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Performance of canola (*Brassica napus* l.) genotypes under drought stress

Kandil A.A.*, A.E. Sharief**, Salwa I. El-Mohandes***, M.M Keshta***

*Department of Agronomy, Faculty of Agriculture, Mansoura University, Egypt
** Corresponding Author: Prof. Ali Sharief Agronomy Dept., Fac. of Agric., Mansoura University, Egypt, 35516 El-Mansoura, Egypt Tel: +201222986347 Fax: +2052221688,
*** Agriculture Research Center, Ministry of Agriculture, Egypt.

***Abstract*— *Drought is a wide spread problem seriously influencing rapeseed (Brassica napus L.) production, mostly in dryland regions. To investigate the effects of water deficit on some canola (Brassica napus L.) genotypes. Four drought treatments i.e. 4800m^3/ha, 3840m^3/ha, 2880 m^3/ha and 1920 m^3/ha on yield and yield components of six canola genotypes i.e. Serw 4, Serw 10, Pactol, Line 51. Two field experiments were conducted during 2014/2015 and 2015/2016seasons. Results revealed that irrigation using 3840 m^3/ha at four times came in the second rank for all studied parameters It increased above aforementioned traits using 1920 m^3/ha as two times by 9.4, 26.2, 40.5, 45.6, 46.0,54.4, 20.5, 25.8 and 58.3%, respectively comparing by irrigation using 1920 m^3/ha in two times as average of both seasons. Whereas, sown Serw 4 cultivar surpassed Serw 10 cultivar in plant height, No. of branches/plant, No. of silica/plant, seed weight/plant, seed, oil and protein yield/ha by 3.0, 21.8, 30, 21.6, 33.9, 26.7 and 37.9%, respectively as average in both seasons. It could be recommended that irrigation five times by 4800 m^3/ha of Serw 4 cultivar significantly maximized seed, oil protein yield/ha.*

Keywords*— Brassica napus L., genotypes, drought treatments, seed and oil yield.

I. INTRODUCTION

Increasing plant productivity is one of the main targets of the Ministry of Agriculture in Egypt. This could be achieved through the suitable agricultural practices, i.e. using promising cultivars under different irrigation water regimes. Canola cultivation in Egypt may deliver an opportunity to overcome the shortage of edible oil production in Egypt. Drought tolerance consists of ability of crop for growth and production under water deficit conditions. A long term drought stress effects on plant metabolic reactions associates with, plant growth stage, water storage capacity of the soil and physiological aspects of plant. Canola is one of the most important oil crops in the world [1].The agricultural use of water in the world is more than 85% of total water use, moderate to severe intermittent or terminal drought is a common occurrence, and dry most crops cannot be grown without supplemental irrigation [2]. Water deficits in plants may lead to physiological disorders, such as a reduction in photosynthesis and transpiration [3]. Under drought stress in plant growth is affected by a number of morph-physiological disorders that cause reduction in nutrient uptake and impaired active transport of photosynthesis [4]. It has been observed that seed yield can be hampered, even by short period of soil moisture stress during reproductive stages [5]. Shortage of good quality water limits the production of agricultural crops to varying degree throughout the world, particularly in arid and semi-arid regions [6].The canola cultivars showed a variable response to drought stress and variation mainly depended on the cultivar, growth stage and the plant's ability to tolerate drought stress [7]. Research on drought tolerance in rapeseed is limited and mostly based on a few genotypes [8]. Water deficit during reproductive growth was more than that during vegetative growth of canola [9]. Oil yield was affected by water stress and it was dramatically decreased. Highest seed yield was obtained from GKH1103 cultivars under the conditions of full irrigation. The reproductive growth stage was found to be more sensitive to spells of drought stress than other growth stages [10]. The generated information suggested that managing water supply at reproductive stage to reduce yield losses in canola under the environments with low moisture availability [11]. Therefore, the objectives of this investigation were aimed to explore the educating growth and productivity of canola by using different cultivars at various irrigation water regimes under the reclaimed soils.

II. MATERIALS AND METHODS

2.1. *Research time and location*:

Two field experiments were conducted out at the experimental Station Farm of El-Serw Agricultural Research Station of the Agricultural Research Center, during the two successive winter seasons of 2014/2015 and 2015/2016 to study the performance of canola genotypes to irrigation treatments under newly reclaimed saline soil conditions. Two experiments were designed with a strip plot design in a RCBD with four replications. Each experiment included sixty treatments comprising, four canola genotypes and four irrigation treatments. The horizontal-plots were included the following four irrigation treatments, i.e.1-Irrigation five times (I_1)by 400 m^3 for each (4800m^3/ha).2-Irrigation four times (I_2)by 400 m^3 for each (3840m^3/ha).3-Irrigation three times (I_3)by 400 m^3 for each (2880 m^3/ha).4-Irrigation two times (I_4)by 400 m^3 for each (1920 m^3/ha).The vertical-plots were included the four canola genotypes i.e.1-Serw 4: Egyptian cultivar was produced via anther culture as mid early flowering.2-Pactol: A mid flowering, French cultivar introduced to Egypt by Agriculture Research Center, ARE.3-Serw 10: Local line mid flowering, was produced by Field Crop Institute, Agriculture Research Center, ARE.4-Line 51: Local line late flowering, was produced by Field Crop Institute, Agriculture Research Center, ARE.A plastic strip, sheet between horizontal stripes was made to insulate between the experimental units. Seeds of the studied cultivars were obtained from Oil Research Section, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Each experimental unit included five ridges 60 m apart and 3.5 m long occupying an area of 10.5 m^2. The soil in the preceding crop was sunflower in both seasons. The soil of experimental site was characterized as saline loamy clay soil, PH was 7.8 and 7.7, E.C. dS/m^{-1} was 4.6 and 4.8, Organic matter was 1.28 and 1.31%, available nitrogen was 14.9 and 17.8 ppm and available phosphorus was 41.8 and 39.6 ppm, which mechanical and chemical properties according to [12,13].

2.2. *Agricultural practices:*

The experimental field was well prepared through two ploughings, compaction, division and then divided into the experimental units with dimensions as previously mentioned. Calcium super phosphate (15.5 % P_2O_5) was applied during soil preparation (after ploughing and before division) at the rate of 476 kg/ha. Potassium sulfate (48 % K_2O) at the rate of 178 kg/ha was applied during soil preparation. Nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) was applied at the rate of 108 kg/ha was added in two equal portions before the first and second irrigation. Seed was sown in hills 15 cm apart on 20th and 25th of November for both seasons. The common agricultural practices for growing canola, according to the recommendations of the Ministry of Agriculture were followed, except the factors under study.

2.3. *Studied Characters:*

At harvesting, the middle row was harvested randomly from each plot to estimate the following characters: 1-Number of days to 50% flowering (days):Number of days from sowing to 50% flowers/plot.2- Plant height (cm): It measured from the soil surface to the top of the main stem.3- Number of branches/plant: Its determined from average of five plants.4- Number of silica/plant: It was measured by counting the number of silica/plant from average of five plants.5- Seed weight/plant: It was estimated by weight seed of five plants.6-Oil Percentage: Oil content was determined according to[14]. 7-Crude protein percentage: Total nitrogen was estimated by the improved Kjeldahl method according to [14], modified by distilling the ammonia into saturated boric solution and titration in standard acid. The crude protein percentage was calculated by multiplying the total nitrogen values in canola flour by 5.75. 8-Seed yield/ha: It was calculated by weighting of two ridges and air dried, the seed at 15 % moisture were weighted and converted to kg/ha. 9- Oil yield kg/ha: multiplied with seed yield/ha to obtain protein and oil yields in kg/ha.10-Crude protein yield/ha: It calculated by multiplying the crude protein percentage then multiplied with seed yield/ha to obtain protein and oil yields in kg/ha.

2.4. *Experimental analysis:*

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip - plot design as published by[15]by using MSTAT statistical package (MSTAT-C with MGRAPH version 2.10, Crop and Soil Sciences Department, Michigan State University, USA). Least Significant Difference (LSD) method was used to test the differences between treatment means at the 5 % level of probability as described by[16].

III. RESULTS AND DISCUSSION

3.1. *Drought treatment effects:*

Results accessible in Tables 1 and 2 clearly designated that irrigation five times by 400 m^3 for each, *i.e.* 4800 m^3/ha, 960m^3/ha for each significantly affected No. of days from sowing to 50% flowering, plant height, No. of branches/plant, No. of silica/plant, seed weight/plant, oil and protein percentage, seed, oil protein yield/ha in both 2014/2015 and 2015/2016 seasons. Irrigation using 3840 m^3/ha at four times,960 m^3/ha for each came in the second rank for all studied parameters It increased above aforementioned traits using 1920 m^3/ha as two times960 m^3/ha by 9.4, 26.2, 40.5, 45.6, 46.0,54.4, 20.5, 25.8 and 58.3%, respectively comparing by irrigation using1920 m^3/ha in two times as average of both seasons. The results showed that increases in seed yield/ha due to irrigation five times using 4800 m^3/ha960 m^3/ha may be due to increases in yield attributes such as number of branches, silica and seed/plant as shown in Table (1). Regarding to increases in both oil and protein yields/ha due to irrigation five times using 4800 m^3/ha,960 m^3/ha, it’s the fact that these increases due to increases in seed yield/ha and both oil and protein percentages as shown in Table (2).Results revealed that reducing irrigation to two times by 400 m^3 for each, *i.e.* 1920 m^3/ha recorded the lowest values of No. of days from sowing to 50% flowering, plant height, number of branches, silica and seed/plant, oil and protein percentage, seed, oil protein yield/ha in both 2014/2015 and 2015/2016 seasons. Physiological growth indices were reduced under drought stress. This condition can be the most important environmental factor for the increase of total dry matter of control of irrigation [17]. A long term drought stress effects on plant metabolic reactions associates with, plant growth stage, water storage capacity of the soil and physiological aspects of plant. Canola is one of the most important oil crops in the world[1].The agricultural use of water in the world is more than 85% of total water use, moderate to severe intermittent or terminal drought is a common occurrence, and dry most crops cannot be grown without supplemental irrigation [2].Regularly, water deficit stress has detrimental effects on many processes in plants, which include reducing photosynthesis, accumulation of dry matter, stomatal exchanges, and protein synthesis that affects their growth stages[18,19].Grain yield showed high sensitivity to water deficit, proving that irrigation can definitely benefit crop grain yield [20]. Generally, plants respond to water deficit stress through developmental, biochemical and physiological changes and the type of the observed response depends on several factors such as stress intensity (SI), stress duration and genotype [21]. The stresses imposed at a later stage of development, reduce sink size, shorten the duration of seed filling and decrease the opportunity of crop to recover. Irrigation had more influence on seeds per pod than other yield components and water deficit influenced flowering to maturity stages more than other growth stages [5]. Water stressed conditions, those of rapeseed cultivars which were able to maintain their relative water content at high levels had a higher seed yield. Since water stress during seed development did effect on the sink size (seeds per plant), decreased source capacity led to reduction of seed weight [22].A similar result was reported by[3,4,5,6,23].

3.2. ***Canola genotypes performance:***

Regarding to canola genotypes performance, the results existing in Tables 1 and 2 clearly showed that studied canola genotypes significantly differed in No. of days from sowing to 50% flowering, plant height, number of branches, silica and seed/plant, oil and protein percentage, seed, oil protein yield/ha in both 2014/2015 and 2015/2016 seasons. Sown Serw 4 cultivar surpassed studied canola genotypes in all above aforementioned traits followed by sown Line 51 and Serw 10 cultivar came in the last rank in both seasons. The results clearly showed that sown Serw 4 cultivar surpassed Serw 10 cultivar in plant height, No. of branches/plant, No. of silica/plant, seed weight/plant, seed, oil and protein yield/ha by 3.0, 21.8, 30, 21.6, 33.9, 26.7 and 37.9%, respectively as average in both seasons. The results displayed that Serw 4 cultivar recorded highest values in seed yield/ha may be due to increases in yield attributes such as number of branches, silica and seed/plant as shown in Table (1). Whereas, Serw 4 surpassed studied genotypes in both oil and protein yields/ha due to increases in seed yield/ha and both oil and protein percentages as shown in Table (2). Fido cultivar surpassed Tower in all traits under study which gave seed yield/fed by 12.05% as an average of both seasons [24]. Cultivators the L210 selected as the best cultivar for the normal condition and the L73 is the best cultivars in stress was started from the stem elongation stage and stress was started from flowering stage, also, the cultivar L183 is the best cultivars in stage of stress was started with pod formation [25]. Karaj3 and Talaye cultivars showed the highest seed yield in normal and stress conditions, respectively [26]. The canola cultivars showed a variable response to drought stress and variation mainly depended on the cultivar, growth stage and the plant’s ability to tolerate drought stress [7]. Research on drought tolerance in rapeseed is limited and mostly based on a few genotypes [8]. The effect of water deficit during reproductive growth was more than that during vegetative growth of canola [9].The least reduction of seed yield in water deficit conditions has produced in Zarfam cultivar. Also, this cultivar had lower decreasing of oil yield in stress conditions and it has the best adaptation in water deficit conditions. These results may be due to the reduction of photosynthesis and chlorophyll content [27]. Oil yield was affected by water stress and it was dramatically decreased. Highest seed yield was obtained from GKH1103 cultivars under the conditions of full irrigation. The reproductive growth stage was found to be more sensitive to spells of drought stress than other growth stages [10]. The generated information suggested that managing water supply at reproductive stage to reduce yield losses in canola under the environments with low moisture availability [11].

3.3. ***Interaction between drought treatments and studied genotype effects:***

Concerning to the interaction between drought treatments and studied canola genotypes, the results accessible in Tables 1 and 2 clearly indicated that this interaction insignificantly affected No. of days from sowing to 50% flowering, plant height, number of branches, silica and seed/plant, oil and protein percentage in both 2014/2015 and 2015/2016 seasons. Results graphically illustrated in Fig 1, 2, 3, 4, 5 and 6 showed that irrigation five times by 400 m^3 for each, *i.e.* 4800 m^3/ha of Serw 4 cultivar significantly increased seed, oil protein yield/ha in both 2014/2015 and 2015/2016 seasons. However, Serw 10 cultivar when irrigated with two times by 960 m^3/ha for each, *i.e.* 1920 m^3/ha recorded the lowest values of above aforementioned traits in both seasons. Water stress significantly limits plant growth and crop yield. Hence, the efficient management of soil moisture and the study of metabolic changes which occur in response to drought stress are important for agriculture. Cultivars differed significantly with respect to seed yield. Zarfam and Elvice cultivars under stress condition had the lowest seed yields. They suggested that, Zarfam and Elvice cultivars would be important for breeding programs designed for water-stress environments and in identifying drought-tolerant lines under arid and semi-arid conditions [28].The high oil yield and thousand grain weight were achieved by Okapi cultivar under control irrigation, highest grain yield and silique number per plant were obtained by Licord cultivar under control irrigation and highest grain number per silique was achieved by Zarfam cultivar under control irrigation and high drought tolerance index was exhibited by Licord cultivar [17].Reason of the grain yield reduction in different cultivars can be due to the level of used stress and its effect on some yield components such as pod per plant, seed per pods and the weight of thousand seeds [27]. The interaction between water deficit stress and type of cultivars affected yield, grain per pod, pod per plant and length pod. 'Hyola 308' and 'Sarigol' showed highest and lowest yields under stress conditions [29].

IV. CONCLUSION

It could be recommended that irrigation five times by 4800 m^3/ha,960 m^3/ha of Serw 4 cultivar significantly maximized seed, oil and protein yield/ha.

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Table.1: Mean of No. of days to 50% flowering, plant height, No. of branches/plant, No. of silica/plant and seed weight/plant as affected by irrigation treatments of some canola genotypes during 2014/2015 and 2015/2016 seasons.

Treatments	No. of days to 50% flowering		Plant height (cm)		No. of branches/plant		No. of silica/plant		Seed weight/plant (g)	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A. Irrigation treatments:										
I_1:4800m³/ha.	86.8	93.7	175.2	178.0	11.2	12.5	993.8	1120.2	83.0	92.8
I_2:3840m³/ha.	84.1	90.3	163.7	173.1	10.1	11.3	922.2	1050.3	74.0	82.0
I_3:2880 m³/ha.	81.6	87.8	151.8	162.5	9.1	10.3	741.2	876.9	55.5	62.3
$I_4$1920 m³/ha.	79.8	83.7	138.1	146.8	6.7	7.4	514.3	633.9	45.3	49.6
F-test	*	*	*	*	*	*	*	*	*	*
L.S.D. 5%	1.5	1.0	1.9	3.0	0.8	1.5	10.2	9.0	2.3	3.4
B. Canola genotypes:										
Serw 4	84.1	86.2	156.5	166.5	10.8	12.1	958.2	1163.9	77.5	82.1
Pactol	83.2	89.5	157.1	161.2	9.2	10.0	726.8	800.6	62.4	69.5
Serw 10	79.8	89.5	152.8	160.5	8.8	9.1	716.9	768.3	60.0	65.1
Line 51	85.1	90.3	163.0	172.1	9.4	10.3	869.6	948.5	64.9	70.0
F-test	*	*	*	*	*	*	*	*	*	*
L.S.D. 5%	1.9	1.8	1.7	2.9	0.9	1.4	8.1	12.8	1.4	3.0
Interaction AXB										
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table.2: Mean of seed yield t/ha, oil and protein percentage and oil and protein yield kg/ha as affected by irrigation treatments of some canola genotypes during 2014/2015 and 2015/2016 seasons.

Treatments	Seed yield t/ha		Oil%		Protein%		Oil yield kg/ha		Protein yield kg/ha	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A. Irrigation treatments:										
I_1:4800m^3/ha.	2.329	2.551	43.1	43.5	37.9	37.9	1003.9	1110.8	882.7	964.1
I_2:3840m^3/ha.	2.062	2.115	42.5	42.8	37.6	37.6	876.0	905.0	774.9	799.2
I_3:2880 m^3/ha.	1.561	1.650	41.6	42.0	33.5	33.1	649.2	691.9	530.4	550.5
$I_4$1920 m^3/ha.	1.082	1.132	39.2	39.6	28.2	28.0	431.3	448.5	306.0	318.0
F-test	*	*	*	*	*	*	*	*	*	*
L.S.D. 5%	0.018	0.027	0.7	0.6	0.7	0.7	11.7	15.3	10.6	13.4
B. Canola genotypes:										
Serw 4	2.051	2.248	41.6	41.7	35.0	35.1	709.4	946.5	718.3	814.1
Pactol	1.685	1.854	41.6	41.8	34.2	34.1	700.5	785.7	576.0	655.2
Serw 10	1.381	1.456	42.2	42.9	33.5	33.1	582.5	629.7	462.5	488.8
Line 51	1.726	1.892	41.1	41.4	34.3	34.4	612.9	796.8	593.8	673.4
F-test	*	*	*	*	*	*	*	*	*	*
L.S.D. 5%	0.017	0.023	0.7	0.6	0.9	0.8	11.2	18.7	10.6	17.2
Interaction AXB										
F-test	*	*	N.S.	N.S.	N.S.	N.S.	*	*	*	*

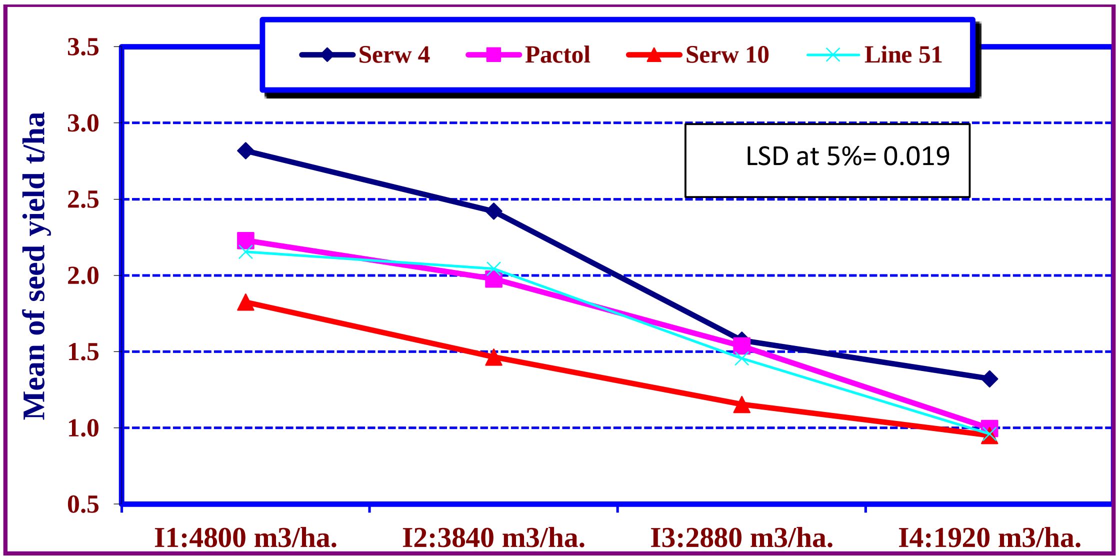

Fig..1: Mean of seed yield t/haas affected by irrigation treatments and canola genotypes during 2014/2015 seasons.

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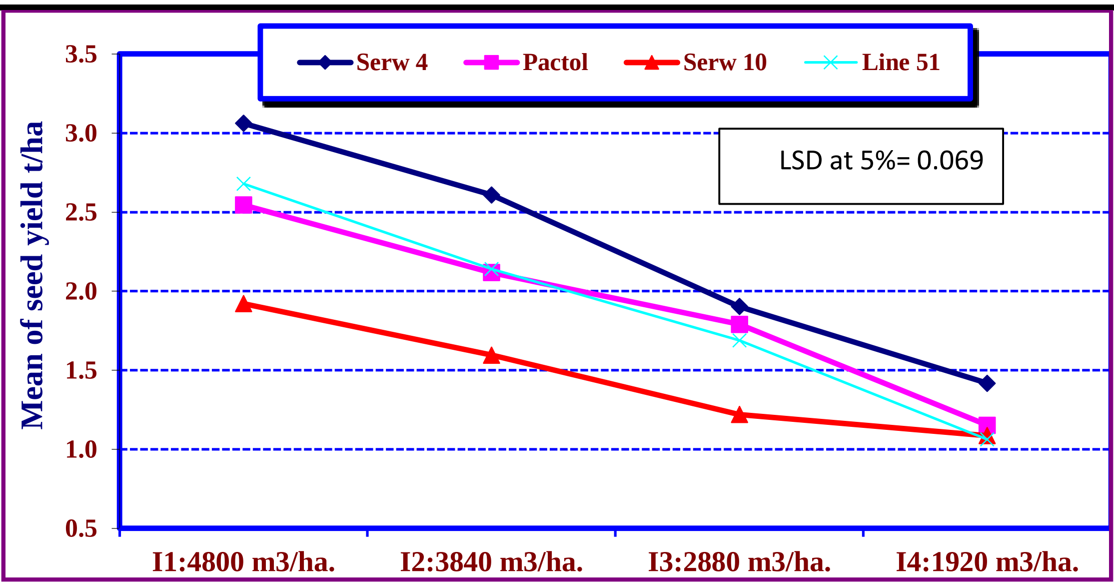

Fig. 2: Mean of seed yield t/haas affected by irrigation treatments and canola genotypes during 2015/2016 seasons.

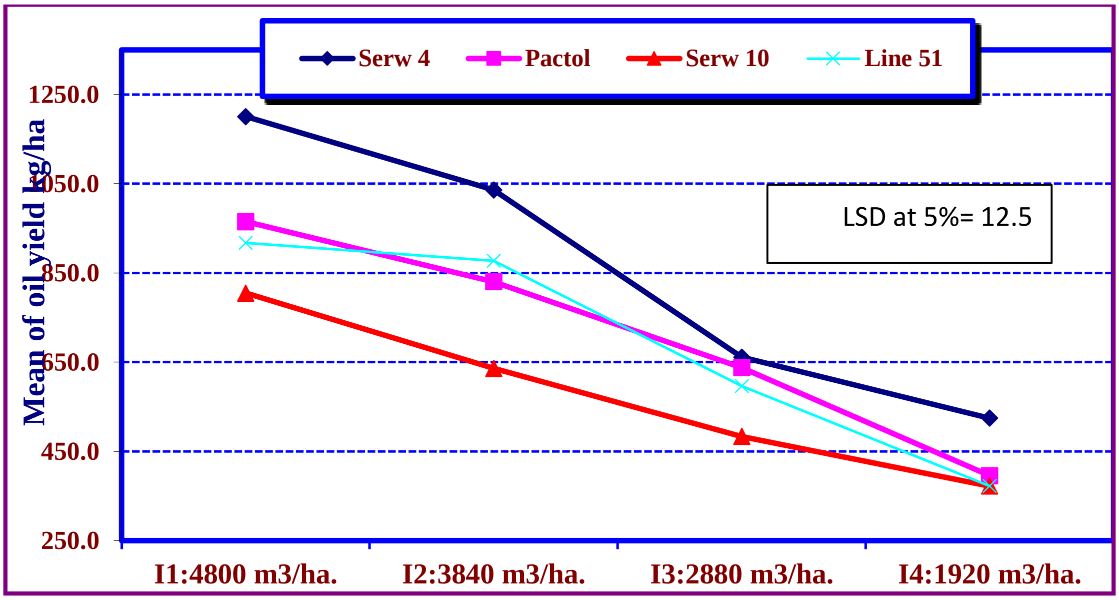

Fig. 3: Mean of oil yield kg/haas affected by irrigation treatments and canola genotypes during 2014/2015 seasons.

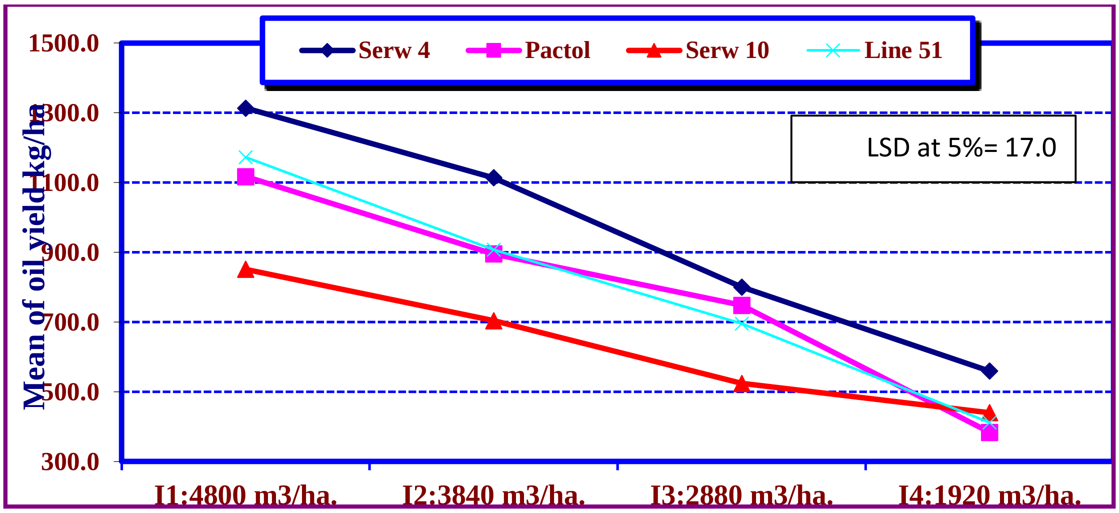

Fig. 4: Mean of oil yield kg/haas affected by irrigation treatments and canola genotypes during 2015/2016 seasons

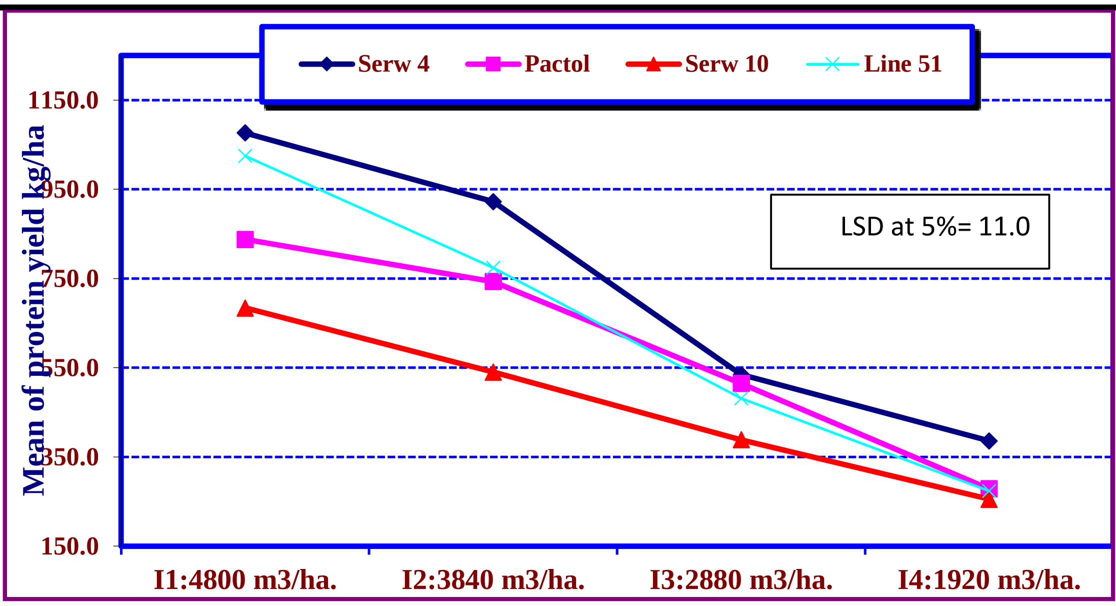

Fig. 5: Mean of protein yield kg/haas affected by irrigation treatments and canola genotypes during 2014/2015 seasons.

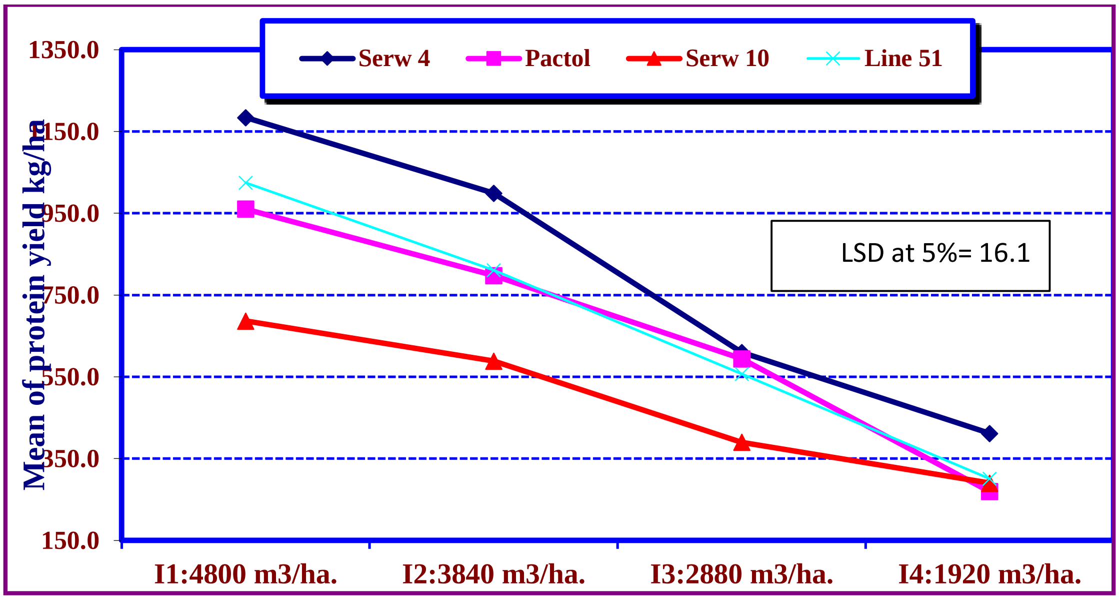

Fig. 6: Mean of protein yield kg/haas affected by irrigation treatments and canola genotypes during 2015/2016 seasons.