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Full Length Research Paper

Seed ageing and field performance of maize under water stress

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A sub-sample of maize (cv.Ksc 301) seeds was kept as control or high vigor seed lot (V_1) and two other sub-samples with about 15% moisture content were artificially aged at 40°C for 9 and 12 days (V_2 and V_3, respectively). Hence, three seed lots with acceptable normal germinations of 98% (V_1), 92% (V_2) and 88% (V_3), but with different levels of vigor were provided. Laboratory tests were carried out as completely randomized design with four replicates. However, the field experiment was conducted as factorial based on RCB design in three replicates. Factors were seed ageing (three levels) and irrigation treatments (irrigation after 70, 90, 110 and 130 mm evaporation). Seeds were then sown with a density of 10 seeds m^{-2} on the 9th May, 2010. Mean germination and emergence times significantly increased, but normal germination percentage, seedling dry weight and emergence percentage decreased with increasing seed ageing and decreasing seed vigor. As a result, plant biomass and grain yield per unit area for plants from aged seeds were considerably lower than those from non-aged seeds. No significant interaction of irrigation × seed ageing was observed for grain yield, suggesting that aged seeds had low yield under both well and limited irrigation conditions. Therefore, production of high vigor seeds and proper storage are necessary to ensure optimum stand establishment and satisfactory yield of maize under favorable and unfavorable field conditions.

Key words: Biomass, harvest index, maize, seed ageing, seedling emergence.

INTRODUCTION

Maximum seed vigor is attained at or slightly after mass maturity (Demir and Ellis, 1992; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009) and thereafter seeds begin to age on mother plant (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009) and during storage, losing vigor and viability (Ellis and Robert, 1981). Oxidative reactions are responsible for the deteriorative changes observed in aged seeds. Free radicals attack membrane lipids and cause major disruption of their viscosity and permeability (Van Zutphen and Cornwell, 1973). Increase of solute leakage at this situation would be due to damaged membrane (Al-Maskri et al., 2003). Seed vigor reflects potential seed germination, field emergence and seedling establishment under different environmental conditions (Sun et al., 2007). High vigor seed lots show rapid and uniform seedling emergence, leading to the production of vigorous plants and optimum stand establishment (Ghassemi-Golezani et al., 2008b, 2010a; Dalil et al., 2010). This may improve plant performance under normal and stressful conditions. One of the important environmental stresses that can strongly limit crop performance is water stress (Ludlow and Muchow, 1990). When the full crop requirements are not met, water deficit in the plant can develop to a point where crop growth and yield are affected. Water stress during vegetative stages has the greatest impact on plant height and biomass (Ghassemi-Golezani et al., 2008a), while water deficit during the reproductive growth is considered to have the most adverse effect on crop productivity (Costa-Franca et al., 2000).

Seed ageing has been reported to decrease field emergence and yield of wheat (Ganguli and Sen-Mandi, 1990), barley (Samarah and Al-Kofahi, 2008) and oilseed rape (Ghassemi-Golezani et al., 2010b). However, the

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Table 1. Comparison of means of seedling emergence time and percentage of maize affected by seed ageing.

Seed lot	Ageing period (day)	Germination percentage (%)	Mean germination time (day)	Seedling dry weight (g)	Emergence percentage (%)	Emergence time (day)
V_1	0	98^a	3.830^b	0.6750^a	75.63^a	11.37^c
V_2	9	92^b	6.707^a	0.2340^b	57.05^b	14.42^b
V_3	12	88^b	7.415^a	0.1500^b	39.52^c	15.96^a

Different letters in each column indicate significant difference at $p \leq 0.05$. V_1, V_2 and V_3: Non-aged and aged seed lots for 9 and 12 days at 40°C, respectively.

effects of seed ageing on potential performance of major crops such as maize under water stress are poorly understood. Thus, this research was carried out to evaluate the deleterious effects of seed ageing on field performance of maize under different irrigation treatments.

MATERIALS AND METHODS

Seeds of maize (*Zea mays* L. cv. Ksc301) were obtained from Seed and Plant Improvement Institute of Karaj, Iran. Seeds were divided into three sub-samples, a sub-sample was kept as control and the other two sub-samples with about 15% moisture content were artificially aged at 40°C for 9 and 12 days. Consequently, three seed lots with 98, 92 and 88% normal germination and different levels of vigor (V_1, V_2 and V_3, respectively) were provided for laboratory and field evaluation.

Laboratory tests were carried out at the Seed Technology Laboratory of the University of Tabriz, Iran, using completely randomized design (CRD). Four replicates of 25 seeds were germinated between double layered rolled germination papers at 15 ± 1°C. The rolled papers with seeds were put into plastic bags to reduce moisture loss. Germination (protrusion of radicle by 2 mm) of seeds was recorded in daily intervals up to 10 days. Mean germination time (MGT) was calculated according to Ellis and Roberts (1980):

$$MGT = \sum (D \times n) / \sum n$$

Where, n is the number of seeds germinated on day D and D is the number of days counted from the beginning of the test. At the end of germination test, radicles and shoots of normal seedlings were cut from the cotyledons and then dried in an oven at 75 ± 2°C for 24 h. The dried radicles and shoots were weighed to the nearest milligram and the mean seedling dry weight was determined.

The field experiment was carried out as factorial based on RCB design with three replicates in 2010 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5'N, 46°17'E). Tabriz is located in North-West of Iran and has a mean annual temperature of 10°C and mean annual precipitation of 245.75 mm. Factors were three seed lots (V_1, V_2 and V_3) and four irrigation treatments (I_1, I_2, I_3, and I_4 for irrigation after 70, 90, 110 and 130 mm evaporation from class A pan, respectively). Seeds were treated with 2 g/kg benomyl and then were sown on 9th May 2010 in 4 cm depth of a sandy-loam soil with a density of 10 seeds m^{-2}. Each plot had 8 sowing rows of 4 m long, spaced 25 cm apart. Hand weeding was done as required. Number of seedlings emerged in each plot was counted in daily intervals until seedling establishment became stable. Mean emergence percentage was then determined and mean emergence time (MET) was calculated according to Ellis and Roberts (1980). Irrigation treatments were applied after seedling establishment. At maturity, plants in 1 m^2 of each plot were harvested and grains per plant, grains per unit area, 100 grain weight, plant biomass, grain yield and harvest index were determined.

Statistical analyses

Analyses of variance of the data appropriate to the experimental design were carried out by MSTATC soft-ware. Means of each trait for different treatments were compared according to Duncan's multiple range test at $P \leq 0.05$.

RESULTS

Seed ageing had significant effects on normal germination percentage, mean germination time, seedling dry weight, emergence percentage and mean emergence time. Mean germination and emergence times significantly increased, but germination percentage, seedling dry weight and emergence percentage decreased with increasing seed ageing (Table 1). Moreover, seed ageing and water supply had significant ($P \leq 0.05$) effects on plant biomass and grain yield per unit area. Grains per plant ($P \leq 0.05$) and grains per unit area ($P \leq 0.01$) significantly affected by seed ageing, but not by irrigation treatments ($P > 0.05$). However, harvest index only affected by water stress and seed ageing had no significant effect on this trait. Effects of seed ageing and irrigation treatments on 100 grain weight and interaction of Irrigation × seed ageing for all the traits were not statistically significant ($p > 0.05$).

Although, the number of grains per plant for plants from aged seed lots (V_2 and V_3) was statistically higher than that for plants from high vigor seed lot (V_1), the highest number of grains per unit area was recorded for plants from vigorous seeds. Mean grain weight of plants from aged seeds was slightly higher than those of plants from non-aged seed lot (Table 2).

Grains per plant and per unit area and also 100 grain weight decreased as water availability became limited, but these differences were not statistically significant. Biological and grain yields per unit area decreased with decreasing seed vigor and water availability. The highest harvest index of maize plants was obtained under I_1, which was not statistically different from that under I_2. Harvest index under I_3 and I_4 was also statistically similar, but was lower than that under I_1 and I_2 (Table 2).

Table 2. Means of yield and yield components of plants from aged and non-aged seeds of maize under different irrigation treatments.

Treatment	Grains per plant	Grains per unit area	100 grain weight (g)	Plant biomass (g/m^2)	Grain yield (g/m^2)	Harvest index
Seed lot						
V_1	263^b	1968^a	20.9^a	780.5^a	414.9^a	51.7^a
V_2	306^{ab}	1718^{ab}	20.5^a	719.5^a	353.2^{ab}	48.5^a
V_3	349^a	1359^b	22.4^a	599.5^b	306.9^b	51.2^a
Irrigation						
I_1	348^a	1971^a	21.9^a	775.7^a	432.4^a	55^a
I_2	320^a	1703^a	21.4^a	704.8^{ab}	365.1^{ab}	51.7^{ab}
I_3	287^a	1585^a	21.3^a	698.4^{ab}	335.8^b	47.1^b
I_4	268^a	1468^a	20.4^a	620.4^b	300^b	48^b

Different letters in each column indicate significant difference at $p \leq 0.05$. V_1, V_2 and V_3: Non-aged and aged seed lots for 9 and 12 days at 40°C, respectively. I_1, I_2, I_3, I_4: Irrigation after 70, 90, 110 and 130 mm evaporation, respectively.

DISCUSSION

Rapid germination of high vigor seeds led to the production of larger seedlings in the laboratory and early emergence in the field, while higher germination percentage of these seeds resulted in better field emergence and establishment (Table 1). Harris et al. (1999) suggested that the resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield. Therefore, optimum stand establishment is a pre-requirement to improve crop performance, particularly under adverse environmental conditions. Since there is a strong relationship between plant density and yield (Ghassemi-Golezani, 1992), low plant population density due to seed ageing can potentially decrease crop yield per unit area. Increased grain yield per plant in soybean cultivars under low plant stand per unit area was due to low competition among plants for moisture, nutrient and sunlight (Saha and Sultana, 2008). When low populations of plants from aged seeds were compared with similar populations obtained from low sowing rates of high vigor seeds, the plants from the former seeds yielded less than those from the latter (Perry, 1980; Ghassemi-Golezani, 1992).

In our research, poor stand establishment of plants from artificially aged seed lots with acceptable germination resulted in comparatively more grains per plant and slightly heavier grains (Table 2). However, efficient use of the environmental resources by the individual plants from aged seeds was not sufficient enough to compensate for yield loss due to low plant density. As a result, biological and grain yields per unit area for plants from aged seeds were considerably lower than those of other seeds. Grain yield of plants from aged seed lots of V_2 and V_3 was 26.03 and 14.87% less than those from high vigor seed lot (V_1) (Table 2). Reduction in seed vigor due to seed aging has also been reported to reduce field emergence and grain yield of wheat (Ghassemi-Golezani et al., 1996), chickpea (Roozrokh et al., 2002) and oilseed rape (Ghassemi-Golezani et al., 2010a, b). Ghassemi-Golezani et al. (2010a) also reported that grain yield per unit area of oilseed rape plants significantly decreased with increasing seed ageing, even within the range of acceptable germination. These results clearly suggest that production and proper storage of high vigor seeds are necessary for satisfactory crop production, particularly under stressful conditions.

High grain yield of well-watered (I_1) plants related with greater grains per unit area and plant biomass (Table 2). According to Ball et al. (2000), greater biological yield can result in increased grain number and yield potential. Increasing intra and inter plant competition for water and nutrients, which are induced by drought stress, caused the plants not to be able to produce their maximum biomass. Toker and Cagirgan (1998) found a positive relation between grain and biological yields of chickpea, especially under drought. However, grain yield is the product of biomass and harvest index. The results of our research therefore indicated that the net changes in biomass and harvest index were reflected in grain yield (Table 2), similar to that reported by Gholipoor (2009) for chickpea.

However, there was no significant interaction of irrigation × seed ageing on field traits, thus suggesting that aged seeds can reduce maize yield under both adequate and limited irrigation conditions. Hence, sowing aged seeds reduces crop yield through decreasing seedling emergence and establishment. It is therefore well justified to produce high vigor seeds of maize and to provide proper storage conditions in order to ensure optimum stand establishment and satisfactory yield under favorable and unfavorable conditions.

REFERENCES

Al-Maskri AY, Khan MM, Khan IA, Al-Habsi K (2003). Effect of accelerated ageing on viability, vigor (RGR), lipid peroxidation and leakage in Carrot (*Daucuscarota*L.) seeds. Int. J. Agric. Biol. 5: 580-

584.
Ball RA, Purcell LC, Vories ED (2000). Short-season soybean yield compensation in response to population and water regime. Crop Sci. 40: 1071-1078.
Costa-Franca MG, Thi AT, Pimental C, Pereyra RO, Zuily-Fodil Y, Laffray D (2000). Differences in growth and water relations among *Phaseolus vulgaris* cultivars in response to induced drought stress. Environ. Exp. Bot. 43: 227-237.
Dalil B, Ghassemi-Golezani K, Moghaddam M, Raey Y (2010). Effects of seed viability and water supply on leaf chlorophyll content and grain yield of maize (*Zea mays*). J. Food Agric. Environ. 8: 399-402.
Demir I, Ellis RH (1992). Changes in seed quality during seed development and maturation in tomato. Seed Sci. Res. 2: 81-87.
Ellis RH, Roberts EH (1980). Towards rational basis for testing seed quality, In Hebblethwaite PD (ed.). Seed production. Butterworths, London. pp. 605-635.
Ellis RH, Roberts EH (1981). The quantification of ageing and survival in orthodoxes seeds. Seed Sci. Technol. 9: 373-409.
Ganguli S, Sen-Mandi S (1990). Some physiological differences between naturally and artificially aged wheat seeds. Seed Sci. Technol. 18: 507-514.
Ghassemi-Golezani K (1992). Effects of seed quality on cereal yields. PhD Thesis, Univer. Reading, UK.
Ghassemi-Golezani K, Andalibi B, Zehtab-Salmasi S, Saba J (2008a). Effect of water stress during vegetative and reproductive stages on seed yield and essential oil content of dill (*Anethum graveolens* L.). J. Food Agric. Environ. 6: 282-284.
Ghassemi-Golezani K, Bakhshi J, Raey Y, Hossinzadeh-Mahootchy A (2010a). Seed vigor and field performance of winter oilseed rape (*Brassica napu*s L.) cultivars. Not. Bot. Hort. Agrobot. Cluj. 38: 146-150.
Ghassemi-Golezani K, Hossinzadeh-Mahootchy A (2009). Changes in seed vigor of faba bean (*Vicia faba* L.) cultivars during development and maturity. Seed Sci. Technol. 37: 713-720.
Ghassemi-Golezani K, Khomari S, Dalil B, Hosseinzadeh-Mahootchy A, ChadordoozJeddi A (2010b). Effects of seed aging on field performance of winter oilseed rape. J. Food Agric. Environ. 8: 175-178.
Ghassemi-Golezani K, Khomari S, Valizadeh M and Alyari H (2008b). Effects of seed vigour and the duration of cold acclimation on freezing tolerance of winter oilseed rape. Seed Sci. Technol. 36: 766-774.
Ghassemi-Golezani K, Mazloomi-Oskooyi R (2008). Effect of water supply on seed quality development in common bean (*Phaseolus vulgaris* var.). Int. J. Plant Prod. 2: 117-124.
Ghassemi-Golezani K, Salehian H, Rahimzadeh-Khoyi F, Moghaddam M (1996). The effect of seed vigour on seedling emergence and grain yield of wheat. Agric. Sci. Nat. Resour. 3: 48-55.
Gholipoor M (2009). Evaluating the response of rainfed-chickpea population density in Iran, using simulation. World Acad. Sci. Eng. Technol. 49: 97-104.
Harris D, Joshi A, Khan PA, Gothkar P, Sodhi PS (1999). On-farm seed priming in semi-arid agriculture development andevaluation in maize, rice and chickpea in India using participatory methods. Exp. Agric. 35: 15-29.
Ludlow MM, Muchow RC (1990). A critical evaluation of traits for improving crop yields in water-limited environments. Adv. Agron. 43: 107-153.
Perry DA (1980). Deterioration of barley seed and its effects on field performance. In: Hebblethwaite PD (ed.). Seed Production. Butterworths, London. pp. 327-337.
Roozrokh, M, Ghassemi-Golezani K, Javanshir A (2002). The relationship of seed vigour with growth and yield of chickpea in the field. Seed Seedling, 2: 156-169.
Saha RR, Sultana W (2008). Influence of seed ageing on growth and yield of soybean. Bangladesh, J. Bot. 37: 21-26.
Samarah NH, Al-Kofahi S (2008). Relationship of seed quality tests to field emergence of artificial aged barley seeds in the semiarid mediterranean region. Jordan J. Agric. Sci. 4: 217-230.
Sun Q, Wang JH, Sun BQ (2007). Advances in seed vigor physiological and genetic mechanisms. Agri. Sci. China. 6: 1060-1066.
Toker C, Cagirgan MI (1998). Assessment of response to drought stress of chickpea lines under rainfed conditions. J. Agri. Forest. 22: 615-621.
Van Zutphen H, Cornwell DG (1973). Some studies on lipid peroxidation in monomolecular and bio molecular lipid films. J. Membrane Biol. 13: 79-88.