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EFFECT OF VARIOUS PRIMING SOURCES ON YIELD AND YIELD COMPONENTS OF MAIZE CULTIVARS

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Abstract

The present field study was carried at Malakandher Research Farms KPK Agricultural University, Peshawar, using randomized complete block design. 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 growing degree days, plant height, number of plants at harvest, number of ears plant^{-1}, number of grains cob^{-1} , thousand grain weight, biological yield, grain yield and harvest index. Growing degree days were maximum (1865) in unprimed seeds. Maximum grains cob^{-1} (419) and biological yield (8060 kg ha^{-1}) were recorded in KNO_3 primed treatments. Among varieties, Sarhad yellow produced maximum (420) grains cob^{-1} and biological yield Maximum 1000 grain weight (231 g) and grain yield of 3498 kg ha^{-1} were recorded in $Na_2S_2O_3$ primed treatments. Among varieties, maximum (239 g) 1000 grain weight and grain yield (3666 kg ha^{-1}) were produced by Sarhad yellow.

Introduction

In semi arid tropics, crops, often fail to establish quickly and uniformly, leading to decreased yields because of low plant populations. Seed priming improves stand, establishment and yield in a range of crops (Harris *et al*., 1999; Mandal *et al*., 1999; Musa *et al*., 1999; Rashid *et al*., 2002; Naeem & Muhmad , 2006); Arif *et al*., 2007). Resource-poor farmers often lack the means to optimize seedbed conditions before sowing and they are particularly at risk from adverse weather after sowing. On the other hand, good 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). Direct benefits due to seed priming 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 in many crops (Harris *et al*., 1999; Harris *et al.,* 2001). The processes which play a role during seed priming include cell cycle-related events (De Castro *et al*., 2000), and endosperm weakening by hydrolase activities (Bradford *et al*., 2000).

The basic aim of seed priming is to partially hydrate the seed to a point where germination processes are begun but not completed (Ashraf & Foolad, 2005). Priming treatments (i.e. pre-germination treatments) are used to synchronize the germination of individual seeds. Priming initiate germination-related processes, but prevent emergence of the radicle. Seed priming has been extensively used to improve germination of many

plant species (McDonald, 2000; Harris *et al.,* 2002). Optimization of such treatments actually rests on carrying out subsequent germination assays, which 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 by the seed industry (Job *et al.,* 2000). The present study was designed to investigate the effect of various priming sources on the yield and yield components of different maize cultivars.

Materials and Methods

Experiments were conducted at Malakandher Research Farms, KPK Agricultural University, Peshawar. Four maize cultivars (Azam, Sarhad white, Pahari and Sarhad yellow) were primed with four priming agents (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. 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. These experiments were carried out in Randomized Complete Block (RCB) design with split plot arrangements having four replications. Varieties were allotted to the main plot and priming sources were randomly distributed to the subplots. A net subplot size of 5m X 3m was kept for priming sources treatments. 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.

Procedures for data recording: Degree days of each treatment were calculated by using the following formula as proposed by Chapman & Lark (1976).

$$\text{Growing degree days} = \frac{\text{Max temperature} + \text{Min temperature}}{2} - \text{Base temperature (Base temperature for corn is 10 }^{o}\text{C)}$$

Plant height data was recorded by measuring the height of 10 representative plants in each sub plot. Number of harvested plants from each plot was counted and then converted to plants ha^{-1}. Grains from 10 randomly selected ears were removed in each treatment and counted to record grains cob^{-1}. Ten representative plants in each treatment were randomly selected and number of ears in each plant was then counted. Thousand grains were randomly selected from each sub plot and weighed to record 1000 grain weight. Four central rows in each sub plot were harvested; the ears were de-husked, dried and threshed. Grain weight was recorded and then converted into kg ha^{-1}. All plants in each subplot were harvested and then weighed to note biological yield. Harvest index was calculated by the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \text{ X } 100$$

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 and Eisensmith, 1983). The significance of differences among means was compared by using Least Significant Difference (LSD) test (Steel & Torrie, 1997).

Results and Discussion

Plant growth: Various priming sources and varieties significantly ($p \leq 0.01$) affected the growing degree days of maize while no significant ($p > 0.05$) variation was found due to interaction of varieties and priming sources (Table 1). Growing degree days were more (1865) in unprimed seeds (check) while minimum growing degree days (1837) were observed in PEG or water treated seeds. Among cultivars, Sarhad yellow took maximum growing degree days (1882) while minimum degree days (1810) were recorded in Phari. Increasing growing degree days increased grain yield and biological yield (Figs. 1 and 2). Early maturity in seed priming treatment could be due to advancement in metabolic state (Harris *et al*., 1999). Plants at harvest were significantly ($p \leq 0.01$) affected by different varieties and priming sources while their interaction was non-significant ($p > 0.05$; Table 2). More plants at harvest (52635 plants ha^{-1}) were produced by those treatments where seeds were primed with PEG followed by water primed seeds (52417 plants ha^{-1}). Minimum plants at harvest (32542 plants ha^{-1}) were recorded in unprimed seeds (check). Azam had maximum plants at harvest (53575 plants ha^{-1}) while minimum (41750 plants ha^{-1}) were recorded in Sarhad white. Similar results are also reported by Harris *et al*., (1999), Mandal *et al*., (1999), Musa *et al*., (1999) and Rashid *et al*., (2002) who concluded that priming improve plant stand and provide benefits in term of maturity. This view is further supported by Harris *et al*., (2001).

Yield and yield components: Number of grains cob^{-1} was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 3). Our results indicated that maximum grains cob^{-1} (419) were produced by those treatments where seeds were primed with KNO_3 while minimum grains cob^{-1} (334) in unprimed seeds (check). Similarly, Sarhad yellow produced maximum grains cob^{-1} (420) whereas minimum were recorded from Pahari. In case of interaction between priming sources and varieties, maximum grains cob^{-1} (480) were noted in Sarhad yellow when primed with KNO_3 compared with other treatments. These results agree with those reported by Rashid *et al*., (2002) who stated that seed priming for 24 h with water significantly increased total biomass, ear weight and grain yield. Thousand grain weight was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 4). Thousand grain weight was maximum (231 g) in $Na_2S_2O_3$ primed seeds while minimum 1000 grain weight of 209 g was observed in unprimed seeds (check). Among cultivars, Sarhad yellow produced maximum 1000 grain weight (239 g) while minimum (205 g) was recorded in Pahari. Interaction between priming sources x varieties indicated that maximum 1000 grain weight (249 g) was noted in Sarhad yellow when primed with water or Sodiumthiosulphate. These results are in line with those reported by Basra *et al*., *(*2003) who recorded heavier grains and greater amount of dry matter for primed seeds.

Table 1. Growing degree days of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	1844	1844	1863	1849	1845	1849 B
Sarhad white	1880	1859	1863	1831	1823	1851 B
Pahari	1832	1808	1815	1795	1800	1810 C
Sarhad yellow	1904	1874	1878	1874	1881	1882 A
Mean	1865 A	1846 BC	1855 AB	1837 C	1837 C	
LSD For Cultuvars at p≤0.01 =			21.336			
LSD For Priming sources at p≤0.01 =			14.903			

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

Table 2. Number of plants at harvest (ha^{-1}) of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	37875	54667	57167	56000	62167	53575 A
Sarhad white	27250	50125	46875	45250	39250	41750 C
Pahari	33375	42875	47375	47125	54125	44975 BC
Sarhad yellow	31667	46750	44833	62167	54125	47908 B
Mean	32542 B	48604 A	49063 A	52635 A	52417 A	
LSD For Cultuvars at p≤0.01 =			5191			
LSD For Priming sources at p≤0.01 =			6112			

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

Table 3. Number of grains cob^{-1} of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	289 K	361 IJ	447 A-C	329 J	370 HI	359 B
Sarhad white	381 F-I	451 AB	453 AB	374 HI	422 B-D	416 A
Pahari	286 K	386 E-I	360 IJ	352 IJ	330 J	343 B
Sarhad yellow	378 GHI	480 A	411 D-G	414 C-F	418 B-E	420 A
Mean	334 C	419 A	418 A	367 B	385 B	
LSD For Cultuvars at p≤0.01 =			21.291			
LSD For Priming sources at p≤0.0 =1			17.899			
LSD For Interaction at p≤0.01 =			35.797			

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

Table 4. Thousand grain weight (g) of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	205 G-J	207 G-J	220 D-F	196 J	209 F-I	207 C
Sarhad white	221 DE	228 CD	249 A	211 E-H	221 DE	225 B
Pahari	198 IJ	202 H-J	214 E-G	203 G-J	210 E-H	205 C
Sarhad yellow	234 BC	245 AB	240 AB	227 CD	249 A	239 A
Mean	214 C	221 B	231 A	209 C	222 B	
LSD For Cultuvars at p≤0.01 =			5.268			
LSD For Priming sources at p≤0.01 =			5.764			
LSD For Interaction at p≤0.01 =			11.529			

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

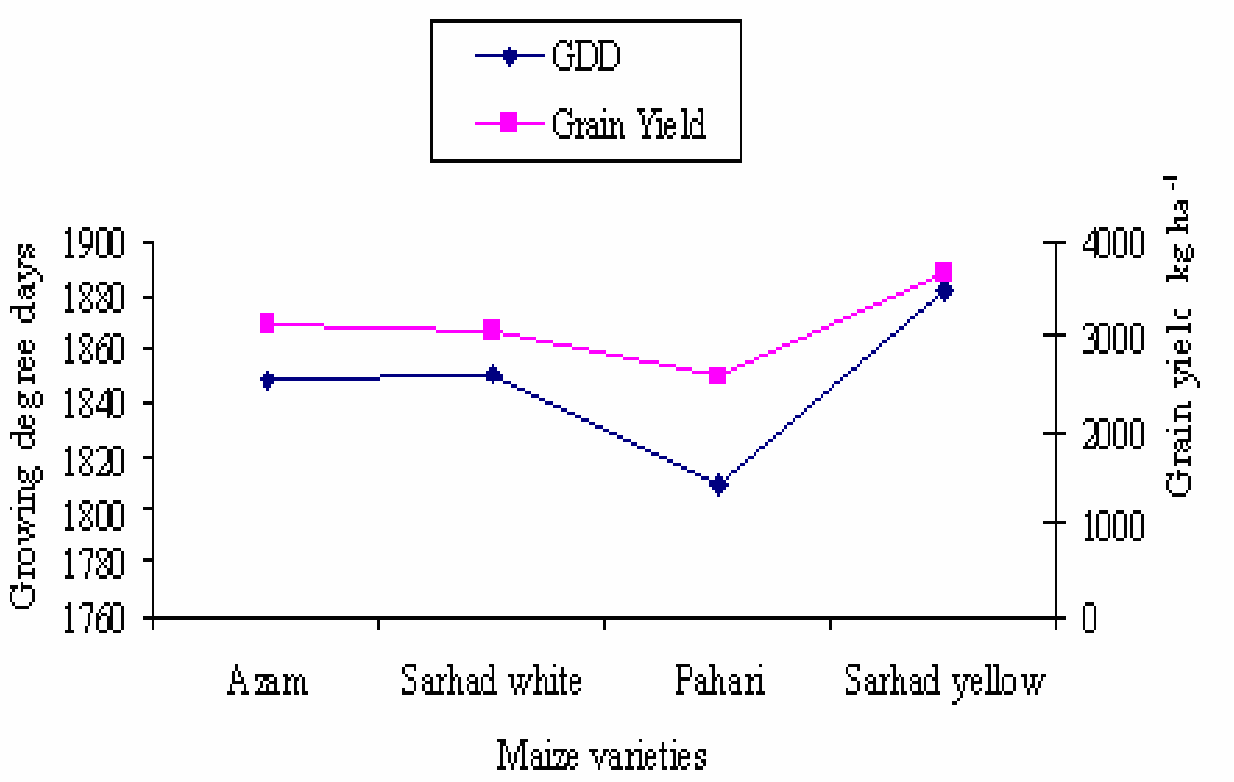

Fig. 1. Correlation between growing degree days and grain yield in maize cultivars.

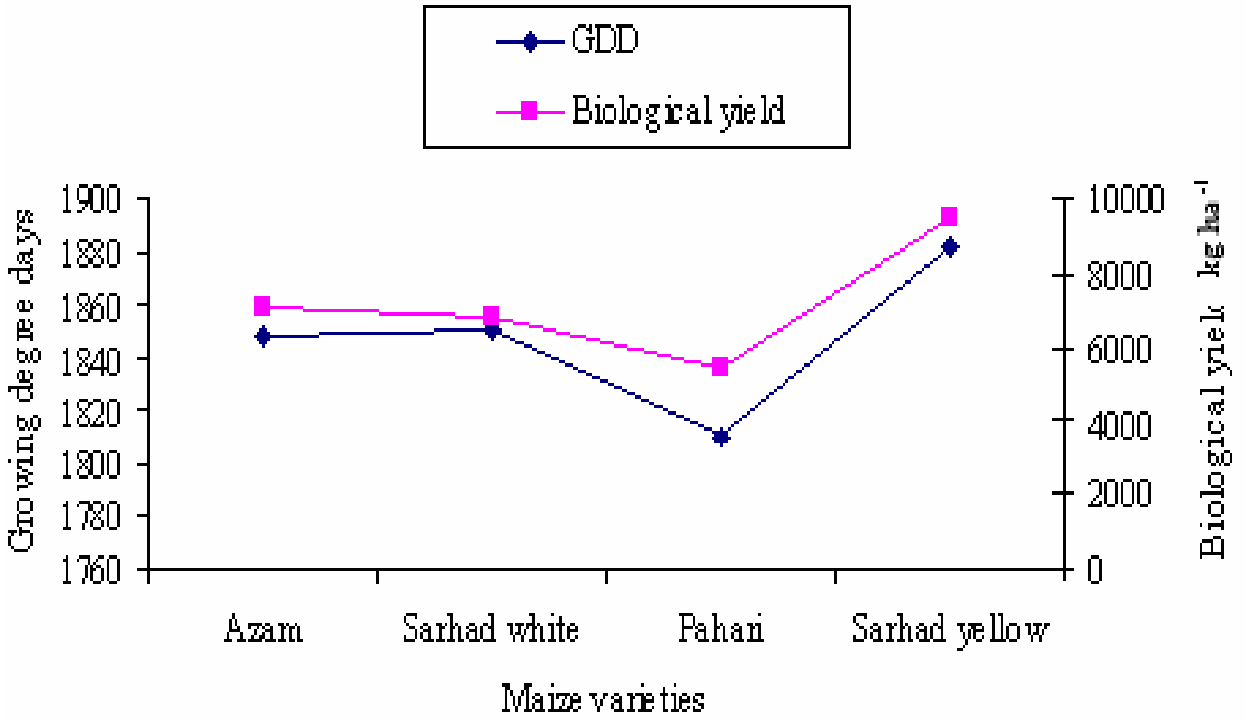

Fig. 2. Correlation between growing degree days and biological yield in maize cultivars.

Grain yield was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 5). Grain yield was maximum (3498 kg ha^{-1}) in Sodium thiosulphate primed treatments while minimum (2727 kg ha^{-1}) was produced by unprimed seeds. Sarhad yellow produced maximum grain yield (3666 kg ha^{-1}) and minimum grain yield (2566 kg ha^{-1}) was recorded from Pahari. In case of interaction, maximum grain yield (4261 kg ha^{-1}) was produced by Sarhad yellow when primed with KNO_3 ande minimum (2136 kg ha^{-1}) was observed in Pahari with out priming (dry seed). Similar results are also reported by Hashmi & Shafiullah (2003) and Rajpar *et al*., (2006). Clark *et al*., (2001) concluded that on an average, primed seeds produced 105 kg ha^{-1} higher yield (14% increases) than unprimed in maize crop. Harris *et al.,* (2001) also demonstrated that maize yields in 35 farmers' trial showed advantages following seed priming. They further stated that yield in primed treatments was more than those where dry seeds were used. 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. Our data also showed that biological yield was significantly ($p \leq 0.01$) affected by different varieties priming sources and interaction between priming sources and varieties (Table 6). Biological yield was maximum (8060 kg ha^{-1}) in KNO_3 primed seeds while minimum (6434 kg ha^{-1}) was recorded in unprimed seeds. Again, Sarhad yellow produced maximum biological yield (9477 kg ha^{-1}) and minimum (5441 kg ha^{-1}) was noted in Pahari. Similarly, maximum biological yield (10591 kg ha^{-1}) was observed in Sarhad yellow when primed with KNO_3 compared with other treatments in case of interaction. These results endorse the findings of Basra *et al*., (2003) and Rashid *et al*., (2002) who reported that primed treatment significantly increased total biomass and dry weight when compared with control. Similar results are also reported by Hashmi & Shafiullah (2003). Harvest index was significantly ($p \leq 0.01$) affected by various priming sources, varieties and their interaction (Table 7). Maximum harvest index (50%) was observed in $Na_2S_2O_3$ primed seeds while minimum were recorded in unprimed seeds

(check). Pahari had maximum harvest index (50%) and minimum (39%) was recorded in Sarhad Yellow. In case of interaction between priming sources and cultivars, our data suggested that maximum harvest index of 60% was observed in Pahari when primed with PEG.

Table 5. Grain yield (kg ha^{-1}) of maize cultivars as affected by various seed priming sources.

Cultivars	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 Cultuvars at p≤0.01 =			139.463			
LSD For Priming sources at p≤0.01 =			53.128			
LSD For Interaction at p≤0.01 =			69.731			

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

Table 6. Biological yield (kg ha^{-1}) of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	6808 G	6977 G	7306 EF	7032 FG	7266 F	7078 B
Sarhad white	6475 H	6826 G	7075 FG	6803 G	7029 FG	6841 B
Pahari	4896 I	7846 D	4821 I	4705 I	4939 I	5441 C
Sarhad yellow	7557 E	10591 A	10409 A	9710 B	9120 C	9477 A
Mean	6434 D	8060 A	7403 B	7062 C	7088 BC	
LSD For Cultuvars at p≤0.01 =			565.371			
LSD For Priming sources at p≤0.01 =			343.579			
LSD For Interaction at p≤0.01 =			282.686			

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

Table 7. Harvest index (%) of maize cultivars as affected by various seed priming sources.

Cultivars	Priming source					
	Dry seeds	KNO_3	$Na_2S_2O_3$	PEG	Water	Mean
Azam	40 EF	47 C	52 B	37 FG	43 DE	44 B
Sarhad white	41 DE	47 C	54 B	38 F	43 DE	44 B
Pahari	44 CD	36 G	58 A	60 A	51 B	50 A
Sarhad yellow	44 CD	40 EF	34 H	35 G	41 D	39 C
Mean	42 B	43 B	50 A	42 B	45 B	
LSD For Cultuvars at p≤0.01 =			6.19			
LSD For Priming sources at p≤0.01 =			3.76			
LSD For Interaction at p≤0.01 =			3.09			

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

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