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Use of Commercial Fertilizers as Osmotica for Rice Priming

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ABSTRACT

In a laboratory study, coarse and fine rice seeds were osmoprimed in fertilizer-based solutions. Priming was done in 5% aerated solution each of urea, nitrophos, DAP and SOP for 48 h. In fine rice, complete failure of germination and emergence was noted in seeds subjected to urea-based osmopriming. Electrical conductivity of seed leachates was also increased by all the seed treatments. In coarse rice, along with urea, nitrophos-based osmopriming treatments resulted in complete failure of germination and emergence. Urea and nitrophos-based osmopriming treatments also resulted in higher electrical conductivity of seed leachates than other treatments including. In both rice types, fertilizer-based osmopriming treatments resulted in lowering the germination and seedling growth.

Key words: Fine rice; Coarse rice; Germination; Seedling; Electrical conductivity; Fertilizer; Osmopriming
Abbreviations: Time taken for 50 % germination= $T_{50,}$ Mean germination time= MGT, Mean emergence time= MET Germination index= GI, Energy of germination= GE, Final germination percentage= FGP, Electrical conductivity= EC

INTRODUCTION

Seed priming is a technique by which seeds are partially hydrated to a point where germination processes begin but radicle emergence does not occur (Bradford, 1986). Priming allows for some of the metabolic processes necessary for germination to occur without actual germination. Primed seeds usually exhibit increased germination rate, greater germination uniformity, and sometimes greater total germination percentage (Basra *et al.*, 2005). Osmopriming is most widely used type of seed priming in which seeds are soaked in aerated low water potential solutions. Examples of such osmotica used include polyethylene glycol (PEG), KNO_3, K_3PO_4, KH_2PO_4, $MgSO_4$, NaCl and manitol. PEG is the most commonly used osmoticum for rice priming (Basra *et al.,* 2003, 2005; Lee & Kim, 1999; Lee & Kim, 2000).

Osmopriming promotes pre-germinative metabolic activities, like enzymatic activation and synthesis, increase in hydrolysis of seed food and overcoming dormancy (Bradford, 1986; Basra *et al.,* 2005; Lee & Kim, 1999). Lee and Kim (1999) reported that osmopriming of rice (*Oryza sativa* L.) seed resulted in increased starch hydrolysis. The radicle and plumule of properly primed germinating seeds developed faster than non-primed seeds (Basra *et al.,* 2005). Non-reducing sugars in primed seeds decreases while reducing sugars and α-amylase activity increases (Basra *et al.,* 2005). However, they also found that sugar contents and α-amylase activity of over primed seeds were lower comparatively with non-primed or properly primed seeds. Ruan *et al.* (2002) used $CaCl_{2,}$ KNO_3 and NaCl in addition to PEG-8000 (–1.25 MPa) for 2, 3 or 4 d at 20ºC on rice seeds. They found all the salts used for osmoconditioning significantly improved the rate and spread of germination and seedling vigor as did the PEG.

Although PEG is successfully being used but its cost and availability are the hindrances in its wide use at farmer's level. While salt molecules during imbibitions may penetrate in the seed and can cause ion toxicity. As an alternative to PEG and salts commercially available fertilizers can be used as an osmoticum for seed priming (Rao *et al*., 1981). Fertilizers are not only cheaper and easily available but can supply nitrogen and other nutrients essential for protein synthesis in imbibing seeds. However, their disadvantage is occasional toxicity to the germinating seedlings (Rao *et al*., 1981).

The present study was therefore, planned to use fertilizers as osmopriming tool and their influence (if any) on the germination and seedling growth in both coarse and fine rice.

MATERIAL AND METHODS

Seed materials. Seeds of coarse rice cultivar KS-282 and of fine rice cultivar Super-Basmati were used. The seeds were obtained from Rice Research Institute, Kala Shah Kakoo, District Sheikhupura, Pakistan. The initial seed moisture contents were 8.04% and 8.43% in coarse and fine rice respectively.

Seed treatments. The seeds were primed in 5% (w/v) aerated solution of urea, nitrophos, sulphate of potash (SOP) and di-ammonium phosphate (DAP) at 27ºC for 48 h. The ratio of seed weight to solution volume was kept 1:5 (g mL^{-1}) (Ruan *et al*., 2002a).

Post priming operations. After soaking, seeds were given three surface washings with distilled water (Khan *et al.,*

1992) and redried near to original weight with forced air under shade (Basra *et al.,* 2002). The seeds were then sealed in polythene bags and stored in refrigerator till further use.

Germination test. Seeds were sown in petri dishes (15 in each) between the layers of moist filter paper whatman 45 at 27°C in an incubator and were replicated four times. Germination was observed daily according to the AOSA method (AOSA, 1990). The time to get 50% germination (T_{50}) was calculated according to the following formulae of Farooq *et al*. (2005):

$$T_{50} = t_i + \frac{\left(\frac{N}{2} - n_i\right)(t_j - t_i)}{n_j - n_i}$$

Where N is the final number of germination and n_j, n_i cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts (1981):

$$MGT = \frac{\sum Dn}{\sum n}$$

Where n is the number of seeds, which were germinated on day D, and D is the number of days counted from the beginning of germination.

Germination index (GI) was calculated as described in the Association of Official Seed Analysts (1983) as the following formulae:

$$\mathrm{GI} = \frac{\text{No. of germinated seeds}}{\text{Days of first count}} + - - - - - - - + \frac{\text{No. of germinated seeds}}{\text{Days of final count}}$$

Energy of germination was recorded 3rd day after start of germination. It is the percentage of germinating seeds 3rd day after start of germination relative to the total number of seeds tested.

Seedling emergence. Control and treated seeds were sown in plastic trays (25 in each) having moist sand, replicated four times and were placed in growth chamber (Windon, England). Day and night lengths were kept 15 and 9 h with 30ºC and 24ºC respectively. The relative humidity was maintained at 70%. Emergence was recorded daily (AOSA, 1990). Mean emergence time was calculated according to the method described earlier.

Electrical conductivity of seed leachates. After washing in distilled water, 5 g seeds were soaked in 50 mL distilled water at 25ºC. Electrical conductivity of steep water was measured 0.5, 1.0, 1.5, 2.0, 6.0, 12.0 and 24.0 h after soaking using a conductivity meter (Model Twin Cod B-173) and expressed as µS/cm (Ashraf *et al.,* 1999).

RESULTS

Fertilizer osmopriming affected the germination, emergence and electrical conductivity of seed leachates significantly at p 0.05 in both coarse and fine rice (Table I, II; Fig. 1-2). In fine rice, earlier germination was recorded in seeds subjected to SOP priming that was similar to that of DAP and control, however, delayed germination was noted in seeds treated with NP while, seeds treated with urea failed to germinate (Table I). Lowest T_{50} was recorded in untreated seeds that was similar to that of SOP priming. However, seeds treated with urea failed to germinate. All the seed treatments resulted in higher MGT, being highest in NP priming that was similar to that of DAP priming (Table I). Highest germination percentage was observed in untreated seeds that were similar to that of SOP osmopriming (Fig. 1a). Maximum GI and, radicle and plumule length were noted in untreated seeds, all the seed treatments resulted in lower values of GI and, radicle and plumule length (Table I). Highest GE was noted in seeds subjected to SOP osmopriming, while GE was zero in urea and NP treated seeds (Table I).

Statistically minimum MET was observed in seeds subjected to NP osmopriming. All other seeds treatments including control behaved similarly (Table II). Maximum root length was observed in seeds treated with DAP osmopriming that was followed by control, all other treatments resulted in smaller roots compared with that of control being smallest in SOP primed seeds (Table II). Longest shoots were measured in DAP primed seeds that was similar to that of untreated seeds, all other treatments resulted in lowering the shoot length (Table II). Maximum root/shoot ratio was noted in DAP primed seeds, root/shoot ratio was similar in all other treatments including control. Maximum seedling fresh and dry weight was recorded in untreated seeds that was similar to that of SOP priming (Table I).

Statistically highest EC of seeds leachates was recorded in seeds subjected to urea osmopriming and was followed by NP priming. While, minimum EC of seeds leachates was measured in untreated seeds (Fig. 2a).

In coarse rice seeds subjected to urea and NP priming failed to germinate (Table I). Untreated seeds germinated earlier as indicated by lower values of time to start germination and MGT than that of treated seeds (Table I). Maximum germination percentage was observed in untreated seeds that was similar to seeds subjected to DAP-based osmopriming. However, seeds treated with urea and NP-based priming failed to germinate (Fig. 1b). The effect of seeds treatments on the time for 50% germination remained non significant (Table I). Maximum GI was noted in untreated seeds, all the seed treatments resulted in lower GI. However, GE was highest in seeds subjected to DAP osmopriming and minimum in untreated seeds (Table I).

Maximum radicle and plumule length was measured in untreated seeds, seed treatments resulted in lower length of both radicle and plumule (Table I). Delayed emergence was noted in DAP-based priming, while untreated and SOP-based priming behaved similarly (Table II). All the seed treatments resulted in lower values of root and shoot length

Fig.1 Influence of fertilizer-based osmopriming treatments on the final germination percentage± S.E. of (a) fine and (b) coarse rice seeds

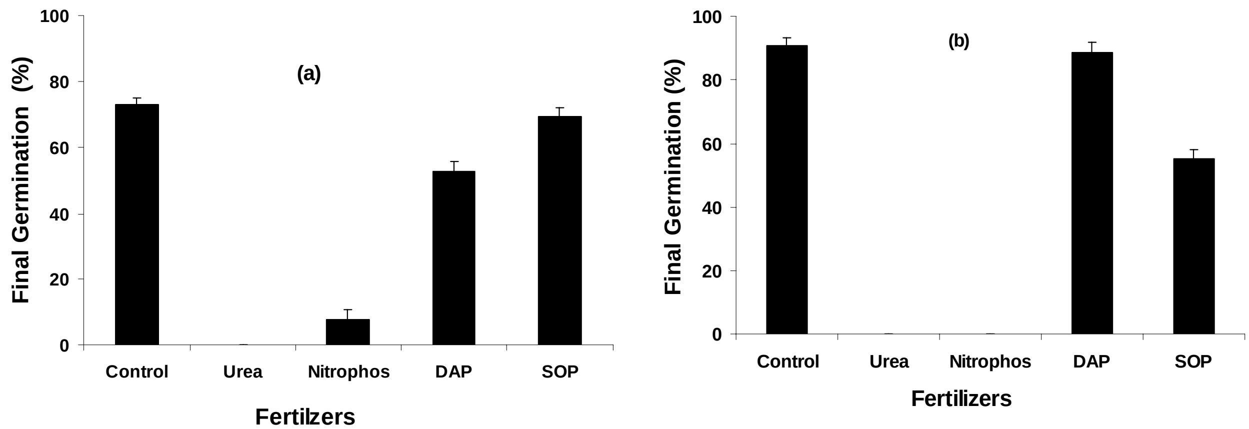
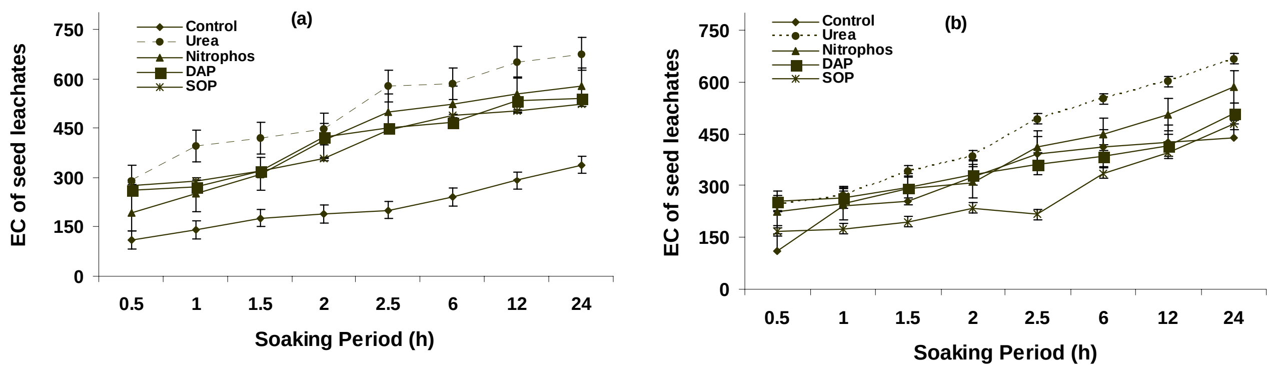


Fig. 2. Influence of fertilizer-based osmopriming treatments on the electrical conductivity of seed leachates (µS cm^{-1} g^{-1}) ± S.E. in (a) fine and (b) coarse rice



and, seedling fresh and dry weight compared with control (Table II). However, effect of seed treatments on root/shoot ratio remained non-significant (Table II).

Maximum EC of seeds leachates was recorded in seeds subjected to urea-based osmopriming that was followed by NP priming, while, minimum EC of seeds leachates was measured in SOP priming seeds (Fig. 2b).

DISCUSSION

Fertilizer osmopriming resulted in lower germination and reduced seedling growth. In both rice types, seeds subjected to urea-based osmopriming completely failed to germinate and emerge. While in coarse rice along with urea, seeds subjected to nitrophos also failed to germinate and emerge. While seed treatments other than urea and nitrophos resulted in lowering the germination vigor and seedling growth. Reduction in germination and seedling vigor in both rice types subjected to fertilizer-based osmopriming treatments might be the result of toxicity of the solutes use, as earlier found in KNO_3 osmopriming in rice (Basra *et al.,* 2003; 2005). In contradiction to present findings, Al-Mudaris and Jutzi (1981) reported germination enhancement from seeds primed with nitrogen, phosphorus and potash fertilizer treatments in *Sorghum bicolor* and *Pennisetum glaucum.*

Both rice types behaved similarly to the priming treatments in contrast to earlier findings of Farooq *et al.* (2004, 2005) and Ruan *et al.* (2002) who reported different behavior of rice types to seed treatments.

Higher seed leachates from the seeds subjected to fertilizer treatments might be the result of membrane rupture during the imbibition process. Higher seed leachates from the urea primed seeds compared with other fertilizers including control might be due to its higher molecular weight than other fertilizers used, that may have damaged the membranes to much greater extent. Earlier, Basra *et al.* (2003) and Basra *et al.* (2005) have reported higher seed leachates from the KNO_3 treated seeds of fine and coarse rice respectively due to membrane damage.

In conclusion, none of the fertilizer-based osmopriming resulted in vigor enhancement in both coarse and fine rice seeds, rather all the treatments resulted in lowering the vigor compared with that of control. However, further research is required in this area to explore the possibility of vigor enhancement especially in cereals.

Table I. Effect of seed treatments on the germination vigor of coarse and fine rice

Treatments		Time to start germination (days)	T_{50} (days)	MGT (days)	GI	GE (%)	Radicle length (mm)	Plumule length (mm)
Fine rice	Control	3.33 b	4.40 b	4.85 c	20.19 a	21.67 c	45.90 a	51.66 a
	Urea	00	00	---	-------	---	----	----
	Nitrophos	5.00 a	5.53 a	8.83 a	0.13 c	00 d	9.667 c	5.66 c
	DAP	3.33 b	5.90 a	7.35 a	4.24 b	44.45 b	37.14 b	28.75 b
	SOP	3.00 b	4.44 b	6.56 b	4.14 b	55.66 a	36.92 b	24.93 b
	LSD at 0.05	*1.56*	*1.23*	*1.53*	*3.45*	*8.45*	*5.34*	*4.23*
Coarse rice	Control	3.67 c	4.16	4.83 c	37.75 a	31.00 c	85.23 a	45.66 a
	Urea	---	---	----	---	----	---	---
	Nitrophos	---	--	----	---	----	---	---
	DAP	5.00 a	4.06	5.64 b	7.43 b	88.86 a	67.26 b	41.1 b
	SOP	4.00 b	5.44	6.43 a	5.23 b	44.43 b	67.35 b	38.99 b
	LSD at 0.05	*0.95*	*n.s.*	*1.01*	*5.45*	*6.45*	*8.54*	*2.34*

Table II. Effect of seed treatments on seedling vigor of coarse and fine rice

Treatments		MET (days)	Root length (cm)	Shoot length (cm)	Root/Shoot ratio	Seedling fresh weight (g)	Seedling dry weight (g)
Fine rice	Control	8.51 a	45.05 b	30.88 a	1.66 b	1.23 a	1.47 a
	Urea	---	----	----	---	---	----
	Nitrophos	6.85 b	24.01 c	27.54 b	1.40 b	0.980 c	0.81 c
	DAP	8.44 a	61.62 a	31.85 a	2.15 a	1.074 b	0.95 b
	SOP	8.70 a	19.92 d	20.78 c	1.54 b	1.192 a	1.41 a
	LSD at 0.05	*1.32*	*3.03*	*2.01*	*0.57*	*0.27*	*0.31*
Coarse rice	Control	6.26 b	88.64 a	61.98 a	1.45	3.99 a	2.28 a
	Urea	---	----	----	----	----	---
	Nitrophos	---	----	----	----	----	----
	DAP	8.02 a	25.70 b	15.77 b	2.032	1.92 b	1.29 b
	SOP	6.06 b	24.00 b	17.86 b	1.145	1.16 b	0.99 b
	LSD at 0.05	*1.32*	*17.23*	*11.21*	*n.s.*	*1.32*	*0.43*

Figures not sharing the same letters differ significantly at p 0.05; Time taken for 50 % germination = $T_{50,}$ Mean germination time= MGT, Mean emergence time= MET Germination index= GI, Energy of germination= GE, Final germination percentage= FGP

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