INFLUENCE OF SOWING DATES AND PLANT DENSITY ON GROWTH AND YIELD OF CANOLA (*Brassica napus*, L.) UNDER SALT AFFECTED SOILS IN EGYPT

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Abstract

Field Experiments were conducted during 1995/96 and 1996/97 growing seasons to study the effect of three sowing dates (15th October, 5th November and 25th November), three plant population densities (8.3, 10.9 and 16.6 plants/m^2) and their interactions on growth and yield of canola "cv. Pactool" under saline conditions. The interrelationships among oil yield / fad and its attributes through simple correlation, multiple linear regression and stepwise regression analysis were also evaluated.

Results showed that sowing canola on 5th November resulted in marked increases in plant height, number of branches / plant as well as seed yield / plant, seed, biological and oil yields / fad, compared with that sown on 15th October and 25th November in both seasons. The highest seed oil percentage was obtained from early planting on mid-October. Highest number of days to 50 % flowering was recorded from sowing on 5th November.

Increasing plants population density from 8.3, 10.9 to 16.6 plants / m^2 significantly increased plant height as well as seed, biological and oil yields/faddan, however, decreased number of branches / plant and seed yield / plant. Number of days to 50 % flowering and seed oil percentage was insignificantly affected by plant population density.

Interaction between sowing dates and plant population density had significant effects on seed yield / plant and faddan in both seasons. A positive and significant correlation coefficients were found between oil yield / faddan and seed yield / faddan, plant height and seed oil percentage.

Multiple linear regression analysis indicated that seed yield / fad (R^2 = 99.8 %) and seed oil percentage (R^2=45.83 %) were the most important variables contributing toward oil yield / fad. Also, stepwise regression analysis showed that seed yield / fad (R^2 = 99.88 %) and seed oil percentage (R^2 = 44.55 %) were the most important variables towards oil yield / faddan.

Finally, it can be concluded that sowing canola in the first week of November at plant population density of 70000 plants / fad was recommended for maximizing seed and oil yields per unit area under the environmental conditions of this study.

Introduction

Canola (*Brassica napus*, L.) has recently been introduced to Egypt hoping to overcome oil deficiency. Little, if any, is known about agricultural practices to maximize canola oil production in Egypt. Sowing time is an important factor that determines the length of growing season and hence yields. Early spring sowing of oil canola delayed flowering and reduced reflection of radiation during flowering which were important factors leading to the highest yields achieved by late sowing (Jenkins and Leitch, 1986). Jasinska *et al.* (1989) reported that seed and oil yields / ha decreased with delay in sowing date. Thomas *et al.* (1990) reported that autumn rape plant density was significantly greater with sowing on late October or early November than on mid - October sowing. Kumar and Shaktawat (1993) found that seed yield / ha significantly increased from late sowing on 22 September, compared with 8 or 15 September sown. Moreover, Leto *et al.* (1995) found that sowing on mid-November produced the highest seed yield / ha, compared to sowing on 31 October, 30 November or mid - December. Johnson *et al*. (1995) reported that the greatest canola seed yield / ha were recorded when sown in early and mid - May with reductions occurring at the later sowing dates. Starner *et al.* (1996) reported that optimum sowing dates for rape cv. Cascade was at late September or early October. Christmas and Janick (1996) showed that winter rape can be successfully grown in northern Indiana and if sown between 25 August and 20 September and that sowings made during September are most likely to be successful in southern Indiana. Meanwhile, Nehra *et al.* (1997) found that seed yield decreased as sowing date delayed.

Another important factor controlling yield is planting density. Boelcke *et al.* (1991) reported that sowing oil seed rape at 60 seeds / m^2 in August maximized seed yield/ha. Chauhan *et al.* (1993) showed that decreasing row spacing from 20, 30 to 40 cm apart significantly increased number of branches / plant and seed yield / plant. The highest seed and oil yields / ha were obtained from the planting on rows 30 cm apart. Recently, Bassal *et al.* (1998) showed that the highest seed and oil yields / fad were produced from increasing plant population density up to 70000 plants / fad.

Concerning the interaction between sowing date and plant population density, Kumar and Shaktawat (1993) stated that sowing on 20 September in rows 40 cm apart produced the highest seed yield / ha, compared with other sowing dates and plant densities. Sowing dates and plant densities significantly affected seed oil content. Saini and Sidhu (1997) reported that highest seed yield was produced from the optimum sowing date in mid - October and row spacing of 60 cm.

The present investigation was aimed to study the effect of different planting date and plant population densities on growth and yield of canola. The interaction effect on the productivity and seed quality will be also studied in the new reclaimed salty lands nearly El-Manzala lake, Egypt. Also, to study the interrelationships between oil yield and its attributes through simple correlation coefficients, multiple linear regression and stepwise regression analysis.

Materials And Methods

Two fields experiments were carried out during 1995/96 and 1996/97 growing seasons at the Experimental Station Farm of El Serw Agricultural Research Station to study the effect of sowing dates and plant population density as well as their interaction on yield and yield components of canola (cv. Pactol). The experimental soil was heavy clay salty in texture with pH 8.6 and 8.4, available nitrogen was amounted 11.9 and 12.1 ppm, available phosphorus was 9.5 , 10.1 ppm and exchange potassium was 201, 219 ppm in the first and second seasons, respectively of the upper 30-cm of the soil.

A spilt-plot design with four replicates was used. Three sowing dates i.e. 15th October, 5th November and 25th November were assigned to main plots. The sub-plots were devoted to three plant population densities (8.3, 10.9 and 16.6 plants / m^2) i.e. 35000, 46000 and 70000 plants / fad, respectively. The experimental unit included five ridges 60 cm in width and 3.5 m length, (i.e. 10.5 m^2 = 1/400 fad). Phosphorus as calcium superphosphate (15.5 % P_2O_5) at a rate of 15.5 Kg P_2O_5 / faddan and potassium as potassium sulphate (48 % K_2O) at a rate of 24 Kg K_2O / faddan were applied during soil preparation. Nitrogen was given as urea (46.5 % N) at a rate of 45 Kg N /

fad, in two equal portions, one added before sowing and the rest was added after thinning and just before the second irrigation. Seeds were hand sown on one side of the ridge according to the dry method on 15th October, 5th November and 25th November in both seasons. Seeds were placed in hills 10, 15 and 20 cm apart. Thinning took place after 20 days from sowing to one plant per hill given plant population density of 8.3, 10.9 and 16.6 plants / m^2 i.e. 35000, 46000 and 70000 plants / faddan. The normal recommended agronomic practices were followed except factors under study.

Number of days to 50 % flowering was determined for each sub - plot. At harvest, ten guarded plants were taken at random from each sub plot and the following characters were determined: plant height (cm), number of branches / plant, seed yield / plant and seed oil percentage. Biological and seed yields / faddan were recorded according to the yield taken from the two central ridges. Oil yield / faddan was calculated by multiplying seed yield per faddan by seed oil percentage. Seed oil percentage was determined according to A.O.A.C. (1984) by using soxhelt apparatus and petroleum ether as an organic solvent and then the oil percentage was calculated on dry weight basis.

Data were exposed to the appropriate statistical analysis as the technique on analysis of variance of the split-plot design as mentioned by Gomez and Gomez (1984). Least significant difference (LSD) at 5% level of significance was used to compare treatment means. Data over both seasons of oil yield / fad and its attributes were subjected to simple correlation coefficients and multiple linear regression analysis according to Sendecor and Cochran (1980) to construct the prediction model for oil yield of canola was performed.

Stepwise regression analysis was done as applied by Draper and Smith (1996) to determine the best variables accounted for most variance in oil yield. The relative contribution was calculated as coefficient of determination (R^2).

Results And Discussion

Results in Tables 1 and 2 showed marked differences in most of the studied characteristics. Sowing canola in November 5th significantly

surpassed both early sowing on mid - October or late sowing on November 25th in both seasons in plant height, number of branches / plant, seed yield / plant, seed, oil and biological yields / fad. However, the early sowing on mid - October markedly surpassed others in seed oil percentage in both seasons. Days after sowing to 50 % of flowering significantly increased when sowing on 5th November followed by sowing on mid – October, while the sowing on 25th November came in the last rank. Sowing canola on November 5th exceeded those sown in mid-October and late November in plant height by 4.1, 14.0 %, number of branches / plant by 34.7, 47.8 %, seed yield / plant by 21.9, 25.8 %, seed yield / fad by 27.2, 71.1 %, biological yield by 30.5, 24.9 % and oil yield by 26.3, 74.1 % over both seasons compared with those sown on mid - October and 25th November, respectively. The increases in seed yield / faddan may be attributed to the increase in seed yield / plant, number of branches / plant and plant height. It could be stated that planting canola on November 5th was the most suitable sowing date for canola because late sowing on November 25th may reduce the growth period and reducing number of days to 50 % flowering (Table 1) as well as reduced number of branches / plant that reflected increases in seed yield / faddan. These results are in similar to that obtained by Thomas *et al.* (1990), Leto *et al.* (1995), Starner *et al.* (1996) and Saini and Sidhu (1997).

The response of seed yield and its attributes to plant population density are presented in Tables (1) and (2). Significant differences were found for all studied characters as affected by plant population density except number of days to 50 % flowering and seed oil percentage in both seasons. Increasing plant population density from 8.3, 10.9 to 16.6 plants / m^2 significantly increased plant height, seed yield / faddan, biological and oil yields / faddan, but decreased number of branches / plant and seed yield / plant. Moreover, plant population density insignificantly affected number of days to 50 % flowering and seed oil percentage in both seasons. The increases in plant height and decreases in number of branches / plant and seed yield / plant due to increase plant population density may be attributed to more competition between plants for light, water and nutrients. The increases in seed, biological and oil yields / fad due to increases in plant population density may be attributed to increases in number of plants per unit area. It could be stated that increasing plant population density up to

16.6 plants / m^2 significantly increased seed yield by 15.6 and 8.7 % as well as oil yield by 15.3 and 8.7 % compared with plant density of 8.3 and 10.9 plants / m^2, respectively over both seasons. The increase in seed yield / fad due dense population may be attributed to the reduced competition from weeds as well as to the more light absorption by plant canopies thus increasing crop photosynthetic capacity. These results are in good accordance with those reported by Chauhan *et al.* (1993), Kumar and Shaktawat (1993) as well as Bassal *et al.* (1998).

Table (1)

Means of plant height, no. of branches/plant, number of days to 50 % flowering and seed yield /plant as affected by sowing date and plant population density in 1995 and 1996 seasons.

Characters	Plant height (cm)		branches / plant (No.)		Days to 50 % flowering		Seed yield / plant	
Treatments	95/96	96/97	95/96	96/97	95/96	96/97	95/96	96/97
Sowing date:								
15th October	170.9	185.8	4.8	5.3	107.6	111.9	20.3	21.7
5th November	182.6	188.7	6.6	7.0	113.3	115.9	25.1	26.1
25th November	151.2	174.6	4.0	5.2	103.6	107.2	18.6	19.4
F-test	**	**	**	**	**	**	**	**
LSD at 5%	3.0	4.9	0.3	0.3	0.6	0.8	1.3	1.2
LSD at 1%	4.5	7.4	0.5	0.5	1.0	1.2	2.0	1.8
Plant density:								
35000 pl/fad	164.1	178.8	6.7	7.0	108.7	111.9	25.9	28.1
46000 pl/fad	167.5	184.2	5.6	6.0	108.0	111.9	22.2	22.9
70000 pl/fad	173.1	186.3	3.1	4.4	107.8	110.6	15.9	16.3
F-test	**	**	**	**	N.S	N.S	**	**
LSD at 5%	3.2	3.5	0.4	0.4	---	---	0.9	1.0
LSD at 1%	4.3	4.8	0.6	0.5	---	---	1.2	1.4
Interaction:								
F-test	N.S	N.S	N.S	N.S	N.S	N.S	**	**

(**) and (N.S) significantly and insignificantly at 1% probability, resp.

Table (2)

Means of oil percentage, seed, biological and oil yields /fad as affected by sowing date and plant population density in 1995 and 1996 seasons.

Characters / Treatments	Oil %		Seed yield (kg/fad)		Biological yield (ton/fad)		Oil yield (kg/fad)	
	95/96	96/97	95/96	96/97	95/96	96/97	95/96	96/97
Sowing date:								
15th October	45.03	45.62	916.2	943.6	4.946	5.136	412.9	428.6
5th November	44.91	44.90	1141.7	1224.2	6.490	6.667	513.6	549.5
25th November	43.33	44.10	683.6	699.0	4.432	4.961	302.7	308.1
F-test	**	**	**	**	**	**	**	**
LSD at 5%	0.38	0.11	18.2	21.6	0.198	0.308	11.3	12.6
LSD at 1%	0.57	0.17	27.6	32.7	0.299	0.515	17.1	19.0
Plant density:								
35000 pl/fad	44.38	44.92	859.2	884.3	4.804	4.960	386.3	396.5
46000 pl/fad	46.56	44.75	904.9	950.0	5.270	5.680	406.9	424.1
70000 pl/fad	44.33	44.95	977.5	1038.5	5.774	6.047	437.0	465.7
F-test	N.S	N.S	**	**	**	**	**	**
LSD at 5%	---	---	18.7	19.1	0.214	0.230	9.8	8.6
LSD at 1%	---	---	25.9	26.5	0.295	0.316	13.6	11.9
Interaction:								
F-test	N.S	N.S	*	**	N.S	N.S	N.S	N.S

(**) and (N.S) significantly and insignificantly at 1% probability, resp.

In both seasons, the interaction between sowing date and plant population density had a significant effect on seed yield / plant and per faddan (Tables 3 and 4). Sowing canola on November 5th with the density of 8.3 plants / m^2 produced the highest seed yield / plant (30.6 and 31.9 gm / plant in the first and second seasons, respectively). However, the lowest seed yield / plant was obtained from sowing canola on November 25th and plant density of 16.6 plants /m^2, which produced 14.5 and 14.7 gm / plant in the first and second seasons, respectively. Maximum seed yield / faddan was produced with sowing canola on November 5th at density of 16.6 plants / m^2, which gave 1231.3 and 1315.0 Kg / faddan in the first and second seasons, respectively. However, the lowest seed yield / faddan was obtained from sowing canola on November 25th and plant population density 8.6 plants / m^2, and were 653.3 and 657.5 Kg / fad in the first and second seasons, respectively. These results in good agreement with those reported by

Kolsavici and Er (1988), Kumar and Shakatawat (1993) as well as Saini and Sidhu (1997).

It could be recommended that the planting date should be in November 5th and planting 16.6 plant/m2 to give maximum seed yield/fad in the region of salty reclaimed soil nearly El-Manzala lake North Delta region, Egypt.

Table (3)

Averages of seed yield/plant as affected by the interaction between sowing date and plant population density in 1995 and 1996 seasons

Season / Treatments	1995			1996		
	15th October	5th November	25th November	15th October	5th November	25th November
Plant density:						
35000 pl/fad	24.3	30.6	22.9	27.3	31.9	25.2
46000 pl/fad	21.1	27.3	18.3	21.9	28.3	18.4
70000 pl/fad	15.6	17.6	14.5	15.9	18.2	14.7
F-test		**			**	
LSD at 5%		2.1			1.2	
LSD at 1%		2.9			2.2	

Table (4)

Averages of seed yield/fad as affected by the interaction between sowing date and plant population density in 1995 and 1996 seasons.

Season / Treatments	1995			1996		
	15th October	5th November	25th November	15th October	5th November	25th November
Plant density:						
35000 pl/fad	861.1	1063.2	653.3	870.3	1125.2	657.5
46000 pl/fad	911.3	1130.8	672.5	895.6	1232.4	722.0
70000 pl/fad	976.3	1231.3	725.0	1065.0	1315.0	717.5
F-test		*			**	
LSD at 5%		20.2			19.5	
LSD at 1%		---			27.1	

The interrelationship among oil yield / faddan and yield attributes was measured using simple correlation technique Table (5). It can be seen from data that positive and significant correlation coefficients were found between oil yield and seed yield / fad (0.999), plant height (0.787) and seed oil percentage (0.685). Seed yield / fad significantly and positively associated with plant height (0.783) and seed oil percentage (0.668). Seed oil percentage positively and significantly correlated with plant height (0.949).

A positive and significant correlation coefficient was also found between number of branches / plant and seed yield / plant (0.949).

Table (5)

Simple correlation coefficients of oil yield /faddan as affected by yield attributes (Data over both seasons)

Variables	5	4	3	2	1
Y: Oil yield /fad	0.999 **	0.685 **	0.261	0.313	0.787 **
1- Plant height	0.783 **	0.781 **	0.165	0.263	1.000
2- No. of branches/plant	0.314	0.344	0.949 **	1.000	
3- Seed yield/plant	0.261	0.301	1.000		
4- Oil %	0.668 **	1.000			
5- Seed yield/fad	1.000				

Data in Table (6) shows the relative contribution for yield components in predicting oil yield / faddan, regression coefficient and standard error. By examining this Table, it can be noted that, adjusted squared R (R^2 = 99.92 %) of the total variation in oil yield / fad. could be linearly related to variations in all variables and 0.08 % could be due to residual. The most important variables that contributing towards oil yield / fad were seed yield / fad (R^2 = 99.84 %) and oil percentage (R^2 = 45.83 %).

Table (6)

The relative contribution of 5 characters in predicting oil yield/fad of rapeseed by using multiple linear regression analysis (Data over both seasons)

Variables	Regression coefficient	Standard error	Relative contribution (R^2 %)
1- Plant height	- 0.0807	0.1052	4.68
2- No. of branches/plant	- 0.6605	1.3166	2.05
3- Seed yield/plant	0.1082	0.4215	0.55
4- Oil %	5.1358	1.6118	45.83 **
5- Seed yield/fad	0.4532	0.0053	99.84 **
Y intercept = -218.3605		Adjusted R^2 = 0.9992	
R^2 = 0.9994		Multiple R = 0.9997	

Variables acceptance and removal and relative contributions of variables in predicting oil yield / fad are given in Table (7). The results indicated that seed yield / faddan (R^2 = 99.88 %) and seed oil percentage (R^2 = 44.55 %) were accepted as significantly contributing to variation in oil yield / fad. The prediction equation of oil yield / fad (Y) was formulated as follows: $Y = -190.3572 + 0.4503\ X_1 + 4.2232\ X_2$, Where X_1 = seed yield / fad and X_2 = seed oil percentage.

According to this equation, adjusted squared R = 99.94 % of the total variation in oil yield / fad and 11.21 % could be due to removal variables. Seed yield / faddan (R^2 = 99.88 %) and seed oil percentage (R^2 = 44.55 %) were the important variables toward oil yield / faddan.

Table (7)
Accepted and removal variables according to stepwise analysis and their relative contribution (R^2 %) in oil yield variance in rape seed
(Data over both seasons)

Variables	Regression coefficient	Standard Error	Relative contribution (R^2 %)
Accepted variables:			
1- Seed yield/ fad	0.4503	0.0040	99.88 **
2- Oil %	4.2232	1.2165	44.55 **
Removed variables:			
1- Plant height			5.19
2- No. of branches/plant			4.04
3- Seed yield/plant			1.98
Y intercept = -190.3572		Adjusted R^2= 0.9993	
R^2 = 0.9994		Multiple R = 0.9997	

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تأثير مواعيد الزراعة والكثافة النباتية على نمو ومحصول الكانولا تحت ظروف الأراضي المتأثرة بالأملاح في مصر

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الملخص :

أجريت هذه الدراسة بمحطة البحوث الزراعية بالسرو تحت ظروف الأراضي الملحية خلال موسمي ١٩٩٦/٩٥ ، ١٩٩٧/٩٦ بهدف دراسة تأثير مواعيد الزراعة والكثافة النباتية على إنتاجية الكانولا وعلاقة محصول الزيت ببعض صفات مكونات المحصول من خلال معامل الارتباط البسيط، معامل الانحدار المتعدد ومعامل الانحدار المرحلي٠

أثرت مواعيد الزراعة معنويا على جميع الصفات تحت الدراسة، حيث سجلت زراعة الكانولا في الخامس من نوفمبر أعلى قيم لصفات طول النبات وعدد الفروع / نبات، محصول البذور / نبات ، المحصول البيولوجي، محصول البذور والزيت للفدان في كلا موسمي الزراعة مقارنة بالزراعة في منتصف أكتوبر أو في الخامس والعشرون من نوفمبر. لقد سجل ميعاد الزراعة في منتصف أكتوبر أعلى قيم لنسبة الزيت بالبذور. لقد سجل ميعاد الزراعة في الخامس والعشرون من نوفمبر أقل عدد من الأيام حتى ٥٠ ٪ إزهار في كلا موسمي الزراعة.

أدت زيادة الكثافة النباتية حتى ٧٠٠٠٠ نبات للفدان إلى زيادة معنوية في طول النبات والمحصول البيولوجي ومحصول البذور والزيت للفدان بينما انخفض عدد الفروع / نبات ومحصول البذور / نبات بزيادة الكثافة النباتية. لم تتأثر كل من صفتي نسبة الزيت بالبذور وعدد الأيام حتى ٥٠ ٪ أزهار.

أثر التفاعل بين مواعيد الزراعة والكثافة النباتية تأثيرا معنويا على صفة محصول البذور للنبات والفدان في كلا موسمي الزراعة وكان هناك ارتباط معنوي موجب بين محصول الزيت /فدان وكل من محصول البذور/فدان، طول النبات ونسبة الزيت .

أوضحت نتائج تحليل معامل الانحدار المتعدد أن محصول البذور/فدان ونسبة الزيت بالبذور هي الصفات الأكثر أهمية ومساهمة في محصول الزيت للفدان.

يمكن التوصية بزراعة الكانولا في النصف الأول من شهر نوفمبر بمعدل ٧٠٠٠٠ نبات للفدان للحصول على أعلى إنتاجية من محصول البذور والزيت لوحدة المساحة تحت ظروف هذه الدراسة. وهذه تتأتى من الزراعة على خطوط عرض ٦٠ سم ومسافة ١٠ سم بين الجور.