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EFFECT OF VARIOUS SEED HALO-PRIMING TREATMENTS ON SEED YIELD AND QUALITY IN MAIZE

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Abstract

The present investigations were carried out at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University to study the effect of various seed halo-priming treatments on seed yield and quality in maize. The Maize seeds cv. Co 1 was imposed with various seed halo priming treatments (i.e.,) Soaking in water for 6 h, Soaking in KH_2PO_4 1% for 6 h , Soaking in KNO_3 3% for 6 h, Soaking in $CaCl_2$ 2% for 6 h, Soaking in $ZnSO_4$ 1% for 6 h, Soaking in KCl 1% for 6 h. The above treated seeds along with control were evaluated for their, growth, gas exchange and yield parameters in field condition and seed quality parameters under laboratory condition. The study revealed that the production potential of various halo-priming treatments to maize revealed that maize seeds halo-priming with 1% KH_2PO_4 for 6 hours seeds recorded the higher seed yield and resultant seed quality when compared to other treatments and control.

Key words: Maize, Halo priming, Seed yield

Introduction

Maize (*Zea mays* L.) is the third important cereal crop of the world next to wheat and rice. It is one of the economically important cereal crops grown almost in all the continents of tropics, sub-tropics and temperate regions. It ranks second in production and first in productivity among the cereals and millets at global level. Maize has its significance as a source for large number of industrial products, besides its use as human food, animal food, diversified uses of maize for starch industry, corn oil production, baby corn, popcorn, etc., and potential for exports have added to the demand of maize all over the world. Seed being a living entity, deterioration beyond physiological maturity is inevitable especially when stored under ambient conditions. Seed producers and farmers are confronted with serious problems of loss of viability and vigour when stored under local conditions within a season. Good quality seeds imply vigour, uniformity and structural soundness besides its genetic and physical purity. In ancient days, various seed treatments were practiced as initial production techniques for improved productivity. In the last two decades, seed priming, an effective seed in vigouration method, has become a common seed treatment to increase the rate and uniformity of emergence and crop establishments in most vegetable and flower crops especially in advanced countries. Seed priming is a controlled hydration process that involves exposing seeds to low water potentials that restrict germination, but permits pregerminative physiological and biochemical changes to occur. With this background, studies were carried out in maize with to study the effect of various seed halo-priming on seed yield and quality in maize.

Materials and Methods

The present study was carried using genetically pure seeds of maize (*Zea mays* L.) cv. Co 1 obtained from the Tamilnadu Agricultural University Coimbatore, Tamilnadu. The experiments were conducted at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar (11°24'N latitude and 79°44'E longitude with an altitude of +5.79 mts above mean sea level). The bulk seeds were first dried to below 12% moisture content, cleaned, then graded with suitable sieves and imposed for following priming treatments *viz.,* Soaking in water for 6 h, Soaking in KH_2PO_4 1% for 6 h, Soaking in KNO_3 3% for 6 h, Soaking in $CaCl_2$ 2% for 6 h, Soaking in $ZnSo_4$ 1% for 6 h, Soaking in Kcl 1% for 6 h. After the treated seeds were removed from the solutions, rinsed in water, shade dried at room temperature and assessed for the seed yield and quality parameters along with unprimed control.

Field trials were conducted by adopting Randomised Block Design (RBD) with four replications. The plot size was 4×2.5 m^2. The crop was raised with the spacing of 60 × 25 cm and recommended package of practices for maize were followed. Along with normal irrigation, proper irrigation was done at critical stages of flowering, milking and seed formation. Ten plants in each replication and treatments were randomly selected and observations on growth, gas exchange and yield parameters were recorded.

Field emergence was calculated on seven days after sowing in each treatment and replication, the number of seedlings emerged were counted and the mean value was expressed in percentage. Plant height was recorded by measuring the height of 10 plants at random was measured from ground level to the tip of the central branch of tassel at flowering was measured and expressed in centimeter. The number of leaves were counted at flowering stage from randomly selected ten plants from each replication and expressed in whole number. The internodal length was measured with the help of a scale in-between the two nodes of a plant at flowering stage and the mean was expressed in centimeter. The leaf length was measured at flowering stage with the help of a scale and the mean was expressed in centimeter. The leaf breadth was measured at flowering stage with the help of a scale at the widest point of the leaf and expressed in centimeter. Leaf Area Index was computed from the selected five plants at flowering stage. Dry matter production was recorded at flowering stage the five plants were selected at random from the sampling rows and uprooted, made free from soil through washing with water and roots were separated for further study. The shoots were dried under shade and then oven dried at 70^0C till a constant weight was obtained. The weight of shoot was recorded using an electrical balance and the dry matter was expressed in Kg ha^{-1}. The root volume per unit area was calculated and expressed in cc.

The total chlorophyll was calculated using the formula as suggested by Yoshida *et al.* (1971) and expressed as mg/g. Leaf photosynthetic rate, transpiration rate, stomatal conductance and intercellular CO_2 concentration were measured from two, uppermost fully expanded leaves on intact plants in the field using LICOR-6400×T Portable Photosynthetic System (Lioncoln, USA). All these estimations and measurements were made between 10.00-11.00.A.M on the five replicates for each treatment. Numbers of days taken from sowing to first flowering in the population were recorded and the mean values expressed in days. Numbers of days taken from sowing to 50 % of population to flower was recorded and the mean values expressed in days. Numbers of days taken from sowing to first silking in the population were recorded and the mean values expressed in days. Numbers of days taken for silk emergence in 50% population was recorded and the mean values expressed in days. The length of the cob was measured from bottom to the tip of the cob and the mean was expressed in centimeter. The cobs were harvested from female plant at physiological maturity i.e., 95 days after sowing. Ten cobs were selected at random and the following attributes were recorded before drying of cobs. The breadth was measured with the help of cotton thread at the widest point of the cob and the mean was expressed in centimeter. The cobs were dried under sun to bring the moisture to 10 -12% and the observations given below were recorded.

The number of seed rows cob^{-1} were counted and mean of ten cobs was recorded and expressed in number. The total number of seeds row^{-1} was counted in each cob and mean of ten cobs were recorded in number. The total number of seeds cob^{-1} were counted and mean of the ten cobs was expressed in number. The seeds were separated from sample cobs by manual shelling and dried to 12% moisture. The Shelling Percentage was calculated by using the cob dry weight as well as shelled seed weight. Harvest Index (HI) was worked out using the economic yield and biological yield (kg ha^{-1}). The seeds were cleaned and weighed in an electronic balance and the mean seed yield $plant^{-1}$ was expressed in grams. Seed yield was computed per hectare from the seed yield obtained per plot in each of the treatment and. expressed in Kg ha^{-1}. Four replicates of 100 seeds were drawn from each treatment randomly, weighed in an electronic balance and the mean weight was expressed as 100 seed weight in grams (ISTA, 1999). The above treatments were also evaluated for their seed quality parameters i.e., germination percentage (ISTA, 1999), speed of germination (Maguire, 1962), shoot length (ISTA, 1999), root length (ISTA, 1999), dry matter production (ISTA, 1999), vigour index (Abdul-Baki and Anderson, 1973), under laboratory condition. The data were statistically analyzed as per the method of Panse and Sukhatme (1985).

Result and Discussion

Stand establishment is of primary importance for optimizing field production of any crop plant. Emergence and establishment are the two basic requirements for the successful seed programme as they offer scope not only for uniformity in the field but also for full exploitation of yield potential of the crop (Austin *et al.,* 1969). Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance.

In the present study, the KH_2PO_4 1% for 6 h halo-primed seeds were also evaluated under irrigated field condition, the growth, gas exchange and yield parameters were observed. It revealed that the KH_2PO_4 1% for 6 h halo-primed seeds recorded higher values for the biometrical traits viz., Field emergence %, plant height, which were 10, 6.6 percentage higher than the control respectively with the above mentioned characters (Table 1). The KH_2PO_4 priming which was attributed to micronutrients to the seeds that often act as co-factors in enzyme systems and participate in redox reactions, in addition to having several other vital seed functions. Most importantly, they are involved in the key physiological processes (Mengel *et al.,* 2001). It was reported earlier that KH_2PO_4 participated in regulation of many growth and developmental processes in plants (Guan *et al.,* 2014) and was particularly important in regulating stem elongation (Zhang, *et al.,* 2009). The results were in agreement with the findings Raja *et al*. (2011) in rice and Sathish *et al*. (2011) in maize hybrid who reported the positive role of nutrients in improving germination.

The above mentioned treatment also recorded higher number of leaves higher intermodal length higher leaf length and higher leaf breaths. It was 14, 18, 7.8, 21.5 percentage higher than the control respectively with the above mentioned characters (Table. 1). The results were in agreement with the findings of Raja *et al*. (2011) in rice and Sathish *et al*. (2011) in maize hybrid. The KH_2PO_4 priming induces a range of biochemical changes in the seed that required initiating the germination process i.e., breaking of dormancy, hydrolysis or metabolism of inhibitors, imbibitions and enzymes activation (Ajouri *et al.,* 2004). Some previous researcher indicated that some or all process that precede the germination are triggered by The KH_2PO_4 priming and persist following the re-desiccation of the seed (Asgedom and Becker, 2001). Thus upon sowing, primed seed can rapidly imbibe and revive the seed metabolism, resulting in higher germination percentage and a reduction in the inherent physiological heterogeneity in germination (Rowse, 1995) This was in confirmatory with the previous findings of Gayathri (2001), who reported increase in germination percentage with KH_2PO_4 priming. Sathish *et al.* (2011) proved that 1% KH_2PO_4 priming to be more effective, showing higher germination and emergence percentages, shoot length, root length and dry matter production. Increased germination due to KH_2PO_4 priming might be due to ions absorption by seeds as reported by Alvarado *et al*. (1987). Moreover, the potassium salts had been reported to raise the ambient oxygen level by making less oxygen available for the citric acid cycle (Bewley and Black, 1982) and influencing plant development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance.

This KH_2PO_4 1% for 6 h halo-primed seeds also recorded high leaf area index, heavier dry matter production and higher root volume. It recorded 65, 32.8, 7 percentage higher than control respectively with the above mentioned characters (Table.1). The results were in agreement with the findings Raja *et al*. (2011) in rice and sathish *et al*. (2011) in maize hybrid. Increase in fresh weight was observed in roots primed with KH_2PO_4, leads to supply of high P which was in line with root weight increase due to priming reported by Afzal *et al*. (2006). Jacob and Lawlor (2003) reported that high P influences the rate of regeneration of ribulose1, 5-bisphosphate, as well as the activity and the content of ribulose 1,5-bisphosphate carboxylase in maize leaves which eventually affects photosynthesis in leaves. Phosphorus priming in our study led to enzymatic changes in the seed and hence resulted in increased shoot and root biomass.

The Physiological and gas exchange parameter such as chlorophyll content, photosynthesis, transpiration, intercellular CO_2 concentration and stomatal conductance also higher in KH_2PO_4 1% for 6 h halo-priming treatment which was 19.4, 22.8, 76.9, 11.2 and 37.9 percentages higher than control respectively with the above mentioned characters (Table. 2). The results were in agreement with the findings Raja *et al*. (2011) in rice and sathish *et al*. (2011) in maize hybrid. This increase may be attributed to the fact that the availability of phosphorus (P) in the KH_2PO_4 is one of the most significant determinants of plant growth. Recent reports have confirmed that deprivation of P has a detrimental effect on the rate of photosynthesis in maize (Usuda and Shimogawara, 1992). These findings are in agreement with Ullah, *et al.* (2002). Due to the priming treatments, KH_2PO_4 Primed crops grew more vigorously, flowered earlier, increase in leaf area index, dry matter accumulation and ultimately more seed yield. Increased leaf area duration due to early emergence by priming might have enhanced yield by increasing the amount of light intercepted by canopy throughout the season (Harris *et al.,* 2001). Due to early emergence by priming might have enhanced yield by increasing the amount of light intercepted by canopy throughout the season (Harris *et al.,* 2001). These findings are in line with Farooq *et al.* (2006).

The above treatment was also recorded the yield attributes character such as cob length, cob grith, number of rows cob^{-1}, number of seeds row^{-1}, total number of seeds cob^{-1}, shelling percentage, 100 seed weight, seed yield ha^{-1} and harvest index were also 35.2, 20.5, 55.5, 19.8, 52.5, 12.2, 16.8, 30.5 and 23.8

percentage higher than control respectively with the above mentioned characters (Table 3 and 4). The results were in agreement with the findings; Raja *et al*. (2011) in rice and Sathish *et al*. (2011) in maize hybrid. The KH_2PO_4 priming-improved seed performance might be attributable in part to metabolic repair processes, a build up of germination metabolites or osmotic adjustment during treatment (Haghpanah, *et al*., 2009). KH_2PO_4 in raising the P content of seeds and as effective at increasing the biomass and shoot P content of seedlings which leads to increasing biomass and grain yield. (Miraj *et al*, 2013). Phosphorus (P) is an important plant macronutrient, making up about 0.2% of a plant's dry weight. After nitrogen, P is the second most important nutrient. The increase grain yield may be due to the fact that priming advances the metabolism of the seed and the seed protein is synthesized which has a direct affect in increasing seed performance and hence yield (Varier *et al.,* 2010). These results were also supported by Harris *et al.* (2007) and Miraj *et al.* 2013 in maize.

In present investigation seeds halo-primed with KH_2PO_4 1% for 6 h recorded higher values for the resultant seed qualities such as speed of germination, germination, root length, shoot length, dry matter production, vigour index and protein content which was 22, 8.8, 33.8, 5, 36.3, 54.6 and 7.7 percentage higher than control respectively with the above mentioned characters (Table 5). The results were in agreement with the findings of Raja *et al.* (2011) in rice and Sathish *et al*. (2011) in maize hybrid. Germination and seedling establishment are critical stages which affected both quality and quantity of crop yields. The present study showed that, compared with the control group, the rate of hydration increased dramatically after seed primed by 1% KH_2PO_4. This implies that KH_2PO_4 seed priming may improve seed germination of maize seeds by speeding up imbibition, which could contribute to facilitate emergence phage of maize. Similar results were also reported that priming improved germination of sunflower (Farahani *et al.,* 2011). Generally, seed germination entails three distinct phases: (i) imbibition, (ii) lag phase, and (iii) radicle growth and emergence Anosheh (2014). The purpose of KH_2PO_4 priming is to prolong the lag phase, which allows some pre germinative physiological and biochemical processes to take place but prevents germination (Bradford, 1986). The results of our germination tests indicated that KH_2PO_4 priming seed significantly increased the final germination percentage and germination rate of maize. The increment in seed germination due to KH_2PO_4 seed priming treatment is in conformity with sathish *et al.* (2011) in maize hybrid. When compared with different priming 1% KH_2PO_4 for 6 hours showed greater influence on germination rate. It was reported earlier that KH_2PO_4 participated in regulation of many growth and developmental processes in plants (Guan *et al.,* 2014) and was particularly important in regulating stem elongation (Zhang *et al.,* 2007). The KH_2PO_4 treated seed was closely associated with their rapid utilization in the synthesis of various amino acids and amides, which could be the reason for the increased germination rate. It had the beneficial effects on shoot and root biomass. This was mainly due to the accelerated metabolism occurring in primed seeds, which increases the imbibition speed as compared to unprimed seeds. Similar results were also reported by Guan *et al.,* 2014 on sorghum seeds. Farooq *et al.,* 2011 in wheat and sathish *et al*., 2011 in maize hybrid reported that pre-soaking with inorganic KH_2PO_4 salts improved seedling emergence, shoot and root length, and biomass, which leads to increase in the vigour index and protein. The beneficial effects of priming are associated with the repair and build up of nucleic acids the increased synthesis of proteins as well as the repair of membranes (McDonald, 2000). The KH_2PO_4 priming also enhances the activities of anti–oxidation in treated seeds (Wang *et al.,* 2003). Moreover, priming increases the activities of isocitrate lyase and malate synthase, enzyme activity and this increase in the activities of glyoxysome enzymes were linked to the improved emergence responses in primed bitter gourd seeds (Lin and Sung, 2001). Hence the study revealed that, the production potential of various halo-priming treatments to maize revealed that maize seeds halo-priming with 1% KH_2PO_4 for 6 hours seeds recorded the higher seed yield and resultant seed quality when compared to other treatments and control.

Table 1 : Effect of various seed halo-priming treatments on various growth parameters of Maize cv. CO 1

Treatments	Field emergence (%) (7DAS)	Plant height (cm)	No. of leaves plant^{-1}	Internodal Length (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf area Index	Dry matter production (kg ha^{-1})	Root volume (cc plant^{-1})
T_0	88	158.3	12.1	9.4	61.7	6.5	2.6	9145.3	59.6
T_1	91	163.6	12.2	9.9	62.5	7.0	3.4	10106.7	60.3
T_2	98	168.7	13.8	11.1	66.5	7.9	4.3	12152.4	63.8
T_3	95	165.3	13.2	10.7	64.3	7.6	3.7	10507.6	62.7
T_4	94	162.6	13.0	9.9	64	6.7	2.8	10485.5	61.5
T_5	92	162.5	12.4	9.5	63.6	7.2	3.1	9545.3	60.8
T_6	90	160.3	12.8	9.6	63.2	7.4	3.6	10505.5	62.5
MEAN	**92.57**	**163.04**	**12.79**	**10.01**	**63.69**	**7.19**	**3.36**	**10349.76**	**61.60**
SEd	**2.12**	**3.30**	**0.21**	**0.26**	**1.66**	**0.06**	**0.09**	**169.17**	**1.12**
CD(P=0.05)	**4.62**	**7.19**	**0.46**	**0.56**	**3.62**	**0.12**	**0.20**	**368.60**	**3.42**

Table 2 : Influence of various seed halo-priming treatments on physiological parameters in Maize Cv. CO 1

Treatment	Chlorophyll content	Photosynthetic rate Pn- (mg $CO_2 m^{-1} S^{-1}$)	Transpiration rate Tr- (mg H_2O CO_2 $m^{-1}S^{-1}$)	Intercellular CO_2 concentration Ci- (mol/mol^{-1})	Stomatal conductance CS (mol/mol $^{-1}$ S^{-1})
T_0	43.2	17.7	2.648	274.6	0.298
T_1	50.2	20.2	4.165	298.3	0.326
T_2	51.6	22.8	4.685	305.6	0.411
T_3	50.7	21.5	4.179	302.2	0.381
T_4	49.2	21.8	3.265	285.5	0.345
T_5	44.6	18.9	2.785	296.3	0.299
T_6	48.5	21.5	3.895	265.4	0.375
Mean	**48.29**	**20.63**	**3.66**	**289.70**	**0.35**
SEd	**1.08**	**0.46**	**0.07**	**5.56**	**0.11**
CD	**2.35**	**0.99**	**0.15**	**12.11**	**0.02**

Table 3 : Effect of various seed halo-priming treatments on yield attributing parameters of MaizeCv. Co.1

Treatments	Days to first tasselling	Days to 50% tasselling	Days to first sliking	Days to 50 % silking	Cob length	Cob grith	Number of rows cob $^{-1}$
T_0	51	58	55	61	10.2	10.7	9
T_1	48	55	53	59	11.5	12.1	10
T_2	41	52	47	55	13.8	12.9	14
T_3	43	55	49	58	12.6	12.1	12
T_4	45	57	51	60	12.5	10.9	11
T_5	50	56	54	58	11.6	11.2	12
T_6	43	55	49	58	10.5	11.8	9.5
MEAN	**45.86**	**55.43**	**51.14**	**58.43**	**11.81**	**11.67**	**11.07**
SEd	**0.82**	**1.08**	**0.62**	**1.21**	**0.28**	**0.22**	**0.22**
CD (P=0.05)	**1.78**	**2.35**	**1.35**	**2.64**	**0.61**	**0.47**	**0.48**

Table 4 : Effect of various seed halo-priming treatments on yield parameters in Maize Cv. C0 1

Treatments	Number of seeds row $^{-1}$	Total number of seeds cob $^{-1}$	Shelling percentage	100 seed weight	Seed yield ha $^{-1}$	Harvest index
T_0	24.7	267.3	64.1	22.0	3211	0.21
T_1	27.9	298.5	65.2	22.5	3345	0.22
T_2	29.6	407.5	76.3	25.7	4193	0.26
T_3	28.6	381.2	74.1	24.1	4011	0.23
T_4	25.5	285.4	66.5	23.6	3965	0.23
T_5	24.9	315.6	71.2	24.0	3896	0.21
T_6	27.2	365.2	72.5	23.9	4010	0.22
MEAN	**26.91**	**333.53**	**69.99**	**23.69**	**3804.43**	**0.23**
SEd	**0.65**	**7.65**	**0.88**	**0.55**	**80.69**	**0.01**
CD(P=0.05)	**1.41**	**16.67**	**1.92**	**1.20**	**175.80**	**0.01**

Table 5 : Influence of various seed halo-priming treatments on resultant qualities of Maize Cv. CO 1

Treatments	Speed of germination	Germination (%)	Root length	Shoot length	Dry matter production	Vigour index	Dehydrogenase activity (OD) Value
T_0	10.3	91	19.8	12.7	3.3	2958	0.104
T_1	10.5	92	22.8	13.5	3.6	3340	0.168
T_2	12.58	99	26.5	19.7	4.5	4574	0.194
T_3	12.16	97	24.1	18.6	4.1	4142	0.181
T_4	11.2	94	20.5	14.2	3.9	3262	0.125
T_5	11.8	96	21.6	15.6	4.1	3572	0.142
T_6	12.10	96	23.5	17.5	3.8	3936	0.105
MEAN	**11.51**	**95**	**22.69**	**15.97**	**3.90**	**3683**	**0.15**
SEd	**0.21**	**2.32**	**0.60**	**0.35**	**0.08**	**83.66**	**0.00**
CD (P=0.05)	**0.46**	**5.05**	**1.30**	**0.77**	**0.17**	**182.28**	**0.01**

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