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EFFECT OF OSMOPRIMING SOURCES AND MOISTURE STRESS ON WHEAT

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Abstract

Wheat yield in Pakistan is very low due to poor germination and poor stand establishment and optimum amount of water availability at critical growth stages. To cope with these problems experiments were planned including control and nine osmopriming sources per liter of water that is PEG (100 g), KCl (37.25 g), KNO_3 (101 g), NaCl (58.5 g), NH_4Cl (53.5 g), $CaCl_2$ (55.5 g), Mannitol (20 g), Na_2SO_4 (71 g) and hydropriming. In the filed these were studied at three moisture stresses of 60, 70 and 80% MAD (management allowable depletion). The experiments were repeated during 2008 and 2009 and were laid out in randomized complete block design with split plot arrangement replicated three times. Moisture stress was allotted to main plots and osmopriming sources to sub plots. Best combinations of moisture stress (M) and osmopriming sources (OPS) significantly affected phenological and grain yield components of wheat. Increased moisture stress showed decreased phenological life of the wheat. Hence lowest days to maturity (157.1) were noted for 80% MAD. The optimum MAD (70%) contributed to maximum grain yield (3348.6 kg ha^{-1}). Wheat showed variation in response to osmopriming sources. Minimum days to emergence (8.1) were noted for PEG. While KNO_3 osmoprimed seeds took lowest days to maturity (155.4). Highest emergence m^{-2} (82), thousand grains weight (39.97 g), and grain yield (3481 kg ha^{-1}) were recorded for PEG (100 g L^{-1} of water). Likewise KNO_3 (101 g L^{-1} of water) osmoprimed seeds attained highest number of grains $spike^{-1}$ (51.0). From this study it was concluded that wheat seeds may be osmoprimed with PEG, Na_2SO_4, KNO_3, $CaCl_2$ and water along with the application of 70% MAD irrigation at critical growth stages for gaining high yield. However, due to the high prices of PEG and other osmopriming sources in the market hydropriming is recommended for gaining high net benefit and income.

Introduction

Wheat yield per hectare in Pakistan is far below as compared to most countries where the yield per hectare is three times more and almost double in China (Anon., 2009). The causes could be low germination and stand establishment. In Khyber Pakhtunkhwa more than 60% of the wheat is cultivated on rainfed land. Drought stress reduces yield of grain crops (Hugh *et al*., 2003; Khan & Khan, 2010). Seeds osmopriming improves percentage and time to germination and it is more successful in wheat (Ghazi, 1998; Khakwani *et al*., 2011). Ahmad *et al*., (1998) reported that priming benefits wheat germination under mild drought stress.

Priming permits early DNA replication (Bray *et al*., 1989), faster embryo growth (Dahal *et al*., 1990), and repair of deteriorated seed parts (Saha *et al*., 1990), compared with checks. In recent studies salinity tolerance also reportedly to be improved using priming techniques. According to Jamal *et al*., (2011), priming of six wheat varieties (Tatara-96, Ghaznavi-98, Fakhri Sarhad, Bakhtawar-92, Pirsabaq-2004 and Auqab-2000) under salinity enhanced shoot, K content and shoot K /Na ratio. Hamid *et al*., (2008) also reported that cv. Inqlab and S-24 when soaked in water sustained salinity. Therefore, the present experiments were planned to investigate different osmopriming sources at various moisture statuses at critical growth stages for yield components of wheat.

Materials and Methods

Two field experiments "Effect of osmopriming sources and moisture stress on wheat" were designed during 2008 and 2009 at Khyber Pakhtunkhwa Agricultural University, Peshawar. A net sub-plot of 5.4 m^2 replicated three times was used. Soil moisture stress and osmopriming sources were allocated to main and sub-plots respectively. The three moisture stresses studied were 60, 70 and 80% MAD (management or maximum allowable depletion) against control and nine osmopriming sources per liter of water that is PEG (100 g), KCl (37.25 g), KNO_3 (101 g), NaCl (58.5 g), NH_4Cl (53.5 g), $CaCl_2$ (55.5 g), Mannitol (20 g), Na_2SO_4 (71 g) and hydropriming. Each moisture stress was maintained at tillering (jointing), heading and milky stages of wheat through irrigation from water channels made for this purpose. Desired MAD was calculated from the ratio of readily available water (RAW) to the available water (AW). The soil was silty clay loam with 38% field capacity (FC) and 21% permanent wilting point (PWP). The difference of FC and PWP is available water (AW). The effective root zone depth at tillering, heading and milky stages was taken as 30, 70 and 90 cm respectively. The time required for application of the required amount of water was calculated from the area (A) x depth (D) divided by water discharge (Q). Random soil samples were collected before and after the irrigations and soil mass wetness measured as given below:

$$\text{Mass wetness} = w = \frac{(\text{wet weight}) - (\text{dry weight})}{(\text{dry weight})} \times 100$$

Data were obtained on phenological and yield parameters of wheat. Days after sowing were counted for days to emergence and maturity. Seedling counted at three different spots of one meter long in each plot and emergence m^{-2} was calculated by using formula. Ten spikes were randomly selected from each plot for recording grains $spike^{-1}$ and thousand grains weight. For grain yield was calculated by the following formula:

$$\text{Grain yield (kg ha}^{-1}) = \text{Grain yield/sampled area x 10000 m}^{-2}$$

Results and Discussions

Days to emergence: Analysis of the variance showed years (Y), osmopriming sources (OPS), interactions of YxOPS and moisture stress (M) x OPS significantly affected days to emergence (Table 1). Lowest days (9.6) to emergence were noted during 2008 experiment. The main objective of the seed priming is to motivate rapid and uniform emergence. Shortest days (8.1) to emergence were observed for seeds primed in PEG, followed by 8.5 and 8.7 days to emergence noted for hydropriming and KNO_3 respectively. Basra *et al*., (2003) also achieved early emergence of wheat seeds primed with distilled water and saturated gunny bags. Interaction of OPS showed that minimum 7.7 days to emergence taken by seeds primed with PEG and Na_2SO_4 respectively during 2008. Regarding interaction of MxOPS, minimum 7.3 days to emergence recorded for 80% MAD, followed by 8.1 and 8.3 noted for KNO_3 and KCl respectively at 60% MAD.

Table 1. Days to emergence of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean
	60	70	80	
PEG 8000	9.00 g-i	8.00 ij	7.33 j	8.11 e
KCl	8.33 h-j	10.17 d-f	10.17 d-f	9.56 c
KNO_3	8.17 ij	9.33 f-h	8.67 hi	8.72 de
NaCl	11.50 bc	10.33 d-f	11.17 cd	11.0 b
NH_4Cl	10.50 c-e	11.00 cd	10.83 c-e	10.78 b
$CaCl_2$	10.83 c-e	10.67 c-e	10.33 d-f	10.61 b
Mannitol	9.83 e-g	9.83 e-g	10.17 d-f	9.94 c
Na_2SO_4	8.83 g-i	9.00 g-i	8.67 hi	8.83 d
Hydropriming	8.50 hi	8.17 ij	9.00 g-i	8.56 de
Control	13.17 a	12.50 ab	12.83 a	12.83 a
Years				
2008	9.57	9.77	9.73	9.69
2009	10.17	10.03	10.1	10.1
Mean	9.87	9.90	9.92	

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	NS	NS	0.63	0.87	1.09	NS

NS = Not significant

Days to maturity: Table 2 presents data for days to maturity of wheat. Analysis of variance showed that years (Y), moisture stress (M) and osmopriming sources (OPS) significantly affected days to maturity. Between years shortest days to maturity (154.6 days) were recorded during 2008 experiment. Available soil moisture content may influence plant life cycle and hence minimum days to maturity (157.1) recorded for 80% MAD. Kilic & Yağbasanlar (2010) found positive correlation for days to maturity of 14 durum wheat cultivars and moisture stress and concluded that drought stress minimized number of days to maturity. Osmopriming sources showed significant lowest days to maturity. Among osmopriming sources reduced number of 155.4, 155.7, 155.9 and 158.1 days to maturity noted for KNO_3, PEG, Na_2SO_4, and hydropriming respectively. These results are in agreement with Murungu & Madanzi (2010) who indicated minimum days to anthesis and maturity for primed wheat seeds. Harris *et al*., (2001) supported these findings who revealed that wheat seed soaked in tap water overnight results in earlier emergence, deeper roots and earlier maturity.

Emergence m^{-2}: Data obtained for emergence m^{-2} revealed years (Y), osmopriming sources (OPS), and interaction of YxM had significant effect on emergence (Table 3). Variations in weather and soil conditions across consecutive years may affect emergence. Maximum emergence m^{-2} (77.8) was observed for the 2009 experiment. Among osmopriming sources PEG primed seeds resulted highest emergence (82 plant m^{-2}), followed by 78.9, 78.2 and 78.1 plants m^{-2} for KNO_3, hydropriming and Na_2SO_4 respectively. These results are in coincidence with findings of Farooq *et al*., (2008) who achieved improved emergence from wheat seeds primed in water, KCl and $CaCl_2$. Similarly Basra *et al*., (2003) also obtained improved wheat emergence through priming seeds with distilled water and saturated gunny bags. Interaction of YxM revealed that moisture content of the soil across years might affect wheat emergence. Therefore, maximum emergence m^{-2} (79.2) was noted during 2009 experiment at 80% MAD, while at the same moisture stress minimum emergence m^{-2} (68.0) was recorded during 2008.

Grains spike^{-1}: Analysis of variance of the data showed that grains spike^{-1} of wheat were significantly affected by years (Y) and osmopriming sources (OPS) as indicated in Table 4. Significant difference observed for grains spike^{-1} across two years experiment. Mean values for the years showed that 2009 experiment resulted in 49.7 grains spike^{-1} as compared to 45.9 grains spike^{-1} during 2008. These differences may be attributed to number of variations persisting over different years like weather and soil conditions. Vigorous wheat growth depends on strong and healthy seedlings. Priming gives seeds ability to germinate and give vigorous emergence even under unfavorable conditions and hence primed wheat seeds attained highest number of grains spike^{-1}. Wheat seeds primed with KNO_3, PEG, Na_2SO_4 and hydropriming attained maximum 51.0, 50.8, 50.7 and 48.5 grains spike^{-1} respectively. Arif *et al*., (2007) noticed highest number of grains spike^{-1} for the primed wheat seeds as compared to unprimed.

Table 2. Days to maturity of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean	
	60	70	80		
PEG 8000	157.17	154.83	155.17	155.72	f
KCl	160.83	159.33	157.17	159.11	d
KNO_3	159.67	154.00	152.67	155.44	f
NaCl	165.00	163.00	159.83	162.61	ab
NH_4Cl	163.67	161.83	159.33	161.61	bc
$CaCl_2$	164.67	160.33	159.67	161.56	bc
Mannitol	163.33	159.50	157.83	160.22	cd
Na_2SO_4	159.17	155.83	152.83	155.94	ef
Hydropriming	160.50	158.67	155.33	158.17	de
Control	168.17	164.33	161.5	164.67	a
Years					
2008	157.2	154.37	152.43	154.67	
2009	167.23	163.97	161.83	164.34	
Mean	162.2 a	159.2 b	157.1c		

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	0.52	NS	2.34	NS	NS	NS

NS = Not significant

Table 3. Emergence m^{-2} of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean	
	60	70	80		
PEG 8000	81.17	81.50	83.33	82.00	a
KCl	77.33	74.50	72.54	74.79	bc
KNO_3	77.50	82.33	77.13	78.99	ab
NaCl	67.83	68.17	67.00	67.67	de
NH_4Cl	68.33	69.00	68.83	68.72	de
$CaCl_2$	74.21	72.00	71.83	72.68	cd
Mannitol	74.50	77.83	75.33	75.89	bc
Na_2SO_4	75.50	79.33	79.50	78.11	ab
Hydropriming	76.67	80.00	78.17	78.28	ab
Control	63.83	64.00	62.83	63.56	e
Years					
2008	70.07 bc	72.97 b	68.07 c	70.37	
2009	77.31 a	76.77 a	79.23 a	77.77	
Mean	73.69	74.87	73.65		

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	NS	3.34	5.34	NS	NS	NS

NS = Not significant

Thousand grains weight (g): Data for thousand grains weight is presented in Table 5. Analysis of the data revealed years (Y), osmopriming sources (OPS) and interaction of YxOPS had a significant effect on thousand grains weight. Regarding years` effect heaviest thousand grains weight (38.01 g) observed for 2009 experiment while 2008 experiment indicated lowest thousand grains weight (35.1 g). Osmoprimed seeds attained maximum 39.9, 38.9, 38.7 and 38.6 g thousand grains weight for PEG, KNO_3, Na_2SO_4 and hydropriming respectively. These results are supportec by Arif *et al*., (2007) who revealed that wheat and chickpea seed priming enhanced thousand grains weight. Akhter *et al*., (2009) also explored that priming increased 1000-grain weight (g) significantly for six wheat genotypes at two salinity levels. Interaction of YxOPS showed that wheat seeds primed during 2009 experiment with PEG, KNO_3, Na_2SO_4, hydropriming and KCl recorded highest thousand grains weight of 40.3, 39.8, 39.5, 39.4 and 39.2 g respectively. Comparison of osmopriming sources during 2008 experiment showed that maximum thousand grains weight of 39.6 and 38.1 grams were obtained for PEG and KNO_3 respectively.

Table 4. Grains spike^{-1} of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean	
	60	70	80		
PEG 8000	49.32	53.70	49.43	50.82	a
KCl	46.20	48.87	47.78	47.62	bc
KNO_3	51.72	51.05	50.50	51.09	a
NaCl	45.02	47.18	46.72	46.31	cd
NH_4Cl	45.48	44.73	45.35	45.19	de
$CaCl_2$	46.02	47.3	46.27	46.53	b-d
Mannitol	47.08	48.67	49.12	48.29	bc
Na_2SO_4	51.12	51.18	49.90	50.73	a
Hydropriming	48.22	49.8	47.77	48.59	b
Control	43.32	43.98	43.70	43.67	e
Years					
2008	45.73	45.94	46.24	45.97	
2009	48.97	51.35	49.07	49.79	
Mean	47.35	48.65	47.65		

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	NS	NS	2.07	NS	NS	NS

NS = Not significant

Table 5. Thousand grains weight (g) of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean	
	60	70	80		
PEG 8000	39.36	41.05	39.51	39.97	a
KCl	36.72	37.02	35.46	36.40	bc
KNO_3	39.13	38.09	39.74	38.98	a
NaCl	35.00	35.11	33.62	34.58	d
NH_4Cl	33.77	34.28	35.85	34.64	d
$CaCl_2$	35.09	34.94	35.54	35.19	cd
Mannitol	36.17	37.91	36.20	36.76	b
Na_2SO_4	39.07	39.10	37.94	38.70	a
Hydropriming	37.55	40.30	38.20	38.68	a
Control	31.73	32.51	31.43	31.89	e
Years					
2008	34.84	35.39	35.23	35.15	
2009	37.88	38.68	37.47	38.01	
Mean	36.36	37.03	36.35		

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	NS	NS	1.49	2.11	NS	NS

NS = Not significant

Grain yield (kg ha^{-1}): Sources of variation in the experiment i.e. years (Y), moisture stress (M), osmopriming sources (OPS) and interaction of YxOPS scored significant effect on grain yield of wheat (Table 6). Between years 2009 experiment showed highest grain yield of 3450 kg ha^{-1} as compared to 2008 experiment grain yield (3012 kg ha^{-1}). Moisture content of the soil greatly influenced grain yield and maximum 3348 kg ha^{-1} grain yield was noted for 70% MAD while 60% MAD produced minimum grain yield (3107 kg ha^{-1}). Xue *et al*., (2006) suggested that deficit irrigation between jointing and anthesis significantly increased wheat yield. Similarly Malik *et al*., (2010) observed that grain yield was positively correlated with moisture stress at critical growth stages of wheat. Regarding osmopriming sources highest grain yield of 3481, 3454, 3420 and 3355 kg ha^{-1} was recorded for PEG, Na_2SO_4, KNO_3 and hydropriming respectively. These results are supported by Iqbal *et al*., (2006) and Arif *et al*., (2007) who observed different priming agents for wheat improved growth and grain yield. Similarly Ghassemi-Golezani *et al*., (2010) found that hydro priming of pinto bean seed increased grain yield indirectly through high seedling establishment and grains m^{-2}. Supporting the benefits of priming wheat seeds in water, KCl and $CaCl_2$ solutions also showed positive effect on grain yield (Farooq *et al*., 2008). Interaction of YxOPS showed that 2009 experiment attained maximum grain yield of 3626, 3566, 3560 and 3532 kg ha^{-1} for PEG, KNO_3, hydropriming and Na_2SO_4 respectively. Data obtained for 2008 experiment revealed that highest grain yield recorded for Na_2SO_4, PEG and KNO_3 osmoprimed wheat seeds attaining grain yield of 3377, 3337 and 3274 kg ha^{-1} respectively.

Table 6. Grain yield (kg ha^{-1}) of wheat as affected by osmopriming sources and moisture stress during 2008 and 2009.

Osmopriming sources	Moisture stress (% MAD)			Mean	
	60	70	80		
PEG 8000	3449.87	3680.32	3315.35	3481.85	a
KCl	3218.38	3265.50	3040.67	3174.85	cd
KNO_3	3480.07	3472.28	3308.89	3420.41	ab
NaCl	2999.00	3119.17	2973.50	3030.56	de
NH_4Cl	3171.33	3219.67	2895.83	3095.61	d
$CaCl_2$	3055.50	3255.00	3089.17	3133.22	cd
Mannitol	3287.53	3424.50	3173.33	3295.12	bc
Na_2SO_4	3514.92	3529.00	3319.98	3454.63	ab
Hydropriming	3292.94	3601.78	3171.50	3355.41	ab
Control	2915.50	2919.00	2783.67	2872.72	e
Years					
2008	2997.50	3146.87	2892.43	3012.27	
2009	3479.51	3550.38	3321.94	3450.61	
Mean	3238.50 b	3348.62 a	3107.19 c		

LSD value at $p \leq 0.05$

Y	M	YxM	OPS	YxOPS	MxOPS	YxMxOPS
**	78.12	NS	169.9	240.2	NS	NS

NS = Not significant

Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test

References

Ahmad, S., A. Muhammad and Hameedullah. 1998. Wheat seed presoaking for improved germination. *J. of Agron. and Crop Sci*., 2: 125-127.

Arif, M., M. Waqas, K. Nawab and M. Shahid. 2007. Effect of seed priming in Zn solution on chickpea and wheat. *African Crop Sci. Con. Pro*., 8: 237-240.

Akhter Abro, S., A.R. Mahar and A.A. Mirbahar. 2009. Improving yield performance of landrace wheat under salinity stress using on-farm seed priming. *Pak. J. Bot*., 41(5): 2209-2216.

Bray, C.M., P.A. Davison, M. Ashraf and R.M. Taylor. 1989. Biochemical events during osmopriming of leek seed. *Ann. Appl. Biol*., 102: 185-193.

Basra. S. M.A., I. A. Pannu and I. Afzal. 2003. Evaluation of seedling vigor of hydro and matriprimed wheat (*Triticum aestivum* L.) seeds. *Int. J. of Agric. & Bio*., 5(2): 121-123.

Dahal, P., K.J. Bradford and R.A. Jones. 1990. Effects of priming and endosperm integrity on seed germination rates of tomato genotypes. II. Germination at reduced water potential. *J. Exp. Bot*., 41: 1441-1453.

Farooq, M., M. Basra, H. Rehman and B.A. Saleem. 2008. Seed priming enhances the performance of late sown wheat (*Triticum aestivum* l.) by improving chilling tolerance. *J. of Agron. and Crop Sci*., 194(1): 55-60.

Ghazi , N. 1998. Response of wheat and barley during germination to seed osmopriming at different water potential. *J. of Agron. and Crop Sci*., 4: 229-235.

Ghassemi-Golezani, K., A. Chadordooz-jeddi, S. Nasrollahzadeh and M. Moghaddam. 2010. Effects of hydro-priming duration on seedling vigour and grain yield of Pinto Bean (*Phaseolus vulgaris* L.) cultivars. *Not. Bot. Hort. Agrobot. Cluj*., 38(1): 109-113.

Hamid. M., M. Y. Ashraf, K. Rehman and M. Arashad. 2008. Influence of salicylic acid seed priming on growth and some biochemical attributes in wheat grown under saline conditions. *Pak. J. Bot*., 40(1): 361-367.

Harris, D., B. Rahguwanshi, J.S. Gangwar, S.C. Singh, K.D. Joshi, A. Rashid and P.A. Hollington. 2001. Participatory evaluation by farmers of on-farm seed priming in Wheat in India, Nepal and Pakistan. *Exp Agric*., 37(3): 403-415.

Hugh, J.E. and D.F. Davis. 2003. Effect of drought stress on leaf and whole canopy radiation use efficiency and yield of maize. *Agron. J*., 95: 688-696.

Iqbal, M. and M. Ashraf. 2006. Wheat seed priming in relation to salt tolerance: growth, yield and levels of free salicylic acid and polyamines. *Ann. Bot. Fennici*., 43 (4): 250-259.

Jamal. Y., M. Shafi, J. Bakht and M. Arif. 2011. Seed priming improves salinity tolerance of wheat varieties. *Pak. J. Bot*., 43(6): 2683-2686.

Khakwani, A.A., M.D. Dennett and M. Munir. 2011. Early growth response of six wheat varieties under artificial osmotic stress condition. *Pak. J. Agri. Sci*., 48: 121-126.

Khan, S. and J. Khan. 2010. Drought tolerant wheat cultivar (Raj) for rainfed areas of KPK, Pakistan. *Pak. J. Agri. Sci*., 47: 355-359.

Kilic, H and T. Yağbasanlar. 2010. The effect of drought stress on grain yield, yield components and some quality traits of durum wheat (*Triticum turgidum* ssp. durum) cultivars. *Not. Bot. Hort. Agrobot. Cluj*., 38 (1): 164-170.

Anonymous. 2009. Ministry of Food, Agriculture and Live Stock (Pakistan).

Murungu, F.S. and T. Madanzi. 2010. Seed priming, genotype and sowing date effects on emergence, growth and yield of wheat in a tropical low altitude area of Zimbabwe. *African J. of Agric. Res*., 5(17): 2341-2349.

Malik, A.U., I. Hussain, A.K. Chaudhary and M.A.A.H.A. Bukhsh. 2010. Effect of different irrigation regimes on grain yield of wheat under local conditions of Dera Ghazi Khan. *Soil & Environ*., 29(1): 73-76.

Saha, R., A.K. Mandal and R.N. Basu. 1990. Physiology of seed invigoration treatments in soybean (*Glycine max* L.). *Seed Sci. Tech*., 18: 269-276.

Xue, Q., Z. Zhu, J.T. Musick, B.A. Stewart and D.A. Dusek. 2006. Physiological mechanisms contributing to the increased water-use efficiency in winter wheat under deficit irrigation. *J. Plant Physiology*, 163(2): 154-164.

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