AJA. VOL (2) ISSUE 2, 2015: 40-45

Azarian Journal of Agriculture

www.azarianjournals.ir

Azarian Journals

Research article ISSN:2383-4420

Seed vigor of maize (*Zea mays*) cultivars affected by position on ear and water stress

Kazem Ghassemi-Golezani[1*], Shabnam Heydari[1] and Sirous Hassannejad[1]

Article Info

Accepted:
10 Apr. 2015

Keywords:
Maize
Seed position
Seed vigor
Water tress

ABSTRACT

A field experiment was conducted in 2014 to investigate the effects of different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 60, 80, 100 and 120 mm evaporation from class A pan, respectively), cultivars (SC_{704}, NS_{640} and DC_{303}: late, mid and early maturing, respectively) and positions on ear (upper, lower and middle) on seed vigor of maize. The experiment was arranged as split-split plot based on RCB design with three replications. Irrigation treatments, cultivars and seed positions were considered as main, sub and sub-sub plots, respectively. Although, water limitation had no significant effect on seed weight, seeds produced under limited irrigation conditions showed low vigor as measured by electrical conductivity of seed leachates, germination rate and seedling dry weight. Seeds of SC_{704} germinated earlier and consequently produced larger seedlings in comparison with other cultivars. The higher seedling dry weight of the lower position seeds of ear was mainly the result of larger reserve accumulation and rapid germination. The advantage of the lower position seeds was more evident under severe water deficit. Thus, selection of the large and uniform seeds could be a simple way for improving seed and seedling vigor in maize cultivars.

INTRODUCTION

Maize (*Zea mays* L.) is one of the major cereals in the world. The economic importance of maize is due to the broad possibilities of use in fresh or processed form. However, the development of increasingly productive maize hybrid varieties resulted in a loss of nutritional value, especially with decreases in protein and oil, due to the negative correlation with yield (Uribelarrea et al. 2004; Zhang et al. 2008; Bueno et al. 2009). Another way of improving maize yield is the production and cultivation of high vigor seeds (Ghassemi-Golezani et al. 2011).

Seed vigor frequently affects seedling size soon after emergence (Perry 1980a; Roberts and Osei-Bonsu 1988). High vigor seed lots may improve crop yield in two ways: first because seedling emergence from the seedbed is rapid and uniform, leading to the production of vigorous plants, and second because percentage seedling emergence is high, so optimum plant population density could be achieved under a wide range of environmental conditions (Ghassemi-Golezani 1992). This is particularly true for crops such as maize (*Zea mays* L.), which has not the capacity to adjust to incomplete stand by tillering (Ghiyasi et al. 2008). Reports have shown that low seed vigor causes poor stand establishment in the field and consequently yield loss of maize (Ghassemi-Golezani and Dalil 2011), wheat (Ram and Wiesner 1988; Ganguli and Sen-Mandi 1990), barley (Abdalla and Roberts 1969; Copeland and McDonald 2001), rapeseed (Ghassemi-Golezani et al. 2010) soybean (Ghassemi-Golezani and Lotfi 2012) and chickpea (Ghassemi-Golezani and Ghassemi 2013) . Many researchers (Demir and Ellis 1992; Ellis and Pieta Filho 1992; Sanhewe and Ellis 1996; Ghassemi-Golezani and Mazloomi-Oskooyi 2008b; Ghassemi-Golezani and Hossinzadeh-Mahootchy 2009; Ghassemi-Golezani et al. 2010) suggested that maximum seed vigor could be achieved at or slightly after mass maturity (end of seed filling period).

Seed position on the mother plant may also account for part of the variation in physical (weight and shape) or physiological (viability and vigor) seed attributes (Illipronti et al. 2000). In non-stressed soybean plants, seeds located within the upper canopy had a higher germination percentage

[1-] Department of Plant Eco-physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.
*Email: golezani@gmail.com

and a greater seedling size than seeds from the lower canopy (McDonald et al. 1983). In contrast, seeds of lower position of chickpea (Ghassemi-Golezani et al. 2010b) and pinto bean (Ghassemi-Golezani et al. 2012) had high weight and vigor under both full and limited irrigation conditions. Since variation in physiological quality of maize seeds at different positions of ear was not clear, this research was undertaken to examine the effects of seed position and water stress on seed germination and vigor of late, mid and early maturing maize cultivars.

MATERIALS AND METHODS

A split-split plot experiment based on RCB design with three replications was conducted in 2014 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (latitude 38.05°, longitude 46.17°E, altitude 1360 m). The climate is characterized by mean annual precipitation of 245.75 mm per year and mean annual temperature of 10°C. Irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 60, 80, 100 and 120 mm evaporation from class A pan, respectively) were located in main plots, cultivars (S.C_{704}, N.$_{S640}$ and D.C_{303}: late, mid and early maturing, respectively) in sub plots and seed positions (upper, lower and middle parts of ear) in sub-sub plots. Seeds of maize cultivars were treated with 2g.kg-1 Mancozeb and then were sown by hand on 3rd May 2014 in 5 cm depth of a sandy loam soil. At the same time, plots were fertilized with 200 kg/ha urea (46% N). Each plot consisted of nine rows of 2.5 m length, spaced 50 cm apart. All plots were irrigated immediately after sowing. After seedling establishment, irrigations were applied according to the treatments and hand weeding of the experimental area was carried out as required.

Ears of the maize plants from 1 m^2 of the middle part of each plot were harvested when seed moisture content was 16-18%. Subsequently, seeds were separately detached from the upper, middle and lower parts of the ears and individual seed weight of each sample was determined. Seed samples within separate sealed bags were then placed in a refrigerator at 3-5°C for laboratory tests. Seed quality tests were carried out at the seed Technology Laboratory of Tabriz University.

Two replicates of 50 seeds from each sample were weighed (SW_1 and SW_2) and then seeds of each replicate immersed in 250 ml deionized water in a container at 20˚C for 24 hours. The seed-steep water was then gently decanted and electrical conductivity (EC) of seed leachates was measured, using an EC meter (EC_1 and EC_2). Following equation was applied to calculate the conductivity per gram of seed weight for each sample (Powell et al. 1984).

$$\mathbf{EC\ (\mu s/cm/g) = [(EC_1/SW_1) + (EC_2/SW_2)]/2}$$

Four replicates of 25 seeds from each sample were treated with Benomyl at a rate of 2 g/ kg, before testing. Seeds of each replicate were placed between two 30 × 30 cm wetted filter papers, which were then rolled and placed in plastic bags to prevent water loss. These bags were incubated at 20±1°C for 10 days. Germinated seeds (protrusion of radicle by 2 mm) were recorded every day. Rate of seed germination (*R*) was calculated according to Ellis and Roberts, (1980):

$$R = \Sigma n / \Sigma Dn$$

Where n is the number of seeds germinated on day D and D is the number of days from the beginning of the test. At the end of each test, normal and abnormal seedlings were recorded and the germination percentage was calculated. Seedlings were then cut from the storage tissues and dried in an oven at 75°C for 24 h. Subsequently, mean seedling dry weight for each treatment at each replicate was determined.

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

RESULTS

Analyses of variance of the data showed significant effects of irrigation, cultivar and seed position on seed weight, electrical conductivity of seed leachates, germination rate and seedling dry weight (p≤0.05). Interaction of cultivar × seed position was only significant for electrical conductivity (p≤0.01). Irrigation × cultivar and irrigation × seed position were significant for seed weight and germination rate (p≤0.05). Irrigation × cultivar × seed position was only significant for seed weight (p≤0.05).

Irrigation had no significant effect on seed weight of maize cultivars. NS_{640} was a superior cultivar in mean seed weight, but had no significant difference with SC_{704}. The lowest seed weight was recorded for early maturing cultivar of DC_{303}. Mean weight of upper position seeds was significantly less than that of middle and lower position seeds (Table 1). Seeds of all positions of late maturing cultivar (SC_{704}) were smaller under well-watering (I_1), but they were larger under limited irrigation conditions (I_2, I_3 and I_4), compared with other cultivars. However, there were little differences in seed weight of NS_{640} and DC_{303} at different positions and irrigation treatments (Fig. 1).

Electrical conductivity of seeds produced under severe water stress (I_4) was significantly higher than the seeds attained under

Table 1. Means of seed vigor parameters of maize affected by irrigation treatments, cultivars and seed position

Treatment	Mean seed weight (mg)	Electrical conductivity (μS/cm/g)	Germination rate (per day)	Seedling dry weight (g)
Irrigation				
I_1	167.11 a	5.09 c	0.71 a	0.44 a
I_2	175.16 a	5.49 bc	0.70 a	0.35 ab
I_3	176.63 a	6.72 a	0.50 b	0.29 b
I_4	167.96 a	6.51 ab	0.37 b	0.24 b
Cultivars				
C_1	165.74 b	7.31 a	0.50 c	0.25 c
C_2	178.32 a	5.49 ab	0.59 b	0.32 b
C_3	171.09 ab	5.0 4 b	0.70 a	0.41 a
Position				
P_1	158.86 b	7.06 a	0.59 b	0.28 b
P_2	176.43 a	6.21 ab	0.58 b	0.34 a
P_3	179.86 a	4.57 b	0.62 a	0.37 a

Different letters in each column indicate significant difference at $p \leq 0.05$. I_1, I_2, I_3, I_4: irrigation after 60, 80, 100 and 120 mm evaporation, respectively. C_1, C_2, C_3: DC_{303}, NS_{604} and SC_{704} cultivars, respectively

other irrigation treatments. Electrical conductivity of DC_{303} was more than that of other cultivars. The highest electrical conductivity was recorded for seeds of upper position on the ear (Table 1). Seed leachates of late maturing cultivar (SC_{704}) at all positions were lower than those of mid (NS_{640}) and early (DC_{303}) maturing cultivars. However, in middle and lower positions there were little differences in electrical conductivity of NS_{640} and DC_{303} (Fig. 2).

Mean germination rate of seeds produced under I_1 and I_2 was higher than that of those produced under I_3 and I_4. The highest germination rate was recorded for seeds of SC_{704}, compared with other two cultivars. Seeds of lower position showed comparatively higher germination rate (Table 1). Germination rate of late maturing cultivar (SC_{704}) was higher under all irrigation treatments, but this superiority increased with decreasing water availability (Fig. 3a). Germination rate of seeds of all ear positions was almost similar under I_1, I_2 and I_3 treatments. However, seeds of lower position showed higher germination rate under severe water deficit (I_4) (Fig. 3b).

Seedling dry weight was higher for seeds produced under well-watering (I_1), compared with seeds developed under limited irrigation conditions. SC_{704} was a superior cultivar in mean seedling dry weight, followed by NS_{640} and DC_{303}. Seedlings from lower and middle position seeds were larger than those from upper position seeds (Table 1).

DISCUSSION

Seed size depends on the genotype and environmental conditions in which they developed, and that has an impact on seedling survival, growth and development (suelwska et al. 2014). No significant difference in mean seed weight among irrigation treatments (Table 2) may be related with less number of seeds per ear and per plant in maize (Dalil and Ghassemi-Golezani 2012). Production of large seeds by late maturing cultivar of SC_{704} (Fig. 1) could be the result of longer seed filling duration

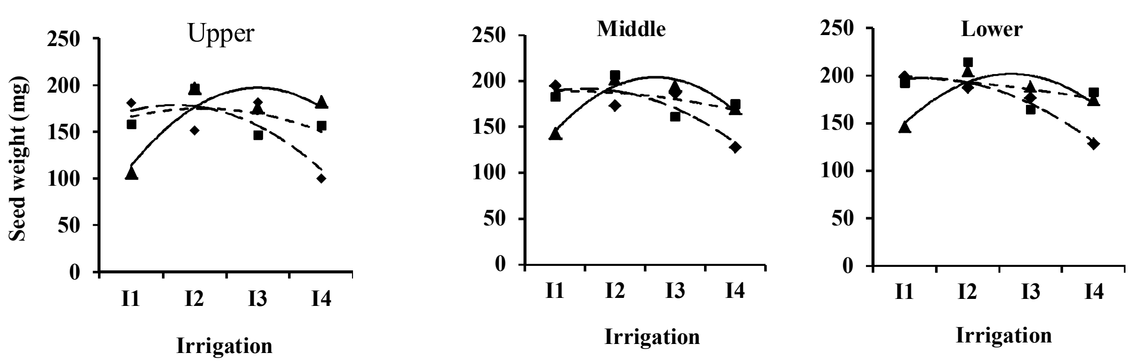


Fig. 1. Changes in seed weight of maize cultivars at different seed positions on ear. C_1, C_2, C_3: DC_{303}, NS_{640} and SC_{704} cultivars. I_1, I_2, I_3, I_4: irrigation after 60, 80, 100 and 120 mm evaporation, respectively

(Ghassemi-Golezani et al. 2010). Seeds of lower and middle positions of ear formed earlier and received more assimilates than upper position seeds. This is the main cause of producing smaller seeds at upper position of ear (Table 2). Similar results were reported for seeds of upper plant position in chickpea (Ghassemi-Golezani et al. 2010b) and pinto bean (Ghassemi-Golezani et al. 2012). Different sizes of seeds having different levels of food storage may be the important factor which influences seed and seedling vigor (Perry, 1980 and Ghassemi-Golezani et al. 2010a).

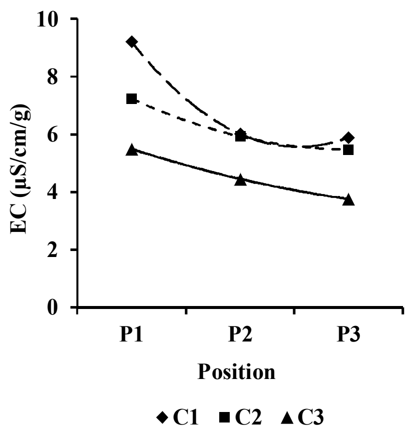
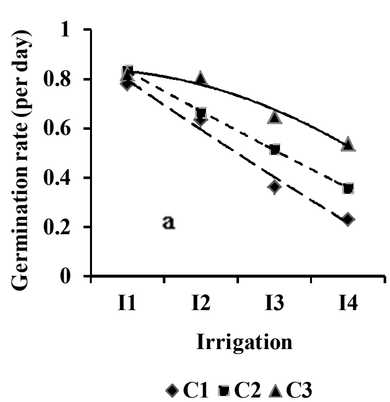


Fig. 2. Changes in electrical conductivity of seed leachates (µS/cm/g) in three maize cultivars (C_1, C_2, C_3: DC_{303}, NS_{640} and SC_{704}) at different seed positions (P_1, P_2, P_3: upper, middle and lower parts of ear).

Increasing mean electrical conductivity of seeds produced under limited irrigations (Table 2), could be the result of damages to cells membranes caused by water stress (Hurch et al. 2002). Differences in seed leakages among cultivars (Table 2) were the consequence of differences in their genetic constitution. Higher electrical conductivity of upper position seeds of maize ear (Fig. 2) could be attributed to incomplete maturity of these seeds. Seeds of upper plant position also had the highest electrical conductivity in pinto bean (Ghassemi-Golezani et al. 2012) and chickpea (Ghassemi-Golezani et al. 2010b). In contrast, Ghassemi-Golezani et al. (2012) reported that larger and better quality seeds were obtained from the upper position of soybean plants in comparison with the seeds from the lower and middle positions. These results clearly indicate that the differences in vigor of seeds at different plant positions directly related with time of their formation and maturity.

Reductions in germination rate with increasing duration of water stress (Fig. 3), could result from the stimulation of seed maturity under stress as reported in chickpea (Silim and Saxena 1993), barley (Samarah 2005) and soybean (Gassemi-Golezani et al. 2012a). Harris et al. (1999) suggested that the resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield. Production of rapid germinating seeds of SC_{704} (Fig. 3a) may be associated with superior genetic constitution and reserve accumulation of this cultivar (Fig. 1). The higher germination rate of lower position seeds produced under severe water stress (Fig.3b) also resulted from early formation and proper development of these seeds. The larger seeds tend to give a faster and more even emergence than the smaller ones, partly, because they contain larger food reserves which are used to sustain the young seedlings before they are fully established (Garba and Namo 2013).

Decreasing seedling dry weight of maize seeds



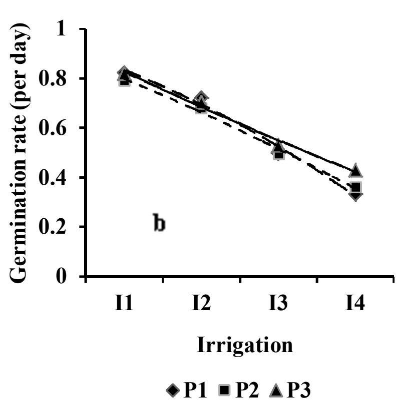


Fig. 3. Changes in germination rate of three maize cultivars at different seed positions and irrigation treatments
C_1, C_2, C_3: DC_{303}, NS_{640} and SC_{704} cultivars
P_1, P_2, P_3: upper, middle and lower parts of ear, respectively
I_1, I_2, I_3, I_4: irrigation after 60, 80, 100 and 120 mm evaporation, respectively

produced under water stress directly related with higher electrical conductivity and lower germination rate of these seeds. Seeds of SC_{704} germinated earlier and consequently produced larger seedlings in comparison with other cultivars. The higher seedling dry weight of the lower position seeds was mainly the result of larger reserve accumulation and rapid germination (Table 2). Therefore, seed size and germination rate were the most influential factors on seedling size of maize cultivars as also reported for chickpea (Ghassemi-Golezani et al. 2010b) and pinto bean (Ghassemi-Golezani et al. 2012). Seed position on mother plant can strongly influence these parameters in different crops (Ghassemi-Golezani et al. 2010, 2012).

CONCLUSION

Seeds of maize cultivars produced under water stress had low vigor as measured by electrical conductivity of seed leachates, germination rate and seedling dry weight. Seeds of late maturing cultivar (SC_{704}) produced larger seedlings as a result of rapid germination, compared with other cultivars. The lower position seeds of maize ears showed higher reserve accumulation and germination rate, leading to the production of the largest seedlings. The superiority of the lower position seeds was more pronounced under severe water stress. Thus, selection of the large and uniform seeds may improve seed and seedling vigor in maize cultivars, providing they are harvested at about 16-18% moisture content and stored under proper conditions.

REFERENCES

Abdalla F. H. Roberts E. H. (1969) The effect of seed storage conditions on the growth and yield of barley, broad beans and peas. Annals of Botani, 33: 169-84.

Bueno L. G. Chaves L. J. Oliveira J. P. Brasil E. M. Reis A. J. S. Assunção A. Pereira A.F. Ramos M. R. (2009) Controle genético do teor proteico nos grãos e de caracteres agronômicos em milho cultivado com diferentes níveis de adubação nitrogenda. Pesquisa Agropecuária Brasileira, 44: 590-598.

Copeland L. O. McDonald M. B. (2001) Seed vigour and vigour tests. In: Principles of Seed Science and Technology, 4th edn. Copeland, L. O. and McDonald, M. B (eds.). Kluwer Academic Publishing Group. PP 121-44.

Demir I. Ellis R. H. (1992) Changes in seed quality during seed development and maturation in tomato. Seed Science Research, 2: 81- 87.

Dalil B. Ghassemi-Golezani K. (2012) Changes in leaf temperature and grain yield of maize under different levels of irrigation. Research on crops, 13: 481-485.

Ellis R. H. Pieta Filho C. (1992) Seed development and cereal seed longevity. Seed Science Research, 2: 9-15.

Enayat Gholizadeh M. R. Bakhshandeh A. M. Shoar Dehgan M. Ghaineh M. H. Alami Saeid K. H. Sharafizadeh M. (2012) Effect of source and seed size on yield component of corn S.C704 in Khuzestan. African Journal of Biotechnology, 11: 2938–2944.

Ganguli S. Sen-Mandi S. (1990) Some physiological differences between naturally and artificially aged wheat seeds. Seed Science Technology, 18: 507-14.

Garba L.L. Namo O.A.T. (2013) Productivity of maiz hybrid maturity classes in savanna agro-ecologies in nigeria. African Crop Science Journal, 21: 323-335.

Ghassemi–Golezani K. (1992) Effects of seed quality on cereal yields. PhD Thesis, Univesity of Reading, UK. PP 205-222.

Ghassemi-Golezani K., Akbari H. Bandeh-Hagh A. (2012) Effects of plant density and pod position on seed vigour of pinto bean cultivars. Research on Crops, 13: 529-533.

Ghassemi-Golezani K. Bakhshy J. Raey Y. Hossinzadeh-Mahootchy A. (2010) Seed vigour and field performance of winter oilseed rape (*Brassica napus* L.) cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 3: 146-50.

Ghassemi-Golezani K. Dalil B. (2011) Seed ageing and field performance of maize under water stress. African Journal of Biotechnology. PP 18377-18380.

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. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 39:160-163.

Ghassemi-Golezani K. Ghassemi S. (2013) Effect of water supply on seed development and quality chickpea cultivars. Plant breeding and seed science, 67: 37-44.

Ghassemi-Golezani K. Hossinzadeh- Mahootchy A. (2009) Changes in seed vigour of faba bean (*Vicia faba* L.) cultivars during development and maturity. Seed Science and Technology, 37: 713-20.

Ghassemi-Golezani K. Khomari S. Dalil B. Hosseinzadeh-Mahootchy A. Chadordooz-Jeddi A. (2010a) Effectsm of seed aging on field performance of winter oilseed rape. Journal Food Agriculture Environ, 8:175-178.

Ghassemi-Golezani K. Lotfi R. (2012) Response of soybean cultivars to water stress at reproductive stages. International journal of plant, animal and environmental sciences, 2: 2231- 4490.

Ghassemi-Golezani K. Lotfi R. Norouzi M. (2012a) Seed quality of soybean cultivars affected by pod positon and water stress at reproductive stage, 2: 119-125.

Ghassemi-Golezani K. Mazloomi-Oskooyi, R. (2008) Effect of water supply on seed quality development in common bean (*Phaseolus vulgaris* var.). Journal Plant Production, 2:117-124.

Ghassemi-Golezani K. Mousabeygi T. Raey Y. Aharizad S. (2010b) Effects of water stress and pod position on the seed quality of chickpea *(Cicer arietinum* L.) cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38: 114-118.

Ghiyasi M. Miyandoab M. P. Tajbakhsh M. Salehzade H. Meshkat M. V. (2008) Influence of different osmo-priming treatments on emergency and yield of maize (*Zea mays* L.). Research Journal of Biological Sciences, 3:1452-1455.

Hurch R. (2002) The use of molecular markers for drought tolerance. Workshop drought stress in plants Faculty of Agriculture, Ferdowsi University of Mashhad.

Illipronti Jr. R. A. Lommen W. J. M. Langerak C. J. and Struik P. C. (2000) Time of pod set and seed position on the plant contribute to variation in quality of seeds within soybean seed lots. Netherlands journal agricultural science, 48 : 165-80.

Perry D. A. (1980) D. (ed.). Butterworths. pp Deterioration of barley seed and its effects on field performance. In: Seed Production, Hebblethwaite. PP 327-37.

Perry D.A. (1980a) Seed vigour and seedling establishment. Advances in Research and Technology of Seeds, 5: 25-40.

Roberts E. H. Osei-Bonsu K. (1988) Seed and seedling vigour. In: World Crops: Cool Season Food Legumes, Summerfield, R. J. (ed.). Kluwer Academic Publishers, Dordrecht, Netherlands. pp. 65-89.

Ram C. Wiesner E. (1988) Effect of artificial ageing on physiological and biochemical parameters of seed quality in wheat. Seed Science Technology, 16: 579-87.

Samarah N. H. (2005) Effects of drought stress on growth and yield of barley. Agronomy for Sustainable Development, 25, 145-149.

Sanhewe A. J. Ellis R. H. (1996) Seed development and maturation in *Phaseolus vulgaris*. I. Ability to germinate and to tolerate desiccation. Journal experimental botany, 47: 949- 58.

Silim S. N. Saxena M. C. (1993) Adaptation of spring- sown *chickpea* to the Mediterranean basin. II. Factors influencing yield under drought. Field Crops Research, 34: 137-146.

Uribelarrea M. Below F. E. Moose S. P. (2004) Grain composition and productivity of maize hybrids derived from the Illinois protein strains in response to variable nitrogen supply. Crop Science, 44: 1593-1600.

Zhang J. Lu X.Q. Song X. F. Yan J. B. Song T. M. Dai J. R. Rocheford T. and Li J. S. (2008) Mapping quantitative trait loci for oil, starch, and protein concentrations in grain with high-oil maize by SSR markers. Euphytica, 162: 335-334.

Journal sponsorship

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