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Research Article

Impact of fertilizer priming on seed germination behavior and vigor of maize

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Abstract

Laboratory experiments were conducted to examine the efficacy of fertilizer priming on seed germination behavior and vigor of two maize cultivars "Azam and Phari" at Agronomy Research Laboratory, University of Agriculture, Peshawar- Pakistan during 2015. Studied treatments include hydropriming (distilled water) and osmopriming with Calcium Ammonium Nitrate (CAN) at 0.5% for 24 hours. Non primed seed were used as control. Data were recorded on germination and vigor parameters according to standard procedures. Results showed that both hydro and osmo-priming significantly improved germination %, mean germination time, germination index, plumule and radical length, seedling fresh and dry weight of both cultivars as compared to control treatment. Cultivar Azam performed better in all germination and vigor attributes than Phari. It was concluded that both hydro and osmopriming with Calcium Ammonium Nitrate (CAN) at 0.5% for 24 hours are practical approaches for improving growth and vigor of maize crop under harsh environment.

Keywords: Seed priming; Fertilizer priming; Hydropriming; Germination; Vigor attributes

Introduction

Maize is a multipurpose crop and widely grown for human and animal nutrition and used for agro-industrial purposes worldwide **[1]**. Its grain is a rich source of starch (72%), vitamins A & B (3 – 5%), proteins (10%), oil content (4.8%), 5.8 % fiber, 3.0% sugar and 1.7% ash. In spite of high yield potential of maize, its yield per unit area is low as compare to other advanced countries of the world. In Pakistan maize was cultivated over an area of (1130) thousand hectares with an annual production of (4695) thousand tones with an average yield of (4155) kg ha^{-1} (PES, 2014-15). In KP it was grown on about (470.9) thousand hectares with production of (914.8) thousand tons annually. The average yield of maize in KP was (1943) kg ha^{-1} **[2]**. In KP, maize crop grown in Peshawar, Mardan, Swabi, Malakand, Charsada, Haripur include irrigated belt of D.I.Khan, Bannu and Kohat **[3]**. In semi-arid tropic of Khyber Pukhtunkhwa, maize production is widely limited by poor stand establishment and nutrient deficiencies. Poor seed germination and seedling establishment are determined by many factors including quality of seeds and environmental factors. Physical, chemical and biological factors within the environment influence seed vigor, germination speed and seedling growth.

Seed priming is a pre-sowing strategy for influencing seedling development by enhancing pre germination metabolic activity prior to emergence of the radical and generally enhances germination rate and plant performance. Seed priming has been shown to improve seed performance under sub-optimal temperature conditions **[4]**. Germination and emergence both are sensitive to adverse soil conditions **[5]**. It has been reported that on-farm trials of priming in maize, increase yield up to 6% (non-primed yield 4.4 t ha^{-1}; **[6]** and 33% (non-primed yield 3.1 t ha^{-1}; **[7]** were recorded. Nitrate solutions produce more vigorous seedling and higher dry matter accumulation and root length as compared to non-primed seeds. Seed priming treatment can lead to better germination and establishment in many crops such as maize, wheat, rice, canola **[8]**. Priming treatments help in faster seedling emergence and increase seedling shoot fresh weight as compared to non-primed seeds. Many researchers have reported that seed priming in rapeseed improved germination percentage and increased seedling establishment **[9, 10]**. Seed priming had positive effect on germination characteristics of other crops, such as corn **[11, 12]**, popcorn (Zea mays sacharum L) **[13]**, and cotton (Gossypum hirsutum L.) **[14, 15]** reported that nutripriming in 4% mono ammonium phosphate can improve effective tillers and grain yield of direct sown rice. Keeping in view the significance of seed priming, present study was designed to evaluate hydro and fertilizer priming technique on germination behavior and vigor of maize cultivars under laboratory conditions.

Materials and methods

A laboratory experiment entitle "Impact of fertilizer priming on seed germination behavior and vigor of maize" was conducted at Agronomy Research laboratory, University of Agriculture Peshawar, Pakistan, during 2015. The experiment was laid out in completely randomized (CRD) design having two factors. Factor "A" was consist of maize cultivars "Azam and Phari" while factor "B" was consist on three priming treatments i.e: hydro-priming (distilled water), osmo-priming (CAN @ 0.5%) and dry seed/control. Seeds of both cultivars were obtained from the Research Farm, Agriculture University, were surface sterilized in 10% sodium hypochlorite solution for 10 minutes, then rinsed with sterilized water and air-dried at room temperature closely to original moisture level. Seeds of both cultivars were subjected to 24 hours priming in distilled water and Calcium Ammonium Nitrate solution @ 0.5%. Non primed seeds were used as control. The solution to seed ratio was **1:2.5** for all the treatments. Germination potential of controlled and treated seeds was estimated in accordance with (AOSA, 1983).To test seed germination and seedling vigor, four replicates of 25 seeds were germinated in plastic trays with moist blotting paper, replicated four times and were placed in growth chamber at 25°C temperature for 7 days. A seed was considered to have germinated when coleoptile and radical lengths have reached 2 mm. Counts of germinating seeds were made daily, starting on the first day of imbibition and terminated when maximum germination was achieved. The time to reach 50% germination (T_{50}) of final germination was calculated according to the following formula of Coolbear et al. (1984):

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

Where N is the final number of germination and ni, nj cumulative number of seeds germinated by adjacent counts at time ti and tj when ni < N/2 < nj.

Germination index (GI) was calculated according to AOSA (1983) formula:

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

Seedling emergence

Control and treated seeds were sown in plastic trays (25 in each) having moist sand, replicated three times and were placed in growth chamber at 25°C temperature in completely randomized design. Emergence was recorded daily according to AOSA rules (2009). Mean emergence time (MET) was calculated according to the equation of Ellis and Roberts (1981) as under:

$$\textbf{MET} = \Sigma Dn / \Sigma n$$

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 emergence. The plants were harvested 12 days after planting and seedling vigor data were recorded according to AOSA (2009).

Measurement of root and shoot length

Root and shoot length of all 25 seedlings were measured after 12 days of experiment. It was measured with a measuring scale and expressed in centimeters. These seedlings were kept in brown paper and weighed the fresh weight first and were died in oven at 70°C for 48 hours to record the dry weight. These were measured with electronic balance and expressed in gram.

Statistical analysis

The data was analyzed statistically using analysis of variance techniques appropriate for Completely Randomized Deign on computer based software "Statistix" version No (8.1). The treatments mean were compared using least significant difference (LSD) test at 0.05 level of probability [22].

Results

Germination (%)

Perusal of the data shows that seed priming treatments significantly affected the germination of both cultivars. Whereas the interaction between priming treatments and varieties (P x V) was found non-significant (figure 1). Osmo priming enhanced germination percentage as compared to other priming treatments. Optimum germination percentage (82%) was observed in osmo primed seed followed by dry/non-primed seed (64%). Minimum germination percentage (64%) was noted when the seeds were primed with water (hydro-priming). Cultivars positively responded to priming treatments. Optimum germination percentage (73%) was given by cultivar "Azam" followed by cultivar "Phari" having lowest germination percentage (64%).

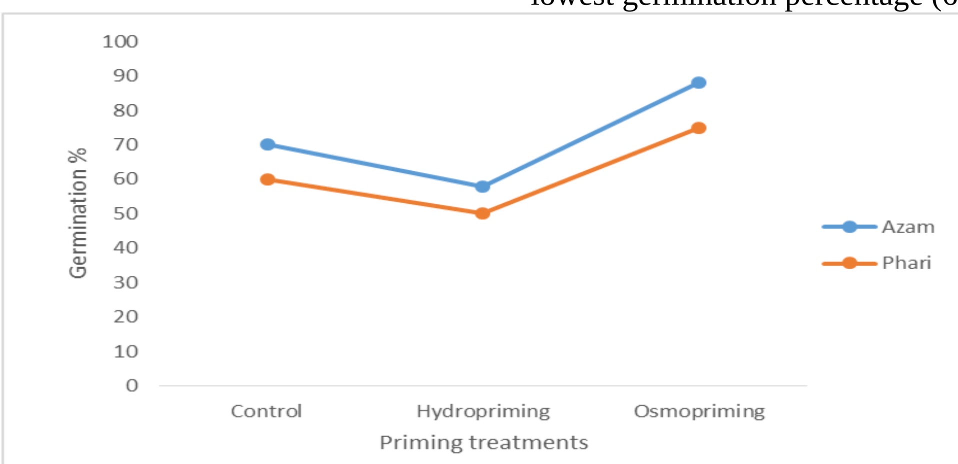

Figure 1. Germination % of maize influenced by priming treatments

Germination index and mean germination time (GI, MGT)

Priming treatments significantly affected the germination vigor of both cultivars. The response of both cultivars to different priming techniques approximately was similar. Earlier germination was recorded for hydroprimed seeds and mean germination time (MGT). Seeds hydroprimed had lowest values and MGT was observed in osmoprimed seeds which were subjected to Calcium Ammonium Nitrate (CAN) at 0.5% for 24-hours solution. All the seed treatments resulted in higher MGT, being highest in CAN priming. Maximum GI and were noted in untreated seeds, all the seed treatments resulted in lower values of GI.

Plumule length (cm)

Data regarding plumule length (cm) are presented in Figure 2. Analysis of the data showed that plumule length (cm) was significantly affected by priming treatments and varieties. Interaction between priming treatments and varieties (P x V) was found non-significant. Maximum plumule length (3.34 cm) was noted in seeds treated with CAN 0.5% followed by non-primed seed (2.73 cm). Minimum plumule length (2.25 cm) was produced by seeds primed with water. Non primed seed showed better performance than hydro primed seed in term of plumule length. Similarly varieties responded positively to priming and optimum plumule length was noted in cultivar "Azam" having 2.95 cm plumule length followed by cultivar "Phari" (2.60 cm) respectively.

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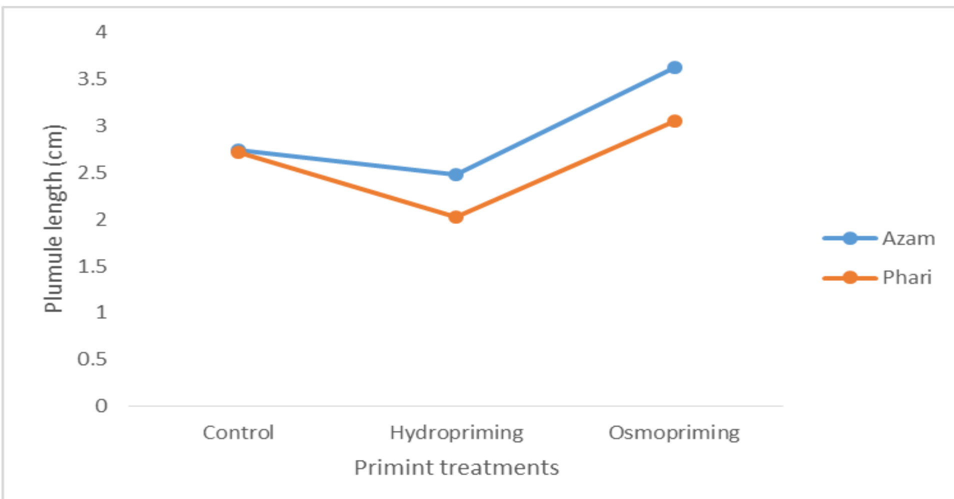

Figure 2. Plumule length (cm) of maize influenced by priming treatments

Radicle length (cm)

The influence of priming on root length of cultivars are presented in Figure 3. Perusal of the data revealed that priming treatments and interaction between priming and varieties (P x V) had significant effect on root length while varieties had non-significant effect in this order. Dry seed/control treatment (non-primed seed) shows highest radicle length (5.95 cm) as compared to hydro and osmo-priming having at par radicle length 4.47 and 4.65 cm respectively. Mean data of varieties indicates that Phari have maximum root length (5.11 cm) than Azam (4.95 cm). The combine effects of priming and varieties data indicate significant ($P \leq 0.05$) on root length. Phari variety maximum root length (6.75 cm) under control treatment of priming than hydro and chemo treatments of priming. In case of interaction cultivar "phari" showed optimum radicle length (6.75 cm) as compared to cultivar "Azam" in control treatment. As seeds were primed with water the radicle length was observed with short length as compared to CAN primed seed. Cultivar " Azam" showed relatively better performance than "Phari" in term of radicle length when primed with water and CAN at 0.5% while highest radicle length (6.75 cm) was gave by cultivar " Phari" when seeds were non primed.

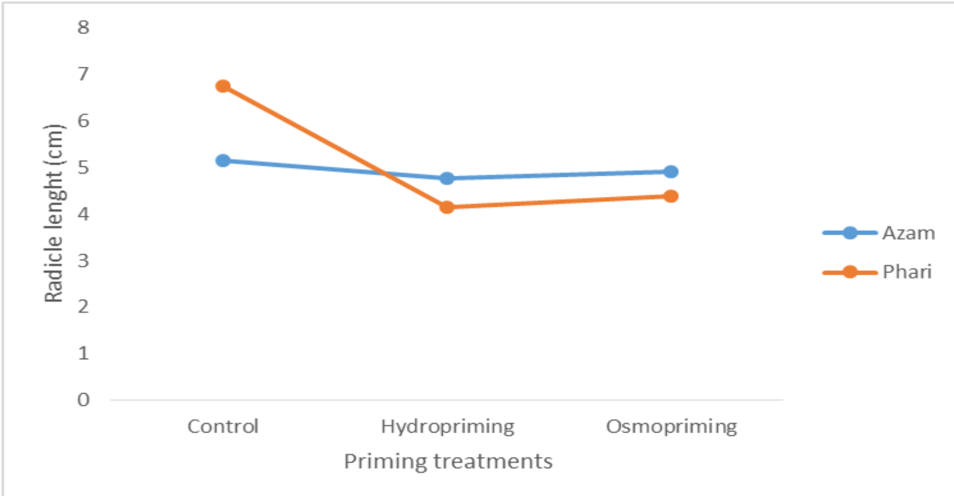

Figure 1. Radicle length (cm) of maize influenced by priming treatments

Fresh and dry weight of seedling (mg)

Dry weight of seedling (DWS) was non-significant at all the treatments whereas perusal of the data indicated that priming had significant effect on SFW of maize whereas varieties and interaction between priming and varieties (P x V) had non-significant effect of SFW. Mean data showed that FDW was responded positively to priming treatments and significant difference was found in SFW of all the priming treatments. Highest SFW (3533.8 mg) was produced by the seeds primed with chemical followed by non-primed seed (2811.2 mg). The lowest SFW (1178.8 mg) was recorded when the seeds were treated with hydro priming

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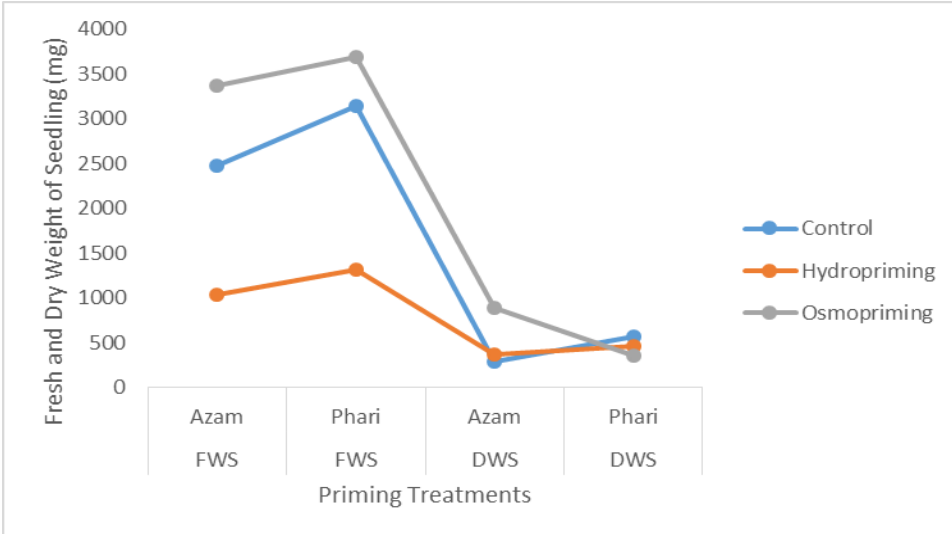

Figure 2. Fresh and dry weight of seedling (mg) influenced by priming treatments

Discussion

The effect of osmo priming has high germination % as compared to control and hydro priming. Cultivar Azam have maximum germination % than Phari. Germination % was significantly affected by priming and varieties. Similar results was observed by [15] reported that germination and early growth of inbred lines of maize were enhance by priming. This might be due to chemical changes in seeds and might be due to enzyme activation by various priming techniques. [16] Reported that dry seeds took 10 day to reach 50% emergence while water and osmo primed seeds reached 50% emergence in five days. They concluded that osmo primed seeds (2% Zn solution and 1% P solution) produce superior seed emergence as compared to dry seeds in control condition. [12, 13, 18] also concluded the same findings of priming for crop stand, germination and emergence. Plumule length of maize cultivars significantly affected by priming. [2, 3, 16] also noted the same results of on-farm seed soaking on emergence. Maximum shoot length was recorded for osmo priming (81.625 cm). [12,19] also recorded that priming treatment significantly affect fresh weight, shoot length, number of roots, root length, and seedling growth of three maize varieties. Earlier germination was recorded for hydroprimed seeds and mean germination time (MGT). Seeds hydroprimed had lowest values and MGT was observed in osmoprimed seeds which were subjected to Calcium Ammonium Nitrate (CAN) at 0.5% for 24-hours solution. All the seed treatments resulted in higher MGT, being highest in CAN priming. Maximum GI and were noted in untreated seeds, all the seed treatments resulted in lower values of GI. The influence of priming showed significant effect on radical length. Control treatment showed highest root length as compared to hydro priming and osmo priming. Similarly the interaction of priming and varieties showed significant effect on radical length. [17,18, 21] studied the osmo priming of Ca and Zn combination on maize and confirmed that seeds behavior and germination was optimized with fertilizer treatments. Similar results was founded by [13]. They examined that increase in germination rate, seed vigor, seedling fresh weight, seedling height and root length and number was recorded when the seeds primed with fertilizers. [17, 19, 23] also reported the significant effect of priming on three varieties of maize. They divulge that fresh weight, shoot length, number of roots and root length was enhanced with various priming. Seedling fresh weight of maize indicates that osmo priming optimize internal behavior of the concern enzymes involved in germination process and other seed vigor attributes stimulated by priming treatments. The results of this experiment agreed with the finding of **[14, 15, 18, 24]** who reported that priming increase the germination rate, seed vigor, seedling fresh weight, seedling height and root length and number.

Conclusions

The overall results of the present investigations lead us to the conclusion that both hydro and osmopriming with calcium ammonium nitrate (CAN) enhanced germination behavior and vigor of both cultivars. However, fertilizer priming with 0.5% Calcium Ammonium Nitrate for 24 hours gave best results as compared to hydro-priming. Cultivar Azam performed better over Phari in all studied parameters.

Authors' contributions

Conceived and designed the experiments: AZ Khan, Performed the experiments: A Khalil & H Gul, Analyzed the data: Imran & A Muhammad, Contributed reagents/ materials/ analysis tools: H Akbar & S Wahab, Wrote the paper: AZ Khan & Imran.

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