A Study of the Importance of Sowing Dates and Plant Density Affecting Some Rapeseed Cultivars *(Brassica napus L.)*

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Abstract:

In order to illustrate the Importance of studying sowing date of rapeseed crop (*Brassica napus L.*), yield components and quality, three cultivars including Opera, Licord and Oscar were sown from 15th September to 15th November, during two winter successive seasons 2008-2009, 2009-2010, with two plant density (62.500,125.000 plants.ha^{-1}). The experiment carried out at AL-Quba in the west north region of Mosul city at Nineveh region. It was conducted according to factorial experiment in a randomized completely block design [cultivars(a)=3, sowing date(b)=3, plant density(c)=2] with three replications. The results could be summarized as:

The results revealed that the Licord cultivar gave a high level of characters plant height, number of primary branches, number of silique per plant, leaf area(cm^2\plant), leaf area index, dry weight/plant (g.), number of seeds/ silique, weight of thousand seed (g), total yield and oil yield (ton.ha^{-1}) and oil percentage in both seasons 2008-2009, 2009-2010.

The second planting date (mid of October) gave the highest rate of prescriptions of plant height, number of primary branches, leaf area (cm^2\plant), leaf area index, number of silique/ plant, dry weight (g.)/plant, number of seed/silique, weight of thousand seed (g.), total yield and oil yield (ton.ha^{-1}), While the third planting date (mid of November) gave the highest percentage of oil in seeds in both seasons.

Decreasing plant density to 62.500 caused a significant increase in number of primary branches, number of silique/plant,leaf area(cm^2\plant) ,dry weight /plant(g.), weight of thousand seed, oil percentage in seed and yield, oil yield, While increasing plant density to 125.000 plants.ha^{-1} led to significant increases in plant height, leaf area index, in both seasons 2008-2009, 2009-2010.

دراسة أهمية مواعيد الزراعة والكثافة النباتية المؤثرة في بعض أصناف السلجم *(Brassica napus L.)*

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ملخص البحث:

لتوضيح أهمية دراسة مواعيد زراعة محصول السلجم *(Brassica napus L.)* ومكونات حاصله ونوعيته، تم زراعة ثلاثة أصناف هي أوبرا،ليكورد واوسكار بتاريخ 15 أيلول لغاية 15 تشرين الثاني أثناء فصلي

الشتاء المتعاقبين للموسمين 2008–2009 و2009–2010 بكثافتين نباتيتين (62.500 و125.000 ألف نبات /هكتار). أجريت التجربة في منطقة القبة الواقعة شمال غرب مدينة الموصل ضمن محافظة نينوى، ونفذت على وفق نظام التجربة العاملية [الأصناف (a)=3 ومواعيد الزراعة (b)=3 والكثافة النباتية (c)=2)] بتصميم القطاعات العشوائية الكاملة بثلاثة مكررات. وتم التوصل إلى النتائج الآتية :

بينت النتائج بأن الصنف ليكورد أعطى أعلى معدل لصفات: ارتفاع النبات ، عدد الأفرع الأولية /نبات، عدد الخردلات/نبات، المساحة الورقية (سم^2/نبات)، دليل المساحة الورقية، الوزن الجاف غم/نبات، عدد البذور/خردله ، وزن الألف بذرة/غم ، حاصل البذور الكلي وحاصل الزيت (طن/هكتار) ونسبة الزيت في البذور في كلا الموسمين 2008–2009 و2009–2010.

أعطى موعد الزراعة الثاني (15 تشرين الأول) أعلى معدل لصفات: ارتفاع النبات، عدد الأفرع الأولية/نبات، المساحة الورقية (سم^2/نبات)، دليل المساحة الورقية ، عدد الخردلات/نبات، الوزن الجاف غم/نبات، عدد البذور/خردله ، وزن 1000 بذرة/غم ، حاصل البذور الكلي وحاصل الزيت (طن/هكتار)، في حين أعطى موعد الزراعة الثالث (15 تشرين الثاني) أعلى نسبة للزيت في كلا موسمي الزراعة.

سبب انخفاض الكثافة النباتية إلى 62.500 ألف نبات/هكتار زيادة معنوية في صفات: عدد الأفرع الأولية/نبات، عدد الخردلات/نبات، المساحة الورقية (سم^2/نبات)، الوزن الجاف (غم/نبات)، وزن الألف بذرة(غم) ونسبة الزيت في البذور وحاصل الزيت (طن/هكتار)، في حين سبب زيادة الكثافة النباتية إلى 125.000 ألف نبات /هكتار زيادة معنوية في ارتفاع النبات (سم) ودليل المساحة الورقية في كلا الموسمين 2008–2009 و2009–2010.

Introduction

Rapeseed cultivars differed in growth and development according to the prevailing environmental conditions. Its largely varied in seed yield and oil seed content. In this respect, Chaudhary *et al.* (1987) found significant differences for number of silique per plant, seed yield per plant and weight of thousand seed. Similar conclusions were reported on a number of silique per plant and seeds weight by several investigators such as Kolsarici and Er, (1988); Jasinka *et al.* (1989); Budzynski *et al.* (1990); Thomas *et al.*,(1990); Yusuf and Bullock, (1993); Kandil *et al.* (1995); Noureldin *et al.*, (1995); Keshta, (1998); Abbas *et al.*, (1999); Keshta, (1999) and Sharief, (2000). Al-Doori and Hasan, (2010) reported that Conl cultivar surpassed Pactol cultivar in weight of thousand seed up to 111.68 %, total seed yield per hactar reach up to 49.61%, and oil yield (ton.ha^{-1}) by 55.95% as an average of both seasons. Meanwhile, Pactol cultivar surpassed Olga and Elvira cultivars in number of seeds/silique, weight of thousand seed and yield, oil percentage in both seasons.

Environmental factors greatly affect plant growth and yield. Sowing date is an important determinant of crop yield. It depends on the onset of significant rainfall, temperature and humidity of a region. Decreasing crop yield in delayed sowing date has been reported by many workers (Kohn and Storrier, 1970, Doly and Marcellos, 1974; Degenhardt and Kondra, 1981; McDonald *et al*., 1983). Determining suitable planting date plays an important role in conformation of plant growth stages with desirable environmental conditions which results in maximum yield. Planting date has a considerable effect on seed yield by influencing the yield components so that late planting decreases primary branches/plant and silique/plant and finally causes a remarkable reduction in seed yield (Thurling, 1974). The late sowing of rapeseed decreased seed yield through synchronization of silique filling period with high

temperatures, the decrease in assimilates production, drought stress occurrence, shortened silique filling period and acceleration of plant maturity (Mendham *et al.*, 1981).

Apart from other factors responsible for increasing per hectare yield, Plant density is considered to play a remarkable role in boosting up production. The objectives of this investigation are to study the effect of sowing dates and two different plant densities as well as their interactions with seed yield and its components of three rapeseed cultivars under the environmental conditions of AL-Quba district.

Materials and Methods

Three rapeseed cultivars were selected based on their adaptation to the rapeseed production areas in the AL-Quba. AL-Quba is located in the west north region of Mosul city at Nineveh province (which is far about 25km). A representative soil sample (0-30 cm depth) was taken before planting (table1) using the methods description by Black (1965), Jackson (1973), Page *et al.* (1982) and Tandon (1999).

Based on soil test conducted in two test seasons, super phosphate 80kg.ha^{-1} (48%P_2O_5) and 40 kg.ha^{-1} potassium fertilizers (48%K_2O) were applied to the soil during the sowing period. Nitrogen fertilizers was applied in the form of urea (46%N) as split in two equal doses (40,40 kg nitrogen.ha^{-1}) half with sowing and the remaining half immediately after thinning (20 days from sowing). Cultural practices, control of insects and weeds and furrow irrigation were given as needed during the growth seasons according to the local recommendations.

Table -1-

The physical and chemical characters of soil filed experiments in both seasons

Seasons	2008-2009	2009-2010
physical characters		
Sand (%)	63.00	45.00
Silt (%)	19.00	39.00
Clay (%)	17.00	13.00
Texture	Sandy Loom	Silty Sandy
chemical characters		
O.M. (g.kg^{-1})	0.912	1.04
Available N (ppm)	33.60	35.64
Available P (ppm)	17.20	19.68
Available K (ppm)	170.00	183.00
Total $CaCo_3$ (g.kg^{-1})	27.80	28.20
pH	7.42	8.62
E.C. mmhos/cm	0.62	0.82

Seeds of these cultivars were obtained from the crops industrial company, Baghdad. The experimental design was factorial experiment in a Randomized Completely Block Design (a=3, b=3, c=2) with three replications according to Steel and Torrie (1980). Then Duncan's multiple range test (Duncan, 1955 and Gomez and Gomez, 1976) was used to compare among means. Each experiment included 54

treatments. Each plot consisted of 6 rows, 5 m in length with 40, 80 cm in width between rows and the distance between hills was 20 cm apart to attain a plant density of 125.000 and 62.500 plants .ha^{-1}, respectively. The seeds were sown by putting seeds to hills by hand, at three sowing dates (mid of September, mid of October, and mid of November). Plants were thinned to one plant per hill 20 days after sowing. Ten randomly tagged plants from each plot were evaluated for characters. At harvesting (when the color of seed coat presented in the lower zone of the terminal raceme was darkish at 140, 144, 158 and 149, 155, 160 days after sowing for each cultivars Opera, Licord and Oscar to both seasons 2008-2009, 2009-2010, respectively), two inner rows were taken to determinate of the following characters (dry weight, weight of thousand seed, no. of seeds.silique^{-1} and total yield). The following data were recorded: Plant height (cm), number of primary branches, number of silique/plant, leaf area(cm^2\plant), leaf area index, dry weight (g.)/plant and weight of 1000 seed(g). Oil seed content was determined using Soxhlet method (A.O.A.C., 1980).

Table -2-
Monthly and growing season precipitation, temperature, and relative humidity in AL-Quba location in 2008-2009, 2009-2010 seasons

2008-2009 season					
Month	Temperature (c°)			Months Precipitation(mm)	Relative humidity (%)
	Max	Min	Mean		
September	38.6	22.9	30.75	0.50	35
October	30.4	15.6	23.00	34.20	48
November	22.3	8.6	15.45	72.60	62
December	15.0	3.2	9.10	18.60	71
January	14.3	−0.1	14.30	0.001	68
February	17.5	5.6	11.55	24.90	63
March	19.7	8.5	14.10	28.10	60
April	25.8	11.7	18.75	35.70	52
May	34.2	18.2	26.20	0.001	37
Total				214.60	
2009-2010 season					
September	34.4	21.6	28	1.50	34
October	32.3	15.0	23.65	13.30	43
November	20.4	9.3	14.85	28.30	73
December	16.0	7.0	11.5	92.00	81
January	10.0	6.2	8.1	32.50	60.6
February	15.8	8.8	12.3	61.50	58.2
March	16.6	10.2	13.4	112.00	62.2
April	24.6	22.8	23.7	64.50	58.0
May	36.2	24.0	30.1	17.50	32.8
Total				423.10	

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Results and Discussion

1- Effect of cultivars:

All investigated characteristics were significantly affected by cultivars (table 11). Data reported in table (3) indicate that the Licord cultivar produced the highest plant (158.98, 172.96 cm), more primary branches (11.41, 11.03), number of silique per plant (189.69, 209.46), leaf area (6740, 5866 cm^2\plant) compared to the other two tested cultivars in the two seasons. The differences among the three cultivars in the number of silique/plant may be attributed to the general differences in the plant height and number of primary branches per plant (Potter *et al*., 1999). Moreover, the differences in leaf area index may be attributed to the differences in leaf area per plant. In this concern, Al-Doori and Hasan, (2010) showed that taller cultivars had more number of primary branches and leaf primordial than the others rapeseed cultivars. It can also noted that the dry weight per plant of Licord cultivar out weighed Opera and Oscar in a descending order at both seasons. The superiority of Licord cultivar in the dry matter production may be attributed to having the tallest plants and had more number of primary branches per plant, and the highest area of photosynthetic and this in turn increased the capacity of dry matter accumulation in the different plant parts.

Mean values of seed yield, yield components and some related traits for the three tested cultivars are presented in table (3). The data revealed that Licord cultivar surpassed Opera and Oscar cultivars in number of seeds/silique (10.48,10.61), weight of thousand seed (1.68,1.96gm) in both seasons, respectively. Opera surpassed Oscar in those traits in both seasons. This means that Licord plants were more efficient to accumulate dry mater in their silique. Regarding the seed characters i.e., weight of thousand seed and oil percentage, data show that there were significant variations among the three tested rapeseed cultivars in both seasons. Licord cultivar surpassed significantly Opera and Oscar cultivars in oil percent (41.55, 40.09%), yield and oil yield (0.637,0.621,0.265,0.249 $ton.ha^{-1}$.) in both seasons, respectively. However, the differences in oil percent of seeds may be attributed to genetic factors and their interaction with the prevailing environmental conditions. This increase in oil yield ($ton.ha^{-1}$) of Licord cultivar may be due to their high seed yield per ha. (table 3) rather than differences in seed oil content. Similar conclusion were reported by Auld, *et al*., (1990) and Al-Doori and Hasan, (2010). The superiority of Licord cultivar in the most seed characters may be due to that Licord cultivar had better vegetative growth and greater photosynthetic area which led to more carbohydrates which was translocated from the source (number of primary branches and stem) to the sink (seeds) (Mengel and Kirkby, 1982). The results showed that number of seeds/silique, weight of thousand seed and yield, oil yield ($ton.ha^{-1}$) were always significantly higher for Licord than that Opera and Oscar cultivars. This indicates that Licord cultivar was more efficient to translocate enough photo assimilates to developing seeds.

2- Effect of sowing dates:

Temperature, rainfall and relative humidity for the experiment site during the study years are presented in table (2). The average rainfall for 2008-2009 (214.60 mm) was lower than that observed in 2009-2010 (423.10 mm). Data reported in table (4) indicate a significant effect of sowing dates on rapeseed attributes i.e. plant height (cm), number of primary branches, number of silique/ plant, leaf area(cm^2\plant), leaf area index, dry weight(g.)/plant, weight of thousand seed, number of $seeds.silique^{-1}$

and total yield in two seasons. The promising date of sowing was mid of October for rapeseed attributes criteria, these results are true in the two growing seasons. The superiority of 2009-2010 season in some growth characters and yield components such as number of seeds/silique, weight of thousand seed, seed yield and oil yield may be due to the high available of nutrients in experimental site of this season (table1). The beneficial effect of nutrients could be attributed to its vital role in the activity of growth enzymes which lead to increase in the biological processes and this in turn increase plants yield components, the same results were obtained by Degenhardt and Kondra, (1981); Christensen *et al*., (1985); Taylor *et al*., (1991); Nanda *et al*., (1995); Shirani and Ahmedi, (1995) and Siadat and Hemayati, (2009) who found that the nutrients play vital role in the growth enzymes. The decrease in number of silique/ plant, number of seeds.silique^{-1} and total yield which obtained with sowing in the mid September, most likely due to lower rainfall which lead to decrease leaf area index and dry weight (gm)/plant, (table 4).

It was evident, from table (4), that number of seeds/ silique, 1000 seeds weight (g.), yield and oil yield (ton.ha^{-1}) as affected by sowing dates, it was found that mid of October, mid of September and mid of November sowings had statistically different yield, mid of October sowing had the highest seed yield (0.642,0.743 ton.ha^{-1}) followed by mid of September sowing. This was true in both seasons. The increases of seed yield per hactar in mid of October sowing due to increases of dry matter accumulation in the later formed silique, which may be attributed to temperature (16.6, 19.6 C°) and long photoperiod that exist during silique development (tables 2). The same results were stated by Ganga and Rajat, (1979) and Jenkins and Leitch, (1986) who found that sowing in mid of October was associated with the highest seed yield of rapeseed per plant. Oil content of seed much influenced during two growing seasons of this study (tables4), higher oil content (41.66, 41.83%) was recorded at mid of November sowing as compared to mid of September and October sowing. However, higher oil content by delaying sowing crop may be due to favorable prolonged environmental conditions for better growth and development of the crop, that resulted in photosynthetic products accumulated in the source (leaves) and transported to the sink (seeds) (tables 2) which enhanced the oil content. This result is in agreement with the findings of Schuster and Sra, (1979); Degenhardt and Kondra, (1981); Humaira and Ahmad, (2007) who found that the delay of sowing plantings significantly increased oil content and oil yield.

Table -3- : Effect of rapeseed cultivars on some growth characters, yield, yield components and quality in both seasons.

seasons	cultivars	plant height (cm)	no. of primary branches /plant	no. of silique.plant^{-1}	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	number of seeds/silique	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2008 2009	Opera	136.17b	11.10a	175.25b	6368.40a	5.32b	47.67b	7.92c	1.46b	0.520b	39.21b	0.205b
	Licord	158.98a	11.41a	189.69a	6740.00a	5.65a	49.18a	10.48a	1.68a	0.637a	41.55a	0.265a
	Oscar	93.62c	10.01b	176.81b	5722.70b	4.80c	47.84b	8.02b	1.11c	0.401c	39.88b	0.156c
2009 2010	Opera	169.21b	9.56b	194.77b	5593.3a0b	4.66b	48.97b	10.61b	1.74b	0.577b	38.52b	0.224b
	Licord	172.96a	11.03a	209.46a	5866.20a	4.94a	51.29a	10.78a	1.96a	0.621a	40.09a	0.249a
	Oscar	165.58c	9.84b	186.94c	5424.40b	4.47b	47.83c	9.31c	1.50c	0.533c	38.99ab	0.205b

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -4- : Effect of sowing dates on some growth characters, yield, yield components and quality in both seasons.

seasons	Sowing dates at mid of month	plant height (cm)	no. of primary branches /plant	no. of silique.Plant^{-1}	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	number of seeds/silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2008 2009	September	123.16c	10.35b	167.55b	6248.90	5.17b	47.17c	7.83b	1.33b	0.383c	38.68c	0.148c
	October	135.88a	11.29a	187.42a	6384.40	5.40a	48.82a	11.30a	1.90a	0.642a	40.30b	0.262a
	November	129.72b	10.87ab	186.78a	6197.80	5.20b	48.70b	7.92b	1.02c	0.532b	41.66a	0.217b
2009 2010	September	164.37c	9.61b	184.74c	4637.80c	3.84c	48.63b	8.61c	1.45b	0.453c	37.13c	0.167c
	October	173.85a	10.83a	207.34a	6501.30a	5.50a	50.17a	11.66a	1.89a	0.743a	38.64b	0.287a
	November	169.53b	9.99b	199.09b	5744.90b	4.73b	49.29b	10.13b	1.86a	0.535b	41.83a	0.224b

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -5- : Effect of plant density on some growth characters, yield, yield components and quality in both seasons.

seasons	plant density (plants .ha^{-1})	plant height (cm)	no of primary branches /plant	no. of silique.Plant^{-1}	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	number of seeds/silique	Weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2008 2009	62.500	124.05b	10.92a	182.04a	8383.36a	5.2396b	48.40a	8.84a	1.47a	0.520a	41.87a	0.219a
	125.000	135.12a	10.76a	179.12b	4226.08b	5.2826a	48.06b	8.77b	1.36b	0.518b	38.56b	0.199b
2009 2010	62.500	165.53b	10.46a	201.08a	7265.12a	4.5407b	49.59a	10.39a	1.77a	0.584a	40.12a	0.234a
	125.000	172.97a	9.82b	193.03b	3875.52b	4.8444a	49.14b	9.88b	1.69b	0.570b	38.28b	0.218b

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

3- Effect of plant density:

Data pertaining to plant density are presented in table (5). All investigated characteristics were significantly affected by plant density (table 11). Although the high density (125.000 plant.ha.$^{-1}$) produced the highest plant height (135.12,172.97cm) and leaf area index (5.28,4.84), the low density (62.500 plant.ha.$^{-1}$) gave the highest number of primary branches (10.92,10.46), number of silique/plant (182.04,201.08), leaf area (8383,7265 cm^2\plant), dry weight/plant (48.40,49.59gm), number of seeds/ silique (8.84,10.39), 1000 seeds weight (1.47,1.77gm), yield and oil yield (0.52,0.58,0.21,0.23 ton.ha^{-1}) in the two growing seasons, respectively. This increase may be due to the increase in the dry matter accumulated in plants with wide spacing which might lead to increase the yield components and also because of sufficient of environmental elements as light, Co_2, nutrients, water, which increase plant ability to build metabolites (Kondra, 1975 and Ohlsson, 1976; Rood and Major, 1984). Similar observations were made by Morrison *et al*. (1990); Khan and Muendel (1999); Bryan *et al*., (2001) and Al-Doori and Hasan, (2010), who reported that taller plants at high density may be due to inter plant competition for light and aerial resources.

4- Effect of interaction between cultivars and sowing dates:

The interaction between the studying factors (cultivars and sowing dates) showed significant effects on all investigated characteristics except seed yield (ton.ha^{-1}) in 2008-2009 season, number of seeds/silique in 2009-2010 season as illustrated in table (6). Data illustrated in table (6) show generally that Opera, Licord and Oscar cultivars appeared to be clearly affected by sowing dates for plant height (cm), number of primary branches, leaf area(cm^2\plant), leaf area index. On the other hand, Licord cultivar reflected the greatest response to sowing dates for these traits, with this regard, Singh and Singh (1985); Hassan and El-Hakeem, (1996); Christmas, (1996); Al-Barzinjy *et al*., (1999); Panwar *et al*., (2000); Aziz *et al*., (2005); Assey *et al*., (2006) and Siadat and Hemayati, (2009) found that early sowing dates in 7th November produced maximum number of seeds/silique (25.33) and seed yield (285.23 g.m^2). The insignificant effect between sowing dates and cultivars on seed yield and number of seeds/silique showed that each of these two factors acted independently on these traits.

5- Effect of interaction between cultivars and plant density on growth characters, yield and yield components and quality:

Data illustrated in table (7) show generally that Opera, Licord and Oscar cultivars appeared to be clearly significantly affected by plant density for all characters in the two growing seasons except of number of primary branches, number of silique.plant^{-1}, leaf area index, dry weight (g.)/plant and weight of 1000 seed (gm) in the first season, plant height, no. of primary branches, no. of silique.plant^{-1}, leaf area index and weight of 1000 seed in the second season. On the other hand, Licord cultivar reflected the greatest response to plant density for these traits, with this regard, Khan and Muendel, (1999) and Bryan *et al*., (2001) found that increasing row spacing produced maximum 1000 seeds weight (2.91gm) and seed yield (2852 kg ha^{-1}). The insignificant effect between cultivars and plant density on some growth

characters and yield components showed that each of these two factors acted independently on these traits.

6- Effect of interaction between sowing dates and plant density on growth characters, yield and yield components and quality:

The interaction effect between sowing dates and plant density reached the 0.05 and 0.01 levels of significance for number of silique.Plant^{-1}, number of seeds/silique and total yield in 2008-2009 seasons, plant height, number of silique.plant^{-1}, number of seeds/silique, weight of 1000 seed(g), and total yield in 2009-2010 season (table 8). The sowing dates at mid of October with plant density 62.500 yielded the highest means for, number of silique.plant^{-1} (196.31,214.37), number of seeds/silique (10.9811.68) and total yield (0.6780.632 ton.ha^{-1}) in both seasons, respectively. This result clearly indicated the importance of sowing at mid of October and low plant density for higher seed production in rapeseed. Similar conclusion were reported by Mudholkar, and Ahlawat, (1981); Potter *et al*., (1999) and Sharief, (2000). Such increase may be due to increasing the dry weight per plant when planting at wide spacing, and increase in the photosynthetic and transporting efficiency of the plant (Bryan *et al*., 2001).

7-Effect of interaction between cultivars, sowing dates and plant density on growth characters, yield and yield components and quality:

The effect of this interaction was significant for some characters in the two growing seasons (tables 9,10). Other characters under investigation were not significantly affected by this interaction (table11), therefore the data were not discussed. Licord cultivars with sowing at mid of October at plant density 62.500 plants.ha^{-1} gave highest means for number of silique.plant^{-1} (212.60), dry weight (52.31g.), number of seeds/silique (14.03) and total seed yield (0.976 ton.ha^{-1}), oil yield (0.433ton.ha^{-1}) only in 2008-2009 season, number of primary branches (13.19), number of silique.plant^{-1}(234.20), leaf area (9248.7cm^2\plant), dry weight (56.60gm), number of seeds/silique (13.55) total seed yield (0.980 ton.ha^{-1}) oil yield (0.387ton.ha^{-1}) only in 2009-2010 season, while the Licord cultivars with sowing at mid of October at plant density 125.000 plants.ha^{-1} gave highest plant height (186.13cm) only in 2009-2010 season.

Table -6-

Effect of interaction between cultivars and sowing date on some growth characters, yield and yield components and quality in 2008-2009 and 2009-2010 seasons respectively.

cultivars	sowing dates at mid of month	Plant height (cm)	no. of primary branches	no. of silique /plant	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds/ silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	September	126.96d	10.74bd	144.81e	5904.00bc	4.88cd	45.71c	7.09de	1.19c	0.321	36.64d	0.117e
	October	137.96c	11.16bc	187.95ac	6273.30ab	5.24ac	47.98b	9.91b	2.05a	0.585	42.33b	0.246b
	November	143.58bc	11.40b	193.00ab	6928.00a	5.84ab	49.33ab	6.75e	1.15c	0.655	38.66c	0.253b
Licord	September	148.53b	10.55bd	188.16ac	6656.00ab	5.47ac	47.78b	7.96cd	1.60b	0.405	41.66b	0.168cd
	October	178.93a	12.59a	195.16a	6976.00a	5.98a	50.73a	13.38a	2.28a	0.865	41.83b	0.364a
	November	149.48b	11.09bc	185.75ac	6588.00ab	5.49ac	49.02ab	10.11b	1.17c	0.641	41.17b	0.264b
Oscar	September	94.00e	9.765d	169.68d	6186.70ab	5.16bc	48.03b	8.45c	1.20c	0.425	37.75cd	0.160cd
	October	90.76e	10.12cd	179.15cd	5904.00bc	4.98dc	47.74b	10.6b	1.37bc	0.478	36.75d	0.175c
	November	96.10e	10.14cd	181.60bd	5077.30c	4.26d	47.75b	5.01f	0.76d	0.300	45.15a	0.134de
2009-2010 season												
cultivars	Sowing dates at mid of month	Plant height (cm)	no. of primary branches	no. of silique /plant	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds/ silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	September	164.20d	9.04d	180.33e	4349.30e	3.65f	46.50e	8.65	1.22e	0.433d	35.30e	0.152e
	October	172.01bc	9.96bd	206.16bc	6380.00b	5.37b	49.40cd	12.18	1.86bc	0.713b	39.29bc	0.280b
	November	171.43bc	9.69cd	197.83cd	6050.70bc	4.96bc	51.00ab	10.99	2.15ab	0.585c	40.96b	0.239c
Licord	September	163.10d	10.46bc	189.73de	4744.00de	3.95ef	50.86bc	8.74	1.70cd	0.458d	36.96ed	0.168de
	October	181.01a	11.79a	221.56a	7514.70a	6.50a	52.39a	11.49	2.32a	0.858a	39.18bc	0.337a
	November	174.76b	10.83b	217.09ab	5340.00cd	4.37de	50.64bc	11.22	1.85bc	0.548c	44.15a	0.242c
Oscar	September	165.81cd	9.33d	184.16de	4820.00de	3.92ef	48.52d	8.44	1.44de	0.468d	39.12bc	0.182d
	October	168.53bd	10.74b	194.29ce	5609.30c	4.64cd	48.74d	11.30	1.49ce	0.658b	37.46cd	0.244c
	November	162.40d	9.45d	182.36e	5844.00bc	4.84bd	46.24e	8.19	1.58ce	0.473d	40.39b	0.191d

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -7-

Effect of interaction between cultivars and plant density on some growth characters, yield and yield components and quality in 2008-2009 and 2009-2010 seasons respectively.

cultivars	plant density (plants .ha^{-1})	plant height (cm)	no. of primary branches	no. of silique /plant	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds/ silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	62.500	131.42d	11.17	177.30	8416.70	5.26	48.01	8.24c	1.55	0.518c	40.34b	0.210bc
	125.000	140.92c	11.03	173.21	4304.20	5.38	47.34	7.59d	1.38	0.522c	38.08c	0.201c
Licord	62.500	149.15b	11.75	193.41	8656.00	5.41	49.41	10.56a	1.84	0.674a	44.33a	0.299a
	125.000	168.81a	11.08	185.97	4704.00	5.88	48.94	10.40ab	1.53	0.600b	38.78c	0.231b
Oscar	62.500	91.60e	9.83	175.43	7504.10	4.69	47.80	7.72d	1.04	0.367d	40.93b	0.146d
	125.000	95.64e	10.18	178.18	3928.20	4.91	47.88	8.32b	1.18	0.434d	38.84c	0.166d
2009-2010 season												
cultivars	plant density (plants .ha^{-1})	plant height (cm)	no. of primary branches	no. of silique /plant	leaf area (cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds /silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	62.500	165.47	9.98	199.79	7440.70	4.65	49.60bc	10.28ac	1.86	0.591b	38.90b	0.231b
	125.000	172.95	9.15	189.75	3736.00	4.67	48.33d	10.94ab	1.62	0.563b	38.13bc	0.217bc
Licord	62.500	169.76	11.44	213.93	7408.40	4.63	52.27a	11.44a	2.04	0.673a	40.87a	0.273a
	125.000	176.15	10.61	204.99	4200.00	5.25	50.32b	9.52bc	1.88	0.570b	39.51ab	0.225b
Oscar	62.500	161.34	9.96	189.53	7392.00	4.62	46.89e	9.43c	1.43	0.487c	40.79ab	0.198c
	125.000	169.82	9.71	184.35	3456.90	4.32	48.77cd	9.19c	1.58	0.578b	37.19c	0.213bc

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -8-

Effect of interaction between sowing dates and plant density on some growth characters, yield and yield components and quality in 2008-2009 and 2009-2010 seasons respectively.

sowing dates at mid of month	plant density (plants .ha^{-1})	plant height (cm)	no. of primary branches	no. of silique /plant	leaf area cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds/ Silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2008-2009 season												
September	62.500	129.20	11.05	160.42d	7968.00	4.98	46.34	8.32bc	1.54	0.397e	38.98	0.158c
	125.000	143.14	11.15	190.08ab	4528.30	5.66	49.01	7.51c	1.39	0.643b	39.44	0.253b
October	62.500	154.04	11.56	196.31a	8784.20	5.49	49.29	9.98ab	2.04	0.595c	42.55	0.256b
	125.000	163.92	11.26	183.07ac	4648.10	5.81	49.06	10.98a	1.33	0.678a	40.56	0.274a
November	62.500	92.42	9.797	173.53cd	8064.40	5.04	48.08	8.86ac	1.19	0.424d	37.61	0.159c
	125.000	94.82	10.22	180.08bc	3656.20	4.57	47.60	7.18c	1.02	0.377e	42.16	0.153d
2009-2010season												
September	62.500	166.51b	9.40	191.15bc	6672.30	4.17	47.50	9.54b	1.53bc	0.523d	36.69	0.194
	125.000	171.92ab	9.731	198.39bc	4120.00	5.15	50.43	11.68a	1.96ab	0.631ab	40.34	0.254
October	62.500	167.36b	11.37	204.55ab	7744.20	4.84	52.77	10.34ab	2.08a	0.632a	37.83	0.241
	125.000	178.55a	10.68	214.37a	4032.20	5.04	49.82	10.62ab	1.84ac	0.611b	42.36	0.256
November	62.500	165.84c	9.917	188.86c	6704.10	4.19	47.82	9.480b	1.44c	0.492e	39.23	0.192
	125.000	165.32c	9.768	185.01c	3792.10	4.74	47.84	9.150b	1.56bc	0.574c	38.75	0.219

* The means values within column followed by the different letter are significant at 0.05 and 0.01 probability levels, respectively.

Table -9-

Effect of interaction between cultivars, sowing dates and plant density on some growth characters, yield and yield components and quality in 2008-2009 season.

cultivars	sowing dates at mid of month	plant density (plants .ha^{-1})	plant height (cm)	no. of primary branches	no. of silique /plant	leaf area (cm^2\plant)	Leaf area index	dry weight (g.)/plant	no. of seeds/ silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	September	62.500	122.26	10.53	149.86de	7968.20	4.98	47.43bd	7.26hi	1.22	0.290hi	38.04	0.110i
		125.000	131.66	10.96	139.76e	3824.20	4.78	44.00e	6.92ij	1.16	0.353gi	35.25	0.124gi
	October	62.500	133.66	11.66	191.63b	8288.40	5.18	47.59bd	10.80cd	2.23	0.550ed	43.66	0.239ce
		125.000	142.26	10.66	184.26b	4248.20	5.31	48.37bd	9.03eg	1.87	0.620cd	41.00	0.253bd
	November	62.500	138.33	11.33	190.40b	8992.10	5.62	49.01bd	6.67ij	1.20	0.716bc	39.33	0.281bc
		125.000	148.83	11.46	195.60b	4848.50	6.06	49.66b	6.83ij	1.09	0.593cd	38.00	0.225de
Licord	September	62.500	136.40	10.59	183.73b	9104.20	5.69	46.35de	7.37hi	1.49	0.400gh	43.33	0.173fg
		125.000	160.66	10.50	192.60b	4192.00	5.24	49.20bc	8.54fh	1.72	0.410fh	40.00	0.164fh
	October	62.500	165.06	13.59	212.60a	8752.00	5.47	52.31a	14.03a	2.91	0.976a	44.33	0.433a
		125.000	192.80	11.60	177.73bc	5184.30	6.48	49.15bd	12.73ab	1.65	0.753b	39.33	0.296b
	November	62.500	146.00	11.06	183.90b	8752.20	5.47	49.57b	10.28ce	1.11	0.646bd	45.34	0.293b
		125.000	152.96	11.13	187.60b	4408.00	5.51	48.48bd	9.93df	1.24	0.636bd	37.01	0.235ce
Oscar	September	62.500	93.86	9.463	162.53cd	8208.00	5.13	48.54bd	7.92gi	1.16	0.430eg	38.50	0.165fh
		125.000	94.13	10.06	176.83bc	4152.10	5.19	47.52bd	8.99eg	1.24	0.420fh	37.00	0.155fi
	October	62.500	89.26	9.863	181.23bc	7664.30	4.79	48.18bd	9.68f	1.19	0.423fg	37.33	0.158fi
		125.000	92.26	10.39	177.06bc	4144.30	5.18	47.31bd	11.52bc	1.56	0.533df	36.17	0.193ef
	November	62.500	91.66	10.17	182.53b	6640.10	4.15	46.68cd	5.58jk	0.77	0.250i	46.96	0.117hi
		125.000	100.53	10.10	180.66bc	3504.10	4.38	48.82bd	4.44k	0.74	0.350gi	43.34	0.151fi

* The means values within column followed by the different letter are significant at 0.05 and 0.01 probability levels, respectively.

Table -10-

Effect of interaction between cultivars, sowing dates and plant density on some growth characters, yield and yield components and quality in 2009-2010 season.

cultivars	sowing dates at mid of month	plant density (plants .ha^{-1})	plant height (cm)	no. of primary branches	no. of silique /plant	leaf area cm^2\plant)	leaf area index	dry weight (g.)/plant	no. of seeds/ silique	weight of 1000 seed (g.)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Opera	September	62.500	153.73f	9.56cf	184.26fh	5712.00d	3.57g	48.85dg	8.53de	1.43eg	0.470dg	36.12	0.169hi
		125.000	174.66bc	8.52f	176.40h	2984.70f	3.73g	44.15j	8.78de	1.01g	0.396g	34.49	0.136i
	October	62.500	171.13cd	10.13be	212.80bd	8336.00ab	5.21bd	49.51cf	11.31ad	2.15bc	0.703b	39.46	0.277b
		125.000	172.90bc	9.80bf	199.52cf	4424.00e	5.53bc	49.30cf	13.06ab	1.57cg	0.723b	39.12	0.282b
	November	62.500	171.56cd	10.26be	202.33bf	8304.00ab	5.19bd	50.45be	11.01ad	2.01be	0.600c	41.12	0.246bd
		125.000	171.30cd	9.13df	193.33dh	3792.30ef	4.74cf	51.56bc	10.97ad	2.30b	0.570cd	40.79	0.232ce
Licord	September	62.500	151.13f	10.46bd	187.73fh	6320.70d	3.95fg	49.73be	8.80de	1.61cf	0.460eg	37.79	0.172gi
		125.000	175.06bc	10.46bd	191.73eh	3152.30f	3.94fg	52.00b	8.69de	1.80bf	0.456eg	36.12	0.164hi
	October	62.500	175.90bc	13.19a	234.20a	9248.70a	5.78b	56.60a	13.55a	2.82a	0.980a	39.57	0.387a
		125.000	186.13a	10.39be	208.92be	5776.00d	7.22a	48.18eh	9.43ce	1.81bf	0.736b	38.79	0.286b
	November	62.500	182.26ab	10.66bc	219.86ab	7344.30bc	4.59df	50.49be	11.99ac	1.68cf	0.580c	44.66	0.259bc
		125.000	167.26cd	10.99bc	214.32bc	3328.70f	4.16eg	50.79bd	10.45be	2.03bd	0.516cf	43.63	0.225cf
Oscar	September	62.500	162.93de	8.92ef	183.80fh	6720.30cd	4.20eg	46.86gi	8.16e	1.33fg	0.426fg	41.79	0.178gi
		125.000	168.70cd	9.73bf	184.53fh	2912.70f	3.64g	50.19be	8.72de	1.55dg	0.510cf	36.46	0.185fh
	October	62.500	165.90cd	11.09b	198.26cg	7568.30bc	4.73cf	46.42hi	11.56ac	1.45dg	0.540ce	39.46	0.213dg
		125.000	171.16cd	10.39be	190.33eh	3640.30ef	4.55df	51.06bd	11.05ad	1.54dg	0.776b	35.46	0.275b
	November	62.500	155.20ef	9.88bf	186.53fh	7872.30b	4.92ce	47.40fh	8.59de	1.51dg	0.496cg	41.12	0.204eh
		125.000	169.60cd	9.02df	178.19gh	3808.70ef	4.76cf	45.08ij	7.80e	1.65cf	0.450eg	39.67	0.178gi

* The means values within column followed by the different letter are significant at 0.05 and 0.01 probability levels, respectively.

Table- 11-

Analysis of variance F values for some growth characters, yield and yield components and quality in 2008-2009 and 2009-2010 seasons.

S.O.V	D.f	M.S. for 2008-2009 season										
		plant height (cm)	no. of primary branches	no. of Silique\ plant	leaf area (cm^2\plant)	leaf area index	dry weight(g.) \plant	no. of seeds\ silique	1000 seeds weight	seed yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)
Replications	2	1006.51	4.1624	778.48	1208698.1	0.749	1.1666	0.956	0.264	0.022	3.3130	0.00312
A	2	19808.77**	9.7829**	1130.64**	4770148.7**	3.263**	12.208**	13.614**	1.513**	0.169**	24.7777**	0.02281**
B	2	728.57**	4.0075**	2294.40**	167496.3 n.s	0.283*	15.165**	25.529**	3.560**	0.211**	12.6921**	0.03494**
C	1	1653.36**	0.3189 n.s	115.281 n.s	215041066.7**	0.024*	1.639 n.s	0.0763 n.s	0.164 n.s	0.0008 n.s	33.4490**	0.00015 n.s
A × B	4	767.88**	1.8335**	1147.18**	1848771.0*	1.486**	9.1208**	31.476**	0.239**	0.139 n.s	73.4522**	0.01615**
A × C	2	282.45**	1.1834 n.s	121.38 n.s	609176.9 n.s	0.636 n.s	0.6799 n.s	7.995**	0.238 n.s	0.065**	4.3422*	0.00919**
B × C	2	21.32 n.s	1.5947 n.s	535.65**	533699.6 n.s	0.2608 n.s	3.1780 n.s	3.726**	0.325 n.s	0.021*	0.0416 n.s	0.00396*
A×B × C	4	97.32 n.s	0.7280 n.s	286.40*	236577.8 n.s	0.1742 n.s	12.085**	10.83**	0.412 n.s	0.029**	1.9285 n.s	0.00492**
Error	34	43.55	0.7496	101.37	563824.0	0.346	2.049	0.672	0.100	0.005	1.0988	0.00086
Total	53											
S.O.V	D.f	M.S. for 2009-2010 season										
Replications	2	124.07	3.352	153.166	21404419.6	15.378	0.907	0.89726	0.011	0.01342	4.666	0.00365
A	2	244.96**	10.86**	1949.621**	894478.2 n.s	1.0197**	56.150**	5.31533**	0.930**	0.0860**	48.473**	0.02165**
B	2	405.75**	7.032**	2432.256**	15812227.6**	12.468**	10.851**	26.935**	1.064**	0.4087**	37.349**	0.08166**
C	1	748.91**	5.440**	907.986**	188369124.7**	1.2451*	2.666 n.s	1.9760**	0.089*	0.0253**	39.697**	0.00112 n.s
A × B	4	130.42**	0.411 n.s	512.234**	2901025.8**	2.4891**	18.693**	6.1572**	0.466**	0.0645**	50.205**	0.01122**
A × C	2	4.911 n.s	0.502 n.s	74.420 n.s	162763.9 n.s	0.4592 n.s	18.812**	2.7391**	0.185 n.s	0.0247**	48.220**	0.00358**
B × C	2	341.20**	1.640 n.s	375.609**	1043350.5*	0.1038 n.s	3.059 n.s	2.9030**	0.673**	0.0146*	12.236 n.s	0.00163 n.s
A×B × C	4	244.31**	2.176*	193.055*	245016.3 n.s	0.5115*	39.967**	3.8587**	0.237*	0.0436**	10.089 n.s	0.00721**
Error	34	26.27	0.572	62.46	335805.3	0.1924	1.515	0.1477	0.0907	0.0032	4.605	0.00063
Total	53											

*, ** Significant at the 0.05 and 0.01 probability levels, respectively. and n.s. not Significant.

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