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RESEARCH PAPER

Relative performance of seed priming with tap water and inorganic salts on germination, invigoration, growth and yield of wheat (*Triticum aestivum* L.)

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Abstract : In a field experiment, one year old seeds of two late sown wheat varieties *viz.*, HUW 234 and WR544 were primed with tap water and inorganic salts including KNO_3 and Mg $(SO_4)_2$ singly (in 0.2% solutions) for 12 hours. After priming, the seeds were taken out and allowed for shade drying till returning to their original moisture content. One set of unprimed control was also kept simultaneously. Those primed and unprimed seeds were sown in the last week of December during 2011-12 in allocated plots in four replicates following Factorial Randomized Block Design (RBD) at the research farm of IISR Lucknow, taken temporarily by Directorate of Seed Research, Mau. The data showed that seed priming with tap water and inorganic salts including KNO_3 and Mg $(SO_4)_2$ singly in 0.2 per cent solution for 12 h significantly enhanced seed germination, shoot/root length, seedling dry weight, vigour index and finally the total biomass and grain yield in both the varieties evaluated over unprimed control. Among the treatment, KNO_3 priming displayed maximum values in respect of all characters studied followed by Mg $(SO_4)_2$ and tap water. Varieties differed significantly in respect of shoot/root length, seedling dry weight, spike length, number of spikelets / spike, number of grains and test weight. Variety HUW 234 superceded WR 544 in respect of seedling dry weight, vigour index, number of tillers/ run. meter and total biomass whereas WR 544 displayed maximum seed germination, shoot/root length, plant height and finally the total grain yield. Differences between varieties were found to be significant for some characters, however, insignificant for remaining others.

Key Words : Germination, Invigoration, Inorganic salts, Seed priming, Tap water, Varieties

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INTRODUCTION

Wheat is the world's number one cereal crop. Wheat is grown in almost all the states in northern and central India. Uttar Pradesh ranks first in terms of area under and total production but the productivity is very low in U.P. as well as in the nation as a whole because of several factors including its cultivation under rain fed un-irrigated lands, prevalence of insect-pests, diseases and use of very old and low quality seeds by the farmers. The farmers generally use traditional and poor methods of seed storage which in turn gives low seed germination,

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delayed emergence and unhealthy seedlings that ultimately results exceedingly low yield. Booming up population warn us to intensify an effort to enhance the productivity of wheat crop /unit area and in this context sustained increase in agriculture production and productivity is dependent to a large extent on the development of new and improved varieties of crops and an efficient system for timely supply of quality seed to the farmers at affordable cost in time. It is mentionable that seed is the most important determinant of agriculture production potential, on which the efficiency of other agricultural inputs is largely dependent upon. Seed enhancement is the techniques defined as any post treatment that improves germination, seedling emergence or facilitate the development of more number of normal, rapid, uniform and healthy seedlings under field conditions (Mc Donald Miller, 2000). Seed quality enhancement techniques including seed priming, seed coating and seed pelleting are being used in agriculture for negotiating adverse biotic and edaphic situations, protecting agriculture and prolonging the storability of seed. Seed priming is a powerful tool in which seeds are soaked in water or an osmotic solution allows water imbibitions and permits early stages of germination but does not permit radical protrusion through seed coat (Heydecker, 1973). According to Basu (1994) seed priming induces faster emergence and more uniform field stand in normal as well as under stress condition. Besides uniformity and synchrony, significant yield increase in many field crops has been reported. Seed priming with different inorganic salt including KNO_3, $MgNO_3$ and $MgSO_4$ etc. has been reported to improve the germination, speed of emergence, seedling vigour, growth and yield of different vegetable and field crops by several workers (Saxena and Singh, 1987; Fujikura and Karssen, 1992; Brockehurst and Dearman, 1983; Taigi, 2001; Pandita *et al.*, 2003; Misra and Sahoo, 2003; Thakur and Thakur, 2006; Tiwari *et al.*, 2013; 2014 and 2015) but the information regarding beneficial effect of seed priming in wheat crop is very scanty though it constitutes the major crop of the country. Keeping the above facts in purview, the present investigation was under taken to study the relative performance of tap water and different inorganic salts used as osmoticum for seed priming on the germination, root/shoot length, seedling dry weight and vigour index in two wheat varieties and also to study the effects of these improvements on growth, yield attributes and seed yield of two wheat varieties.

MATERIAL AND METHODS

One year old seeds of two late sown wheat varieties *viz.*, HUW 234 and WR 544 were obtained from breeding section of ICAR- DSR, Mau and were surface sterilized with 0.1 per cent $HgCl_2$ for 5 minutes. Those seeds were thoroughly washed after surface sterilization and soaked as per treatments in tap water (T_1) and in 0.2 per cent conc. of KNO_3 and $Mg(SO_4)_2$ separately in plastic containers for 12 h. Seeds were taken out from the solution and allowed for shade drying until it attained its original moisture content. One set of unprimed control was also maintained simultaneously. Dried seeds of each variety were sown in allocated plots of 6 x 2.4 m. size at 22.5 cm row spacing in four replicates following factorial RBD in the field at the Research farm of Indian Institute of Sugarcane Research, Lucknow. Recommended NPK @ 120:60:40 kg/ha were applied, half dose of nitrogen and full dose of phosphorus and potassium were applied at the time of planting and remaining half dose of nitrogen were top dressed in two split doses at tillering and at dough stages. Irrigation and other cultural practices were applied as per the recommendations. Germination was recorded one week after sowing while root/shoot length were recorded after 15 days of germination count and at the same time 50 (fifty) fresh seedlings were uprooted and kept for drying in oven at $80^{o}C$. Dried samples were taken out and weighed with an electronic balance and the vigour index was calculated as mentioned here under.

Vigour index = Germination per cent × seedling dry weight

In standing crop at 60 days after sowing (DAS) number of tillers per running meter was recorded. At harvest the yield attributes including spike length, number of spikelets/spike, number of grains / spike, total bio-mass, test weight and grain yield were recorded. Data collected were analyzed following statistical procedure as described by Panse and Sukhatame (1967).

RESULTS AND DISCUSSION

Seed priming of wheat seeds with tap water and inorganic salts including KNO_3 and $Mg(SO_4)_2$ in 0.2 per cent solution singly, significantly enhanced seed germination over unprimed control (Table 1a). Among the treatments, seed priming with KNO_3 salts in 0.2 per cent conc. displayed highest mean germination (93.5%) followed by $Mg(SO_4)_2$ (90%) and found to be significantly higher over tap water (83.5%). The varieties of wheat evaluated responded well to priming treatment and the germination per cent was slightly higher in WR 544 over HUW 234, the differences between varieties were insignificant. Per cent improvement in germination was also higher in WR 544 as compared to HUW 234 (Fig. 1). Shoot and root length of seedlings recorded were also increased significantly with priming treatment, KNO_3 priming showed maximum values in both shoot and root length followed by $Mg(SO_4)_2$ and tap water priming over unprimed control (Table 1b, c). Wheat varieties evaluated differed significantly in their shoot/root length and the maximum improvement was recorded with WR 544. Differences in between the treatments (T_2 and T_3) and (T_3 and T_4) were found significant. Table 1d. clearly revealed that seedling dry weight was significantly enhanced by the priming treatments, the maximum values were observed in KNO_3 priming followed by Mg $(SO_4)_2$ and tap water but the differences between KNO_3, $Mg(SO_4)_2$ and tap water priming in respect of seedling dry weight were found to be insignificant. Varieties differed significantly in their seedling dry weight and the highest values were observed in HUW 234. Improvement in seedling dry weight as a result of seed priming was found to be 9.30 - 15.11 per cent in HUW 234 and 8.43 - 14.45 per cent in WR 544 as depicted in Fig. 2.

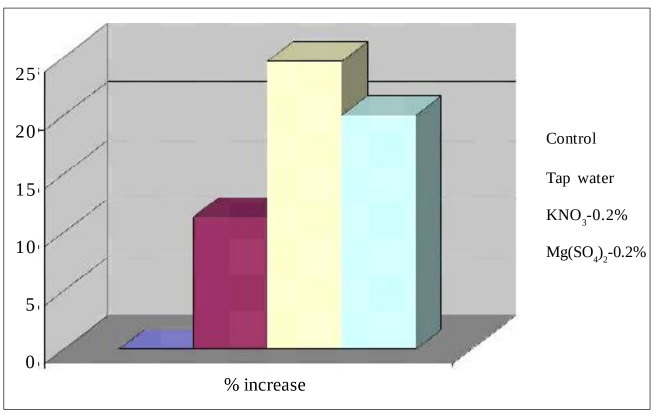

Fig. 1 : Influence of seed priming on improvement of germination in wheat

Vigour index is the product of germination per cent × seedling dry weight and it was considerably increased in response to priming treatments applied. Maximum vigour index was obtained by KNO_3 priming followed by $Mg(SO_4)_2$ and tap water. HUW 234 displayed highest vigour index over WR 544. Fig. 3 clearly revealed that KNO_3 priming was most effective in enhancing the seedling vigour in wheat varieties followed by Mg $(SO_4)_2$ and tap water (Table 1e).

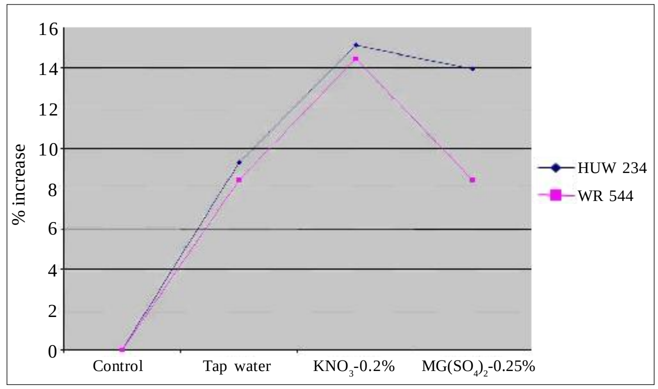

Fig. 2 : Enhancement in seedling dry weight through seed priming in wheat varieties

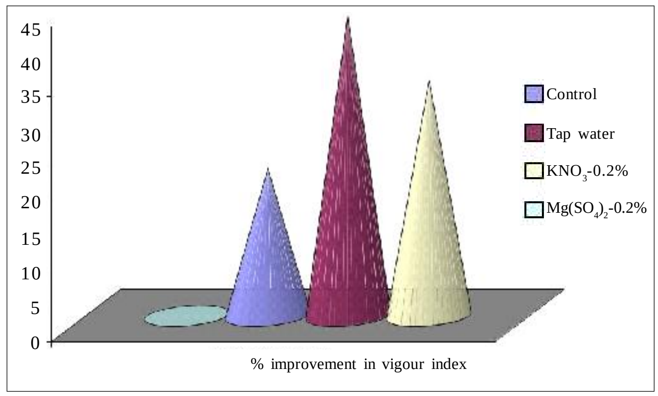

Fig. 3 : Influence of seed priming on improvement vigour index in wheat

Thus, HUW 234 displayed higher seedling dry weight and vigour index whereas WR 544 showed higher seed germination and shoot/root length. Above improvement by seed priming with tap water and inorganic salts KNO_3 and $Mg(SO_4)_2$ in germination, shoot/root length, seedling dry weight and finally in vigour index is might be due to induced large free space between embryo and endosperm in primed seed, which is deemed to play a role in accelerating germination rate by facilitating more uptake of water as observed earlier by Argerich and Bradford (1989) in tomato.

Present findings are also similar with the findings of Pandita *et al.* (2003); Bose and Sharma (2000); Bose and Pandey (2003); Pandey and Bose (2006) and Tiwari *et al.* (2013 and 2014) who had reported the improvement in germination, vigour and seedling dry weight by halo priming with KNO_3 (15 and 13 mM) in tomato, maize, mustard, okra, moongbean and pegionpea seeds. Chemical priming of tomato and cauliflower seed with NaCl, Na_2HPO_4 and urea also showed higher germination, shoot/root length and vigour index under

Table 1 : Effect of inorganic priming agents on various characters (a) Seed germination (%) (b) Shoot length (cm.) (c) Root length (cm.) (d) Seedling dry weight (g.) (e) Vigour index (f) Number of tillers/run. meter (g) Plant height (cm.) (h) Spike length (cm.) (i) Number of spikelets/spike (j) Number of grain/spike (k) Test weight (g.) (l) Total biomass (kg/plot) (m) Total grain yield (kg/plot) in late sown wheat varieties

Treatments	Variety		Mean
	HUW 234	WR 544	
(a) Seed germination (%)			
Control (T_1)	78	72	75
Tap water (T_2)	80	87	83.5
KNO_3 0.2% (T_3)	89	98	93.5
$Mg(SO_4)$ 0.2% (T_4)	92	88	90
Mean	84.75	86.25	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.399	0.82983	1.12988
T	0.564	1.17356	1.59788
VT	0.79806	1.65967	2.25975
CV = 4.82%			
(b) Shoot length (cm)			
Control (T_1)	11.3	11.3	11.3
Tap water (T_2)	11.75	14.15	12.95
KNO_3 0.2% (T_3)	11.9	15.49	14.69
$Mg(SO_4)$ 0.2% (T_4)	12.52	13.95	13.25
Mean	12.36	13.72	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.5634	1.17173	1.59539
T	0.5968	1.65708	2.25623
VT	1.1268	2.34347	3.19079
CV = 10.20%			
(c) Root length (cm)			
Control (T_1)	11.02	11.3	11.16
Tap water (T_2)	12.1	13.77	12.93
KNO_3 0.2% (T_3)	14.0	15.72	14.86
$Mg(SO_4)$ 0.2% (T_4)	12.1	14.92	13.86
Mean	12.48	13.92	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.49868	1.03707	1.41204
T	0.50524	1.46664	1.99692
VT	0.99736	2.07414	2.82408
CV = 10.89%			
(d) Seedling dry weight (g)			
Control (T_1)	0.86	0.83	0.84
Tap water (T_2)	0.94	0.90	0.92
KNO_3 0.2% (T_3)	0.99	0.95	0.97
$Mg(SO_4)$ 0.2% (T_4)	0.98	0.90	0.94
Mean	0.94	0.89	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.01606	0.03340	0.04548
T	0.002271	0.04724	0.0632
VT	0.03212	0.06680	0.09096
CV = 3.93%			

Table 1: Contd.............

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(e) Vigour index			
Control (T_1)	67.08	59.76	63.42
Tap water (T_2)	75.2	78.30	76.75
KNO_3 0.2% (T_3)	88.11	93.1	90.60
$Mg(SO_4)$ 0.2% (T_4)	9016	79.2	84.68
Mean	80.13	77.59	
(f) Number of tillers/run. meter			
Control (T_1)	78.70	70.90	74.80
Tap water (T_2)	82.40	77.10	79.75
KNO_3 0.2% (T_3)	91.10	90.80	90.95
$Mg(SO_4)$ 0.2% (T_4)	84.40	82.37	83.38
Mean	84.15	80.30	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	3.74588	7.79001	10.60662
T	5.29748	11.01674	15.00003
VT	7.49176	15.58002	21.21325
CV = 13.05%			
(g) Plant height (cm)			
Control (T_1)	89.7	97.0	93.35
Tap water (T_2)	92.4	98.1	95.25
KNO_3 0.2% (T_3)	100.5	97.1	98.8
$Mg(SO_4)$ 0.2% (T_4)	93.4	96.8	95.1
Mean	94.0	97.25	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	4.87131	10.13.47	13.79332
T	6.88907	14.32665	19.50670
VT	9.741262	20.26095	27.58664
CV = 14.21%			
(h) Spike length (cm)			
Control (T_1)	9.07	7.47	8.27
Tap water (T_2)	8.62	8.12	8.37
KNO_3 0.2% (T_3)	9.65	7.62	8.63
$Mg(SO_4)$ 0.2% (T_4)	8.97	7.55	8.26
Mean	9.07	7.69	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.31043	0.64558	0.87901
T	0.43902	0.91299	1.24310
VT	0.62087	1.29117	1.75801
CV = 10.87%			
(i) Number of spikelets/ spike			
Control (T_1)	40.37	34.62	37.49
Tap water (T_2)	40.37	37.72	39.04
KNO_3 0.2% (T_3)	45.05	38.37	41.71
$Mg(SO_4)$ 0.2% (T_4)	43.2	38.28	40.74
Mean	42.25	37.25	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	2.07018	4.30518	5.86179
T	2.92767	6.08844	8.28982
VT	4.14035	8.61036	11.72358
CV = 13.11%			

Table 1: Contd.............

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(j) Number of grains/ spike			
Control (T_1)	32.2	33.72	32.96
Tap water (T_2)	39.9	36.12	38.01
KNO_3 0.2% (T_3)	45.15	38.05	41.6
$Mg(SO_4)$ 0.2% (T_4)	41.6	36.6	39.1
Mean	39.7	35.99	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	2.19059	4.55560	6.20275
T	3.09796	6.44259	8.77201
VT	4.38118	9.11119	12.40550
CV = 15.71%			
(k) Test weight (g)			
Control (T_1)	34.0	38.25	36.12
Tap water (T_2)	34.25	39.5	36.87
KNO_3 0.2% (T_3)	37.5	41.75	39.62
$Mg(SO_4)$ 0.2% (T_4)	40.5	40.25	40.37
Mean	36.56	39.93	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	1.23804	2.57465	3.50556
T	1.75085	3.64110	4.95761
VT	2.47608	5.14930	7.01112
CV = 9.67%			
(l) Total biomass (kg/plot)			
Control (T_1)	16.25	14.75	15.5
Tap water (T_2)	18.05	15.05	16.55
KNO_3 0.2% (T_3)	19.75	18.75	19.25
$Mg(SO_4)$ 0.2% (T_4)	16.50	16.75	16.62
Mean	17.75	16.44	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.66774	1.38864	1.89072
T	0.94432	1.96383	2.67388
VT	1.33547	2.77727	3.78144
CV = 11.04%			
(m) Total grain yield (kg/plot)			
Control (T_1)	6.85	5.75	6.3
Tap water (T_2)	8.11	7.63	7.87
KNO_3 0.2% (T_3)	8.93	8.54	8.73
$Mg(SO_4)$ 0.2% (T_4)	7.23	7.08	7.15
Mean	5.75	7.25	
Variables	S.E. ±	C.D. (P=0.05)	C.D. (P=0.01)
V	0.45376	0.94364	1.28483
T	0.64171	1.33451	1.81702
VT	0.90751	1.88728	2.56966
CV = 17.27%			

accelerated and natural ageing condition.

Data (Table 1f and g) revealed that there was a slight (numerical) improvement in both tiller production and plant height by priming of seeds with tap water and inorganic salts but it was found to be statistically insignificant. Among the treatments, KNO_3 priming displayed maximum value in respect of both number of tillers/running meter and plant height. Differences between varieties were also not significant. Co-efficients of variation for both the characters were high in the tune of 13.05 and 14.21 per cent, respectively.

Yield attributes including spike length, number of spikelets/ spike, number of grains/ spike and test weight responded differentially with applied priming treatments (Table 1h, i, j and k). Spike length was not affected with the priming treatments, only the differences between varieties were found significant. Var. HUW 234 showed significantly higher spike length over WR 544 (Table 1h). Seed priming treatment also did not influence the number of spikelets / spike and number of grains/spike, only the differences between varieties were found significant for those characters. HUW 234 also displayed significantly higher number of spikelets/ spike as well as number of grains / spike.

Test weight in both the varieties was increased by the priming of seeds with inorganic salts including KNO_3 and Mg $(SO_4)_2$ and it was significant at 5 per cent level of significance over unprimed control. Tap water priming did not affect the test weight in any of the varieties evaluated. WR 544 showed significantly higher test weight over HUW 234 (Table 1k.)

Total biomass production at harvest (Table 1(l) showed that seed priming with tap water and inorganic salts including KNO_3 and Mg $(SO_4)_2$ significantly improved total biomass production over unprimed control. Amongst the treatments, KNO_3 (0.2%) priming produced significantly higher biomass over tap water and Mg $(SO_4)_2$ priming indicating there by the beneficial role of KNO_3 over Mg $(SO_4)_2$ salts and tap water. HUW 234 produced higher total biomass than WR 544 but the differences between varieties were found to be insignificant since both the varieties were of late sown nature and medium yielder. Grain yield recorded at threshing (Table 1m) indicates that seed priming with tap water and inorganic salts (KNO_3 and Mg $(SO_4)_2$) in 0.2 per cent solution significantly enhanced grain yield in wheat varieties over unprimed control. Among the treatments, KNO_3 priming registered highest grain yield followed by tap water and Mg $(SO_4)_2$. Per cent increase in grain yield in response to different priming treatments (Fig. 4) displayed that WR 544 had produced higher grain yield over HUW 234 but the differences were not significant and it might be due to very higher co-efficient of variation (17.27%) observed in the field.

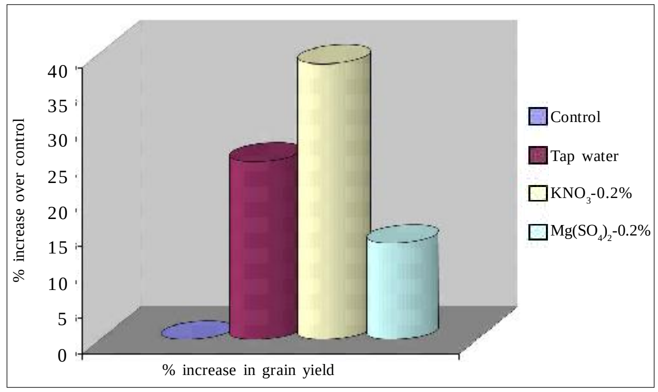

Fig. 4 : Enhancement in wheat yield by seed priming

Osmo–priming with diverse chemicals to seeds eventually enhances the rate of germination and encourages fast emergence of seedling in field (Bose and Mishra, 1992 and Bose, 1997) and this might be lead to enhancement in subsequent phases of plant growth and finally to higher yield of a crop. Bose and Mishra (1999 and 2001) opined that during soaking of seed in $Mg(NO_3)_2$ or KNO_3 solution the cations Mg^{++} or K^+ and anions NO_3 influxed in the seeds and showed their carry over effect during vegetative growth period and consequently the yield was increased and it was also supported by Bose and Pandey (2003) and Tiwari *et al.* (2013 and 2014).

In the present investigation two the inorganic salts used *viz.*, KNO_3 and Mg $(SO_4)_2$ might have resulted their carry over effect of influx of ions and consequently the yield has been enhanced. In the same context it is also important that both nitrate and magnesium are not only the nutrients but also potential salts acting as signal for initiating various metabolic process and directly involved in biosynthesis part (Tischener, 2000) even while subjected as seed priming material.

Conclusion :

In essence the present investigation concludes that seed priming of one year old wheat seeds with tap water and inorganic salts including KNO_3, Mg $(SO_4)_2$ in 0.2 per cent conc. separately for 12 h before sowing, enhanced seed germination, shoot/root length, seedling dry weight, vigour index and ultimately the total biomass and grain yield in late shown wheat varieties.

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