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CHANGES IN GERMINATION AND SEEDLING GROWTH OF DIFFERENT CULTIVARS OF CUMIN TO DROUGHT STRESS

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ABSTRACT. Cumin (*Cuminum cyminum* L.) is one the most appropriate choice for investing in dry and semi dry areas. In order to analyse influence of drought stress on germination and seedling growth of two masses of cumin, an experiment was conducted in seed technology laboratory of Faculty of Agriculture of Islamic Azad University of Isfahan, in 2016. In this experiment, polyethylene glycol (PEG 6000) at six levels (0, -0.144, -0.18, -0.216 and -0.288 MP) and NaCl at six levels (0, 4, 5, 6, 7, and 8 ds/m) and distilled water as control were applied to investigate the influence of dryness and salinity stresses on seed germination and seedling growth of two cultivars of cumin plant masses gathered from Mashhad-e-Ardahal and Kerman, then fulfilled in two separate factorial trials, on the basis of randomized design with four replications. Cultivar had significant influence on germination percentage, germination uniformity, radicle length, plumule length, fresh radicle weight, dry radicle weight, fresh and dry plumule weight. Drought stress impact on all treatments, except germination uniformity, fresh radicle weight and dry radicle weight was meaningful, but, just radicle length, plumule length, fresh plumule weight and dry plumule weight significantly affected by interaction between cultivar and drought stress. The rate of germination, germination percentage, as well as seedling growth and establishment were considerably lowered with the rise of stress levels using PEG. Control treatment had obtained the highest germination percentage, mean time of germination, radicle and plumule length, fresh plumule weight and seed stamina index. Taking all traits into account, this experiment found that Mashhad-e-Ardahal was most tolerant hybrid to water stress conditions.

Keywords: dry area; seed technology; polyethylene glycol; NaCl; radicle.

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INTRODUCTION

Cumin (*Cuminum cyminum* L.) is a member of *Umbelliferae* and annual plant, which is originated in Iran, Egypt, Turkistan and East Mediterranean (Ahmadian *et al.,* 2009; Neamatollahi *et al.,* 2009; Roodbari *et al.,* 2013). The germination ability and germination percentage of crop is fundamental importance, influencing the viability of the plants developing from the grains (Soleymani *et al.,* 2012a; Ogbaji *et al.,* 2013). Cumin is sensitive toward salinity and dryness at the germination stage (Haghighi *et al.,* 2012). Drought stress affect the plants in a similar way; reduced water potential is a common consequence of both salinity and drought, and both of these stresses are harmful during early stages of seed germination and seedling growth (Soleymani & Shahrajabian, 2011; Soleymani*et al.,* 2012; Soleymani & Shahrajabian, 2013; Shahrajabian *et al.,* 2013; Soleymani *et al.,* 2013; Shahrajabian & Soleymani, 2017; Shahrajabian *et al.,* 2017). Drought stress is a limited factor that influenced the seed germination (Rasaei *et al.,* 2013; Hadi *et al.,* 2014). Water deficit not only affects seed germination, but also increase mean germination time (Willenborb *et al.,* 2004).

Germination is the most sensitive stage in the life cycles of plant and perfect and uniform germination is essential to having a good green area and crop growth rate that will get better radiation and increase the yield (Ashraf & Mehmood, 1990), the seeds exposed to unfavorable environmental conditions, such as drought may compromise the subsequent seedling establishment (Soleymani *et al.,* 2012b; Muscolo *et al.,* 2014). Polyethylene glycol (PEG), widely used to induce water stress, is a non-ionic water polymer, which is not expected to penetrate into plant tissue rapidly (Kawasaki *et al.,* 1983). PEG has been used to control water potential in seed germination studies to assess plant drought tolerance at germination and seedling stages. Researchers concluded that seed soaking in solutions of PEG was expressed as sowing seeds in an osmotic solution that permits seed to absorb water for germination, but inhibits radicle extension via seed coat (Giri & Schillinger, 2003; Golzardi *et al.,* 2012). This research was conducted to study the influence of drought stress induced by PEG on germination and seedling growth traits of cumin.

MATERIAL AND METHODS

This research accomplished in seed technology laboratory of Faculty of Agriculture of Islamic Azad University of Isfahan (Khorasgan), in 2016 (latitude 32°40′N, longitude 51°58′E, and 1570 m elevation). During this trial, polyethylene glycol (PEG 6000) at six levels (0, -0.144, -0.18, -0.216 and -0.288 MP) and control treatment (distilled water) were applied to investigate the influence of dryness and salinity stresses on germination and seedling growth of two cultivars of cumin plant masses gathered from Mashhad-e-Ardahal and Kerman, then fulfilled in two separate factorial trials, on the basis of

absolute randomized design with four replications. In each level of stress, 25 seeds of any cumin plant masses were selected and sterilized in sodium hypochlorite (0.5%), for 30 sec, and then washed in distilled water for three times. During experiments, the seeds were surface-sterilized by being soaked for 3 min in 1% solution of carbandazime fungicide, and then washed with distilled water and dried at room temperature. A number of 25 seeds were placed on filter paper (Whatman No. 2) and put into Petri dishes. The filter paper was moistened with 5 ml of test solution. In order to make the environment for germination moisty the bottom of Petri dishes were covered with sterile tissue. The dish, then, transferred to germinator in appropriate conditions for cumin, temperature 20 ± 2°C and photoperiod 16 h light and 8 h dark. A seed scored germinated when radicle length reached 2 or 3 mm. Germinating seed were counted daily, and terminated when no further germination occurred.

The following equation (Agrawal & Dadlani, 2004) was used for calculation of amount of polyethylene glycol on the basis of gram:

$$Y = 3.5876X^2 + 24.191X + 4.3488,$$

where, Y was the amount of PEG on the basis of gram and X was required potential on the basis of mega Pascal.

Germination percentage (GP) was calculated using the following formula (Scott *et al.,* 1984):

$$GP = \frac{\text{Total seeds germinated (when no further germination occured)}}{\text{Total number of seeds}} \times 100$$

Mean germination time (MGT), which expressed as speed of germination, was calculating using the following modified formula:

$$MGT = \sum \frac{NiTi}{\sum Ni},$$

where, Ti is the number of days after sowing, Ni is the number of seeds germinated on the first day (Shoor*et al.,* 2014).

Germination rate (GR) was calculating using the following formula:

$$GR = \sum \frac{N}{\sum (n \times g)},$$

where, n is the number of germinated seed on growth day and g is the number of germination seeds (Ellis & Roberts, 1981).

Germination uniformity was calculated by using following formula:

$$CUG = \frac{\sum n}{\sum \left[\left(\bar{t} - t \right)^2 \times n \right]},$$

where, n was the number of germinated seeds in each day, t and ṫ were the number of days from beginning of germination and the average of germination time, respectively.

Seed stamina index was calculated by using the following formula:

$$SSI = \frac{G \times (SHL + RL)}{100},$$

where, G is germination percentage, SHL is average of shoot length, and RL is average of root length (Abdul-Baki & Anderson, 1970).

Mean radicle and plumule lengths at the end of germination were measured per replication with a millimeter ruler. To obtain radicle and plumule, seedlings were placed for 48 h at 70°C, in the oven and then the dry was measured with a laboratory balance with an accuracy of 0.0001 g. Analysis of variance (ANOVA) was used to determine the significant differences. Duncan's Multiple Range

Test was used for the separation of means (5% level probability). All statistics were performed with MSTAT-C program.

RESULTS AND DISCUSSION

Cultivar had significant influence on germination percentage, germination uniformity, radicle length, plumule length, fresh radicle weight, dry radicle weight, fresh and dry plumule weight. Khodarahmpour (2011) also mentioned that germination percentage, root and shoot length of different corn hybrids significantly influenced by drought stress induced by polyethylene glycol (PEG). Drought stress impact on all treatments except germination uniformity, fresh radicle weight and dry radicle weight was meaningful, but, just radicle length, plumule length, fresh plumule weight and dry plumule weight significantly affected by interaction between cultivar and drought stress. Golzardi *et al.* (2012) also found the significant effect drought stress on radicle length, germination and seedling fresh weight of swallow wort (*Cynanchum louiseae*). In agreement with results of this experiment, Mohammadkhani & Heidari (2008) mentioned that germination and seedling development of maize cultivars was affected by PEG. Mashhad-e-Ardahal cultivar had obtained the highest germination percentage, plumule length, fresh radicle weight, dry radicle weight and dry plumule weight, which had significant differences with Kerman cultivar. The maximum germination uniformity and radicle length was achieved in Kerman, and its differences with Mashhad-e-Ardahal were significant. There were no meaningful differences in mean time of germination, germination rate and seed stamina index between masses. The highest germination percentage and mean time of germination was obtained for control treatment, which had significant differences with other treatments. Both of these parameters decreased significantly by increasing drought stress. The result of this experiment is consistent with Sayar *et al.* (2010), who affirm that growth medium salinity or drought (induced by PEG) may affect seed germination. The maximum and the minimum germination rates was related to application of -0.288 (MP) PEG and control treatment, which had significant differences with each other (*Table 1*).

There was no meaningful differences in germination uniformity, fresh radicle weight and dry radicle weight between treatments. The biggest amount of radicle length and plumule length was achieved in control treatment, which had significant differences with other treatments. Kalefetoğlu Macar *et al.* (2009) found that drought stress induced by PEG prevented radical extension in chickpea.

Table 1 - Mean comparison of germination percentage, mean time of germination, germination rate, germination uniformity, radicle length (cm), plumule length (cm), fresh radicle weight (g), dry radicle weight (g), fresh plumule weight (g), dry plumule weight (g), and seed stamina index under drought stress

Treatment	Germination percentage	Mean time of germination	Germination rate	Germination uniformity	Radicle length	Plumule length	Fresh radicle weight	Dry radicle weight	Fresh plumule weight	Dry plumule weight	Seed stamina index
Cultivar											
Mashhad-e-Ardahal	36.66a	10.51a	0.0970a	0.0281b	4.1595b	3.4790b	0.0371a	0.0142a	0.1067a	0.0250a	2.7807a
Kerman	29.12b	10.63a	0.0959a	0.0402a	4.9554a	4.3796a	0.0271b	0.0108b	0.0854b	0.0163b	2.5936a
Drought stress (MP)											
Control	47.125a	11.00a	0.076e	0.0302a	5.5094a	4.5707a	0.0350a	0.0112a	0.1212a	0.0237ab	3.8394a
-0.144	37.500ab	10.65b	0.085de	0.0290a	4.2350b	3.9248b	0.0350a	0.0137a	0.1087a	0.0250a	2.8413b
-0.180	36.125ab	9.62c	0.093dc	0.0301a	4.0694b	3.8552b	0.0312a	0.0137a	0.0900bc	0.0200ab	2.8705b
-0.216	29.375bc	9.37de	0.107ab	0.0375a	4.1613b	3.6442b	0.0337a	0.0137a	0.0937b	0.0237ab	2.4686b
-0.252	26.625bc	10.01dc	0.099bc	0.0417a	4.5438b	3.8302b	0.0300a	0.0112a	0.0775c	0.0162bc	2.2219b
-0.288	20.625c	8.62e	0.116a	0.0365a	4.8260ab	3.7505b	0.0275a	0.0112a	0.0850bc	0.0150c	1.8814b

Common letters within each column do not differ significantly; MP = Mega Pascal.

Table 2 - Mean comparison of germination percentage, mean time of germination, germination rate, germination uniformity, radicle length (cm), plumule length (cm), fresh radicle weight (g), dry radicle weight (g), fresh plumule weight (g), dry plumule weight (g), and seed stamina index under drought stress in interaction between masses and different treatments of drought stress

Treatment	Germination percentage	Mean time of germination	Germination rate	Germination uniformity	Radicle length	Plumule length	Fresh radicle weight	Dry radicle weight	Fresh plumule weight	Dry plumule weight	Seed stamina index
Interaction between cultivar (C) and Drought stress (D)											
C1*Control	50.00a	13.12a	0.073a	0.013a	4.442bc	3.487cd	0.0375a	0.0100a	0.120a	0.020bcde	3.95a
C1*D1	45.75a	11.81a	0.085a	0.021a	3.840c	3.292d	0.0400a	0.0176a	0.120a	0.040a	2.97a
C1*D2	38.75a	10.08a	0.096a	0.026a	3.529c	3.324d	0.0350a	0.0150a	0.102abc	0.027bc	2.67a
C1*D3	38.75a	9.88a	0.109a	0.030a	4.321bc	3.487cd	0.0375a	0.0175a	0.107ab	0.030ab	3.01a
C1*D4	26.50cd	10.06a	0.100a	0.036a	4.401bc	3.528cd	0.0350a	0.0125a	0.082cde	0.022cde	2.07a
C1*D5	21.25cd	8.43a	0.117a	0.040a	4.421bc	3.753bcd	0.0375a	0.0125a	0.107ab	0.010e	1.98a
C2*Control	44.25a	12.19a	0.080a	0.047a	6.575a	5.654a	0.0325a	0.0125a	0.122a	0.027bc	3.72a
C2*D1	29.25a	11.55a	0.085a	0.036a	4.629bc	4.557b	0.0300a	0.0100a	0.097bcd	0.010e	2.70a
C2*D2	33.50a	10.83a	0.091a	0.034a	4.609bc	4.385bc	00270a	0.0125a	0.077de	0.012de	3.06a
C2*D3	21.00a	9.90a	0.104a	0.044a	4.001c	3.800bcd	0.0300a	0.0100a	0.080de	0.017cde	1.92a
C2*D4	26.75a	10.13a	0.099a	0.046a	4.685bc	4.132bcd	0.0250a	0.0100a	0.072e	0.010e	2.36a
C2*D5	20.12a	8.90a	0.114a	0.032a	5.230b	3.747bcd	0.0175a	0.0100a	0.062e	0.020bcde	1.77a

Common letters within each column do not differ significantly; MP = Mega Pascal; C1= Mashhad-e-Ardahal, C2 = Kerman. D1= -0.144 MP, D2 = -0.180 MP, D3 = -0.216 MP, D4 = -0.252 MP, D5 = -0.288 MP.

Mohammadkhani & Heidari (2008) also noted that root and shoot length and seedlings fresh and dry weight of maize cultivars were decreased by increasing PEG. Control treatment had obtained the maximum fresh plumule weight and seed stamina index, which had significant differences with other treatments. The highest and the lowest dry plumule weight was obtained for application of -0.144 MP and -0.288 MP of polyethylene glycol. Water stress, due to drought, is probably the most significant abiotic factor limiting plant and also crop growth and development. Growth of plants in arid and semi-arid land is dependent upon plants susceptibility to drought stress and also related to the ability of seeds to achieve optimum germination under these unfavorable conditions. Therefore, it is important to identify cultivars and masses tolerance to drought at the primary growth stage.

Interaction between Mashhad-e-Ardahal and control treatment has obtained the highest germination percentage, which had significant different with the lowest number which related to Kerman and application of -0.216 MP polyethylene glycol interaction. There were no meaningful differences in mean time of germination, germination rate and germination uniformity among interaction of cultivar and drought stress treatments. The lowest radicle lenght was related to interaction between Mashhad-e-Ardahan and application of -0.144 MP PEG, which had significant differences with Kerman and control treatment interaction. The highest number of plumule length and fresh plumule weight was also obtained in interaction of Kerman cultivar and control treatment, and in both experimental characteristics, there was meaningful difference between the mentioned interactions and the lowest numbers. Interaction between Mashhad-e-Ardahal and application of -0.144 MP polyethylene glycol had obtained the highest fresh radicle weight, dry radicle weight and dry plumule weight. The maximum number of seed stamina index was achieved in interaction between Mashhad-e-Ardahal and control treatment. There were no significant difference between treatments in fresh radicle weight, dry radicle weight and seed stamina index (*Table 2*).

CONCLUSIONS

Cultivar had significant influence on germination percentage, germination uniformity, radicle length, plumule length, fresh radicle weight, dry radicle weight, fresh and dry plumule weight. Drought stress impact on all treatments except germination uniformity, fresh radicle weight and dry radicle weight was meaningful, but, just radicle length, plumule length, fresh plumule weight and dry plumule weight significantly affected by interaction between cultivar and drought stress. The rate of germination, germination percentage, as well as seedling growth and establishment were considerably

lowered with the rise of stress levels using PEG. Control treatment had obtained the highest germination percentage, mean time of germination, radicle and plumule length, fresh plumule weight and seed stamina index. Taking all traits into account, this experiment found that Mashhad-e-Ardahal was most tolerant hybrid to water stress conditions. Germination and seedling establishment from laboratory experiments does not necessarily mean that germination and seedling emergence from the field soils.

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