Influence of Sowing Dates on Growth, Yield and Quality of Some Flax Genotypes (*Linum usitatissimum L.*)

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Abstract:

Two field experiments were carried out at Sheikh Mohamed location which is far about 30 km west north Mosul city conducted during 2007-2008 and 2008-2009 winter seasons to study three genotypes performance of flax crop *(Linum usitatissimum L.)*, three planting dates, and their interactions on some growth characters, yield and its components traits as well as oil yield.
The main findings could be summarized as follows:

The results showed that planting dates significantly affected in growth characters, yield and its component as well as oil yield in both seasons. The sowing of flax crop on the first November gave the highest number of capsules per plant, number of seeds per capsule, weight of thousand seed, seed, oil yield per hector. Sowing on the first November surpassed these sown on mid November in seed yield per hectare^{-1} by 20.32% and 20.67% as well as sown on mid October by 17.80% and 12.55% in the first and second seasons respectively.

Flax crop genotypes significantly differed for all studied yield and its component in both seasons. The highest number of capsules per plant, weight of thousand seed, seed and oil yield per hectare^{-1} were produced from Strain genotype in both seasons. The results indicated that Strain genotype exceeded Belinka genotype by 12.88% and 15.59% and Hera genotype by 15.26% and 18.86% in total seed yield per hectare^{-1} in the first and second seasons, respectively.

The interaction between planting dates and genotypes significantly affected in plant height, stem diameter, number of fruiting branches, number of capsules per plant, number of seeds per capsule, weight of thousand seed, total seed yield per hector, oil percentage and oil yield in both seasons, except for number of capsules per plant, number of seeds per capsule, weight of thousand seed and oil percentage in the second season only. The sowing of Strain genotype in the first of November gave the highest number of capsules per plant and total seed yield per hectare^{-1} in both seasons.

تأثير مواعيد الزراعة في نمو وحاصل ونوعية بعض التراكيب الوراثية من الكتان (*Linum usitatissimum L.*)

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ملخص البحث:

نفذت تجربتين حقليتين في موقع الشيخ محمد الذي يبعد 30 كم غرب شمال مدينة الموصل أثناء فصل الشتاء للعامين 2007 -2008 و2008 -2009 لدراسة أداء ثلاثة تراكيب وراثية من محصول الكتان (*Linum usitatissimum L.*) وثلاثة مواعيد زراعة وتداخلاتهم في بعض صفات النمو والحاصل ومكوناته، بالإضافة إلى حاصل الزيت.

ويمكن تلخيص النتائج الرئيسة بالاتي:ـ

أشارت النتائج بان مواعيد الزراعة أثرت معنوياً في صفات النمو والحاصل ومكوناته، بالإضافة إلى حاصل الزيت في كلا الموسمين. أعطى محصول الكتان عند زراعته في الأول من تشرين الثاني أعلى عدد من الكبسولات.نبات$^{-1}$، عدد البذور.كبسولة$^{-1}$، وزن الألف بذرة وحاصل البذور الكلي والزيت.هكتار$^{-1}$. تفوق موعد الزراعة في الأول من تشرين الثاني على موعد الزراعة في منتصف تشرين الثاني في حاصل البذور الكلي بنسبة 20.32% و 20.67%، بالإضافة إلى انه تفوق على موعد الزراعة في منتصف تشرين الأول بنسبة 17.80% و12.55% في الموسمين الأول والثاني على التوالي.

اختلفت التراكيب الوراثية لمحصول الكتان بشكل معنوي في جميع صفات الحاصل المدروسة ومكوناته في كلا الموسمين. أنتج التركيب الوراثي سترين أعلى عدد من الكبسولات.نبات$^{-1}$،وزن الألف بذرة وحاصل البذور الكلي وحاصل الزيت في كلا الموسمين. أشارت النتائج بان التركيب الوراثي سترين تفوق على التركيب الوراثي بلنكا بنسبة 12.88% و 15.59% والتركيب الوراثي هيرا بنسبة 15.26% و 18.86% في حاصل البذور الكلي.هكتار$^{-1}$ في الموسمين الأول والثاني على التوالي.

اثر التداخل بين مواعيد الزراعة والتراكيب الوراثية معنوياً في ارتفاع النبات، قطر الساق، عدد الأفرع الثمرية، عدد الكبسولات.نبات$^{-1}$، عدد البذور.كبسولة$^{-1}$، وزن الألف بذرة وحاصل البذور الكلي.هكتار$^{-1}$ ونسبة وحاصل الزيت في كلا الموسمين، عدا عدد الكبسولات.نبات$^{-1}$، عدد البذور.كبسولة$^{-1}$، وزن الألف بذرة ونسبة الزيت في الموسم الثاني فقط. أعطى التركيب الوراثي

[1-] سترين عند زراعته في الأول من تشرين الثاني أعلى عدد الكبسولات وحاصل البذورالكلي.هكتار في كلا الموسمين.

Introduction:

Oilseed flax *(Linum usitatissimum L.)* is grown primarily for the oil that is produced in its seed. A high content of linolenic acid in linseed oil makes it a good drying oil because it oxidizes rapidly (Diepenbrock and Porksen, 1993). The oil crushed from the seeds can either be used for industrial or edible purposes, depending on the fatty acid composition (Burton, 2007). Since flaxseed oil contains more than 50% linolenic acid, it is well suited for industrial use in protective coatings such as varnishes, paints, stains and lacquers. An important product also made from flaxseed oil is linoleum flooring, which is durable, long lasting, and biodegradable. Furthermore, flaxseed oil is a component in other products such as soaps, automotive brake linings, and printer's ink. Oil from flax cultivars contains less than 5% linolenic acid, making it suitable for use as a cooking or salad oil (Abd El-Rahman and Youssef 1979; Declercq, 2004). Seeding date and its influence on flax performance is linked to weather, with early or later seeded flax having a higher chance of encountering frost or drought (Casa *et al.*, 1999). An early spring frost may injure a crop, but the potential loss from a fall frost is far greater. Sheppard and Bates (1988) also found earlier seeding resulted in greatest seed yield. Later seeding significantly decreased the mean yields. A study conducted in Alexandria university in Egypt, found that a late sowing date to December 1st and December 15th led to reduced seed, oil yield and oil percentage (Ibrahim, 2009). El-Refaey *et al*. (2010) conducted a study in Egypt, and found that oil yield decreased when seeding was postponed past November 25th. The primary objective of this study was to determine the effects of sowing dates on growth, yield and quality of some flax genotypes (*Linum usitatissimum L.*).

Materials and Methods:

Two field experiments were carried out at Sheikh Mohamed which is far about 30 km west north Mosul city. Field experiments were conducted during 2007-2008 and 2008-2009 winter seasons to study three genotypes performance of flax with three planting dates, and their interactions on yield and its components traits as well as oil yield/hector.

The preceding crop was sunflower (*Helianthus annuus L.*) in both seasons. The experimental soil was sandy loam in texture, the pH was 7.2, 8.4, available nitrogen was 26.6, 28.4 ppm, the available phosphorus was 12.2, 13.6 ppm in both seasons, respectively (table1), determined by using the methods described by Black, 1965; Jackson, 1973; Page *et al*., 1982 and Tandon, 1999.

Table -1-
The physical and chemical characters of soil filed experiments in both seasons at 0 to 30 depth.

Seasons	2007-2008	2008-2009
physical characters		
Sand (%)	59.00	45.00
Silt (%)	21.00	39.00
Clay (%)	20.00	13.00
Texture	Sandy loom	Silty sandy
chemical characters		
O.M. ($mg.kg^{-1}$)	0.824	0.986
Available N (ppm)	26.60	28.44
Available P (ppm)	12.20	13.68
Available K (ppm)	154.00	162.00
Total $CaCo_3$ ($mg.kg^{-1}$)	1.64	2.42
pH	7.20	8.42
E.C. mmhos/cm	0.84	0.66

A factorial experiment in a Randomized Completely Block Design was used in each experiment. Each plot consisted of twelve rows 4 meter long and 30 cm apart occupying an area of $14.4m^2$ (4*3.6). Flax genotypes were obtained from the crops industrial company, Baghdad. Seeds of flax genotypes (Belinka, Strain and Hera) were hand sown in 15th October, 1st November and 15th November in 2007-2008 and 2008-2009 seasons, and harvested at 170, 172, 176 and 175, 174, 176 days after sowing for each genotypes Belinka, Strain and Hera to both seasons 2007-2008, 2008-2009 respectively in the one separate experiment in each season. Plants were thinned 14 days after sowing to one plant per hill at 20 cm distance to insure 166666 plants/hector. The nitrogen fertilizer in the form of urea 80 kg $hectare^{-1}$ (46%N) was applied in two equal doses, half with sowing and the remaining half after thinning. Phosphorus in the form of calcium super phosphate (45% P_2o_5) at a rate of 150 $kg.hectare^{-1}$ and potassium in the form of potassium sulphate (48%K_2o) at a rate of 50 kg/hector, were incorporated to the soil during the sowing period. All other agronomic practices were kept normal and uniform for all the treatments. two inner rows were taken to determine the following characters (weight of thousand seed, number of seeds. $capsules^{-1}$, yield and oil yield). The following data were recorded: Plant height (cm), stem diameter (cm), number of fruiting branches, number of capsule per plant. Oil seed content was determined using Soxhlet method (A.O.A.C., 1980). Data were exposed to the proper statistical analysis of variance of the factorial experiment in a Randomized Completely Block Design with three replications as mentioned by Snedecor and Cochran (1982). Then Duncan's multiple range test (Duncan,1955) at 0.05 % and 0.01 % level of significance were used to compare treatment means.

Table -2-
The temperature, months precipitation and relative humidity in Sheikh Mohamed location at 2007-2008, 2008-2009 seasons, respectively.

Month	Temperature (C°)			Months Precipitation (mm)	relative humidity (%)
	Max	Min	Mean		
2007-2008					
October	28.2	11.0	19.6	0.0	60.2
November	20.4	8.6	14.5	36.0	62.0
December	18.8	4.2	11.5	18.2	65.6
January	12.0	-2.2	4.9	21.5	63.0
February	15.6	2.9	9.2	39.2	69.0
March	25.2	9.9	17.5	28.9	53.0
April	30.9	14.9	22.9	0.8	38.0
May	33.3	17.2	25.2	0.001	33.0
June	40.5	23.0	31.7	0.001	26.0
Total				144.60	
2008-2009					
October	30.4	15.6	23	34.2	48.0
November	22.3	8.6	15.4	72.6	62.0
December	15.0	3.2	9.1	18.6	71.0
January	14.3	-0.1	7.1	0.001	68.0
February	17.5	5.6	11.5	24.9	63.0
March	19.7	8.5	14.1	28.1	60.0
April	25.8	11.7	18.7	35.7	52.0
May	34.2	18.2	26.2	0.001	37.0
June	40.3	23.6	31.9	0.001	26.0
Total				214.10	

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Results and Discussion:

1-Sowing dates effect:

The rainfall and mean values for minimum and maximum temperatures which related to the main stages of vegetative and reproductive development of flax sown at the different dates in 2007-2008 and 2008-2009 are presented in table 2. The results concerned average number of capsules per plant, number of seeds per capsules, weight of thousand seed, seed, oil yields per hectare^{-1} as affected by sowing dates are shown in Table 3. Sowing dates significantly affected all studied yield and its component characters (table 6). The results indicated that sowing flax on the first of November surpassed the other sowing dates in number of capsules per plant, weight of thousand seed,

seed, oil yield.hectare^{-1} in both seasons. Moreover, sowing flax on the first November surpassed these sown on mid November by 20.32%,20.67% in seed yield per hector, by 30.85,% 29.67 % in oil yield per hectare and surpassed these sown on mid October by 17.80%, 12.55% in seed yield per hector, by 22.31% 16.97% in oil yield per hectare^{-1} in the first and second seasons respectively. The increases in seed yield per hectare^{-1} due to sown on the first of November may be attributed to increases in number of fruiting branches per plant which reflected increases in capsules number as well as seed number per unit area and that in turn reflected increases in seed yield per hector. The inferiority of delaying sowing to mid November may be attributed to the short period of vegetative growth, the adverse weather conditions such as temperature and months precipitation (table 2), which were beyond the optimum degree for vegetative and reproductive stages that resulted in low photosynthetic products accumulated in the source (leaves) and transported to the sink (seeds). Ghanem, (1990) reported that increases of seed yield due to increases of dry matter accumulation in the later formed capsules may be attributed to high temperature and long photoperiod that exist during capsules development (table 2). The increases in seed yield per hectare^{-1} due to sowing on the first of November may be due to the increases in number of branches per plant and number of capsules per plant reflecting increase in seed yield. Similar conclusions were reported by El-Refaey *et al* (2010). The increases in oil yield per hectare^{-1} in the first November sowing compared the other studied sowing dates may be due to the increases in both oil percentage and seed yield per hector. Similar conclusions were reported by Ghanem, 1990; El-Deeb and Abd El-Fatah, 2006 and Ibrahim, 2009.

2-Genotypes performance:

The results in table 4 indicate that flax genotypes significantly differed in plant height, stem diameter, number of fruiting branches, number of capsules per plant, no. of seeds per capsule, 1000 seeds weight (g.), seed yield per hector, oil percentage and oil yield (ton.ha^{-1}) in both seasons. Strain genotype exceeded Belinka and Hera genotypes in plant height, stem diameter, number of fruiting branches, number of capsules per plant, no. of seeds per capsule, 1000 seeds weight (g.), seed yield per hector, oil percentage and oil yield (ton.ha^{-1}) in both seasons. However, Strain genotype exceeded Belinka genotype by 12.88% and 15.59% and Hera genotype by 15.26% and 18.86% in total seed yield per hectare^{-1} in the first and second seasons, respectively. Strain genotype exceeded Belinka and Hera genotypes in number of seeds per capsules in both seasons. The differences between flax genotypes in seed yield per hectare^{-1} might be attributed to their differences in growth traits such as number of fruiting branches reflected differences in yield components such as number of capsule per plant as well as 1000 seed weight and hence increased seed yield per plant as well as per unit area. Similar results were

obtained by many investigators such as Gubbels, and Kenaschuk, 1989; El-Shimy *et al*, 1997; Sankari, 2000; El-Shimy, *et al*, 2001; Rennebaum, *et al*, 2002; Couture *et al*, 2002; El-Sweify, *et al*, 2003; Dimmock *et al*, 2005; Salem, *et al*, 2006; El-Deeb and Abd El-Fatah 2006; Hussein, 2007 and El-Sweify, *et al*, 2007. The increases of Strain genotype in oil yield per hectare^{-1} compared with Belinka and Hera genotypes may be attributed to the genetically variation among the tested genotypes in yield components and consequently seed yield as well as oil percentage. Similar results were obtained by many investigators such as El-Sweify *et al*, 2006 and Abd El-Fatah, 2007.

3- Significant interactions:

The interaction between planting dates and flax genotype had a significant effect on plant height, stem diameter, number of fruiting branches, number of capsules per plant, no. of seeds per capsule, 1000 seeds weight (g.), seed yield per hector, oil percentage and oil yield (ton.ha^{-1}) in both seasons, except for number of capsules per hector, number of seeds per capsule, weight of thousand seed and oil percentage in the second season only as shown in table 5. The results indicated that planting Strain genotype in the first November produced the highest number of capsules per plant and maximum total seed yield per hectare^{-1} in both seasons, which were 26.48, 2.66 (ton. hectare^{-1}) and 27.96, 3.07 (ton.ha^{-1}) in the first and second season respectively. However, the lowest number of capsules per plant and seed yield per hectare^{-1} were produced from sowing Belinka genotype on mid of November in both seasons. Similar conclusions were obtained by Ghanem, 1990; El-Deeb and Abd El-Fatah, 2006. It could be concluded that maximizing seed and oil yields per unit area could be achieved by sowing flax Strain genotype on the first November under the environmental conditions of west north Mosul city.

Table -3-

Means number of some growth characters, yield components and quality as affected by planting dates during 2007-2008 and 2008-2009 seasons, respectively.

seasons	sowing dates	plant height (cm)	stem diameter (cm)	number of fruiting branches	number of capsule /plant	no. of seeds/ capsule	1000 seeds weight (g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2007-2008	15th October	103.38b	2.06b	8.24b	22.45b	5.71b	7.38b	1.91b	35.98b	0.690b
	1st November	117.37a	2.73a	9.74a	25.12a	6.43a	8.50a	2.25a	37.30a	0.844a
	15th November	94.44c	2.00b	7.91b	20.07c	5.25c	6.29c	1.87c	34.31c	0.645b
2008-2009	15th October	107.05b	2.13b	9.02b	23.07b	7.07b	7.97b	2.23b	36.02b	0.807b
	1st November	115.26a	2.99a	10.39a	26.45a	7.79a	9.21a	2.51a	37.39a	0.944a
	15th November	101.22c	2.19b	8.35c	21.24c	6.21c	7.32c	2.08c	34.86c	0.728c

* The means values within column followed by the different letter are significant at 0.01% and 5% probability levels, respectively.

Table -4-

Means number of some growth characters, yield components and quality as affected by genotypes during 2007-2008 and 2008-2009 seasons, respectively.

seasons	genotypes	Plant height (cm)	Stem diameter (cm)	number of fruiting branches	number of capsule /plant	no. of seeds/ capsule	1000 seeds weight (g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2007-2008	Belinka	106.44b	2.34b	8.58b	21.92b	5.92b	7.23b	1.94b	35.64b	0.695b
	Strain	116.18a	2.53a	9.23a	23.81a	6.33a	8.06a	2.19a	37.29a	0.824a
	Hera	92.578c	1.93c	8.07c	21.91b	5.14c	6.88c	1.90b	34.65c	0.659b
2008-2009	Belinka	110.22b	2.47b	9.03b	23.18b	6.44c	7.89b	2.18b	35.79b	0.785b
	Strain	119.30a	2.83a	9.82a	25.15a	7.49a	8.96a	2.52a	37.53a	0.952a
	Hera	94.02c	2.01c	8.92b	22.43c	7.14b	7.65c	2.12c	34.95c	0.742c

* The means values within column followed by the different letter are significant at 0.01% and 5% probability levels, respectively.

Table -5-

Means number of some growth characters, yield components and quality as affected by interaction between planting dates and genotypes during 2007-2008 and 2008-2009 seasons, respectively.

sowing dates	genotypes	plant height (cm)	Stem diameter (cm)	number of fruiting branches	number of capsule /plant	no. of seeds/ capsule	1000 seeds weight (g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
2007-2008 season										
15th October	Belinka	103.80cd	2.13bc	8.10cd	21.65	5.70	7.19	1.95bc	36.01	0.702bc
	Strain	117.26b	2.16bc	8.63c	24.20	6.20	8.18	2.00bc	37.21	0.744b
	Hera	89.10e	1.89d	8.00cd	21.50	5.23	6.76	1.79c	34.72	0.623cd
1st November	Belinka	118.40b	2.94ab	9.93b	24.65	6.50	8.33	2.05b	36.93	0.759b
	Strain	128.36a	3.13a	10.84a	26.48	7.01	9.17	2.66a	38.74	1.033a
	Hera	105.36c	2.13bc	8.46c	24.25	5.80	8.00	2.04b	36.23	0.741b
15th November	Belinka	97.13d	1.94cd	7.73d	19.47	5.56	6.16	1.83bc	33.99	0.625cd
	Strain	102.9cd	2.30b	8.23cd	20.76	5.80	6.83	1.93bc	35.93	0.695bd
	Hera	83.26e	1.78d	7.76d	19.99	4.40	5.88	1.86bc	33.01	0.614d
2008-2009 season										
15th October	Belinka	111.46c	2.22d	8.90ce	22.85d	7.13cd	7.86e	2.318bc	36.15c	0.837bc
	Strain	119.60b	2.23d	9.36cd	25.40c	7.40bc	8.72c	2.371b	37.21b	0.882b
	Hera	90.10e	1.96e	8.80de	20.97fg	6.70d	7.34f	2.020de	34.72d	0.701ef
1st November	Belinka	117.40b	3.21b	10.20b	26.55b	7.00cd	9.20b	2.320bc	37.13b	0.861b
	Strain	125.70a	3.57a	11.59a	27.96a	8.48a	9.97a	3.070a	39.07a	1.199a
	Hera	102.70d	2.20d	9.40c	24.85c	7.90b	8.47cd	2.148cd	35.97c	0.772cd
15th November	Belinka	101.80d	1.98e	8.00f	20.14g	5.20e	6.63g	1.931e	34.09e	0.658f
	Strain	112.60c	2.70c	8.50ef	22.10ed	6.60d	8.19de	2.131ce	36.33c	0.774cd
	Hera	89.26e	1.89e	8.56ef	21.49ef	6.83d	7.15f	2.206bd	34.18de	0.753de

* The means values within column followed by the different letter are significant at 0.01% and 5% probability levels, respectively.

Table- 6-

Analysis of variance F values for some growth characters, yield and yield components and quality during 2007-2008 and 2008-2009 seasons, respectively.

S.O.V	D.f	M.S. for 2007-2008 season								
		Plant height (cm)	stem diameter (cm)	number of fruiting branches	number of capsule /plant	no. of seeds/ capsule	1000 seeds weight (g.)	yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})
Replications	2	217.81	0.2028	1.784948	7.96094	9.772503	3.283514	0.474065	0.07847	0.06454
S	2	1202.4**	1.4764**	8.6278**	57.447**	3.1998**	10.989**	0.3906**	20.207**	0.098**
G	2	1267.0**	0.8321**	3.0418**	10.779**	3.3025**	3.2971**	0.2316**	15.975**	0.067**
S × G	4	16.88*	0.1432**	0.9326**	0.81369 n.s.	0.0996 n.s.	0.0440 n.s.	0.0933**	0.153 n.s.	0.014**
Error	16	16.523	0.014740	0.12019815	0.4222815	0.10483704	0.0635898	0.01417704	0.1999777	0.0020730
Total	26									
S.O.V	D.f	M.S. for 2008-2009 season								
Replications	2	3.592593	0.000048	0.22734444	0.8400037	0.17717037	0.0737148	0.01361293	0.192292	0.0013341
S	2	448.04**	2.0786**	9.77230**	62.89957**	5.649837**	8.27744**	0.416090**	14.344**	0.10755**
G	2	1475.7**	1.5106**	2.16141**	17.75183**	2.567837**	4.32769**	0.412961**	15.607**	0.11009**
S × G	4	18.412**	0.3350**	1.05441**	3.70024**	0.908059**	0.34966**	0.238280**	0.6313**	0.04013**
Error	16	3.259259	0.006548	0.09821944	0.2447120	0.08358704	0.0572231	0.01295876	0.1019259	0.0013925
Total	26									

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

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