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SOME PHYSIOLOGICAL AND MORPHOLOGICAL RESPONSES OF CANOLA VARIETIES (*BRASSICA NAPUS* L.) TO DIFFERENT AMOUNTS AND INTERVALS BETWEEN IRRIGATIONS

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ABSTRACT

Drought is considered as one of the most important limiting factors for oil seed canola plant (*Brassica napus* L.) growth and productivity in Iran. This study was carried out in farm of the university of Tehran - Iran, to examine the effect of different irrigation levels (6, 8 and 10 days intervals irrigations) on growth and yield of two varieties of canola (RGS003, option500) for plant height, lateral branch number, Silique length, Seed oil content (SOC), Oil percentage, Oil yield, number of silique/plant, Biological yield (BY), and Grain yield (GY), 1000-seeds weight, silique infertility ratio in plant in 2007/8. The design was split plots arranged in randomised complete block with four replications. Net irrigation depth, irrigation gaps and the amount of irrigation water at every turn which was given to the ground were calculated by using related equations. The results of this experiment indicate that the highest seed yield, biological yield, oil yield, total silique number, plant height, lateral branch number, silique length was produced in RGS003 cultivar and 6 days irrigation interval. The highest 1000-seeds weight, harvest index, oil percentage and grain number plant, was produced in Option500 cultivar and 6 days irrigation interval. Also highest silique infertility ratio in plant was produced in Option500 cultivar and 10 irrigation interval.

Key words: *Canola*, irrigation levels, silique, seed yield, oil yield.

INTRODUCTION

Canola is the third most important source of plant oil in the world after soybean (*Glycine max* (L.) Merr.) and palm oil (*Elaeis guineensis* L.) (Reyes, 2007). Rapeseed is an important oilseed crop in the agricultural systems of many arid and semiarid areas where its yield is often restricted by water deficit and high temperatures during the reproductive growth. Seed yield can be primarily limited even by the relatively short period of soil moisture shortage during the reproductive development. The effect of drought stress is a function of genotype, intensity and during of stress, weather, conditions, growth and developmental stages of rap seed (Roberson and Holland, 2004). The occurrence time is more important than the water stress intensity (Korte, 1983). It is known that the most sensitive growth stages to water stress are seed filling in bean (*Phaseolus vulgaris* L.) (Nielsen and Nelson, 1998), heading and flowering in wheat (*Triticum aestivum* L.) (Muostafa, 1996), seed filling in soybean (*Glycine max* L.) (Breyedan and Eagli, 2003), flowering and seed filling in peas (*Cicer arientinum* L.) (Singh, 1991), 2-3 weeks after silking in maize (*Zea mays* L.) (Lilley and Fukai, 1994). Other researchers like Angadi et al. (2003), Mailer and Cornish (1987) and Walton and Bowden (1997), also reported that during their experiments the post anthesis duration was the most sensitive stage. Maliwal et al. (1998) and Patel (1999) have reported reduced yield in *Brassicas* in response to water stress. By decreasing the irrigation gap time, the weight of the seeds increased (Pazoki, 2001). Increasing the planted area of oil seed crops is an indication of the success of plant breeders and agronomists in developing suitable cultivars

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and production methods in semi arid regions (Rahnema and Bakhshande, 2006). It is necessary to develop varieties which can tolerate water stress to increase planted area and yield of the oilseed crops. The present study was proposed to achieve these goals and to identify the varieties of canola which can withstand drought spells and also to estimate correlation among different traits. The information derived from the study will be helpful in Canola breeding for drought tolerance and early selection of genotypes with the desirable traits to be used in the breeding programs.

MATERIAL AND METHODS

A field experiment was carried out at the agronomic research area University of Tehran during winter and spring seasons 2008/9. Soil in the test area was silty loam and organic matter content of approximately 0.9%. Saturated paste extract Electrical Conductivity (EC) of this soil was 1.39 Ds^{-1} with $CaCO_3$ equivalent of 2% and pH of 7.3. The experimental design was a randomised complete block in a split-plot arrangement with four replications. Canola varieties were taken as main plots and irrigation interval treatments were kept in subplots. Treatments were: Canola varieties (RGS003, Option500) and 6, 8 and 10 days intervals irrigation. Soil moisture (water content) was measured directly by the gravimetric method. The soil was sampled with a core sampler on day before irrigation, weighing the moist soil, then drying it in an oven (105°C) and then weighing the dry soil. Amount of required water was calculated on the basis of difference between moisture content before irrigation (Eq1):

Equation (1): TAD= MAD (FC- PWC)Dr
where:

TAD = Total Allowable Depletion (mm);
MAD = Management Allowed Deficit;
FC = Field Capacity;
PWC = Permanent Wilting Point;
Dr = Rooting depth (m).

Water used by plants is usually expressed as mm water per m soil depth. The interval between the irrigations i.e. the number of days between two consecutive irrigations was computed using the following equation:

Equation (2): Ti = TAD/ETcp;

Ti = interval between two irrigations, days; ETcp = plant water requirements during the peak (maximum), mm per day.

Soil moisture measurement: for soil moisture measurement, weight method was used. In this method, 30 cm depth soil sample taken with a drill, and after weighing, the wet samples were dried for 24 hours in the oven to 105 degrees Celsius. After drying and weighing the amount of moisture of this soil sample was obtained by using the following equations:

Equation (3): $\Theta_m = w_1\text{-}w_2/w_2$;

Equation (4): $\Theta = \Theta_m P_b$;

Θm = mass of moisture, Θ = percent volumetric moisture, Pb = soil bulk density (g/cm^3).

Soil bulk density was calculated by using equation 5:

Equation (5): pb = ms/v.

The amount of irrigation water at every turn depends on soil moisture before watering and on the depth of root development. It was calculated using equation 6:

Equation (6): IRRI = Dr(FC-Θ)A/Ei

Θ = volumetric moisture content before irrigation; FC = volume percent moisture level of field capacity; Dr = depth development of roots (cm); Ei = irrigation efficiency, A = plot area; IRRI = the amount of water that should be given to the ground in each irrigation (cm).

All data obtained were analysed using the statistical software SAS-contrast analysis of variance and means were compared by Duncan multiple range test levels.

RESULTS AND DISCUSSION

Plant height and number of branches per plant

Plant height and number of branches of canola varied significantly due to different irrigation treatments. The maximum plant height and number of branches were recorded with RGS003 variety in level 6 days interval between irrigations and minimum plant height and number of branches were obtained with

Option500 variety in level 10 days interval between irrigations (Tables 1, 2).

Number of silique per plant

Number of silique is an important factor for increasing yield. Different irrigation levels had a significant effect on number of silique per plant (Tables 1, 2). The maximum number of silique and number of seeds per silique were obtained with RGS003 variety in level 6 days interval irrigation and the minimum number of silique per plant were recorded with Option500 variety in level 6 day interval between irrigations**.** These results most probably reflect the fact that flowering and primary development of silique are critical stages for irrigation in canola. So, if sufficient water could not be supplied in this stage the number of silique would be considerably decreased. Tribuay and Reynard (1999) studies showed that drought produced a significant decrease in the number of silique in canola. Shirani Rad and Daneshian (2006) showed that drought stress at flowering stage considerably reduced the number of silique in the bush. Most probably shortage of photosynthetic substances during the water stress causes a reduction of silique sizes (Rao and Mendham, 1991). In general, an increase in number of irrigations produced a linear increase in number of silique per plant and number of seeds per silique.

Silique length

Silique length showed significant differences due to different irrigation levels. The maximum Silique length was recorded with RGS003 varieties in level 6 days interval between irrigations and the minimum biological yield was recorded with Option500 variety in level 10 days interval between irrigations (Tables 1, 2**)**.

Table 1. Effect of irrigation intervals and canola varieties on plant height and number of branches per plant, plant silique number, silique length per plant, 1000-seeds weight, seed yield, oil percentage, oil yield, silique infertility ratio, and biological yield (BY)

Source of variations	Degree of freedom	Plant height	Number of branches / plant	The plant silique numbers	Silique length	1000-seeds weight	Seed yield	Oil percentage	Oil yield	Silique infertility ratio	Biological yield (BY)
Repetition	3	20	0.86	231.434	0.57	0.074	222620	39.718	27858.10	64.37	12424.4
Variety	1	957*	0.03	51.979	2.24**	0.591*	480251*	51.773	19582.96	12.53	15571926**
Error a	3	85.2	2.12	1950.16	0.77	0.065	101097**	7.781	7885.09	246.93	921137
Water stress	2	1091**	8.28*	12225.56**	1.39**	0.947**	777871**	85.418*	95313.52**	1239.87	8417785**
Linear	1	2146**	15.6*	22024.42**	2.69**	1.565**	1242110**	124.601**	142173.67**	2465**	16623967**
Second	1	36	0.96	4226.71	0.09	0.333**	313633	46.236	48453.380	14.74 **	211603
Variety × Water stress	2	75	0.76	2837.87	199*	0.180*	31338	33.503	5813.19	206.71*	3247
Error b	12	142	2.23	1814.11	0.25	0.082	62136	19.132	5921.28	72.59	860763
CV %	-	15.83	25.1	16.12	9.41	11.40	21.41	16.26	25.35	21.12	26.12

1000-seed weight

Effect of different irrigation levels on 1000-seed weight was significant. The maximum 1000-seed weight was recorded with Option500 variety in level 6 days interval irrigation**.** Saffari (2006) as well as Khani and his colleagues (2005) mentioned in their reports that water stress reduces the seed weight significantly, which is in accordance with the results of our study (Tables 1, 2). The reasons for weight reduction of the seeds during stress is are the decreased water and minerals absorption, producing a reduction of production and transfer of photosynthetic substances and assimilate sap to the seeds. The minimum 1000-seed weight was recorded in RGS003 variety in level 8 day irrigation. The 1000-seed weight increased significantly with each increase in irrigation number.

Seed yield

Seed yield showed significant differences due to different irrigation levels. The maximum seed yield was recorded with RGS003 varieties in level 6 days interval between irrigations. Since formation and development of silique in canola bush essentially require water, water stress at these stages has a negative effect upon absorption of assimilates.

These results are in accordance with reports of Tahmasebi Sarvestani et al. (2003) Further, Niknam et al. (2003) reported that water stress after pollination stage would considerably reduce seed yield. The minimum yield was recorded when only one irrigation was applied in Option500 variety in level 10 days irrigation (Tables 1, 2).

Seed oil yield

Oil yield is the result of seed yield multiplied by seed oil percentage. Seed oil yield was not affected significantly by differences between varieties, but showed significant differences between different irrigation levels (Tables 1, 2).

The maximum seed oil yield was recorded with RGS003 variety in level 6 days interval irrigation. Reduction of oil yield with higher irrigation gaps is a result of seeds weight reduction.

Seed oil percentage

Seed oil percentage was not affected significantly by varieties. The maximum seed oil percentage was recorded with Option500 variety in level 6 days interval between irrigation. Some researches mentioned that reduction of seed filling time which occurs due to water stress or a high temperature within this period, would lead to reduced oil accumulation in the seed (Tables 1, 2).

Biological yield (BY)

BY was significantly influenced by the treatments. The maximum biological yield was obtained with RGS003 variety in level 6 days interval irrigation and the minimum biological yield was recorded with Option500 variety in level 10 days interval between irrigation (Tables 1, 2).

Table 2. Average plant height, number of branches per plant, plant silique number, silique infertility ratio, biological yield (BY) , seed yield, 1000-seeds weight, oil percentage, oil yield, silique length in two cnola cultivars at different irrigation levels

Variety	Intervals between irrigations (days)	Plant height	Number of branches per plant	The plant silique number	Silique infertility ratio	Biological yield (BY)	Seed yield	1000-seeds weight	Oil percentage	Oil yield	Silique length
OPTION500	6	75.8 bc	6.85 a	127.54ab	98.62 a	3758.3 bc	977.3ab	3.23 a	34.78 a	342.98ab	5.13ab
	8	71.53bc	5.9 a	105.79ab	93.38 a	2529.5 cd	559.8bc	2.47 b	26.17 b	180.24c	5.16 ab
	10	58.4 c	4.75 a	64.25 b	69.17 d	1748.3 d	411.1c	2.31 b	28.43ab	127.38 c	4.47 b
RGS003	6	95.4 a	7.0a	162.21 a	97.69 ab	5381.5 a	1323.3a	2.59b	34.63 a	399.96a	6 a
	8	81.75 ab	5.13a	67.10 b	81.49bcd	4173.8 ab	698.5bc	2.23 b	32.76 a	183.53c	5.46 ab
	10	66.48 bc	5.15a	77.10 b	77.52 cd	3314.3 cd	775.1bc	2.55 b	30.08ab	248.39bc	5 b

Silique infertility ratio

The maximum silique infertility ratio was obtained with Option500 variety in level 10 days interval between irrigations and the minimum infertility ratio was recorded with Option500 variety in level 6 days irrigation (Tables 1, 2).

CONCLUSIONS

Like in many parts of the world, in Iran drought is the main factor limiting agricultural activities. In this study we observed that highest grain yield, biological yield, oil yield, plant height, number of branches per plant in cultivar RGS003 irrigated once every six days. Maximum grain weight and oil content were obtained in cultivar Option500, irrigated once every six days. In general we can say that supplying the irrigation water every six days is necessary to achieve maximum yield.

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