Azarian J. Agric. VOL (4) ISSUE 1, 2017: 18-23

Azarian Journal of Agriculture

www.azarianjournals.ir

Azarian Journals

Research article

ISSN:2383-4420

Field establishment and grain yield of maize affected by hydro-priming of differentially aged seeds

Kazem Ghassemi-Golezani*, Sohrab Mamnabi, Safar Nasrollahzadeh

Article Info

Accepted:
10 Feb. 2017

Keywords:
Germination, grain yield, hydro-priming, seedling emergence, seed vigor

ABSTRACT

A sub-sample of maize seeds (cv. SC-AR68) with a 100% germination was kept as control, and two other sub-samples were artificially deteriorated at 40 °C for 2 and 3 days, reducing normal germination to 98% and 93%, respectively. Consequently, three seed lots of maize with different levels of vigor were provided. Each seed lot was then divided into four sub-samples, one unprimed and the other three lots were primed in distilled water at 15 °C for 7, 14 and 21 hours, and then dried back to initial moisture content (about 20%) at a room temperature of 20–22 °C for 24 hours. The field experiment was arranged as factorial based on randomized complete block design with three replications. Although germination percentage of seed lots was not significantly affected by hydro-priming, germination rate and seedling dry weight were considerably enhanced as a result of seed priming. Hydro-priming for 21 hours enhanced seedling emergence rate of all seed lots with different levels of vigor. This hydro-priming duration also increased grain yield of maize by about 32%, although this superiority was not statistically significant. This advantage in grain yield of plants from primed seeds was related with rapid germination and seedling growth and early emergence in the field.

INTRODUCTION

Maize is the first most produced cereal grain in the world, followed by rice and wheat (FAO 2014). It is used as a staple food for humans, as feed for livestock and as raw material for industry. The first important factor which can largely influence field performance of maize is seed physiological quality which is related to germination capacity and vigor (Ghassemi-Golezani and Dalil 2014).

When seeds are stored without proper humidity and temperature, they begin to deteriorate, loosing vigor and viability (Ghassemi-Golezani et al. 2011). Several biochemical and physiological changes have been observed in seeds during aging, resulting in a progressive decline in seed quality and performance (McDonal 1999). Membrane disruption is one of the main causes of seed aging, leading to increased free fatty acid levels and free radical productivity by lipid peroxidation (Grilli et al. 1995). Free radicals attack membrane lipids, and cause major disruption of their viscosity and permeability (Van Zutphen and Cornwell 1973). Oxidative damages are responsible for deterioration in aged seeds. Free radical oxidations and protein enzymatic dehydrogenation and aldehyde oxidation might reasonably contribute to seed vigor reduction (Ghassemi-Golezani et al. 2010). Seed aging is generally marked by a reduction in increased solute leakage (Basra et al. 2003; Ghassemi-Golezani et al. 2012), rate and uniformity of seed germination and seedling emergence (Abdulrahmani et al. 2007; Ghassemi-Golezani et al. 2008a). Some of the damages due to seed deterioration could be repaired by seed priming such s hydro-priming (Ghassemi-Golezani and Hossainzadeh-Mahootchi 2013).

Hydro-priming is a simple and environmentally friendly technique used for improving pre-germination processes such as DNA replication, RNA and protein synthesis and seedling growth and establishment (McDonald 2000; Ghassemi-Golezani et al. 2008b). It was reported that hydro-priming could enhance seed

[1] Department of Ecophysiology, Faculty of Agriculture, University of Tabriz, 5166614766, Tabriz, Iran.
*Email: golezani@gmail.com

and seedling vigor in wheat (Giri and Schellinger 2003), maize (Dezfuli et al. 2008), barley (Rashid et al. 2006), chickpea (Ghassemi-Golezani and Hossainzadeh-Mahootchi 2013), lentil (Ghassemi-Golezami et al. 2008a) and milk thistle (Ghassemi-Golezani et al. 2016). Earlier works showed that the success of seed priming is influenced by different factors including plant species, water availability during priming, duration of priming, temperature, seed vigor and storage conditions (Parera and Cantliffe 1994).

Invigoration of seeds by hydro-priming can improve crop yield in two major ways: first, optimum plant density could be established under a wide range of environmental conditions, and second, early emergence of seedlings which could result in vigorous plants tolerant to biotic and abiotic stresses (Ghassemi-Golezani et al. 2016). Some researchers reported that priming could enhance the quality of aged seeds by increasing enzymes activity such as antioxidant enzymes and amylases (Seiadat et al. 2012; Ansari et al. 2013). Priming may reverse the deleterious effects of seed aging by repairing and building-up nucleic acids, increasing synthesis of proteins, as well as repairing membranes (McDonald 2000; Ghassemi-Golezani and Hossainzadeh-Mahootch 2013). Priming is also thought to counteract the effects of lipid peroxidation and reduce leakage of metabolites (McDonald 1999; Hsu et al. 2003; Wang et al. 2003). Hence, this research was aimed to investigate the effects of seed aging and hydro-priming duration on seed vigor, field establishment and grain yield of maize.

MATERIALS AND METHODS

Seed treatments

Seeds of maize (cv. SC AR68) were obtained from the Dryland 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 (V_1). The other two samples were artificially aged at 40 °C for 2 and 3 d, reducing normal germination to 98% and 93% (V_2 and V_3), 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_1) and the other three samples were soaked in distilled water at 15 °C for 7 (P_2), 14 (P_3) and 21 (P_4) h, and then dried back to initial moisture content at a room temperature of 20–22 °C for 24 h.

Laboratory tests

Laboratory tests were carried out as a factorial experiment laid out in a completely randomized design at the Seed Technology Laboratory of the University of Tabriz, Iran. Four replicates of 25 seeds were placed between moist filter papers and germinated in an incubator at 20 °C (ISTA 2010). Germinated seeds (protrusion of radicle by 2 mm) were recorded every day for 7 d. Rate of seed germination was calculated according to Ellis and Roberts (1980) as:

$$GR = \Sigma n / \Sigma Dn \qquad (1)$$

where n is the number of seeds germinated on day D, D is the number of days from the beginning of the test and GR is the mean germination rate.

Field experiment

The field experiment was conducted at the Research Farm of the University of Tabriz (Latitude 38˚05' N, Longitude 46˚17' E, Altitude 1360 m above sea level) in 2016. All the seeds were treated with Benomyl at a rate of 2 g kg^{-1} before sowing. Seeds were then hand sown in about 4-5 cm depth with a density of 10 seeds m^{-2} on 4^{th} May 2016. This experiment was arranged as factorial, based on RCB design with three replications.

Number of emerged seedlings in an area of 1 m^2 within each plot was counted in daily intervals until seedling establishment became stable. Seedling emergence rate was calculated in accordance with the equation 1 (Ellis and Roberts 1980).

At maturity, plants in 1m^2 of each plot were harvested and grain yield per unit area was determined. The data were analyzed by MSTATC and SPSS-20. The means were compared using Duncan multiple range test at $P \leq 0.05$. Excel software was used to draw the figures.

RESULTS AND DISCUSSION

Analysis of variance of the laboratory data showed significant effects of aging on percentage and rate of germination and seedling dry weight. Germination rate and seedling dry weight were also significantly affected by hydro-priming. The interaction of seed aging × hydro-priming duration was only significant for germination rate and seedling dry weight (Table 1).

Germination percentage of V_3 seeds was significantly lower than that of V_1 and V_2 seeds, with no significant difference between two latter seed lots (Table 3). Although germination

Table 1. Analysis of variance of the effects of seed aging and hydro-priming duration on seed germination and seedling dry weight of maize.

S.V.	df	MS		
		Germination percentage	Germination rate	Seedling dry weight
Aging (A)	2	12.646**	0.039**	0.471**
Hydro-priming (Hp)	3	0.972^{ns}	0.017**	0.11**
A × Hp	6	0.451^{ns}	0.003**	0.017*
Error	36	0.573	0.001	0.007
CV%	-	3.13	5.39	9.23

ns, *, **: Not significant and significant at $p \leq 0.05$ and $p \leq 0.01$, respectively

percentage of seed lots was not significantly affected by hydro-priming ($p > 0.05$), germination rate of seeds, particularly aged seeds was considerably improved by hydro-priming. Germination rate of all seed lots was increased by all priming durations particularly by hydro-priming for 14 and 21 hours, with no significant difference between these two durations (Figure 1A). Almost similar changes were observed for seedling dry weight of maize affected by interaction of seed aging × hydro-priming duration (Figure 1B). These results clearly indicated that there is a strong relationship between germination rate and seedling dry weight. Similar results were reported by Ghassemi-Golezani and Hossainzadeh-Mahootchi, (2013) for chickpea. They showed that seed reserve utilization rate was reduced by aging, but it was enhanced by hydro-priming, leading to an improvement in germination rate and seedling dry weight.

Seed aging was associated with a decrease in the activity of superoxide dismutase, catalase and glutathione reductase, the main enzymes involved in cell detoxification (Serge Kibinza et al. 2006). Improving germination rate and seedling growth of aged seeds by priming could be attributed to repair of DNA (Sivritepe and Dourado 1994), RNA (McDonal 1999), protein (Dell Aquila and Tritto 1991), membrane (Petruzzeli 1986) and enzymes (Jeng and Sung 1994) during priming.

Seedling emergence percentage and grain yield were significantly influenced by seed aging, but not by hydro-priming and interaction of these two factors. However, seedling emergence rate was significantly affected by aging, hydro-priming and interaction of these two factors (Table 2). The highest seedling emergence percentage was obtained for the high vigor seed lot, and it was decreased with decreasing seed vigor, although there was no significant difference between V_2 and V_3 seed lots. The superiority of high vigor seed lot in plant establishment led to the production of 23% and 65% more grain yield per unit area, compared to aged seed lots of V_2 and V_3, respectively (Table 3).

Hydro-priming duration for 21 (P_4) h enhanced seedling emergence rate in all seed lots with different levels of vigor. The highest improvement of this trait was recorded for the non-artificially aged seed lot (V_1). Hydro-priming durations for 7 (P_2) and 14 (P_3) h did not show any advantage in emergence rate, compared with unprimed seeds (P_1) (Figure 2). The high emergence rate of seedlings from primed seeds can be attributed to faster water uptake in primed seeds

Table 2. Analysis of variance of the effects of seed aging and hydro-priming duration on seedling emergence and grain yield of maize

S.V.	df	MS		
		Emergence percentage	Emergence rate	Grain yield
Replication	2	885.061*	0.001^{ns}	218673.147^{ns}
Aging (A)	2	798.302*	0.002*	804540.326**
Hydro-priming (Hp)	3	84.434^{ns}	0.001^{ns}	141997.882^{ns}
A × Hp	6	20.743^{ns}	0.0001^{ns}	151539.753^{ns}
Error	22	183.411	0.000028	89274.526
CV%	-	25.25	16.36	14.25

ns, *, ** Not significant, significant at $p \leq 0.05$, and significant at $p \leq 0.01$, respectively.

Table 3. Means of seedling emergence percentage, seedling emergence rate and grain yield following different seed aging periods

Aging	Germination (%)	Emergence (%)	Grain yield (gm^{-2})
V_1	100a	62.31a	1320.31a
V_2	98a	52.44ab	1069.21a
V_3	93b	46.13b	802.52b

Different letters in each column indicate significant difference at $p \leq 0.05$ V_1, V_2, V_3: control and aging for 2 and 3 d at 40 °C, respectively.

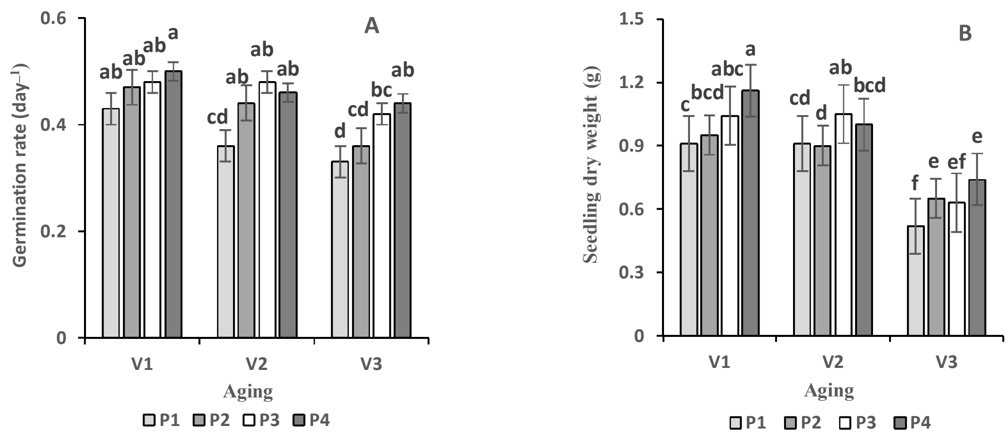

Figure 1. Means of germination rate (A) and seedling dry weight (B) for interaction of seed aging × priming
V_1, V_2, V_3: control and aging for 2 and 3 days at 40 °C, respectively.
P_1, P_2, P_3, P_4: unprimed and hydro-primed seeds for 7, 14 and 21 hours, respectively

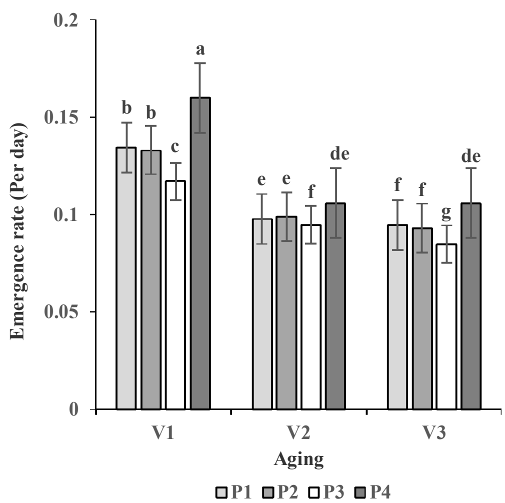

Figure 2. Mean emergence rate of seedlings for interaction of seed aging × priming
V_1, V_2, V_3: control and aging for 2 and 3 days at 40 °C, respectively
P_1, P_2, P_3, P_4: unprimed and hydro-primed seeds for 7, 14 and 21 hours, respectively

(Ghassemi-Golezani et al. 2008a), mediation of cell division in germinating seeds (Sivritepe et al. 2003), increasing the activity of enzymes such as amylase, protease and lipase, which play a large role in the breakdown of macromolecules for growth and embryo development (Dell-Aquila and Tritto 1990) and metabolic repair during imbibition.

Reductions in grain yield per unit area were mainly influenced by large reductions of plant density, due to seed aging, as also reported for soybean (Saha and Sultana 2008), oil-seed rape (Ghassemi-Golezani et al. 2010), chickpea (Ghassemi-Golezani et al. 2012) and wheat (Ghassemi-Golezani et al. 2014). Seed hydro-priming for 21 h improved grain yield of maize by about 32%, although this improvement was not statistically significant ($p > 0.05$). This superiority of primed seeds was resulted from rapid germination and seedling growth (Figure 1) and early emergence in the field (Figure 2).

CONCLUSION

Seed hydro-priming for 21 hours increased germination rate, seedling dry weight and seedling emergence rate of all seed lots with different levels of vigor, leading to an improvement in grain yield of maize by about 32%. Therefore, hydro-priming of maize seeds before sowing could be a promising way for improving field establishment and grain yield of this important cereal crop.

REFERENCES

Abdulrahmani B. Ghassemi-Golezani K. Valizadeh M. Feizi-Asl V. (2007) Seed priming and seedling establishment of barley (*Hordeum vulgare* L.). International Journal of Farming and Allied Sciences, 5: 179- 184.

Ansari O. Sharif-Zadeh Moradi A. Azadi MS.Younesi E. (2013) Heat shock treatment can improve some seed germination indexes and enzyme activity in primed seeds with gibberellin of mountain rye (*Secale montanum*) under accelerated aging conditions. Cercetari Agronomice in Moldova, 4: 21-30.

Basra SM A. Pannu I.A. Afzal I. (2003) Evaluation of seedling vigor of hydro and matri-primed wheat (*Triticum aestivum* L.) seeds. International Journal of Agriculture and Biology, 2: 121- 123.

Dell Aquila A. Tritto V. (1990) Ageing and osmotic priming in wheat seeds: effects upon certain components of seed quality. Annals of Botany, 65: 21-26.

Dell Aquila A. Tritto V. (1991) Germination and biochemical activities in wheat seeds following delayed harvesting, ageing and osmotic priming. Seed Science and Technology, 19: 73- 82.

Dezfuli P.M. Sharif-zadeh F. Janmohammadi M. (2008) Influence of priming techniques on seed germiantion behavior of maize inbred lines (*Zea mays* L.). Journal of Agricultural and Biological Science, 3:22-25.

Ellis R.H. Roberts EH. (1980). Towards a rational basis for testing seed quality. In: Seed Production. Hebblethwaite P.D. (ed.), Butterworths, London, pp. 605–635

FAO (2014) Agriculture Statistics, FAOSTAT, United Nation Organization.

Ghassemi-Golezani K. Aliloo A.A. Valizadeh M. Moghaddam M. (2008a) Effects of different priming techniques on seed invigoration and seedling establishment of lentil (*Lens culinaris* Medik). Journal of Food, Agriculture and Environment, 2: 222-226.

Ghassemi-Golezani K. Chadordooz-Jeddi A. Nasrullahzadeh S. Moghaddam M. (2010) Effects of hydropriming duration on seedling vigor and grain yield of pinto bean (*Phaseolus vulgaris* L.) cultivars. Notulae Botanicae Horti AgrobotaniciCluj-Napoca, 38:109- 113.

Ghassemi-Golezani K. Dalil B. (2014) Effects of seed vigor on growth and grain yield of maize. Plant Breeding and Seed Science, 70: 81-90.

Ghassemi-GolezanI K. Dalil B. Moghaddam M. Raey Y. (2011) Field performance of differentially deteriorated deed lots of maize (*zea mays*) under different irrigation treatments. Notulae Botanicae Horti AgrobotaniciCluj-Napoca, 39: 160-163.

Ghassemi-Golezani K. Hosseinzadeh- Mahootchi A. (2013) Influence of hydro-priming on reserve utilization of differentially aged chickpea seeds. seed technology, 35: 117-124.

Ghassemi-Golezani K. Hosseinzadeh-Mahootchi A. Zehtab-Salmasi S. Tourchi M. (2012) Improving field performance of aged chickpea seeds by hydro priming under water stress. International Journal of Plant, Animal and Environmental Sciences, 2: 168-176.

Ghassemi-Golenzani K. Sheikhzadeh-Mosassogh P. Valizadeh M. (2008b) Effects of hydro-priming duration and limited irrigation on field performance of chickpea. Seed Science Research, 1: 34-40.

Ghassemi-Golezani K. Yaeghoubian I. Raei Y. (2016) The impact of hydro-priming duration on seed invigoration and field emergence of milk thistle. Journal of Biodiversity and Environmental Sciences, 2: 229-234.

Giri G.S. Schillinger W.F. (2003) Seed priming winter wheat for germination, emergence, and yield. Crop Science, 43: 2135-2141.

Grilli I. Bacci E. Lombardi T. Spano C. Floris C. (1995) Natural aging: Poly (A) polymerase in germinating embryos of Triticum durum wheat. Annals of Botany, 76: 15- 21.

Hsu C.C. Chen C.L. Chen J.J. Sung J.M. (2003) Accelerated aging-enhanced lipid peroxidation in bitter gourd seeds and effects of priming and hot water soaking treatments. Scientia Horticulturae, 98: 201-212.

ISTA. (2010) Seed vigor testing, International rules for seed testing. International Seed Testing Association, Bassersdorf, Switzerland.

Jabbarpour S. Ghassemi-Golezani K. Aghazade R. (2014) Effects of salt priming on seedling vigor and field establishment of aged winter wheat seeds. International Journal of Biosciences, 3: 67-72.

Jeng T.L. Sung J.M. (1994) Hydration effect on lipid peroxidation and peroxide-scavenging enzymes activity of artificially aged peanut seed. Seed Science and Technology, 22: 531-539.

Kibinza S. Vine D. Come D. Bailly C. Corbineau F. (2006) Sunflower seed deterioration as related to moisture content during ageing, energy metabolism and active oxygen species scavenging. Physiologia Plantarum, 128: 496-506.

McDonald M.B. (1999) Seed deterioration: physiology, repair and assessment. Seed Science and Technology, 27: 177-237.

McDonald M.B. (2000) Seed priming. In: Seed technology and its biological basis. Black M. and Bewley J.D. (eds.), Sheffield Academic Press, England, pp. 287-325

Panobianco M. Viera R.D. (2007) Electrical conductivity and deterioration of soybean seeds exposed to different storage conditions. Revista Brasileira de Sementes, 29: 27-105.

Parera C.A. Cantliffe D.J. (1994) Pre-sowing seed priming. Horticulture revisions, 16: 109-141.

Petruzzeli L. (1986) Wheat viability at high moisture content under hermetic and aerobic storage conditions. Annals of Botany, 58: 259-265.

Rashid A. Hallington P.A. Harris D. Khan P. (2006) On-farm seed priming for barley on normal, saline, saline-sodic soils in Northwest Frontier Province, Pakistan. European Journal of Agronomy, 24: 276-281.

Saha R.R. Sultana W. (2008) Influence of seed ageing on growth and yield of soybean.Bangladesh Journal of Botany, 37: 21-26.

Seiadat S.A. Moosavi A. Sharafizadeh M. (2012) Effect of seed priming on antioxidant activity and germination characteristics of Maize seeds

under different aging treatments. Research Journals of Seed Scienc, 2: 51-62.
Sivritepe H.O. Dourado A.M. (1994) The effects of humidification treatments on viability and the accumulation of chromosomal aberrations in pea seeds. Seed Science and Technology, 22: 337- 348.
Sivritepe N. Sivritepe H.O. Eris A. (2003) The effects of NaCl priming on salt tolerance in melon seedling grown under saline conditions. Scientia Horticulturae, 97: 229-237.
Van Zutphen H. Cornwell D.G. (1973) Some studies on lipid peroxidation in monomolecular and bimolecular lipid films. Journal of Membrane Biology, 13: 79- 88.
Wang H.Y. Chen C.L. Sung J.M. (2003) Both warm water soaking and solid priming treatments enhance anti-oxidation of bitter gourd seeds germinated at sub-optimal temperature. Seed Science and Technology, 31:47-56.

Journal sponsorship

Azarian Journal of Agriculture is grateful to the ***University of Maragheh*** and its faculty members for their ongoing encouragement, support and assistance.