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RESPONSE OF MAIZE CULTIVARS TO VARIOUS PRIMING SOURCES

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Abstract

Experiments were conducted to study the effect of seed priming on germination and yield of different maize varieties at the Department of Agronomy and Malakandher Research Farms KPK Agricultural University, Peshawar Pakistan. Seeds of four maize varieties viz., Azam, Sarhad white, Pahari and Sarhad yellow were primed with 5 different priming sources i.e. Polyethylene glycol (PEG), Potassium nitrate (KNO_3), Sodium thiosulphate ($Na_2S_2O_3$) and Water (H_2O) for 17 hours. Various priming sources and maize varieties had a significant ($p<0.05$) effect on days to emergence, emergence m^{-2}, 50% tasseling, 50% silking, maturity, growing degree days and grain yield. Seed germination and emergence occurred 2 days (48-51 h) earlier in primed seeds than unprimed. Azam germinated and emerged earlier than the rest of the varieties. Maximum germination (99%) and emergence (6 m^{-2}) were recorded in seeds primed with PEG compared with other treatments. Among varieties, Azam gave maximum germination (99%) and emergence (6.5 m^{-2}). Maximum seedling dry weight (0.61 g) was observed in seeds primed with $Na_2S_2O_3$ Minimum days to tasseling (54), silking (61) and maturity (98) were observed in seeds primed with water or KNO_3. Among varieties, maximum days to tasseling (59), silking (65) and maturity (99) were recorded in Sarhad yellow. Maximum grain yield (3498 kg ha^{-1}) was recorded in $Na_2S_2O_3$. Similarly, grain yield was more (3666 kg ha^{-1}) in Sarhad yellow compared with other varieties.

Introduction

Seed priming is a technology that has been shown to positively influence germination and establishment of crop (Harris *et al*., 1999; Mandal *et al*., 1999; Musa *et al.,* 1999; Rashid *et al.,* 2002; Murungu *et al.,* 2004; Naeem & Muhmad, 2006; Arif *et al.,* 2007; Snapp *et al.,* 2008). Good crop establishment increases competitiveness against weeds, increases tolerance to dry spells, maximizes yields and avoids the costly and time consuming need for re-sowing (Clark *et al.,* 2001). By partially hydrating the seed, priming pre-activates enzymes and DNA replication which may improve germination processes and early seedling vigor (Cheng & Bradford, 1999; Bradford *et al.,* 2000; Giri & Schillinger, 2003; Snapp *et al.,* 2008). Seed priming generally causes faster germination and field emergence, which have practical agronomic implications, notably under adverse germination conditions (De Castro *et al.,* 2000; McDonald, 2000; Rajpar *et al.,* 2006; Abdulrahmani *et al.,* 2007; Ajouri *et al.,* 2009). Direct benefits in many crops included: faster emergence, better and more uniform stands, less need to re-sow, more vigorous plants, better drought tolerance, earlier flowering and higher grain yield from priming (Harris *et al.,* 2001). This simple and low cost technology also have a positive impacts on the wider farming system. Optimization of seed actually rests on carrying out subsequent germination assays, which only provide retrospective indications of the effectiveness of the priming conditions. Therefore, there is strong interest in identifying molecular markers of germination and/or priming for use in the seed industry (Job *et al.,* 2000).

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Materials and Methods

Both field and laboratory experiments were carried out at KPK Agricultural University, Peshawar Pakistan to study the response of maize cultivars to various priming sources. Four different maize varieties viz., Azam, Sarhad white, Pahari and Sarhad yellow were primed with four priming agents viz., Potassium nitrate (KNO_3 3%), Sodium thiosulphate ($Na_2S_2O_3$ 3%), Polyethylene glycol 4000 (PEG 5%) and distilled Water. These cultivars were selected on the basis of short and long durations of their life cycle. Field experiment was carried out in Randomized Complete Block (RCB) design with split plot arrangements having four replications. Seeds were fully immersed in priming sources at room temperature for 17 hours (already experimentally determined for maximum absorption). A non-treated check for all 4 cultivars was also included. Seeds were rinsed thoroughly with distilled water and then dried using blotting paper, as described by Giri & Schillinger (2003). Osmotic potential of KNO_3, $Na_2S_2O_3$, PEG and H_2O was determined following the method of Bohn *et al.,* (2001) which revealed KNO_3 = -1.09 MPa; $Na_2S_2O_3$ = -0.74 MPa; PEG = -0.02 MPa and H_2O = 0 MPa. A basal dose of NPK @ 150:50:50 kg ha^{-1} was applied during the course of experiment. All P and K and half dose of N was applied at the time of sowing while the remaining half dose of N was applied at knee height stage. Standard agronomic practices were carried out during the experiment. Laboratory experiment measured the time after seed placement for germination, rate of germination and seedling dry weight using a two factors factorial CR design with 20 treatment combinations repeated 4 times.

Procedures for recording data: Time to rate of 50% germination was recorded by counting the number of hours from the date of placement of seeds till when 50% of seeds got germinated. For recording germination, 50 seeds of each variety from each treatment were germinated between two layers of Whatman filter paper (No. 2) in germinator. Radical protrusion of 5 mm was scored as germination. Germination of individual seed was noted at 12 h intervals and continued until no further germination occurred (Giri & Schillinger, 2003). Seedling dry weight was determined as described by Chiu *et al.,* (2002). Days to emergence was recorded by counting the number of days from the date of sowing till when 50% of plants emerged. Emergence m^{-2} was recorded by counting the number of plants in one meter long row in each subplot. Days to tasseling and silking were recorded by counting days from the date of sowing till when 50% of tasseling and silking occurred in each treatment. Days to maturity were calculated from the days of sowing till when 75% of plants reached to their physiological maturity. Four central rows in each sub plot were harvested, ears de-husked, dried and threshed. Grain weight was recorded and then converted into kg ha^{-1}.

Statistical analysis: All data are presented as mean values of three replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez & Gomez (1984). MSTATC computer software was used to carry out statistical analysis (Russel & Eisensmith, 1983). The significance of differences among means was compared by using Least Significant Difference (LSD) test (Steel & Torrie, 1997).

Results and Discussion

Time to 50% germination (h): Time to 50% germination was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 1). Time to 50% germination was maximum (96 h) in unprimed seeds (check) while minimum of 45 h to 50% germination was recorded in seeds primed with water. Among varieties, Azam took minimum time of 55 h to 50% germination while Sarhad yellow recorded 66 h to 50% germination. In case of interaction between priming sources and varieties, maximum time of 96 h to 50% germination was recorded for all varieties in check. The probable reason for early germination in primed seeds could be the completion of "Lag phase" of germination during priming of seeds for 17 h. These results agree with Cheng & Bradford, (1999), Bradford *et al.,* (2000), Giri & Schillinger (2003) and Snapp *et al.,* (2008). Similarly, Harris *et al.,* (1999) concluded earlier germination in 20 h when they primed maize seeds for 24 hrs in water.

Germination (%): Statistical analysis of the data showed that germination was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 2). Our result indicated that total germination was maximum (99%) in those treatments where seeds were primed with PEG followed by treatments primed with water or $Na_2S_2O_3$. Similarly, Azam gave maximum (99%) germination while minimum (94%) germination was recorded in Sarhad white. In case of interaction of priming sources x varieties, maximum (100%) germination was noted in three cultivars i.e., Azam, Sarhad white and Pahari when primed with PEG or KNO_3. The probable reason could be enhanced production of antioxidant compounds and/or enzymes (superoxide dismutase) which might have accelerated germination. The observed improvements in germination of PEG primed seed may be attributed to various biochemical changes which might have improved membrane integrity and enhanced physiological activities. Similar results are also reported by Baily *et al.,* (2000). Shafi *et al.,* (2006) also observed maximum germination in Azam and minimum in Sarhad white while comparing different priming sources. They further observed that maximum germination was noted when seeds were primed with water followed by PEG. Faster germination due to seed priming has been also reported by Cheng & Bradford, (1999), Bradford *et al.,* (2000), Giri & Schillinger, (2003) and Snapp *et al.,* (2008).

Seedling dry weight: Seedling dry weight was significantly ($p \leq 0.01$) affected by various priming sources and their interaction with varieties while no significant variations were found among different varieties (Table 3). The data suggested that seedling dry weight was maximum (0.61 g) in those treatments where seeds were primed with $Na_2S_2O_3$ followed by seeds primed with water (0.56 g). Among varieties, Sarhad white produced maximum (0.56 g) seedling dry weight while minimum (0.53 g) seedling dry weight was recorded in Sarhad yellow. In case of interaction, maximum seedling dry weight (0.67 g) was observed in Azam when primed with Sodiumthiosulphate and compared with other treatments. Chiu *et al.,* (2002) concluded that priming can improve germination, reduced lipid per-oxidation, enhance anti-oxidative activity and increase seedling growth. Similarly, Ajouri *et al*., (2009) reported enhanced germination and seedling growth of barley under conditions of P and Zn deficiency.

Table 1. Time to 50% germination of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	96 A	48 D	48 D	48 D	36 E	55 C
Sarhad white	96 A	60 C	48 D	48 D	36 E	58 B
Pahari	96 A	48 D	48 D	48 D	48 D	58 B
Sarhad yellow	96 A	79 B	48 D	48 D	60 C	66 A
Mean	96 A	59 B	48 C	48 C	45 D	
LSD for varieties at p≤0.01			4.02			
LSD for priming sources at p≤0.01			4.50			
LSD for interaction at p≤0.01			8.99			

Table 2.Germination (%) of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	97 AB	100 A	99 AB	100 A	99 AB	99 A
Sarhad white	86 C	87 C	95 B	99 AB	100 A	94 C
Pahari	90 C	98 AB	98 AB	100 A	98 AB	97 B
Sarhad yellow	79 D	99 AB	99 AB	99 AB	96 AB	94 C
Mean	88 C	96 B	98 AB	99 A	98 AB	
LSD for varieties at p≤0.01			1.32			
LSD for priming sources at p≤0.01			2.46			
LSD for interaction at p≤0.01			4.92			

Means followed by different letters are significantly different at p≤0.01 using LSD test.

Table 3. Seedling dry weight (g plant^{-1}) of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	0.35 F	0.51 DE	0.67 A	0.59 BC	0.59 BC	0.54
Sarhad white	0.47 E	0.55 CD	0.55 CD	0.61 ABC	0.62 AB	0.56
Pahari	0.38 F	0.62 AB	0.63 A	0.51 DE	0.63 AB	0.55
Sarhad yellow	0.46 E	0.45 E	0.61 ABC	0.62 AB	0.51 DE	0.53
Mean	0.42 C	0.54 B	0.61 A	0.58 A	0.59 A	
LSD for priming sources at p≤0.01			0.032			
LSD for interaction at p≤0.01			0.064			

Phenology: Days to 50% emergence were significantly (p≤0.01) affected by various priming sources, varieties and their interaction (Table 4). Maximum days to 50% emergence were noted in unprimed seeds (check) while minimum in treatments of primed seeds. Our results indicated that Azam took minimum days to 50% emergence while Sarhad yellow recorded maximum days to 50% emergence. Priming sources x varieties showed that maximum number of 8 days to 50% emergence was recorded for all varieties in check when compared with other treatments. Emergence is an important determinant of successful establishment. Rapidly emerging seedling could produce deep root system before the upper layers of soil dried out, hardened or become dangerously hot. Moon & Soon (2004) reported that priming reduced time to 50% emergence and increased plumule weight. Days

to 50% tasseling were significantly ($p \leq 0.05$) affected by various varieties while different priming sources and their interaction with varieties showed non significant effect (Table 5). The results revealed that days to 50% tasseling were maximum (59 days) in Sarhad yellow while minimum of 53 days to 50% tasseling were recorded in Pahari. Though the effect of priming sources and their interaction with varieties was not significant, however, maximum days to 50% tasseling were recorded in unprimed Sarhad yellow.

Analysis of the data also revealed that days to 50% silking were significantly ($p \leq 0.05$) affected by varieties and their interaction with priming sources whereas the effect of priming sources was non significant (Table 6). Days to 50% silking were maximum (63 days) in unprimed seeds (check) or when treated with $Na_2S_2O_3$ while minimum of 61 days to 50% silking. Our data also indicated that maximum of 65 days to 50% silking were recorded in Sarhad yellow while minimum (59) in Pahari. In case of interaction, maximum of 66 days to 50% silking were recorded in Sarhad yellow when sown as dry seed (check) while minimum of 56 days to silking was observed in Pahari when primed with PEG. Various priming sources and varieties had significantly ($p \leq 0.01$) affected days to maturity while no significant variation was found between their interaction (Table 7). The data indicated that days to maturity were maximum (98 days) in unprimed seeds (check) while minimum of 96 days to maturity were noted in those treatment where seeds were primed with KNO_3 or water. Among varieties, Sarhad yellow took more (99) days to maturity while minimum of 94 days to maturity were recorded in Pahari. Similar results are also reported by Harris *et al.,* (2001) who concluded that primed crops matured 7-15 days earlier than unprimed seeds. Early maturity in seed priming treatment could be due to advancement in metabolic state (Harris *et al.,* 1999). Similarly, Rashid *et al.,* (2002) concluded that priming has been shown to improve plant stand and provide benefits in term of maturity.

Emergence m^{-2}: Various priming sources and varieties had significantly ($p \leq 0.01$) affected emergence m^{-2} whereas their interaction showed non significant differences (Table 8). Emergence was maximum (6 plants m^{-2}) in those treatments where seeds were primed with $N_2S_2O_3$, PEG or water followed by seeds primed with KNO_3 (5 plants m^{-2}). Among varieties, Azam recorded maximum emergence m^{-2} (6.5 plants m^{-2}) while Sarhad white noted minimum (4.7 m^{-2}) emergence. These results agree with Murungu *et al.,* (2003) who concluded that final percent emergence and seedling growth decreased with initial metric potential but increased with priming in both cotton and maize crop.

Grain yield: Grain yield was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 9). Grain yield was maximum (3498 kg ha^{-1}) in those treatments where seeds were primed with Sodium thiosulphate while minimum (2727 kg ha^{-1}) was produced by unprimed treatments (check). Our results further suggested that Sarhad yellow produced maximum grain yield (3666 kg ha^{-1}) while minimum (2566 kg ha^{-1}) was recorded from Pahari. In case of interaction, more grain yield (4261 kg ha^{-1}) was produced by Sarhad yellow when primed with KNO_3 compared with other treatments. These results agree with those reported by Hashmi & Shafiullah (2003) and Rajpar *et al.,* (2006). Harris *et al.,* (1999) reported that seed priming improves crop establishment in many crop which results in faster development, earlier flowering and maturity and higher yield. Clark *et al.,* (2001) concluded that on average primed seeds produced 105 kg ha^{-1} (14% increases) higher yield than unprimed in maize crop. Harris *et al.,* (2001) also demonstrated that maize cob yields in 35 farmers' trial showed advantages following priming. They further stated that yield in primed plots were larger than those where dry seeds were used.

Table 4. Days to emergence of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	7 B	5 D	5 D	5 D	5 D	5 C
Sarhad white	8 A	6 C	6 C	6 C	5 D	6 B
Pahari	8 A	6 C	6 C	6 C	6 C	6 B
Sarhad yellow	8 A	8 A	7 B	7 B	7 B	7 A
Mean	8 A	6 B	6 B	6 B	6 B	
LSD for varieties at p≤0.01			0.16			
LSD for priming sources at p≤0.01			0.20			
LSD for interaction at p≤0.01			0.40			

Means followed by different letters are significantly different at p≤0.01 using LSD test.

Table 5. Days to 50% tasseling of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	55	55	56	57	55	56 bc
Sarhad white	57	57	57	58	57	57 ab
Pahari	56	55	56	52	46	53 c
Sarhad yellow	60	58	59	59	59	59 a
Mean	57	56	57	57	54	
LSD for varieties at p≤0.05			3.578			

Table 6. Days to 50% silking of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	61 c-f	59 e-g	62 b-f	63 a-e	62 b-f	61 bc
Sarhad white	63 a-e	61 c-f	67 a	64 a-d	62 b-f	63 ab
Pahari	63 a-e	60 d-g	59 e-g	56 g	58 fg	59 c
Sarhad yellow	66 ab	65 a-c	64 a-d	65 a-c	63 a-e	65 a
Mean	63	61	63	62	61	
LSD for varieties at p≤0.05			3.260			
LSD for interaction at p≤0.05			4.235			

Means followed by different letters are significantly different at p≤0.05 using LSD test.

Table 7. Days to maturity of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	96	96	98	97	96	96 B
Sarhad white	99	97	98	96	95	97 B
Pahari	96	94	95	93	94	94 C
Sarhad yellow	101	98	99	98	99	99 A
Mean	98 A	96 C	97 B	96 C	96 C	
LSD for varieties at p≤0.01			1.294			
LSD for interaction at p≤0.01			0.965			

Table 8. Emergence m^{-2} of maize varieties as affected by various seed priming sources

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	5	6	7	6	8	6.5 A
Sarhad white	3	5	5	5	5	4.7 C
Pahari	4	5	5	5	6	5.0 BC
Sarhad yellow	3	5	6	7	6	5.5 B
Mean	4 C	5 B	6 A	6 A	6 A	
LSD for varieties at p≤0.01			0.538			
LSD for priming sources at p≤0.01			0.696			

Table 9. Grain yield (kg ha^{-1}) of maize varieties as affected by various seed priming sources.

Varieties	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	2757 I	3274 F	3836 B	2611 JK	3109 H	3118 B
Sarhad white	2673 J	3179 G	3790 BC	2564 KL	3058 H	3053 B
Pahari	2136 M	2811 I	2787 I	2594 K	2503 L	2566 C
Sarhad yellow	3342 E	4261 A	3580 D	3396 E	3751 C	3666 A
Mean	2727 E	3381 B	3498 A	2791 D	3105 C	
LSD for varieties at p≤0.01			0.16			
LSD for priming sources at p≤0.01			0.20			
LSD for interaction at p≤0.01			0.40			

Means followed by different letters are significantly different at p≤0.01 using LSD test.

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