African Journal of Agricultural Research Vol. 7(19), pp. 2983-2988, 19 May, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.1021
ISSN 1992 - 1950 ©2012 Academic Journals

Full Length Research Paper

Turnip rape yield and yield components response to different sowing dates under different irrigation regimes

M. Zaman Fashami[1]*, B. Delkhosh[2], A. H. Shirani Rad[3] and G. Noor mohammadi[1]

[1]Department of Agronomy, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Department of Agro Ecology, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[3]Department of Oilseed Crops, Seed and Plant Improvement Institute, Karaj, Iran.

Accepted 10 April, 2012

Water stress is the most important factor limiting crops production in the world. Water stress effect could be modified in different ways such as choosing the most appropriate sowing date. To assess the effect of sowing date on yield and yield components of turnip rape (*Brassica campestris* L.-cv. Goldrush) under different irrigation regimes, a field experiment was conducted in Qazvin, Iran during 2010 to 2011 growing season. The experiment was laid out in a three-replicated-randomized complete block, factorial design with four irrigation levels (I: I_1= normal irrigation (control), I_2= interruption of irrigation from flowering stage, I_3= interruption of irrigation from silique formation stage and I_4= interruption of irrigation from seed filling stage) and four sowing date levels (D: D_1= 2 October 2010, D_2= 12 October 2010, D_3= 22 October 2010, D_4= 1 November 2010). It was shown that seed yield and yield components decreased by postponing the sowing date and water stress. Water stress at flowering stage had the most negative effect on these traits. Study of interaction effects of D × I on assessed traits revealed that the highest and lowest means were obtained in D_1I_1 and D_4I_2, respectively. Postponing the sowing date in all irrigation regimes decrease assessed traits, and flowering stage was the most sensitive stage to water stress in all sowing dates. The highest seed yield obtained in D_1I_1 by average is 3875 kg/ha.

Key words: Turnip rape (*Brassica campestris* L.), sowing date, irrigation regimes, yield, yield components.

INTRODUCTION

Oil seed crops are very important for human food and have gained third position among crops next to cereals and legumes (Downey, 1990). About 40 different plant species, including some trees, have been used for the commercial production of fatty oils (Weiss, 1983). The average yield of oil crops in Iran is 245000 tons (Area harvested 521000 ha), whereas the world average yield of oil crops is 261,099,000 tons (Area harvested, 157,382,000 ha). Oilseed crops production needs to be increased through both increasing the land area under cultivation and increasing the yield per unit of land area due to increasing demand for edible oils (Tuncturk and Ciftci, 2004). Since arable land throughout the world is decreasing, increasing yield within the available lands is possible through introducing oilseed crops which is adaptable with weather conditions of a region in addition to amending planting methods and improving cultivars with high oil rate. Recently, the production of rapeseed as a well adapted oilseed crop with the weather condition in Iran is taken into consideration (Bonyadi Bala Deh, 2000). Agricultural cultivars of rapeseed (Brassicaceae) belongs to two species of common rapeseed (*Brassica napus* L.) and turnip rape (*Brassica campestris* L. or *Brassica rapa* L.) (Azizi, 1998). Turnip rape has been cultivated since about 2000 years ago in an extended area from West Europe to China and Korea, and from

*Corresponding author. E-mail: zfashami@yahoo.com.

Norway to African desert and India (Hedge, 1976) and its seeds contains 40 to 45% oil and 20 to 25% protein (Nuttall et al., 1987). The direct yield components of turnip rape are number of plants per plot, number of siliques per plant, number of seeds per silique and weight of seeds. Yield components are important as they correlate with the final seed yield. The relative importance of each yield component is affected by many factors, including genotype, environmental conditions (e.g. drought and salinity) and cultural practices. At present, low water availability is the main environmental factor limiting plant growth and yield worldwide, and global change will likely make water scarcity an even greater limitation to plant productivity across an increasing amount of land (Chaves et al., 2003; Hamdy et al., 2003). Drought stress reduces the capacity of plants to take up water from the soil (Munns, 2002). Even temporary drought can cause substantial losses in crop yield (Moselev, 1983). The limitation of plant growth imposed by low water availability is mainly due to reductions in plant carbon balance, which is dependent on the balance between photosynthesis and respiration. The effect of drought stress is a function of genotype, intensity and duration of stress, weather conditions, growth and developmental stages (Robertson and Holland, 2004). The occurrence time is more important than the water stress intensity (Korte et al 1983). Severe stress decreases the duration of reproductive growth (Hall, 1992) and stress during flowering or ripening stages results in large yield losses (Stoker and Carter, 1984). Water stress occurring at any time during reproductive growth can result in a drastic change in seed yield. The worst time to experience water stress on many grain crops is during stem elongation and flowering. Sowing at a proper time allows sufficient growth and development of a crop to obtain a satisfactory yield and modify the undesirable effect of drought stress. Different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey et al., 1981). The greatest drawback for late sowing date is that irrespective of the sowing time, the flowering period falls in June, when evapotranspiration reaches high values and a long water stress period starts (Koutroubas et al., 2004, 2009; Yau, 2007). Flowering is the most sensitive plant stage to water deficit (Movahhedy-Dehnavy et al., 2009). Moreover, various safflower diseases tend to spread and intensify towards and after flowering. Therefore, plants are subjected to several biotic and abiotic stresses during the seed filling period that diminish photosynthesis and crop nitrogen uptake limits their production. The importance of carbohydrate and nitrogen storage in vegetative parts and their translocation to seeds to obtaining high yields under stress conditions has been widely recognized in many plant species. Keeping all this in view, the present investigation was taken up to find out suitable sowing date in turnip rape cultivation, considering the probability of water stress occurrence in different developmental stages of turnip rape.

MATERIALS AND METHODS

Experimental site and design

This experiment carried out at the experimental farm in Qazvin, Iran (49°57′E, 36°18′N; 1314 m a.s.l) during 2010 to 2011 growing season aimed to assess sowing dates and irrigation regimes effects on yield and yield components (number of siliques per plant, number of seeds per silique and 1000 seeds weight) of turnip rape (*B. campestris* L.). Qazvin is a semi arid region and receives average annual rainfall of 312 mm. Maximum and minimum temperatures are 8.2 and 38.7°C in a 30 year period in this region. The soil type where the experiment was conducted is a clay loam soil with 29% clay, 45% silt, 26% sand, 165 mg/kg available K, 14.2 mg/kg available P, 0.08% total N, 0.83% organic carbon, 8.25% total neutralizing value (TNV), 35% Sp, 7.8 (1:1 H_2O) pH and 1.33 dS/m electrical conductivity (EC) in the depth of 0 to 30 cm and 27% clay, 46% silt, 27% sand, 148 mg/kg available K, 15.3 mg/kg available P, 0.06% total N, 0.96% organic carbon, 8.46% TNV, 37% Sp, 7.4 (1:1 H_2O) pH and 1.15 dS/m EC in the depth of 30 to 60 cm.

The experiment was laid out in a three-replicated-factorial design in the form of randomized complete block with irrigation in four levels (I: I_1= normal irrigation (control), I_2= interruption of irrigation from flowering stage, I_3= interruption of irrigation from silique formation stage and I_4= interruption of irrigation from seed filling stage) and sowing date in four levels (D: D_1= 2 October 2010, D_2= 12 October 2010, D_3= 22 October 2010, D_4= 1 November 2010). Each experimental plot consisted of 6 rows, 6 m long with 30 cm spaced between rows and 4 cm distance between plants on the rows. Goldrush (*B. campestris* L.-cv. Goldrush) was used as the turnip rape cultivar.

Seeds were planted according to sowing date treatments. P and K were applied at a rate of 150 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} pre-plant in the form of triple superphosphate and K_2SO_4, respectively, and were incorporated in the soil before sowing. N was applied at a rate of 300 kg N ha^{-1} in the form of urea in three stages: one-third in 2 to 4 leaves stage, one-third in stemming stage and one-third in flowering stage. The final harvest was performed at physiological maturity on 1 July 2011, 28 June 2011, 26 June 2011, 23 June 2011, 6 July 2011, 2 July 2011, 30 June 2011, 27 June 2011, 9 July 2011, 6 July 2011, 4 July 2011, 2 July 2011, 11 July 2011, 8 July 2011, 6 July 2011, 3 July 2011 for D_1I_1, D_1I_2, D_1I_3, D_1I_4, D_2I_1, D_2I_2, D_2I_3, D_2I_4, D_3I_1, D_3I_2, D_3I_3, D_3I_4, D_4I_1, D_4I_2, D_4I_3, D_4I_4, respectively. Also, the crop was kept free from weeds by applying 2.5 L/ha Treflan pre-plant and 1 L/ha Galant super in 2 to 4 leaves stage.

Measurements of traits

At harvest stage, the four middle rows were used for sampling and measured parameters. For sampling, ten plants from the middle of each plot were harvested. The following traits were studied: seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary siliques and 1000 seeds weight. Seed yield in each plot was measured with 14% humidity.

Statistics

Analyses were performed with a personal computer using the MSTATC software. A factorial analysis of variance (ANOVA) was performed for all parameters. In addition, the Duncan's Multiple

Table 1. Factorial analysis of variance for assessed traits.

Source of variation	DF	SY	NS/P	NS/PB	NS/SB	NS/S	NS/PS	NS/SS	TSW
Replication	2								
Sowing date	3	**	**	**	**	**	**	**	**
Irrigation regimes	3	**	**	**	**	**	**	**	**
Irrigation regimes × Sowing date	9	**	**	**	**	*	NS	*	**
Error	30	-	-	-	-	-	-	-	-
Total	47	-		-	-	-	-	-	-
CV (%)	-	10.25	2.5	3.97	3.68	3.84	5.68	4.18	8.94

*, **Significant at 5 and 1% respectively, NS: not significant.

Table 2. Effects and mean comparisons (simple effect) of sowing date and irrigation regimes for assessed traits.

Treatment	Mean							
	SY (kg/ha)	NS/P	NS/PB	NS/SB	NS/S	NS/PS	NS/SS	TSW (g)
Sowing date								
D_1	2627^a	124^a	51.22^a	72.75^a	11.09^a	12.32^a	9.825^a	3.2^a
D_2	2240^b	111.7^b	46.45^b	65.2^b	10.47^b	11.68^b	9.2^b	2.95^b
D_3	1972^c	99^c	40.88^c	58.13^c	9.758^c	10.9^c	8.575^c	2.65^c
D_4	1111^d	66.88^d	25.58^d	41.3^d	7.308^d	8.275^d	6.3^d	1.825^d
Irrigation regime								
I_1	2806^a	130.1^a	54.9^a	75.25^a	11.48^a	12.73^a	10.2^a	3.4^a
I_2	938^d	59.88^d	22.65^d	37.22^d	6.958^d	7.95^d	5.925^d	1.65^d
I_3	1708^c	88.88^c	35.33^c	53.55^c	9.133^c	10.23^c	8^c	2.425^c
I_4	2498^b	122.6^b	51.25^b	71.35^b	11.05^b	12.27^b	9.775^b	3.15^b

Any two means sharing a common letter do not differ significantly from each other at 5% probability.

Range Test (DMRT) (P = 0.05) was used to conduct mean comparison of treatments and find the significant differences among means.

RESULTS AND DISCUSSION

Factorial analysis of variance and mean comparisons for seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight are presented in Tables 1 and 2, respectively. The results of factorial analysis of variance revealed that the simple effects of treatments (D and I) were significant at P = 0.01 for all assessed traits. The interaction effect of treatments (D × I) were significant for all assessed traits (at P = 0.01 for seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches and 1000 seeds weight and at P = 0.05 for number of seeds per silique and number of seeds per secondary silique) except for the number of seeds per primary silique (Table 1).

Traits in *italic*, *SY, NS/P, NS/PB, NS/SB, NS/S, NS/PS, NS/SS* and *TSW* are assigned for seed yield in kg/ha, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight in g, respectively.

Seed yield and yield component were affected by different sowing dates and decreased by postponing the sowing date. The highest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight by average of 2627 kg/ha, 124, 51.22, 72.75, 11.09, 12.32, 9.825 and 3.2 g, respectively were obtained in D_1 (early October) and the lowest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight by average of 1111 kg/ha, 66.88, 25.58, 41.3, 7.308, 8.275, 6.3 and 1.825 g, respectively were obtained in D_4 (early November) (Table 2). Most previous studies have

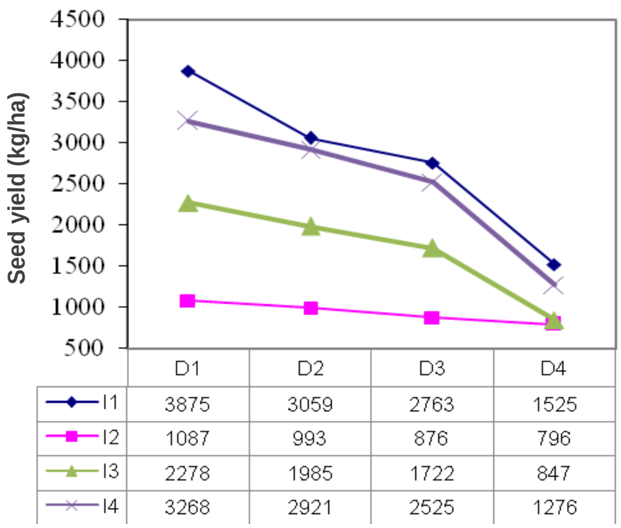


Figure 1. Interaction effect of D and I on the seed yield (kg/ha).

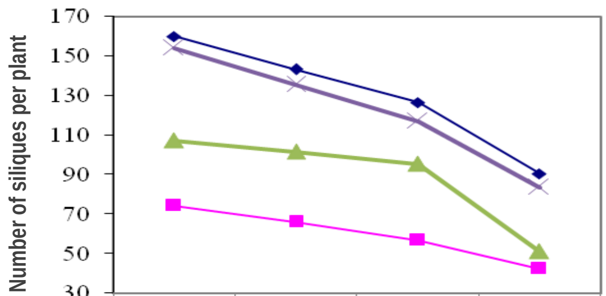
revealed that late sowing in many crops results in lower yields (Scott et al., 1973; Kondra et al., 1983; Hocking and Stapper, 2001; Oz, 2002; Ozer, 2003; Robertson et al., 2004; Uzun et al., 2009). Delay on sowing date causes flowering period falls in June when evapo-transpiration reaches high values and the crop experiences water stress (Yau, 2007). Thus, it is important for high yield that the plant should flower as early as possible. By bringing forward the date of flowering can ultimately increase seed yield (Dordas et al., 2008; Yau, 2007; Koutroubas et al., 2004). The late sowing usually causes a decline in grown leaf area and a faster maturation (Mckay and Schneiter, 1990). Stapper and Fischer (1990) reported that late sowing date resulted in a shortening of the flowering period and decreases in seed yield, yield components and harvest index. In the yield components, number of pods per plant was correlated significantly with seed yield (Ozer et al., 1999). Also, a significant correlation was observed between pod numbers per plant and seed yield in species of *B. napus* and *B. compestris* by Thurling (1974).

Also, seed yield and yield components were affected by different irrigation regimes and decreased by water stress. Water stress at flowering stage and seed filling stage had the most and less negative effects on seed yield and yield components, respectively. The highest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight by average of 2806 kg/ha, 130.1, 54.9, 75.25, 11.48, 12.73, 10.2 and 3.4 g, respectively obtained in I_1 (normal irrigation) and the lowest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per primary silique, number of seeds per secondary silique and 1000 seeds weight by average of 938 kg/ha, 59.88, 22.65, 37.22, 6.958, 7.95, 5.925 and 1.65 g, respectively obtained in I_2 (interruption of irrigation from flowering stage) (Table 2). Water stress at flowering stage significantly decreases these traits which show that the flowering stage is the most sensitive stage to water stress. Plants respond to drought by closing their stomata, which reduces leaf transpiration and prevents the development of excessive water deficits in their tissues. The drawback of the stomatal closure for plants is that their carbon gain is lowered and their growth is impaired. Seed yield potential of *Brassica* crops depend on the events occurring prior to and during the flowering stage, while the reproductive period is the most susceptible stage (Mendham and Salisbury, 1995). The most pronounced effects of water stress are observed when water shortage occurs during the flowering or pod filling stages (Richards and Thurling, 1978). Gammelvind et al. (1996) reported that water deficient in late vegetative and early reproductive growth stages reduces photosynthetic rate in leaves and yield (Gammelvind et al., 1996). Water stress decrease seed yield mainly by decrease of number of silique per plant (Kafi Ghasemi and Isfahani, 2006).

The study of the interaction effects of D × I on seed yield and yield components revealed that the highest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per secondary silique and 1000 seeds weight by average of 3875 kg/h, 160.1, 68.4, 91.7, 13.03, 11.7 and 4.1 g, respectively were obtained in D_1I_1, although the difference among D_1I_1 and D_1I_4 in production of the highest rate of number of siliques on secondary branches and 1000 seeds weight was negligible. The lowest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per secondary silique and 1000 seeds weight by average of 796 kg/ha, 42.4, 15.1, 27.3, 5.167, 4.1 and 1.3 g, respectively were obtained in D_4I_2, although the difference among D_4I_3, D_3I_2 and D_4I_2 in production of the lowest rate of seed yield was negligible (Figures 1 to 7). In all sowing dates, the lowest means were obtained by water stress at flowering stage. Postponing the sowing date in all irrigation regimes decreases assessed traits, so planting as early as possible could prominently decrease the water stress effect.

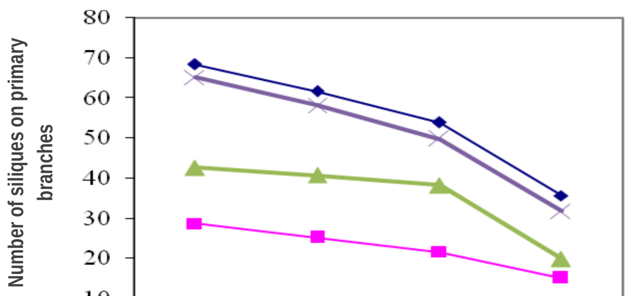
Conclusions

Choosing the most appropriate sowing date is one of the key points in crop management to optimizing productivity. This study provides new information about the effect of different sowing dates on yield and yield components of



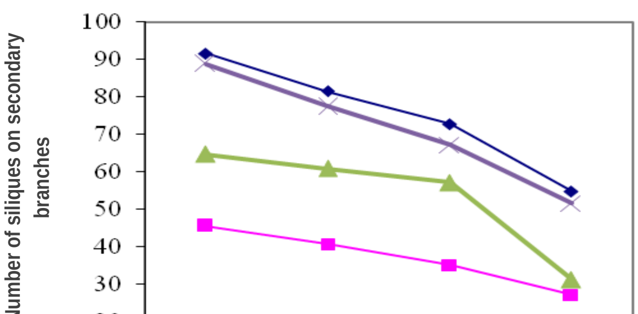
	D1	D2	D3	D4
I1	160.1	143.3	126.7	90.5
I2	74.3	66	56.8	42.4
I3	107.4	101.6	95.4	51.1
I4	154.1	135.7	117.1	83.5

Figure 2. Interaction effect of D and I on the number of siliques per plant.



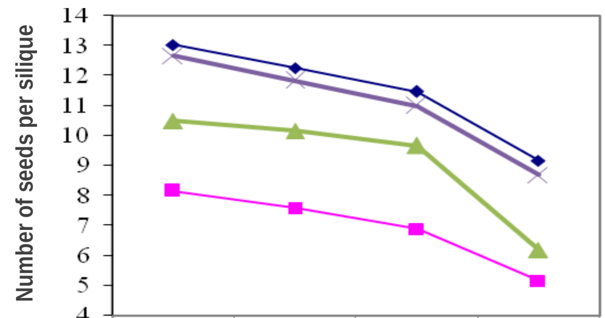
	D1	D2	D3	D4
I1	68.4	61.7	53.9	35.6
I2	28.7	25.2	21.6	15.1
I3	42.6	40.7	38.2	19.8
I4	65.2	58.2	49.8	31.8

Figure 3. Interaction effect of D and I on the number of siliques on primary branch.



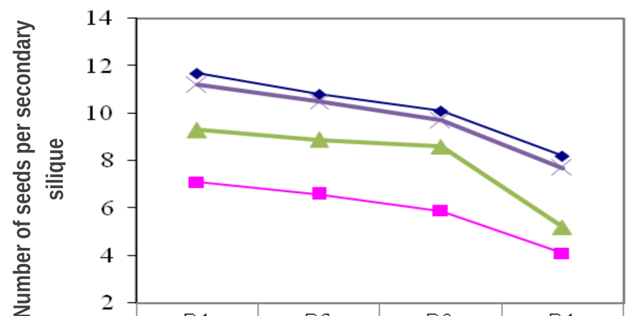
	D1	D2	D3	D4
I1	91.7	81.6	72.8	54.9
I2	45.6	40.8	35.2	27.3
I3	64.8	60.9	57.2	31.3
I4	88.9	77.5	67.3	51.7

Figure 4. Interaction effect of D and I on the number of siliques on secondary branches.



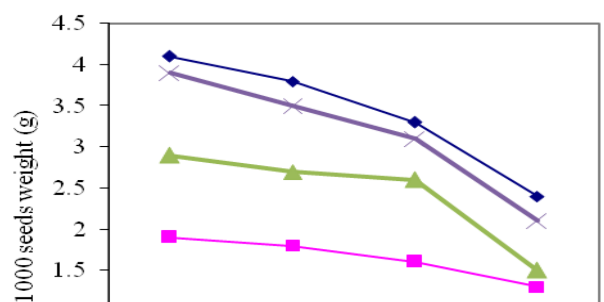
	D1	D2	D3	D4
I1	13.03	12.27	11.47	9.167
I2	8.167	7.6	6.9	5.167
I3	10.5	10.17	9.667	6.2
I4	12.67	11.83	11	8.7

Figure 5. Interaction effect of D and I on the number of seeds per silique.



	D1	D2	D3	D4
I1	11.7	10.8	10.1	8.2
I2	7.1	6.6	5.9	4.1
I3	9.3	8.9	8.6	5.2
I4	11.2	10.5	9.7	7.7

Figure 6. Interaction effect of D and I on the number of seeds per secondary silique.



	D1	D2	D3	D4
I1	4.1	3.8	3.3	2.4
I2	1.9	1.8	1.6	1.3
I3	2.9	2.7	2.6	1.5
I4	3.9	3.5	3.1	2.1

Figure 7. Interaction effect of D and I on 1000 seeds weight.

turnip rape (*B. campestris* L.-cv. Goldrush) under different irrigation regimes. Since water stress condition occur ubiquitously during the growing season of many plants and could have a profound negative effect on crop productivity, choosing the most appropriate sowing date considering the probability of water stress occurrence could modify the water stress effect, and since postponing the sowing date in all irrigation regimes, specially flowering stage decreased assessed traits in our study, so planting as early as possible is recommended.

Our results showed the highest seed yield, number of siliques per plant, number of siliques on primary branch, number of siliques on secondary branches, number of seeds per silique, number of seeds per secondary silique and 1000 seeds weight by average of 3875 kg/ha, 160.1, 68.4, 91.7, 13.03, 11.7 and 4.1 g, respectively obtained in D_1I_1.

REFERENCES

Azizi M, Soltani A, Khavari Khorasani S (1998). Rapeseed- Physiology, Agronomy, Plant Breeding and Biotechnology. Jahad-e Daneshgahi of Mashhad Press, pp. 33-39.

Bonyadi Bala Deh T (2000). Rapeseed *Brassica napus* Cultivation. Ministry of Agriculture, Agricultural Jihad Organization of Guilan Province, Iran. pp. 54-58.

Chaves MM, Maroco JP, Pereira JS (2003). Understanding plant responses to drought from genes to the whole plant. Funct. Plant Biol., 30: 239–264.

Dordas CA, Lithourgidis AS, Matsi TH, Barbayiannis N (2008). Application of liquid cattle manure and inorganic fertilizers affect dry matter, nitrogen accumulation, and partitioning in maize. Nutr. Cycl. Agroecosys, 80: 283–296.

Downey RK (1990). Brassica oil seed reading achievements and opportunities. Plant Breed Abst., 60: 1165-1169.

Gammelvind LH, Schjoerring JK, Mogensen VO, Jenson CR, Bock JGH (1996). Photosynthesis in leaves and siliques of winter oilseed rape (*Brassica napus* L.), Plant Soil, 186: 227-236.

Hall AE (1992). Breeding for heat tolerance. Plant Breed. Rev., 10: 129-168.

Hamdy A, Ragab R, Scarascia-Mugnozza E (2003). Coping with water scarcity, water saving and increasing water productivity. Irrig. Drain, 52: 3–20.

Hedge IC (1976). A systematic and geographical survey of the word Cruciferae, Academic Press, New York, pp. 1-45.

Hocking PJ, Stapper M (2001). Effect of sowing time and nitrogen fertilizer on canola and wheat, and nitrogen fertilizer on Indian mustard, Dry matter production, grain yield, and yield components, Aust. J. Agric. Res., 52: 623-634.

Kafi Ghasemi A, Isfahani M (2006). Study of Time and Rate of Nitrogen fertilizer Application Effect on Yield and Yield Components of Rapeseed. J. Agric. Sci. Ind., 20(7): 63-72.

Kondra ZP, Campell DC, King JR (1983). Temperature effects on germination of rapeseed (*Brassica napus* L. and *Brassica campestris* L.). Can. J. Plant Sci., 63: 1063-1065.

Korte LL, Williams JH, Specht JE, Sorenson RC (1983). Irrigation of soybean genotypes during reproductive ontogeny: II. Yield component responses. Crop Sci., 23: 528-533.

Koutroubas SD, Papakosta DK, Doitsinis A (2004). Cultivar and seasonal effects on the contribution of pre-anthesis assimilates to safflower yield. Field Crop Res., 90: 263–274.

Koutroubas SD, Papakosta DK, Doitsinis A (2009). Phenotypic variation in physiological determinants of yield in spring sown safflower under Mediterranean conditions. Field Crop Res., 112: 119–204.

Mckay KR, Schneiter AA (1990). Response of spring canola and Crambe to several dates of planting (In 1990 agronomy abstracts). ASA. Madison WI. pp. 109-114.

Mendham NJ, Salisbury PA (1995). Physiology, crop development, growth and yield. Brassica Oilseeds: Production and utilization. CAB International, London. pp. 11-64.

Moselev G (1983). Variation in the epicuticular wax content of white and red clover leaves. Grass Forage Sci., 38: 201-204.

Movahhedy-Dehnavy M, Modarres-Sanavy SAM, Mokhtassi-Bidgoli A (2009). Foliar application of zinc and manganese improves seed yield and quality of safflower (*Carthamus tinctorius* L.) grown under water deficit stress, Ind. Crops Prod., 30: 82–92.

Munns R (2002). Comparative physiology of salt and water stress, Plant Cell Environ., 25: 239–250.

Nuttall WF, Ukrulentz H, Stewart JWB, Spurr DT (1987). The effect of nitrogen, sulphur and boron on yield and quality of rapeseed. Can. J. Soil Sci., pp. 545-559.

Oz M (2002). The effect of different sowing time on the yield and yield components in winter rapeseed varieties under Bursa, Mustafakemalpaşa Conditions. Uludag Universitesi Ziraat Fakultesi Dergisi 16: 1-13.

Ozer H (2003). Sowing data and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. Euro. J. Agron., 19: 453-463.

Ozer H, Oral E, Dogru U (1999). Relationships between yield and yield components on currently improved spring rapeseed cultivars. Turkish. J. Agric. For., 23: 603–607.

Pandey BP, Sirvastava SK, Lal RS (1981). Genotype and environment interaction in lentil. LENS, 8: 14-17.

Richards RA, Thurling N (1978). Variation between and within species of rapeseed (*B. campestris* and *B. napus*) in response to drought stress. I. Sensitivity at different stages of development. Aust. J. Agric. Res., 29: 469-477.

Robertson MJ, Holland JF (2004). Production risk of canola in the semiarid subtropics of Australia. Aust. J. Agric. Res., 55: 525-538.

Robertson MJ, Holland JF, Bambach R (2004). Response of canola and Indian mustard to sowing date in the grain belt of north-eastern Australia. Australian J. Exp. Agric., 44: 43-52.

Scott RK, Ogunremi EA, Ivins JD, Mendham NJ (1973). The effect of sowing data and season on growth and yield of oilseed rape (*Brassica napus* L.). J. Agric. Sci., 81: 277-285.

Stapper M, Fischer RA (1990). Sowing date and planting spacing influence on high-yielding irrigated wheat in southern New South Wales. I. Phasic development, canopy growth and spike production. Aust. J. Agric. Res., 41: 997-1019.

Stoker R, Carter KE (1984), Effect of irrigation and nitrogen on yield and quality of oilseed rape, N. Z. J. Exp. Agric., 12: 219-224.

Thurling N (1974). Morphophysilogical determinates of yield in rapeseed (*Brassica compestris* & *Brassica napus*). II. Yield components. Austr. J. Agric. Res., 25: 711–721.

Tuncturk M, Ciftci W (2004). Relationships among traits using correlation and path coefficient analysis in safflower (*Carthamus tinctorius* L.) sowed different fertilization levels and row spacing. Asian J. Plant Sci., 3(6): 683-686.

Uzun B, Zengin U, Furat S, Akdesir O (2009). Sowing date effects on growth, flowering, seed yield and oil content of canola cultivars. Asian J. Chem., 21: 1957-1965.

Weiss EA (1983). Oilseed Crops, Longman Inc., New York.

Yau SK (2007). Winter versus spring sowing of rain-fed safflower in a semi-arid, high-elevation Mediterranean environment. Eur. J. Agron., 26: 249–256.