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Morphological traits of maize affected by seed vigor and water limitation

Bahareh Dalil and Kazem Ghassemi-Golezani*

Department of Plant Eco-Physiology, Faculty of Agriculture, University of Tabriz, Iran

Corresponding author: Kazem Ghassemi-Golezani

ABSTRACT: An experiment was conducted as factorial based on RCB design with three replicates in 2010 to investigate the effects of seed vigor (three seed lots with acceptable normal germinations of 98%, 92% and 88%) and different irrigation treatments (irrigation after 70, 90, 110 and 130 mm evaporation from class A pan, respectively) on some morphological characteristics of maize (cv. KSC301). Mean emergence percentage was decreased, but plant height, ear length and diameter and grains per ear of plants significantly increased with decreasing seed vigor. The higher plant height and ear length and diameter of plants from low vigor seeds were attributed to the great availability of environmental resources for these plants, due to the low stand establishment (Figure1), compared with high density of plants from high vigor seed lot. Decreasing water availability led to 10.9-14.2 % reduction in plant height. The other traits were not significantly affected by this factor, due to mild water stress.

***Keywords*:** maize, morphological traits, seed vigor, water stress

INTRODUCTION

Germination and vigor are the most important aspects of seed physiological quality (Ghassemi-Golezani et al., 2012). Seed vigor affects seedling establishment and crop growth and ultimately production rate (Zakaria, 2009). 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). After genetic structure, seed deterioration had the most effect on seed vigor (Ghassemi-Golezani, 1994).

Deterioration means irreversible destructive changes that reduce the seed germination ability. Seed vigor could be decreased with increasing deterioration. Oxidative reactions are responsible for the deteriorative changes observed in aged seeds (Van Zutphen and Cornwell, 1973). Several reports have shown that seed deterioration causes poor stand establishment in the field and consequently yield loss of wheat (Ganguli and Sen-Mandi, 1990), canola (Ghassemi-Golezani et al., 2010) and lentil (Chadordooz-Jeddi et al., 2013). Seed deterioration may result in lower tolerance to environmental stresses (Khan et al., 2003).

One of the important environmental stresses that affect crop production worldwide is water stress (Ludlow and Muchow, 1990). Ghassemi-Golezani and Mardfar (2008) indicated that drought during vegetative stage has the greatest impact on plant height and biomass, while water deficit during the reproductive growth has an effect on crop productivity (Costa-Franca et al., 2000). Although, maize had its origin in a semi-arid area (Arnon, 1972), the growth of this crop is sensitive to water limitation (Van Volkenburgh and Boyer, 1985). Water deficit may reduce the yield of maize in the field (Ghassemi-Golezani et al., 1997). The objective of this research is to investigate the effects of seed vigor on field performance of maize under full and limited irrigation conditions.

MATERIALS AND METHODS

Seeds of maize (*Zea mays* L. cv. Ksc301) were divided into three sub-samples. A sub-sample was kept as control or high vigor seed lot (V_1). The two other sub-samples with about 16% moisture content were artificially aged at 40°C for 9 and 12 days to reduce seed vigor (V_2 and V_3, respectively). The three seed lots had normal germinations of 98% (V_1), 92% (V_2) and 88% (V_3). So, three seed lots with different levels of vigor were provided.

This research was carried out in 2010 as factorial based on RCB design with three replicates at the Research Farm of Tabriz University, Tabriz, Iran (latitude 38.05N, longitude 46.17E, Altitude 1360m above sea level). The climate is characterized by mean annual precipitation of 245.75 mm, mean annual temperature of 10˚C, mean annual maximum temperature of 16.6˚C and mean annual minimum temperature of 4.2˚C. Factors were three seed lots (V_1, V_2 and V_3) and four irrigation treatments (I_1, I_2, I_3, I_4: irrigation after 70, 90, 110 and 130 mm evaporation from class A pan, respectively).

The seeds were sown on 9 May 2010 in a sandy-loam soil (PH=8.1) at a depth of about 4 cm with a density of 10 seeds m^{-2}. Each plot had 8 sowing rows of 4 m long, spaced 25 cm apart. All plots were irrigated immediately after sowing, but subsequent irrigations were carried out according to the treatments. 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. At maturity, plants in 1 m^2 of each plot were harvested to determine plant height, ear length, ear diameter, grain rows per ear, grains per ear and 100 grain weight. Analysis of variance of the data for emergence percentage was carried out as randomized complete block design and for other data it was conducted as factorial, using MSTAT-C software. Duncan test was applied to compare means of each trait at $p \leq 0.05$.

RESULTS AND DISCUSSION

Analysis of variance showed that seed vigor had significant effect on emergence percentage ($P \leq 0.01$). Plant height, ear length, ear diameter and grains per ear were significantly affected by seed vigor, while the effect of irrigation was only significant for plant height (Table1).

Table1. Analysis of variance of the effects of seed vigor and irrigation on morphological traits of maize

Source of variance	df	Plant height	Ear length	Ear diameter	Grain rows per ear	Grains per ear	100 grain weight
Replication	2	826.14**	26.72**	68.48**	2.86^{ns}	73251.22**	7.35^{ns}
Vigor (A)	2	1150.13**	48.42**	84.39**	3.69^{ns}	61397.36**	11.62^{ns}
Irrigation (B)	3	671.93**	1.39^{ns}	13^{ns}	3.48^{ns}	10035.36^{ns}	3.80^{ns}
A*B	6	57.37^{ns}	2.33^{ns}	7.81^{ns}	1.62^{ns}	5552.57^{ns}	3.61^{ns}
Error	22	63.84	3.11	8.71	2.28	4602.24	9.5

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

Seedling emergence percentage for high vigor seed lot (V_1) was considerably higher than those for low vigor seed lots (V_2 and V_3). Mean seedling emergence percentage significantly decreased with decreasing seed vigor (Figure1).

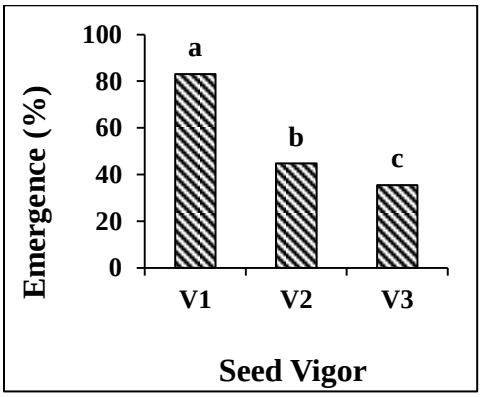

Figure 1. Percentage of seedling emergence in the field for seeds of different vigor
Different letters indicate significant difference at $p \leq 0.01$.
V_1, V_2 and V_3: Seed lots with 98%, 92% and 88% germination

Plant height, ear length and diameter significantly increased with decreasing seed vigor. Although, the effect of seed vigor on grain rows per ear was not significant (Table1), this trait for plants from low vigor seeds was higher than that for high vigor seeds. The highest number of grains per ear was obtained for plants from the lowest vigor seed lot (V_3), followed by those from V_2 and V_1 seed lots. However, this trait was not statistically different between plants from V_2 and V_3 seed lots. The higher plant height and ear length and diameter of plants from poor vigor seeds (Table2) can be attributed to the availability of great environmental resources for these plants, due to the lower stand establishment (Figure1), compared with higher density of plants from vigorous seed lot. Ramezani et al. (2011) also reported that plant height and ear length increased with increasing row spacing in maize. The higher number of rows per ear of plants from low vigor seeds could be the result of high ear diameter of these plants. However, the high grains per ear of plants from poor vigor seeds related with greater plant height, ear length and diameter and rows per ear (Table 2). It has been reported that grains per ear highly correlated with rows per ear (Khalili et al., 2013).

Mean 100 grain weight was statistically similar for plants from seed lots of different vigor. So, efficient use of environmental resources by individual plants from poor vigor seeds, due to low and scattered plant establishment led to the production of more grains per ear, but with similar mean grain weight compared with plants from high vigor seeds (Table 2). Similar results were reported for winter oil seed rape (Ghassemi-Golezani et al., 2010) and soybean (Saha and Sultana, 2008).

Table 2. Means of morphological traits of maize affected by seed vigor

Treatments	Plant height (cm)	Ear length (cm)	Ear Diameter (mm)	Grain Rows per ear	Grains per ear	100 grain Weight (g)
Vigor						
V_1	108.88c	11.97c	34.08b	16.42a	219.91b	20.87a
V_2	121.12b	13.56b	37.14a	16.75a	321.92a	20.55a
V_3	128.24a	15.96a	39.36a	17.50a	357.78a	20.39a

V_1, V_2 and V_3: Seed lots with 98%, 92% and 88% germination

The plants under I_2, I_3 and I_4 were 13.2, 10.9 and 14.2% shorter than those under I_1, respectively (Figure 2). Deduction in photosynthetic production (Singh and Wilkens, 1999), chlorophyll synthesis (Dalil et al., 2010) and cell enlargement (Manivannan et al., 2007) in plants with limited irrigation diminished plant height (Table2). Reduction in plant height due to water stress was also reported for lentil (Chadordooz-Jeddi et al., 2013) and wheat (Abayomi and Wright, 1999) has been reported. Since water limitation was not severe; the other traits were not significantly affected by this factor (Table 1).

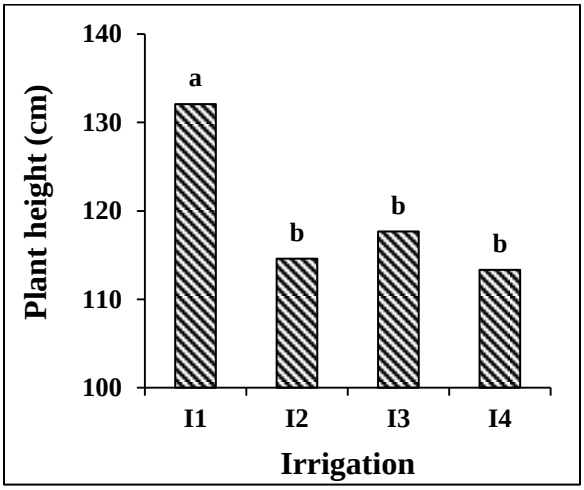

Figure 2. Mean plant height under different irrigation treatments
Different letters indicate significant difference at p ≤0.01.
I_1, I_2, I_3 and I_4: irrigation after 70, 90, 110 and 130 mm evaporation from class A pan, respectively

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