

Effects of Osmo- and Hydro-priming on Seed Parameters of Grain Sorghum (*Sorghum bicolor* L.)

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Abstract: The influence of priming treatments and subsequent accelerated aging on seed parameters of grain sorghum was investigated. Seeds of sorghum were treated by osmo-priming (polyethylene glycol 6000 solution with osmotic potential -1.5 MPa) and hydro-priming for different time (12, 24 and 36 hours). Both osmo- and hydro-priming improved the percentage and mean emergence time (MET) of seeds at sub-optimal temperature of 15 °C. Seed treatment for 12 and 24 hours had a positive statistically significant effect on percentage and speed emergence. Nevertheless priming for 36 hours failed to improve emergence percentage and mean emergence time (MET). After receiving accelerated aging, osmo- and hydro-primed seeds showed a lower emergence percentage and longer mean emergence time (MET) than their non-aged counterparts. Moreover, treated seeds subjected to accelerated aging showed lower emergence responses than aged control seeds, which was particularly clear for hydro-primed seeds.

Key words: Accelerated aging; Emergence; Hydro-priming; Osmo-priming; Sorghum

INTRODUCTION

In arid regions, cereal production is widely limited by poor stand establishment (Jones and Wanbi, 1992). Particularly in drought-prone environments, cereal germination tends to be irregular and can extend over long periods (Bougne *et al.*, 2000). The resulting poor crop stands leave gaps in the canopy, which are rapidly filled by vigorously growing weeds at the onset of the short rainy season. These weeds compete with the crop plants for light, water and nutrients (Kropff and Van Laar, 1993). Accelerating and homogenizing the germination process is a prerequisite for a good crop establishment, the efficient use of resources, and eventually to increase yields (Harris, 1996).

Seed quality (viability and vigor) can have a profound influence on the establishment and the yield of a crop. Healthy plants with well developed root systems can better withstand adverse conditions and a vigorous early seedling growth has been shown to be associated with higher yields (Harris *et al.*, 2000). The vigor of seeds can be improved by techniques generally known as seed priming, which enhance the speed and uniformity of germination (Demir and Van De Venter., 1999).

The principle of priming is based on the fact that it is possible to hydrate seed in some ways at a moisture level sufficient to initiate the early events of germination but not sufficient to permit radicle protrusion.

Methods of seed priming can be divided into two groups depending on whether water uptake is uncontrolled (hydro-priming) or controlled (osmotic-priming and solid matrix priming) (Taylor *et al.*, 1998).

Water uptake during hydro-priming is governed only by the affinity of the seed tissue for water. Seeds are imbibed on moistened blotters or soaked in water. Because water is not limited, seeds can eventually germinate assuming that they are viable, not dormant, and optimal conditions are provided. Therefore, in uncontrolled systems the process must be arrested at a specific time to prevent radicle protrusion.

In controlled priming the amount of water available for seeds is restricted or the water potential of priming medium can be regulated. During osmotic priming seeds are imbibed in an osmotic solution of e.g. KNO₃, K₃PO₄, glycerol, mannitol and polyethylene glycol-PEG. After hydration, seeds are dried to enable normal handling, storage and planting.

Although priming is one of the physiological methods, which improves seed performance and seed faster and synchronized germination (Sivritepe and Dourado, 1995), it has been shown that the longevity of primed seeds in storage is often reduced (Van Pijlen *et al.*, 1996. Chang and Sung, 1998. Taylor *et al.*, 1998). Whether the benefits of priming on seed performance could be maintained during dry storage still remains unknown.

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Accelerated aging of seeds induced by several days of exposure to high temperature and high humidity is recognized as an accurate indicator of seed vigor and storability. The seeds that deteriorate rapidly under accelerated aging conditions generally show a marked depression in their ability to germinate (McDonald, 1999).

Sorghum is a warm season crop growing well in tropical and subtropical climates. The optimum temperature for germination of sorghum seeds is between 23 and 25 °C. Poor germination is common at sub – optimal temperature conditions (Peter *et al.*, 1998). Pre – sowing treatments such as osmo-priming and hydro-priming are recommended to ensure successful seedling establishment under sub – optimal temperature conditions (Lin and Sung, 2001). The present study was conducted to examine the effect of piming treatments and accelerated aging on seed parameters of grain sorghum.

MATERIALS AND METHODS

The experiment was conducted at research laboratory of Agriculture College, University of Tehran, Iran in 2007. Sorghum seeds (*Sorghum bicolor* L. c.v. Kimia) were washed with water, dipped in 0.1% HgCl₂ for 5 min and again washed thoroughly with sterilized water under aseptic conditions.

Hyro- priming was carried out in distilled water, without aeration, at a temperature 20 °C. Osmo- priming was done in PEG 6000 solution at 20 °C, with osmotic potential -1.5 MPa, prepared according to Michel and Kaufmann (1973). The solution of PEG was autoclaved for 15 min at psi pressure for osmo- priming and similarly distilled water was also sterilized for hydro - priming of seeds. The washed sorghum seeds were fully immersed in these solutions under aseptic conditions and kept for different time intervals (12, 24 and 36 h) at 20 ± 1 °C. The seeds were then washed with distilled water and dried on a filter paper at room temperature. Accelerated aging of control, osmo- and hydro- primed seeds was achieved by incubated the seeds in a closed plastic chamber at 40 °C and 100 % relative humidity for 6 days. Following aging, the seeds were air – dried at 25 °C until their original weight had been restored. After drying, all the treated and non-treated seeds were sealed in aluminum foil bags coated with polyethylene and stored at 5 °C. Assessment was conducted within a month after treatment.

The quality of sorghum seeds was examined by using a laboratory emergence test. Four replicates of 50 seeds each were planted 1.5 cm deep in vermiculite n. 3 and watered with distilled water as necessary. Seeds were incubated in controlled chambers with 12 h photoperiod at 15 °C and emergence was counted daily for 14 days. A germination temperature of 15 °C (a sub – optimal temperature for the emergence of sorghum seeds) was chosen instead 25 °C because it allows a better expression of the effects of pre- sowing seed treatments on emergence (Lin and Sung, 2001). Seeds were recorded as emerged when the seedlings were visible on the vermiculite surface. Mean emergence time (MET) was calculated using the formula of Ellis and Roberts (1980):

$$\frac{\sum nd.d}{\sum nd}$$

where: *nd* – number of seeds that germinated on the day (*d*), *d* – serial number of the day.

The experiment was conducted with a factorial arrangement based on completely randomized design with four replications. All data were analyzed with analysis of variance using a Proc GLM procedure of SAS (SAS Institute, 1994). Mean separation was obtained using a Duncan's New Multiple Range Test at the 0.05 probability level.

RESULTS AND DISCUSSION

Seed values of unprimed (control) and primed treatments are shown in Table 1. Non- treated sorghum seeds (control) had an average emergence percentage of 87/5 at 15 °C, with a Mean emergence time (MET) of 10/ 7 days, indicating the superior quality of the sorghum seeds we used in our experiment.

Results:

Both method of priming showed significant advancement in start of emergence and reduced substantially the time to reach 50% of emergence (Table 2 and 3). Osmo- Priming enhanced Emergence percentage of

sorghum seeds. Emergence percentage was increased from 87/5 to 95 and Mean emergence time (MET) reduced from 10/7 to 7/6 days. Minor improvements in Emergence percentage (increased from 87/5 to 91) and Mean emergence time (MET) (decreased from 10/7 to 8/6 days) were also obtained for hydro-primed seeds. Emergence percentage of seeds with prolonged priming time decreased and Mean emergence time (MET) had an increasing tendency relative to the longer time of priming. Priming of seeds for 12 and 24 hours had a positive statistically significant effect on a decrease in Mean emergence time (MET) (on average) compared with Mean emergence time (MET) of untreated seeds. Nevertheless, priming for 36 hours failed to improve Germination percentage and Mean emergence time (MET).

Accelerated aging lowered emergence percentage from 87/5 to 78 and reduced emergence speed of sorghum seeds to some extent (Mean emergence time (MET) increased from 10/7 to 12/2 days.) as compared to that of non – aged control. After receiving accelerated aging, osmo and hydro - primed seeds also showed a lower emergence percentage and longer Mean emergence time (MET) than their non – aged counterparts. Moreover, both osmo- and hydro - primed seeds subjected to accelerated aging showed lower emergence responses than aged control seeds, which was particularly clear for hydro - primed seeds. Negative effects of accelerated aging on seed parameters of primed seeds increased with prolonged priming time and the lowest emergence percentage observed in hydro – priming treatment for 36 h.

Table 1: Mean squares for emergence percentage and mean emergence time (MET) traits of sorghum in 2007

s.o.v	d.f	Emergence percentage	Mean emergence time
Priming treatment	1	0/163**	12/09**
Priming period	3	0/973*	23/13**
Accelerated aging	1	0/657**	14/11**
cv		15/3	18

* P < 0.05

** P < 0.01

Table 2: Emergence percentage of sorghum seeds as affected by priming treatment for different time and subsequent accelerated aging (%)

Seed treatment	Time of treatment(h)	Non-aged(days)	Aged(days)
Control	0	87.5 b	78.7 c
Hydro-priming	12	88.7 b	75.0 c
Hydro-priming	24	91.5 a	68.5 d
Hydro-priming	36	78.4 c	55.3 e
Osmo-priming	12	88.0 b	77.0 c
Osmo-priming	24	95.9 a	76.1 c
Osmo-priming	36	84.0 b	68.8 d

Values in columns marked with the same letter are insignificantly different on significance level $\alpha = 0.05$

Table 3: Mean emergence time (MET) of sorghum seeds as affected by priming treatment for different time and subsequent accelerated aging

Seed treatment	Time of treatment(h)	Non-aged(days)	Aged(days)
Control	0	10.7d	12.2 e
Hydro-priming	12	9.8 c	12.5 e
Hydro-priming	24	8.6 b	11.6 de
Hydro-priming	36	11.1d	14.2 f
Osmo-priming	12	9.5 c	11.6 de
Osmo-priming	24	7.6 a	10.0 cd
Osmo-priming	36	9.9 c	12.3e

Values in columns marked with the same letter are insignificantly different on significance level $\alpha = 0.05$

Discussion:

After seed priming of sorghum for different periods, we identified that osmo- and hydro- priming for 12 and 24 h improved emergence percentage and mean emergence time (MET) under sub – optimal temperature conditions. The priming-improved seed performance might be attributable in part to the decreased lipid peroxidation and increased antioxidative activities during seed imbibitions. These results are in accordance with the results of other researchers who reported either improvement of germination percentage (Mauromicale and Cavallaro, 1995) and mean emergence time (MET) reduction after priming (Tarquis and Bradford, 1992). Also Lin and Sung (2001) reported that priming the bitter gourd seeds before sowing overcame sub-optimal environmental effects on germination subsequent seedling establishment performance. Wang *et al.*, (2003) reported that, both hot water– soaked and primid seeds showed significant increase in germination performance.

The resultant effect of priming depends on the used method and time of treatment. Hydro- priming is a simple method of priming treatment. It does not require any special technical equipment and owing to the use of distilled water as a priming medium. It is probably the cheapest priming method. Similarly Fujikura et al. (1993) presented hydro- priming as a simple and inexpensive method of seed priming.

Osmotic priming is methodically, technically and financially more exacting than hydro- priming. A solution of osmotic substance whose price can be high is used priming. In the case of PEG, this method also demands an equipment for aeration of hydration solution. Owing to these two requirements osmotic priming is a more expensive and suitable priming method.

Optimal time of osmo- and hydro - priming for sorghum seeds in this experiment was 24 hours in the solution of PEG with osmotic potential -1.5 Mpa and distilled water. A shorter time of priming seems to have a little effect on the seed parameters of sorghum.

Accelerated aging is known to reduce viability in peanut (*Arachis hypogaea*) (Sung and Jeng, 1994) and soybean (*Glycine max*) (Sung, 1996) seeds. In the present study accelerated aging lowered emergence percentage of sorghum seeds. Osmo- and hydro- Primed seeds receiving aging also showed a lower emergence performance than their non aged counterparts. Both primed seeds subjected to accelerated aging showed lower emergence responses than aged control seeds. These results indicate that both osmo- and hydro - primed sorghum seeds are more susceptible to stressful storage environment.

The exact causes of faster deterioration of primed seeds are still well defined. The deleterious effects of accelerated aging on the emergence process are associated with the damage occurring at the membrane, nucleic acid and protein levels (Fujikura and Karssen, 1995). Accelerated aging also resulted in increased lipid peroxidation, decreased levels of anti- oxidants and reduced activity of several enzymes involved in scavenging of free radicals and peroxides (Chiu *et al.*, 1995. Hsu and Sung, 1997. Bailly *et al.*, 1998). Thus, reduced anti-oxidative activities, along with other mechanisms, may contribute to the increased susceptibility to deterioration of primed seeds. Van Pijlenet al., (1996) hypothesized that the reduced longevity of primed seeds is caused by a decrease in DNA repair activity due to progression in the cell cycle during hydration.

Thus, in order to maintain a high viability, it is important to store the pretreated sorghum seeds under more favorable conditions than untreated seeds. Bruggink et al., (1999) reported that, for impatient (*Impatiens walleriana* Hook), pansy (*Viola wittrockiana*) and pepper (*Capsicum annum* L.) seeds, the desired longevity were obtained by keeping the seeds, after a priming treatment, under a mild water and/ or temperature stress for a period of several hours to days. Perhaps this recommendation can also be considered for primed sorghum seeds.

In conclusion, the results described here demonstrate that both osmo- and hydro- priming improve the quality of sorghum seeds. The present data further indicate that primed seeds are susceptible to accelerated aging. Therefore, the seeds receiving these pre-sowing treatments should be stored under favorable conditions to maintain a high viability during long – term storage.

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