Productivity and Water Use Efficiency of Two Canola Genotypes Under Different Irrigation Systems, Fertigation Levels and Sowing Space in New Vally

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Abstract:

In order to increase productivity in Egypt, we must be cultivate oil crops outside the Nile Valley to conduct the strategic goal to minimizing the gab between oil production and its consumption. The field experiments were conducted in a sandy loam soil at Experimental Farm of the Agricultural Research Station, New valley Governorate during the winter seasons of 2011/2012 and 2012/2013. The objective of this investigates was aimed to study the productivity of two canola genotypes under modern irrigation and fertigation systems which preferable as a new techniques in the newly reclaimed soils. The relationship among plant, soil and water are presented in the form of consumptive water (CU) and the water use efficiency (WUE) of two canola genotypes, fertigation levels and plant spacing under sprinkler and drip compared with surface irrigation systems. Results revealed that tallest plants, No of primary racemes/plant, No of siliquas/plant, seed index and consequently seed yield/plant (gm) were obtained under drip irrigation system compared with the other irrigation systems. Planting Serw 6 genotype under fertigation rate of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively with 10 cm sowing space and one plant in hill must be recommended. The results indicated that highest water use efficiency (WUE) was obtained from sown Serow 6 genotype compared with the other genotypes. Drip irrigation system proved to be the best in decreasing consumptive use (CU) and consequently increased water use efficiency (WUE) compared to either sprinkler or surface irrigation systems.

It could be recommended that soun of Canola Serow 6 genotype in hills 10 cm between in rows 20 cm abart one fertigation using 60, 30 and 36 g N,P_2O_5 and K_2O, respectively during drip irrigation to maximize Canola productivity and increase water use efficiency under of soil condition of New Vally governorate.

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Introduction:

Oil is consider as one of principal food commodities related to Egyptian economic because the vast gab between locally oil production which reached 117 thousand ton and the consumption which reached 1.23 million to annually in season 2011 F.A.O. (2011). This gab is improved from outside and consequently represented big problem related to the country balance especially the foreign coins which reached 500 thousand $. Moreover, the agriculture soil which represented the old soils of the valley is less than 4% of total area in Egypt. These soil was grown with strategic crops such as cotton and wheat etc. while more than 96% of Egypt total area are desert soils. New soils are available for cultivation especially by Canola crop which grown successfully in the newly reclaimed soils when fertilization and irrigation problems will be solve. Drip irrigation system in desert improved plant height when compared with sprinkler one (Ali, 1999 and Ahmed, 2001). Highest irrigation frequency increased number of primary branches/plant, number of siliquas/plant and seed yield. (Patel, 1999). Ahmed (2001) found that earliness of sunflower wasn't affected significantly by irrigation systems, i.e. drip, sprinkler and surface. Moreover, the drip irrigation system in desert land was favoured to seed index and oil yield compared with sprinkler one. El-Saidi *et al.* (1992) reported that seed oil content was increased with decreasing of water depletion. Patel (1999) and Quyyum *et al.* (1999) reported that application of nitrogen up to 120 kg/ha increased plant height. Regarding nitrogen fertilize N, Hassan & El-Hakeem (1996) reported that increasing N fertilizer rate up to 90 kg/ha increased height of 1st raceme significantly. Bali *et al.* (2000) stated that increasing P ratio up to 30 kg/ha increased this trait. Sharief and Keshta (2000) found that number of days to 50% flowering was increased significantly by increasing N ferilizer rate from 25 to 75 kg N/fed. Cheema *et al.* (2001) showed that number of siliquas/plant, 1000-seed weight and seed yield/ha were increased by increasing N and P fertilizer up to 90 and 60 kg/ha of N and P, respectively. A significant increase in seed yield per plant was obtained when N applied at rate of 75 kgN/fed. as demonstrated by Sharief and Keshta (2000). Brennan *et al.* (2000) concluded that increasing of N fertilizer decreased seed oil content significantly. Canola yield and nutrient uptake are highly dependent on N fertility and peak seed yields occur with 120 to 180 kg/ha (Jackson, 2000). Many researchers indicated that oil content of oilseed rape declined with increasing rate of N fertilizer that had positive effect on crude protein (R athke *et al* . , 2005) , but Brennan *et al.*, (2000) reported that high N rate did not always affect oil content. The effect of water stress on crop is a function of genotype, intensity and duration of stress, weather conditions and developmental stages of rapeseed (Robertson, *et al.*, 2004). Seed yield potential of *Brassica* crops depends on the events occurring prior to and during flowering stage, while the reproductive period is most susceptible to stress (Mendham *et al.*, 1995). Masoud Sinaki *et al.*, 2007) found that highest rapeseed yield reduction was obtained when water stress occurred at flowering and then at pod developmental stages. Moreover, seed yield reduction by short term water stresses during stem elongation, flowering and pod development were mostly associated with the reduction of pods per plant. Muhammad *et al*., 2007) found that highest seed yield was obtained with three times irrigation at early vegetative, flowering and seed formation. Under dry land conditions, soil moisture often limits yield. Nitrogen only increase yield to the limits imposed by the moisture supply. Increased moisture supply increased the yield potential of the crop and increased the amount of N required for optimum yield.

The management of canola in Egypt particularly on desert land and in the new valley are scanty so far. Therefore, the need for precise irrigation management for canola in Egypt have been solicited. Thus, knowledge of consumptive use of water, evapotranspiration is necessary in arid and semi-arid irrigated areas of the world (Jensen *et al.* 1990) and very essential for estimating water requirements (Doorenbos, and Pruitt 1997). Numerous investigators emphasized that environment and vegetation properties are the most significant impacts on evaporative and transpiration processes which reflect up on the consumptive use or evapotranspiration (Hassan, 1980 and Jensen *et al.* (1990). Maximization of canola seed production per unit volume of irrigation water owing to the limitation of water resources through finding proper systems of irrigation and fertilization management such as a network of sprinkler and drip systems of irrigation. Concerning the consumptive water use and water use efficiency of the grown canola crop, Ali (2002) indicated that the water use of canola crop under drip irrigation in sandy soil were 1794.6 and 1794.3 m^3/fed. Which produced the maximum seed and oil yield/fed. The subsequently water use efficiently recorded, i.e. 1.07 and 1.10 in 1999/2000 seasons, respectively. Drip irrigation in desert land reduced water consumptive use (CU) when compared with sprinkler or surface irrigation for sunflower crop (Ahmed, 2001). Moreover, Ali (1999) and Ahmed (2001) showed that WUE for sunflower were increased by using drip irrigation as compared with sprinkler and surface irrigation. The highest value of water use efficiency (WUE) for seed production was obtained by the treatment of 25% from the allowable soil moisture depletion (ASMD) (El-Wakil *et al*., 1992). Moreover, Dawood and Hamad (1995), Phene *et al.* (1993) and Ahmed (2001) reported that WUE significantly increased with drip irrigation when compared with sprinkler one. Ahmed *et al* (2007) found that oil content increased significantly up to 20 kg S \ha but further increase in S level did not enhance oil content. Oil content responded negatively to the increasing N levels. Ahmed and Bahrani (2009), found that full irrigation and highest N level had the highest plant height, number of branches per plant, seed and oil yield. However, increased N levels decreased seed oil content and had no significant effect on 1000- seed weight. Overall, supplying sufficient water to rapeseed crop, comparison with 225 kg\ha 0f N fertilizer are important to produce higher yields.

Khosro *et al*., (2012) found that highest percentage of oil was obtained from farmyard manure and compost application and highest oil yield belonged to combined application of chemical and organic fertilizer treatment .

The present research was aimed to study the productivity of two canola varieties by using new systems of irrigation and fertigation under New valley conditions.

Materials and Methods:

Three experiments were conducted during 2011/2012 and 20112/2013 seasons. These experiments were subjected to surface, sprinkler and drip irrigation systems. Each experiment of each irrigation system included three variables the first include genotypes, fertigation and plant spacing with the drill sown. Two Canola genotypes Serw 6 (Local one released from oil crop Department in Agricultutre Research Center (A.R.C.) and Pactol (Introduced from France). The second include two levels of combined macronutrients studied were 40, 15 and 24 (first) and 60, 30 and 36 (second) of N, P_2O_5 and K_2O kg/fed, respectively. This level was chosen because our hypothesis in this respect refers to the limitation of leaching expected by using new systems of irrigation and the third include four plant spacing was studied, i.e. 10 cm within drill one plant in the hill, 10 cm with drill two plants in the hill, 20 cm within drill one plant in the hill and 20 cm within drill two plants in the hill.

The three studied variables were distributed randomized in four replications through each experiment according to the importance of each variable in a split-split-plot design. Therefore, the varieties were allowed in the main plots, fertigation in sub-plot and sowing plant spacing in the sub-sub-plots. Each plot was 1/200 of fed. The experiments were conducted in the New valley Agriculture Research Station, the soil is sandy loam. Physical and chemical properties of the represented soil samples were shown in Table 1. It should be noted that the experimental soil is supplying with a network of sprinkler and drip irrigation systems. These systems are connected with fertilizer tanks using the injection method of flowing the soluble nutrients added through the irrigation water of each fertigation system. The nutrients flowing through each system must be solved in the irrigation water before application. Therefore, the selected forms of macronutrients have to be soluble such as Ammonium Nitrate 33% N as a source of irrigation. Phosphoric acid 85% P_2O_5 as a source of Phosphorus. Potassium sulfate 48% K_2O as a source of potassium. Each rate of nutrients applied was splitted into 8 times. This splitting was done to dilute the concentration of such compounds to avoid harmful effect of high concentration on leaves and roots of canola. The seeds of varieties were sown in hills 10 and 20 cm within the drill, which was 7 m long and 50 cm apart between drills, i.e. among lines with one and two plants were left per hill during thinning. Therefore, the theoretical population densities for plant spacings were studied was 168.000, 84.000, and 84.000 plant/fed. for the spacings of 10 and 20 cm, respectively with one and two plants per each hill, respectively.

Table (1): Some physical and chemical properties of a representative soil sample used in the experimental site in New Valley Agricultural Research Station.

Soil depth cm	pH 1:1 suspention	EC (1:1extract) dsm $^{-1}$	$CaCO_3$ %	Soluble cations meq/100 g soil				Soluble anions meq/100g soil	
				Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	CO_3+ HCO_3	Cl
0-15	8.21	0.66	8.02	0.310.25	0.26	0.09	0.01	0.31	0.30
15-30	8.33	0.71	8.00	0.30	0.22	0.070.10	0.04	0.32	0.30
30-45	8.27	0.69	8.11	0.33	0.25	0.08	0.030.02	0.30	0.27
45-60	8.31	0.71	8.25		0.20			0.28	0.25

Soil depth cm	Available nutrients Ppm			Mechanical analysis %			Soil texture
	N	P	K	Sand	Silt	Clay	
0-15	160	3.48	110	66.3	28.0	5.7	Sandy loam
15-30	90	4.15	128.7	66.3	28.0	5.7	
30-45	88	3.58	111.6	64.7	29.2	6.1	
45-60	102	3.12	109.2	61.9	30.4	7.7	

Five guarded plants were taken from each plot to measure yield and yield components traits. These traits were number of days to 50% flowering, plant height, number of primary racemes/plant, number of siliquas/plant, seed index (Average weight of 1000-seeds, g) and seed yield/plant.

Study the relationship between plant, soil and water including the following traits consumptive water (CU) and the water use efficiency (WUE) of studied varieties under sprinkler and drip compared with surface irrigation systems in the New Valley. The irrigation schedule was based on the flowing rate of each system/hour, i. e 30 m^3/hour/fed in sprinkler irrigation system and 3 liter/hour for each dripper in the drip one.

Calculation of CU and WUE:

a-Water consumption use (CU): calculated by using the equation described by Israelsen and Hansen (1962) as follows:

CU = (moisture % after irrigation – moisture % before irrigation)/100] x irrigation depth (0.6 m) x bulk density (1.381 gm/cm^3) x cultivated area (one feddan). Samples of soils for each experiment and for each depth were taken every two days to calculate the evapotranspiration all over the growing season.

b- Water use efficiency (WUE), calculated by using the formula described by Begg & Turner (1976) as follows:

WUE = Seed yield in kg per feddan / Evapotranspiation m^3/fed.

The mature canola plants for plot were harvested, and seed yield was weighed in kg/plot and transferred into seed yield in kg/fed. Moreover, oil yield in kg/fed was calculated by the multiplication of oil percentage by seed yield in kg/fed. Also, 50 gm of air dried seeds representing each replicate were ground into fine powder for determine the Crude oil content (%). It was estimated using Soxhlet apparatus and petroleum (60-80 b.p) ether as solvent according to A.O.A.C. (1995).

Statistical Analysis:

Each experimental was subjected to analysis of variance for split- split plot design as described by Gomez and Gomez (1984). Means were compared by using L.S.D. at 5% level of probability.

Results and Discussion:

The main effect of the studied variables.

A. Growth traits :

Means of plant height and number of primary racemes/plant as affected by canola genotype are manifested in Table (2) Plant height and number of primary racemes/plant did not exert any significant affect between the studied canola genotypes. Number of primary racemes/plant tended to be reacted significantly to the genotypes studied in favour of Serw 6 under surface irrigation. This result is only true under surface irrigation. El-Ghamary *et al.* (1992) indicated that the differences between cultivars in this respect were not significant. However, drip irrigation gave the tallest plants compared with the other irrigation systems. This may be due to the genotypic behavior in combination with the environmental conditions which may be suitable for Serw 6 variety more than Pactol one. Similar results in this respect were detected by Om Prakash *et al.* (2000). Regarding fertigation effect in this respect the data exhibited in Table (2) indicated that fertigation rates of 60, 30 and 36 kg/fed. of N, P_2O_5 and K_2O, respectively produced significantly tallest plants when compared with the lower doses studied. This trend was achieved under all irrigation systems. This indicated that the recommended amount of nutrients favored growth of canola plants and consequently plant height at harvest. This trend is in general accordance with those obtained by Ahmed (2001) and Kandil *et al.* (2001). The same trend was obtained in the number of primary racemes/plant except under sprinkler irrigation. This indicated that the second fertigation treatment favored this trait because this doses favored previously plant height as shown before. Similar tends in this respect were revealed by Ahmed (2001) who found that the number of primary racemes/plant was increased significantly with increasing N and P_2O_5 fertilizers up to 60 and 30 kg/fed of N and P, respectively. Moreover, the results Table (2) showed that spacing within drill affected significantly plant height and the number of primary racemes/plant under all irrigation systems except under drip irrigation in second year for latter one. The narrow spacing of 10 cm within drill produced the tallest plants when compared with the wider ones especially under drip irrigation. This is to be expected since the narrow spacing may cause highest competition among canola plants for light as well as nutrients and consequently plants tended to be directed towards the light. These results are in general harmony with those obtained by Buttar and Aulakh (1999). On the other hand, Mekki (1990) and Thakur (1999) reported that plant height was not affected significantly by plant density or spacing. The significantly wider spacing may be due to that wider spacing produced lower first primary raceme to the soil surface when compared with the narrow one as shown before. In addition to, low competition expected among canola wider spacing plants may cause the increase of number of primary racemes/plant. Similar results in this respect were obtained by Thakur (1999). Results in Table (2) revealed that plant height tended to be reacted positively to irrigation system studied in favour of drip irrigation in the two growing seasons. This tend could be ascribed to that holding of soil moisture content in the root zone, which tended to be higher than field capacity (7.4 by volume) in case of trickle irrigation as mentioned by Cho and Yamammoto (1973). This in turn encouraged the growth of canola plants by using this system.

B- Earliness trait:

Results presented in Table (2) showed that irrigation system had a positive effect on the average intervals to 50% flowering under all irrigation systems. Sprinkler irrigation system caused canola plants to reach 50% flowering earlier than drip one. While, surface irrigation system caused to 50% flowering late when compared to the other systems. The present trend could be attributed to that canola plants subjected to sprinkler irrigation system suffer from some water stress which may lead to the present results. As known that stress makes the plants grow earlier. However, the same trend was observed through the first season. These results contradict those obtained by Ali (1999) and Ahmed (2001). Moreover, results in Table (2) showed marked differences in earliness character among studied genotypes in the three irrigation systems. The results indicated that Serw 6 genotype was earlier than Pactol. This trend may be due to genotypic make-up in combination with environmental conditions. The same trend was obtained by Om Prakash *et al.* (2000), Sharief and Keshta (2000), Ahmed (2001) and Ali (2002). Whereas earliness characters failed to react significantly to the different fertigation rates studied under surface irrigation system. The present results are in harmony with that obtained by Ahmed (2001). On the contrary, Sharief and Keshta (2000) noted that number of days from planting to 50% flowering was increased by increasing nitrogen fertilizer applied. Spacing within drill did not affect significantly earliness character as shown in Table (2) under sprinkler irrigation system. However, narrow spacing under surface irrigation in the contrary of drip irrigation caused earliness relatively with wider one. Such findings are in a good accordance with those stated by Mekki (1990).

C- Yield and yield components :

a. Number of siliquas/plant :

Results presented in Table (3) showed that number of siliquas/plant tended to be reacted positively to irrigation system studied in favour of drip irrigation compared with the other systems. This trend could be ascribed to that holding of soil moisture content in the root zone, which tended to be higher than field capacity (7.4) in case of trickle irrigation as mentioned by Cho and Yamammoto (1973). This, in turn, encouraged the growth of canola plants such as plant height and number of primary racemes/plant as shown before and consequently increased number of siliquas/plant. Means of number of siliquas/plant seemed to be significantly different among the studied canola varieties. However, Serw 6 surpassed Pactol genotype under drip irrigation system The present trend may be due to genotypic behavior in combination with the environmental conditions, which may be suitable for Serw 6 genotype more than Pactol one. This caused increased in plant height and number of primary racemes/plant of Serw 6 genotype led to an increase in number of siliquas/plant. Such findings in this respect are in good accordance with those obtained by Raihana *et al.* (2000). On the other hand, Ahmed (2001) concluded that differences between oilseed rape cultivars in number of siliquas/plant were not significant. Regarding fertigation effect in this respect, the results exhibited in Table (3) revealed that fertigation rates of 60, 30 and 36 kg/fed. of N, P_2O_5 and K_2O, respectively, produced significantly highest number of siliquas/plant when compared with the lower doses studied. This indicated that the recommended amount of nutrients favored plant height and number of primary racemes/plant of canola as shown before which in turn, increased number of siliquas/plant. Such findings are in the same line with those obtained by Om Prakash *et al.* (1999) and Qayyum *et al.* (1999). Concerning spacing within drill effect on number of siliquas/plant, results presented in Table (3) showed that narrow spacing produced highest number of siliquas/plant when compared with wider under all irrigation systems except under drip irrigation which the wider spacing produced highest number of siliquas/plant when compared with narrow one. The statistical analysis proved that these differences were significant. This trend is to except since the wider spacing produced highest number of primary and secondary racemes/plant when compared with narrow one. These, in turn increased number of siliquas/plant with wider spacing. These

Results confirmed the findings of earlier researchers (Arthamwar *et al.*, (1996), Mobasser *et al.*, (2008) and Siadat *et al.*,(2010). Plant population of 80 plant m^2 recorded significantly higher siliqua number per plant (86.70) as compared to 120 plant m^2 which caused lowest siliqua number per plant (73.68) as shoun in (Table 1). Generally, lower population increased and higher population decreased number of siliquae per plant. These findings are in agreement with those of McGregor (1987), Ali *et al.* (1996) and Cheema *et al.* (2001). Nitrogen and plant density interaction showed that most siliqua /plant (115.6) was noticed in 200 kg ha-1 nitrogen application rate and 80 plant m^2 (Table 1). Similar results have been observed by Kazemeini *et al.* (2010) on rapeseed in south of Iran.This trend is in a general agreement with those obtained by Buttar and Aulakh (1999) and Thakur (1999).

b. Seed index :

Mean of 1000-seed weight as affected by canola varieties are shown in Table (3). 1000-seed weight exhibited to be non-significantly different among studied canola varieties under all irrigation systems. Ahmed (2001) pointed out that 1000-seed weight was not reacted significantly to studied oilseed rape genotypes. Regarding fertigation effect in this respect, the results shown in Table (3) revealed that fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively produced heaviest 1000-seed weight when compared with lower doses studied in the two growing seasons. These differences were significant only under sprinkler and drip irrigation system. The recommended doses of fertilizers favored canola plants growth as explained before reflected 1000-seed weight. The present trend is in harmony with those stated by Om Prakash *et al.* (1999) and Sharief and Keshta (2000). Also, results in Table (3) revealed that spacing within drill affected significantly seed index in the all irrigation systems in favour of wider spacing specially under drip irrigation. This trend may be due to that wider spacing may lead to less competition among canola plants for light as well as nutrients and consequently increased amount of metabolites, which contributed in heavy seed weight. The obtained results are in harmony with those reported by Thakur (1999).

c. Seed yield/plant (g).

The results in Table (3) stated that seed yield/plant tended to be reacted significantly to studied canola genotypes. However, Serw 6 variety surpassed Pactol one in under all irrigation systems. This trend is to be expected since Serw 6 genotype surpassed Pactol one in each of plant height and number of primary racemes/ plant, number of siliquas/plant and 1000-seed weight as indicated before. These, in turn, increased seed yield/plant for Serw 6 genotype more Pactol one. Similar results in this respect were obtained by Sharief and Keshta (2000).

It is clear from results presented in Table (3) that fertigation had a significant influence on seed yield/plant in both seasons only under drip irrigation system in favour of the second level of nutrients, i.e. 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively. This may be due to that the highly doses of nutrients increased each of plant height, number of primary racemes/plant, number of siliquas/plant and 1000-seed weight as illustrated before and consequently increased seed yield/plant. The present results are confirmed with those obtained by Ahmed (2001). Spacing within drill had a pronounced significant effect in this respect under all irrigation systems of study in favour of wider spacing as recorded in Table (3). The present results are logic since wider spacing enhanced each of number of primary racemes/plant, number of siliquas/plant and 1000-seed weight as explained before. Such findings are in a good line with those obtained by Buttar and Aulakh (1999). Yousaf and Ahmad (2002), Danesh -shahraki *et al.* (2008) and Kazemeini *et al.* (2010). They found higher seed yield of rapeseed at higher levels of both nitrogen and plant density.

The first order interactions:

Regarding the interactions involved in plant height, the results in Table (4) showed that the interaction of genotype X Fertigation did not excert any significant effect on plant height under the irrigation systems except sprinkler irrigation. The maximum value (204.2 cm) was obtained under drip irrigation for Serw 6 with fertigation rates of 60, 30 and 36 kg/fed. of N, P_2O_5 and K_2O, respectively. Also, the interaction of variety X spacing has the same trend as aforementioned. The presented results in Table (4) revealed that tallest plants for Serw 6 and Pactol were obtained under narrow spacing (10 cm) under all irrigation systems. The obtained results revealed that tallest plants (200.7 cm) was obtained under drip irrigation with fertigation rates of 60, 30 and 36 kg/fed. of N, P_2O_5 and K_2O_3 respectively under narrow spacing (10 cm, 2 plant/hill).Regarding this interactions on number of primary racemes/plant seemed to be significant for both varieties with fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively and narrow spacing (10 cm, 2 plants) for Pactol and (10 cm,1 plant for serw 6). Regarding the interactions involved in this respect (Table 4) showed that the interaction of genotype X Fertigation tended to be significant in the two growing seasons of study. The results showed that Serw 6 surpassed Pactol in this response to the recommended doses of nutrients especially under both sprinkler and drip irrigation system. Concerning the interaction of genotype X spacing which proved to be significant in the two growing seasons. The results revealed that Serw 6 variety surpassed Pactol as rate of response to wider spacing. The interaction of fertigation X spacing tended to be significant in the two growing seasons. Results showed that wider spacing surpassed the narrow one in the response to the low doses of nutrients. Regarding the interactions involved on No of siliquas/plant (Table 5) showed that the interaction of genotype X Fertigation gave maximum number/plants (1051.2) for Serw 6 with the second fertigation ratio under drip irrigation system. While, genotype X spacing for Serw 6 with 10 cm spacing with 1 plant/hill and for Pactol with 10 cm spacing with 2 plant/hill gave the maximum number/plant (1061.6and 1145.0), respectively. Also, fertigation X spacing seemed to be significant for both varieties with fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively and narrow spacing. The same trend was obtained to some extend under sprinkler and drip irrigation system. Regarding the interactions involved on seed index results in (Table 5) showed that the interaction of genotype X Fertigation seemed to be not significant except under all irrigation systems for seed index. While, genotype X spacing for Serw 6 with 10 cm spacing with 1 plant/hill and for Pactol with 10 cm spacing with 2 plant/hill. The interaction among fertigation X spacing were significant under drip irrigation and seemed to be significant for both fertigation rates. Regarding the interactions involved on seed yield/ plant, the results in Table (5) showed that the interaction of genotype X Fertigation, genotype X spacing fertigation X spacing seemed to be not significant for both seasons except under drip irrigation system. Such findings are in a good line with those obtained by Ahmadi and Bahrani (2009) found that the interaction between N levels and water stress treatments showed that full irrigation and 225 kg/ha N application had the highest seed yield, pods per plant and 1000-seed weight. Diepenbrock (2000) suggested that duration of growth is crucial for enhancing biomass and seed yield. Daneshmand *et al.* (2009) suggested that at water stressed conditions, those rapeseed cultivars which were able to maintain their relative water content at high levels had higher seed yield. Increase N application significantly increased seed yield, mainly due to an increase the number for pods per plant and seeds per pod Buttar *et al* (2006) and Diepenbrock (2000). Yousaf and Ahmad (2002), Danesh -Shahraki *et al.* (2008) and Kazemeini *et al.* (2010), they found higher seed yield of rapeseed at higher levels of both nitrogen and plant density.

The second interaction order:

The second interaction order between varieties, fertigation and plant spacing on plant height (Table 6) the results showed that plant height was significantly affected under sprinkler and drip irrigation. In for Serw 6 were (162.5,182.4,cm) and for Pactol (166.0,186.5,cm) in first and second seasons, respectively While, under drip irrigation for serw 6 were (191.0, 210.9,cm) and for Pactol genotype were (183.3, 206.0,cm) in the first and second seasons, respectively. These findings were true under' the second level of fertigation (60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively) with narrow plant spacing (10 cm, 2 plant in hill). In this respect, No of primary racemes/plant has no significant effect under all irrigation systems. Earliness trait (50% flowering) seemed to be significant under surface and drip irrigation systems. The obtained results in Table (7) indicated that both genotypes gave highest No. of siliquas/plant under the second level of fertigation (60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively) with narrow plant spacing. Seed index has no trend in the contrary of seed yield/plant which tended to be significant under all irrigation systems. Al-Kaisi and Yin (2003) reported that the interaction between irrigation and N on seed yield of corn was significant and varied by year and also seed yield response to N levels was affected by irrigation and year. Yousaf and Ahmad (2002), Danesh -Shahraki *et al.* (2008) and Kazemeini *et al.* (2010) and they found higher seed yield of rapeseed at higher levels of both nitrogen and plant density.

Seed and oil yields/fed :

Regarding genotype performance in this respect, results recorded in Table (8) showed that seed yield/fed tended to be reacted significantly to genotypes studied under all irrigation systems in favour of Serw 6 genotype. Maximum seed yield/fed (1702.3 kg/fed) was obtained for Serw 6 under drip irrigation system. The present trend is in a general accordance with those obtained by Raihana *et al.* (2000) and Kandil (2001).

The results obtained in Table (8) emphasized clearly that highly recommended doses of nutrients significantly favored average seed yield/fed under all irrigation systems as compared with low doses in the two growing seasons. This is to be expected since the highly doses of nutrients enhanced each of plant height, number of primary and secondary racemes/plant, number of siliquas/plant, 1000-seed weight and seed yield/plant as illustrated before which consequently contributed in the increase of seed yield/fed. Similar results were detected by Cheeema *et al.* (2001) and Kandil *et al.* (2001).

Results in Table (8) revealed that seed yield/fed react significantly to plant spacing within drill in the different irrigation systems.

Concerning genotype performance in seed oil content, the results presented in Table (3) revealed that different varieties studied did not affect significantly canola seed oil content under drip irrigation. Meanswhile, this trend was significantly affected in favour with Serw 6 genotype under both surface and sprinkler irrigations. Such findings are agreement with those declared by Ahmed (2001) and Ali (2002). Results in Table (8) stated that fertigation rates affected significantly canola seed oil percentage in favour of higher doses of nutrients, i.e. 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively. The present trend is due to the fact which proved that positive correlation is existed between nitrogen rate and amino acids which, in turn, increase protein content as shown in Table (8). This may be on the account of seed oil percentage. The same trend was detected by Cheema *et al.* (2001).

Regarding plant spacing within drill effect in this respect, the data exhibited in Table (8) proved that plant spacing within drill did not affect significantly canola seed oil content under surface irrigation systems. However, canola seed oil varied slightly between the two spacing studied in favour of wider one. Such findings are in a good line with those obtained by Hassan and El-Hakeem (1996) who found that seed content of oilseed rape was increased significantly by increasing plant density.

Oil yield/fed was significantly affected with canola genotype in favour to Serw 6 in both growing seasons and under all irrigation systems.The same trend was obtained under the highly doses of fertigation rates except under surface irrigation system. Results reported that plant spacing within drill affect significantly canola seed oil yield/fed under all irrigation systems. Regarding the interactions involved on seed yield/fed, the results in Table (9) showed that the first order interaction of genotype X Fertigation gave maximium seed yield/fed (1420.8) for Serw 6 with the second fertigation ratio. While, genotype X spacing for Serw 6 with 10 cm spacing 1 plant/hill and for Pactol with 10 cm spacing 2 plant/hill were significant with fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively. The interaction among fertigation X plant spacing. seemed to be significant for both genotypes with fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively and narrow spacing. Regarding the interactions involved seed oil content, the results in Table (10) showed that the first order interaction of genotype X Fertigation, variety X spacing, and fertigation X spacing. seemed to be significant for both varieties with fertigation rates of 60, 30 and 36 kg/fed of N, P_2O_5 and K_2O, respectively and narrow spacing .Ahmed *et al* (2007) found that the nitrogen x Sulfur interaction values indicated that oil content was higher when nitrogen and Sulfur were applied in combination at the rate of 40 kg nitrogen /ha and 20 kg Sulfur /ha, respectively. It has been reported by several researches that combined application of S and N enhances the oil and protein contents of the seeds of Brassica genotypes. The excessive nitrogen in soil, as a nutrient material, generates harmful materials in seed oil and causes its difficult extraction (Karimian kelishadrokhi *et al.*2009). Presence of N compounds in seed oil complicates the procedure of oil extraction and increases the amount of undesirable materials such as glucosinolates Zangani, (2002). Zhao *et al.* (2006) and Omirou *et al.* (2009) concluded that glucosinolate content increased with the increasing rate of N. Highest oil content in N2 (60,30 and 36) treatment comparing to other nitrogen levels might be due to decreasing the amount of N-compounds in the seed oil. Seyyed *et al.* (2013) stated that there was significant difference between different levels of nitrogen about grain oil and protein percentages in 1% level, Highest and lowest percentages of grain oil, were obtained from 0 and 240 Kg nitrogen treatments.

Effect of variety, fertigation and spacing on CU and WUE:

Results presented in Table (11) explained that studied genotypes did not exert any significant effect under all irrigation systems on consumptive use (CU) except the second growing seasons under surface and drip irrigation. The highly CU values were obtained for Pactol compared with Serw 6 genotype. Serw 6 may decrease the evaporation rate and consequently decreased ET or CU of such genotype. This may be due to the different genotypic among genotypes studied which led to different growth attributes (El-Wakil *et al.*, 1992) or my be due to plant density (Kramer and Boyer, 1995) which means that evaporation from the soil usually decreases as stand density increases.

The effect of different genotype on WUE, results showed that studied genotypes significantly affected water use efficiency in the two growing seasons. Sere 6 genotype surpassed Pactol one in this respect. This could be explained that maximium seed yield/fed and lower consumptive use obtained by using Serw 6 genotype as indicated before which consequently raised water use efficiency (WUE). The same trend was obtained by Sharma and Arvind (1991) and El-Wakil *et al.* (1992)

Results demonstrated in Table (11) denoted that fertigation rates affected significantly consumptive and water use efficiency in favour of the recommended doses of nutrients in the two growing seasons produced highest seed yield/fed and the lowest amount of water consumptive use when compared with the lower one. These, in turn, increased water use efficiency. This finding was in harmony with those mentioned by Katole and Sharma (1991) and Rana *et al.* (1991).

Regarding spacing within drill, the obtained results showed that plant spacing within drill significantly affected this trait through the two growing seasons under all irrigation. Narrow hill spacing gave the minimum values of consumptive use CU and consequently gave maximum water use efficiency WUE. This results are in agreement with

Rana *et al.* (1991) stated that water use efficiency was increased with increasing plant density except the second season under surface irrigation.

Effect of the first order interaction of variety, fertigation and spacing on consumptive use (CU) and water use efficiency (WUE):

Results in Table (12) clearly that the interaction of genotype X Fertigation did not exert any significant affect on CU and WUE except on WUE in the first growing season under all irrigation systems. The highly WUE values were obtained by using the second level of fertigation under both canola genotypes. The maximum water use efficiency values (WUE) were obtained for Serw 6 genotype with the second level of fertigation. This results are true in both growing seasons under all irrigation systems. The interaction of genotype X spacing turned to be significant only under sprinkler irrigation for both CU and WUE. Results showed that CU values under wider hill spacing were high compared with the values under the narrow one. This hill is true under both varieties genotypes.

In the contrary of, WUE under narrow hill spacing was significantly affected compared with the wider one. The interaction of fertigation X spacing revealed that WUE significantly affected under both sprinkler and drip irrigation systems. The highly WUE values were obtained under the first and second level of fertigation with narrow hill spacing. This results are in agreement with Zohreh Ansar *et al.* (2013) all estimated Ncriticals) for all irrigation levels were higher than the current recommendation of 130 kg N ha-1. This show the capability of increasing canola genotypes yield in study region by reasonable increasing of fertilizer rate (decreasing gap between recommended N rate and estimated values) in advisable irrigation regime (I2). Cultivars tended to respond similarly to irrigation and nitrogen for seed yield, but Talayh was more efficient than Sarigol in respect to response to diverse treatments.

Effect of the second order interaction of variety, fertigation and spacing on CU and WUE:

Results in Table (13) clearly indicated that the second order interaction had no significant effect in consumptive use under all irrigation systems under study. Meanswhile, water use efficiency (WUE) under sprinkler irrigation system tended to be significant compared to drip or either surface irrigation. The obtained results showed that cultivation of Serw 6 in narrow hill spacing fertigated with the second level of nutrients (60, 30 and 36 from N, P_2O_5 and K_2O kg/fed) gave the highest water use efficiency (WUE) when compared with the other interactions. This results are in agreement with Zohreh Ansar *et al.* (2013) all estimated Ncriticals) for all irrigation levels were higher than the current recommendation of 130 kg N ha-1. This show the capability of increasing canola cultivars yield in study region by reasonable increasing of fertilizer rate (decreasing gap between recommended N rate and estimated values) in advisable irrigation regime (I2). Cultivars tended to respond similarly to irrigation and nitrogen for seed yield, but Talayh was more efficient than Sarigol in respect to response to diverse treatments. Zhang *et al.* (2004) have reported WUE values that are higher under deficit than adequate irrigation, especially when irrigation is applied to critical stages of plant development. Lower WUE with increasing irrigation interval more than 70 mm. MAD could be due to the decrease in seed yield with increasing the drought period.

Mandal and Sinha, (2004) reported that the increase in root biomass, length and volume. Thus, nutrient application positively influenced the WUE. The greater increase in seed yield in N2, N3 and N4 over N1 and relatively less increase of the corresponding ET have evidently resulted in significantly higher WUE with the treatment of 70 mm MAD, particularly in the case of application the highest N rate (270 kg N ha-1).

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الإنتاجية وكفاءة استخدام الماء لسلالتين من الكانولا تحت نظم الري المختلفة ومستويات التسميد ومسافات الزراعه في الوادي الجديد

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الملخص:

اجريت تجارب حقلية فى تربة رملية طميية بمحطة البحوث الزراعية بمحافظة الوادى الجديد خلال موسمى الزراعة ٢٠١١/٢٠١٢، ٢٠١٢و٢٠١٣ لدراسة امكانية زراعة الكانولا كمحصول زيتى غير تقليدى فى تلك المنطقة ودراسة الاستهلاك المائى وكفائة استهلاك الماء لبعض سلالات الكانولا ولتحقيق هذا الغرض أقيمت ثلاث تجارب حقلية تحت كل نظام رى (سطحى تنقيط) استخدم فيها سلالتين من الكانولا عالية الإنتاج لتحديد الاحتياجات الأساسية تحت ظروف المنطقة وتم استخدام تصميم القطع المنشقة مرتين حيث تم دراسة تأثير أنسب مسافة للزراعه وأنسب معدل تسميد تحت كل نظام رى والاستهلاك المائى وكفائة استهلاك الماء خلال الموسمين.

١- أوضحت النتائج أن زراعة السلالة (سرو ٦) تحت ظروف المنطقة سجل أعلي محصول بما يعادل ١٦٥٠ كجم/للفدان تحت نظام الرى بالتنقيط مقارنة بنظم الرى الاخرى .

٢- أشارت النتائج الي أن زراعة السلالة (سرو ٦) بتصرف يعادل البخر نتح مع معدلات تسميد ٦٠ ، ٣٠ و ٣٦ كجم للفدان من كل من النيتروجين (N) والفسفور(P_2O_5) والبوتاسيوم (K_2O)علي التوالي بمسافة زراعة ١٠ سم لنبات ت واحد في الجورة.

٣- أظهرت النتائج أن أعلى كفائه لاستخدام مياه الري عند المستوي الاول ٤٠ ، ١٥ و ٢٤ والمستوي الثاني ٦٠ ، ٣٠ و ٣٦ من كل من النيتروجين (N) والفسفور(P_2O_5) والبوتاسيوم (K_2O)على التوالى بمسافات زراعة ١٠سم فى الجورة لنبات واحد.

٤- أوضحت النتائج أن أعلي القيم لطول النباتات وعدد القرون لكل نبات ووزن الالف بذرة وبالتالى محصول الحبوب للنبات عند نظام الري بالتنقيط مع معدلات تسميد ٦٠ ، ٣٠ و٣٦كجم/فدان من كل من النيتروجين (N) والفسفور (P_2O_5) والبوتاسيوم (K_2O)على التوالى بمسافات زراعة ١٠سم لنباتين بالجورة.

٥- أشارت النتائج الي أن أفضل نظم الري المستخدمة هو نظام الري بالتنقيط حيث تفوق علي النظم الأخرى في طول النبات ، عدد الافرع علي النبات ، عدد القرون علي النبات ، دليل البذور علي النبات ، محصول البذور للفدان ومحصول الزيت للفدان .

Table 2: Effect of irrigation systems, varietis, fertigation and spacing on growth and earliness traits of Canola, 2011/2012 and 2012/2013 seasons.

Treatments	Agronomic traits												Earliness traits					
	Plant height (cm)						No. of primary racemes/plant						50% flowering					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Variety																		
Serw 6	133.9	143.1	154.1	174.7	177.5	196.6	8.4	8.0	6.8	7.7	13.5	14.9	102.8	103.8	79.2	80.8	86.9	85.4
Pactol	132.8	141.7	154.6	174.9	170.6	191.8	7.6	7.7	6.6	7.8	14.1	15.9	104.3	109.3	78.3	79.9	93.2	93.1
F. value	NS	NS	NS	NS	NS	NS	**	*	NS	NS	NS	NS	**	**	*	*	*	**
Fertigation																		
40, 15, 24	130.8	141.2	149.7	170.1	168.9	187.8	7.8	7.7	6.6	7.7	13.5	15.3	103.6	104.6	78.5	79.9	88.3	88.1
60, 30, 36	135.9	143.7	158.4	179.3	179.2	200.5	8.2	8.0	6.8	7.9	14.1	15.6	103.4	104.5	79.0	80.9	91.8	90.4
F. value	**	*	**	**	**	**	*	*	NS	NS	*	*	NS	NS	*	*	*	**
Spacing																		
10 cm 1 pl	135.8	144.7	157.6	178.1	173.9	194.3	7.8	7.8	6.5	7.4	13.5	15.1	102.2	103.6	78.5	79.8	91.8	89.6
10 cm 2 pl	142.2	150.8	160.3	180.6	181.2	199.7	6.9	6.8	6.0	7.2	13.3	15.3	103.3	104.3	78.5	80.1	89.6	88.9
20 cm 1 pl	122.6	131.9	147.7	168.1	168.1	189.3	9.2	8.7	7.6	8.5	14.8	16.2	104.5	105.6	79.3	81.8	91.6	88.1
20 cm 2 pl	132.7	148.3	150.6	172.3	172.9	193.6	8.1	8.2	6.8	8.1	13.6	15.1	103.8	104.7	78.7	80.3	87.4	90.3
F. value	**	**	**	**	**	*	**	**	**	**	**	NS	*	**	NS	NS	*	**
L.S.D. 0.05	4.3	4.9	2.2	2.3	5.6	6.5	0.5	0.6	0.2	0.4	0.5		0.5	0.6	-	-	0.6	0.9

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 3: Effect of irrigation systems, varietis, fertigation and spacing on yield components of Canola, 2011/2012 and 2012/2013 seasons.

Treatments	Yield components																	
	No. of siliquas/plant						Seed Index						Seed yield/plant (gm)					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Varity																		
Serw 6	717.2	725.6	420.7	431.9	951.6	976.4	3.1	3.7	3.3	3.3	3.5	3.6	28.8	28.7	27.7	28.8	38.3	37.7
Pactol	765.2	765.5	397.7	408.1	864.4	912.1	3.0	3.8	3.2	3.3	3.5	3.7	21.8	22.7	25.8	27.0	34.7	36.6
F. value	NS	NS	NS	NS	*	**	NS	NS	NS	NS	NS	NS	**	**	*	**	*	*
Fertigation																		
40, 15, 24	667.6	666.8	385.6	396.5	837.5	865.7	3.0	3.7	3.1	3.2	3.3	3.4	24.8	25.2	26.5	27.5	33.9	35.5
60, 30, 36	814.9	824.3	432.8	443.6	978.5	1022.9	3.2	3.8	3.3	3.4	3.7	3.9	25.9	26.2	27.0	28.2	39.1	38.8
F. value	**	**	**	**	**	**	NS	NS	**	**	**	**	NS	NS	NS	NS	*	*
Spacing																		
10 cm 1 pl	858.3	866.1	443.8	455.3	964.5	994.3	3.2	3.8	3.2	3.3	3.4	3.4	23.1	24.1	25.5	26.7	36.6	36.8
10 cm 2 pl	840.5	802.2	443.7	454.3	742.4	807.9	3.2	3.8	3.1	3.4	3.5	3.8	21.4	22.7	24.1	25.5	34.5	34.0
20 cm 1 pl	590.7	616.2	370.4	381.2	1064.0	1088.5	3.0	3.7	3.5	3.2	3.5	3.5	30.0	28.5	30.3	31.0	39.2	40.5
20 cm 2 pl	675.3	697.7	379.1	389.5	861.1	886.9	3.1	3.8	3.2	3.4	3.4	3.8	26.8	27.4	27.2	28.3	35.7	37.6
F. value	**	**	**	**	**	**	**	*	**	**	*	*	**	**	**	*	**	*
L.S.D. 0.05	11.9	17.6	18.9	18.9	67.0	12.2	0.1	0.1	0.1	0.1	0.1	0.1	1.5	1.2	1.2	1.4	2.1	4.3

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 4: Effect of interactions, VxF, VxS and FxS on growth and earliness of Canola in 2011/2012 and 2012/2013 seasons under irrigation systems.

Treatments	Agronomic traits												Earliness traits					
	Plant height						No. of primary racemes/pL						50% flowering					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
V X F																		
Serw6 X F1	131.2	142.2	153.5	173.7	170.8	188.9	8.4	8.2	6.4	7.4	12.7	14.3	103.8	104.9	78.9	80.8	87.6	86.7
X F2	136.6	144.0	154.6	175.7	189.2	204.2	8.3	7.8	7.3	8.2	14.2	15.7	101.8	102.8	79.5	80.9	86.3	84.1
Pactol X F2	130.4	140.3	145.9	166.6	166.9	186.8	7.1	7.2	6.8	7.9	14.3	16.3	103.5	104.3	78.0	79.0	96.1	94.1
X F2	135.2	143.3	162.1	183.2	174.3	196.9	8.1	8.4	6.4	7.6	13.9	15.4	105.0	106.3	78.5	80.9	96.4	92.0
F. value	NS	NS	**	**	NS	NS	*	**	**	**	**	*	**	**	NS	NS	NS	NS
L.S.D. 0.05	-	-	2.3	2.8	-	-	0.6	0.4	0.4	0.4	0.6	1.03	0.7	0.7	-	-	-	-
V X S																		
Serw6 X S1	133.8	142.3	159.0	179.4	177.8	198.4	8.5	8.4	6.6	7.5	12.4	14.2	101.5	102.6	79.0	80.8	89.5	88.4
X S2	141.3	150.3	161.9	181.8	185.2	200.7	7.4	7.4	5.8	6.8	13.3	15.4	102.5	103.5	79.5	81.8	85.0	84.0
X S3	124.4	133.8	147.9	168.8	171.6	191.7	9.3	8.4	8.1	8.8	14.9	15.7	104.0	105.1	79.5	81.0	88.1	86.1
X S4	136.1	146.0	147.5	168.9	175.4	195.3	8.4	8.3	6.9	8.0	13.4	14.6	103.0	104.0	78.9	79.9	85.0	83.1
Pactol X S1	137.9	147.1	156.3	176.9	170.0	190.0	7.0	7.2	6.4	7.4	14.7	15.9	103.5	104.6	78.0	79.0	94.0	92.3
X S2	143.1	151.3	158.8	179.4	177.3	198.7	6.4	6.5	6.3	7.5	13.4	15.1	104.0	105.0	77.5	78.5	94.1	92.3
X S3	120.9	130.1	147.5	167.5	164.7	186.8	9.2	8.9	7.1	8.3	14.8	16.7	105.0	106.1	79.0	81.5	95.0	93.0
X S4	129.3	138.6	153.6	175.7	170.4	191.8	7.9	8.0	6.8	8.1	13.8	15.7	104.5	105.4	78.5	80.8	89.8	94.8
F. value	NS	NS	*	**	NS	NS	*	**	**	*	**	*	NS	NS	NS	NS	NS	NS
L.S.D. 0.05	-	-	4.1	3.2	-	-	0.7	0.4	0.3	0.5	0.7	0.5	-	-	-	-	-	-
F X S																		
F1 X S1	132.8	143.2	153.8	173.8	166.6	186.5	7.6	7.7	6.5	7.5	13.4	15.3	103.0	104.0	78.5	79.8	91.0	89.3
X S2	138.7	149.4	156.2	176.7	175.3	190.9	6.6	6.5	6.3	7.4	12.9	14.9	103.0	103.9	78.0	80.1	89.5	87.5
X S3	122.1	132.8	149.9	165.2	164.1	183.8	9.0	8.8	7.1	8.1	14.8	16.1	105.5	106.6	79.0	80.3	90.5	88.5
X S4	129.5	139.5	144.1	164.9	170.0	190.2	7.9	8.0	6.5	7.8	13.0	14.8	103.0	103.9	78.4	79.4	82.3	87.0
F2 X S1	138.9	146.2	161.5	182.5	181.9	202.0	7.9	7.9	6.5	7.4	13.6	14.4	102.0	103.3	78.5	80.0	92.5	91.4
X S2	145.6	152.2	164.5	184.5	187.1	208.4	7.1	7.1	5.8	6.9	13.8	15.6	103.5	104.6	79.0	80.1	89.6	88.8
X S3	123.1	131.1	150.5	171.1	172.2	144.7	9.5	8.6	8.0	8.9	14.9	16.3	103.5	104.6	79.5	82.1	92.6	90.6
X S4	135.9	145.0	157.0	179.7	175.8	196.9	8.4	8.4	7.1	8.3	14.1	15.4	104.5	105.5	79.0	81.2	92.5	90.9
F. value	NS	NS	**	**	NS	NS	*	*	**	**	NS	NS	**	**	NS	NS	NS	Ns
L.S.D. 0.05	-	-	4.1	3.2	-	-	0.5	0.6	0.3	0.5	-	-	0.8	0.9	-	-	-	-

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

S1: 10 cm 1 plant/hill
S2: 10 cm 2 plant/hill
S3: 20 cm 1 plant/hill
S4: 20 cm 2 plant/hill

F1: 40, 15 and 24 kg of N, P_2O_5 and K_2O
F2: 60, 30 and 36 kg of N, P_2O_5 and K_2O
Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 5: Effect of interactions, VxF, VxS and FxS on yield components of Canola in 2011/2012 and 2012/2013 seasons under irrigation systems.

Treatments	Yield components																	
	No. of siliquas/plant						Seed Index						Seed yield/plant (gm)					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
V X F																		
Serw6 X F1	590.1	613.4	398.8	410.4	874.5	901.7	3.0	2.7	3.2	3.4	3.3	3.4	27.7	26.6	27.4	28.3	34.7	34.1
X F2	844.4	837.8	442.6	453.6	1028.8	1051.2	3.3	3.8	3.3	3.8	3.7	3.8	29.8	29.5	28.0	29.1	41.9	48.3
Pactol X F2	745.1	720.2	372.5	382.6	800.0	829.6	3.0	3.7	3.1	3.5	3.3	3.5	22.8	21.4	25.6	26.8	33.3	37.1
X F2	785.3	610.8	423.0	433.7	928.2	994.6	3.2	3.8	3.4	3.8	3.7	3.8	22.6	22.3	26.1	27.3	36.2	36.2
F. value	**	**	**	**	NS	NS	NS	NS	NS	NS	NS	NS	*	*	**	*	*	*
L.S.D. 0.05	10.2	24.8	16.4	15.74	-	-	-	-	-	-	-	-	1.2	1.5	1.1	1.0	3.0	7.9
V X S																		
Serw6 X S1	938.7	949.3	462.8	474.2	1031.8	1061.6	3.4	3.9	3.4	3.5	3.5	3.5	27.2	23.8	26.2	27.5	37.7	41.5
X S2	698.5	684.8	441.6	452.9	880.9	905.3	3.2	3.8	3.1	3.6	3.5	3.6	23.5	23.3	23.4	24.9	35.5	34.2
X S3	570.3	594.6	394.0	405.6	1009.2	1031.9	3.0	3.6	3.4	3.7	3.5	3.7	32.9	35.7	32.8	33.2	42.8	47.8
X S4	661.5	673.8	384.5	395.3	884.7	906.9	3.1	3.7	3.2	3.6	3.4	3.6	31.4	30.5	28.4	29.4	37.3	41.1
Pactol X S1	778.0	783.9	124.8	436.4	897.2	927.0	3.1	3.8	3.0	3.6	3.4	3.6	21.0	19.2	24.8	25.9	35.7	37.0
X S2	982.6	919.6	445.7	455.6	603.9	710.5	3.3	3.8	3.1	3.7	3.6	3.7	22.0	20.6	24.8	26.1	33.5	33.6
X S3	611.2	637.8	346.7	356.8	1118.9	1145.0	3.0	3.7	3.7	3.7	3.6	3.7	24.2	24.3	27.9	28.9	35.6	39.4
X S4	689.1	721.6	373.7	383.7	837.6	865.9	3.1	3.7	3.2	3.7	3.5	3.7	23.4	23.2	26.0	27.1	34.1	36.6
F. value	**	**	*	*	**	**	NS	NS	**	*	NS	NS	**	**	*	*	NS	*
L.S.D. 0.05	16.9	24.9	26.8	26.8	78.3	17.2	-	-	0.2	6.2	-	-	2.1	1.7	1.6	1.4	-	
F X S																		
F1 X S1	755.2	760.2	415.3	426.0	875.3	905.1	3.1	3.7	3.1	3.8	3.6	3.2	33.3	19.1	25.3	26.5	33.8	35.1
X S2	982.4	736.3	411.5	421.9	723.0	751.3	3.1	3.7	3.0	3.7	3.3	3.4	22.5	21.3	24.7	25.9	34.2	30.5
X S3	516.3	540.6	365.4	376.9	1000.0	1027.1	3.0	3.7	3.4	3.7	3.5	3.7	27.9	29.5	29.3	29.9	33.4	34.8
X S4	616.5	630.0	350.5	361.1	750.9	779.2	3.0	3.6	3.1	3.6	3.3	3.5	26.9	25.9	26.8	27.8	34.5	36.9
F2 X S1	961.5	972.1	472.3	484.5	1053.7	1083.6	3.4	4.1	3.3	3.9	3.8	3.9	24.7	23.9	25.7	26.8	39.6	43.5
X S2	989.7	666.0	475.9	486.6	761.8	864.5	3.4	3.8	3.2	3.9	3.8	3.9	23.0	21.6	23.4	25.0	34.9	37.5
X S3	665.2	691.8	375.4	385.5	1127.2	1149.8	3.0	3.5	3.6	3.6	3.6	3.7	29.1	30.5	31.4	32.1	44.9	47.4
X S4	734.1	765.3	407.8	417.8	971.4	993.7	3.2	3.2	3.3	3.8	3.6	3.7	27.9	27.7	27.6	28.7	36.9	40.7
F. value	**	**	*	*	**	**	NS	NS	NS	NS	**	**	NS	NS	NS	NS	*	*
L.S.D. 0.05	16.9	24.9	26.8	26.8	78.3	17.7	-	-	-	-	0.2	0.2	-	-	-	-	3.0	2.8

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

S1: 10 cm 1 plant/hill
S2: 10 cm 2 plant/hill
S3: 20 cm 1 plant/hill
S4: 20 cm 2 plant/hill

F1: 40, 15 and 24 kg of N, P_2O_5 and K_2O
F2: 60, 30 and 36 kg of N, P_2O_5 and K_2O
Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 6: Effect of interactions, V x F x S on growth and earliness traits of Canola plants growen in 2011/2012 and 2012/2013 seasons under irrigation systems.

Treatments	Agronomic traits												Earliness traits					
	PL height						No. of primary racemes/Pl						50% flowering					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
V X F X S																		
V1XF1XS1	130.0	140.6	158.0	176.7	170.6	191.7	8.5	8.7	6.5	7.4	11.5	13.6	102.0	103.3	79.0	80.5	89.0	88.8
V1XF1XS2	136.3	147.3	161.3	181.1	179.4	190.6	7.5	7.2	5.8	6.8	12.3	14.4	103.0	104.0	79.0	82.3	86.0	86.0
V1XF1XS3	126.3	137.2	152.3	172.9	164.4	184.6	9.3	8.6	7.1	7.9	14.5	15.2	106.0	107.3	79.0	80.8	90.3	88.3
V1XF1XS4	132.3	143.7	142.5	164.1	168.8	188.7	8.5	8.6	6.3	7.4	12.5	13.9	104.0	105.0	78.0	79.5	85.0	83.8
V1XF2XS1	137.5	143.9	160.0	182.0	185.0	205.3	8.5	8.1	6.8	7.5	13.3	14.8	101.0	102.0	79.0	81.0	90.0	88.0
V1XF2XS2	146.3	153.3	162.5	182.4	191.0	210.9	7.3	6.9	5.8	6.9	14.3	16.5	102.0	103.0	80.0	81.3	84.0	82.0
V1XF2XS3	122.5	130.5	143.5	164.7	178.8	198.8	9.3	8.3	9.0	9.6	15.3	16.3	102.0	103.0	80.0	81.3	86.0	84.0
V1XF2XS4	140.0	148.4	152.5	173.7	181.9	201.9	8.3	8.0	7.5	8.6	14.2	15.2	102.0	103.0	79.0	80.0	85.0	83.5
V2XF1XS1	135.5	145.8	149.5	170.8	161.3	181.3	6.8	6.8	6.5	7.5	15.3	16.9	104.0	104.8	78.0	79.0	96.0	94.0
V2XF1XS2	141.2	151.4	151.1	172.3	171.3	191.3	5.8	5.8	6.8	7.9	13.5	15.4	103.0	103.8	77.0	78.0	9303	91.5
V2XF1XS3	118.0	148.5	137.5	157.5	163.8	182.9	8.7	8.9	7.1	8.2	15.0	17.1	105.0	106.0	79.0	80.0	95.0	93.0
V2XF1XS4	126.8	135.4	145.8	165.8	171.3	191.7	7.3	7.4	6.8	8.3	13.5	15.7	102.0	102.8	78.0	79.0	100.0	98.0
V2XF2XS1	140.3	148.6	163.0	183.0	178.8	198.8	7.3	7.7	6.3	7.3	14.0	14.9	103.0	104.5	78.0	79.0	92.0	90.5
V2XF2XS2	145.0	151.2	166.0	186.5	183.3	206.0	7.0	7.2	5.8	6.9	13.3	14.7	105.0	106.3	78.0	79.0	95.0	93.0
V2XF2XS3	123.8	131.7	157.5	177.5	165.6	190.7	9.8	8.9	7.0	8.3	14.5	16.4	105.0	106.3	79.0	83.0	95.0	93.0
V2XF2XS4	131.8	141.7	161.5	185.7	169.6	191.9	8.5	8.7	6.8	7.9	14.0	15.7	107.0	108.0	79.0	82.5	79.0	91.5
F value	NS	NS	*	**	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS	NS	*	**
L.S.D.	-	-	4.5	4.4	-	-	-	-	-	-	-	-	1.3	1.2	-	-	1.5	1.9

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

S1: 10 cm 1 plant/hill
S2: 10 cm 2 plant/hill
S3: 20 cm 1 plant/hill
S4: 20 cm 2 plant/hill

F1: 40, 15 and 24 kg of N, P_2O_5 and K_2O
F2: 60, 30 and 36 kg of N, P_2O_5 and K_2O
Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 7: Effect of interactions, V x F x S on yield components of Canola plants growen in 2011/2012 and 2012/2013 seasons under irrigation systems.

Treatments	Yield components																	
	No. of siliquas/plant						Seed iNdex						Seed yield/plant					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
V X F X S																		
V1XF1XS1	754.3	759.3	450.3	461.3	943.8	973.4	3.2	3.7	3.3	3.4	3.0	3.0	26.0	25.9	26.3	27.6	33.4	33.4
V1XF1XS2	607.5	632.5	422.8	434.0	766.0	792.3	3.0	3.7	3.0	3.1	3.3	3.4	21.5	22.7	24.1	25.6	34.9	27.4
V1XF1XS3	432.5	476.3	386.5	399.5	981.3	1003.7	2.9	3.7	3.4	3.5	3.4	3.6	35.3	31.5	31.2	31.3	34.4	39.3
V1XF1XS4	566..0	585.5	335.8	346.9	806.8	836.9	3.0	3.6	3.2	3.3	3.3	3.5	29.8	30.6	27.9	28.9	36.1	36.2
V1XF2XS1	1123.0	1139.4	475.3	487.1	1119.8	1149.6	3.6	3.6	3.6	3.7	3.9	4.0	28.0	28.5	26.1	27.4	41.9	39.6
V1XF2XS2	789.0	737.0	460.5	471.9	995.8	1018.2	3.3	4.1	3.1	3.2	3.6	3.8	23.0	24.2	22.6	24.1	36.1	41.3
V1XF2XS3	708.0	713.0	401.5	411.7	1037.0	1059.9	3.0	3.8	3.3	3.4	3.6	3.8	36.0	34.2	34.3	35.1	51.3	43.8
V1XF2XS4	757.0	762.0	433.3	443.6	962.5	976.9	3.2	3.5	3.2	3.3	3.5	3.7	31.1	23.3	28.9	29.9	38.4	41.1
V2XF1XS1	756.0	761.0	380.3	390.8	806.8	836.5	3.0	3.8	2.9	3.0	3.0	3.4	18.0	21.1	24.2	25.5	34.1	36.7
V2XF1XS2	957.3	840.1	400.2	409.8	680.0	710.2	3.1	3.8	2.9	3.0	3.2	3.4	21.1	22.3	25.3	26.3	33.4	33.5
V2XF1XS3	600.0	605.0	344.2	354.3	1020.5	1050.4	2.9	3.8	3.4	3.5	3.6	3.7	23.7	24.4	27.3	28.6	32.5	40.3
V2XF1XS4	667.0	674.5	365.2	375.3	695.0	721.6	2.9	3.7	3.1	3.2	3.3	3.5	22.1	23.3	25.7	26.7	32.9	37.8
V2XF2XS1	800.0	805.0	469.3	481.9	987.5	1017.6	3.1	3.7	3.0	3.1	3.7	3.9	19.8	21.0	25.3	26.3	37.3	37.4
V2XF2XS2	1007.9	999.1	491.3	501.4	577.8	710.8	3.4	3.8	3.2	3.3	3.9	4.0	20.1	21.8	24.2	25.9	33.6	33.7
V2XF2XS3	622.3	670.6	349.2	359.3	1217.3	1239.7	3.0	3.9	3.9	4.0	3.5	3.7	25.0	23.9	28.5	29.3	38.6	38.6
V2XF2XS4	711.2	768.7	382.3	392.0	980.2	1010.4	3.2	3.7	3.3	3.4	3.6	3.8	24.3	23.5	26.2	27.5	35.3	35.3
F value	**	**	**	**	**	**	*	NS	NS	NS	NS	NS	*	*	*	*	*	*
L.S.D.	23.9	35.2	37.9	37.9	39.4	24.3		-	-	-	-	-	1.6	1.7	1.6	1.5	3.1	2.4

Su. : surface irrigation
Sp. : Sprinkler irrigation
Dr : Drip irrigation.

S1: 10 cm 1 plant/hill
S2: 10 cm 2 plant/hill
S3: 20 cm 1 plant/hill
S4: 20 cm 2 plant/hill

F1: 40, 15 and 24 kg of N, P_2O_5 and K_2O
F2: 60, 30 and 36 kg of N, P_2O_5 and K_2O
Y1: growing season 2011/2012
Y2: growing season 2012/2013

Table 8: Effect of irrigation systems, varieties, fertigation and spacing on seed, oil yields kg/fed and seed quality of Canola, 2011/2012 and 2012/2013 seasons.

Treatments	Seed and oil yields/fed												Seed quality					
	Seed yield/fed kg/fed						Oil %						Oil yield/fed kg/fed					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2010	2011	2011	2012
Varity																		
Serw 6	1400.0	1383.5	1480.1	1490.6	1672.5	1702.3	45.7	44.9	46.0	45.5	44.5	45.5	640.8	611.9	682.8	678.8	743.9	774.5
Pactol	1282.4	1266.8	1344.6	1349.7	1466.0	1529.2	43.3	43.1	44.2	44.6	44.3	45.6	548.8	545.4	595.6	602.2	648.5	697.5
F. value	**	**	**	**	**	**	**	*	**	**	NS	NS	**	**	**	**	**	**
L.S.D. 0.05	26.2	27.9	13.2	16.4	10.5	28.3	0.7	0.6	0.9	0.6	-	-	28.4	31.6	16.0	-	0.3	-
Fertigation																		
40, 15, 24	1326.0	1305.8	1357.7	1368.4	1552.5	1601.0	43.9	43.9	43.5	43.7	43.5	44.6	582.3	575.1	592.2	598.5	673.0	713.9
60, 30, 36	1356.4	1344.5	1467.1	1471.9	1586.0	16305	45.2	43.9	46.7	46.3	45.3	46.5	607.4	582.3	686.2	682.5	719.4	758.2
F. value	*	**	**	**	**	**	NS	NS	**	**	**	**	NS	NS	**	**	**	**
L.S.D. 0.05	20.6	24.5	6.6	8.7	7.6	9.5	-	-	1.0	1.2	0.3	0.5	-	-	14.4	15.2	8.9	9.4
Spacing																		
10 cm 1 pl	1390.6	1373.5	1446.4	1456.6	1573.0	1605.7	44.6	43.9	45.6	45.1	45.2	46.3	609.7	604.3	661.4	657.3	712.0	742.9
10 cm 2 pl	1348.5	1336.2	1447.6	1458.6	1650.0	1678.1	44.7	44.3	46.0	45.8	44.1	45.1	603.8	592.6	666.3	667.8	725.3	757.8
20 cm 1 pl	1298.3	1278.3	1351.4	1362.7	1522.5	1546.5	44.2	43.6	44.7	44.9	44.6	45.9	573.7	538.2	607.4	613.3	678.8	710.1
20 cm 2 pl	1327.5	1312.5	1404.0	1402.9	1531.5	1632.8	44.6	44.1	44.2	44.4	43.7	44.9	592.1	579.5	621.7	623.6	668.6	733.1
F. value	**	**	**	**	**	**	NS	NS	**	*	*	**	*	**	**	**	**	**
L.S.D. 0.05	15.12	18.20	8.3	7.0	8.1	9.2	-	-	0.8	0.5	0.4	0.5	22.2	31.6	12.2	11.4	10.4	9.8

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

CU: Water consumptive use
WUE: Water use efficiency

Su : Surface irrigation
Sp : Sprinkler irrigation
Dr : Drip irrigation

Table 9: Effect of interactions, VxF, VxS and FxS on seed & oil yields and seed quality of Canola in 2011/2012 and 2012/2013 seasons.

Treatments	Yield components												Seed quality					
	Seed yield/fed. kg/fed						Oil %						Oil yield/fed. kg/fed					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
V X F																		
Serw6 XF1	1379.3	1358.2	1431.4	1441.8	1650.0	1682.7	45.2	45.3	43.8	43.8	43.1	44.1	623.8	615.7	628.3	630.7	710.3	742.1
XF2	1420.8	1408.6	1528.8	1339.5	1695.0	1721.9	46.3	44.5	48.2	47.2	45.9	46.9	657.8	608.1	737.3	726.9	777.4	806.9
Pactol XF2	1272.8	1253.3	1283.9	1295.1	1455.0	1519.3	42.5	42.7	43.3	43.7	43.9	45.1	540.7	534.3	556.1	566.3	635.7	685.6
XF2	1292.1	1280.3	1405.4	1404.3	1437.0	1539.1	44.1	43.5	45.2	45.4	44.8	46.1	536.9	556.4	635.2	638.1	661.3	709.4
F. value	Ns	Ns	**	*	**	*	*	*	*	**	**	**	NS	NS	*	*	**	**
L.S.D. 0.05	-	-	9.3	11.4	10.8	12.4	0.5	0.7	1.4	1.5	0.5	0.7	-	-	20.3	31.4	12.7	11.7
V X S																		
Serw6 XS1	1458.5	1444.0	1533.2	1545.0	1675.0	1710.2	46.9	45.9	46.8	45.4	45.4	46.3	584.2	662.0	719.1	702.5	760.1	792.7
XS2	1412.5	1393.4	1480.1	1490.5	1760.0	1785.2	45.7	44.9	46.4	45.8	44.3	45.1	644.8	626.4	688.3	682.9	779.7	806.1
X 3	1346.5	1326.5	1430.1	1441.2	1595.0	1620.2	45.0	44.0	45.7	45.6	44.6	45.7	605.5	546.3	656.7	657.6	711.4	740.3
XS4	1382.5	1369.9	1475.1	1484.9	1660.0	1693.6	45.5	44.7	45.2	45.4	43.6	44.7	628.6	612.9	666.9	672.1	723.5	758.8
Pactol XS1	1322.7	1302.7	1357.6	1367.1	1471.0	1501.2	42.4	41.9	44.5	44.7	45.1	46.2	535.2	546.6	603.7	612.1	662.9	693.2
XS2	1284.5	1279.1	1415.2	1426.7	1540.0	1570.9	43.8	43.7	45.5	45.7	43.9	45.2	562.8	558.8	644.2	652.7	671.0	709.5
XS3	1250.0	1230.1	1272.8	1284.2	1450.0	1472.8	43.4	43.1	43.8	44.2	44.6	46.1	·541.8	530.1	558.2	569.1	646.2	679.8
XS4	1272.5	1255.0	1333.0	1320.9	1403.0	1572.0	43.7	43.5	43.2	43.5	43.8	45.0	555.5	596.1	578.5	575.0	613.8	707.5
F. value	*	*	**	**	**	**	**	*	Ns	Ns	Ns	Ns	**	*	**	**	**	**
L.S.D. 0.05	21.4	20.0	11.7	14.5	11.5	15.1	1.1	0.8	-	-	-	-	31.5	44.7	17.3	15.4	14.7	13.8
F X S																		
F1 X S1	1376.0	1355.1	1583.3	1395.2	1551.5	1591.7	44.1	44.3	44.5	43.9	44.3	45.2	607.7	600.8	617.8	613.5	687.4	720.4
X S2	1335.5	1317.2	1375.2	1386.9	1635.0	1665.9	43.6	43.8	44.8	45.2	42.4	43.6	583.2	577.2	615.8	626.9	687.7	725.4
X S3	1280.0	1260.4	1310.0	1321.1	1507.5	1531.5	43.7	43.8	42.1	43.0	44.1	45.4	558.9	552.4	554.9	567.7	664.6	694.2
X S4	1312.5	1290.4	1360.1	1370.5	1516.0	1615.1	44.1	44.1	42.6	42.9	43.1	44.3	579.3	569.7	580.3	585.9	652.3	715.4
F2 X S1	1405.2	1391.8	1507.5	1517.9	1594.5	1614.7	45.2	43.6	46.7	46.1	46.2	47.3	611.7	607.7	705.0	701.0	736.5	765.6
X S2	1361.5	1355.3	1520.1	1530.2	1665.0	1690.2	45.9	44.9	47.1	46.3	45.8	46.7	624.4	608.0	716.8	708.7	763.0	790.2
X S3	1316.5	1296.3	1392.8	1404.3	1537.5	1561.5	44.7	43.3	47.3	46.9	45.0	46.4	588.5	523.9	660.0	658.9	693.0	725.9
X S4	1342.5	1334.6	1418.2	1435.5	1547.0	1650.6	45.0	44.1	45.7	46.0	44.2	45.4	604.8	589.3	663.1	661.3	685.0	750.9
F. value	Ns	NS	**	**	NS	NS	Ns	Ns	**	*	**	**	NS	NS	NS	NS	Ns	Ns
L.S.D. 0.05	-	-	11.7	14.0	-	-	-	-	1.4	1.5	0.7	0.7	-	-	-	-	-	-

Table 10: Effect of interactions, V x F x S on seed yield/fed, oil content and oil yield/fed of Canola yield in 2011/2012 and 2012/2013seasons. under irrigation systems.

Treatments	Seed and oil yields/fed												Seed quality					
	Seed yield/fed kg/fed						Oil %						Oil yield/fed kg/fed					
	SU		SP		Dr		SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
V X F X S																		
V1XF1XS1	1437.0	1416.0	1460.3	1470.7	1650.0	1695.2	46.5	46.6	45.6	44.2	45.0	45.7	668.3	660.6	665.6	649.9	792.6	774.9
V1XF1XS2	1392.0	1373.5	1400.0	1411.8	1745.0	1770.2	45.1	45.3	44.3	44.7	42.0	43.2	627.7	621.4	619.7	631.3	733.1	764.2
V1XF1XS3	1323.0	1302.8	1420.2	1430.9	1570.0	1595.2	44.3	44.5	47.1	42.9	43.1	44.3	586.1	579.1	604.2	614.9	677.2	705.7
V1XF1XS4	1365.0	1341.0	1445.2	1433.6	1635.0	1670.4	44.9	44.9	43.2	42.4	42.1	43.3	613.1	601.8	623.7	626.5	688.4	723.4
V1XF2XS1	1480.0	1472.0	1610.0	1621.2	1700.0	1725.2	47.3	45.1	48.0	46.6	45.8	46.9	700.1	663.5	772.7	755.0	779.4	810.6
V1XF2XS2	1433.0	1413.3	1560.1	1569.2	1775.0	1800.3	46.2	44.7	48.5	46.8	46.5	47.1	661.9	631.5	757.0	734.5	826.2	848.1
V1XF2XS3	1370.0	1350.3	1440.0	1451.5	1620.0	1645.3	45.6	43.6	49.2	48.2	46.0	47.1	625.0	513.5	709.3	700.2	745.6	774.9
V1XF2XS4	1400.0	1398.9	1505.0	1516.3	1685.0	1716.9	46.0	44.6	47.1	47.3	45.0	46.2	644.1	623.9	710.1	717.7	758.5	794.1
V2XF1XS1	1315.0	1294.3	1310.2	1319.8	1453.0	1488.2	41.6	41.8	43.5	43.7	43.5	44.7	547.1	541.0	570.0	577.1	632.3	665.9
V2XF1XS2	1279.0	1261.0	1350.3	1362.1	1525.0	1561.7	42.1	42.3	45.3	45.7	42.7	43.9	538.6	532.9	611.9	622.4	642.3	686.7
V2XF1XS3	1237.0	1218.0	1200.0	1211.3	1445.0	1467.7	43.0	43.2	42.1	43.0	45.1	46.5	531.7	525.7	505.6	520.4	652.0	686.2
V2XF1XS4	1266.0	1339.8	1275.0	1287.4	1397.0	1559.7	43.3	43.4	42.1	42.4	44.1	45.4	545.5	537.6	536.8	545.3	616.1	707.4
V2XF2XS1	1330.0	1311.6	1405.0	1414.5	1489.0	1514.2	43.1	42.1	45.5	45.7	46.6	47.6	523.3	532.2	637.3	647.0	693.6	720.6
V2XF2XS2	1290.0	1297.3	1480.1	1491.2	1555.0	1580.2	45.5	45.1	45.7	45.8	45.0	46.3	586.9	584.6	676.5	682.9	699.7	732.3
V2XF2XS3	1263.0	1242.3	1345.5	1357.1	1455.0	1477.8	43.2	43.0	45.4	45.5	44.0	45.8	551.9	534.5	610.7	617.7	640.5	676.9
V2XF2XS4	1285.0	1270.3	1390.9	1354.6	1409.0	1584.3	44.0	43.7	44.3	44.7	43.4	44.7	565.5	554.6	616.1	604.8	611.5	707.7
F value	NS	NS	*	**	**	*	NS	NS	NS	NS	**	**	NS	NS	*	*	**	**
L.S.D.	-	-	-		16.2	15.0	-	-	-	-	1.0	1.0	-	-	24.5	21.2	20.8	15.7

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

CU: Water consumptive use
WUE: Water use efficiency

Su : Surface irrigation
Sp : Sprinkler irrigation
Dr : Drip irrigation

Table 11: Effect of irrigation systems, variety, fertigation and spacing on consumptive use of Canola, 2011/2012 and 2012/2013 seasons.

Treatments	Cu m3/fed						WUE					
	SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Variety												
Serw 6	3012.8	2832.9	1986.7	2015.3	1664.3	1763.7	0.47	0.49	0.74	0.74	1.08	0.97
Pactol	3017.9	3011.7	1982.1	2020.7	1673.3	1784.8	0.43	0.42	0.68	0.67	0.88	0.86
F. value	NS	*	NS	NS	NS	*	**	**	**	**	**	**
L.S.D. 0.05	-	47.1	-	-	-	18.2	0.01	0.02	0.008	0.02	0.04	0.02
Fertigation												
40, 15, 24	3055.0	2961.5	2007.7	2039.7	1683.5	1795.3	0.43	0.44	0.68	0.67	0.93	0.89
60, 30, 36	2975.7	2883.0	1961.1	1996.3	1654.1	1753.2	0.46	0.47	0.75	0.74	1.03	0.93
F. value	*	*	*	*	**	**	**	**	**	**	**	*
L.S.D. 0.05	52.1	49.9	13.4	21.9	12.7	21.2	0.009	0.01	0.01	0.008	0.05	0.02
Spacing												
10 cm 1 pl	2963.2	2886.1	1948.5	1981.8	1641.6	1752.2	0.47	0.48	0.74	0.73	1.05	0.92
10 cm 2 pl	2997.2	2916.2	1974.1	2010.7	1652.6	1764.2	0.45	0.46	0.73	0.73	1.04	0.95
20 cm 1 pl	3043.4	2935.6	2005.9	2037.9	1685.9	1784.9	0.43	0.44	0.67	0.67	0.91	0.87
20 cm 2 pl	3057.6	2951.3	2008.9	2041.6	1694.9	1795.8	0.44	0.45	0.69	0.69	0.92	0.91
F. value	*	NS	*	*	*	*	**	**	**	**	**	**
L.S.D. 0.05	47.8	-	16.1	14.2	17.8	20.9	0.01	0.01	0.007	0.01	0.08	0.02

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

CU: Water consumptive use
WUE: Water use efficiency

Su : Surface irrigation
Sp : Sprinkler irrigation
Dr : Drip irrigation

Table 12: Effect of interactions, VxF, VxS and FxS on consumptive use and WUE of Canola in 2011/2012 and 2012/2013 seasons .

Treatments	Cu m3/fed						WUE					
	SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
V X F												
Serw6 X F1	3069.3	2876.3	2007.5	2040.4	1682.3	1789.7	0.45	0.47	0.71	0.71	0.99	0.94
X F2	2956.3	2789.5	1965.9	1990.3	1646.3	1737.6	0.48	0.51	0.78	0.77	1.17	0.99
Pactol X F2	3040.8	3046.8	2007.9	2039.0	1684.7	1800.9	0.42	0.41	0.64	0.64	0.87	0.84
X F2	2995.1	2976.6	1956.3	2002.4	1661.8	1768.7	0.43	0.43	0.72	0.70	0.89	0.87
F. value	NS	NS	NS	NS	NS	NS	*	NS	*	NS	*	NS
L.S.D. 0.05	-	-	-	-	-	-			0..008		0.008	
V X S												
Serw6 X S1	2971.0	2809.2	1947.9	1982.8	1633.1	1743.4	0.49	0.52	0.79	0.78	1.20	0.98
X S2	2979.2	2615.6	1952.9	2030.1	1643.0	1754.5	0.47	0.50	0.76	0.74	1.15	1.02
X S3	3040.7	2840.7	2026.7	2020.2	1690.5	1770.9	0.44	0.47	0.70	0.71	0.96	0.92
X S4	3060.1	2866.0	2019.2	2028.2	1690.6	1785.8	0.45	0.48	0.73	0.73	1.02	0.95
Pactol X S1	2955.4	2963.0	1949.1	1980.9	1650.1	1760.9	0.44	0.44	0.70	0.69	0.90	0.85
X S2	3015.2	3016.8	1995.3	1991.4	1662.3	1773.8	0.43	0.43	0.71	0.72	0.93	0.89
X S3	3046.1	3030.5	1985.2	2055.6	1681.4	1798.7	0.41	0.41	0.64	0.63	0.86	0.82
X S4	3055.1	3036.4	1998.8	2055.1	1699.2	1805.8	0.42	0.42	0.67	0.64	0.83	0.87
F. value	NS	NS	*	*	NS	NS	NS	NS	**	**	NS	*
L.S.D. 0.05	-	-	22.7	20.1	-	-			0.001	0.02		0.03
F X S												
F1 X S1	3040.3	2944.6	1977.8	2010.5	1660.6	1778.4	0.45	0.46	0.70	0.69	0.94	0.90
X S2	3047.8	2955.4	1990.3	2020.3	1666.9	1784.8	0.44	0.45	0.69	0.70	0.98	0.93
X S3	3061.8	2970.9	2026.8	2057.7	1701.1	1805.4	0.42	0.43	0.65	0.64	0.90	0.85
X S4	3070.2	2975.3	2035.5	2070.2	1705.4	1812.2	0.43	0.44	0.67	0.67	0.89	0.89
F2 X S1	2886.1	2827.7	1919.1	1953.2	1622.5	1725.9	0.48	0.49	0.78	0.78	1.16	0.94
X S2	2946.5	2877.2	1957.8	2001.2	1638.4	1743.3	0.46	0.48	0.77	0.77	1.10	0.97
X S3	3025.0	2900.3	1985.0	2018.0	1670.9	1746.4	0.44	0.45	0.70	0.70	0.92	0.88
X S4	3045.0	2927.2	1982.5	2013.0	1684.4	1779.2	0.44	0.46	0.73	0.71	0.95	0.93
F. value	*	NS	NS	*	NS	NS	NS	NS	**	**	NS	NS
L.S.D. 0.05	67.7	-	-	20.1	-	-			0.02	0.02	0.01	0.02

Table 13: Effect of interactions, V x F x S consumptive use of Canola plants growen in 2011/2012 and 2012/2013 seasons under irrigation systems.

Treatments	Cu m3/fed						WUE					
	SU		SP		Dr		SU		SP		Dr	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
V X F X S												
V1XF1XS1	3060.1	2863.4	1965.5	2025.6	1654.6	1780.4	0.47	0.50	0.74	0.73	1.00	0.95
V1XF1XS2	3065.4	2870.3	1970.4	2040.2	1663.4	1788.5	0.45	0.48	0.71	0.70	1.05	0.99
V1XF1XS3	3071.4	2881.3	2043.5	2044.3	1710.6	1790.4	0.43	0.45	0.69	0.70	0.95	0.89
V1XF1XS4	3080.2	2890.1	2050.6	2051.3	1700.5	1799.4	0.44	0.47	0.70	0.71	0.96	0.93
V1XF2XS1	2882.0	2755.0	1930.2	1940.0	1611.5	1706.5	0.51	0.54	0.83	0.84	1.40	1.01
V1XF2XS2	2893.0	2761.0	1935.2	2020.0	1622.6	1720.5	0.49	0.52	0.80	0.78	1.25	1.05
V1XF2XS3	3010.0	2800.0	2010.0	1996.0	1670.5	1751.5	0.46	0.49	0.72	0.73	0.97	0.94
V1XF2XS4	3040.0	2842.0	1988.0	2005.0	1680.6	1772.2	0.46	0.49	0.76	0.76	1.07	0.97
V2XF1XS1	3020.5	3025.7	1990.4	1995.4	1666.6	1776.4	0.44	0.43	0.66	0.66	0.89	0.84
V2XF1XS2	3030.3	3040.6	2010.4	2000.5	1670.3	1781.5	0.43	0.42	0.67	0.68	0.92	0.88
V2XF1XS3	3052.2	3060.4	2010.3	2071.2	1691.7	1820.4	0.41	0.40	0.60	0.56	0.85	0.81
V2XF1XS4	3060.2	3060.5	2020.4	2089.2	1710.3	1825.6	0.41	0.41	0.63	0.62	0.82	0.86
V2XF2XS1	2890.2	2900.4	1907.9	1966.3	1633.6	1745.4	0.45	0.45	0.74	0.72	0.91	0.87
V2XF3XS1	3000.0	2993.1	1980.3	1982.3	1654.3	1766.2	0.43	0.42	0.75	0.75	0.94	0.90
V2XF2XS3	3040.0	3000.5	1960.0	2040.0	1671.2	1777.2	0.42	0.44	0.69	0.67	0.87	0.83
V2XF2XS4	3050.0	3012.3	1977.0	2021.0	1688.2	1786.1	0.42	0.42	0.71	0.56	0.84	0.89
F value	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS	NS
L.S.D.	-	-	-	-	-	-			0.01	0.02		

10 cm 1 plant/hill
10 cm 2 plant/hill
20 cm 1 plant/hill
20 cm 2 plant/hill

CU: Water consumptive use
WUE: Water use efficiency

Su : Surface irrigation
Sp : Sprinkler irrigation
Dr : Drip irrigation