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Effect of drought stress on seed quality of summer oilseed rape produced on drought stressed mother plants

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Abstract

In order to study of drought stress and normal irrigation effect on summer oilseed rape cultivars seed germination, the experiment was conducted as a Factorial in Randomize Complete design with 4 replications, in central laboratory of Seed and Plant Certification Research Institute (SPCRI) Karaj. Experimental treatments were the seed produced in normal irrigation (S1) and drought stress in floral stage (S2) with cutting irrigation of floral time until the maturity stage and ten cultivars of summer oilseed rape as RGS003, Sarigol, Option500, RGS006, 19-H, ORS 3150-3006, ORS 3150-3008, RG 4403, RG 405/03 and RGAS 0324. Some seed and seedling germination traits such as 1000-seed mass, Final Germination Percentage (FGP), Mean Time of Germination (MTG), Coefficient of Germination Velocity (CGV), Mean Daily Germination (MDG), Daily Germination Speed (DGS), seedling length, root, shoot and seedling fresh and dry weight and traits of Longitudinal Vigour Index and Weight vigour Index were studied after accelerated ageing test on seeds. The results showed that significant differences were observed regarding FGP, MTG, CGV, MDG, DGS, traits of longitudinal vigour index and root dry weight by drought stress and cultivar. The means comparison results of drought stress and cultivar interaction on 1000-seed mass showed that the cultivars of RG 4403 with 3.498g had the most and RGS006 with 3.082g had the lowest 1000-seed mass respectively. Where Sarigol cultivar produced with normal irrigation 983.4 and RGS003 277.1 had the most LVI1 and LVI2. As a point of view of MTG, CGV, MDG and DGS respectively the seeds of Sarigol produced under the drought stress, RGS003 produced in normal irrigation and Sarigol produced under the drought stress. In general, it can be concluded that drought stress on investigated reduced the seed quality of the cultivars.

Keywords: oilseed rape, drought stress, seedling vigour.

Introduction

Oilseeds because of deferent reasons, in a few recent decades has been paid much attention in the countries of the world and its reasons are the considerable oil and protein accumulation consumable of human feed program, livestock, value of independent feeding of materials, its production, comfortable natural changes, possibility of changeability and modification of breeding and genetic engineering and biotechnological methods (Rehm *et al.*, 2001). Among the oil plant, Oilseed rape is becoming more important due to its unique characteristic, including its high oil content, during recent years had been with high planting development in the world. Also in our country, along with obtaining plant oil of domestic resources, has made the authorities develop the cultivars of Oilseed rape oil plant (Dehshiri, 1999). The under planting level of oilseed rape in our country in agronomical year of 2006-2007 has been estimated about 169160 hectares of which 53.08 percent of the fields were irrigational and the rest of it was planted by dry farming. The amount of oilseed rape production in the country has been estimated about 356890 tons of

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which 57.59 percent obtained by irrigational planting and 42.41 percent by dry farming. Plants wherever they are, they grow and meet by many stresses that these stresses limit their chance of growing and survival (Kuchaki *et al.*, 2003). Drought and the resulted stress are the most common environmental stresses that approximately limit production planting in 25 percent of world agricultural fields (Hashemi Dezfuli *et al.*, 1995). Water deficit can effect on oilseed rape yield, but this effect depends on genotype, the stage of development and adaptability plant to drought (Mendham and Salisbury, 1995). Breeders and farmers aim to get higher seedling establishment in crops, but some biotic and abiotic stresses reduce seedling establishment in field conditions (Yagmr and Kydan, 2008). An understanding of the ecological and evolutionary responses to environmental stresses is necessary in order to predict the viability of natural plant populations and the persistence on survival of species in a geographic area (Aronson *et al.*, 1993; Dudley, 1996; Heschel *et al.*, 2002; Heschel and Rigions, 2005).

The drought stress is considered one of the main factors that imposes crops yield. The effects of water deficiencies depend on several factors such as its intensity, duration, phonological phase of growth and genetic resistance capacity of plants. The water limitation affects plant growth and its productivity. The most typical symptom of water deficiencies in higher plants is a retarded growth due to inhibition of cell elongation by water limitation (Clua *et al.*, 2006). Low water availability in drought stress treatments can enhance the number of dormant seeds and the properties of the seed coat can explain the differences found in the rate and average speed of germination between treatments (Clua and Gimez, 2003). In order to reduce resulted stress damage, selection of cultivars that have a good yield under drought stress conditions, is the main goal in improving racing programs. Because of changing climatic conditions and unsuitable distribution of rainfall, for cultivars suitable selection, a series of indexes must be considered so that by means of it the selection of those cultivars indexes are carried on more scientifically (Dow *et al*, 1984). Principally, oilseed rape at the time of germination and also in floral stage is sensitive to drought. Drought in the germination stage is preventing water absorption by seeds. The sensitivity of subject intensifies when the sufficient water exists for beginning germination but growth of the new established young seedling meets the lack of water (Pouzet, 1995).

Gunansikera *et al.* (2003), during study of water stress effects on water relationships and yield oilseed rape and Mustard, reported that water stress after flowering had an unsuitable effect on dry material and the oilseed rape and Mustard seed yield and unlike their imagination, the mustard didn't show up any yield increase against to oilseed rape. Oilseed rape in principle during germination and the pods growth stage is sensitive to drought (Tomas, 1984). According to the experiments of greenhouse which has been done on Pea, it has been known that this plant during flowering stage and at beginning of the seed filling is sensitive to drought stress (Sharp, 1993). Drought stress in various stages of plant growth has a different influence (Blum, 1998). Carter and Paterson (1985), have considered the effect of drought stress and cutting irrigation on germination and seed viability in oilseed rape, and reported that the drought stress didn't influence on germination and seed viability and also during the studies performed they concluded that drought stress reduced the seed germination and seed viability a little. Sekia and Yano (2002), reported that stress happening after physiological maturation, at the time of pre-harvesting has caused to reduce germination and seed viability and also during the course of seed perfection and consequently it causes harvested seeds to become smaller. Considering the effect of drought stress on seed germination and seedling establishment of oilseed rape and the importance of recognition of tolerant cultivars to drought of this plant, this research was performed in order to study the effect of creating drought stress in mother plant flowering stage on germination characteristics of produced seeds.

Materials and methods

This research was conducted in order to study the practicing drought stress and normal irrigation effect on some oilseed rape spring cultivars seed germination in central laboratory of Seed and Plant Certification Research Institute (SPCRI) Karaj. Experimental treatments are the seed produced in normal irrigation (S1) and drought stress in floral stage (S2) with cutting irrigation of floral time until cutting maturity and 10 cultivars of summer oilseed rape as RGS003, Sarigol, Option500, RGS006, 19-H, ORS 3150-3006, ORS 3150-3008, RG 4403, RG 405/03 and

RGAS 0324.

It was done as a factorial experimental design in complete randomized 2 × 10 (Ten spring cultivars × practicing and non-practicing drought stress of flowering stage of mother plant). Any experimental unit consisted of 100 seeds that they were by 4 replications (400 seeds all together) under the germination standard test. At first the seeds were placed inside the internal dish of accelerated ageing seed boxes and some specific water was added to the external dish and also the lid of the dish was closed and the dishes were put into the germinator at 40°C temperature for 48 hours.

In order to execute this test according to International Seed Testing association (ISTA), the seeds were planted between germination wetted papers and then were placed into the germinator in 25°C for 7 days.In order to determine the indexes of Mean Time of Germination, Coefficient of Velocity of Germination, Mean Daily Germination, Daily Germination Speed by each day planted seeds were visited and written a number of germinated seeds and some indexes related to the above mentioned seed germination determined by equations below:

Mean Time of Germination (MTG) that is an index of germination rate and acceleration computed by equation 1:

(1) $$MTG= \sum(nd)/ \sum n$$

In this equation: n = the number of germinated seeds days, d = the number of days until the end of standard germination test, ∑n = all of the number of germinated seeds (Ellis and Roberts, 1981).

Coefficient of Germination Velocity(CGV) is the distinguish of rate and acceleration seeds computed by the equation below:

(2) $$CGV=G1+G2+\ldots+Gn/(G1\times1)+(G2\times2)+\ldots+(Gn\times n)$$

In this equation: G1 – Gn is the number of germinated seeds from first day until the end of the day of the standard germination test (Scott *et al.*, 1984).

At the end of the test also the number of the normal seedlings as the Final Germination Percentage (FGP) were counted and notes were taken and the obtained data for computation of the Mean Daily Germination (MDG) was used that is the index of Daily Germination Speed were obtained by the equation below:

(3) $$MDG=FGP/d$$

In this equation: FGP is the Final Germination Percentage and d is the number of days to reach to maximum final germination (Hunter *et al.*, 1984).

Daily Germination Speed (DGS) is also reverse of Mean Daily Germination obtaining by equation below (Maguire, 1962):

(4) $$DGS=1/MDG$$

Also in order to determine the seed vigour the number of 10 seedlings of each replication sampling by random and then by separating of the primary roots, shoots and the seedlings, their length, fresh weight and dry weight were determined (by placing them in germinator within a period of 24 hours in 75°C temperature). Also seedling longitudinal vigour index (SVI1) and seedling weight vigour index (SVI2) relations were determined by equations below (Abdul-baki and Anderson, 1973):

(5) $$SVI1= (\text{primary shoot length} + \text{primary root length}) \times \text{viability}$$

(6) $$SVI1= \text{dry weight seedling} \times \text{viability}$$

In the end, the obtained data by using the statistic software of MSTAT-C, the variance analysis was accomplished and the mean comparison was done by Duncan's method.

Results and Discussion

The results of variance analysis showed that drought stress and cultivar interaction on Final Germination Percentage, Mean Time of Germination, Coefficient of Velocity of Germination, Mean Daily Germination, Daily Germination Speed, LVI1 and LVI2, dry weight root under the effect of investigated to drought stress and cultivar as a point of view of these traits had a significant together (Table1). The results of the variance analysis table showed that the interaction of drought stress and cultivar treatments on 1000–seed mass of investigated oilseed rape cultivars were significant on 1 percent level of probability error but the effect of drought stress and cultivar non-significant in 1000–seed mass (Table1). The results of means comparison of drought stress effect on 1000–seed mass showed that the produced seeds in normal irrigation conditions had the most 1000–seed mass as compared with drought stress conditions (Fig. 1). Also the means comparison results of the cultivars effect on investigated oilseed rape cultivars showed that, the RG 4403 cultivar with 3.498g had the most and the RGS006 cultivar with

Table 1. Analysis of variance (Mean squares) studied traits of summer oilseed rape cultivars seeds.

S. O.V	d.f	1000-seed mass (g)	Final Ger. Percentage (%)	Mean Time of Ger. (MTG)	Coefficient Of Germination Velocity. (CGV)	Mean Daily Ger. (MDG)	Daily Ger. Speed (DGS)	Primary Root length (cm)	Primary Shoot length (cm)	Seedling length (cm)	Seedling Fresh weight (mg)	Primary Root Dry weight (mg)	Primary Shoot Dry weight (mg)	Seedling Dry weight (mg)	Seedling Longitudinal Vigour Index	Seedling Weight Vigour index
Drought stress (S)	1	5.346**	812.813**	0.008^{ns}	0.0001^{ns}	12.347*	0.002**	0.369n.s	0.459n.s	1.650n.s	409.512**	0.021n.s	1.220**	1.540**	148664.077*	29001.729**
Cultivar (C)	9	0.132**	587.568**	0.124*	0.001*	4.331*	0.001*	0.494n.s	0.156n.s	0.435n.s	45.761n.s	0.048**	0.109n.s	0.194n.s	84637.179*	8389.896**
S × C	9	0.034^{ns}	627.313**	0.531**	0.004**	17.674**	0.002**	1.457n.s	0.434n.s	1.133n.s	8.381n.s	0.033n.s	0.044n.s	0.108n.s	83124.128**	5411.479**
Error	60	0.029	104.313	0.053	0.0001	1.788	0.0001	0.836	0.269	1.239	28.190	0.017	0.072	0.099	22503.219	1339.019
Total	79															
CV (%)		5.06	14.62	6.51	6.43	12.30	15.47	14.14	12.39	10.45	11.75	23.65	11.84	11.23	20.03	18.58

n.s : Non.significant, * and ** Significant at 5% and 1% levels respectively.

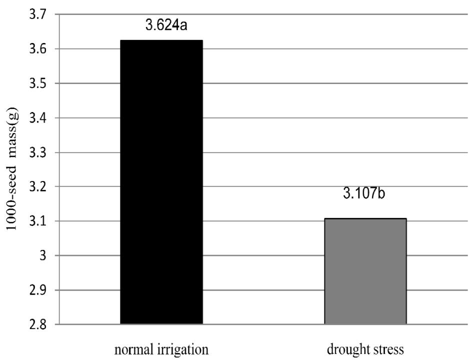

Fig. 1. The chart of drought stress effect on 1000-seed mass of investigated oilseed rape cultivars in Accelerated Ageing Test

3.082g had the lowest 1000–seed mass (Fig. 2).

The means comparison results of drought stress and cultivar interaction on final germination percentage showed that the seeds of RGS003 and Sarigol cultivars produced in normal irrigation with 89.50 and 89 percent respectively had the most and the seeds of 19–H cultivar that produced in drought stress conditions with the mean of 51 percent had the lowest final germination percentage (Fig. 3). Deloche and Baskin (1973), reported that the changes in amount of seeds germination of seeds lots with the high and low quality after the accelerated ageing test had the process similar to seeds germination of the same seeds lots after during seeds storing in the granary. The seeds size influences on the final moisture seed and amount of germination after seed ageing too. The Soybean larger seeds in comparison with the smaller seeds when the same numbers placed into the trays of accelerated ageing rooms, the amount of their final moisture seed decreases and final germination reduced (Tomas *et al.*, 1988). Rao and Mendham (1991), concluded that the oilseed rape cultivars with small seed size, as compared with the large seed size cultivars, had the highest seed quality in drought stress conditions. Viera *et al.* (1992), during the experiment on Soybean said that drought stress by direct effect on seed metabolism causes to reduce the maximum of harvested seeds germination percentage with drought stress conditions. The means comparison results of drought stress and cultivar interaction on Mean Time of Germination showed that the seeds of Sarigol produced in normal irrigation had the highest and lowest Mean Time of Germination respectively (Fig. 4). The means comparison results of drought stress and cultivar interaction on Coefficient of Germination Velocityshowed that the seeds of Sarigol-and RGS003 produced in normal irrigation respectively 0.3252 and 0.3248 had the highest and the Sarigol cultivar seeds produced under drought stress conditions with the mean of 0.2513 had the lowest Coefficient of Germination Velocity (Fig. 5). Ritchi *et al.* (1999), reported that the reason of reduction of germination speed, is the seeds deterioration before harvesting and also the high Coefficient of Germination Velocityrelated to 1000–seed mass. The means comparison results of drought stress and cultivar interaction on Mean Daily Germination showed that the RGS003 seeds produced in normal irrigation with the mean of 13.57 seed in a day had the most and the Sarigol seeds produced in drought stress conditions with 7.462 seed in a day had the lowest amount of Mean Daily Germination (Fig. 6). The means comparison results of drought stress and cultivar interaction on Daily Germination Speed showed that the Sarigol produced seeds from drought stress conditions with the mean of 0.1395 had the highest and the seeds of the same cultivar produced from normal irrigation conditions with the mean of 0.07373 had the lowest amount of Daily Germination Speed (Fig. 7). The germination speed and viability seed show the amount of Daily Germination Speed (Hunter *et al.*, 1984). Gurusamy (1999), reported that the delay in seed harvesting cause to reduce its germination speed and announced that the reason of this reduction is the pre-harvesting seeds deterioration. The results of means comparison of drought stress effect on seedling fresh weight showed that the produced seeds in normal irrigation conditions had the most seedling fresh weight compared with drought stress conditions (Fig. 8). The means comparison of cultivar simple effect on investigated oilseed rape root dry weight by Duncan's test in 5 percent error level showed that the Option500 with 0.6750ml had the most and the cultivar treatment of ORS 3150-3006 with 0.4375ml had the lowest root dry weight (Fig. 9). Hobbs *et al.* (1983) with the studies on plant Soybean seeds, concluded that plants seeds under the drought stress in comparison with plant seeds that were under the normal irrigation, they had a higher seedling dry weight. The results of means comparison of drought stress effect on shoot and seedling fresh weight showed that the produced seeds in normal irrigation conditions had the most shoot and seedling fresh weight compared with drought stress conditions (Figs. 10 and 11). The means comparison of drought stress effect on Longitudinal Vigour Index (LVI1) showed that the seeds produced from normal irrigation had the most LVI1 compared with the produced seeds in drought stress and also the means comparison of drought stress and cultivar interaction on longitudinal vigour index of seedling on investigated oilseed rape cultivars showed that Sarigol seeds produced by normal irrigation with 983.4 had the most and the

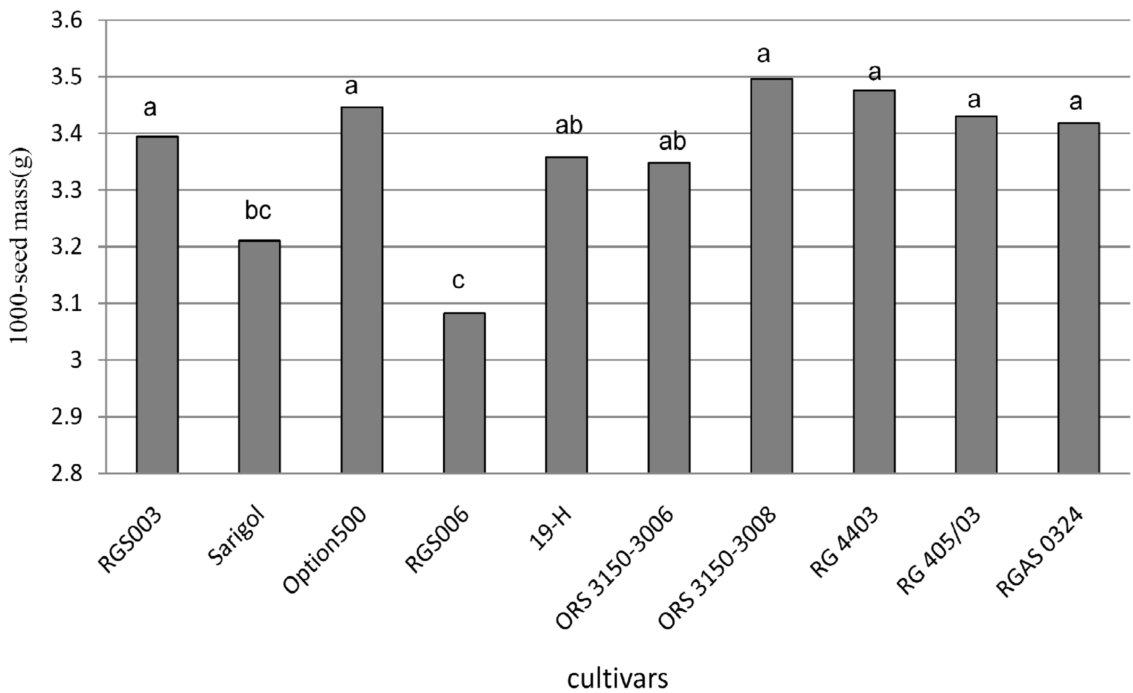

Fig. 2. The chart of cultivar effect on 1000-seed mass of investigated oilseed rape cultivars

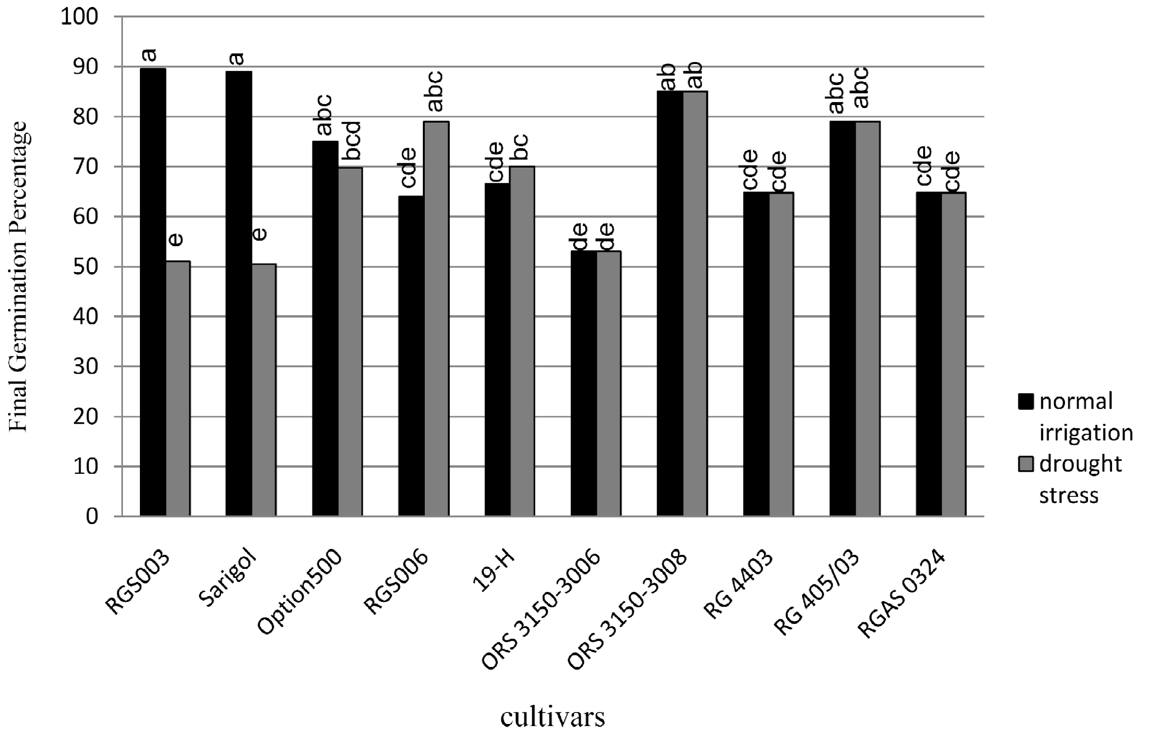

Fig. 3. The chart of means comparison of drought stress and cultivar interactions on Final Germination Percentage of

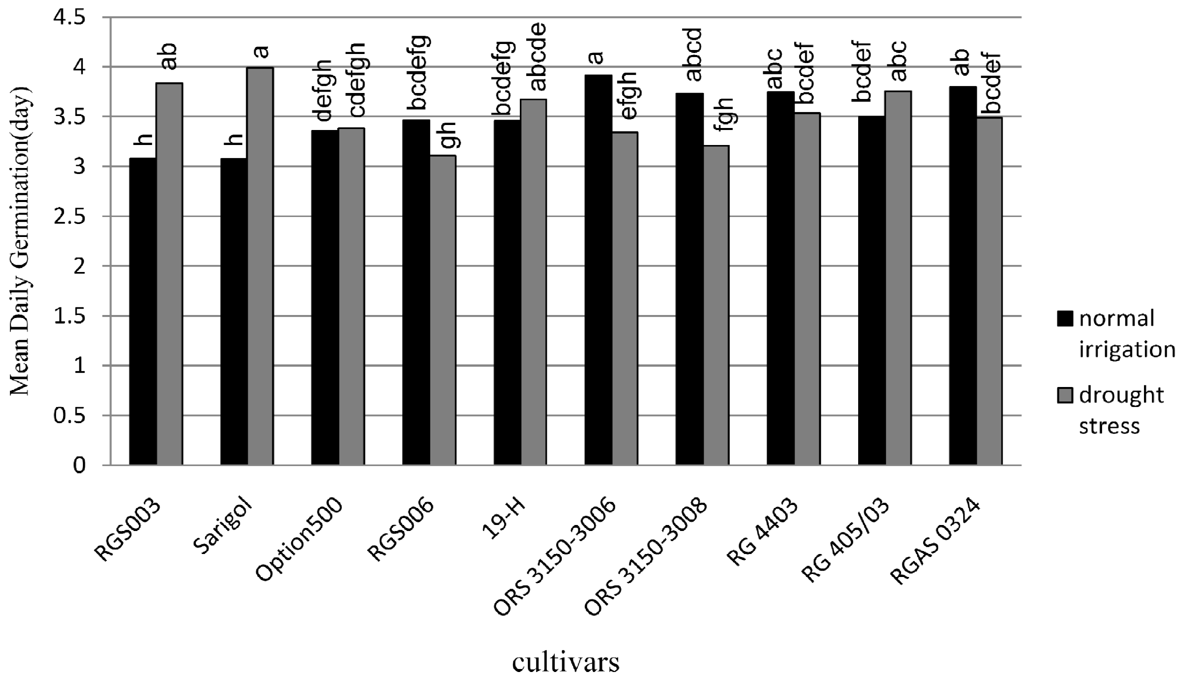

Fig. 4. The chart of means comparison of drought stress and cultivar interaction on Mean Daily Germination of investigated oilseed rape cultivars in Accelerated Ageing Test

cultivars of Sarigol and RGS003 produced from drought stress with 519.6 had the lowest LVI1 (Fig. 12). The means comparison of drought stress effect on Longitudinal Vigour Index (LVI2) showed that the produced seeds by normal irrigation conditions as compared with the produced seeds by drought stress conditions had the most LVI2. Also the means comparison

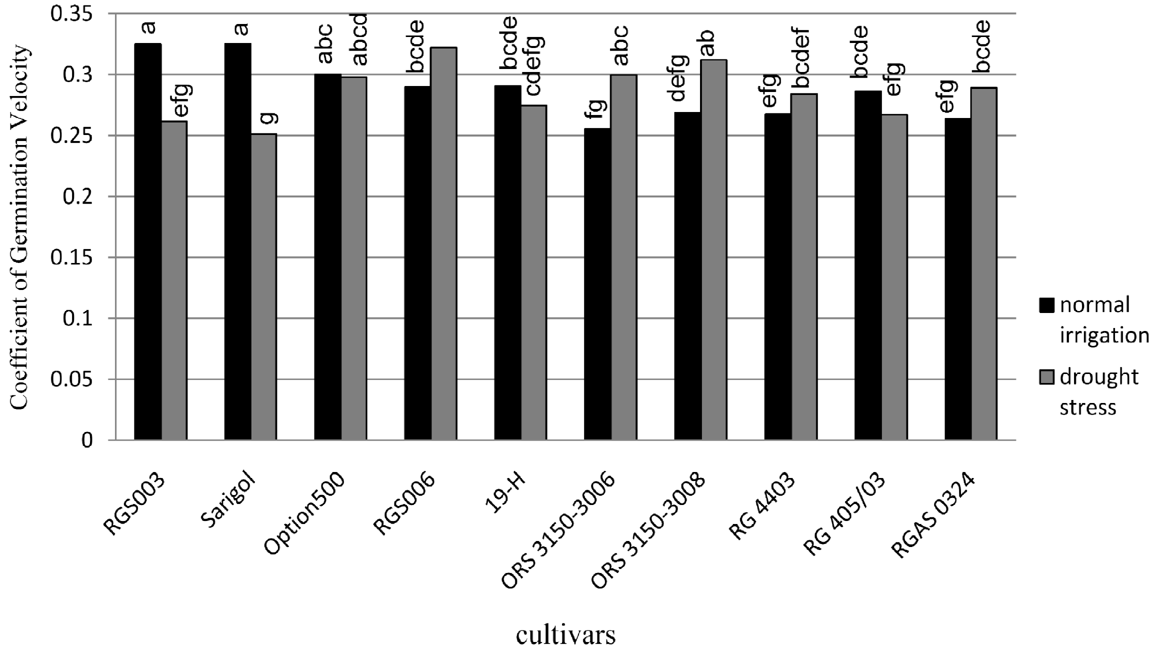

Fig. 5. The chart of means comparison of drought stress and cultivar interaction on Coefficient of Germination Velocity investigated oilseed rape cultivars in Accelerated Ageing Test

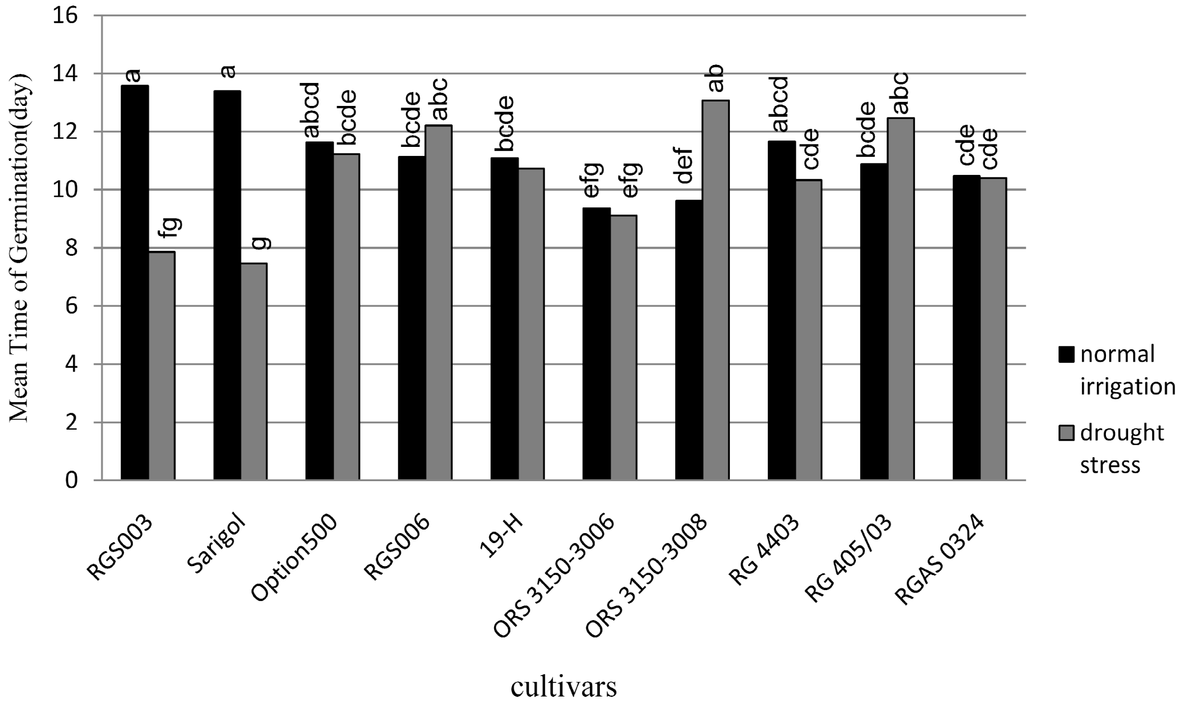

Fig. 6. The chart of means comparison of drought stress and cultivar interaction on Mean Time of Germination of investigated oilseed rape cultivars in accelerated ageing test

results of drought stress and cultivar interaction on investigated oilseed rape showed that the RGS003 cultivar seeds produced by normal irrigation with 277.1 had the highest and the sarigol cultivar produced from drought stress conditions with 128.3 had the lowest LVI2 (Fig. 13). In the end, taking granted that whether the characteristics of germination seed and seedling emergence of the seeds that their mother plant has been influenced by drought stress with the resulted seeds from the normal irrigated mother plant is different or not and considering the available drought

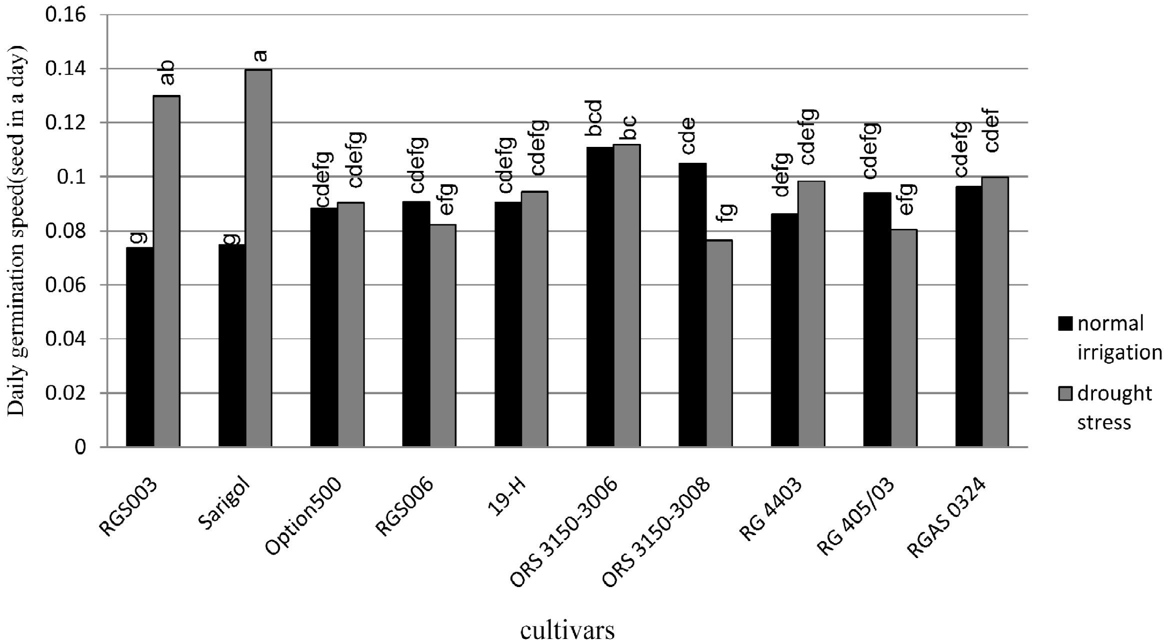

Fig. 7. The chart of means comparison of drought stress and cultivar interaction on Daily Germination Speed of investigated oilseed rape cultivars in accelerated ageing test

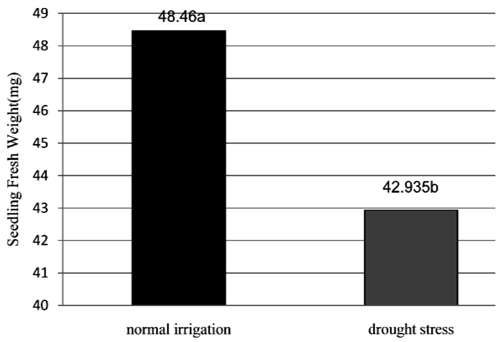

Fig. 8. The chart of drought stress effect on seedling fresh weight of investigated oilseed rape cultivars in accelerated ageing test

conditions in the country, using the resistant cultivar in drought conditions that have the best germination seed index, they were the important goal of this study and considering the above results it is suggested that, those group of cultivars seeds which their mother basis has been met with the drought stress in order to plant in dry regions and there is a probability of drought year in those regions, is not suitable. As a general conclusion and considering the investigated traits, the cultivars of RGAS 0324 and Sarigol had the most final germination seed and also Sarigol cultivar had the most CGV and SVI1 and the cultivar of RGS003 had the most SVI2 and CGV.

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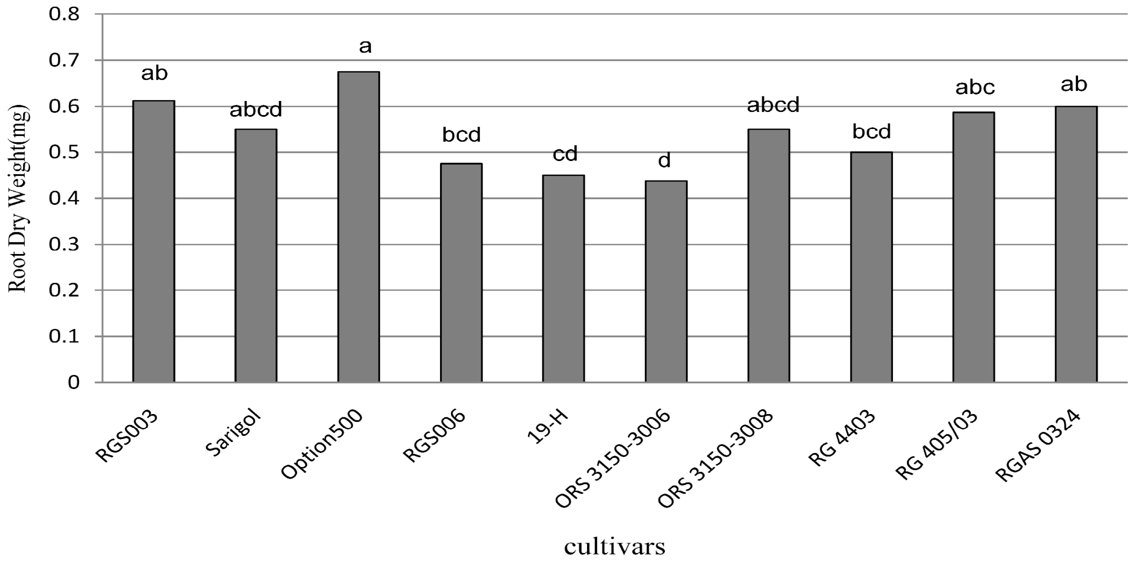

Fig. 9. The chart of cultivar effect on root dry weight of investigated oilseed rape cultivars

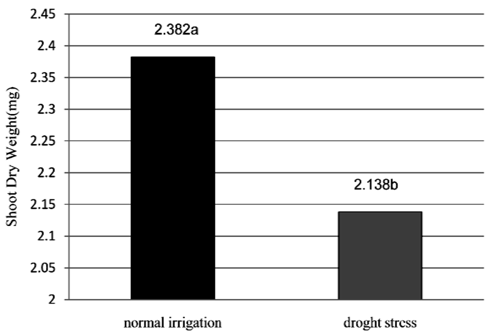

Fig. 10. The chart of drought stress effect on Shoot Dry weight of investigated oilseed rape cultivars in Accelerated Ageing

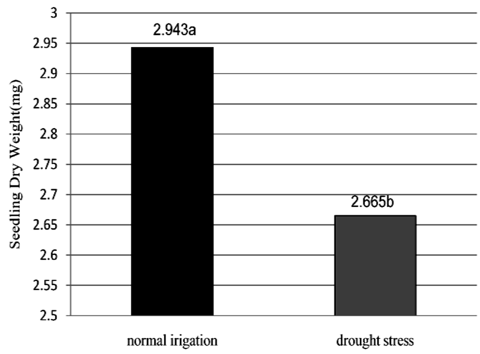

Fig. 11. The chart of drought stress effect on Seedling Dry weight of investigated oilseed rape cultivars in Accelerated Ageing Test

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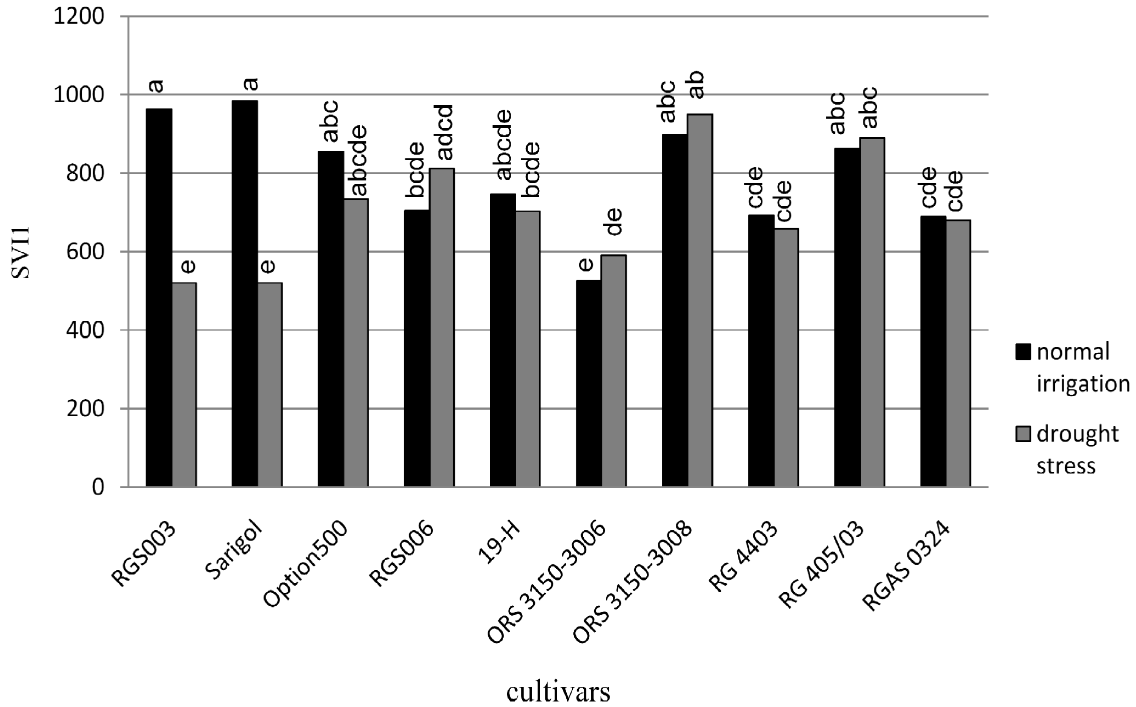

Fig. 12. The chart of means comparison of drought stress and cultivar interaction on SVI1 of investigated oilseed rape cultivars in accelerated ageing test

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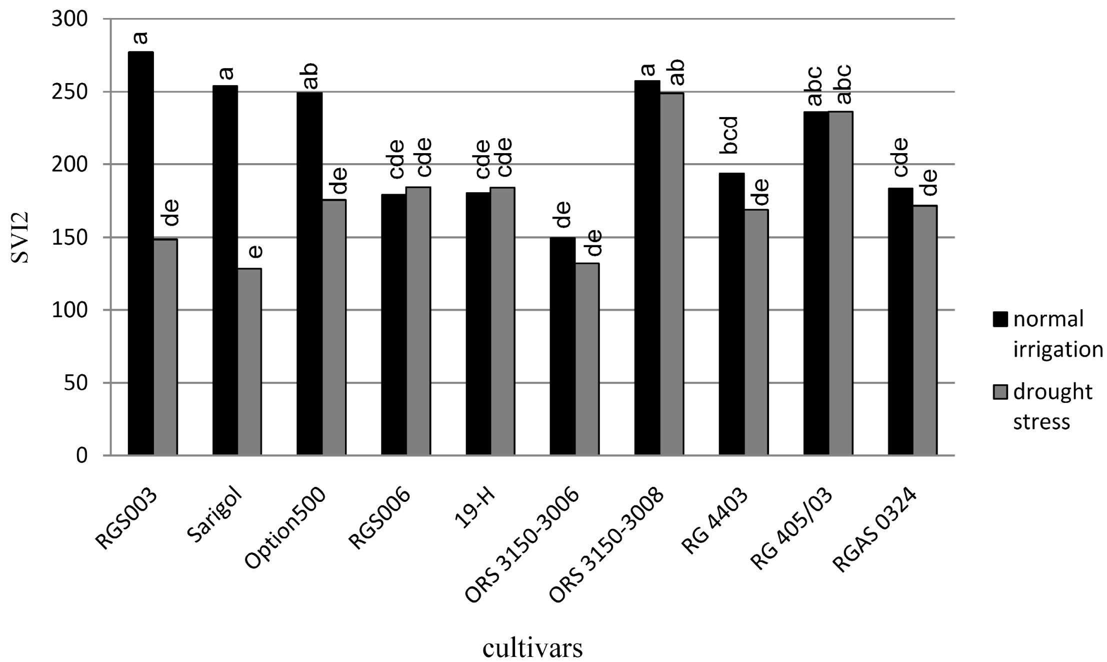

Fig. 13. The chart of means comparison of drought stress and cultivar interaction on SVI2 of investigated oilseed rape cultivars in accelerated ageing test

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