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STUDIES ON CANOLA (*Brassica napus* L.) AND CAMELINA (*Camelina sativa* L.) UNDER DIFFERENT IRRIGATION LEVELS

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ABSTRACT

To study the performance of Canola (*Brassica napus* L.) and Camelina (*Camelina sativa* L.) under different irrigation levels, a field experiment was conducted on 20th of November 2013. The experiment was laid out in a randomized complete block design (RCBD) with split plot arrangement with four replications and a plot size of 3 m × 5 m. In experiment, growth and yield of two crops (V_1= Canola and V_2= Camelina) were compared under four different irrigation levels (T_o= Control, T_1= 3 irrigations, T_2= 2 irrigations, T_3= 1 irrigation). Both crops were sown by using hand drill with R × R distance of 30 cm. The growth parameters (Plant population, Plant height , Leaf area index, Root fresh and dry weight), yield parameters (seed yield, number of pods per plant, number of seeds per pod, pod length, biological yield and harvest index) and quality parameters (Protein contents & Oil contents) were recorded using standard procedures. The data obtained was analyzed statistically by using Fisher's analysis of variance technique at 5% probability level. The results revealed that camelina performed best in terms of growth and yield under various drought levels. Quality of camelina oil was also superior as compared to canola oil. It was concluded that camelina was more adaptive to water deficit conditions and produced more yield and high quality oil as compared to canola.

Keywords: canola, camelina, irrigation levels, oil quality.

INTRODUCTION

Edible oil is a main component of our regular food consumption. Due to increase in requirement of edible oil in order to fulfill the requirements of increasing population and deficit in local oilseed production, Pakistan has became the third leading importer of cooking oil in the world. Conventional oilseed crops are contributing up to 70 % in the local edible oil production in Pakistan while the non conventional oilseed crop contributes only 6 % (GOP, 2013). Mustard and rapeseed are main winter oilseed crops which are the main source of domestic oil seed production. Mustard and rapeseed oil is not used in our daily life as cooking oil because oil contains higher level of erusic acid and glucosinolates. The Brassica spp. contains sulphur containing compounds glucosinolates which are mainly present in their oil (Schung and Haneklaus 1988). Glucosinolates are responsible for low quality of rapeseed cake deliciousness which creates a number of dietary disorders (Vermorel *et al.*, 1986).

After soybean and palm oil, Canola is third important source of plant oil in the world (Sovero, 1997). Canola oil is superior as compared to conventional cooking oils from health point of view (Rice, 1994) as it contains lower amount of saturated fatty acids (< 7.0%), higher concentration of the unsaturated fatty acids (n-3 and n-6) and Vitamin E (Ackman,1994). Phenolic compounds are also higher in canola seed than other oilseed (Naczk, 1998).

Camelina sativa (L.) Crantz is a prehistoric oilseed crop that belongs to the family Cruciferae (Brassicacea). Camelina is also.known as Gold of Pleasure, false flax, Dutch flax, German sesame and Siberian oilseed. The origin of Camelina crop is Germany and camelina later on spread to Central Europe (Budin *et al.*, 1995). It was supposed.that the seeds of *Camelina linicola* were used along with flaxseeds and cereals.principally in the form of bread and porridge (Zubr, 1997).

Camelina has an .extraordinary fatty .acid profile, consists of relatively higher level of alpha-linolenic acid .and lower concentration of erucic acid (Zubr and Matthaus, 2002). Camelina oil can be used as a remarkable source of n-3 (omega-3) fatty acid due to its cholesterol lowering effects which are beneficial for human health (Karvonen *et al.,* 2002). Due to presence of antioxidants in the seed, the camelina oil remains satisfactory stable during storage. Compared to other spring sown oilseed crops Camelina has been observed better alternate with respect to agronomic performance (Marquard. and .Kuhlmann, 1986; Seehuber, 1984; Vollmann *et al.,* 1996 and Zubr, 1997).

As a result of increasing population, there is need to increase the food production. For this purpose higher amount of water is required but water availability for agriculture sector is decreasing day by day due to increase water requirement for domestic, industrial and power generation purposes. In future, irregular water supply and water deficiency will lead to greater chance of water shortage for agriculture productivity. To overcome this problem, a number of researches have been done on the global water deficit regimes for many food crops and bio energy crops (Kang *et al.*, 2000; Bassinger and Helman, 2006 and Okwany *et al.*, 2010).

It is a big task to cultivate winter canola in the environment of raising temperature and less moisture accessibility with the high water requirement for seed and pod filling stage (Walton *et al.*, 1999). Therefore, in arid and semi arid environment, yield and oil contents of canola are affected by environmental factors like drought and heat stress. Canola variety and soil type are other factors which had major influences on canola yield (Walton *et al.*, 1999; Jensen, *et al.*, 1996). There should be knowledge about the effect of drought stress levels to determine the water and nitrogen management options for getting optimal seed yield and oil production.

During the critical stage, there is need to apply the required amount of water by managing the appropriate scheduling of irrigation, however to get good growth and yield there is need to allow reasonable stress at vegetative and maturity stages (Al-Barrak, 2006). The accessibility of irrigation has been declined due to growing competition for water. Due to limited water supplies, inadequate irrigation system capacities, low commodity prices and high cost of irrigation pumping, the farmer apply low quantity of water than required quantity for getting higher yield (Craciun and Craciun, 1999). The aim of efficient management of irrigation water is to increase profit with minimum use of energy and water. Limited irrigation means the reduction in utilization of water while reducing bad affects on final yield (Sidhu *et al.*, 2008). Illustrating critical stages of specific cultivars under local climatic conditions and soil status provides basis for scheduling of irrigation to maximize crop yield and most judicious use of limited water resources (Mahal and Sidhu, 2006). The objective of the study was to compare growth, yield and quality components of Canola (*Brassica napus* L.) and Camelina (*Camelina sativa* L.) under different irrigation regimes.

Humaira and Rafique (2003) conducted a pot experiment to investigate the impact of drought stress on canola growth and yield. Three different irrigation intervals (two days, four days and six days interval) were used in the experiment. Results revealed that with increasing irrigation intervals, growth and yield of canola decreased. Maximum leaf area index (3.89), shoot dry weight (35.87) and root dry weight (11.81 g) was recorded in treatment with irrigation interval of two days followed by four days and minimum in six days interval. Similarly yield attributes were also reduced under drought stress as compared to control one.

Amir *et al*. (2013) conducted a field trial to investigate the effect of drought on canola. Three irrigation intervals (T_1=control, T_2= drought at flowering stage and T_3= drought at pod formation stage) were followed in the experiment. Among the growth parameters maximum number of branches per plant, stem diameter and plant height was recorded in T_1 followed by T_2 and minimum in T_3. Similarly yield attributes like number of pods per plant, pod length, number of seeds per pod, 1000 seeds weight and seed yield also showed the similar trend. Drought stress and high temperature can decrease crop productivity by disturbing both source and sink for assimilates (Mendham and Salsbury, 1995). Canola reaction against drought stress depends on the developmental stages (Mendham & Salsbury, 1995 and Angadi *et al*., 1999).

Mir Mousavi *et al*. (2006) reported that the seed oil yield and oil contents were most positively affected by seed yield in plants. In experiment of summer rapeseed, Chango and McVetty (2001) found that seed yield had a considerable association with total dry matter and harvest index. Krogman and Hobbs (1975), Henry and MacDonald (1978) and Wright *et al*. (1995) observed that early drought (at green bud stage) could lead to low oil contents in seeds as compared with the normal treatment, indicating that at early stage the final oil concentration could be correlated to distribution of assimilates to the ovule at the megaspore.

In plants, water deficit stress causes reduction in leaf chlorophyll contents (Paknejad *et al*., 2007 and Sun *et al*., 2011). Consequently, for improved yields under drought stress, high chlorophyll contents could play an important role in achieving higher production (Rao *et al*., 2012). Crop plants survive under drought conditions to some extent by the exogenous application of different organic compounds (Raza *et al*., 2012), application of different nutrients also reduce the damaging effects of drought stress on plants and improve the growth and physiological performance of plants (Raza *et al*., 2013). Plant growth regulators like salicylic acid, gibberellins, cytokinin and abscisic acid modify the plant responses towards drought stress (Farooq *et al*., 2009).

Zahedi and Tohidi Moghdam (2011) concluded that under water deficit stress, antioxidants are produced which disturbs many physiological activities of the plant. Bouchereau *et al*. (1996) stated that in rapeseed drought conditions during flowering stage resulted in accumulation of glucosinolates which decreased the yield. Drought tolerance under water deficit conditions is one of the major criteria for selection of a variety especially under arid and semi arid environment (Talebi, 2009). With increasing population, usage of water is also increase. This situation makes water a rare commodity in arid areas as well as in areas with abundant rainfall (Malano and Burton 2001).

MATERIAL AND METHODS

A field experiment was conducted to investigate the **"**Studies on Canola (*Brassica napus* L.) and Camelina (*Camelina sativa* L.) under different irrigation regimes" at Agronomic research area of University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, on 20^{th} November, 2013. The experiment was comprised of two crops (V_1= Canola, V_2= Camelina) and four irrigation levels (T_o= Control (4 irrigations),T_1= 3 irrigations, T_2= 2 irrigations, T_3= 1 irrigation) laid out in randomized complete block design with split plot arrangement having four replications, keeping crops as main plot factor and irrigation levels as sub-plot factor and a net plot size of 3 m × 5 m. Crop was sown with hand drill method maintaining keeping row

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to row distance of 30 cm. Physico-chemical analysis of the soil was carried out before sowing the crop.

Methodology for recording the treatments

Growth parameters

Leaf area was measured at a regular interval of fifteen days with the help of leaf area meter. Sampling was initiated 30 days after sowing (DAS) and terminated at the harvest of the crop. Plant height was recorded by taking ten plants from each plot and plants height was measured by using meter rod from the soil surface to the top of the plant then average height was recorded. Plant population was recorded by using meter square method. The meter square was thrown in the plots randomly. The numbers of plants in the meter square were counted and their average population was recorded. Root fresh and dry weight was recorded by selecting ten plants from each sub-plot, uprooted, roots were separated and their fresh and dry weight was recorded by using electric balance.

Yield parameters

The number of primary, secondary branches, pods per plant, seeds per pod and pod length was counted by taking 10 plants from each plot and their mean value was recorded. 1000 seed weight was recorded by taking three representative samples each of 1000 seeds from each treatment, then weighing them on electrical balance and converted to average 1000 seed weight in grams. The bundles of each plot were threshed manually and the seed obtained was weighed and then converted into kg ha^{-1}. For biological yield, after harvesting bundles were made in each sub plot and weighed with the help of a spring balance to determine the totals biomass of each plot and then converted into Kg ha^{-1}.The harvest index (HI) was calculated as the ratio of seed yield to biological yield and was expressed in % as follows:

Harvest index = seed yield / biological yield x 100

Quality parameters

Protein contents of seed are determined by CHNO analyzer. Oil contents of seeds were determined by Soxhlet Fat Extraction method (A.O.A.C., 1990).

Statistically analysis

Data was collected and analyzed statistically by using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997).

RESULTS

Data regarding plant height is shown in the table (1). Significant difference was recorded among the crops, maximum plant height was observed in canola and minimum height was observed in camelina. Among the irrigation levels, maximum plant height was observed in T_o where 4 irrigations were applied. Minimum plant height was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum plant height was observed in T_oV_1(4 irrigation in Canola) and minimum plant height in T_3V_2 (1 irrigation in Camelina).

Significant difference was recorded among the crops, maximum plant population was observed in camelina and minimum population was observed in canola. Among the irrigation levels, maximum plant population was observed in T_o where 4 irrigations were applied. Minimum plant population was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum plant population was observed in T_oV_2 (4 irrigation in Camelina) and minimum plant population in T_3V_1 (1 irrigation in Canola).

Data regarding leaf area index is shown in the fig. no. 1. Significant difference was recorded among the crops, maximum leaf area index was observed in canola and minimum leaf area index was observed in camelina. Among the irrigation levels, maximum leaf area index was observed in T_o where 4 irrigations were applied. Minimum leaf area index was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum leaf area index was observed in T_oV_1(4 irrigation in Canola) and minimum leaf area index in T_3V_2 (1 irrigation in Camelina).

Data regarding root fresh and dry weight is shown in the fig. no. 2, 3. Significant difference was recorded among the crops, maximum root fresh and dry weight was observed in canola and minimum root fresh and dry weight was observed in camelina. Among the irrigation levels, maximum root fresh and dry weight was observed in T_o where 4 irrigations were applied. Minimum root fresh and dry weight was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum root fresh and dry weight was observed in T_oV_1(4 irrigation in Canola) and minimum root fresh and dry weight in T_3V_2 (1 irrigation in Camelina).

Data regarding number of primary, secondary branches and number of pods per plant is shown in the table no. 2. Significant difference was recorded among the crops, maximum primary, secondary branches and number of pods per plant was observed in camelina and minimum primary, secondary branches and number of pods per plant was observed in canola. Among the irrigation levels, maximum primary, secondary branches and number of pods per plant was observed in T_o where 4 irrigations were applied. Minimum primary, secondary branches and number of pods per plant was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum primary, secondary branches and number of pods per plant was observed in T_oV_2(4 irrigation in Camelina) and minimum primary, secondary branches and number of pods per plant in T_3V_1 (1 irrigation in Canola).

Significant difference was recorded among the crops, maximum number of seeds per pod and length of pod was observed in canola and minimum height was observed in camelina. Among the irrigation levels, maximum number of seeds per pod and length of pod was observed in T_o where 4 irrigations were applied. Minimum number of seeds per pod and length of pod was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum number of seeds per pod and length of pod was observed in T_oV_1(4 irrigation in Canola) and minimum number of seeds per pod and length of pod in T_3V_2 (1 irrigation in Camelina).

Data regarding 1000 seed weight is shown in the table no. 3. Significant difference was recorded among the crops, maximum 1000 seed weight was observed in canola and minimum 1000 seed weight was observed in camelina. Among the irrigation levels, maximum 1000 seed weight was observed in T_o where 4 irrigations were applied. Minimum 1000 seed weight was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum 1000 seed weight was observed in T_oV_1(4 irrigation in Canola) and minimum 1000 seed weight in T_3V_2 (1 irrigation in Camelina).

Significant difference was recorded among the crops, maximum biological yield, harvest index and final seed yield was observed in camelina and minimum biological yield, harvest index and final seed yield was observed in canola. Among the irrigation levels, maximum biological yield, harvest index and final seed yield was observed in T_o where 4 irrigations were applied. Minimum final seed yield, biological yield and harvest index was observed in T_3 (only a single irrigation was applied). Among the interaction, maximum biological yield, harvest index and final seed yield was observed in T_oV_2 (4 irrigation in Camelina) and minimum final seed yield, biological yield and harvest index in T_3V_1 (1 irrigation in Canola).

Significant difference was recorded among the crops, maximum final protein contents were observed in camelina and minimum protein contents were observed in canola. Among the irrigation levels, maximum protein contents were observed in T_o where 4 irrigations were applied. Minimum protein contents were observed in T_3 (only a single irrigation was applied). Among the interaction, maximum protein contents were observed in T_oV_2(4 irrigation in Camelina) and minimum protein contents observed were in T_3V_1 (1 irrigation in Canola).

Significant difference were recorded among the crops, maximum oil contents were observed in canola and minimum oil contents were observed in camelina. Among the irrigation levels, maximum oil contents were observed in T_o where 4 irrigations were applied. Minimum oil contents were observed in T_3 (only a single irrigation was applied). Among the interaction, maximum oil contents were observed in T_oV_1(4 irrigation in Canola) and minimum oil contents were observed in T_3V_2 (1 irrigation in Camelina).

DISCUSSION

Plant height is considered as an important growth parameter, related to crop yield. With increasing plant height, number of nodes also increases which results in more number of primary and secondary branches and ultimately higher yield (Rathore *et al.,* 1990). For both crops T_o showed more plant height than all other treatments. However more height was recorded in canola as compared to camelina. Less plant height under low irrigated treatments was due to loss of turgidity of plant cells, less cell division and cell elongation. These results were supported by the findings of Mesbah (2009).

Leaf area index and crop growth rate are important yield determining parameters (Levit, 1980). Decrease in leaf area and crop growth rate under drought conditions was due to fluctuation in leaf area adjustment process. Maximum value of leaf area index and crop growth rate was recorded in canola as compared to camelina for all irrigation levels. Similar results were reported by Condon *et al.* (2002).

Root growth is very important regarding crop growth and yield. Roots absorb water and nutrients from the soil and supply it to rest of the plant. Root growth is also badly affected by drought stress (Ali and Komatsu, 2006). Drought stress reduced root dry weight in both crops but more reduction was observed in camelina. These results are in line with Ghoulam *et al.* (2001) they reported has that drought stress marked effect on root growth.

Number of pods per plant is direct measure of yield of canola crop. More the number of pods, more the yield per hectare can be harvested which is the desired goal. Each seed contributes towards the final yield. Greater number of seeds per pod resulted in better crop yield. Pod length is also an important parameter that determines the yield of the crop. Vigor of seed is represented by its weight. Seed weight not only presents the vigor but also contribute towards the final seed yield. More number of pods per plant was recorded in camelina as compared to canola. Greater the number of seeds per pod, length of pod and 1000 seed weight was observed in canola as compared to camelina. These results are supported by Wrigth *et al.,* (1995), Rathore and Patel (1990), Sinaki *et al*. (2007) and pandy *et al.* (2001).

Seed yield is the most important parameter which is use to estimated the total productivity. Many studies revealed that drought affect yield by disturbing leaf photosynthesis and plant water relations, biological yield, seed yield. Biological yield of a plant is determined by a combination of factors like plant height, number of branches, number of pods and weight of seeds etc. Harvest Index is ability of a plant to convert biomass into economic yield (Mutegi, 2009) and reflects the partitioning efficiency of assimilates towards economically important organs (Okogbenin *et al.*, 2003). Biological yield, harvest index and higher seed yield was observed in camelina as compared to canola. These results are in line with Ma *et al.* (2006), Gunasekara *et al.* (2006) and Turk *et al.* (1980).

Seed protein is an important parameter that determines the quality of the seed. Better percentage of protein in the seed is an indicator of good quality seed. Camelina shows better seed protein as compared to canola. These results are supported by Lazcano and Lowatt (1999).

To get the higher oil content is the main purpose for which oil seeds crop are raised. Better oil percentage is also desirable in this experiment. Canola shows higher oil contents as compared to camelina. These results are in line with Rahnema and Bakhshandeh (2006) they reported that oil contents decreased under drought stress.

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CONCLUSION

On the basis of results camelina performed best in terms of both growth and yield under full and deficit irrigation levels. Protein contents and quality of camelina oil was also higher as compared to canola oil. It was concluded that camelina is more adaptive to water deficit conditions and produced more yield and high quality oil as compared to canola.

Table-1. Effect of irrigation levels on growth parameters of Canola and Camelina.

Treatments	**Plant height** (cm)	**Plant population** (m^{-2})
Crops		
V_1(Canola)	127.97 A	184.94 B
V_2(Camelina)	118.06 B	209.94 A
Irrigation levels		
T_o(Control)	139.13 A	216.00 A
T_1(3 irrigations)	128.38 B	204.38 B
T_2(2 irrigations)	117.75 C	190.63 C
T_3(1 irrigation)	106.81 D	178.75 D
Interactions		
T_oV_1 (4 irrigations in Canola)	144.00 a	202.75 c
T_oV_2 (4 irrigations in Camelina)	134.25 b	229.25 a
T_1V_1 (3 irrigations in Canola)	133.75 b	190.25 d
T_1V_2 (3 irrigations in Camelina)	123.00 c	218.50 b
T_2V_1 (2 irrigations in Canola)	122.50 c	178.00 e
T_2V_2 (2 irrigations in Camelina)	113.00 d	203.25 c
T_3V_1 (1 irrigation in Canola)	111.63 d	168.75 f
T_3V_2 (1 irrigation in Camelina)	102.00 e	188.75 d

Table-2. Effect of irrigation levels on yield parameters of Canola and Camelina.

Treatments	**Number of primary branches**	**Number of secondary braches**	**Number of pods per plant**	**Number of seeds per pod**	**Length of pod** (cm)
Crops					
V_1(Canola)	6.87 B	3.50 B	220.56 B	16.62 A	6.0 A
V_2(Camelina)	17.31 A	8.00 A	634.50 A	12.12 B	2.2 B
Irrigation levels					
T_o(control)	16.25 A	8.75 A	500.25 A	18.87 A	5.2 A
T_1(3 irrigations)	13.00 B	6.50 B	458.50 B	14.87 B	4.5 B
T_2(2 irrigations)	10.75 C	4.62 C	400.13 C	12.62 C	3.8 C
T_3(1 irrigation)	8.37 D	3.12 D	351.25 D	11.12 D	3.1 D
Interactions					
T_oV_1 *	9.50 e	5.50 cd	241.50 e	20.50 a	7.6 a
T_oV_2	23.00 a	12.00 a	759.00 a	17.25 bc	2.7 e
T_1V_1	7.25 f	3.75 e	228.75 f	17.50 b	6.7 b
T_1V_2	18.75 b	9.25 b	688.25 b	12.25 d	2.4 f
T_2V_1	6.00 g	2.75 e	213.25 g	15.25 c	5.5 c
T_2V_2	15.50 c	6.50 c	587.00 c	10.00 e	2.1 g
T_3V_1	4.75 h	2.00 f	198.75 h	13.25 d	4.4 d
T_3V_2	12.00 d	4.25 de	503.75 d	9.00 f	1.7 h

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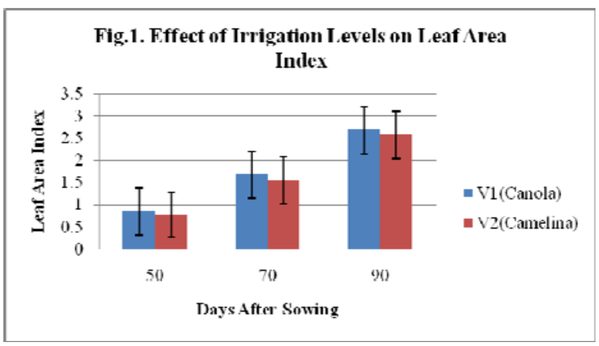
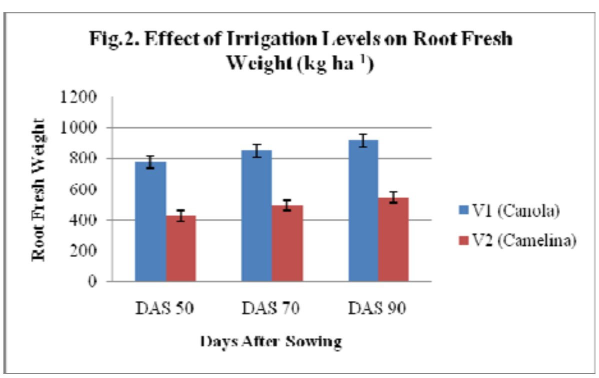
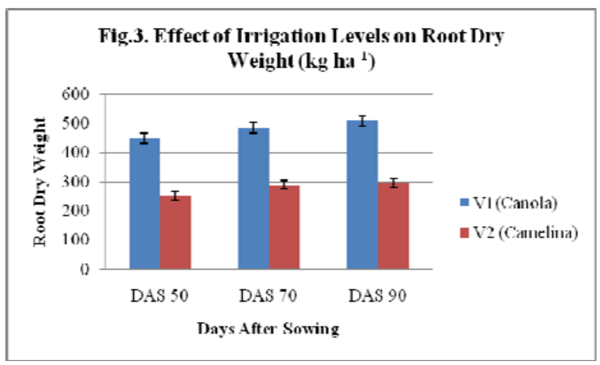
Table-3. Effect of irrigation levels on yield and quality parameters of Canola and Camelina.

Treatments	1000 Seed weight (g)	Final Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Protein contents (%)	Oil contents (%)
Crops						
V_1(Canola)	3.5 A	2306.9 B	6419.4 B	35.9 B	19.35 B	33.46 A
V_2(Camelina)	1.5 B	4230.6 A	9546.6 A	44.1 A	32.88 A	30.90 B
Irrigation levels						
T_o(Control)	2.8 A	3542.5 A	8433.3 A	41.1 A	30.36 A	35.98 A
T_1(3 irrigations)	2.6 B	3381.3 B	8205.5 B	40.5 B	28.16 B	33.81 B
T_2(2 irrigations)	2.4 C	3173.8 C	7844.1 C	39.6 C	24.77 C	31.01 C
T_3(1 irrigation)	2.1 D	2977.5 D	7449.3 D	38.8 D	21.17 D	27.93 D
Interactions						
T_oV_1*	3.8 a	2550.0 e	6918.3 e	36.7 e	22.50 e	37.50 a
T_oV_2	1.8 e	4535.0 a	9948.3 a	45.5 a	38.22 a	34.47 b
T_1V_1	3.6 b	2430.0 f	6683.8 f	36.5 e	20.97 f	35.12 b
T_1V_2	1.6 f	4332.5 b	9727.3 b	44.5 b	35.35 b	32.50 c
T_2V_1	3.3 c	2232.5 g	6262.0 g	35.6 f	18.55 g	32.55 c
T_2V_2	1.4 g	4115.0 c	9426.3 c	43.6 c	31.00 c	29.47 d
T_3V_1	3.1 d	2015.0 h	5813.8 h	34.6 g	15.40 h	28.70 d
T_3V_2	1.2 h	3940.0 d	9084.8 d	43.0 d	26.95 d	27.17 e

*T_oV_1 = (4 irrigations in Canola), T_oV_2= (4 irrigations in Camelina), T_1V_1= (3 irrigations in Canola), T_1V_2= (3 irrigations in Camelina), T_2V_1= (2 irrigations in Canola), T_2V_2= (2 irrigations in Camelina), T_3V_1= (1 irrigation in Canola), T_3V_2= (1 irrigation in Camelina)







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