PLANT BREEDING AND SEED SCIENCE
Volume 79 2019

Kazem Ghassemi-Golezani*, Sohrab Mamnabi

Department of Ecophysiology, Faculty of Agriculture, University of Tabriz, 5166614766, Tabriz, Iran; *Corresponding author: e-mail: golezani@gmail.com

SOME PHYSIOLOGICAL RESPONSES AND YIELD OF MAIZE AFFECTED BY SEED AGING AND PRIMING DURATION

ABSTRACT

Seeds of maize (cv. SC AR68) were divided into three sub-samples, one of which with a 100% germination was kept as high vigor seed lot (V_1). The other two samples were artificially aged at 40°C for 2 and 3 days, reducing normal germination to 98% (V_2) and 93% (V_3), respectively. Each of these samples was subsequently divided into four sub-samples, one of which was kept as unprimed and three other samples were hydro-primed at 15°C for 7, 14 and 21 h, and then their moisture content reduced to about 20% in a room at 20–22°C. The experiment was undertaken in 2016 as factorial based on randomized complete block design in three replicates. seed aging and hydro-priming had no significant effects on leaf temperature, Fv/Fm, CCI and plant biomass due to regular irrigation. Seed aging reduced, but hydro-priming enhanced LAI, grain yield and harvest index of the resultant plants. Grain yield of plants from high vigor seed lot (V_1) was 23.5% and 64.5% greater than that of V_2 and V_3 plants. Seed hydro-priming for 21 h also increased grain yield of maize by about 32%. Therefore, hydro-priming for 21 h is the best pretreatment to improve field performance and yield of maize.

Key words: aging, grain yield, harvest index, hydro-priming, leaf area index, maize

INTRODUCTION

Maize grains may be consumed by humans or could be used as the main component of animal feed (Steduto *et al.,* 2012). The area devoted to this plant and the yield per hectare have been increasing over time. The total production in 2014 was 1017 million tons in the world (FAO, 2016). 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).

Seed vigor is defined as, the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of

Communicated by Grzegorz Żurek

environments (ISTA, 2010). Aging and deterioration could reduce seed vigor at later harvests and during storage (Ghassemi- Golezani *et al.,* 2014). The rate of seed deterioration, due to aging, is positively related to the ambient temperature, relative humidity and seed moisture content (Ellis *et al.,* 1981). The oxidative damages are responsible for the deteriorative changes observed in aged seeds (Ghassemi- Golezani *et al.,* 2010b). Free radical oxidations, enzymic dehydrogenation and oxidation of aldehydes of protein molecules might contribute to the progress of seed deterioration (Kapilan and Thiagarajah, 2015).

Seed deterioration is inexorable, and the best that can be done is to control its rate. In general, deteriorated parts of seeds might be repaired by priming (McDonald, 1999; Ghassemi-Golezani and Hossainzadeh-Mahootchi, 2013). Seed priming induces a range of biochemical changes in the seed that are required to start the germination process (Asgedom and Becker, 2001). Priming allows seed hydration to initiate the early events of germination, but not permit radicle emergence, followed by drying to initial moisture (McDonald, 2000; Ashraf and Foolad, 2005). One of the simple techniques for on-farm priming is hydro-priming. The beneficial effects of hydro-priming have been reported for many field crops such as sugar beet (Sadeghian and Yavari, 2004), lentil (Ghassemi-Golezani *et al.,* 2008), sorghum (Moradi and Younesi, 2009), chickpea (Ghassemi-Golezani and Hossainzadeh-Mahootchi, 2013) and milk thistle (Yaghoubian *et al.,* 2016).

Poor stand establishment of maize plants from low vigor seeds was led to deductions in leaf area index (LAI), dry matter accumulation (DMA), crop growth rate (CGR) and consequently grain yield per unit area (Ghassemi-Golezani and Dalil, 2014). Priming appears to reverse the detrimental effects of seed aging (McDonald, 2000). The early improvements may increase the rate and uniformity of seed germination and seedling emergence (Farooq *et al.,* 2005; Ghassemi-Golezani *et al.,* 2010a). It was reported that hydro-priming can improve relative water content, membrane stability, chlorophyll content and grain yield of chickpea plants from differentially deteriorated seed lots via invigoration of the seeds (Hossainzadeh-Mahootchi and Ghassemi-Golezani, 2013).

However, responses of maize seed lots with different levels of seed aging to priming were not evaluated. Thus, this research was aimed to assess the effects of hydro-priming duration on some physiological traits and grain yield of different seed lots of maize.

MATERIALS AND METHODS

Seed treatments

Seeds of maize (cv. SC AR68) were obtained from the Dryland Agricultural Research Institute of Moghan, Iran, and divided into three sub-samples. A sub-sample, with a tested germination of 100%, was kept as control (V_1). The other two sub-samples, with a final moisture content (MC) of about 20%, were artificially aged at 40°C for 2 and 3 days, 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 lot was divided into four sub-samples, one of which kept as a control (unprimed, P_1) and the other three 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 MC at a room temperature of 20–22°C for 24 h.

Experimental design

The field experiment was conducted in 2016 at the Research Farm of the University of Tabriz, Iran (latitude 38°05′N, longitude 46°17′E, altitude 1360 mabove sea level). The experiment was arranged as factorial laid out in a RCB design with three replications. Seeds were treated with Benomyl at a rate of 2 g × kg^{-1} before sowing and sown on plots at a depth of about 4 cm in May 2016. Weeds were controlled by hand during crop growth and development.

Leaf temperature

Leaf temperature (°C) of upper, middle and lower leaves of a plant in each plot was measured by an infrared thermometer (TES-1327) at tasseling stage (VT) and then the mean value for each plot was calculated.

Efficiency of photosystem II (F_v/F_m)

The efficiency of photosystem II (Fv/Fm) was measured in leaves by a chlorophyll fluorometer (OS-30, OPTISCIENCES, USA) at flowering stage, just before irrigation of each plot. Fluorescence emission was monitored from the upper surface of the leaves. Dark-adapted leaves (30 min.) of a plant in each pot were initially exposed to the weak modulate measuring beam, and then exposes to saturated white light and initial (F_0) and maximum (F_m) fluorescence values were recorded. Variable fluorescence (F_v) was calculated as:

$$F_v = F_m - F_0$$

Chlorophyll content index (CCI)

Leaf chlorophyll content index (CCI) was measured using a portable chlorophyll meter (CCM-200, Opti-Sciences, USA). Three plants were marked in each plot and the CCI of the upper, middle and lower leaves of each plant was measured at the flowering stage. Subsequently, the mean CCI for each treatment and replicate was calculated.

Leaf area index (LAI)

Two plants were randomly selected from the central rows of each plot and then all of the leaves were counted and detached from the shoots. Leaf area was measured by a leaf area meter (LI-COR, Model Li-3100C Area Meter, USA). The leaf area index was calculated as:

$$LAI = \frac{L_A}{G_A}$$

where LAI – leaf area index, L_A – leaf area and G_A ground area

Grain yield

At maturity, the plants in 1 m^2 of each plot were harvested and grains were detached from the ear. These plants were then dried in an oven at 75°C for 48 h and weighed. Finally, plant biomass, grain yield per unit area and harvest index were determined for each plot.

Statistical analysis

All the data were analyzed on the basis of the experimental design, using MSTATC and SPSS. The means of each trait were compared according to Duncan multiple range test at $P \leq 0.05$. Excel software was used to draw figures.

RESULTS AND DISCUSSION

Analyses of the data showed that seed aging had significant effects on leaf area index (LAI), grain yield and harvest index. Leaf area index and harvest index were significantly affected by hydro-priming. The interaction of aging × hydro-priming was also significant for leaf area index and harvest index (Table 1).

Table 1

Analysis of variance of the effects of seed aging and hydro-priming duration on leaf temperature, Fv/Fm, CCI, LAI, plant biomass, grain yield and harvest index of maize

S.V.	DF	MS						
		Leaf temperature	Fv/Fm	CCI	LAI	Plant biomass	Grain yield	Harvest index
Replication	2	3.34*	0.00262^{ns}	12.90^{ns}	0.618**	1054661.10**	218673.15^{ns}	15.43^{ns}
Aging (A)	2	0.40^{ns}	0.00122^{ns}	63.89^{ns}	2.101**	405073.58^{ns}	804540.33**	377.62**
Priming (P)	3	1.25^{ns}	0.00028^{ns}	1.97^{ns}	0.475**	3921.79^{ns}	141997.88^{ns}	210.57*
A × P	6	0.62^{ns}	0.00161^{ns}	20.10^{ns}	0.398**	45295.70^{ns}	151539.75^{ns}	151.54*
Error	22	0.71	0.001	68.94	0.095	181622.42	89274.55	51.27
CV%	-	3.52	3.62	26.46	17.85	19.17	14.25	16.29

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

Since plots were irrigated regularly, no significant changes in leaf temperature, Fv/Fm, CCI and plant biomass due to seed aging and priming were not observed (Table 1). Nevertheless, mean plant biomass of plants from high vigor seed lot (V_1) was 13.3% and 20.4% more than the plants from V_2 and V_3 seed lots, respectively (the data are not shown). Seed aging was generally led to reductions in LAI of plants from primed and unprimed seeds. Hydro-priming of all seed lots enhanced LAI of the resultant plants.

However, LAI of the plants from different seed lots was best improved by hydro-priming for 21 h (P_4). This improvement was the highest for the non-aged seed lot (V_1) (Fig. 1). Reductions in LAI of plants from aged seed lots was the consequence of delayed and less emergence of seedlings in the field, compared with high vigor seed lot (Chadordooz-Jeddi *et al.,* 2015). Soltani *et al.* (2009) also found that leaf area of wheat plants reduced as a result of seed aging. Less leaf area means less photosynthesis which can potentially reduce final yield (Ghassemi-Golezani and Dalil, 2014). The advantage of seed priming in improving LAI was closely related with rapid seedling emergence and optimal stand establishment. Optimum stand establishment and early achievement of maximum LAI are essential for the efficient use of resources (Mohammadi, 2009).

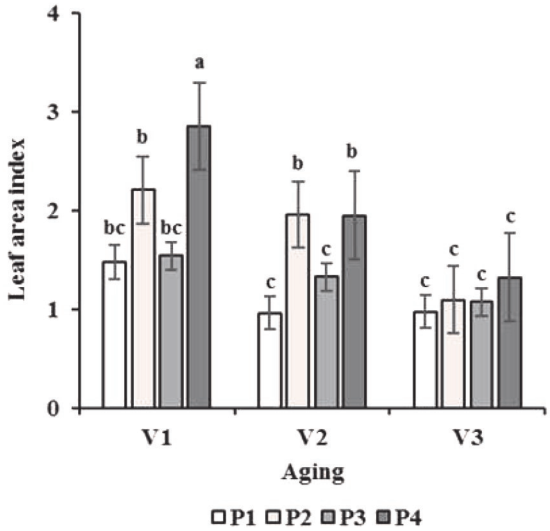

Fig. 1. Mean LAI for interaction of seed aging × priming; V_1, V_2, V_3: control and aging for 2 and 3 days at 40 °C, respectively; P_1, P_2, P_3, P_4: unprimed and hydro-primed seeds for 7, 14 and 21 h, respectively

Grain yield of maize decreased with enhancing seed aging, although there was no significant difference between V_1 and V_2 plants. Grain yield of plants from high vigor seed lot (V_1) was 23.5% and 64.5% greater than that of V_2 and V_3 plants, respectively (Fig. 2). This superiority was directly related with high leaf area index of plants from vigorous seed lot (Fig. 1). Ghassemi-Golezani *et al.* (2010b) reported that low grain yield of lentil plants from aged seed lots was associated with slow emergence of seedlings, poor stand establishment and delayed flowering of these plants. With increasing aging LAI of plants decreases which may result in reducing in mean grain number and weigh and consequently grain yield per unit area (Ghassemi-Golezani and Dalil, 2014).

Seed hydro-priming for 21 h increased grain yield of maize by about 32%, although this increment was not statistically significant (Table 1). The increased grain yield of plants from primed seeds, particularly those from hydro-primed seeds, can be attributed to improvements in leaf area index of these plants (Fig. 1). This advantage in grain yield most likely was achieved by rapid seedling emergence and optimal stand establishment of plants from primed seeds. The early emergence of seedlings from primed seeds leads to more efficient use of light and soil resources during growth and development of plants (Ghassemi-Golezani *et al.,* 2012).

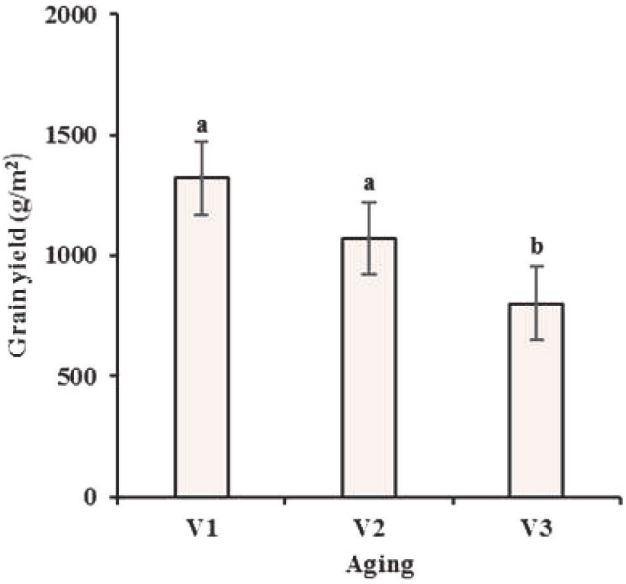

Fig. 2. Mean grain yield for seed aging V_1, V_2, V_3: control and aging for 2 and 3 days at 40 °C, respectively.

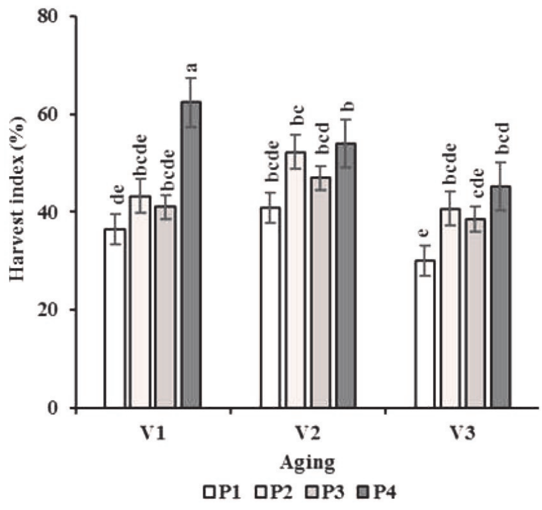

Fig. 3. Mean harvest index for interaction of seed aging × priming; V_1, V_2, V_3: control and aging for 2 and 3 days at 40°C, respectively; P_1, P_2, P_3, P_4: unprimed and hydro-primed seeds for 7, 14 and 21 h, respectively

Harvest index of maize was generally decreased by enhancing seed aging. However, seed hydro-priming, particularly for 21 h, considerably enhanced harvest index of plants from all seed lots (Fig. 3). These results are compatible with plant biomass and grain yield of plants from differentially treated seeds. This means that seed aging reduced grain yield more than plant biomass, but priming enhanced grain yield more than plant biomass.

CONCLUSION

Seed aging was generally led to reductions in LAI, grain yield and harvest index of plants from primed and unprimed seeds. However, these field traits for all seed lots were enhanced by hydro-priming, especially for 21 h. Grain yield of plants from aged seed lots was considerably less than plants from non-aged seed lot. Seed hydro-priming for 21 hours improved grain yield by about 32%. This suggests that hydro-priming for 21 h is the best pretreatment for enhancing field performance and yield potential of differentially aged maize seed lots.

REFERENCES

Asgedom H, Becker M. 2001. Effects of seed priming with nutrient solutions on germination, seedling growth and weed competitiveness of cereals in Eritrea. In: Proc. Deutscher Tropentag, University of Bonn and ATSAF, Magrraf Publishers Press, Weickersheim. p. 282.

Ashraf M, Foolad M.R. 2005. Pre-sowing seed treatment: A shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions. Advances in Agron. 88: 223-271.

Chadordooz-Jeddi A, Ghassemi-Golezani K, Zehtab-Salmasi S. 2015. The impact of seed size and aging on physiological performance of lentil under water stress. J Plant Physiol Breed. 5:13-21.

Ellis RH, Robert EH. 1981. The quantification of ageing and survival in orthodoxes seeds. Seed Sci Technol. 9:373-409.

FAO. 2016. Food and agriculture organization of the United Nations. Rome, Italy.

Farooq M, Basra SMA, Hafeez K, Ahmad N. 2005. Thermal hardening: A new seed vigor enhancement tool in rice. J Int Plant Biol. 47: 184- 193.

Ghassem-Golezani K, Aliloo AA, Valizadeh M, Moghaddam M. 2008. Effects of hydro and osmoprimingon seed germination and field emergence of lentil (*lens culinaris* Medik.). J Food Agri Environ. 6: 222-226.

Ghassemi-Golezani K, Chadordooz-Jeddi A, Nasrullahzadeh S, Moghaddam M. 2010a. Effects of hydro-priming duration on seedling vigor and grain yield of pinto bean (*Phaseolus vulgaris* L.) cultivars. Not Bot Hort Agron. 38:109-113.

Ghassemi-Golezani K, Chadordooz-Jeddi A, Zehtab-Salmasi S. 2014. Effects of seed size and aging on field performance of lentil *(Lens culinaris* Medik.) under different irrigation treatments. Acta agriculturae Slovenica. 2:158-166.

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

Ghassemi-Golezani K, Dalil B, Moghaddam M, Raey Y. 2011. Field performance of differentially deteriorated seed lots of maize (*Zea mays*) under different irrigation treatments. Not Bot Horti Agrobo. 39: 160-163.

Ghassemi-Golezani K, Hosseinzadeh-Mahootchi A. 2013. Influence of hydro-priming on reserve utilization of differentiallyaged chickpea seeds. Seed Technol. 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. Int. J Plant, Animal Environ Sci. 2: 168-176.

Ghassemi-Golezani K, Khomari S, Dali Bl, Hosseinzadeh-Mahootchi A, Chadordooz-Jeddi A. 2010b. Effects of seed aging on field performance of winter oilseed rape. J Food, Agri Environ. 8: 175-178.

Hosseinzadeh-Mahootchi A, Ghassemi-Golezani K. 2013. The impact of seed priming and aging on physiological performance of chickpea under different irrigation treatments. Plant Breed Seed Sci. 67: 13-25.

International Seed Testing Association. 2010. International rules for seed testing. Seed Vigour Testing. Chapter 15: 1-20.

Kapilan R, Thiagarajah M. 2015. Effect of aging on the germination characteristics and enzyme activity of sunflower seeds. Int J Res Inno Earth Sci. 7: 147-150.

McDonald MB. 1999. Seed deterioration: physiology, repair and assessment. Seed Sci Technol. 27: 177-237.

McDonald MB. 2000. Seed priming. In: Seed Technology and Its Biological Basis (Black M, Bewley JD. Eds). Sheffield Academic Press, Sheffield, UK pp. 287–325.

Mohammadi GR. 2009. The effect seed priming on plant traits of late-spring seeded soybean (*Glycine max* L.). American-Eurasian J Agri Environ Sci. 5: 322-326.

Moradi A, Younesi O. 2009. Effects of osmo and hydro-priming on seed parameters of grain sorghum (*Sorghum bicolor* L.). Aus. J Basic Applied Sci. 3: 1696-1700.

Sadeghian SY, Yavari N. 2004. Effect of warerdeficit stress on germination and early seedling growth in sugar beet. J Agro Crop Sci. 190:138-144.

Soltani E, Ghaleshi S, Kamkar B, Akramghaderi F. 2009. The effect of seed aging on seedling growth as affected by environmental factors in wheat. Res. J Environ Sci. 3: 184-192.

Steduto P, Hsiao TC, Fereres E, Raes D. 2012. Crop yield response to water. In: Herbaceous crops (Hsiao TC. Ed.). Food and Agriculture Organization of the United Nations. 500 p.

Yaghoubian I, Raei Y, Ghassemi-Golezani K. 2016. Influence of hydro-priming duration on morpho-physiological traits of milk thistle under water stress. J Bio Env Sci 9:177-184.