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The Effect of Priming on Seedling Emergence of Differentially Matured Sorghum (*Sorghum bicolor* L.) Seeds

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Abstract: The influence of priming (polyethylene glycol 6000 solution with osmotic potential -1.5 MPa for 24 h at 20 °C) on seedling emergence, emergence rate, seedling weight and length of sorghum seeds harvested in three stages (the beginning of doughing stage(h_1), 112 days after sowing (between doughing and physiological maturity stages)(h_2) and physiological maturity stage(h_3)) was investigated. Priming improved the percentage and mean emergence time (MET) of sorghum seeds at sub-optimal temperature of 15 °C. The maximum benefit of priming was observed in seeds harvested at beginning of doughing stage (h_1). Primed seeds of this harvest had 18 higher seedling emergence percentages, 57 h faster emergence rate, 16 mg heavier seedling weights and 3 mm longer length compared to control. Smaller effects of priming were also seen in the decreased mean emergence time and increased seedling weight and seedling lengths of seeds harvested 112 days after sowing (h_2) and physiological maturity stages (h_3). Priming reduced the percentage of seeds that germinated but failed to emerge from 13 to 4.4% for h_1 seeds. Few of the more mature seeds germinated but failed to emerge. Thus, it is seem priming can be used to increase sorghum emergence and produce well-developed seedlings particularly in early spring sowings at sub – optimal temperature conditions.

Key words: Emergence; Priming ; Seed maturity ; Sorghum

INTRODUCTION

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[21].

A wide variety of presowing hydration treatments have been used to enhance seed germination response. These treatments include equilibration under conditions of high humidity[7], soaking in water[3] or osmotic solution[16], equilibration with a mat+-potential control surface[8,10,11], intermixture with a porous matrix[24,15], and simple water addition to sub- germination water content[17]. The main objective of these treatments is to allow water uptake and germination metabolism to proceed to a point just short of radical extension[1].

Presowing hydration treatments are presented in literature as a possibility of improvement of seed parameters, especially of an increase in germination percentage, faster and more uniform emergence and germination under a broader range of environmental conditions[18]. The beneficial effects of priming treatments are associated with the repair and build up of nucleic acid, the increased synthesis of protein as well as the repair of membranes[18]. Seed priming treatments also enhances the activities of anti-oxidation[25,14].

Seed maturation stage can also be an influential factor in germination performance at low temperatures and response to priming treatment[20,4]. In general, mature seeds tend to show a better germination performance at stress temperatures than those of earlier and later harvests, while advancement obtained by priming was greater in earlier harvests (e.g. premature seeds). Priming can be a valuable process for improving germination and uniformity of heterogenously matured seed lots[20]. In this study we consider the effect of priming on sorghum seedling emergence and growth using seeds harvested at three different maturity stages after anthesis.

MATERIALS AND METHODS

The experiment was conducted at research laboratory of Agriculture College, University of Tehran, Iran in 2007. The influence of PEG 6000 solution (with osmotic potential -1.5 MPa ,24 h, 20 ○C) on seedling emergence, emergence rate, seedling weight and seedling length of sorghum seeds harvested in

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three stages (beginning of doughing stage(h_1), 112 days after sowing (between doughing and physiological maturity stages) (h_2) and physiological maturity stage(h_3)) was investigated. 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.

Seeds of each harvest were primed on top of filter paper moistened with 18 ml PEG 6000 solution of and kept at 20°C for 24 h in the dark in 9 cm Petri dishes[1]. During the priming treatment, dishes were covered with plastic film to prevent loss of liquid. At the end of the treatment, seeds were washed under tap water and dried to the original moisture content determined by weighing (approximately 8–9%) on top of filter paper on the laboratory bench (20 ± 2°C) for 2 days. Three replicates of 50 seeds of primed and control seeds of each lot 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. 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).Emergence was counted daily for 14 days with seeds recorded as emerged when the seedling appeared on or above the surface of peat moss. Mean emergence time (MET) was calculated using the formula of Ellis and Roberts[5]:

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

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

Seedlings were counted, cleaned and seedling length (mm/plant) and above-ground fresh weight (mg/plant) were determined after 14 days. Finally, those seeds that germinated but were failed to emerge through the peat moss surface were determined. The experiment was conducted with a factorial arrangement based on completely randomized design with three 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 at each maturity stage.

RESULTS AND DISCUSSION

Emergence: Interaction of priming × seed maturity was found significant for emergence percentage and mean emergence time (Table1). Rapid emergence was observed as seed maturated and when primed. The primed seeds emerged earlier and maintained a higher level of emergence throughout the emergence period. Final emergence percentages of seeds harvested at the beginning of doughing stage was significantly lower than seeds harvested 112 days after sowing and physiological maturity stage. Seeds harvested 112 days after sowing (h_2) and physiological maturity (h_3) showed, respectively 90 and 99% emergence whether they were primed. The maximum and significant advancement from priming was obtained in h_1 seeds in which, control seeds had 61 emergence but corresponding values were 79 %, in primed seeds grown. Mean emergence time (MET) decreased as seed maturation increased and was at minimum values of 256 h in control and 192 h in primed seeds of h_3(Table1). Mean emergence time of h_1 seeds was significantly higher than those of h_2 and h_3.

Seedling Growth: Analyses of variance showed that the interaction of priming × seed maturity was significant for seedling weight but priming and seed maturity did not affect seedling length ($P > 0.05$) neither individually nor interactively(Table 2). Seedling fresh weight increased as the seed matured and at h_3 priming treatment resulted in an increase in seedling weight from 112 mg/plant (control) to 121 mg/plant (primed). The greatest and significant advancement in seedling weight was observed from h_1 seeds in which primed seeds produced seedlings that were 16 mg heavier compared to control. Seedling length increased as seed maturity increased. The proportion of seeds that germinated, but failed to emerge was high for seeds of h_1, with values of 13. This was reduced to 4.4 when seeds were primed (Table 3). As the seeds matured the percentage of seeds that germinated but failed to emerge decreased to 0.5–2.3%.

In a previous study reported that priming before sowing overcame sub-optimal environmental effects on emergence and subsequent seedling establishment performance[21]. We re-confirmed their findings. In this study, we found Priming decreased mean emergence time and increased sorghum seedling emergence and weight under sub-optimal temperature conditions.

The priming-improved seed performance might be attributable in part to metabolic repair processes, a buildup of germination metabolites or osmotic adjustment during treatment[2]. The degree of enhancement depends upon the temperature, duration, and other conditions specific to the treatment medium. Some long duration and very low or high temperature priming treatments can have a negative effect on subsequent emergence response[11,12,8,6]. Presowing seed hydration treatments are limited to those conditions that do not result in premature radicle extension[13]. This limitation does not greatly narrow the range of potential treatment combinations that could be tested to determine optimal priming conditions.

Table 1: The effect of priming on emergence and emergence rate of sorghum seeds harvested in three stages (beginning of doughing stage(h_1), 112 days after sowing (between doughing and physiological maturity stages)(h_2) and physiological maturity stage(h_3)).

	Seed treatment	Seed harvest stage		
		h_1	h_2	h_3
Emergence percentage(%)				
	Untreated	61	73	97
	Primed	79	90	99
		**	NS	NS
Mean emergence time (h)				
	Untreated	312	275	256
	Primed	255	212	192
		**	**	*

NS: Non-significant.
Significant at $P < 0.05$.
Significant at $P < 0.01$.

Table 2: The effect of priming treatments on seedling weight and length from sorghum seeds harvested in three stages (beginning of doughing stage (h_1), 112 days after sowing (between doughing and physiological maturity stages) (h_2) and physiological maturity stage (h_3))

	Seed treatment	Seed harvest stage		
		h_1	h_2	h_3
Seedling fresh weight (mg)				
	Untreated	59	88	112
	Primed	75	96	121
		**	*	*
seedling length (mm)				
	Untreated	18	31	46
	Primed	21	33	49
		NS	NS	NS

NS: Non-significant.
Significant at $P < 0.05$.
Significant at $P < 0.01$

Table 3: Percentage of primed and control sorghum seeds germinated in the peat moss but unable to emerge to the surface by 14 days after planting

Seed treatment	Seed harvest stage		
	h_1	h_2	h_3
Untreated	13	2.3	1.6
Primed	4.4	1	0.5
	**	NS	NS

NS: Non-significant.
Significant at $P < 0.01$

The maximum advantage of priming was observed for seeds harvested at the beginning of doughing stage. Seeds harvested later (h_2 and h_3) had higher emergence, emergence rate and seedling fresh weight than those of less mature (h_1) ones. Priming had smaller effects on these more mature seeds. Less mature seed lots responded more positively to priming than the more mature ones.

It was reported that priming was more beneficial for muskmelon seeds of 40DAA than those of 60DAA concerning germination under stress[26] and repair of post-harvest ageing[20]. This might be due to overcoming some seed dormancy or improving embryonic development. Agreeing with that assumption, Nerson *et al*.[19] reported that priming increased embryo length in watermelon seeds. Also mature seeds (larger and heavier seeds) may have stronger seedling emergence strength. Priming might also be effective through softening the seed coat and ease of the mechanical restriction of coat (i.e. softening).

It has been long known that one of the main merits of priming treatments to increase germination and emergence rate and in turn improved emergence[13]. However, the question arises whether rapid radicle protrusion is always reflected in rapid seedling emergence. Halmer and Bewley[9] proposed that emergence losses in the soil are not generally due to germination failure, but failure of seedlings to grow and emerge above soil surface. Results of the present study confirmed that a large number of sorghum seeds particularly from early harvests (h_1) were not able to emerge despite their germination in the soil. A reduction in the percentage of such seeds after priming indicated that the beneficial effect of priming extended beyond radicle emergence and increased the vigor of emerging sorghum seedlings. This positive effect of priming was clearly reflected in subsequent seedling weights agreeing with the observations of Sung and Chiu[23] in watermelon seeds. In conclusion, priming can be used to increase seed emergence percentage and rate in early sowings to ensure production of well-developed, uniform seedlings. This will be of particular benefit when samples are heterogenous, including seeds of different levels of maturity.

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