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SEED PRIMING AND PHOSPHORUS APPLICATION ENHANCE PHENOLOGY AND DRY MATTER PRODUCTION OF WHEAT

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Abstract

Phenology and dry matter are important traits being affected by seed priming and soil phosphorus (P_2O_5) application. Wheat variety Saleem-2000 was primed in 0.1, 0.2 and 0.3% P_2O_5 solutions and water for 10 hours. Unprimed treatment was included as control. Four levels of P_2O_5 (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) were applied to soil. Priming enhanced days to emergence, anthesis and increased dry matter (DM) production compared with non primed (control). Seed primed with 0.3% P_2O_5 solution took less time to anthesis (110 days). DM yield increased with each increment of priming and maximum DM yield (6051 kg ha^{-1}) was obtained from seeds primed in 0.2% P_2O_5 solution. Priming had non significant effect on spike length, spike m^{-2} and days to maturity. Water primed seed took less time to emergence (16 days). Soil P_2O_5 application enhanced days to heading, anthesis, maturity and increased DM yield, while days to emergence, spike m^{-2} and spike length were not affected. Earlier heading, anthesis, maturity and highest DM yield was recorded at 75 kg P_2O_5 ha^{-1}. Priming with 0.2% P_2O_5 solution and 50 kg P_2O_5 ha^{-1} soil application are the best for obtaining maximum DM and enhancement of phenology.

Introduction

Pre-sowing seed treatments seems to be a promising technique to raise successful crop in arid and semi-arid tropics. It has been claimed that pre-sowing treatment of the seed stimulates germination and subsequent seedling growth under the normal as well saline soil conditions (Idris & Aslam, 1975). Priming is recommended practice in many states of India, but was not widely adopted. The farmers have used primed seed in the past to fill gapes (Harris *et al*., 1999). In recent years, the use of priming has grown following participatory methods in Pakistan, India, and Bangladesh (Harris *et al*., 2001).

Seed priming enhances speed and uniformity of germination (Khalil *et al*., 2010; Khan *et al*., 2008; Heydecker *et al*., 1975), and induces several biochemical changes in the seed that are required to start the germination process such as breaking of dormancy, hydrolysis or mobilization of inhibitors, imbibitions and enzyme activation. Some or all of these processes that precede the germination are trigged by priming and persist following the re-desiccation of the seeds (Asgedom & Becker, 2001). Thus upon seeding, 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). The resulting improved stand established can reportedly increase the drought tolerance, reduce pest damage and increase crop yield in cereals and legumes (Harris *et al*., 1999; Mussa *et al*., 1999; Harris *et al*., 2000; Khan *et al*., 2005). Nutrient priming has been proposed as a novel technique that combines the positive effects of seed priming with an improved nutrient supply (Al Mudaris & Jutzi, 1999).

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Among the major nutrients required by the crop plant, phosphorus is an essential nutrient, both as a part of several important plant structural compounds as well as in the catalysis of numerous fundamental biochemical reactions of plant. Phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds and is needed for the development and production of a normal plant (Chhabra, 1985; Rashid *et al*., 1992; Sharma & Gupta, 1994; Ryan, 1997). The present experiment was therefore designed to evaluate the effect of seed priming and P_2O_5 application on phenology, leaf area and dry matter yield of wheat.

Materials and Methods

To study effect of seed priming and phosphorus application on phenology and dry matter yield of wheat, an experiment was conducted at New Developmental Farm, NWFP Agricultural University, Peshawar, during 2005-06. The experiment was laid out in randomized complete block design with split plot arrangements having four replications. A sub plot size of 15 m^2 consisting of 10 rows, 5 meter long and 0.3 m apart was used. Single super phosphate was used as a source of phosphorous containing 18% P_2O_5. Wheat was sown in 0.30 m apart rows in N-S direction, using seed rate of 100 kg ha^{-1} with a basal dose of 135 kg N ha^{-1}. Uniform cultural practices were used for all the experimental units. Irrigation was applied whenever required. Five priming treatments (0.1% P = 4.38g, 0.2% P = 8.77, 0.3% P = 13.16 g KH_2PO_4 L^{-1} H_2O, water soaking, and no priming = control) and four levels of soil applied phosphorus (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) were used. Soil phosphorous levels were applied to main plot while priming treatments were maintained in sub-plots. Wheat variety Saleem-2000 was soaked in water and phosphorus solution having concentrations of 0.1, 0.2 and 0.3% for 10 hours. Data on days to emergence, days to heading, days to anthesis, days to maturity, spikes m^{-2}, spike length, and dry matter (DM) yield were recorded using the following procedure:

Phenology: Days to emergence, days to heading, days to anthesis and days to maturity data were recorded by counting number of days from sowing till 80% of the plants in each sub plot emerged, produced heads, anthesis and maturity respectively.

Spikes m^{-2}: Numbers of spikes were counted in two central rows in each plot and converted to spikes m^{-2} using the following formula:

$$\text{Spikes m}^{-2} = \frac{\text{Number of spikes counted}}{\text{R-R distance (m) x row length (m) x No. of rows}} \text{ X 1}$$

Spike length: Five spikes were randomly selected in each plot and length was measured in cm from the edge of peduncle where the spike is attached to the terminal portion of the stem.

Dry matter yield: For dry matter (DM) yield four central rows five meter long from each sub plot were harvested, tied into bundles and sun-dried. After drying, bundles were weighted with a balance to record DM yield. DM yield was converted to kg ha^{-1} using following formula:

$$\text{DM yield (kg ha}^{-1}) = \frac{\text{DM yield plot}^{-1}}{\text{R-R distance (m) x row length (m) x No. of rows}} \text{ x 10,000}$$

Data were analyzed according to RCB design with split plot arrangement. LSD test was applied upon obtaining significant F value for comparison among the means of different treatments (Steel & Torrie, 1980).

Results and Discussion

Days to emergence: Statistical analysis of the data revealed that seed priming (SP) significantly affected days to emergence while soil applied phosphorous (P) and interaction between the two variables was non significant (Table 1). Seed primed in water took minimum days to emergence (16 days) followed by seeds primed in 0.1% phosphorus solution which took 17 days to emergence. Control (dry seed) took maximum days to emergence (23). The early emergence of the water primed seeds may be due to completion of pre-germinative metabolic activities during priming process, making the seed ready for radical protrusion and the seeds germinated soon after planting compared with unprimed dry seeds. These findings are in line with Bray *et al*., (1989) and Arif *et al*., (2005) who reported that seed priming enhanced germination which may be attributed to repair processes, a buildup of germination metabolites or osmotic adjustments during priming treatment.

Days to heading: Seed priming (SP), phosphorus rates (P), and their interaction significantly affected days to heading (Table 2). Minimum days to heading (99) were taken by the seeds primed in 0.2% phosphorus while control and water primed seed took more days to heading. These results agree with Tahir *et al*., (1968) who reported enhancement in days to heading due to phosphorus. Each increment of soil applied phosphorus enhanced days to heading and minimum days to heading (98) were taken by application of 75 kg P_2O_5 ha^{-1}. Interaction of SPx P revealed that maximum days to heading were taken by control or water primed receiving no P_2O_5, while minimum days to heading were taken by seed primed with 0.2% phosphorous receiving 75 kg P_2O_5 ha^{-1}.

Days to anthesis: Seed priming and P significantly affected days to anthesis, while SP x P interaction showed non significant (Table 3). Maximum days to anthesis (113) were recorded from control. Phosphorus application enhanced days to anthesis and minimum days to anthesis (110) were recorded for plots receiving 75 kg P_2 O_5 ha^{-1}. These results agree with Tahir *et al*., (1968) who reported that optimum amount of phosphorous minimized days of plant growth. Seed priming with phosphorus revealed that maximum days to anthesis (113 days) were recorded from control plots. Days to anthesis enhanced with priming and minimum days to anthesis (110 days) were recorded from seeds primed in 0.3% phosphorous. These findings are in line with Mauromicale *et al*., (2000) who reported that seeds primed in salts exhibited advances of 2.5 to 7.5 days in anthesis.

Days to maturity: P significantly affected days to maturity while seed SP and interaction between the two variables had non-significant effect on days to maturity (Table 4). Maximum days to maturity (148) were recorded for control. P enhanced days to maturity and minimum days to maturity (144 days) were recorded from 75 kg P_2O_5 ha^{-1}. These results agree with Khan (1985) and Gill & Sindhu (1983) who reported enhanced maturity with higher amount of phosphorus.

Table 1. Days to emergence of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	22	15	17	18	20	18
25	23	16	17	18	20	19
50	23	17	17	19	19	19
75	22	16	18	18	20	19
Mean	23 a*	16 e	17 d	18 c	20 b	

LSD value at $p \leq 0.05$ for phosphorous concentrations = 0.9326

Table 2. Days to heading of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	103 ab	104 a	102 bcd	103 b	102 bc	103 a*
25	101 de	102 cd	100 fgh	99 ij	101 ef	100 ab
50	99 ij	98 jk	99 hi	99 i	97 lm	98 b
75	99 ghi	97 jl	98 gk	96 m	100 fg	98 b
Mean	100 a	100 a	100 a	99 b	100 a	

LSD value at $p \leq 0.05$ for phosphorous concentrations = 0.9336
LSD value at $p \leq 0.05$ for phosphorous levels = 2.579
LSD value at $p \leq 0.05$ for interaction = 0.8351
*Means of same category following by different letters are significantly different at $p \leq 0.05$ using LSD test.

Table 3. Days to anthesis of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	114	113	113	133	111	113 a*
25	113	114	112	112	109	112 ab
50	113	111	110	111	108	111 b
75	111	109	110	109	112	110 b
Mean	113 a	112 a	111 ab	111 ab	110 b	

LSD value at $p \leq 0.05$ for phosphorous concentrations = 1.626
LSD value at $p \leq 0.05$ for phosphorous levels = 1.798

Table 4. Days to maturity of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	149	147	149	147	147	148 a*
25	146	146	146	144	145	145 b
50	145	145	143	144	143	144 b
75	145	144	144	143	143	144 b
Mean	146	145	145	144	144	

LSD value at $p \leq 0.05$ for phosphorous levels = 2.834
*Means of same category following by different letters are significantly different at $p \leq 0.05$ using LSD test.

Table 5. Spikes m^{-2} of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	171	155.25	198	173.25	169.5	173.4
25	200.75	189.75	222	193.25	231.5	207.45
50	212.5	234.5	263.25	191.75	220.75	224.55
75	187	238.75	196.5	202.5	200.5	203.15
Mean	190.56	204.43	219.93	190.18	205.5	

LSD value at $p \leq 0.05$ for phosphorous levels = 2.834
*Means of same category following by different letters are significantly different at $p \leq 0.05$ using LSD test.

Spikes m^{-2}: Analysis of the data revealed that P, SP and interaction between the two variables had non-significant effect on spikes m^{-2} (Table 5). However, maximum spikes m^{-2} (224) were recorded from 50 kg P_2O_5 ha^{-1}, while minimum spikes m^{-2} (173) were recorded from control. Increase in number of spikes m^{-2} was also reported by Sharma & Gupta (1994). Mean values of seed priming indicated that maximum spikes m^{-2} (220) were recorded from 0.1% P_2O_5, while minimum spikes m^{-2} (190) were produced by control.

Spike length: P, SP and Px SP interaction showed non significant effect on spike length (Table 6). However, longest spikes (10cm) were recorded from 0.1% phosphorous. Spike length slightly increased from control to 50 Kg P_2O_5, thereafter further increase in phosphorus slightly decreased spike length. These findings are in line with Qasim *et al*., (1994).

Table 6. Spike length (cm) of wheat as affected by seed priming with phosphorous concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	9.3	9.5	9.8	9.4	9.57	9.51
25	9.5	9.75	10.2	9.9	9.7	9.81
50	9.85	9.9	10.1	9.95	9.9	9.94
75	9.52	9.7	9.95	10	9.72	9.78
Mean	9.54	9.79	10.01	9.81	9.72	

Table 7. Dry matter yield (kg ha^{-1}) of wheat as affected by seed priming with phosphorus concentrations and application rates.

Phosphorous levels (kg ha^{-1})	Seed priming (% P)					Mean
	Unprimed (control)	water	0.1	0.2	0.3	
0	3752	4601	4516	5391	5043	4660 b*
25	4706	5966	5664	5893	5914	5616 a
50	4175	5851	5726	6760	6333	5818 a
75	5048	5664	6035	6184	5905	5767 a
Mean	4420 b	5505 a	5485 a	6043 a	5874 a	

LSD value at $p \leq 0.05$ for phosphorous concentrations = 714.1

LSD value at $p \leq 0.05$ for phosphorous levels = 646.3

*Means of same category following by different letters are significantly different at $p \leq 0.05$ using LSD test.

Dry matter: Dry matter (DM) yield was significantly affected by P and SP, however, interaction of the two variables showed non-significant on DM yield (Table 7). Control produced minimum DM yield (4420 kg ha^{-1}). DM increased with priming and maximum DM yield (6043 kg ha^{-1}) was obtained from seeds primed in 0.2% phosphorus. Thereafter priming did not increase DM yield. The increase in DM yield due to priming might be due to better early seedling growth and plant nutrition (Zhang *et al*., 1993; Chhipa *et al*., 1993 & Basra *et al*., 2003). Among P, lowest DM yield (4460 kg ha^{-1}) was obtained from control. DM yield increased with each increment of P and maximum DM yield (5818 kg ha^{-1}) was obtained from 50 kg P_2O_5 ha^{-1}. Thereafter P did not increase DM yield. The increase in DM yield may be due to better seedling growth and more emergence m^{-2} compared with control (Sami *et al*., 1976; Sharma & Gupta, 1994; Ryan, 1997; Azimzadeh & Koocheki, 1999). It can be concluded that 50 kg P_2O_5 ha^{-1} and seed priming with 0.2% phosphorus solution is the best for obtaining maximum DM yield and enhancement of phenology under Peshawar conditions.

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