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SEED PRIMING IMPROVES EMERGENCE AND YIELD OF SOYBEAN

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Abstract

Field experiments were conducted to study the effect of seed priming on emergence and yield of soybean (*Glycine max*) cv. William-82 at NWFP Agricultural University, Peshawar, Pakistan during 2003 and 2004. The seed was primed using 0 (deionized water), -0.2, -0.5, -1.1 and -1.8 MPa Polyethylene glycol (PEG) solutions for 6, 12 and 18 h using dry seed (non primed) as a control. Thereafter, the seed was washed and dried back to its original moisture content at room temperature and sown in the first week of May during both years. The experiment was laid out in randomized complete block (RCB) design having four replications. The plot size was 2m x 3m with 50 cm apart rows and plant to plant distance of 10 cm was used. Seed primed at different osmotic potentials differed significantly for days to emergence, emergence m^{-2} and grain yield. Seed primed at osmotic potential of -1.1 MPa had quicker and improved emergence per unit area and resulted in higher grain yield of soybean. Likewise, seed priming duration of 6 h resulted in faster and improved emergence and higher grain yield of soybean. It is concluded that seed priming hastens and improves emergence and enhances grain yield of soybean.

Introduction

Soybean (*Glycine max* (L.) Merrill) is one of the most important contributors to protein and world’s edible vegetable oils. Despite numerous uses of soybean products, the yield per unit area of the crop is still low in Pakistan. Poor germination and low seed viability are among the serious problems in the production of soybean. The use of high quality seed with appropriate seed rate is essential to establish a suitable plant population in a soybean field for better returns. Vigorous seeds germinate rapidly, uniformly and are able to withstand environmental adversity after sowing (Ajouri *et al.*, 2004; Marwat & Nafziger, 1990).

Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses (Heydecker & Coolbaer, 1977; Bradford, 1986). The beneficial effects of priming have also been demonstrated for many field crops such as wheat, sugar beet, maize, soybean and sunflower (Parera & Cantliffe 1994; Singh, 1995; Sadeghian & Yavari, 2004). However, few detailed studies have been reported on the performance of osmotically treated seed under field condition. Park *et al.*, (1997) reported that priming the aged seed of soybean resulted in good germination and stand establishment. Chiu *et al.*, (2002) observed enhanced germination in sweet corn when primed using polyethylene glycol. Gongping *et al.*, (2000) and Finch-Savage *et al.*, (2004) reported that seed pretreatment with PEG-6000 increased seed germination and vigor index. Likewise, Harris *et al.*, (2001a) reported that the direct benefits of seed priming in all crops included faster emergence, better, more and uniform stands, less need to re-sow, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield. Harris *et al*., (2001b) further reported that maize genotypes responded positively to priming (i.e. in 11 trials) in terms of extra grain produced that varied from 0.3 t ha^{-1} to about 1.4 t ha^{-1} and represented increases ranging from 17-76%. The experiments were carried out to evaluate the beneficial effects of seed priming for emergence and yield of soybean as ultimate goal.

Materials and Methods

Experimental site: Field experiments were conducted at Agricultural Research Farm, NWFP Agricultural University Peshawar, Pakistan during summer 2003 and 2004. The experimental site is located at 34° N, 71.3° E and an altitude of 317 m above sea level. The soil of the experimental field was silty clay loam, low in nitrogen (0.03-0.04%), low in organic matter (0.7-0.9%) and alkaline in reaction (pH 8.0-8.2). Meteorological data of the experimental site for both years are shown in Fig. 1.

Seed treatment: The seed (8% seed moisture) of soybean cultivar William-82 was primed using 0 (de-ionized water), -0.2, -0.5, -1.1 and -1.8 MPa Polyethylene glycol (ave. mol. wt. 8000) solutions at 25^{o}C for 6, 12 and 18 h (Michel & Kaufmann, 1973). Dry seed was used as control. The osmotic potentials of PEG 8000 solutions were determined according to Michel (1983). Thereafter, the seed was washed with tap water (Lee & Kim 1999). The treated seed was dried back to its original moisture content at room temperature.

Field experiments: The treated seed was sown in the field on 3rd May, 2003 and 5th May, 2004. The control treatment was dry seed (non primed). The experiment was laid out in randomized complete block (RCB) design and four replications. The plot size of 2x3 m^{2} with row to row distance of 50 cm and plant to plant distance of 10 cm was used. One hundred twenty seed were planted in each plot. Two manual hoeing were done for the control of weeds. Plots were watered when needed. A basic fertilizer dose of 30:90 kg NP ha^{-1} in the form of urea and triple super phosphate was applied before sowing. The experiments were harvested in the second week of September during both years. All standard agronomic practices were adopted for all plots uniformly.

Data were recorded on days to 50% emergence, emergence m^{-2} and grain yield of soybean. Data on days to 50% emergence were calculated from the date of sowing and date of 50% emergence by counting seedling emergence in each plot daily. Emergence m^{-2} data was recorded by counting number of plants emerged in one meter row length at three randomly selected rows in each plot. The data were then converted to emergence m^{-2}. For grain yield data, the crop bundles were threshed separately; the grains were thoroughly cleaned and weighed with an electronic balance to record grain yield. The data were then converted to grain yield ha^{-1}.

Statistical analysis: The data were statistically analyzed using analysis (ANOVA) procedure for combined analysis. Means were separated using LSD test at 0.05 level of probability (Steel & Torrie, 1984).

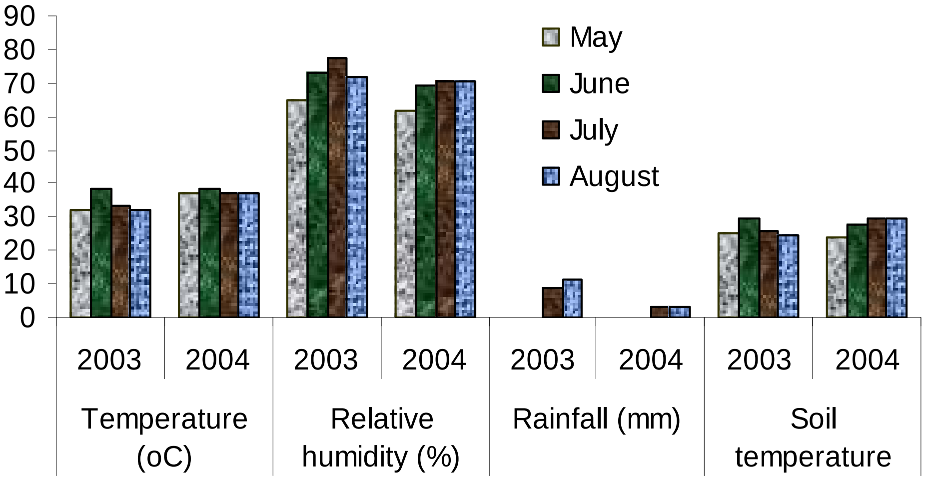

Fig. 1. Average monthly temperature (^oC), relative humidity (%), rainfall (mm) and soil temperature (^oC) of the experimental site during 2003 and 2004.

Results and Discussion

Days to 50% emergence: The difference between primed and non primed seed for days to 50% emergence was significant. The non primed seed took significantly more days to emerge as compared with primed seed (Fig. 2 a). Days to emergence decreased with decrease in osmotic potential (OP) from -0.2 MPa to -1.1 MPa and thereafter increased with further decrease in osmotic potential. Plants emergence was faster at osmotic potential -1.1 MPa, however, seed treated with osmotic potential of 0 (water) and -1.8 MPa took fewer days to emerge than seed treated with -0.2 MPa and -0.5 MPa. Plants emergence delayed with increase in duration of seed priming (D). Faster emergence was observed for 6 h primed seed and further increase in D delayed emergence (Table 2). The interaction between the two factors (OP x D) for days to 50% emergence was not significant (Table 1). Year as a source of variation had significant effect on days to 50% emergence. Plant emergence was comparatively delayed in year 1 (Fig. 2 b).

The probable reason for early emergence of the primed seed may be due to the completion of pre-germinative metabolic activities making the seed ready for radicle protrusion and the primed seed germinated soon after planting compared with untreated dry seed (Heydecker & Coolbear, 1978). Emergence enhancement in PEG primed seed may be attributed to metabolic repair processes, a build up of germination metabolites or osmotic adjustments during priming treatment (Bray *et al.*, 1989). These findings agree with Brocklehurst *et al.*, (1987) who reported faster emergence of primed seed. Similarly Harris & Jones (1997) showed 50% reduced germination time of rice cultivars from West Africa after water priming for 12-24 h. In agreement with these findings, several other reports showed improved and early seedling emergence in sorghum, millet, cotton, beans and maize as a result of water priming (Harris, 1996; Harris *et al.*, 1999; Murungu *et al.*, 2004).

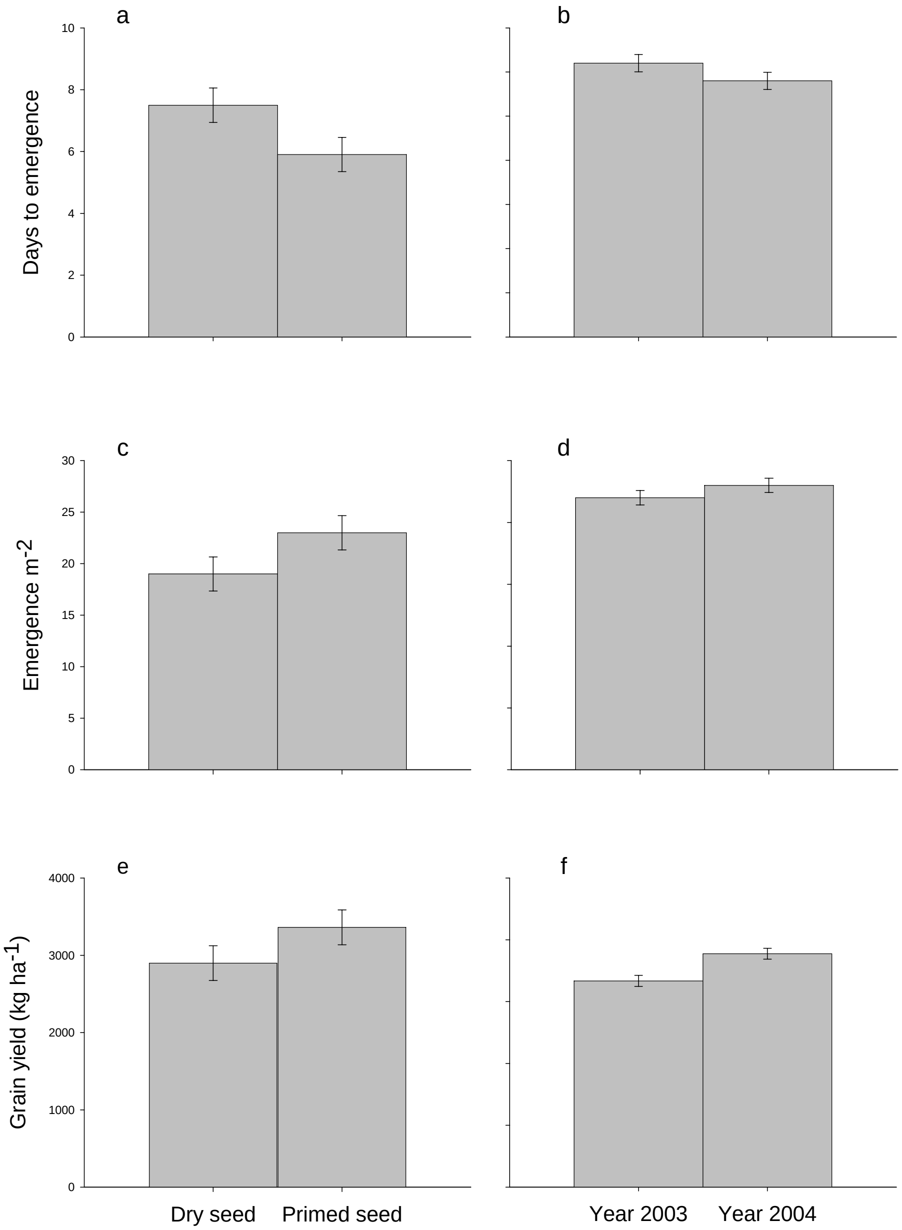

Fig. 2. Effect of seed priming on days to 50% emergence (a) during 2003 and 2004 (b), emergence m^{-2} (c) during 2003 and 2004 (d), grain yield (e) during 2003 and 2004 (f).

Table 1. Mean squares values for days to emergence, emergence m^{-2} and grain yield of soybean.

Source of variance	df	Days to 50% emergence	Emergence m^{-2}	Grain yield
		Mean squares		
Year (Y)	1	3.38 **	15.96	4047348.15 **
Replication (Y)	4	0.63	4.34	382485.27
Treatments	15	4.71	30.57 **	683819.70 **
Cont vs Primed seed	(1)	14.40 **	73.20 **	1205516.98 **
Duration (D)	(2)	9.38	9.38	9.38
Osmotic potential (O)	(4)	42.04 **	42.04 **	42.04 **
D x O	(8)	12.84	12.84	12.84
(Cont. vs Rest) x Y	1	0.63	14.19	1212974.10 **
Y x D	2	22.04	22.04	22.04
Y x O	4	11.32	11.32	11.32
Y x D x O	8	6.45	6.45	6.45
Error	60	0.93	8.24	186204.27

** Significant at 1% level of probability

Table 2. Two years means for days to 50% emergence of soybean as affected by seed priming.

Seed priming duration (h)	Osmotic potential (MPa)					Mean
	0	-0.2	-0.5	-1.1	-1.8	
06	5.8	5.2	6.3	4.5	5.5	5.5 b
12	5.7	7.0	6.0	4.8	5.7	5.8 b
18	6.3	7.7	6.5	5.3	6.2	6.4 a
Mean	5.9 b	6.6 a	6.3 ab	4.9 c	5.8 b	

Means of the same category followed by the different letters are significantly different from one another using LSD test ($p \leq 0.05$).

LSD for Osmotic potential = 0.6820
LSD for Seed priming duration = 0.4981

Emergence m^{-2}: The difference between primed and non primed seed for emergence m^{-2} was significant. More plants emerged in primed seed plots as compared with non primed seed plots (Fig. 2 c). Emergence m^{-2} increased with decrease in osmotic potentials from 0 to -1.1 MPa but further decrease in osmotic potential adversely affected plant emergence. Highest emergence m^{-2} was recorded for seed treated with osmotic potential of -1.1 MPa followed by -0.5 MPa. Similar emergence m^{-2} was recorded for seed treated with osmotic potential of 0 and -0.2 MPa. Emergence m^{-2} decreased with increase in priming duration. The shortest priming duration of 6 h proved superior in terms of emergence per unit area. Prolonging priming duration decreased emergence (Table 3). The interaction between the two factors for emergence m^{-2} was not significant (Table 1). No significant variation amongst the years was found for emergence m^{-2} (Fig. 2 d). These results confirm the findings of Basra *et al*., (2003), Salinas (1996), Chimmad *et al*., (1987) and Xiang *et al*., (1995) who reported highest germination, improved emergence and good stand establishment in the field trials of PEG primed seed. Likewise Arif *et al*., (2003); Sung & Chang (1993) & Arif *et al*., (2005) reported improved and early germination as well as enhanced emergence in hydro primed seed.

Table 3. Two years means for emergence m^{-2} of soybean as affected by seed priming.

Seed priming duration (h)	Osmotic potential (MPa)					Mean
	0	-0.2	-0.5	-1.1	-1.8	
06	22	22	25	29	22	24 a
12	21	21	23	25	23	23 a
18	21	20	21	22	22	21 b
Mean	21 b	21 b	23 ab	25 a	22 b	

Means of the same category followed by the different letters are significantly different from one another using LSD test ($p \leq 0.05$).

LSD for Osmotic potential = 2.030
LSD for Seed priming duration = 1.483

Table 4. Two years means for grain yield of soybean as affected by seed priming.

Seed priming duration (h)	Osmotic potential (MPa)					Mean
	0	-0.2	-0.5	-1.1	-1.8	
06	3237	3736	3804	3777	3438	3598 a
12	3174	3305	3608	3655	3151	3379 a
18	2604	3297	3161	3461	3011	3107 b
Mean	3005 c	3446 ab	3524 a	3631 a	3201 bc	

Means of the same category followed by the different letters are significantly different from one another using LSD test ($p \leq 0.05$).

LSD for Osmotic potential = 305.2
LSD for Seed priming duration = 222.9

The observed improvements in emergence of primed seed may be attributed to priming that induces quantitative changes in biochemical content of the seed and improves membrane integrity and enhances physiological activities at seed germination (Sung & Chang, 1993). The improvement in emergence of primed seed may be due to the fact that priming induces a range of biochemical changes in the seed that are required to initiate the germination process i.e., breaking of dormancy, hydrolysis or metabolism of inhibitors, imbibition and enzymes activation (Ajouri *et al*., 2004). Likewise Asgedom & Becker (2001) reported that some or all processes that precede the germination are triggered by priming and persist following the re-desiccation of the seed. Thus upon sowing, primed seed can rapidly imbibe and revive the seed metabolism, resulting in a higher germination rate and a reduction in the inherent physiological heterogeneity in germination (Rowse, 1995).

Grain yield: The difference between primed and non primed seed plots for grain yield was significant. Yield obtained from the primed seed plots was significantly higher than non primed seed plots (Fig. 2 e). Grain yield of primed seed plots enhanced with decrease in osmotic potential from 0 to -1.1 MPa but declined with further decrease in osmotic potential. The seed treated with osmotic potential of -1.1 MPa produced highest grain yield followed by seed treated with -0.5 MPa. Seed treated with osmotic potential of 0 MPa (water) produced lower grain yield. Grain yield decreased with extending seed priming durations. The seed primed for 6 h produced highest grain yield as compared with seed primed for 12 h and 18 h (Table 4). The interaction between the two factors for grain yield was not significant (Table 1). Year as a source of variation had significant effect on grain yield. More grain yield was recorded in year 2 as compared with year 1 (Fig. 2 f).

The improved yield of primed seed plots may be due to early and improved emergence in the priming treatments that ultimately resulted in the higher yield. Similar arguments were made by Sharma *et al*., (1993) who attributed higher yield to early floral initiation, more flowers and pods plant^{-1} in salicylic acid primed seed. The resulting improved stand establishment due to priming can reportedly increase drought tolerance, reduce pest damage and increase crop yield (Harris *et al*., 1999; Mussa *et al*., 1999; Harris *et al*., 2000). The increase in yield of primed seed plots may be due to the fact that primed seed emerge faster and more uniformly and seedlings grow more vigorously, leading to a wide range of phenological and yield related benefits (Harris *et al*., 2000). Harris *et al*., (1999) further reported that primed crops produced higher yields than non primed crops. These results are also in conformity with Rao & Singh, (1997) and Basra *et al*., (2003) who reported that seed priming increase grain yield. However, the results are not in line with Ghana & William, (2003) who found no significant impact of priming media on the grain yield of wheat cultivars. Similarly, Subedi & Ma, (2005) reported that none of the seed-priming treatments showed beneficial effects on grain yield of corn some positive effects of seed priming on seedling vigor and stand establishment.

It has been concluded from this study that priming of soybean seed in PEG 8000 for 6 h improved emergence and grain yield. However, keeping in view the least understood phenomenon of metabolic activities occurring in seed suggests that further studies are required in this area.

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