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EFFECT OF OSMOPRIMING ON THE EMERGENCE OF MAIZE (*Zea mays* L.) SEEDLING

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Abstract

The research work was carried out at the Seed Laboratory of Agronomy Department of Bangladesh Agricultural University, Mymensingh, Bangladesh during the period from March to November in 2008 to find out the effect of different osmopriming techniques on seedling emergence of maize. Seventeen osmopriming techniques viz., T_1 = 1% Na_2SO_4, T_2 = 3% Na_2SO_4, T_3 = 5% Na_2SO_4, T_4 = 1% K_2HPO_4, T_5 = 3% K_2HPO_4, T_6 = 5% K_2HPO_4, T_7 = 1% $ZnSO_4$, T_8 = 3% $ZnSO_4$, T_9 = 5% $ZnSO_4$, T_{10} = 1% $Ca(H_2PO_4)_2$, T_{11} = 3% $Ca(H_2PO_4)_2$, T_{12} = 5% $Ca(H_2PO_4)_2$, T_{13} = 1% H_2O_2, T_{14} = 3% H_2O_2, T_{15} = 5% H_2O_2, T_{16} = Hydropriming, T_{17} = Non-priming (control) were used as experimental variables. Different osmopriming methods on seedling emergence performance of maize was evaluated at two moisture levels viz., 30 and 60% moisture of saturated sand in the experiment. Germination percentage, germination index and mean germination time were influenced significantly by osmopriming methods. Seed priming with 3% $ZnSO_4$ showed the highest seedling emergence which was followed by 1% H_2O_2 and 3% Ca $(H_2PO_4)_2$.

Keywords: Maize, osmopriming, emergence.

Introduction

Maize is the important cereal crop of Bangladesh. Good seedling establishment of maize is a prerequisite for successful production because it has no capacity to adjust sub-optimal stand by tillering (Finch Savage *et al*., 2004). Rapid, uniform, and optimum crop stand establishment is necessary for obtaining higher yield of maize. Seed priming can be a simple solution towards expected stand establishment (Harris *et al*., 2001). Heydecker *et al*. (1973) defined osmotic seed priming as a pre-sowing treatment in an osmotic solution that allows seeds to imbibe water to proceed to the first stage of germination but prevent radicle protrusion through the seed coat. Seed priming allows the seed to imbibe water slowly, permitting the early stages of germination to begin without radicle protrusion through the seed coat. Osmopriming is the most widely used type of seed priming in which seeds are soaked in aerated low water potential solution (Farooq *et al*., 2005). Priming of seeds in osmoticums has been reported to be an

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economical, simple and a safe technique for seedling establishment and crop production under stressed conditions (Guzman and Olave, 2006).

Different osmotica can be used in seed priming, such as osmotica used include Polyethylene Glycol (PEG), KNO_3, K_3PO_4, KH_2PO_4, $MgSO_4$, NaCl, manitol and others (Lee and Kim, 1999; Basra *et al*., 2005). Sunflower seeds treated with PEG-8000 solution at 15 ^oC had an increased germination rate (Bailly *et al*., 2000). Kattimani *et al*. (1999) found that seed primed with nitrate solutions produced more vigorous seedlings, higher dry matter and root length. The beneficial effect of osmopriming on germination has been reported in tomato seeds (Ozbingol *et al*., 1998. Guzman and Olave (2006) reported that seed priming with nitrate solutions resulted in an improved germination rate, radicle growth, and germination index. It has been observed that physiological and biochemical changes take place during the seed treatments which could allow seeds to begin the germination sequences before sowing (Basra *et al*., 2005; Ghiyasi *et al*., 2008).

Although quite a good number of works have been done on seed priming of maize in abroad but under Bangladesh condition such works are a few. To use the benefit of seed priming technology in Bangladesh, it is necessary to study the effects of seed priming in plant stand establishment of maize. The present study was therefore, undertaken to study the effect of different osmopriming techniques on seedling emergence of maize.

Materials and Method

The research was conducted at the Seed Laboratory of Agronomy Department of Bangladesh Agricultural University, Mymensingh during the period from March to November in 2008. Seventeen osmopriming treatments were T_1 = 1% Na_2SO_4, T_2 = 3% Na_2SO_4, T_3 = 5% Na_2SO_4, T_4 = 1% K_2HPO_4, T_5 = 3% K_2HPO_4, T_6 = 5% K_2HPO_4, T_7 = 1% $ZnSO_4$, T_8 = 3% $ZnSO_4$, T_9 = 5% $ZnSO_4$, T_{10} = 1% $Ca(H_2PO_4)_2$, T_{11} = 3% $Ca(H_2PO_4)_2$, T_{12} = 5% $Ca(H_2PO_4)_2$, T_{13} = 1% H_2O_2, T_{14} = 3% H_2O_2, T_{15} = 5% H_2O_2, T_{16} = Hydropriming, and T_{17} = Non-priming (control). The experiment was laid out in completely randomized design with three replications. For each of these chemicals 1, 3, and 5% solutions were prepared by adding 2, 6, and 10g chemicals, respectively, in 200 ml distilled water. For H_2O_2, 1, 3. and 5% solution were created by adding 2, 6, and 10 ml H_2O_2 in 198, 194, and 190 ml water, respectively. Three hundred seeds of maize (var. BARI Hybrid Maize-5) were taken in plastic bowl and were dipped in the osmotic solution as per experimental specification. After 18 hours of soaking, the seeds were taken out from the bowl and washed under tap water for several times. Then it was surface dried for two hours under shade. Hydropriming was done by dipping 300 seeds in

200 ml water. Plastic pots (21 cm diameter and 9 cm depth) were filled with 2.5 kg dried sand. Two levels of moisture viz., 30% and 60% moisture of the saturated sand was created in the pot sand by adding 195 and 390 ml distilled water, respectively. Fifty seeds were placed in the sand at 2 cm depth maintaining equal distance from seed to seed on 11 March 2008. The seedling emergence performance was tested at 30 and 60% moisture of saturated sand. After seed placement in the pot no water was added in the sand until completion of the experiment. The trial was repeated twice on 20 October and 10 November 2008. Data on germination percentage, germination index, and mean germination time were recorded as follows:

i. Germination percentage: The seedlings were counted daily until complete emergence. Germination was calculated in percentage using the following formula:

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

ii. Germination index: The germination index (GI) was calculated by following formula (AOSA, 1983):

$$GI = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \text{---------} + \frac{\text{Number of germinated seed}}{\text{Days of final count}}$$

iii. Mean germination time (MGT): The mean germination time (days) was calculated according to the following formula (Scott *et al.*, 1984):

$$\text{MGT (days)} = \frac{?\,Ti\,Ni}{S}$$

Where, Ti = Number of days after beginning of experiment
Ni = Number of seeds germinated on day i
S = Total number of seeds germinated

Data were subjected to statistical analysis using ANOVA technique through computer based statistical package programme MSTATC. Arc sine transformations were done for percentage data where applicable before the analysis (Gomez and Gomez, 1984). Mean comparison was done by Duncun's Multiple Range Test (DMRT).

Results

Germination percentage

Germination percentage of maize seed varied significantly due to different osmopriming treatments both at 30 and 60% moisture levels (Table 1). In all the three trials, seeds primed with 3% $ZnSO_4$ solution showed the highest germination, which was followed by the seeds primed with 1% H_2O_2, 3% Ca $(H_2PO_4)_2$ and the lowest was found with control. Hydropriming performed better than some of the chemical priming but gave much lower germination than those primed with 3% $ZnSO_4$, 1% H_2O_2, and 3% Ca $(H_2PO_4)_2$ solution. However, any of the chemical priming treatment was superior to non-priming. At 30% moisture level, mean germination was highest ((75%) for primed with 3% $ZnSO_4$ and it was lowest (47%) at non-priming. Similarly, at 60% moisture, mean germination was the highest (85%) for priming with 3% $ZnSO_4$ and it was lowest (63%) from non-primed control.

Germination index

Germination index of maize seed also varied significantly due to different osmopriming treatments when tested both at 30% and 60% moisture levels (Table 2). In all the three trials, seed priming with 3% $ZnSO_4$ showed the highest germination index, which was followed by seed primed with 1% H_2O_2 and 3% Ca $(H_2PO_4)_2$. The lowest germination index was found with non-priming. Hydropriming performed better than some of the chemical primings but gave much lower germination index than 3% $ZnSO_4$, 1% H_2O_2, and 3% Ca $(H_2PO_4)_2$. However, any of the chemical priming treatment was superior to non-priming control. At 30% moisture level, the mean germination index was highest ((22.17) with 3% $ZnSO_4$ and it was lowest (11.00) from non-priming. At 60% moisture- the mean germination index was highest (25.74) with 3% ZnSO4 and it was lowest (15.62) from non priming control.

Mean germination time

Mean germination time of maize seed varied significantly due to different osmopriming treatments for tests both at 30 and 60% moisture levels (Table 3). In the all trials, priming with 3% $ZnSO_4$ showed the lowest mean germination time, which was followed by 1% H_2O_2, 3% Ca $(H_2PO_4)_2$ and the highest was found with non-priming control. Hydropriming performed better than some of the chemical priming but gave higher mean germination time than 3% $ZnSO_4$, 1% H_2O_2, and 3% Ca $(H_2PO_4)_2$. However, any of the chemical priming treatment was superior to non-priming control. At 30% moisture level, the average mean germination time was lowest ((3.40 day) with 3% $ZnSO_4$ and it was highest (4.54 day) in control treatment. Similarly, at 60% moisture level, the average mean germination time was lowest (3.39 day) for seeds primed with 3% $ZnSO_4$ and it was the highest (4.52 day) for non priming control.

Table 1. Effect of osmopriming treatment on germination percentage of maize seed during 2008.

Treatments	Germination percentage							
	30% moisture				60% moisture			
	Trial-1(March)	Trial-2 (Oct.)	Trial-3 (Nov.)	Mean	Trial-1(March)	Trial-2 (Oct.)	Trial-3(Nov.)	Mean
1% Na_2SO_4	63 (50.49)cd	68 (53.59)c	60 (48.99)e-g	63 (51.02)de	72 (56.01)cd	78 (59.85)cd	78 (59.85)de	76 (58.57)d-f
3% Na_2SO_4	59 (48.23)e	65 (51.64)d	56 (46.75)f-h	60 (48.87)f	68 (53.59)d-f	74 (57.26)de	74 (57.26)ef	72 (56.04) h-j
5% Na_2SO_4	54 (45.63)f	60 (48.98)e	51 (44.15)hi	55 (46.25)g	65 (51.64)fg	71 (55.19)ef	71 (55.61)fg	69 (54.15) jk
1% K_2HPO_4	59 (48.23)e	65 (51.64)d	57 (47.11)f-h	60 (48.99)f	71 (55.610c-e	77 (59.43)cd	78 (59.85)de	76 (58.29)d-g
3% K_2HPO_4	51 (44.15)f	57 (47.49)e	53 (45.26)g-i	54 (45.63)g	65 (51.64)fg	71 (55.19)ef	74 (57.26)ef	70 (54.70)i-k
5% K_2HPO_4	45 (40.46)g	51 (43.78)f	47 (41.56)i	49 (42.67)h	63 (50.50)g	69 (54.01)f	68 (53.60)g	66 (52.71)k
1% $ZnSO_4$	63 (50.87)cd	68 (53.59)c	72 (56.03)a-c	68 (53.50)bc	74 (57.26)bc	80 (61.21)bc	83 (63.64)bc	79 (60.70) bc
3% $ZnSO_4$	73 (56.42)a	74 (57.25)a	77 (59.43)a	75 (57.69)a	81 (61.67)a	86 (65.66)a	87 (66.79)a	85 (64.70) a
5% $ZnSO_4$	63 (50.87)cd	69 (54.38)bc	69 (54.00)b-d	67 (53.09)b-d	71 (55.59)c-e	77 (59.40)cd	79 (60.76)cd	76 (58.59) d-f
1% $Ca(H_2PO_4)_2$	61 (49.73)de	67 (53.20)cd	69 (54.39)b-d	66 (52.44)cd	68 (53.59)d-f	74 (57.26)de	79 (60.77)cd	74 (57.21) f-h
3% $Ca(H_2PO_4)_2$	65 (52.02)bc	71 (55.59)ab	73 (56.85)ab	70 (54.83)b	76 (58.31)b	83 (63.12)b	85 (64.59)ab	81 (62.23) b
5% $Ca(H_2PO_4)_2$	61 (49.74)de	67 (53.20)cd	63 (50.54)d-f	64 (51.16)de	67 (53.21)ef	72 (56.01)ef	78 (59.85)de	72 (56.36) g-I
1% H_2O_2	67 (52.80)b	71 (55.59)ab	73 (56.83)ab	70 (55.08)b	77 (58.98)b	84 (63.83)b	85 (65.11)ab	82 (62.53) b
3% H_2O_2	64 (51.25)b-d	69 (54.38)bc	70 (54.78)bc	68 (53.48)bc	73 (56.83)bc	79 (60.750bc	81 (61.67)cd	78 (59.75) c-e
5% H_2O_2	61 (49.73)de	67 (53.19)cd	66 (52.42)c-e	65 (51.78)cd	72 (56.03)cd	78 (59.88)cd	75 (57.67)ef	75 (57.86) e-h
Hydropriming	59 (48.23)e	64 (51.26)d	60 (48.99)e-g	61 (49.49)ef	74 (57.26)bc	80 (61.21)bc	81 (61.71)cd	78 (60.06) cd
Non-priming	43 (39.71)g	49 (43.04)f	53 (45.26)g-i	47 (41.93)h	57 (47.48)h	63 (50.88)g	68 (53.59)g	63 (50.66)l
$S_{\bar{x}}$	0.575	0.601	1.255	0.653	0.822	0.878	0.921	0.676
Level of signific.	**	**	**	**	**	**	**	**
CV (%)	2.04	2.79 2.01	4.28	2.24	2.59	2.59	2.66	2.02

Figures in parentheses are arc sine transformed values of germination percentage.

Figures with similar letter(s) or without letter within the column do not differ significantly whereas figures with dissimilar letter(s) differ significantly at 0.05.

level of probability by DMRT, ** = Significant at 0.01 level of probability.

Table 2. Effect of osmopriming treatment on germination index of maize seed during 2008.

Treatments	Germination index							
	30% moisture				60% moisture			
	Trial-1(March)	Trial-2 (Oct.)	Trial-3(Nov.)	Mean	Trial-1(March)	Trial-2 (Oct.)	Trial-3(Nov.)	Mean
1% Na_2SO_4	19.08c-e	20.71c-e	15.30gh	18.36e-g	22.02cd	23.78d-f	21.34de	22.38ef
3% Na_2SO_4	16.86g	18.70g	13.27ij	16.27h	20.02fg	22.03hi	19.71f	20.59hi
5% Na_2SO_4	15.25 h	17.09h	11.98j	14.77i	18.25hi	19.98j	17.91g	18.72j
1% K_2HPO_4	17.60 fg	19.33fg	15.66f-h	17.53g	21.98cd	23.65d-g	21.83cd	22.49ef
3% K_2HPO_4	15.20 h	17.01h	14.25hi	15.49hi	19.22gh	21.06i	20.07ef	20.12i
5% K_2HPO_4	12.56 i	14.40i	12.09j	13.02j	17.33i	19.01j	17.83g	18.06j
1% $ZnSO_4$	19.26 b-d	20.71c-e	19.39cd	19.79cd	22.41bc	24.25 c-e	23.06bc	23.24de
3% $ZnSO_4$	21.31a	22.89a	22.32a	22.17a	25.09a	26.79a	25.34a	25.74a
5% $ZnSO_4$	18.99c-e	20.74c-e	17.42ef	19.05d-f	21.64c-e	23.28 e-g	21.82cd	22.25f
1% $Ca(H_2PO_4)_2$	18.45d-f	20.25d-f	19.24d	19.31c-e	20.62ef	22.55gh	21.99cd	21.72fg
3% $Ca(H_2PO_4)_2$	19.96bc	21.71bc	21.09a-c	20.92b	23.42b	25.29bc	24.08ab	24.26bc
5% $Ca(H_2PO_4)_2$	18.15ef	19.83ef	16.55fg	18.18fg	20.04fg	21.78hi	21.31de	21.05gh
1% H_2O_2	20.28b	21.83b	21.54ab	21.22ab	23.57b	25.51b	24.34ab	24.47b
3% H_2O_2	19.51bc	21.13b-d	20.05b-d	20.23bc	22.02cd	23.79d-f	22.12cd	22.65d-f
5% H_2O_2	18.38d-f	20.34d-f	18.33de	19.02d-f	20.94d-f	22.73f-h	20.26ef	21.31gh
Hydropriming	17.93f	19.53fg	17.38 ef	18.28e-g	22.72bc	24.55b-d	22.99bc	23.42cd
Non-priming	9.96j	11.46j	11.58 j	11.00k	14.72j	16.22k	15.93h	15.62k
$S_{\bar{x}}$	0.328	0.331	0.569	0.345	0.411	0.354	0.435	0.294
Level of signific.	**	**	**	**	**	**	**	**
CV (%)	3.24	2.97	5.83	3.34	3.40	2.70	3.54	2.35

Figures with similar letter(s) or without letter within the column do not differ significantly whereas figures with dissimilar letter(s) differ significantly at 0.05 level of probability by DMRT, ** = Significant at 0.01 level of probability.

Table 3. Effect of osmopriming treatment on mean germination time of maize seed during 2008.

Treatments	Mean germination time (day)							
	30% moisture				60% moisture			
	Trial-1(March)	Trial-2 (Oct.)	Trial-3(Nov.)	Mean	Trial-1(March)	Trial-2 (Oct.)	Trial-3(Nov.)	Mean
1% Na=SO_4	3.44ef	3.42e-g	4.19b	3.68de	3.38d-f	3.41e-h	3.80c-f	3.53e-h
3% Na_2SO_4	3.65b-d	3.62b-d	4.55a	3.94b	3.53b-d	3.51c-e	3.91b-d	3.66bc
5% Na_2SO_4	3.71bc	3.67bc	4.56a	3.98b	3.58bc	3.59 bc	3.95bc	3.71b
1% K_2HPO_4	3.47d-f	3.48e-g	3.79c-g	3.58d-g	3.39d-f	3.38 g-I	3.75d-g	3.51f-h
3% K_2HPO_4	3.54c-e	3.53c-f	3.96b-e	3.68cd	3.54b-d	3.52 cd	3.87b-e	3.64b-d
5% K_2HPO_4	3.73b	3.69b	4.07bc	3.83bc	3.47c-e	3.47d-g	4.01b	3.65b-d
1% $ZnSO_4$	3.44ef	3.40fg	3.94b-f	3.60d-f	3.45c-f	3.43 d-h	3.83b-f	3.57c-f
3% $ZnSO_4$	3.32f	3.33g	3.54g	3.40g	3.31f	3.30 I	3.57h	3.39i
5% $ZnSO_4$	3.48d-f	3.49d-f	4.14b	3.71cd	3.42c-f	3.47d-g	3.84b-f	3.57c-f
1% $Ca(H_2PO_4)_2$	3.47ef	3.46e-g	3.79c-g	3.57d-g	3.43c-f	3.45d-h	3.76d-g	3.55d-g
3% $Ca(H_2PO_4)_2$	3.42ef	3.40fg	3.64d-g	3.49e-g	3.37d-f	3.36 hi	3.71e-h	3.48hi
5% $Ca(H_2PO_4)_2$	3.55c-e	3.57b-e	3.98b-d	3.69cd	3.50b-e	3.45 d-h	3.81c-f	3.59c-f
1% H_2O_2	3.40ef	3.39fg	3.60fg	3.46fg	3.36ef	3.35 hi	3.61gh	3.44 g-i
3% H_2O_2	3.44ef	3.41fg	3.67d-g	3.50e-g	3.51b-e	3.49 d-f	3.85b-f	3.62b-e
5% H_2O_2	3.49d-f	3.44e-g	3.78c-g	3.57d-g	3.65b	3.64 b	3.87b-e	3.72b
Hydropriming	3.38ef	3.42fg	3.63e-g	3.47fg	3.36ef	3.39 f-I	3.68f-h	3.46 f-h
Non-priming	4.47a	4.41a	4.73a	4.54a	4.50a	4.45 a	4.59a	4.52a
$S_{\bar{x}}$	0.054	0.044	0.103	0.051	0.048	0.031	0.054	0.031
Level of signific.	**	**	**	**	**	**	**	**
CV (%)	2.63	2.16	4.47	2.41	2.35%	1.54	2.42%	1.49

Figures with similar letter(s) or without letter within the column do not differ significantly whereas figures with dissimilar letter(s) differ significantly at 0.05 level of probability by DMRT, ** = Significant at 0.01 level of probability.

Discussion

Good seedling establishment is very important for successful maize production because the crop has no capacity to adjust sub-optimal stand by tillering. Seed priming could be used as a viable technology to improve seedling establishment. Rapid and uniform emergence and yield improvement have been achieved by seed priming in vegetables (Bruggink *et al*., 1999) and in some field crops (Giri and Schillinger, 2003; Murungu *et al*., 2004). Osmopriming helps improving germination in many crop seeds. Bailly *et al*. (2000); Kattimani *et al*. (1999); Guzman and Olave (2006) observed similar results in maize. The results of the experiment showed that germination percentage, germination index, and mean germination time varied significantly due to different osmopriming treatments. The highest emergence of maize seed was noticed with osmopriming by 3% $ZnSO_4$. The emergence performance of osmoprimed seeds was also better than hydroprimed seed. Some metabolic and physiological changes occur in the primed seeds which are helpful for faster growth of embryo. Moreover, seed priming contribute to earlier DNA replication, increased RNA and protein synthesis, greater ATP availability, repair of deteriorated seed parts and reduced leakage of metabolites. As a result, osmoprimed seed increase emergence, reduce seedling germination time and improve stand establishment of maize. This result is at par with the observation of Salehzadi *et al*. (2009); Golezani *et al*. (2008) and Farooq *et al*. (2005). The result indicated that better seed emergence could be achieved by osmopriming with 3% $ZnSO_4$ solution. Osmoprimed seed of maize also gave better performance in seed emergence than non-primed seed either at optimum condition or even at stressful environment. So, osmoprimed seed could be used as a tool to improve seedling emergence and better seedling establishment.

Conclusion

Osmopriming of maize seed with 3% $ZnSO_4$ solution gave best emergence under laboratory condition.

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