^{-1} (BRRI, 2019).

Seed priming

Rice seeds were soaked in different priming agent solutions (prepared using distilled water) as per treatments for 12 hours at room temperature (25 ± 2 °C). The ratio of seed weight to solution volume was 1:5 (g mL^{-1}). Then, seeds were removed from the priming agent solution followed by washing several times with distilled water to remove the traces of chemicals. Then, seeds were dried back to the original moisture content by forced air. Dried seeds were put in polythene bags and stored in refrigerator at 5 ± 1 °C for 30 days before use. Control treatment received no seed priming.

Seed sprouting

Both primed and non-primed (control) seeds were immersed in water in a bucket for 24 hrs. Then the seeds were taken out of water and kept in a gunny bag. The seeds started sprouting after 48 hours and sown in the nursery bed after 72 hrs.

Crop husbandry

The experimental land was dry ploughed three times followed by laddering to make it ready for direct seeding. Weeds and stubbles were removed from the field. Sprouted seeds were sown on 21 January 2019 in rows following 25 cm x 15 cm spacing with 5-6 seeds hill^{-1}. A light irrigation was given just after seeding to ensure seed germination and better seedling establishment. Field was fertilized with chemical fertilizers (recommended dose) @ 200 kg, 60 kg, 100 kg and 70 kg ha^{-1} of urea, triple superphosphate (TSP), muriate of potash (MoP), and gypsum, respectively. The full doses of TSP, MoP and gypsum were applied before sowing. Urea was applied at three equal splits at 20 days after sowing (DAS), 40 DAS and 60 DAS. Three hand weddings were done at 20, 40 and 60 DAS. The crop was grown mostly under irrigated condition, although rainfall occurred at the reproductive stage. At the early growth stages 3 surface irrigation were given to maintain soil moisture content at around field capacity. But after panicle initiation, no irrigation was given because of sufficient rainfall.

Observations made

Harvesting was done between 20 May and 30 May due to variation in maturity among treatments. $CaCl_2$ and KCl treated fields were harvested on 20 May, $CuSO_4$ and Na_2MoO_4 treated plots on 23 May, NaCl and $ZnSO_4$ treated plots on 27 May and PEG treated and control plots on 30 May. Five hills (excluding border hills) were selected randomly from each individual plot for recording growth data at different stages, and those five hills were uprooted just before harvesting for recording yield parameters as described by Sarker et al. (2018). Data were recorded on rice growth, yield parameters and yield.

The plant height was measured in cm from the base of the plant to the tip of the upper most leaf or panicle of the sample hills and then averaged. All the tillers (both effective and non-effective) were counted from each hill and then average of 5 hills was calculated to obtain tillering ability. Only the ear bearing tillers (having at least one filled grain) were counted from each hill and then average of 5 hills was calculated to get effective tillers hill^{-1}. Similarly, the non-ear bearing tillers were counted from each hill and then averaged to get non-effective tillers hill^{-1}. Presence of any food material in the spikelet was considered as grain and total number of grains present on each panicle was counted to record grains panicle^{-1}. Thousand grains were taken randomly from five sample hills and weighed in an electric balance after proper sun drying. The weight was adjusted to a seed moisture content of 14% and expressed in g. Grain yield was recorded after harvesting the whole plot then threshed, cleaned and sundried and finally converted to t ha^{-1} at 14% moisture content. Percent sterility was calculated using the following formula:

$$\text{Sterility\%} = \frac{\text{No. of sterile spikelets per panicle}}{\text{No. of total spikelets per panicle}} \times 100$$

A quadrate of size 0.5 m x 0.5 m was placed randomly in two places of each plot for collecting weed samples. Weed were clipped at ground level, identified and counted by species, and separately oven dried at 70 °C for 72 hrs to constant weight. Weed density (WD) and weed dry weight (WDW) were expressed as no. m^{-2} and g m^{-2}, respectively. Dominant weed species were identified using the summed dominance ratio (SDR) which was calculated as per Islam et al. (2017):

$$\text{SDR of a weed species} = \frac{\text{Relative density (RD)} + \text{Relative dry weight (RDW)}}{2}$$

Where,

$$\text{RD\%} = \frac{\text{Density of a given wee species}}{\text{Total weed density}} \times 100$$

$$\text{RDW\%} = \frac{\text{Dry weight of a given weed species}}{\text{Total weed dry weight}} \times 100$$

Statistical analysis

All data were analyzed following the analysis of variance (ANOVA) technique by using computer package MSTAT-C (version 6.1.4) and the mean differences were adjudged by Duncan’s Multiple Rage Test (DMRT) at 5% level of probability.

RESULT and DISCUSSION

Seed priming influence on plant height and tillering ability of rice

Seed priming agent significantly affected rice plant height only at harvest, but not at 40 and 60 days after sowing (DAS) (Table 2). Although insignificant, seed priming with PEG resulted in shorter plants compared to control at both 40 and 60 DAS. At harvest, only $CaCl_2$ priming (20000 and 30000 ppm) and KCl priming (30000 ppm) produced statistically higher plant height than control. Seed priming failed to produce any significant effect on rice tillering ability at 40 and 60 DAS. But at harvest, only seed priming with 20000 or 30000 ppm $CaCl_2$ and 30000 ppm KCl resulted in statistically higher number of tillers hill^{-1} than control. (Table 3). Like plant height, PEG priming resulted in numerically lower number of tillers hill^{-1} as compared to no priming. At harvest, seed priming with 30000 ppm $CaCl_2$ produced the highest number of tillers hill^{-1} (11.43) which was significantly similar to those obtained from seed priming with NaCl (20000 and 30000 ppm), KCl (20000 and 30000 ppm) and $CaCl_2$ (20000 ppm). Other seed priming agents performed better than no priming.

Table 2. Effect of seed priming agent on plant height of rice at different days after sowing (DAS)

Seed priming agent	Plant height (cm)		
	40 DAS	60 DAS	At harvest
20000 ppm NaCl	25.56	47.23	75.60 a-c
30000 ppm NaCl	25.33	47.13	76.26 a-c
20000 ppm KCl	27.83	52.30	78.13 ab
30000 ppm KCl	27.63	53.56	78.56 a
20000 ppm $CaCl_2$	28.33	51.90	78.76 a
30000 ppm $CaCl_2$	28.50	52.70	80.30 a
50 ppm $CuSO_4$	25.36	49.50	76.16 a-c
75 ppm $CuSO_4$	25.33	48.96	77.03 a-c
10000 ppm $ZnSO_4$	25.16	48.30	77.10 a-c
15000 ppm $ZnSO_4$	25.53	48.06	77.70 a-c
2 ppm Na_2MoO_4	26.13	48.00	76.70 a-c
3 ppm Na_2MoO_4	25.66	47.10	77.10 a-c
100 ppm PEG	24.66	46.66	70.43 c
150 ppm PEG	24.43	46.36	70.46 c
Control	25.20	47.56	71.46 bc
$S\bar{x}$	1.334	2.59	1.98
Level of significance	NS	NS	*
CV (%)	8.93	9.15	4.50

* = Significant at 5% level of probability, NS = Not significant, DAS = Days after sowing

Table 3. Effect of seed priming agent on number of total tillers hill^{-1} of rice at different days after sowing (DAS)

Seed priming agent	No. of total tillers hill^{-1}		
	40 DAS	60 DAS	At harvest
20000 ppm NaCl	3.63	7.20	10.60a-e
30000 ppm NaCl	3.63	7.66	10.40a-e
20000 ppm KCl	4.10	8.96	11.27a-c
30000 ppm KCl	4.36	8.46	11.33ab
20000 ppm $CaCl_2$	3.90	9.30	11.20a-d
30000 ppm $CaCl_2$	4.43	9.53	11.43a
50 ppm $CuSO_4$	3.53	7.70	10.20 de
75 ppm $CuSO_4$	3.60	8.06	10.17 de
10000 ppm $ZnSO_4$	4.03	7.60	10.17 de
15000 ppm $ZnSO_4$	3.76	7.60	10.37b-e
2 ppm Na_2MoO_4	3.53	7.40	10.23c-e
3 ppm Na_2MoO_4	3.63	7.66	10.03 e
100 ppm PEG	3.03	6.86	9.933 e
150 ppm PEG	3.20	7.03	9.900 e
Control	3.26	6.96	10.20 de
$S\bar{x}$	0.512	0.710	0.321
Level of significance	NS	NS	**
CV (%)	13.91	15.63	5.30

** = Significant at 1% level of probability, NS = Not significant

Seed priming influence on yield related attributes and yield of rice

Effective tillers production and number of grains panicle^{-1} were significantly affected by seed priming agent, but 1000-grain weight, non-effective tillers and sterility % were not (Table 4). Seed priming with either KCl or $CaCl_2$ irrespective of concentration produced significantly the highest number of effective tillers hill^{-1}, which was 15% higher than control. While all other priming agents performed similar to control. Like effective tillers hill^{-1}, KCl or $CaCl_2$ priming also resulted in highest number of grains panicle^{-1} which was around 10% higher than no priming. Priming with other agents resulted in similar or higher number of grains panicle^{-1} than control. Grain yield of BRRI dhan29 was found significantly affected by different seed priming agents (Table 4). Among the seed priming agents, 30000 ppm KCl yielded the highest (3.99 t ha^{-1}), which was statistically similar to those obtained when priming was done by 20000 ppm KCl, 20000 or 30000 ppm $CaCl_2$. While the grain yield obtained from all other priming agents were similar to that obtained from no priming. Thus, the role of seed priming with $CaCl_2$ or KCl in enhancing rice yield up to 19% under dry direct seeded condition is evident.

Weed species composition

Fifteen weed species belonging to seven different families were identifies in experimental field, among which seven were broadleaves, six grasses and two sedges. Based on summed dominance ratio (SDR), the five most dominant weed species observed were *Panicum distichum*, *Polygonum hydropiper*, *Chenopodium album*, *Solanum torvum* and *Echinochloa crusgali*. Grassy weeds contributed 69.42% of the total weed density and 41.53% of total weed dry matter, while broadleaf weeds respectively contributed 27.23 and 54.13% and sedges contributed 3.35 and 4.34% **(**Table 5).

Seed priming effect on weed growth

No significant effect of rice seed priming on weed density and dry weight in dry direct seeded condition was observed (Table 6). At 40 DAS, weed density ranged from 139.13 to 155.40 m^{-2}, while at 60 DAS the weed density ranged from 55.57 to 66.07 m^{-2}. However, at both the observations no priming allowed numerically more number of weeds to grow compared to any seed priming (Table 6). Although insignificant, numerically higher weed dry matter was recorded with no priming compared to any seed priming method at both the observations. Thus present study confirms no significant role of seed priming in increasing weed competitiveness of rice under direct seeded condition.

Table 4. Effect of seed priming agent on yield related attributes and yield of rice

Seed priming agent	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	No. of grains panicle^{-1}	Sterility (%)	1000-grain weight (g)	Grain yield (t ha^{-1})
20000 ppm NaCl	9.367bc	1.23	50.67 cd	35.56	19.80	3.58 cd
30000 ppm NaCl	9.133 c	1.26	51.10 b-d	35.16	19.70	3.61 cd
20000 ppm KCl	10.17a	1.10	52.13a-c	33.96	20.76	3.97ab
30000 ppm KCl	10.20a	1.13	51.83a-c	33.83	20.96	3.99a
20000 ppm $CaCl_2$	10.07ab	1.13	53.20ab	33.13	20.73	3.87a-c
30000 ppm $CaCl_2$	10.27a	1.16	53.63a	34.03	20.63	3.86a-c
50 ppm $CuSO_4$	9.000 c	1.20	50.10 c-e	36.10	19.76	3.58 cd
75 ppm $CuSO_4$	9.033 c	1.13	49.37 de	35.90	20.03	3.64 cd
10000 ppm $ZnSO_4$	9.100 c	1.06	49.10 de	36.23	20.13	3.61 cd
15000 ppm $ZnSO_4$	9.200 c	1.16	50.43 c-e	36.93	19.70	3.66 b-d
2 ppm Na_2MoO_4	9.067 c	1.16	51.07b-d	35.96	19.56	3.63 cd
3 ppm Na_2MoO_4	8.967 c	1.06	50.80 cd	36.33	19.83	3.60 cd
100 ppm PEG	8.900 c	1.03	48.23 e	37.80	19.50	3.43 d
150 ppm PEG	8.833 c	1.06	48.73 de	38.26	19.63	3.46 d
Control	8.933 c	1.26	48.17 e	39.40	19.50	3.35 d
$S\bar{x}$	0.251	0.188	0.716	1.78	0.442	0.0.101
Level of significance	**	NS	**	NS	NS	**
CV (%)	4.65	8.44	8.53	8.62	3.82	4.77

** = Significant at 1% level of probability, NS = Not significant

Table 5. Dominant weed species with family name, type, relative density (RD), relative dry weight (RDW) and summed dominance ratio (SDR) (averaged over all weedy plots)

Scientific name	Family	Group	RD (%)	RDW (%)	SDR (%)
Paspalum commersonii Lam.	Gramineae	Grass	51.3	23.35	37.32
Polygonum hydropiper L.	Polygonaceae	Broad leaf	8.90	17.22	13.06
Chenopodium album L.	Chenopodiaceae	Broadleaf	7.35	10.21	8.78
Solanum torvum Sw.	Solanaceae	Broadleaf	4.01	12.22	8.11
Echinochloa crus-galli (L.) Beauv	Gramineae	Grass	5.23	8.00	6.61
Physalis minima L.	Solanaceae	Broad leaf	2.70	8.33	5.51
Cynodon dactylon L. Pers.	Gramineae	Grass	6.25	3.21	4.74
Panicum distichum Lam.	Gramineae	Grass	3.22	3.89	3.56
Polygonum orientale L. Spach.	Polygonaceae	Broad leaf	0.89	3.87	2.38
Cyperus rotundus L.	Cyperaceae	Sedge	1.90	2.47	2.18
Echinochloa colona L. Link.	Gramineae	Grass	2.10	1.67	1.88
Cyperus iria L.	Cyperaceae	Sedge	1.45	1.87	1.67
Eclipta alba (L.) Hassk.	Compositae	Broadleaf	1.84	1.14	1.49
Digitaria sanguinalis L. Scop.	Gramineae	Grass	1.32	1.41	1.37
Phyllanthus niruri L.	Euphorbiaceae	Broad leaf	1.54	1.14	1.34

Table 6. Effect of seed priming agent on weed density and dry matter in dry direct seeded winter rice at different days after sowing

Seed priming agent	Weed density (No. m^{-2})		Weed dry matter (g m^{-2})	
	40 DAS	60 DAS	40 DAS	60 DAS
2000 ppm NaCl	147.47	58.80	137.27	43.23
3000 ppm NaCl	142.23	59.83	133.07	45.43
2000 ppm KCl	139.50	57.57	129.37	44.17
3000 ppm KCl	141.57	58.20	132.23	45.53
2000 ppm $CaCl_2$	137.07	58.13	126.60	46.13
3000 ppm $CaCl_2$	139.13	57.73	123.40	43.13
50 ppm $CuSO_4$	144.77	60.23	134.23	43.13
75 ppm $CuSO_4$	141.90	58.23	129.13	45.23
10000 ppm $ZnSO_4$	148.23	55.57	135.93	43.97
15000 ppm $ZnSO_4$	151.27	59.07	131.57	44.60
2 ppm Na_2MoO_4	157.10	62.27	127.13	40.00
3 ppm Na_2MoO_4	151.77	58.00	124.53	44.93
100 ppm PEG	158.53	61.13	133.23	43.00
150 ppm PEG	153.23	59.07	129.17	46.07
Control	155.40	66.07	137.43	47.80
$S\bar{x}$	7.51	5.39	6.07	3.25
Level of significance	NS	NS	NS	NS
CV (%)	8.83	15.73	8.04	12.66

NS = Not significant, DAS = Days After Sowing

DISCUSSION

Dry direct seeded rice (DDSR) is grown in non-saturated and non-puddled soil (aerobic soil) with moisture content at around field capacity, and thus resulted in twice the water productivity of conventional flood irrigated rice (Bouman et al., 2002). But so far, DDSR has not been gained much popularity among the rice farmers because of lees emergence rate, poor crop establishment and high weed pressure (Mahajan et al., 2011). Dry tillage, aerobic soil condition along with lack of head start makes this water-wise rice production system highly vulnerable to weeds, and therefore weed management is always a huge challenge in DDSR (Juraimi et al., 2013). Since primed seed exhibits increased, faster and synchronized germination along with better crop growth (Basra et al., 2005; Farooq et al., 2009), increased weed competitiveness (Juraimi et al., 2012) and ultimately increased yield (Du and Tuong, 2002; Kaur et al., 2005), it was therefore hypothesized that seed priming may counteract those hitches faced by DDSR.

In this study, rice plant growth was assessed in terms of plant stature and tillering ability at early, mid and late growth stages. Although seed priming failed to boost plant height and tillering ability of BRRI dhan29 at early and mid-growth stages, but a clear advantages of seed priming was found at harvest. Juraimi et al. (2012) also observed that plant height of direct seeded aerobic rice was enhanced due to seed priming but not the tillering ability. Mahajan et al. (2011), on the other hand found no significant influence of seed priming on the plant stature of rice grown under dry direct seeded condition.

Plant allometric attributes like leaf area index (LAI) and crop growth rate (CGR) are considered as the key indicators to judge changes in growth of plant over time. As reported by Farooq et al. (2009), increased efficiency of primed stand in resource capture and photosynthates assimilation might be resulted in increased LAI that ended in improved CGR; improved LAI and increased CGR resulted from seed priming might contribute to increased plant stature and tillering ability. Mahajan et al. (2011) opined that increased seedling length and dry weight caused by rapid cell division at the epical meristem due to seed priming might be the cause of increased plant growth. Better field performance of primed stand has also been reported by Basra et al. (2005).

Among the yield attributes, effective tillers $hill^{-1}$ and grains $panicle^{-1}$ were enhanced due to seed priming which eventually translated into increased grain yield. Among the priming agents, KCl and $CaCl_2$ resulted in the highest yield performance. A positive impact of pre-sowing seed treatment with priming agent on the productivity of direct seeded rice has been confirmed by many researchers, but which priming agent is the best is still not conclusive. Farooq et al. (2006a) confirmed that KCl and $CaCl_2$ priming appeared as the promising technique for increasing rice yield under dry direct seeded condition. Mahajan et al. (2011) on the other hand, revealed that hydro-priming was the best seed priming approach in improving yield attributes and yield performance of direct seeded rice. Juraimi et al. (2012) also confirmed the advantages of seed priming with Zappa solution over non-primed control to boost up rice yield grown under aerobic soil condition. Increased grain yield of primed rice stand might be the consequence of well-established vigorous seedlings resulting earlier and enhanced resource capture (Harris et al., 1999; Mahajan et al., 2011). Farooq et al. (2009) on the other hand, opined that rapid and regulated production of emergent metabolites leading to more vigorous and healthier seedlings might lead to better growth and increased yield of rice stands obtained from primed seeds. In addition to successful hydration during priming, K and Ca salts performed the best in terms of rice growth and yield which might be due their role in enzyme activation, in particular, of hydrolases as mentioned by Farooq et al. (2006a).

In the present study, weed growth was monitored in terms of weed density and dry matter at 40 and 60 days after sowing (DAS) of rice seeds. But, seed priming failed to increase the competitiveness of rice cultivar BRRI dhan29 against weeds when grown under dry direct seeded condition. Zhao et al. (2007) also found no advantages of seed priming in terms of weed suppression by dry direct seeded rice. However, conflicting findings have also been reported by many others (Du and Tuong, 2002; Ghiyasi et al., 2008) who confirmed that seed priming increased weed competitiveness of crops. As reported by Ghiyasi et al. (2008), seed priming resulted in robust seedling establishment which offered increased competitiveness against weeds resulting less weed growth. On the other hand, less vigorous and poor stands from unprimed seeds allow more vigorous weed growth (Guillermo et al., 2009). Clark et al. (2001) also revealed that faster and synchronized emergence along with increased vigor resulted from seed priming are the key factors for tolerating weeds. In this study, rice growth *i.e.* plant stature and tillering ability were enhanced due to seed priming only at later stage (at harvest), but not at early (40 DAS) or mid (60 DAS) growth stages which might be resulted in no reduction in weed density and dry matter, because early growth and vigor mostly contribute to weed competitiveness of dry direct seeded rice (Zhao et al., 2006; Anwar et al., 2010; Rahman et al., 2017; Arefin et al., 2018).

CONCLUSION

In crux, seed priming appears as a vital tool for enhancing growth and improving yield of direct seeded rice grown under minimal water; but, advantages of seed priming in enhancing weed competitiveness is not evident. Therefore, present study strongly suggests seed priming with KCl or $CaCl_2$ for boosting up yield of rice under dry direct seeded condition.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the financial support provided by Bangladesh Agricultural University Research System (BAURES), Bangladesh Agricultural University, Mymensingh through the research project number: 2018/597/BAU.

REFERENCES

Anwar MP., Juraimi AS., Man A., Puteh A., Selamat A., Begum M., (2010). Weed suppressive ability of rice (*Oryza sativa* L.) germplasm under aerobic soil conditions. Australian Journal of Crop Science, 4(9): 706-717.

Arefin MA., Rahman MR., Rahman ANMA., Islam AKMM., Anwar MP., (2018). Weed competitiveness of winter rice (*Oryza sativa*) under modified aerobic system. Archives of Agriculture and Environmental Science, 3(1): 1-14. https://doi.org/10.26832/24566632.2018.030101

Ashraf M., Foolad MR., (2005). Pre-sowing seed treatment-a shotgun approach to improve germination, plant growth, and crop yield under saline and non-saline conditions. Advances in Agronomy, 88: 223-271. https://doi.org/10.1016/S0065-2113(05)88006-X

Basra SMA., Farooq M., Tabassum R., (2005). Physiological and biochemical aspects of seed vigor enhancement treatments in fine rice (*Oryza sativa* L.). Seed Science and Technology, 33: 623-628. https://doi.org/10.15258/sst.2005.33.3.09

Bouman BAM., Wang H., Yang X., Zhao J., Wang C., (2002). Aerobic rice (Han Dao): A new way of growing rice in water-short areas. In: Proceedings of the 12th International Soil Conservation Organization Conference, 26-31 May 2002, Beijing, China. Tsinghua University Press, pp. 175-181.

BRRI., (2019). Modern rice cultivation, 22nd Special Edition, p. 96

Clark LJ., Whalley WR., Ellis-Jones J., Dent K., Rowse HR., Finch-Savage WE., Chiduza C., (2001). On farm seed priming in maize: a physiological evaluation, pp. 268- 273. Seventh Eastern and Southern Africa Regional Maize Conference, pp. 268-273.

Du LV., Tuong TP., (2002). Enhancing the performance of dry-seeded rice: effects of seed priming, seedling rate, and time of seeding. In: Pandey S., Mortimer M., Wade L., Tuong TP., Lopes K., Hardy B. (eds.), Direct seeding: research strategies and opportunities, pp. 241-256. International Rice Research Institute, Manilla, Philippines.

Farooq M., Basra SMA., Ahmad N., Murtaza G., (2009). Enhancing the performance of transplanted course rice by seed priming. Paddy Water Environment, 7: 55-63. https://doi.org/10.1007/s10333-008-0143-9

Farooq M., Basra SMA., Rehman, H., (2006a). Seed invigoration by osmohardening in coarse and fi ne rice (*Oryza sativa* L.). Seed Science and Technology, 34: 181-187. https://doi.org/10.15258/sst.2006.34.1.19

Farooq M., Basra SMA., Hafeez K., (2006b). Rice seed invigoration by osmohardening. Seed Science and Technology, 34: 181-186. https://doi.org/10.15258/sst.2006.34.1.19

Farooq M., Basra SMA., Khan MB., (2007). Seed priming improves growth of nursery seedlings and yield of transplanted rice. Arch Agronomy Soil Science, 53: 1-12. https://doi.org/10.1080/03650340701226166

Farooq M., Basra SMA., Rehman H., (2006c). Seed priming enhances emergence yield and quality of direct seeded rice. International Rice Research Notes, 31: 42-44. https://doi.org/10.3860/irrn.v31i2.1132

Farooq M., Siddique KHM., Rehman H., Aziz T., Wahid A., Lee D., (2011) Rice direct seeding: experiences, challenges and opportunities. Soil Tillage Research, 111: 87-98. https://doi.org/10.1016/j.still.2010.10.008

Ghiyasi M., Abbasi AM., Tajbakhsh A., Sallehzade R., (2008) Effect of osmopriming with poly ethylene glycol 8000 (PEG8000) on germination and seedling growth of wheat (*Triticum aestivum* L.) seeds under salt stress. Research Journal of Biological Science, 3: 1249-1251.

Guillermo DA., Pedersen P., Hartzler RG., (2009). Soybean seeding rate effects on weed management. Weed Technology, 23: 17-22. https://doi.org/10.1614/WT-08-060.1

Harris D., Joshi A., Khan PA., Gothkar P., Sodhi PS., (1999). On-farm seed priming in semi-arid agriculture development and evaluation in maize, rice and chickpea in India using participatory methods. Experimental Agriculture, 35: 15-29. https://doi.org/10.1017/S0014479799001027

Harris D., Tripathi RS., Joshi A., (2002). On-farm seed priming to improve crop establishment and yield in dry direct-seeded rice. In S. Pandey, M. Mortimer, L. Wade, T. P. Tuong, K. Lopes, & B. Hardy (Eds.), Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Research Issues and Opportunities. 25-28 January 2000. Bangkok, Thailand.

Islam AKMM., Popy FS., Hasan AK., Anwar MP., (2017). Efficacy and economics of herbicidal weed management in monsoon rice of Bangladesh. Journal of Scientific Agriculture, 1: 275-293. https://doi.org/10.25081/jsa.2017.v1.834

Jisha KC., Vijayakumari K., Puthur JT., (2013). Seed priming for abiotic stress tolerance: an overview. Acta Physiologiae Plantarum, 35: 1381-1396. https://doi.org/10.1007/s11738-012-1186-5

Juraimi AS., Anwar MP., Selamat A., Puteh A., Man A., (2012). The influence of seed priming on weed suppression in aerobic rice. Pakistan Journal of Weed Science and Research, 18: 257-264.

Juraimi AS., Uddin MK., Anwar MP., Mohamed MTM., Ismail MR., Man A., (2013). Sustainable weed management in direct seeded rice culture: A review. Australian Journal of Crop Science, 7(7): 989-1002.

Kaur S., Gupta AK., Kaur N., (2005). Seed priming increases crop yield possibly by modulating enzymes of sucrose metabolism in chick-pea. Journal of Agronomy and Crop Science. 191: 81-87. https://doi.org/10.1111/j.1439-037X.2004.00140.x

Kaya MD., Okçu G., Atak M., Çıkılı Y., Kolsarıcı O., (2006). Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annus* L.). European Journal of Agronomy, 24: 291-295. https://doi.org/10.1016/j.eja.2005.08.001

Mahajan G., Sarlach RS., Japinder S., Gill MS., (2011). Seed priming effects on germination, growth and yield of dry direct-seeded rice. Journal of Crop Improvement, 25: 409-417. https://doi.org/10.1080/15427528.2011.576381

Matsushima KI., Sakagami JI., (2013). Effects of seed hydropriming on germination and seedling vigor during emergence of rice under different soil moisture conditions. American Journal of Plant Sciences, 4: 1584-1593. https://doi.org/10.4236/ajps.2013.48191

Moody K., (1983). Weed control in multiple cropping.-Cropping Systems Research and Development for the Asian Rice Farmer‖, pp. 281-293 International Rice Research Institute, Los Ban˜ os, Laguna, Philippines.

Phill WG., (1995). Low water potential and pre-sowing germination treatments to improve seed quality. In: Basra AS. (ed.) Seed Quality: Basic Mechanisms and Agricultural Implication. Food Products Press, New York, USA, pp. 319- 360.

Rabeya MI., Anwar MP., Rahman MM., Akhter A., Islam AKMM., (2018). Intercropping of dry direct seeded boro rice with leafy vegetable for better weed suppression and higher profitability. Fundamental and Applied Agriculture, 3(3): 545-558. https://doi.org/10.5455/faa.302642844

Rahman ANMA., Islam AKMM., Arefin MA., Rahman MR., Anwar MP., (2017). Competitiveness of winter rice varieties against weed under dry direct seeded conditions. Agricultural Sciences, 8: 1415-1438. https://doi.org/10.4236/as.2017.81210

Rahman MM., (2019). Potential benefits of dry direct seeded rice culture: A review. Fundamental and Applied Agriculture, 4(2): 744-758. https://doi.org/10.5455/faa.16534

Sarker D., Anwar MP., Uddin MR., Hossen K., (2018). Exploring the possibility of using Agroplus Biodecomposer for boosting up rice productivity under Bangladesh condition. Fundamental and Applied Agriculture, 3(1): 372-381. https://doi.org/10.5455/faa.284983

Sunyob NB., Juraimi AS., Rahman MM., Anwar MP., Man A., Selamat A., (2012). Planting geometry and spacing influence weed competitiveness of aerobic rice. Journal of Food, Agriculture & Environment, 10(2): 330-336.

Yadav PV., Kumari M., Ahmed Z., (2011). Seed priming mediated germination improvement and tolerance to subsequent exposure to cold and salt stress in capsicum. Research Journal of Seed Science, 4(3): 125-136. https://doi.org/10.3923/rjss.2011.125.136

Zhao DL., Atlin GN., Bastiaans L., Spiertz JHJ., (2006) Cultivar weeds competitiveness in aerobic rice: heritability, correlated traits, and the potential for indirect selection in weed-free environments. Crop Science, 46: 372-380. https://doi.org/10.2135/cropsci2005.0192

Zhao DL., Bastiaans L., Atlin GN., Spiertz JHJ., (2007). Interaction of genotype × management on vegetative growth and weed suppression of aerobic rice. Field Crops Research, 100: 327-340. https://doi.org/10.1016/j.fcr.2006.08.007

Geliş Tarihi/ Received:Martt/March, 2020
Kabul Tarihi/ Accepted: Haziran/June, 2020

To Cite : Anwar M.P., Ahmed M.K., Islam A.K.M.M., Hossain M.D. and Uddin F.M.J., (2020). Improvement of Weed Competitiveness and Yield Performance of Dry Direct Seeded Rice through Seed Priming. Turk J Weed Sci, 23(1):15-23