



## Changes in morphology and grain yield of maize in response to seed aging and priming

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Article published on March 24, 2017

**Key words:** Grain yield, Hydro-priming, Maize, Morphology, Seed aging

### Abstract

Seeds of maize (cv. SC AR68) were divided into three sub-samples, one of which was kept as high vigor seed lot (A<sub>1</sub>) and two others were artificially aged. Each seed sample was then divided into four sub-samples, one of which was not primed and the other three samples were primed in distilled water for 7, 14 and 21 h, and then dried back to initial moisture content. The field experiment was laid out as factorial based on RCB design with three replications. Plant height, ear length, ear diameter and grains per ear of plants from aged seeds were decreased by seed aging, leading to significant reduction in grain yield per unit area. However, these traits particularly plant height and ear length were enhanced by hydro-priming of seeds for 21 h, improving grain yield of maize by about 32%. These results suggest that hydro-priming for 21 h is a useful technique for repairing seed aging and improving plant morphology and grain yield of maize.

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## Introduction

Maize is used for human food, livestock feed, oil and fuel production, and also as a medical and ornamental plant (Bekric and Radosavljevic, 2008). Field performance of maize may be influenced by many internal and external factors. One of the most important internal factors which may affect field emergence and yield of maize is seed vigor (Ghassemi-Golezani *et al.*, 2011). High vigor seed lots show rapid and uniform seedling emergence, leading to the production of vigorous plants and optimum stand establishment (Dalil *et al.*, 2010), which may increase grain yield (Ghassemi-Golezani *et al.*, 2010).

Seed vigor decreases as a result of aging on mother plant or in storage. Seeds begin to deteriorate on the mother plant shortly after they reach maximum quality (Ghassemi-Golezani and Hossainzadeh-Mahootchi, 2009). If the deterioration continues far enough, then seed viability will be lost (Roberts and Ellis, 1982), giving rise to slow and non-uniform germination and seedling emergence particularly under stressful conditions (Khan *et al.*, 2003). Oxidative reactions are responsible for the deteriorative changes observed in aged seeds (Van Zutphen and Cornwell, 1973). It was found that increasing seed aging could reduce plant height, grains per plant and grain yield of chickpea (Biabani *et al.*, 2011)

In general, deteriorated parts of seeds might be repaired by priming (McDonald, 1999; Ghassemi-Golezani and Hossainzadeh-Mahootchi, 2013). Harris *et al.* (1999) promoted a low cost, low risk technology called 'on-farm seed priming' that would be appropriate for all farmers, irrespective of their socioeconomic status. In seed priming, seeds are partially hydrated to a point where germination-related metabolic processes begin, but radicle emergence does not occur. After priming, seeds are air-dried back to about original moisture. Harris *et al.* (2002a) indicated that hydro-priming is the best option for smallholder farmers in developing countries, since it is a low cost and low risk intervention. Seed priming also promotes germination rate by repair of the damaged proteins, RNA and DNA (Koehler and *et al.*, 1997).

It was reported that hydro-priming can improve grain yield of chickpea plants from differentially deteriorated seed lots via invigoration of the seeds (Hossainzadeh-Mahootchi and Ghassemi-Golezani, 2013). However, morphological characteristics and grain yield of maize seed lots with different levels of seed aging to priming were not evaluated. This research was aimed to examine the effects of hydro-priming durations on some morphological characteristics and grain yield of maize plants.

## Materials and methods

### Seed treatments

Seeds of Maize (cv. SC AR68) were obtained from the Agricultural Research Institute of Moghan, Iran. The moisture content of seeds was about 13.5%, which augmented to about 20% in the laboratory (ISTA, 2010). Then, these seeds were divided into three sub-samples, one of which with a 100% germination was kept as control (A<sub>1</sub>). The other two samples were artificially aged at 40 °C for 2 and 3 d, reducing normal germination to 98% and 93% (A<sub>2</sub> and A<sub>3</sub>), respectively. Consequently, three seed lots with different levels of vigor were provided. Each seed sample was then divided into four sub-samples, one of which was not primed (P<sub>1</sub>) and the other three samples were primed in distilled water at 15 °C for 7 (P<sub>2</sub>), 14 (P<sub>3</sub>) and 21 (P<sub>4</sub>) hours, and then dried back to about initial moisture content at a room temperature of 20–22 °C for 24 hours.

### Experimental design

Field experiment was conducted in 2016 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. The experiment was arranged as factorial laid out in a RCB design with three replications. Each plot had 6 sowing rows of 3 m length and 25 cm apart. Seeds were treated with Benomyl at a rate of 2 g kg<sup>-1</sup> before sowing. The seeds were then sown in a sandy loam soil at a depth of about 4 cm with a density of 10 seeds/m<sup>2</sup>. Weeds were controlled by hand during crop growth and development.

*Morphological traits and grain yield*

Plant height and leaves per plant were determined in 5 random plants from each plot, and then mean values were calculated. At maturity, plants in 1m<sup>2</sup> of each plot were harvested and ear length, ear diameter, grain rows per ear, grains per ear and grain yield per unit area were recorded.

*Statistical analysis*

All the data were analyzed on the basis of the experimental design, using MSTATC and SPSS-20.

The means of each trait for different treatments were compared according to Duncan multiple range test at P ≤ 0.05.

**Results and discussion**

Analysis of variance showed that seed aging had significant effects on plant height, ear length, ear diameter, grains per ear and grain yield. The plant height and ear length were significantly influenced by hydro-priming duration. However, the interaction of aging × hydro-priming was not significant for any of the traits (Table 1).

**Table 1.** Analysis of variance of the effects of seed aging and hydro-priming on morphological traits and grain yield of maize.

S.V.	df	MS						
		Plant height	Leaves per plant	Ear length	Ear diameter	Rows per ear	Grains per ear	Grain yield
Replication	2	17.79ns	0.970*	1.74ns	9.97ns	1.12ns	5381.92ns	218673.15ns
Aging (A)	2	239.76**	0.241ns	21.80*	15.06*	2.10ns	37707.07*	804540.33**
Hydro-priming (Hp)	3	280.13**	0.307ns	17.56*	11.48ns	0.89ns	19516.50ns	141997.88ns
A × Hp	6	22.54ns	0.457ns	4.47ns	5.87ns	2.02ns	16903.73ns	151539.75ns
Error	22	17.28	0.207	4.61	4.14	1.55	10555.40	89274.53
CV%	-	2.35	3.56	10.66	7.88	9.31	22.13	14.25

ns, \*, \*\*: Not significant and significant at p ≤ 0.05 and p ≤ 0.01, respectively.

Plant height was decreased by increasing seed aging. However, there was no significant difference between plants from A<sub>1</sub> and A<sub>2</sub> seed lots. Plant height increased as a result of seed priming. The highest increment in height was observed in plants from hydro-primed seeds for 21 h (Table 2). Plant height at maturity is an important morphological attribute, which may be influenced by genetic constitution, soil nutrition, seed vigor and environmental conditions (Shakeel *et al.*, 2014). The greater height of plants from high vigor seed lot (A<sub>1</sub>) and hydro-primed seeds was the result of rapid and uniform seedling emergence (Ghassemi-Golezani *et al.*, 2012). Hydro-priming enhances DNA and RNA synthesis, α-amylase activities and embryo growth, leading to improve seed germination rate, growth consistency, seedling vigor and plant growth (Basra *et al.*, 2005). Yaghoobian *et al.* (2016) also reported that increasing hydro-priming duration increases plant height of milk thistle. Early emergence of seedlings from primed seeds causes efficient and longer use of plants from light and soil

resources during growth and development, thereby producing taller plants (Hosseinzadeh-Mahootchi *et al.*, 2013).

Ear length of plants from aged seeds was less than those from non-aged seeds, with no significant difference between A<sub>1</sub> and A<sub>2</sub> and also between A<sub>2</sub> and A<sub>3</sub> plants. Hydro-priming for 14 and 21 h significantly increased ear length. The highest improvement in ear length was recorded for P<sub>4</sub> plants. Ear diameter of plants from A<sub>1</sub> seeds was significantly higher than those from A<sub>2</sub> and A<sub>3</sub> seeds. However, no significant difference between A<sub>2</sub> and A<sub>3</sub> plants was observed (Table 2). The higher ear length and diameter of plants from high vigor seeds can be attributed to the availability of greater environmental resources for these plants, due to the early establishment.

The highest grains per ear was obtained from the A<sub>1</sub> seed lot, with no significant difference with A<sub>2</sub> seed lot.

Seed hydro-priming for 21 h increased grains per ear of maize by about 24.7%, although this improvement was not statistically significant.

The higher grains per ear of plants from non-aged and hydro-primed seeds were associated with greater ear length and diameter of these plants (Table 2).

**Table 2.** Means of plant height, ear length, ear diameter, grains per ear and grain yield for maize affected by seed aging and hydro-priming duration.

Treatments	Plant height (cm)	Ear length (cm)	Ear diameter (mm)	Grains per ear	Grain yield (g/m <sup>2</sup> )
Aging					
A <sub>1</sub>	179.56a	21.48a	27.07a	500.20a	1320.80a
A <sub>2</sub>	176.23a	20.13ab	25.20b	493.08a	1069.20a
A <sub>3</sub>	170.95b	18.79b	25.19b	399.74b	802.521b
Hydro-priming					
P <sub>1</sub>	169.16c	18.26c	24.59a	426.70a	930.69a
P <sub>2</sub>	177.19b	19.93bc	25.99a	444.49a	1066.26a
P <sub>3</sub>	172.97c	20.93b	25.41a	454.09a	1027.16a
P <sub>4</sub>	182.13a	21.43a	26.28a	532.09a	1231.93a

Different letters in each column indicate significant difference at  $p \leq 0.05$ .

A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>: control and aged seeds for 2 and 3 days at 40 °C, respectively.

P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>, P<sub>4</sub>: unprimed and hydro-primed seeds for 7, 14 and 21 hours, respectively.

Seed aging reduced grain yield of maize, although there was no significant difference between A<sub>1</sub> and A<sub>2</sub> plants. This reduction could be resulted from decreasing plant height, ear length, ear diameter and grains per ear of plants from aged seeds (Table 2). Al Najjar *et al.* (2015) also found a high significant positive correlation of plant height, ear length and diameter and number of grains per ear with grain yield. Improving these traits by seed hydro-priming for 21 h increased grain yield of maize by about 32%, although this advantage was not statistically significant (Table 2). Harris *et al.* (2001) stated that hydro-priming by improving seed vigor in rice, maize and chickpea caused faster development, earlier flowering and higher yield in these crops. These results suggest that hydro-priming for 21 h is a simple and useful technique for repairing seed aging and improving morphological traits and grain yield of maize.

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