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Impact Of Seed Invigoration Through Phosphatic Fertilizers On Wheat Productivity

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Abstract

Seed invigoration also known as priming is an efficient tool to improve the emergence and stand establishment of field crops like maze, millet and wheat etc. Current study was conducted at Soil and Water Conservation Research Station, Sohawa during the years 2015-2019 to evaluate the impact of seed priming of wheat with various phosphorus fertilizer sources. Effect of seed invigoration through phosphatic fertilizers on the seedling vigour and germination of wheat (Pakistan-2013) were tested under laboratory conditions as well as in field. In hydro-priming the seeds were dipped in water, and in nutrient priming, solutions of KH_2PO_4, DAP and SSP were used keeping 1% P constant in all treatments. There were five treatments and three repeats under both lab and field conditions. All the priming treatments except SSP significantly enhanced the germination percentage, seedling vigour index (SVI), shoot and root length, seedling dry weight compared to control. The germination percentage (91), seedling vigour index (SVI) (19.08), shoot (20.2 cm) and root length (12.5 cm) were maximum with KH_2PO_4 seed priming as compared to control. Under field experiments on wheat extending over the period from 2015-2019, both grain yield (4977 kg ha^{-1} in 2019) and biomass yield of wheat (12194 kg ha^{-1} in 2019) were at the maximum with KH_2PO_4 followed by DAP and hydro priming. Conclusively, it is ascertained that application of P seed priming technique using different sources improved the seedling vigour and germination leading to enhanced wheat yield under field conditions.

Key words: seed priming, phosphorus, seedling vigor, germination, wheat.

Introduction

Wheat is the major staple food being consumed in Pakistan and the main commodity that drives our agricultural policies (Anjum et al., 2020). Currently the wheat crop is grown over an area of 9 m ha and the production stands at about 25 m ton. The consumption requirement of growing population is projected to be at about 35 m ton by 2030. Hence it would be essential to produce additional 10 m ton to meet the wheat consumption in the next 20 years. The average production is about 2.8 t ha^{-1}that needs to be enhanced upto 3.8 t ha^{-1} by 2030 (PARC, 2014). Organic matter is lacking in our soils that is the main cause of its poor fertility. Our soils are phosphorus deficit (Khan et al., 2020; Ali et al., 2020). One of the reasons for low production of wheat is non-availability of quality seed as only 20 percent of the good quality seed is available to the farming community and rest has to sow their own poor quality seed leading to decreased wheat yield over the years (PARC, 2014). To redress the poor quality seed issue, several measures are being adopted. One of the most promising approaches is considered to invigorate low quality seed by seed priming. Seed priming improved germination time, seedling and root length and grain yield in rice (Dhillon et al., 2021). It has been found that seed priming did impact germination, emergence rate, root length, seedling vigor Index (Zheng et al., 2016, Du et al., 2019, Ali et al., 2020), and it was also evinced that the grain yield in cereals enhanced by priming (Farooq et al., 2019). Seed priming also known as seed invigoration is a practice by which seeds are partly hydrated to stimulate germination initiation before emergence. Seed priming was found efficient for growing cereals and legumes as wheat and chickpea production enhanced by hydropriming well before (8 hours) sowing (Rashid et al., 2004). Phosphorus being the second most important macronutrient needed by plants has least mobility in soils from its application site. It is diffused into plants in ionic form as primary and secondary orthophosphate but its solubility is governed by Ca in basic and Al in acidic soils due to fixation of P with these elements (Adnan et al., 2020). The present study was planned and executed to address the issues of low quality seed and P- fixation in alkaline soil of Pothwar region being dominantly rainfed in nature. The seed application of phosphorous may enhance the seed P level and ultimately readily available to the emerging plants in calcareous soils of Pothowar.

Materials and Methods

Experimental site

The research trials were conducted on wheat (Triticum aestivum L) during the Rabi seasons (2015-2019) at farmer field situated at Sohawa district Jhelum (Longitude 73.42308, Latitude33.12775) under rainfed conditions of Pothwar region**.** The climate of research site is defined as subtropical; semi-arid with average annual precipitation of 910 mm, maximum (85%) occurs during monsoon (July-August) (Nizami, et al., 2004). Soil analysis of experimental site accomplished before initiation of research trials revealed the soil as Sandy Loam in texture, low in organic matter (0.56%), insufficient in available P (5.6 mg kg^{-1}), moderate in exchangeable K (115 mg kg^{-1}). The pH of the soil was 7.8 and ECe was 0.25 dS m^{-1}.

Experimental details

Incubation study

An incubation study was conducted before field trials to assess seed priming effect on germination and seed vigour parameters. With thirty percent sodium hypochlorite the wheat seeds (Pakistan-2013) were sterilized for 5 minutes and rinsed thrice using distilled water. There were five treatments and three replications. Three different phosphorous sources were used keeping similar P level i.e., 1% in each treatment. Following treatments were used: T_1 = Control (untreated dry seeds), T_2 = Hydropriming, T_3 = Potassium dihydrogen phosphate (KH_2PO_4), T_4 108 = Diammonium phosphate (DAP), T_5 = Single super phosphate (SSP)

Germination test

An incubation study was conducted at research laboratory of Soil and Water Conservation

Research Station Sohawa. The primed seeds (25 seeds per replication) were tested under complete randomized design (CRD)for germination percentage by using AOSA method (AOSA, 1990). The germination of the seeds was counted at 12 hour intervalsas far maximal germination has been attained. Vigor of the seedling was determined by using by method describe by Islam et al., 2009. Seedling Vigor Index = (SL (cm) × G %)/100 Whereas SL = seedling length and G = germination

Field study

He treatments used in incubation study applied under field conditions of rainfed Pothwar region of Sohawa, District Jhelum during Rabi (2015-2019) of each year under RCBD arrangement replicating thrice. When matured, grain yield was recorded from m^2 and converted into kg ha^{-1}. Accordingly dry matter yield was also recorded as kg ha^{-1} from randomly selected subplots (Hiroko et al., 2019). The climatic data for maximum and minimum temperatures (°C) and rainfall also observed during the growing seasons of wheat crop (Fig. 1). To measure root biomass of wheat, the roots were carefully washed, and then rapidly dried in an oven at 60°C for 72 h (Tambussi et al., 2007)

Statistical analysis

The data were subjected to Fisher's analysis of variance technique and Duncan's Multiple Range Test at 5% level of probability to compare the variations among treatment means (Steel et al.,1997).

Results and Discussion

Incubation study

Various growth parameters were evaluated using primed wheat seed. Germination test revealed that seed primed with KH_2PO_4 1% P solution had maximum (91%) germination followed by DAP solution against control during whole five years of research study (Figure 1). The seedling vigour index was estimated and the results indicated similar trend as in case of germination test described above. The seed treated with KH_2PO_4solution surpassed all other treatments and maximum SVI (19.08 %)) was observed with it (Figure 2).The growth parameters i.e. seedling length and root length were recorded (Figure 3). The results showed that seedling length was significantly enhanced by two priming treatments, DAP and KH_2PO_4, while others did not affected it significantly. Maximum enhancement was observed with KH_2PO_4. In case of root length, data (Fig 4) revealed similar trend as observed for seedling length that two treatments comprising DAP and KH_2PO_4 priming of seed significantly enhanced root length, maximum with KH_2PO_4. Other priming techniques could not influence root length of plants. The germination test revealed that it was enhanced with phosphorus primed seed specifically with KH_2PO_4 and DAP solutions. The results are in accordance with Yari et al. (2010) and Pandit et al. (2010) stating that seed priming incremented the germination % of cereal crops. It may be attributed to the stimulating effect of P absorption on various metabolic activities going on in plants. More precisely, it might be due to early DNA replication, enhanced RNA and protein synthesis and more ATP availability (Varier et al., 2010). The seedling vigour index of phosphorus primed wheat seed significantly improved. This improvement may be due to soothing effect of phosphorus absorption on probable seed infection. It was narrated by Chaluvaraju et al. (2004) that pearl millet showed maximum SVI in seeds primed with phosphorus solution by alleviating pearl millet downy mildew (PMDM).The findings of the present study extending over five years of experimental trials on bread wheat in high rainfall

zone of rainfed region of Pothowar revealed that best results of seed priming were with KH_2PO_4 1% phosphorus solution inducing enhancement in seedling length, root length and dry matter yield by a profound margin of 49%, 34% and 20% respectively.

Dry matter yield

The results (Table 1) revealed that crop biomass was significantly enhanced due to seed priming treatments comprising H_2O, DAP and KH_2PO_4 in all the five years against control. Maximum biomass yield was recorded with KH_2PO_4 seed treatment in all the five years followed by DAP. The treatment having SSP as seed treatment agent did not increase it significantly. The results were in accordance with those reported by Arif, et al. (2005) recording increased fresh weight in treated seeds compared to control. Similar results were narrated by Afzal et al. (2006) as fresh weight of wheat crop enhanced when primed with KH_2PO_4 1% phosphorus solution. The findings of this study are in line with those given by Varier, et al.(2010) reporting that seed priming had significant impact on biomass yield of wheat, the maximum being 6322.9 kg ha^{-1} from the plants primed with KH_2PO_4 over control i.e. 3260.4 kg ha^{-1}. Khalil et al. (2010) found out that wheat biomass yield enhanced with every seed primed treatment while highest obtained biomass yield was due to KH_2PO_4 0.2% phosphorus solution (6051 kg ha^{-1}). Phosphorus application through seed priming in bread wheat induced positive and significant improvements in seedling vigour and eventually biomass production. It might be due to possible increase in the rate of regeneration of ribulose 1, 5-bisphosphate, also augmented the activity and concentration of ribulose 1, 5-bisphosphate carboxylase enzyme in cereal leaves which induced positive effect on photosynthesis production in leaves (Jacob and Lawlor, 2003). The enhanced dry mater and biomass production may also be attributed to effective and better seedling growth and augmented plant nutrition (Basra et al., 2003). The increased dry matter production may be due to enhanced seedling growth and improved emergence m^2 against control (Azimzadeh & Koocheki, 1999). It was reported by Chen et al., 2012 that seed priming leads to improvement in overall crop performance by inducing positive physiological, molecular and biochemical changes.

Table 1. Seed priming effect on dry matter yield of wheat under field study

	Dry Matter Yield (kg ha^{-1})				
Treatments	**Years**				
	2015	**2016**	**2017**	**2018**	**2019**
Control	10110d ±119	9856d ±71	10182d ±157	9968d ±267	10120d ±180
H_2O	11523c ±245	11255c ±78	11376c ±149	11324c ±280	11486c ±121
DAP (1 % P)	10701b ±216	10292b ±153	10579b ±121	10460b ±295	10511b ±130
KH_2PO_4 (1 % P)	11909a ±119	11938a ±199	12071a ±123	11982a ±470	12194a ±205
SSP (1 % P)	9910d ±208	10016d ±261	10078d ±306	9818d ±10	9860d ±232

*indicates significant difference among treatment means, ± stipulates standard error with n=3

Grain yield

The physiological parameters, plant height, number of tillers, spike length and root biomass, were maximally enhanced by KH_2PO_4 followed by DAP and hydro priming. The most important crop parameter recorded was grain yield (Table 2). It was evinced from the findings that similar trend was there as in case of biomass yield. Three treatments i.e. Hydro priming, DAP and potassium di-hydrogen phosphate (KH_2PO_4) priming of seed significantly augmented grain yield of crop consistently in five years. While the most beneficial priming technique proved to be the KH_2PO_4 seed priming as it profoundly enhanced grain yield during the whole five year experimental trials. Grain yield recorded in the present study lying over five years experimental trials on wheat showed 19.6% average increase with seed priming of KH_2PO_4 1 % phosphorus solution against control. The findings are in accordance with Harris et al. (2007) reporting familiar results as in present study i.e. 48% grain yield increase in wheat due to seed priming. The incremented wheat grain yield might be attributed to seed priming effect on the metabolic activities of the seed and the synthesis of seed protein inducing detrimental and direct impact in enhancing seed performance and hence yield (Varier, et al., 2010). Similar findings were recorded by Harris et al. (2004) and Arif et al. (2007) as nutrient-priming resulted in grain yield increment in wheat. The findings of this study revealed that impact of KH_2PO_4 seed priming in wheat was more profound and detrimental than those of DAP and SSP. Single super phosphate (SSP) contains a very common phosphorus compound i.e. Ca $(H_2PO_4)_2$, whereas di-ammonium phosphate (DAP) has $(NH_4)\ H_2PO_4$ (Follett et al., 1981). It is a fact that equivalent solution, i.e. 1% P, of SSP is more strongly acidic than that of KH_2PO_4 and it also hindered wheat germination and damaged seedlings. Single super phosphate (SSP) seed priming alone significantly lowered grain yield of wheat against hydropriming and control treatments.

Table 2. Seed priming effect on grain yield of wheat under field study

Treatments	Grain Yield (kg ha^{-1})				
	Years				
	2015	2016	2017	2018	2019
Control	4127 d* ± 49	4023 d ± 29	4156 d ± 64	4069 d ± 109	4131 d ± 73
H_2O	4368 c ± 100	4201 c ± 32	4318 c ± 61	4269 c ± 114	4290 c ± 49
DAP (1 % P)	4703 b ± 88	4594 b ± 62	4643 b ± 49	4622 b ± 120	4688 b ± 53
KH_2PO_4 (1 % P)	4861 a ± 49	4873 a ± 81	4927 a ± 50	4891 a ± 192	4977 a ± 84
SSP (1 % P)	4045 d ± 85	4088 d ± 106	4114 d ± 125	4007 d ± 4	4025 d ± 95

*indicates significant difference among treatment means, ± stipulates standard error with n=3

Table 3. Seed priming effect on physiological attributes of wheat under field study during 2015-19

Treatments	Plant Height (cm)	No. of Tiller m^{-2}	Spike Length (cm)	Root Biomass (g $plant^{-1}$)
Control	82.4 c ± 1.0	221 d ± 2.0	8.4 d ± 0.10	2.18 d ± 0.05
H2O	84.2 b ± 1.2	255 c ± 3.1	8.6 c ± 0.14	2.82 c ± 0.08
DAP (1 % P)	85.5 b ± 1.3	276 b ± 2.0	8.9 b ± 0.13	3.32 b ± 0.06
KH2PO4 (1 % P)	89.0 a ± 1.3	304 a ± 2.2	9.3 a ± 0.10	4.02 a ± 0.08
SSP (1 % P)	81.4 c ± 1.1	218 d ± 1.2	8.3 d ± 0.12	± 0.04

*indicates significant difference among treatment means, ± stipulates standard error with n=3

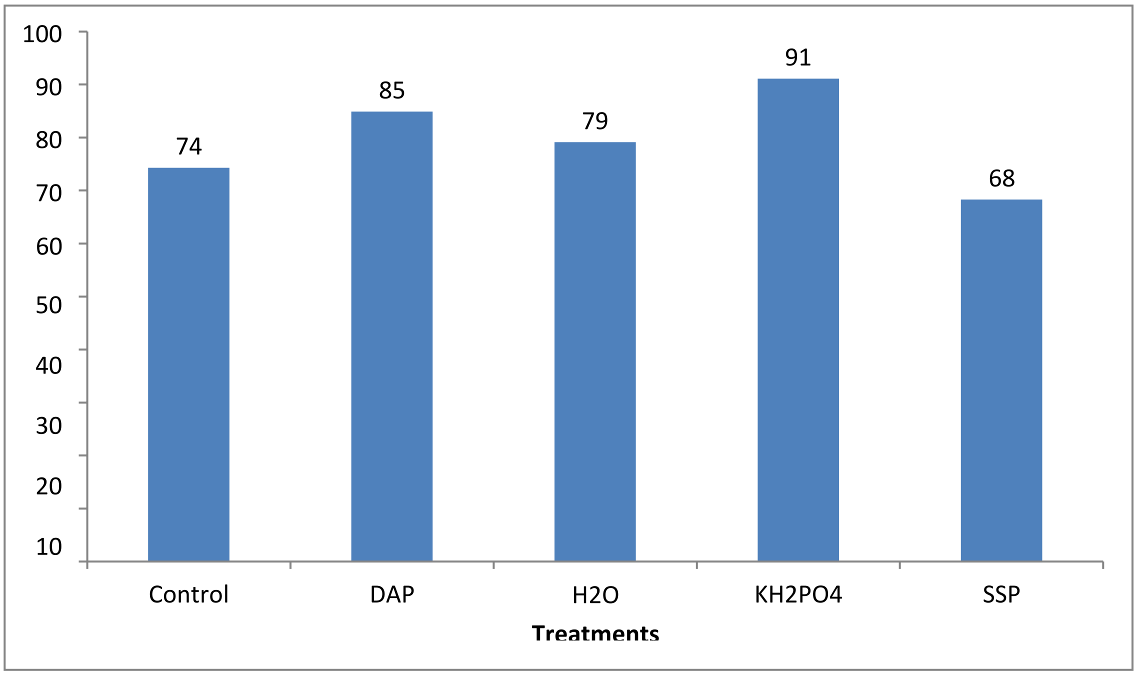

Figure 1. Seed priming effect on germination percentage of wheat under incubation study

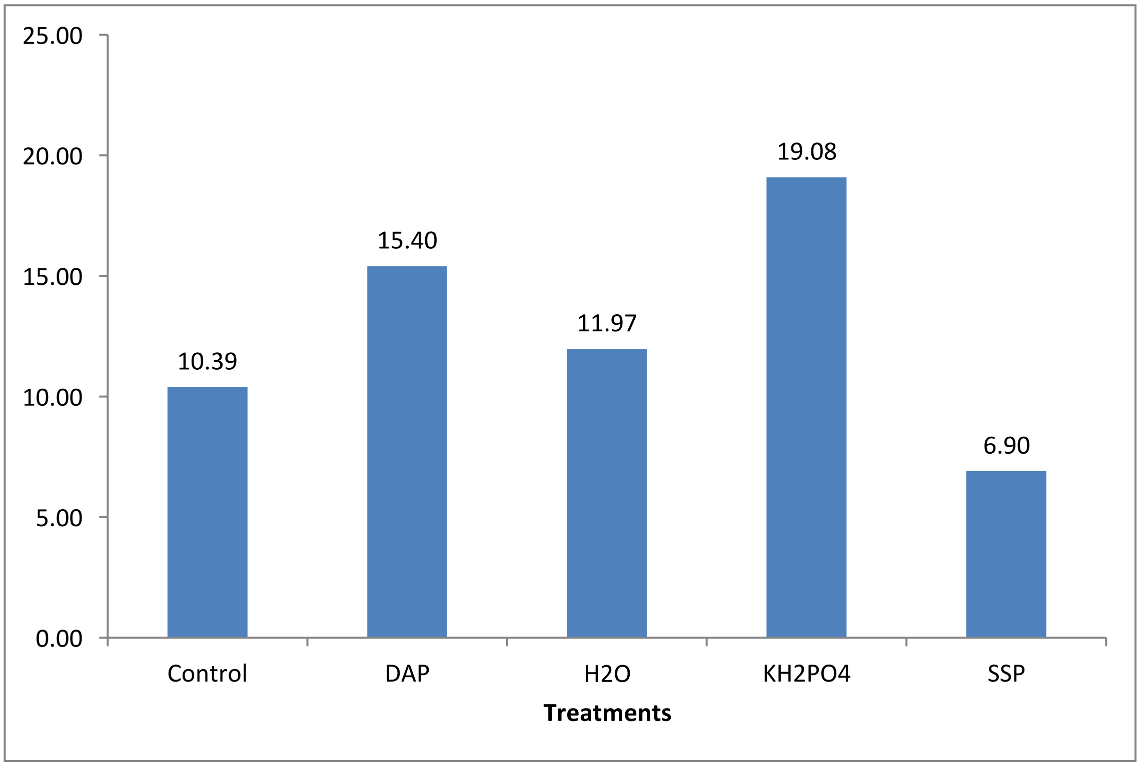

Figure 2. Seed priming effect on seedling vigour index of wheat under incubation study

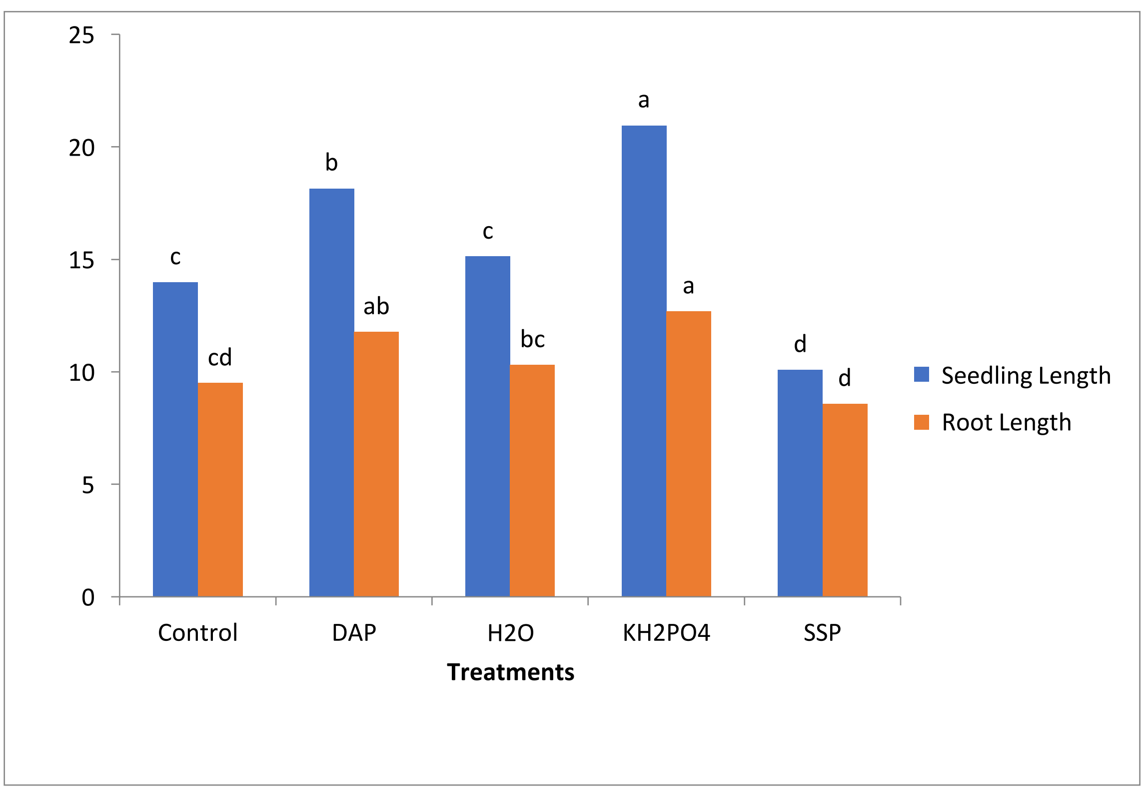

Figure 3. Seed priming effect on seedling and root length of wheat under incubation study

Conclusion

In Pothowar, a less developed agriculture region, where access and costs of specialized agricultural inputs is a limiting factor, it would be in benefit of farming community to be able to enhance the phosphorus content of their seeds to be grown with cheaper and more impactful sources of available P. It has been concluded from present study that seed priming of wheat with KH_2PO_4 is a promising technique in enhancing biomass and grain yield. It would be cost effective and more readily available phosphorus source of seed priming for the resource poor farmers of Pothowar.

Conflict of interest

No conflict of interest among authors.

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