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The Effects of Water Deficit During Growth Stages of Canola (*Brassica napus L.*)

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Abstract: Drought Stress is on of the major problems affecting canola crop production in arid and semi arid regions of the world. This study was carried out in farm of the department of Agronomy in Karaj Iran, 3 Line/cultivars of canola differed in drought tolerance were evaluated in field experiments for Water Use Efficiency Grain Yield (WUEGY), Seed Oil Content (SOC) , Protein Content (PC), Harvest Index (HI), Biological Yield (BY) and Grain Yield (GY) with adequate water and under drought stress in Karaj. The results show that the effects of water stress on WUEGY , SOC, PC, HI, BY and GY was statistically significant ($P<0.01$), whereas, the highest of WUEGY were in Ebonit (0.99 kg m^{-3}) and Elite and SLM046 (0.94 kg m^{-3}). In normal Irrigation the highest WUE were in Ebonit and Elite (0.67 kg m^{-3}) and SLM046 were measured (0.66 kg m^{-3}). Oil Content were highly significant, the Maximum seed oil content (Ebonit, 50.44 %) were obtained and Minimum seed oil content (SLM046, 49.54%) obtained at normal Irrigation. In the stress condition Maximum seed oil content (Ebonit, 47.99%) were obtained. Grain yield reduction by water stress during stress period , the highest HI value at normal Irrigation (Ebonit, 36.01%), HI decreased by water deficit, the lowest of HI value at cut of Irrigation (Elite, 12.2%). Maximum value of Biological yield (1105 g m^{-2}) in Ebonit were obtained and lowest of Grain yield (Elite, 88 g m^{-2}) were obtained, Seed Oil Content ? Harvest Index, Biological Yield and Grain Yield was decreased by water deficit but WUEGY and protein content increased.

Key words: *Brassica napus L* · Water deficit · WUEGY · SOC · BY · GY · HI

INTRODUCTION

Water stress is the most important limitation to canola productivity in semi-arid regions of the world. Therefore the development of canola cultivars that use available water more efficiency and that are able to tolerance drought prone environments. The world is facing serious shortages of fresh water and growing competition for clear water makes less water available for agriculture. the great challenge for the coming decades will be the task of increasing food production with less water, particularly in countries with limited water and land resources. While on a global scale water resources are still ample, serious water shortages are developing in the arid and semi arid regions, as existing water resources are fully exploited. The situation is exacerbated by the declining quality of water and soil resources. Dependency on water for future development has became a critical constraint for development, which threatens to slow down development, endanger food supplies and aggravate rural poverty. Sustainable food production will depend on the judicious use of water resources to meet future food demands and to address the growing competition for clean water. Water productivity in terms of out put per unit of food per m3 of water used needs to be increased in both irrigated and rain fed agriculture substantially: in short: more crop per drop [1]. It is known that on of essential nutrients in human consumption oil or fat is applied from the plant and animal source. Oil seed crops are grown throughout of Iran for use as oils [2]. The increasing area of oil seed crop

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production is an indication of the success of plant breeders and agronomist in developing suitable cultivars and production methods in semi arid region [3]. The lack of oil in Iran has been met by imports that have entailed considerable costs. to make up for the lack of oil in Iran, oil seed production can be increased by growing oil plants in dry land farming or area with deficit water. According to annual precipitation many regions in Iran suffer from water deficit. Canola is one of the best crops for rotation with wheat. High temperature during maturation and ripening is a major source of stress in karaj environments. without sufficient water to maintion transpiration, leaf temperature can rise above their optimum for metabolism [4]. There fore, plants under low water availability are more prone to heat stress, too. Seed yield of *Brassica napus* [5-6], *B.juncea and B.rapa* [7-9]. Decreased due to drought stress. The effect of drought stress is a function of genotype, intensity and duration of stress, weather, conditions, growth and developmental stages of rape seed [10]. The occurrence time is more important than the water stress intensity [11]. It is known that the most sensitive growth stage to drought stress is seed filling in been (*phaseolus vulgarisa* L.) [12], heading and flowering in wheat (*Triticum aestivam* L.) [13], seed filling in soybean (*Glycine max* L.) [14], flowering and seed filling in pea (*Cicer arientinum* L.) [15], 2-3weeks after silking in maize (*zea mays* L.) [16] flowering and anthesis in rice (*Oryza sativa* L.) [17]. other researchers like Angadi *et al.* [18], miler and crnish [19] and Walton and Bowden [20], also reported that during their experiments the post anthesis duration was. Significantly correlated with the post anthesis rainfall and was negatively correlated with the main daily temperature during seed development.

Plants are developmentally and physiologically designed by evolution to reduce water use (WU) under drought stress. Since plant production is a function of WU the issue for the breeder is how to reduce WU under stress, while minimizing the associated reduction in production [21]. Water use efficiency is often equated in a simplistic manner with drought resistance without considering the fact that it is a ratio between 2 physiological(transpiration and photosynthesis) or agronomic(yield and crop water use) [21] For high yield, an adequate water supply is required during the total growing period. The period at the beginning of the flowering stage is most sensitive to water shortage, while maximum yield were obtained with full irrigation, almost the maximum yield generally were obtained when irrigation was made to provide adequate water during flowering and fruit formation periods [21].Water use and biomass were reduced by the stress treatment[21] .

Rahnama *et al.*, [3] reported that the highest rate of yield reduction was occurred by spring irrigation cut off and one spring irrigation treatments in PF which was the late maturity variety. Also the lowest rate of yield reduction were obtained in spring irrigation cut off and one spring irrigation treatments in H308 hybrid respectively. Gunasekera *et al.*, [22] reported that rainfall and thus soil moisture are the most important factors affecting crop production in the typical Mediterranean environment. Seed yield is primarily limited by the relatively short duration of soil moisture during the latter phases of reproductive development. Genotypes having great, tolerance to water stress, in addition to earliness, generally would have positive effect on improving adaptability and seed yield in such environments. Nielsen [23] reported that water stress during the grain-filling stage resulted in a more rapid loss of leaf area than during other growth stages. Lower yield resulted from fewer branches per plant, pods per branch and smaller seed. Sim *et al.*, [24] observed that Canola yield in Montana increased with higher availability of water, but had a lower mean oil content. Miller and Cornish [19] determines that oil content fell from 36.9 to 31.4% when high temperature occurred during the post anthesis seed development in Canola. Final seed number and seed yield reduction was approved by high temperature effect during reproductive and ripening growth stages. Under dry land conditions, Henry and Macdonald [25] reported that severe drought decreased oil and increased protein content of rape seed. Thompson [26] observed little effect of water stress on seed protein content in soybean. Whereas Hobbs [27] reported that drought stress increased protein content. The occurrence time and intensity of drought differ annually in field. Thus, its very important to determine critical stages of oil seed rape crops against drought stress. The growth especially reproductive growth of rape seed is exposed to drought stress in many areas of Iran. for the Iran with high temperature and the shortage of water during stem elongation, flowering and ripening stages still we need to introduce new varieties to farmers which could more adapted to this environment and also to identify the best optimum Irrigation level for this region. According to sustainable agriculture and attention of agriculture economy which caused to raise economic yield, water use efficiency and agronomic characteristic it is very important. Therefore, the aim of this study was to find out the best canola cultivars for Iran region and effects of water stress on some physiological analysis of the growth characteristic of canola.

Table1:Climatic data of experimental farm of karaj in 2004-5 (in growth period) *,**

Year and month	Rainfall (mm)	Min temp (°C)	Average temp (°C)	Max temp (°C)	Evapotranspiration (%)2004-5
September	3.00	19.80	28.65	37.50	111.70
October	3.50	17.10	25.65	34.20	91.20
November	19.70	14.30	20.40	26.50	80.00
December	95.30	9.00	13.35	17.70	67.10
January	115.60	5.10	9.60	14.10	56.80
February	29.10	5.00	9.75	14.50	61.30
March	13.30	10.10	18.40	26.70	107.10
April	9.40	15.70	22.00	28.30	139.20
May	0.00	26.70	32.75	38.80	361.40*

Taken from the recording of irrigation department in agricultural & natural resource faculty . ** (Data recording):meteorological data were collected 300m from the experiment site. Maximum and minimum temperature, rainfall and class A pan evaporation data for the experimental period

Table 2: Result of some chemical and physical analysis of experimental soil*

Depth (cm)	Potassium (ppm)	Phosphor (ppm)	Nitrogen (%)	Organic matter (%)	EC (mmos/cm)	PH	FC	PWP
0-30	171	3.8	0.05	0.49	1.2	7.86	18.75	6.33
30-60	179	2.8	0.04	0.29	2.19	7.67	17.91	6.36

* Soil analysis was done at the laboratories of soil science department in Karaj

Table 3: Different Lines/Cultivars of (*Brassica napus L.*) used for this study and growth type

S.No	Lines/Cultivars	Growth Type
1	Ebonit	Winter
2	Elite	Winter
3	SLM046	Winter

MATERIALS AND METHODS

This study was carried out at the experimental farm of the department of agronomy in Karaj Iran 2004-5. The climatic data of the region are representing in (Table1). The soil has clay has loam texture and low organic matter (Table 2). The experiments were laid out in RCBD design with split plot arrangement with four replications applying water stress to main plots and canola cultivars (Table 3) of application to sub-plots.

Water stress free (i.e. normal irrigation treatment as control), skipping irrigation in growth stage (during stem elongation in spring)were as main-plot and 3 winter canola lines/cultivars were as sub-plot (Table 3). Individual plots consisted of 8 rows ,4m long and spaced 30 cm apart. Seeds were planted 1 to 1.5 cm deep at a rate of 100 seeds m^{-2}on 25 September . For all treatments, N:P:K fertilizers applied at rates of 150:60:50 kg ha^{-1}, respectively. P,K and one-third of N were applied per plant and incorporated. Other two-third of N was split equally at the beginning of the stem elongation and flowering. Weeds were controlled by application of gallant super (Haloxyfop-r methyl ester) at 0.61 ha^{-1} broad leaf weeds were also hand weeded during the season. A furrow irrigation system was applied in irrigation treatments, input and run off water was measured by W.S.C flume in this experiment. It was supposed that plots received equal water for each experiment. In the control treatment was irrigation with the adequate water until the plants harvested. Moisture content of the soil was measured using a Troxler instrument, model sentry 2000 (TDR). Days to maturity were counted from the date of sowing to the date when the colour of the pods turned from green to yellow in each subplot. Final harvests were carried out at the 30 may. Data collected included acheine yield (obtained by combining the six center rows at each experimental unit), dry matter was determined after drying at 70°C for at least 48 h in an air oven. Seed oil and protein content were determined by the Nuclear Magnetic Resonance (NMR)and the Kjeldahl (protein= 6.25*N) methods respectively.

Water use efficiency was computed as follow: WUEGY=grain yield (kg)/water applied (m^3) Where WUE is water use efficiency in a kg m^{-3} , yield of grain (kg)and water applied is amount of water that used and rain during growth processes (m^3) [1]. The experimental data were statistically analyzed for variance using the SAS system [28]. When analysis of variance showed significant treatments effects, Duncan Multiple Range Test was applied to compare the means at (P<0.05).

RESULTS AND DISCUSSION

Water Use Efficiency of Grain Yield (kg m^{-3}): WUEGY were significantly influenced by the treatments. The maximum of main effects obtained in Ebonit (0.83 kg m^{-3}) and minimum obtained in SLM046 (0.80 kg m^{-3}), respectively (Table 4). The highest amount interaction effects of canola cultivars and water stress in Ebonit, Elite (0.67 kg m^{-3}) with non significant different and lowest in SLM046 (0.66 kg m^{-3}) of WUE of Grain yield were obtained in normal irrigation treatment, respectively (Table 5). and the maximum amount interaction effects of canola and skipping irrigation in Ebonit (0.99 kg m^{-3}) respectively and the minimum in SLM046 (0.94 kg m^{-3}) of WUE of Grain Yield were obtained in cut of irrigation treatment, respectively (Table 5). WUE is often equated in a simplistic manner with drought resistance without considering the fact that it is a ratio between 2 physiological (transpiration and photosynthesis) or agronomic (yield and crop water use) entities [21]. Indiscriminant selection for higher WUE with the assumption that it equates with improving drought resistance or improving yield under stress might bring about serious negative consequences [21]. High is largely a function of reduced water use rather than a net improvement in plant production or biochemistry of assimilation. Therefore, in selection programs it may constitute a marker for reducing water use commonly achieved via moderated growth, reduced leaf area and short growth duration. Khozaei and Feizi [29] reported effect of salinity stress on biological yield, grain yield, WUE of biological yield of WUE of grain yield were more significant. While, the greatest amount of mentioned characters were in salinity 4 dSm^{-1} and lowest amount of them declined significantly with the raising salinity in 12 dSm^{-1} and shows the augmented of brakish water caused decreased significantly in amount of WUE of yield in wheat plant.

Protein Content (%): PC were influenced significantly by the treatments. The effects on canola protein content was statically significant (p<0.01), the maximum of main effects obtained in Elite (21%) and minimum obtained in Ebonit (19%), respectively (Table 4). The highest amount intraction effects of canola cultivars in Elite (21.9%) were obtained and the lowest in Ebonit (18%) of protein content were obtained in normal irrigation, respectively (Table 5). Treatment and percentage of protein content in range of 18-21.9% were obtained. Protein content increasing by water deficit increased, because the lowest of PC in Ebonit (18%) were obtained (Table 5). Macdonald [25] reported that severe drought decreased oil and increased protein content of rape seed. Whereas Hobbs [27] reported that drought stress increased protein content.

Harvest Index (%): Hi were influenced significantly by the treatments. The maximum of main effects obtained in

Table 4: Seed oil content, water use efficiency grain yield, protein content, harvest index, biological yield and grain yield of 3 lines/cultivars in the field experiment*

Treatments	Seed Oil Content (%)	WUE Grain^{-3}	Protein Content (%)	HI (%)	BY (g m^{-2})	GY (g m^{-2})
Ebonit	49.21a	0.83a	19c	32a	881a	285a
Elite	48.56b	0.805b	21a	23b	869b	203b
SLM046	48.2c	0.80b	20.2b	23b	850c	200b

* Mean followed by the same letter(s) in each column are not significantly different (Duncan 5%)

Table 5: Mean comparison of Seed Oil Content, grain yield water use efficiency ,protein content , harvest index , biological yield and grain yield in normal and water stress treatment, canola cultivars in the field experiment *

	Seed Oil Content (%)		WUE Grain Yield (kg m^{-3})		Protein Content (%)		HI (%)		BY (g m^{-2})		GY (g m^{-2})	
Treatments	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
Ebonit	50.44a	47.99a	0.67a	0.99a	18c	20c	36.01a	26.17a	1105a	657c	398a	172a
Elite	49.76b	47.36b	0.67a	0.94b	20.1a	21.9a	31.26b	12.2c	1017b	721a	318b	88c
SLM046	49.54c	47.005c	0.66b	0.94b	19.6b	20.8b	30.23b	13.89b	1002c	698b	303c	97b

* Mean followed by the same letter(s) in each column are not significantly different (Duncan 5%)

Ebonit (32%) and minimum obtained in Elite and SLM046 (23%) with non significant different (Table 4). The highest amount interaction effects of canola cultivars in Ebonit (36.01%) were obtained and the lowest in SLM046 (30.23%) of HI were obtained in normal irrigation, respectively (Table 5). Treatment and percentage of HI in range 12.2-36.01 were obtained. The lowest of HI in Elite (12.2%) were obtained in drought stress treatment (Table 5).

Seed Oil Content (%): SOC were influenced significantly by the treatments. The effect on canola seed oil was statically significant ($P<0.01$), the maximum of main effects obtained in Ebonit (49.21%) and the minimum obtained in SLM046 (48.2%), respectively (Table 4). The highest amount interaction effects of canola cultivars in Ebonit (50.44%) were obtained. For Iran with high temperature and shortage of water during ripening and maturation stages still we need to introduce new high oil content varieties to farmers which could more adapted to this environment, therefore selection or breeding of genotype with high seeds per silique and high oil content seems better under water deficit conditions. The lowest in SLM046 (49.54%) of SOC were obtained in normal irrigation, respectively (Table 5). Treatment and percentage of oil content in range of (47.005-50.44%) were obtained (Table 5). Smis *et al.* observed that canola yield in Montana increased with higher availability of water, but had a lower mean oil content [24].

Biological Yield (g m^{-2}): BY were influenced significantly by the treatments. The effects on biological yield was statically significant ($P<0.01$). The maximum of main effects obtained in Ebonit (881 g m^{-2}) and minimum obtained in SLM046 (850 g m^{-2}) respectively (Table 4). The highest amount interaction effects of canola cultivars in Ebonit (1105 g m^{-2}) were obtained and the lowest in SLM046 (1002 g m^{-2}) of BY were obtained in normal irrigation, respectively (Table 5). Treatments and percentage of biological yield in range of (657-1105 g m^{-2}) were obtained in this study ,BY was decreased by water stress increased, Because the lowest of BY in Ebonit (657 g m^{-2}) were obtained (Table 5).

Grain Yield (g m^{-2}): GY were significantly influenced by the treatments. The maximum of main effects obtained in Ebonit (285 g m^{-2}) and minimum obtained in SLM046 (200 g m^{-2}), respectively (Table 4). The lowest amount interaction effects of canola cultivars in Elite (88 g m^{-2}) in water stress treatment and the highest amount obtained in Ebonit (398 g m^{-2}) in normal irrigation. In canola, mendham *et al.* [30] have argued that canola breeders should be aiming to produce plants with fewer pods but with a higher potential number of seeds per pod as this maximizes seeds survival and hence increases seed number per unit area. A similar Ideotype has been suggested for both canola and mustard ,Wright *et al.* [31] observed an decrease in HI following water stress.

CONCLUSIONS

Based on all the physiological attributes measured in this study, it can be concluded that the canola lines differing in water tolerance showed a differing response to stress with respect to physiological and analysis of the growth characteristics. The growth of basil is very sensitive water stress, because it has shown striking negative reaction in water stress treatment The objective of this study was to test the hypothesis that although annual precipitation in Iran has variation in period, time and content but to decrease the oil seed import to Iran is this possible that use the new region with water deficit. Also could be produced oil seed by canola in this area.

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