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Study of Physiological Traits and Analysis of the Growth in Canola (*Brassica napus L.*) Under Water Deficit Conditions

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Abstract: Drought stress is one of the major problems affecting canola crop production in arid and semi arid regions of the world. In this study, 34 line/cultivars of canola differed in drought tolerance were evaluated in field experiments for Water Use Efficiency (WUE), Seed Oil Content (SOC), Leaf Area Index (LAI), Crop Growth Rate (CGR) and Net Assimilation Rate (NAR) with adequate water and under drought stress in karaj in 2005-06. The results show that the effects of water stress on WUE, SOC, LAI, CGR and NAR was statistically significant ($p<0.01$),whereas, the highest of WUE were in Dexter (1 kg m^{-3}) and Ebonite and Sahara (0.99 kg m^{-3}) in skipping of irrigation treatment and Fredric (0.56 kg m^{-3}) had lowest. In normal irrigation the highest WUE were in Ebonite, Elit, Talent, RN3304, N.K-Bilbao and Modena (0.67 kg m^{-3}), Talaye and Vectra with non significant different were measured (0.42 kg m^{-3}). Oil content were highly significant. The maximum seed oil content (Sunday, 51.11%) were obtained, Because in the particulars of Sunday genotype the reason and minimum seed oil content (Herkules 42.41%) obtained at normal irrigation. Skipping irrigation during stem elongation stage resulted in the maximum seed oil content (Sunday 49.05%). The highest LAI value at normal irrigation (opera, 4.99), LAI decreased by water deficit, the lowest of LAI value at cut of irrigation (Dante, 3.41). Maximum value of CGR (13.83 gm^{-2} day^{-1}) resulted in normal irrigation to the G.K.Olivia the optimum LAI and CGR of canola plantation for the area in the study year was 4.605 and 9.55 (g m^{-2} day^{-1}) which obtained. The maximum value of NAR resulted in at normal irrigation in G.K. Olivia 2.581 g m^{-2} day^{-1}, respectively. This observations indicated that drought tolerance is still very complex and canola agronomist and breeders need more efficient techniques, under either dry or wet environments, to improve physiological traits in this crop.

Key words: Canola Cultivars · Water stress · Seed oil content · WUE · LAI · CGR · NAR

INTRODUCTION

Dwindling water resources and growing competition for water will reduce water availability for Irrigation, while the need to meet growing food demands will require that more food is grown with less water. A more effective water use and greater water productivity will be a primary challenge for the near future. Sustainable food production will depend on the judicious use of water resources to meat future food demands and to address the growing competition for clean water. Water productivity in terms of out put per unit of food per unit of food per m^3 of water used needs to be increased in both irrigated and rain fed agriculture substantially: in short: “more crop per drop” [1]. Drought, salinity, heat and freezing are environmental condition that cause adverse effects on the growth of plants. Water deficit more than order stresses limits the growth and the productivity of crops [2]. Drought stress is one of the important limiting factors of plant growth that has limited the production of 25% of world lands [3]. While a lot of intensive and comprehensive researches are done on the relationship between the water stress and land productions, the behavior of plants have n’t been studied well in such cricumstances [4]. Fats and oils are essential components of human diet. Most vegetable oils are edible and have been used in food preparation to make it more palatable and nutritious. Vegetable oils are preferred over the solid animal fats because of health benefits [5]. Rape seed or mustard seed was grown about 300 BC in Indus valley as fodder crop, its oil use started in fifteenth century [6]. Up to the second word war (1945) the oil was used as lubricant and lamp oil [7]. Rape seed is the third most important vegetable oil in the world, after soybean and palm oil [8]. Extraction of seed oil is high,

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with average oil content of 42% and a protein content of approximately 21% [9]. Oil seed crops are grown throughout of Iran for use as oils [10]. The increasing area of oil seed crop production is an indication of the success of plant breeders and agronomist in developing suitable cultivars and production methods in semi arid region [11]. 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 crops in dry land farming or area with water deficit [10]. According to annual precipitation many regions in Iran suffer from water deficit [10]. Canola is one of the best crops for rotation with wheat [10]. High temperature during maturation and ripening is a major source of stress in karaj environments [12]. With out sufficient water to maintion transpiration, leaf temperature can rise above their optimum for metabolism [13]. Plants are developmentally and physiologically designed by evolution to reduce water us (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 [14]. 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 photoynthesis) or agronomic (yield and crop water use) entities [14]. 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 [15] water use and biomass were reduced by the stress treatment [14]. Water use efficiency was the same in both cultivars {semi- dwarf high- yielding cultivar (HYV)and a landrace (LR) of durum wheat} in the control and it increased under stress [14].WUE under stress was higher in the HYV than in the LR because of the relative differences in their water use and biomass [14]. Growth is often expressed on a leaf area basis, Leaf Area Index (LAI) is the ratio of the leaf area of the crop to the surface area [16]. The dry matter (DM) accumulation rate per unit of leaf area and time is defined as the Net Assimilation Rate (NAR), which is a measure of the mean photosynthetic efficiency of leaves in a crop community. Thus, when NAR is multiplied by LAI, the resulting product is CGR [17]. The oil seed yield of canola (*Brassica napus L.*) is related to certain plant characters, such as yield components as well as growth parameters [18] increasing the cell size, which is manifested morphologically in the increased leaf area index and crop growth rate [19]. In augmenting the cell division; cell- elongation besides chlorophyll synthesis [18]. These fertilizers also help in accelerating the photosynthetic activity [20] seen in the healthy green leaf number and also in dry-matter production [21]. The effects of water stress is a function of genotype, intensity and duration of stress, weather conditions, growth and developmental stage of rape seed [22]. The occurrence time is more important than the water stress intensity [23]. It is known that the most sensitive growth stage to drought stress is seed filling in been [24]. Seed filling in soybean (*Glycine max L.*) [25], flowering and seed filling in pea (*Cicer arientinum L.*) [26]. Nilesen [27] reported that water stress during the grain-filling stage resulted in a more rapid loss of leaf area than during other growth stages

Miller [11] determines that oil content fell from 36.9 to 31.4 % when high temperature occurred during the post Anthesis seed development in canola,Henry and Macdonald [28] reported that severe drought decreased oil and increased protein content of rape seed .The growth of rape seed is exposed to drought stress in many areas of 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 characteristics of canola.

MATERIALS AND METHODS

This study was carried out at the experimental farm of the department of agronomy and crop breeding faculty of agriculture and natural resources, Islamic azad university, karaj Iran 2005-06.The climatic data of the region are representing in (Table 2). The soil has clay loam texture (the values of texture components is missing in the Table 3) and low organic matter (Table3). 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 1) of application to sub-plots.

Table 1: 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	Talent	Winter
4	Olpro	Winter
5	Sinatra	Winter
6	Sahara	Winter
7	Celsius	Winter
8	Sunday	Winter
9	Modena	Winter
10	Geronimo	Winter
11	Opera	Winter
12	ARC-5	Winter
13	ARC-2	Winter
14	ARG-91004	Winter
15	Milena	Winter
16	Dexter	Winter
17	SLM046	Winter
18	Reg*Cobra	Winter
19	Okapi	Winter
20	Talaye	Winter
21	Licord	Winter
22	Herkules	Winter
23	Vectra	Winter
24	G K Helena	Winter
25	G K Olivia	Winter
26	G K Gabriela	Winter
27	Orient	Winter
28	RN 3304	Winter
29	N K Bilbao	Winter
30	ORW- 201-3001	Winter
31	ORW- 201-3002	Winter
32	RN 4504	Winter
33	Dante	Winter
34	Fredric	Winter

Two Water Treatments: 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 34 winter canola lines/cultivars were as sub-plot (Table 1). Individual plots consisted of 8 rows, 4 m 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 a 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 0.6l 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. The leaf area (only one side) was determined by estimating the leaf weight and weigh and surface of standard papers with the similar surface of the leaves [18]. Ten plants were sampled randomly in each treatments and averaged for recording the change in dry weight in shoots (above ground). The samples were first sun dried and there after in oven at 70° till a constant weight was recorded. The dry matter accumulation rate per unit of land area.

Table 2: Climatic data of experimental farm of I. A.Univ in 2005-6 (in growth period)*,**

Month	Rainfall (mm)	Min temp (°C)	Average temp (°C)	Max temp (°C)	Evapotranspiration (%)
September	11.0	17.1	26.35	35.6	119.2
October	18.9	9.60	27.30	35.0	85.5
November	25.6	12.2	20.60	29.0	75.2
December	91.4	8.1	13.10	18.1	60.2
January	136.1	6.0	9.0	12.0	55.2
February	45.1	4.8	10.40	16.0	59.0
March	10.2	14.4	20.90	27.4	111.0
April	7.2	15.0	22.0	29.0	140.2
May	1.2	30.4	35.10	39.8	389.0

* Taken from the recording of irrigation department in agricultural and natural resource faculty of Karaj Univ.,**(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 3: Result of some chemical and physical analysis of experimental soil*

Depth (cm)	Potassium (ppm)	Phosphorus (ppm)	Nitrogen (%)	Organic matter (%)	EC (mmos/cm)	PH	FC	PWP
0-30	171	3.8	0.05	0.49	1.20	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 Univ.

(Cgr) Expressed as G M^{-2} Day^{-1} and Was Calculated As: $CGR = (W_2-W_1)/\{SA\ (t_2-t_1)\}$. W1 and w2 are crop dry weight at the beginning and end of the interval t_1 and t_2 and SA is soil area occupied by the plants at each sampling.

The dry matter accumulation per unit of leaf area is termed as Net Assimilation Rate (NAR). It is expressed as g m^{-2} day^{-1} and calculated as:

NAR = 1/A. (dw/dt) here, a is the leaf area and (dw/dt) is the change in plant dry matter per unit time [29].

The seed oil content was determined by the Nuclear Magnetic Resonance (NMR) method, respectively [30].

Water Use Efficiency Was Computed as Follow:

$$WUE = \text{grain yield (kg)/water applied } (m^3)$$

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 [31]. 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

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 Sunday (50.086%) and the minimum obtained in Herkules (38.36%), respectively (Table 4). The highest amount interaction effects of canola cultivars in Sunday (51.11%) were obtained,Because in the particulars of Sunday genotype the reason,and the seed oil yield of canola is related to certain plant characters, such as yield components as well as growth parameters. 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. and the lowest in Herkules (42.4%) of SOC were obtained in normal irrigation, respectively (Table 5). Treatment and percentage of oil content in range of 37.29-51.11% were obtained in this study, SOC was decreased by water stress increased, because the lowest of SOC in Herkules (37.29%) were obtained (Table 5). Smis *et al.* observed

Table 4: Oil content and water use efficiency of some canola lines/cultivars in the field experiment*

Treatments	Oil content (%)	WUE Grain Yield (kgm-3)
Ebonit	49.21cd	0.83a
Elite	48.56e	0.805h
Talent	49.01d	0.82d
Olpro	47.24i	0.785l
Sinatra	49.25c	0.785l
Sahara	44.94l	0.807g
Celsius	47.96j	0.795j
Sunday	50.086a	0.79k
Modena	47.39hi	0.81f
Geronimo	48.58e	0.67q
Opera	47.82g	0.822c
ARC-5	47.52h	0.816e
ARC-2	47.39hi	0.76n
ARG-91004	49.27c	0.742o
Milena	49.94a	0.76n
Dexter	47.94g	0.81f
SLM046	48.27f	0.8i
Reg*Cobra	49.02d	0.758n
Okapi	46.08j	0.76n
Talaye	44.18n	0.5v
Licord	44.41m	0.525u
Herkules	38.36p	0.693p
Vectra	48.67e	0.5v
G K Helena	47.76k	0.76n
G K Olivia	46.14j	0.63r
G K Gabriela	43.17o	0.798i
Orient	44.34mn	0.79k
RN 3304	49.11cd	0.815e
N K Bilbao	49.69c	0.826b
ORW- 201-3001	47.27i	0.615s
ORW- 201-3002	44.44m	0.55t
RN 4504	49.93a	0.63r
Dante	48.23f	0.77m
Fredric	45.71k	0.485w

* Mean followed by the same letter(s) in each column are not significantly different (Duncan5%)

that canola yield in Montana increased with higher availability of water, but had a lower mean oil content [32]. Miller determines that oil content fell from 36.9 to 31.4% when high temperature occurred during the post anthesis development in canola [11]. Henry and Macdonald [28] reported that severe drought decreased oil and increased protein content of rape seed. 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 specially

Table 5: Annual mean comparison of oil content and water use efficiency in normal and water stress treatment, canola cultivars in the field experiment *

	Oil content (%)		WUE Grain Yield (kgm^{-3})	
Treatments	Normal	Stress	Normal	Stress
Ebonit	50.44b	47.99g	0.67a	0.99b
Elite	49.76de	47.36l	0.67a	0.94g
Talent	50.06bcd	47.96i	0.67a	0.97d
Olpro	50.06bcd	46.39t	0.63f	0.94g
Sinatra	50.22bc	48.28e	0.62h	0.95f
Sahara	49.03f	43.96b′	0.625g	0.99b
Celsius	49.03f	46.89p	0.65d	0.94g
Sunday	51.11a	49.05a	0.62h	0.96e
Modena	48.44hi	43.21d′	0.67a	0.95f
Geronimo	49.84cde	47.31m	0.52k	0.95f
Opera	48.86fg	46.77r	0.665b	0.98c
ARC-5	48.4hi	44.65a′	0.66c	0.97d
ARC-2	48.6hg	46.18w	0.62h	0.9i
ARG-91004	50.34b	44.86z	0.6i	0.88j
Milena	51.007a	48.88b	0.62h	0.9i
Dexter	49.01f	46.87q	0.62h	1.0a
SLM046	49.54e	47.005o	0.66c	0.94g
Reg*Cobra	50.06bcd	47.97h	0.62h	0.89i
Okapi	47.27j	44.88y	0.62h	0.9i
Talaye	49.01f	43.39c′	0.42p	0.9q
Licord	45.6lm	43.21d′	0.44o	0.89p
Herkules	42.4lm	37.29g′	0.57j	0.81k
Vectra	49.702de	47.65k	0.42p	0.75q
G K Helena	46.66k	44.86z	0.62h	0.9i
G K Olivia	47.23j	43.96b′	0.52i	0.74m
G K Gabriela	49.76de	42.07f′	0.65d	0.94f
Orient	45.48m	43.2e′	0.64e	0.94g
RN 3304	50.28b	47.94j	0.67a	0.96e
N K Bilbao	50.86a	48.52d	0.67a	0.98c
ORW- 201-3001	48.25hi	44.63a′	0.51m	0.72n
ORW- 201-3002	45.68lm	42.3e′	0.46n	0.72o
RN 4504	50.99a	48.86c	0.52i	0.74m
Dante	49.42e	43.96b′	0.63f	0.91h
Fredric	49.01f	44.63a′	0.41q	0.56r

* Mean followed by the same letter(s) in each column are not significantly different (Duncan5%)

reproductive growth of rape seed is exposed to drought stress in many areas of 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.

Water Use Efficiency of Grain Yield (Kg m^{-3}): WUE were significantly influenced by the treatments.

The maximum of main effects obtained in Ebonit (0.83 kg m^{-3}) and minimum obtained in Fredric (0.485 kg m^{-3}), respectively (Table 4). The highest amount interaction effects of canola cultivars and water stress in Ebonit, Elite, Talent, RN3304, N.K.Bilbao and Modena (0.67 kg m^{-3}) with non significant different and lowest in Fredric (0.41 kg m^{-3}) of WUE of Grain yield were obtained in normal irrigation treatment, respectively (Table 5). and the maximum amount interaction effects of canolaand skipping irrigation in Dexter (1 kg m^{-3}) and Ebonit and Sahara (0.99 kg m^{-3}) its secondary level, respectively and the minimum in Fredric (0.56 kg m^{-3})of WUE of Grain Yield were obtained in cut of irrigation treatment, respectively (Table 5).WUE is mostly discussed in terms of plant production rather than gas exchange. Yield under water-limited conditions can be determined by the genetic factors controlling yield potential and/or drought resistance and/or WUE [14].

Selection for yield generally did not increase total biomass but only the proportion between grain and stover within a given biomass [14].

Hybrid vigour (Hetrosis) in grain yield of sorghum is expressed by way of greater biomass production in shorter time with no effect on harvest index [33].

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 [14], who also reported water use was the same for both cultivars in the control but relatively higher in the LR than in the HYV under stress. WUE was the same in both cultivars in the control and its increased under stress. WUE under stress was higher in the HYV than in the LR because of the relative differences in their water use and biomass. Greater biomass production under stress was associated with relatively greater water use and lower WUE as seen in the LR. Dehydration avoidance as achieved by enhanced capture of soil moisture by roots has been found to be associated with low WUE in such diverse species as rice [34] and ponderosa pine[35] on the other hand, reduced transpiration in rice [34] and reduced evapotranspiration in sorghum [36]. 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 [14]. High WUE is largely a function of reduced water use rather than a net improvement in plant production or biochemistry of assimilation. Therefore, in

Table 6: Main effects of canola cultivars and water stress treatments on LAI, CGR and NAR in the field experiment *

Treatments	Leaf Area Index	CGR ($g.m^{-2}$ day^{-1})	NAR ($g\,m^{-2}$ day^{-1})
Ebonit	4.42c	6.844x	1.312a′
Elite	4.341k	7.46m	1.452m
Talent	4.37d	7.13s	1.373y
Olpro	4.31m	7.71g	1.502g
Sinatra	4.292p	7.21q	1.416q
Sahara	4.366f	7.42n	1.437o
Celsius	4.216w	6.21c′	1.251c′
Sunday	4.145a′	6.84y	1.389v
Modena	4.254t	7.77e	1.534d
Geronimo	4.357g	4.61g′	0.925g′
Opera	4.43a	7.41o	1.41r
ARC-5	4.354h	7.68i	1.488i
ARC-2	4.269r	7.82c	1.539c
ARG-91004	4.369e	7.55j	1.46l
Milena	4.299n	7.52k	1.47k
Dexter	4.293o	6.14d′	1.218d′
SLM046	4.32i	7.11t	1.157e′
Reg*Cobra	4.179z	5.7e′	1.158e′
Okapi	4.216w	7.05v′	1.409s
Talaye	4.257s	7.76f	1.53e
Licord	4.09c′	7.32p	1.494h
Herkules	4.352i	7.69h	1.487j
Vectra	4.291q	7.21q	1.419p
G K Helena	4.185y	6.86w	1.378x
G K Olivia	4.238v	7.97a	1.57a
G K Gabriela	4.351j	7.88b	1.524f
Orient	4.139a′	7.13r	1.448n
RN 3304	4.426b	7.8d	1.488i
N K Bilbao	4.251u	7.06u	1.401t
ORW- 201-3001	4.193x	6.38b′	1.288b′
ORW- 201-3002	4.05e′	7.46l	1.54b
RN 4504	4.0305f′	6.56a′	1.369z
Dante	4.02g′	6.63z	1.382w
Fredric	4.08d′	5.47f′	1.142f′

* Mean followed by the same letter(s) in each column are not significantly different (Duncan5%)

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 [37] reported effect of salinity stress on biological yield, grain yield, WUE of biological yield nad 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 brackish water caused decreased significantly in amount of WUE of yield in wheat plant.

Dagdelen *et al.* [38] reported that the highest pepper yield was obtained from full irrigation treatment, Irrigation Water Use Efficiency(IWUE) and Water Use Efficiency (WUE) were varied from 4.13-6.66 to 3.15-5.12 kg/da^{-mm}, respectively for treatment and the period most sensitive to water stress was flowering stage.

Leaf Area Index (LAI): Crop production is the practical means of trapping solar energy and converting it into food and other useable materials. Crop production strategies are usually designed to maximize light interception by achieving complete ground cover. Leaf Area Index (LAI) expresses the ratio of leaf area to the ground area occupied by the crop. LAI of 3-5 is usually necessary for maximum dry matter production of most cultivated crops. The effect of treatments intensity was significant ($P<0.01$) on the LAI analysis. The maximum of main effects obtained in Opera (4.43) and minimum obtained in Dante (4.02), respectively (Table 6). Maximum amount interaction effects of canola cultivars and water stress in Opera (4.99) and minimum amount in Dante (4.59) of LAI were obtained in normal irrigation, respectively (Fig. 1). In this study LAI was decreased by increasing water stress, because the minimum of LAI in Dante (3.411) and the maximum were obtained in Opera (3.96), respectively (Fig. 1). The rate of increase of leaf area determines the rate of increase in the photosynthetic capacity of plant. Canola plant growth is critical at the rosette stage and if it is able to produce enough leaves before rosette the plant may spend a healthy winter.

Yasari and Patawardhan [18] reported the LAI at rosette stage with a threshold value of (3.4) and the flowering stage were obtained (3.9-4.2) in water stress treatment, the optimum LAI of canola plantation (The LAI which resulted in the maximum value of CGR)was understood to be (4.26) in flowering stage was obtained.

Reduced plant size, Leaf Area Index (LAI) are a major mechanism for moderating water use and reducing injury under drought stress [14]. Often, crop cultivars bred for water-limited environments by selection for yield under stress have a constitutively reduced leaf area. Pathways for constitutive reduction in plant size and leaf area are smaller leaves, reduced tillering and early flowering. Reduced growth duration is associated with reducing leaf number [33].

Crop Growth Rate (g. M^{-2} Day^{-1}): Crop Growth Rate is the gain in weight of a community of plant on a unit of land in a unit of time and is used extensively in growth analysis of field crop. The increase in CGR with

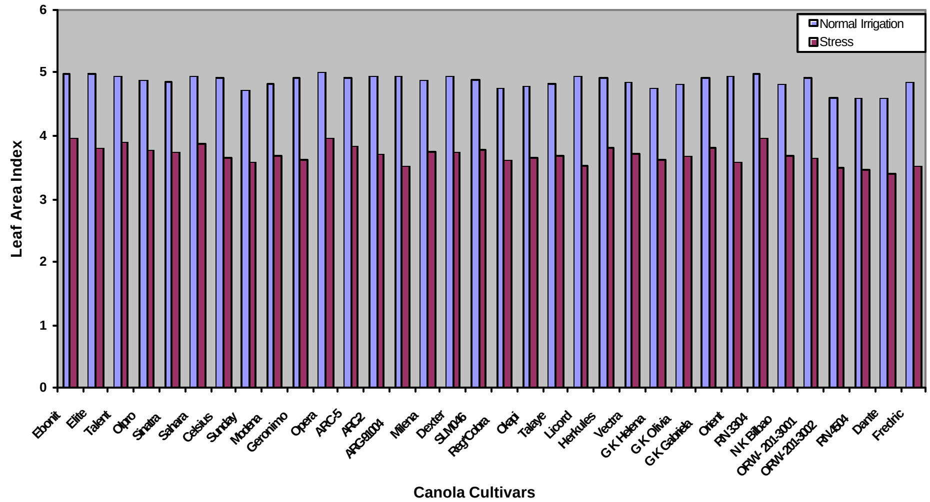

Fig. 1: Intraction Effects of Irrigation and Cultivers on Leaf Area index

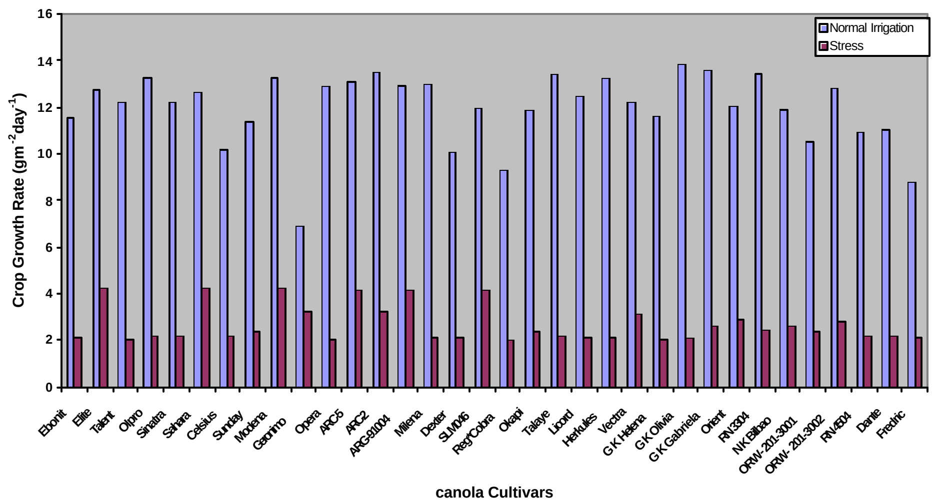

Fig. 2: Intraction Effects of Irrigation and Cultivers on Crop Growth Rate

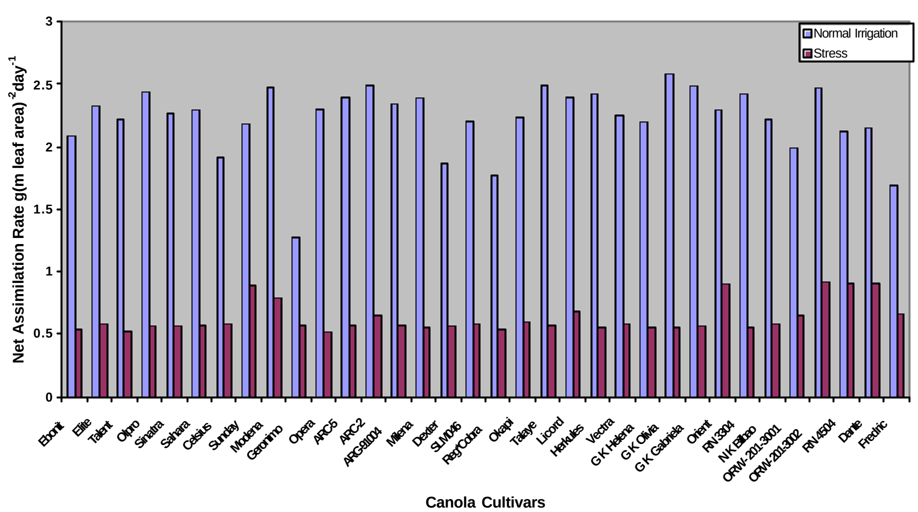

Fig. 3: Intraction Effects of Irrigation and Cultivers on Net Assimikation Rate

decreasing of water stress were obtained. The effect of treatments intensity was significant ($P<0.01$) on the CGR analysis. The maximum of main effects obtained in G.K. Olivia (7.97 $g.m^{-2}$ day^{-1}) and the minimum were obtained in Geronimo (4.61 $g.m^{-2}$ day^{-1}), respectively (Table 6). The maximum value of interaction effects of canola cultivars and water stress in G.K. Olivia (13.83 $g.m^{-2}$ day^{-1}) and minimum value obtained in Geronimo (6.9 $g.m^{-2}$ day^{-1}) in normal irrigation, respectively (Fig. 2). The minimum of CGR in Reg* Cob (2.02 $g.m^{-2}$ day^{-1}) and maximum were obtained in Elite (4.25 $g.m^{-2}$ day^{-1}) in cut of irrigation, respectively (Fig. 2). Sahara and Modena value of CGR (4.25 $g.m^{-2}$ day^{-1}) non significant statistically, respectively (Fig. 2). The decrease in Leaf Area Index and Crop Growth Rate towards maturity was due to senescence of lower leaves. Similar observation was reported by Kumar *et al.* [39]. Jain *et al.* [40] reported that Leaf Area Index and dry matter were significantly increased by providing fertilizer The increase in LAI was attributed to the increase in leaf number and total leaf area/plant. Yasari *et al.* [18] reported the maximum value of CGR resulted at flowering stage (112-133 DAS) in amount 16.313 and 15.373 ($g.m^{-2}$ day^{-1}), respectively The increase in turn, results in greater cell size and leaf area and thus in greater photosynthetic activity. The overall effect is to increase crop growth dramatically in the absence of there limiting factors and to provide in rapeseed, a large frame on which more flowers and eventually more pods can develop [6].

Net Assimilation Rate ($g.m^{-2}$ Day^{-1}): When all leaves are exposed to full sun light, NAR remain the highest. It also remains the highest when plants are small and leaves are few to get maximum sun light without shading effects. The NAR decreases with crop growth due to mutual shading of leaves and reduced photosynthetic efficiency of older leaves [41]. The effect of treatments intensity was significant ($P<0.01$) on the NAR analysis. The maximum of main effects obtained in G.K. Olivia {1.57 $g.m^{-2}$ day^{-1}} and the minimum were obtained in Geronimo {0.925 $g.m^{-2}$ day^{-1}}, respectively (Table 6). The maximum value of interaction effects of canola cultivars and water stress in G.K. Olivia {2.581 $g.m^{-2}$ day^{-1}} and the minimum value obtained in Geronimo {1.274 $g.m^{-2}$ day^{-} }in normal irrigation, respectively (Fig. 3). The minimum of NAR in Talent {0.525 $g.m^{-2}$ day^{-1}}and the maximum were obtained in orient {0.904 $g.m^{-2}$ day^{-1}} in skipping irrigation, respectively (Fig. 3). A rise in the NAR would also mean a resultant gain in photosynthesis over respiration and the reverse would be the case in case of declining NAR in the respective stages of plant growth. Yasari *et al.* [18] reported the maximum value of NAR in flowering stage (112-133DAS) obtained {3.963 $g.m^{-2}$ day^{-1}} and the maturity stage were obtained {-4.33 $g.m^{-2}$ day^{-1}}, respectively.

CONCLUSION

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 reduce water supply. Also could be produced oil seed by canola in this area. Therefore, selection or breeding of genotypes with high WUE, Seed oil content, LAI and Dry matter accumulation better under reduced water supply conditions.

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