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Optimizing the Boron Seed Coating Treatments for Improving the Germination and Early Seedling Growth of Fine Grain Rice

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ABSTRACT

Boron (B) is an essential micronutrient for rice growth and development. This experiment was conducted to explore the potential of seed coating with B for improving the germination and early seedling growth of fine grain rice. Seeds of two fine grain aromatic rice cultivars viz. Super Basmati and Shaheen Basmati were coated with B at 1.0, 1.5, 2, 2.5 and 3.0 g B kg^{-1} seed; while seeds without coating were taken as control. Boron seed coating with 1-2 g B kg^{-1} seed improved the germination energy, germination index and final germination percentage in both the tested cultivars. None of seed coating treatments improve the radicle length and leaf score; however plumule length, number of secondary roots and seedling fresh and dry weights were improved by seed coating with 2 g B kg^{-1} seed in both cultivars. Increasing B concentration beyond 2 g B kg^{-1} seed was toxic for seeds of both cultivars. In conclusion, rice seeds may be coated with B at 2 g B kg^{-1} seed to improve the germination and early seedling growth of fine grain aromatic rice. © 2012 Friends Science Publishers

Key Words: Boron; Germination; Seed coating; Rice; Seedling growth

INTRODUCTION

Improving nutrient use efficiency is an important goal to harvest better crop yield on sustained basis. Fertilizer placement is an important factor responsible for efficiency of nutrients (Robert, 2008). Most commonly, the nutrients are delivered as soil application, fertigation or foliar spray (Robert, 2008). Application of fertilizer in soil is very easy but involves high application cost and risk of nutrient loss by fixation or leaching. Nutrients required in small quantities by the plant may accumulate in soil to toxic level (Fageria *et al*., 2009). Although foliar spray is important for quick supply to plants (Fageria *et al*., 2009), however all nutrients can not be foliage sprayed, while some may cause leaf burn.

Applying nutrients as seed treatment, through seed coating and seed priming, is another option which avoids aforementioned risks (Farooq *et al*., 2012). Seed coating involves the sticking of target materials onto the surface of seeds (Stendahl, 2005). Seeds are pelleted, coated or enclosed with an adhesive film. Coating on seed surface acts as an efficient hauler of any chemical material, which may be beneficial for younger seedling growth (Scott, 1989).

Boron (B), being an important essential micronutrient, plays vital role in plant growth and development and its deficiency substantially reduces the grain yield (Motoh, 1997; Goldbach *et al*., 2001; Farooq *et al*., 2011). Boron also regulates the cell division, flowering and fruiting, carbohydrate and nitrogen metabolism, and acts as catalyst for certain reactions (Goldbach *et al*., 2001).

Zeļonka *et al*. (2005) coated barley seeds with phosphorus and observed that initially seed coating suppressed the seedling emergence but later improved the green plastids resulting in increased yield of barley by 3 to 91%. However in cowpea, seed pelleting with Borax (100 mg kg^{-1} seed) substantially improved pod weight, seeds/pod and pod weight/plant resulting in 37.25% pod yield gain over non-pelleted control (Masuthi *et al.,* 2009). Nonetheless, coating wheat and oat seeds with urea, mono calcium phosphate, ammonium sulphate and calcium nitrate adversely affected seed emergence of wheat and oat (Scott *et al*., 1987). This proposes that certain level of coating material should be pre-optimized before coating seeds on large basis. In our previous studies, we noted improvement in germination and early seedling growth of rice from B application as seed priming (Farooq *et al*., 2011; Rehman *et al*., 2012). To the best of our knowledge, B application as seed coating has been rarely evaluated in rice. This study was conducted to optimize the B seed coating and evaluate its influence on the germination and early seedling growth of fine grain rice.

MATERIALS AND METHODS

This study was conducted in Seed Technology Laboratory, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during 2009. Two fine grain aromatic rice cultivars Super Basmati and Shaheen

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Basmati were used in this study. Seed of Super Basmati and Shaheen Basmati was obtained from Rice Research Institute, Kala Shah Kakoo, District Sheikhupura and Soil Salinity Research Institute, Pindi Bhattian, Hafizabad, respectively. The initial seed moisture contents of cultivars Super Basmati and Shaheen Basmati were 8.06% and 9.02% (on dry weight basis), respectively. Boron seed coating was done using an inert and sticky material 'Arabic gum'. Boron coating treatments include no coating (control), coating with 1.0, 1.5, 2.0, 2.5 and 3.0 g B kg^{-1} seed.

Treated and untreated seeds were sown between layers of moist filter papers in petri plates, and were placed at 27°C in an incubator. Daily germination count was taken according to the Association of Official Seed Analysis method (AOSA, 1990) until a constant count was achieved. The time taken for 50% germination (T_{50}) was calculated according to the formula, modified by Farooq *et al.* (2005):

$$T_{50} = t_i + \frac{\left(\frac{N}{2} - n_i\right)(t_j - t_i)}{n_j - n_i}$$

Where N is the final number of germinated seeds and n_i, n_j are cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

Mean germination time (MGT) was calculated according to following equation (Ellis & Roberts, 1981):

$$MGT = \frac{\sum Dn}{\sum n}$$

Where n is the number of seeds, which were germinated on day D and D is the number of days counted from the beginning of germination.

To calculate germination index (GI), procedure according to the Association of Official Seed Analysts (1983) was followed using formula:

$$GI = \frac{\text{No. of germinated seeds}}{\text{Days of first count}} + - - - - - - - + \frac{\text{No. of germinated seeds}}{\text{Days of final count}}$$

Germination energy, which refers to the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested (Ruan *et al.*, 2002), was recorded on the 4^{th} day after planting.

Number of secondary roots was counted daily, to determine their emergence rate. On 10^{th} day after sowing, the seedlings were tested for vigor after carefully removing. Similarly number of leaves was counted daily and both number of leaves and secondary roots were taken as leaf and root scores, respectively. Radicle and plumule lengths were measured on a scale of five random seedlings per replicate and then averaged. To measure seedling dry weight, seedlings were dried at 70°C in electric oven till constant weight was achieved.

Data collected were statistically analyzed by MSTAT-C software and analysis of variance test was used to check the significance of different sources, while least significant difference (LSD) test (P = 0.05) was used to compare the differences among treatment means. Microsoft Excel was used for graphical presentation of the data. Standard error bars were computed to compare the real difference amongst the treatments by Microsoft Excel.

RESULTS

Rice seed coating with B significantly improved the germination energy, germination index and final germination percentage; however there was no effect ($P>0.05$) of seed coating on T_{50} and MGT. In all cases both cultivars behaved alike, showing no-significant ($P>0.05$) interaction of seed coating and cultivars. Seed coating with 1.0, 1.5 and 2.0 g kg^{-1} seed improved the germination energy, germination index and final germination percentage compared with control (Table I). However seed coating beyond 2.0 g kg^{-1} seed did not improve the final germination (Table I).

Seed coating with B significantly ($P<0.01$) affected the radicle and plumule lengths, seedling fresh and dry weights and the root score; however there was no effect of B seed coating on leaf score (Table II). Varietal differences were only significant ($P<0.01$) for seedling dry weight and leaf score, while the interaction of seed coating with cultivars was not significant in all cases (Table II). Maximum radicle and plumule lengths, root score and seedling fresh and dry weights were observed from seed coating with 2 g B kg^{-1} seed (Table III). However, seed coating with 2.5 and 3.0 g B kg^{-1} seed were toxic for radicle length, root score and seedling fresh and dry weights (Table III).

Table I: Influence of seed coating with boron on germination of rice cultivars

Treatments	T_{50} (days)			MGT (days)			GE (%)			GI			FGP (%)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
Control	3.34	3.45	3.39	8.96	8.99	8.97	60.00	60.00	60.00C	18.20	19.35	18.78B	83.33	90.00	86.67BC
1 g B kg^{-1} seed	3.23	3.21	3.22	8.87	8.87	8.87	70.00	71.67	70.84A	19.94	20.70	20.32A	88.33	91.67	90.00AB
1.5 g B kg^{-1} seed	3.18	3.22	3.21	8.88	8.90	8.88	68.33	68.33	68.34AB	20.25	20.12	20.18A	90.00	90.00	90.00AB
2 g B kg^{-1} seed	3.28	3.22	3.25	8.95	8.89	8.93	63.33	75.00	69.17AB	20.05	20.88	20.47A	91.67	93.33	92.50A
2.5 g B kg^{-1} seed	3.30	3.41	3.35	8.90	8.92	8.92	63.33	63.33	63.34BC	18.56	19.15	18.85B	83.33	86.67	85.00C
3 g B kg^{-1} seed	3.42	3.28	3.35	8.98	8.92	8.95	60.00	63.33	61.67C	17.97	18.44	18.21B	83.33	83.33	83.34C
Mean	3.29	3.29		8.93	8.92		64.17	66.95		19.16	19.77		86.67	89.17	

Means not sharing the same letter for a parameter don't differ significantly at p 0.05

T_{50} = Time to 50% germination; MGT = Mean germination time; GE = Energy of germination; GI = Germination index; FGP = Final germination percentage; V1 = Super Basmati; V2 = Shaheen Basmati

Table II: Analysis of variance for influence of B seed coating on early seedling growth of rice

Source of variation	DF	Mean sum of square					
		Radicle length	Plumule length	Fresh weight	Dry weight	Root score	Leaf score
Rice cultivar (C)	1	0.01^{ns}	0.24^{ns}	0.06^{ns}	0.01*	0.18^{ns}	0.52*
Boron (B)	5	0.74*	6.44**	0.13**	0.01**	7.07**	0.07^{ns}
C × B	5	0.01^{ns}	0.07^{ns}	0.02^{ns}	0.001^{ns}	0.04^{ns}	0.07^{ns}
Error	36	0.24	1.57	0.02	0.001	1.07	0.09

DF = Degree of freedom; * = Significant at p 0.05; ** = Significant at p 0.01

Table III: Influence of seed coating with boron on the stand establishment of rice cultivars

Treatments	Radicle length (cm)			Plumule length (cm)			Root score			Leaf score			Fresh wt. (mg)			Dry wt. (mg)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
Control	6.79	6.82	6.81AB	6.57	6.47	6.52B	6.00	6.25	6.13B	2.00	2.00	2.00	790.00	710.00	0.75CD	70.00	70.00	69.00C
1 g B kg^{-1} seed	6.93	6.95	6.94A	7.48	7.84	7.66AB	7.75	7.75	7.75A	2.00	2.25	2.13	850.00	910.00	0.88AB	70.00	70.00	69.00C
1.5 g B kg^{-1} seed	6.84	6.79	6.82AB	7.74	7.74	7.74AB	7.75	8.00	7.87A	2.00	2.25	2.13	930.00	960.00	0.94AB	70.00	80.00	76.00B
2 g B kg^{-1} seed	7.07	7.10	7.08A	8.89	8.92	9.91A	8.50	8.50	8.50A	2.00	2.50	2.25	980.00	1010.00	0.99A	80.00	80.00	82.00A
2.5 g B kg^{-1} seed	6.29	6.32	6.31C	6.71	6.99	6.85B	6.50	6.75	6.63B	2.00	2.25	2.13	730.00	930.00	0.84BC	60.00	70.00	67.00D
3 g B kg^{-1} seed	6.42	6.42	6.42BC	6.57	6.82	6.69B	6.50	6.50	6.50B	2.00	2.00	2.00	560.00	740.00	0.65D	60.00	60.00	62.00E
Mean	6.73	6.73		7.33	7.46		7.17	7.29		2.00B	2.21A		0.81	0.88		68.00B	74.00A	

Means not sharing the same letter for a parameter don't differ significantly at p 0.05
V1 = Super Basmati; V2 = Shaheen Basmati

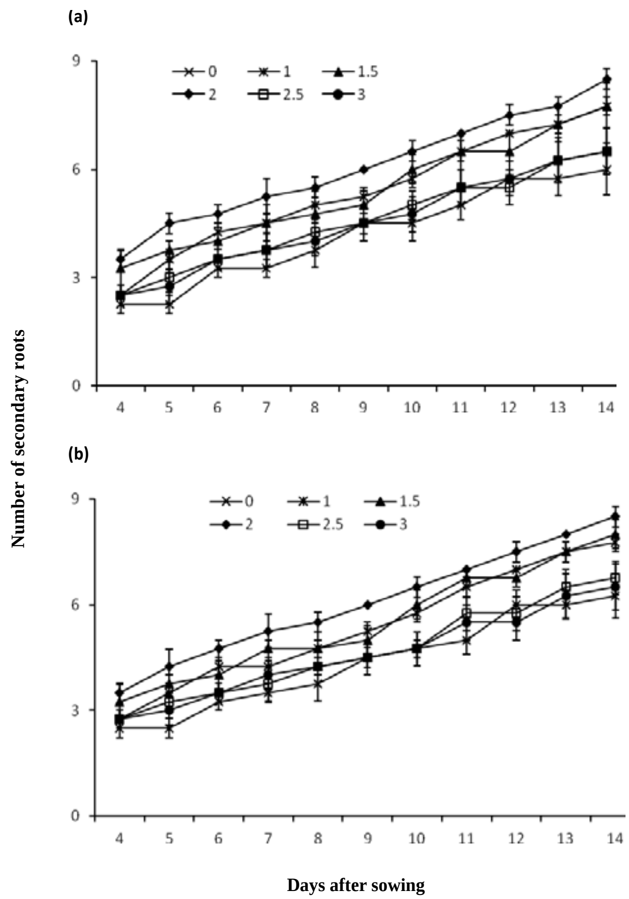
Maximum rate of secondary root emergence was recorded from seeds coated with 2.0 g B followed by 1.0 and 1.5 g B kg^{-1} seed, while other treatments i.e. 2.5 and 3.0 g kg^{-1} seed had lower root emergence rate than control in both rice cultivars (Fig. 1a, b).

DISCUSSION

This study suggests the potential of micronutrient application through seed coating. However, the study also indicates that nutrient to seed ratio should be optimized before application on large scale. Rice seed coating with B, particularly at low concentration, has great opportunity to improve the stand establishment of rice cultivars. Although B coating could not improve the mean germination time and time to 50% germination, it improved the germination energy, germination index and final germination percentage in both rice cultivars (Table I). Low concentration of B maintains the seed viability and release from seed dormancy (Bell *et al*., 1989) and thus affect stand establishment (Rerkasem *et al*., 1997; Bonilla *et al*., 2004). Our previous studies also reported the improved germination and seedling growth of rice from B seed priming (Farooq *et al*., 2011; Rehman *et al*., 2012).

Improvement in radicle and plumule lengths and root score and seedling fresh and dry weights (Tables II, III) seems the involvement of B in meristematic growth of radicle and plumule primodia (Bohnsack & Albert, 1977), cell wall extensibility (Bell *et al*., 1989) and cell division and elongation (Shelp, 1993). Similarly the number and rate of secondary roots were substantially increased with B coating at a lower concentration (Fig. 1). However, an increase in B concentration inhibited the secondary root emergence. This substantiates our previous findings, where priming with a lower concentration of B solution improved root and leaf score and also the number of secondary roots (Farooq *et al*., 2011; Rehman *et al*., 2012).

Fig. 1: Influence of B seed coating on number of secondary roots in fine grain aromatic rice cultivars (a) Super Basmati and (b) Shaheen Basmati ± S.E



In conclusion, seed coating with B is may improve the germination and early seedling growth of rice if applied at optimized concentration. Seed coating at 2 g B kg^{-1} seed was effective in fine grain aromatic rice.

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