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Impact of Seed Priming on Germination Parameters of Maize under Different Temperatures

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Abstract Low temperatures during germination and early emergence of seedlings may constitute a limitation of maize yield, this being a deficiency in early spring cultivation. Seed priming is an efficient method for improvement of germination and seedling growth and also adaptation of abiotic stress factors during germination, and provides faster and synchronous seedling emergence. The effects of different priming treatments on germination parameters of maize seeds under different temperatures (5°C, 10°C, 15°C, 27°C, 35°C) were investigated. Seeds of maize cultivar were primed in different concentration of salicylic acid, calcium chloride and boric acid solutions and water. From the results obtained it has been observed that seeds exposure to temperatures of 5°C and 10°C of all treatments studied did not initiate germination after 7 days, and even after 14 days. All of the priming treatments applied seeds have been effective in attenuation the effects of temperature 15°C, inducing early germination. Results indicated that the best priming treatments for maize seeds were with salicylic acids followed by calcium chloride. Immersion of seeds with boric acid inhibit germination at 15°C and has weak effect on seed germination at 27°C and 35 °C.

Key words

hydropriming, salicylic acid, boric acid, maize seeds

Maize (*Zea mays* L.) is the most widely grown cereal crop in the world and is an important crop in sustaining human life or as feed commodity, as well as significant bioethanol energy resource [18]. Pedo-climatic and agronomic factors, such as soil moisture, temperature extremities, soil salinity poor seed bed preparation, weed competition, low seed quality, and disease pressure adversely can be affecting the germination and emergence of maize seed and establishment of crop.

Maize sowing in early spring are often subjected to temperature below the optimal range of 20°C to 25°C. Low temperature stress during germination and early seedling growth is an important constraint for production of maize and can determine delay germination, low seedling growth vigour and reduced yield. Thus identify and development of maize cultivars tolerant to cold temperatures in early growth stages is essential for high and stable yield. This can be achieved by choosing the appropriate period for sowing, which must be carried out in order to ensure that the termal load is sufficient to reach the reproductive stage during a period of favourable climatic conditions, and maximum incidence of solar radiation [7].

To reduce time of germination a way is soaking or immersion of seeds (priming) in water or different substance to accelerate germination and emergence of seedlings. Seed priming is a pre-sowing treatment which controls the hydration level of seed and the metabolic activity in seeds improved germination rate and uniformity [3,4,6,17]. Seed priming has been reported to improve germination, reduce germination time, and improve stand establishment, increase seedling emergence, earlier flowering, earlier maturing and higher yield in many crops [3,8,10,11,16,19].

There is a lot of information available on the role of priming treatments of maize seeds and posibile physiological processes that lead to the benefits [1,2,9,12,18,19,20, 26].

The present study was carried out to investigate the effect of seed priming with salicylic acid, calcium chloride and boric acid solutions of different concentrations at different temperatures on germination parameters.

Materials and Methods

Seeds of hybrid maize P9486 were used as biological material with initial moisture contents of 12.5%.

Maize seeds were primed in flask using two different concentrations of salicylic acids (SA) solution (50 and 100 mg/ L) corresponding V1 and V2 variants, two different concentrations of $CaCl_2$ (1% and 3%) solution corresponding to V3 and V4 variants and two concentration of boric acid (2% and 3%) solution corresponding to V5 and V6 variants. The untreated dry seeds were used as control (M) and seed treated

with distilled water (hydropriming) corresponded variant A. For priming, maize seeds were soaked in solutions for 20 h at room temperature (25°C). The ratio of seed weight to solution volume was 1:5 (w/v). After each treatment, seeds were rinsed thoroughly with distilled water, spread on thin layer of filter paper and dried back closer to original weight. Three replicates, each of 15 seeds, were germinated in petri dishes 9 cm diameter on Whatman filter paper.

Just enough distilled water (3 ml) to moisten the filter paper was provided initially. Moisture level was checked daily and topped-up as necessary, 5 ml distilled water was added to maintain sufficient moisture for germination. Seeds were incubated at different temperatures (5°C, 10°C, 15°C, 27°C, 35°C) in incubator. Germination was considered to have occurred when the radicles were half of the seed length. The number of germinated seeds was evaluated daily, for 7 days. Seed germination parameters, such as percentage of maximum germination, mean germination time and germination index were calculated.

Mean germination time (MGT) was calculated according to the following formula: MGT= Σ(NiDi)/T; where T is total number of seeds germinated, Ni is the number of seeds germinated on day and D_i is the number of days after experiment initiation [23].

Final germination was calculated in percentage after 7 days using the following formula:

% Germination =total number of seeds germinated /Number of total seeds × 100

Germination index: The germination index (GI) was calculated by following formula (AOSA, 1983): GI =Σ(Ni/Di);Ni is number of germinated seeds/days of first count + -- +Number of germinated seeds/days of final count; Di is the number of days after experiment initiation.

Results and Discussions

In order to ascertain the effect of seed priming in alleviating the adverse effects of temperature stress, different methods were used hydropriming (with water), osmopriming (with $CaCl_2$) and hormonal priming (with salicylic acid) and nutrient priming (with boric acid).

Germination of maize seed was influenced significantly by priming methods, temperature and solutions concentration.

From the results obtained it was observed that the exposure at the temperatures of 5°C and 10°C of the seeds of all the variants under study did not initiate the germination neither after 7 days nor after 14 days. Also, the untreated (M) seed did not germinate at 15°C and 35°C. Similar findings were reported by Janowiak [15] which supported that at temperatures under 10°C, maize seed germination is badly affected. Negative influence of low temperatures on seed germination parameters has been reported by Nascimento, [21] in different plant species.

All priming variants applied to the seeds were effective in alleviating the effects of the temperature of 15°C, inducing early germination. The results in table 1 showed that both hydropriming and different concentration of salicylic acid caused significant increase in seeds germination percentage compared with control treatment.

Maize seeds priming with 100 mg /L salicylic acid (V2) germinated at 100% at 15°C. However, this concentration at 27°C resulted in 98.1% germination and 93.7% germination at 35 ° C. It can be observed that the salicylic acid concentration of variant V2 had a higher efficiency than that of variant V1(50 mg /L) on germination of maize seeds. The use of 50 mg /L salicylic acid improves the percent of germination compared to hydropriming, but the degree of improvement is lower than the other (100 mg /L) salicylic acid concentration. Positive effects of priming with SA on seed maize germination under cool temperature are also confirmed by the studies of Afzal, [1]. In another study, Farooq [12] found that seed priming with SA improve the germination of maize at low temperature.

Table 1

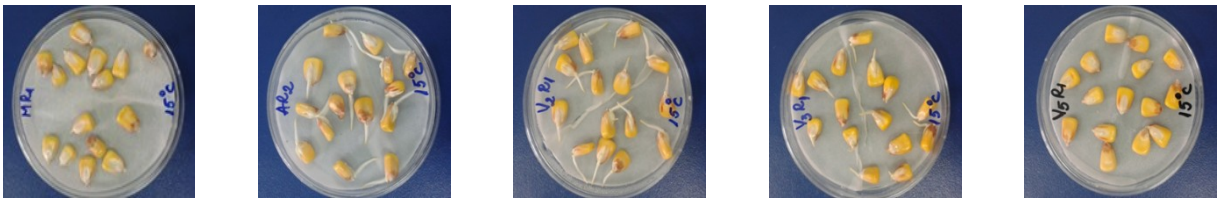
Influence of different seed priming treatments and different temperatures on maize seed germination percentage

Seed priming treatments	*Final germination percentage (%)*				
	Temperature				
	5°C	*10°C*	*15°C*	*27°C*	*35°C*
Control untreated (M)	-	-	-	*15*	-
Hydropriming (A)	-	-	*95.1*	*98*	*86.6*
Salycilic acid 50mg/L(V1)	-	-	*98.25*	*93.3*	*87*
Salycilic acid 100mg/L(V2)	-	-	*100*	*98.1*	*93.7*
$CaCl_2$ 1% (V3)	-	-	*90*	*86*	*93.4*
$CaCl_2$ 3% (V4)	-	-	*66.6*	*55.3*	*75*
H_3BO_3 2 % (V5)	-	-	-	*45*	*60*
H_3BO_3 3 % (V6)	-	-	-	*7*	*15*

Priming of seeds in 1% $CaCl_2$ solution resulted in a seed germination percentage of 90% at 15°C, followed by a germination percentage of 93.4% at 35 °C and then 86% of the seeds at 27°C (table 1). Seed primed with Ca Cl_2 has been found to improve chilling tolerance in hybrid maize [12].

Maize seeds primed in the boric acid solution 2% and 3% did not germinated at 5°C, 10°C and 15°C and low germination at 27°C and medium germination at 35°C (table 1). Low germination probability happened because of the high concentration of boric acid. It is known that boron is involved in various cellular processes such as cell division, and may therefore interfere in germination, considering that this involves division and cell elongation [4].

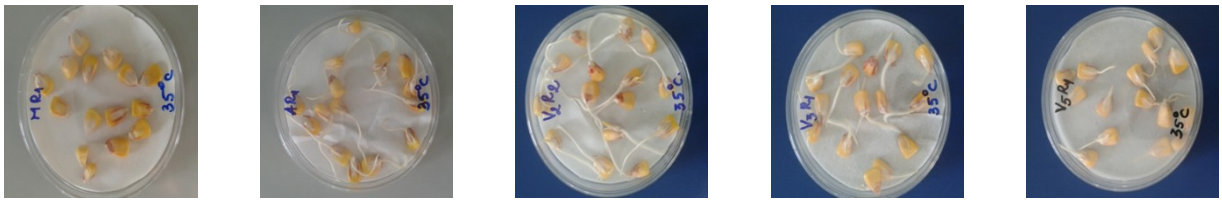
Some experiments shown that rice primed in boric acid solution (0.5%) did not germinate [22] and boric acid solution (2 to 20mM) had germination suppressing effect in wheat and barley [25] and also were unable emerge. Also, some studies on oats seed priming with 0.02% solution of H_3 BO_3 had no marked effect on seed germination and no improvement in the performance of seeds. However, the studies of Farooq [13] have shown that seed priming in 0.001% and 0.01% H_3BO_3 solution improve substantially germination and stand establishment of rice. Also, improvement of germination percent and early seedlings emergence was observed at papaya seeds primed with 2mg/L boric acid [8].



Unpriming hydropriming SA 100mg/L $CaCl_2$ 1% H_3BO_3 2%

Fig.1 Influence of different priming treatments at low temperature (15℃) on the percentage germination of maize seed

Low germination or poor germination of seeds at low temperatures can be attributed to reduced water absorption, low cell respiration, or increased levels of reactive oxygen species. Enhance in germination percentage after priming treatment might be the consequence of breakdown of dormancy in fresh seeds. Alternatively, the earlier and synchronized germination might be attributed to enhanced metabolic activities in treated seeds [24].



Unpriming Hydropriming SA 100mg/L $CaCl_2$ 1% H_3BO_3 2%

Fig.2 Influence of different priming treatments at high temperature (35℃) on the percentage germination of maize seed

Many previous studies on maize [1,5,14], sunflower [10] have reported the enhanced germination and seedling growth under low temperature through priming of seeds.

The highest germination was recorded when primed seeds with salycilic acid followed by $CaCl_2$, hydro-priming, and the lowest germination was noticed from boric acid and nonprime seed.

Table 2

Influence of different seed priming treatments and different temperatures on maize seed mean germination time

Seed priming treatments	*Mean germination time(MGT)*				
	Temperature				
	5°C	*10*°C	*15*°C	*27*°C	*35*°C
Control untreated (M)	-	-	-	*7*	-
Hydropriming (A)	-	-	*6*	*4.4*	*3.5*
Salycilic acid 50mg/L(V1)	-	-	*3.3*	*3*	*2*
Salycilic acid 100mg/L(V2)	-	-	*3.1*	*3*	*2*
$CaCl_2$ 1% (V3)	-	-	*3.8*	*3.1*	*2.8*
$CaCl_2$ 3% (V4)	-	-	*3.5*	*3*	*3*
H_3BO_3 2 % (V5)	-	-	-	*8.5*	*7*
H_3BO_3 3 % (V6)	-	-	-	*8.6*	*7*

The mean germination time (MGT) varied significantly due to priming treatment (table2). Earlier germination was observed in primed seeds compared with those of unprimed and hydropriming. Average mean germination time was lower (3 day) in primed seeds than that of non- primed seeds (7 day). Seed primed in salicylic acid and calcium chloride took minimum time to germinate 3 days at 15°C, 27°C and 35°C while time for unprimed seeds was more 8 days for 15°C and 35°C and 7 days at 27°C. These results are similar to those presented by Canak [5] who found an improvement in the germination rate of seed resulting from a pre-germinated treatment using KNO_3 0.5%.

Seed priming with SA 100mg/L induced highest increase in the germination index. Kumari [18] reported that maize seeds primed with salicylic acid and calcium chloride recorded significantly highest germination index as compared to control.

Conclusions

Seed priming with different concentrations of different compound can be successfully used to improve the germination of maize seeds.

The results indicated that priming treatments with salicylic acid is considered the best treatment for maize seed germination at 15°C.

Seeds primed with boric acid did not germinate at 5°C,10°C,15°C temperatures and at 27°C and 35°C have shown poor germination.

The results revealed that SA and $CaCl_2$ priming were more effective under low temperature than all other seed priming treatments in maize seeds.

Seed priming treatments decreased seed MGT and increase germination index compared with unprimed and hydroprimed treatments.

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References

1. Afzal I., Basra S.M.A., Shahid M., Farooq M., Saleem M., 2008- Priming enhances germination of spring maize (*Zea mays* L.) under cool temperature, Seed Sci. Technol, 36(2): 497-503.

2. Ahmad I., Khaliq T., Ahmad A., Basra S. M. A., Hasnain Z., Ali A., 2012- Effect of seed priming with ascorbic acid, salicylic acid and hydrogen peroxide on emergence, vigor and antioxidant activities of maize, Afr. J. Biotechnol, 11: 1127-1137.

3. Atalou F.R., Mirshekari B., Vishkaei M. N. S. Z. 2014-Hormonal seed priming with GA and kinetin influences seed and oil yields in two sesame cultivars, International Journal of Fundamental and Applied Life Sciences, 4: 266-270.

4. Bewley J. D., Bradford K., Hilhorst H., Nonogaki H. 2013- Seeds: physiology of development, germination and dormancy. New York: Springer.

5. Canak P., Mirosavljevic M., Cirić M., Vujoševic B., Keselj J., Stanisavljevic D., Mitrovic B. 2016- Seed priming as a method for improving maize seed germination parameters at low temperatures, Rotar Povrt, 53(3): 106-110.

6.Chen K., Arora R. 2013- Priming memory invokes seed stress-tolerance, Environmental and Experimental Botany, 94:33-45

7. Cruz R. P., Milach S. C. K. 2004 - Cold tolerance at the germination stage of rice: methods of evaluation and characterization of genotypes, Scientia Agricola, 61(1): 1-8

8. Deb P., Das A., Ghosh S.K., Suresh C.P. 2010- Improvement of seed germination and seedling growth of papaya (*Carica papaya* L.) through different pre-sowing seed treatments, Acta Horticulturae 851: 313–316.

9.Dezfuli P. M., Sharif-Zadeh F., Janmohammadi M. 2008- Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays*L.), ARPN Journal of Agricultural and Biological Science, 3: 22-25.

10. Draganic I., Lekic S. 2012- Seed priming with antioxidants improves sunflower seed

germination and seedling growth under unfavorable germination conditions, Turkish Journal of Agriculture and Forestry, 36: 421-428.
11. Elkoca E. 2014- Osmo- and hydropriming enhance germination rate and reduce thermal time requirement of pea (*Pisum sativum* L. cv.Winner) seeds, Akademik Ziraat Dergisi, 3(1):1-12.
12. Farooq M**.**, Aziz T., Basra S.M.A., Cheema M.A., Rehman H. 2008- Chilling tolerance in hybrid maize induced by seed priming with salicylic acid, J. Agron. and Crop Sci*.,* 194(2):161–168.
13. Farooq M., Rehman A., Aziz T., Habib M. 2011- Boron nutripriming improves the germination and early seedling growth of rice (*Oryza sativa* L.), J. Plant Nutr., 34: 1507–1515.
14. Guan Y.J., Hu J., Wang X.J., Shao C.X. 2009- Seed priming with chitosan improves maize germination and seedling growth in relation to physiological changes under low temperature stress, J. Zhejiang Univ. Sci., B10: 427–433.
15. Janowiak F., Maas B., Dörffling K. 2002- Importance of abscisic acid for chilling tolerance of maize seedlings, J. Plant Physiol., 159: 635–643
16. Korkmaz A., Pill W.G. 2003- The effect of different priming treatments and storage conditions on germination performance of lettuce seeds, European Journal of Horticultural Science, 68(6):260-265
17. Khan A.A. 1992- Preplant physiological seed conditioning, Horticultural Reviews,13(13):131–181.
18. Kumari N., Kumar- Rai P., Bara B.M., Singh I. 2017- Effect of halo priming and hormonal priming on seed germination and seedling vigour in maize (*Zea mays* L.) seeds, Journal of Pharmacognosy and Phytochemistry, 6(4):27-30.
19. Murungu F.S., Nyamugafata P., Chiduza C., Clark L.J., Whalley W.R. 2005- Effects of seed priming and water potential on germination of cotton (*Gossypium hirsutum* L.) and maize (*Zea mays* L.) in laboratory assays. South African J. Plant Soil 22(1): 64-70.
20. Nagar, R.P, Dadlani M., Sharma S. P. 1998- Effect of hydropriming on field emergence and crop growth of maize genotypes, Seed Research, 26(1): 1-5.
21. Nascimento, W. M. 2005- Vegetable seed priming to improve germination at low temperature, Horticultura Brasileira, 23(2):211-214.
22. Rehman A., Farooq M., Cheema Z.A., Wahid A. 2013-Role of boron in leaf elongation and tillering dynamics in fine grain aromatic rice, Journal Plant Nutr., :36(1):42-54.
23. Scott S.J., Jones R.A.,Williams W.A. 1984- Review of data analysis methods for seed germination, Crop Sci. 24: 1192–1199.
24. Shakirova, F.M., Sakhabutdinova A.R., Bezrukova M.V., Fatkhutdinova R.A., Fatkhutdinova D.R. 2003- Changes in the hormonal status of wheat seedlings induced by salicylic acid and salinity, Plant Sci., 164: 317– 322.
25. Shorrocks V.M. 1997- The occurrence and correction of boron deficiency, Plant Soil, 193:121-148.
26. Sikder S., Hasan M.A., Hossain M.S. 2009- Germination characteristics and mobilization of seed reserves in maize varieties as influenced by temperature regimes, J. Agric. Rural Dev., 7(1&2): 51-56.