EFFECT OF SOWING DATE AND N-FERTILIZER LEVELS ON SEED YIELD, SOME YIELD COMPONENTS AND OIL CONTENT IN FLAX

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ABSTRACT

Two field experiments were carried out at the Agricultural Research Station, Alexandria University, Abbis, in 2003/2004 and 2004/2005 winter seasons to study the influence of four sowing dates (November 1 and 15 and December 1 and 15) and three nitrogen levels (107, 143 and 179 kg / ha) on seed yield, some yield components and seed oil content of Giza 8 flax cultivar.

Delaying sowing date beyond November 15 significantly decreased seed yield and all studied seed yield components, in addition to seed oil content. The late sowing might shorten the growing cycle of plants, which, finally, resulted in a fewer number of capsules/ plant and shorter seed filling period.

Increasing the level of applied N fertilizer from 107 up to 179 kg/ ha increased seed yield and all its components , in addition to seed oil content, while, plant height decreased with increasing N fertilization level above 143 kg/ ha. The linear response of flax yield and other studied characters to nitrogen treatments indicated that the higher rates above 179 kg/ ha were suggested to be investigated.

Key words: Flax, Linum usitatissimum, sowing date, nitrogen fertilization.

INTRODUCTION

Flax (*Linum usitatissimum* L.) is a dual purpose crop that is grown for fiber and oil production. Human consumption of flax seed is increasing rapidly for its high dietary fiber, omega-3 oil and anti-carcinogenic lignins, in addition to its high content of polyunsaturated fatty acids. In Egypt, area allocated for flax production decreased during the last two decades, resulting in a gap between production and consumption. To minimize such gap, there is a necessity to increase seed yield per unit area of land through planting high yielding cultivars parallel with adopting optimal cultural practices. Sowing date and nitrogen fertilization are two, among many, factors that are involved in the processes responsible for plant growth and seed yield production in flax.

Several investigators reported that seed yield, generally, decreased with delaying sowing date, as an indicator of the influence of environmental factors (Dixit et al., 1994; Fontana et al., 1996; Shahidullah et al., 1997 and Siddique et al., 2002 a&b). Such decrease in seed yield might be attributed to the unfavorable climatic conditions prevailing with late sowing that might affect vegetative growth, proper seed development and filling (Verma and Pathak; 1993, Rossini et al., 1997 and Siddique et al., 2002 a&b). Moreover, sowing date may have an effect on quality of flax seed in relationship to protein and oil contents (Srivastava et al., 1976 and Siddique et al., 2002 b).

Nitrogen and ,hence, nitrogen fertilization, is an essential element for proper vegetative growth of flax plant and enhancement of seed yield production. Yadav *et al.* (1990) illustrated that increasing N rates increased 1000-seed weight, but did not affect seed oil percentage. Abd EL-Samie and EL-Bially (1996) reported that there was a significant increase in flax plant height, number of fruiting branches/ plant, number of capsules/ plant, 1000-seed weight and seed yield/ fad. with each increase in the applied nitrogen at the rates of 30, 40 and 60 kgN/ fad, in addition to an increase in oil yield with increasing nitrogen rates from 30 to 60 kg N/ fad. However, Rossini *et al.* (1997) reported that seed production was not affected by N fertilizer application up to 80 kgN/ ha. Leilah *et al.* (2003) concluded that the highest seed oil percentage and seed and oil yields/ fad., produced from Giza 8 cultivar, were obtained with the application of 60 kg N + 30 kg P_2O_5/ fad.

The present investigation was conducted to study the effects of sowing date and nitrogen application level on plant growth, seed yield and some yield components and oil production of flax.

MATERIALS AND METHODS

Two different experiments were carried out at the Agricultural Research Station, Alexandria University, Abbis, to study the effect of planting dates and nitrogen levels on seed yield, yield components and oil content of Giza 8flax cultivar during 2003/2004 and 2004/2005 winter seasons.

A split-plot design, with four replications, was used. The main plots were assigned to four sowing dates; i.e., November1(D_1), November 15 (D_2), December 1 (D_3) and December 15 (D_4); while, the sub-plots included three nitrogen fertilization levels; i.e., N_1= 107, N_2= 143 and N_3= 179 kg / ha. Each of the three levels was applied in two equal split-doses after 30 and 45 days from sowing. Nitrogen fertilizer was applied in the form of ammonium nitrate (33.5% N).

Flax was drilled, at the rate of 96 kg seeds/ ha, in rows, 20 cm apart. Each sub-plot contained 10 rows of 3 m length (plot size= 6m^2). All other cultural practices were applied as recommended for flax production in the region.

At harvest, plant height (in cm), number of fruiting branches per plant, number of capsules per plant and seed yield per plant were recorded for 20

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random plants in each sub-plot. Seed yield (in kg/ ha) was calculated from the seed yield of a guarded area of 4.48 m^2 from each sub-plot and transformed in terms of seed yield/ ha. Seed oil content (%) was determined, as an average of two random seed samples from each sub-plot, using Soxhlet apparatus and N-hexane as an organic solvent.

The analysis of variance and the test of homogeneity was performed on the two seasons data. It was found that error variance of the two seasons was not significantly different. According to that, the combined analysis over the two seasons and polynomial fitting equations were carried out, according to Gomez and Gomez (1984), using SAS (Statistical Analyses System) ver. 8.1, 2001. Graphs were drawn and fitted to equation, using Curve Expt.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) indicated highly significant effects for the studied factors; i.e., sowing date and nitrogen application level, on all studied traits in both seasons. In addition, the interaction was significant only for plant height in the first season, seed yield/ plant in both seasons, number of capsules/ plant and oil content in the second season. Losavio *et al.* (1998) reported a significant sowing date × N fertilization interaction on seed yield/ ha., where, the effect of N application was most evident with early, compared to late sowing. Combined analysis of variance over the two seasons (Table 2) revealed significant and highly significant differences between the two seasons in all studied characters, except for number of capsules/ plant. Such significant effect might be attributed to the seasonal effects on the performance of flax plants in the field. The combined analysis of variance, also, indicated a significant effect of seasons on the outcome of applied factors: seed yield/ plant at the different sowing dates (S*A); number of capsules/ plant, seed yield/ plant and oil content at the different nitrogen application levels (S*B). Pageau *et al.* (2006) reported different responses of seed yield, in flax cultivars, as influenced by N-fertilization in the different seasons. However, the seasonal differences, in the present work, did not alter the rankings of the levels within each factor, but changed the magnitude of trait expression in the two seasons, resulting in the significant interaction of seasons × factors.

The further partioning of sum of squares of seed yield/ ha, in addition to one indicative agronomic characteristic; namely, number of fruiting branches/ plant, indicated that the pattern of the relationship between both characters and sowing date was non-linear in both seasons (Table 1 and Figures 1a and 1b) and in the combined data over the two seasons (Table 2). Whereas, the response of the two studied characteristics, to the nitrogen application, was in both seasons (Table 1 and Figures 2a and 2b), and in the combined data over both seasons (Table 2).

The first two sowing dates; i.e., November 1 and 15, gave the highest values for all studied traits in both seasons (Table 3), with an insignificant superiority of either, except for plant height in both seasons, where D_1 significantly gave the tallest plants. In addition, D_1 was significantly superior to D_2 in number of capsules/ plant in the second season, whereas, D_2 was superior to D_1 in seed yield/ ha in the second season and combined data over the two seasons.

All studied characteristics; i.e., agronomic, seed yield and oil characters significantly decreased with delaying sowing date beyond November 15. Early sowing might give sufficient time for crop growth and development under more convenient climatic conditions, whereas, late sowing was, generally, characterized with a shorter vegetative growth period and a shorter seed filling period (number of days from first flowering to harvest), which might cause negative effects on seed yield components and, hence, seed yield, in addition to quality characters. These findings were in agreement with those reported by Dixit et al. (1994), Fontana et al. (1996), Shahidullah et al. (1997), Rossini et al. (1997), Siddique et al. (2002 a&b) and Rossini and Casa (2003), Dimmock et al. (2005).

Means presented in Table 3 revealed that increasing N application level from 107 up to 179 kg N/ ha increased all studied characters, except for plant height, which was significantly decreased with N application above 143 kg N/ ha. Such adverse effect might be attributed to the increase in plants lodging percentage (data not reported) due to the application of the high N dose. Yadav *et al.* (1990) reported that increasing N application increased 1000-seed weight and, hence, seed yield/ ha. Abdel-Samie and EL-Bially (1996) and Kholosy *et al.* (1996) reported that increasing N fertilization level from 30 to 60 kg N/ fed increased number of fruiting branches/ plant, number of capsules/ plant, seed yield/ plant and seed yield/ ha. Similar findings were reported by Leilah (1993), Salama (1996), Haniyat EL-Nimr (1997) and Leilah *et al.* (2003). Moreover, Abdel-Samie and EL-Bially (1996) and Salama (1996) found that oil yield was increased with increasing N fertilization level from 30 to 60 kg N/ fed. However, with the findings of Yadav *et al.* (1990),it was indicated that seed oil percentage was not affected by N rates, while, Kholosy (1996) stated that seed oil content was decreased with increasing N level above 30 kg N/ fad.

The two- factor interaction (Table 3) indicated that either the first or second sowing dates, November 1 and 15, at the highest N fertilization level, 179 kg N/ ha, gave the highest values for seed yield/ plant and oil content, compared to the later sowing dates in December at lower N fertilization rates of 107 and 143 kg N/ ha. These findings illustrated the necessity of early sowing of flax, no later than November 15, in order to benefit from the applied N fertilization, at the rate of 179 kg N/ ha, to produce higher seed and oil yields. However, the significant linear effect, in the present work, of nitrogen fertilization, on the seed yield of flax, suggested that the further increments of nitrogen beyond 179 kg N/ ha might be needed to be investigated at Alexandria Region.

Table (1): Means squares for analysis of variance of studied characters in 2003/2004 and 2004/2005 winter seasons.

Source of Variance	Degrees of freedom	Character					
		Plant height (cm)		No. of fruiting branches/ plant		No. of capsules/ plant	
		2004	2005	2004	2005	2004	2005
Replications	3	11.74	12.63	0.806	0.583	14.632	6.28
Sowing dates (A)	3	687.02**	715.30**	18.306**	38.25**	880.076**	706.06**
Linear	1	**	**	**	**	**	**
Quadr.	1	n.s	n.s	n.s	n.s	n.s	**
Cubic	1	n.s	n.s	n.s	n.s	n.s	*
Error (a)	9	8.04	4.56	1.769	1.27	24.650	2.89
Nitrogen levels (B)	2	176.9**	229.08**	61.396**	92.69**	602.146**	1139.8**
Linear	1	**	**	**	**	**	**
Quadr.	1	**	**	n.s.	n.s.	n.s.	n.s.
A* B	6	9.53*	5.3	2.951	2.77	14.74	23.868*
Error (b)	24	3.31	6.7	1.257	1.39	6.69	9.271

Table (1): Cont.:

Source of Variance	Degrees of freedom	Character					
		Seed yield/ plant (g)		Oil content (%)		Seed yield/ ha (kg)	
		2004	2005	2004	2005	2004	2005
Replications	3	2.693	2.96	0.373	0.058	42166.9	12527.6
Sowing dates (A)	3	97.922**	40.17**	7.866**	10.15**	342402.8**	510854.3**
Linear	1	**	**	**	**	**	**
Quadr.	1	n.s.	*	**	**	*	**
Cubic	1	n.s.	n.s.	**	**	n.s.	**
Error (a)	9	2.478	2.43	0.107	0.113	36486.7	5084.3
Nitrogen levels (B)	2	105.106**	73.93**	2.736**	12.69**	223129.5**	84932.313**
Linear	1	**	**	**	**	**	**
Quadr.	1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
A* B	6	4.656*	3.25**	1.648**	0.06	4062.134	4152.31
Error (b)	24	1.530	0.72	0.184	0.08	3684.45	3350.9

*, ** Significant at 0.05 and 0.01 probability levels , respectively.
n.s. = Not significant .

Table (2): Combined analysis of variance over the two seasons for all studied characters.

Source of Variance	Degrees of freedom	Character					
		Plant height (cm)	No. of fruiting branches/ plant	No. of capsules/ plant	Seed yield/ plant (g)	Oil content %	Seed yield/ ha (kg)
Seasons (S)	1	1998.38**	28.167**	29.26	14.415*	21.565**	95457.71*
R	6	12.188	0.694	10.455	2.83	0.216	27347.26
Sowing date (A)	3	1401.50**	54.250**	1546.594**	129.07**	17.906**	813873.26**
Linear	1	**	**	**	**	**	**
Quadr.	1	n.s.	*	n.s.	**	**	**
Cubic.	1	n.s.	n.s.	n.s.	*	**	**
S*A	3	0.819	2.306	39.538	9.02*	0.106	39383.76
Error (a)	18	6.299	1.519	13.770	2.45	0.110	20785.54
Nitrogen levels (B)	2	404.07**	151.385**	1667.625**	175.64**	13.597**	290588.93**
Linear	1	**	**	**	**	**	**
Quadr.	1	**	n.s.	n.s.	n.s.	n.s.	n.s.
S * B	2	1.906	2.698	74.292**	3.40*	1.832**	17472.88
A * B	6	7.365	4.844	16.667	7.29**	0.816**	27304.25
S * A * B	6	7.476	0.878	21.944*	0.624	0.893**	16910.19
Error (b)	48	4.979	2.323	7.98	1.125	0.133	20097.72

*, ** Significant at 0.05 and 0.01 probability levels, respectively.
n.s. = Not significant .

Table (3): Means of the studied characters as influenced by sowing dates, nitrogen application levels and their interaction in 2003/2004 and 2004/2005 winter seasons and combined analysis over the two seasons.

Factor	Plant height (cm)			No. of fruiting branches/ plant			No. of capsules/ plant		
	2004	2005	comb.	2004	2005	comb.	2004	2005	comb.
	Sowing date								
D_1	91.17a[1]	100.0a	95.83 a	6.67 a	8.08 a	7.38 a	34.92 a	32.8 a	33.88 a
D_2	87.67 b	96.7 b	92.12 b	6.50 a	8.00 a	7.25 a	27.75 b	30.6 a	29.17 b
D_3	78.92 c	88.4 c	83.67 c	4.83 b	6.08 b	5.45 b	19.42 c	22.9 b	21.17 c
D_4	74.83 d	83.5 d	79.12d	4.17 b	4.30 b	4.25 b	15.83 d	16.0 c	15.92 d
	Nitrogen patterns								
N_1	80.00 c	88.8 c	84.41c	3.44 c	4.30 c	3.84c	17.88 c	17.8 c	17.84c
N_2	86.63 a	96.3 a	91.47a	5.88 b	6.60 b	6.22b	25.56 b	24.4 b	24.97b
N_3	82.81 b	91.7 b	87.25b	7.31 a	9.10 a	8.19a	30.00 a	34.6 a	32.28a
	Sowing date * nitrogen patterns								
$D_1 * N_1$	89.25	96.3	92.75	3.50	5.00	4.25	28.25	24.3	26.25
$D_1 * N_2$	95.00	104.3	99.63	7.25	7.50	7.38	39.25	30.5	34.88
$D_1 * N_3$	89.25	101.0	95.13	9.25	11.80	10.5	37.25	43.8	40.50
$D_2 * N_1$	83.50	92.3	87.88	5.00	5.50	5.25	20.50	21.3	20.88
$D_2 * N_2$	91.25	102.3	96.75	7.00	8.30	7.63	27.25	30.5	28.88
$D_2 * N_3$	88.25	95.5	91.88	7.50	10.30	8.88	35.50	40.0	37.75
$D_3 * N_1$	75.00	84.5	79.75	2.50	3.80	3.13	12.00	15.0	13.50
$D_3 * N_2$	82.25	93.0	87.63	4.75	6.00	5.38	19.75	21.8	20.75
$D_3 * N_3$	79.50	87.8	83.63	7.25	8.50	7.88	26.50	32.0	29.25
$D_4 * N_1$	72.25	82.3	77.25	2.75	2.80	2.75	10.75	10.8	10.75
$D_4 * N_2$	78.00	85.8	81.88	4.50	4.50	4.50	16.00	14.8	15.38
$D_4 * N_3$	74.25	82.5	78.38	5.25	5.80	5.50	20.75	22.5	21.63
$LSD_{0.01}$	2.65	-[2]	-	-	-	-	-	6.02	-

(1) Means followed by the same letter(s) are not significant, but different letters are not significant

(2) The ignored L.S.D. indicates that (D×N) interaction was not significant.

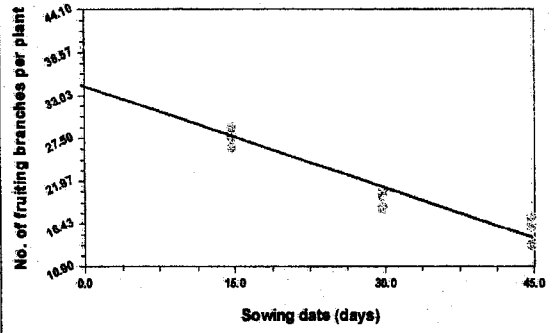
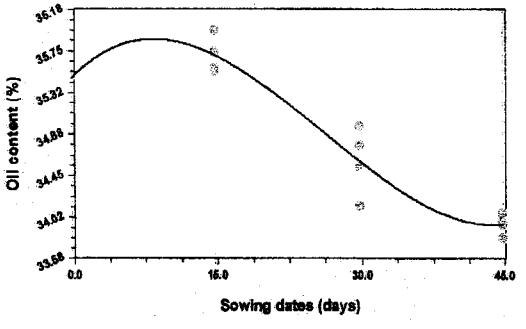
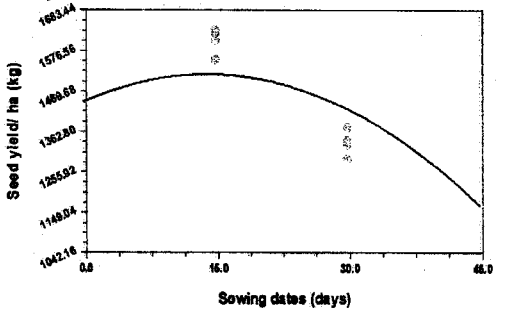
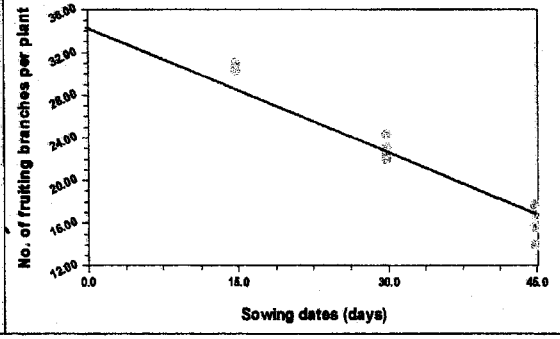
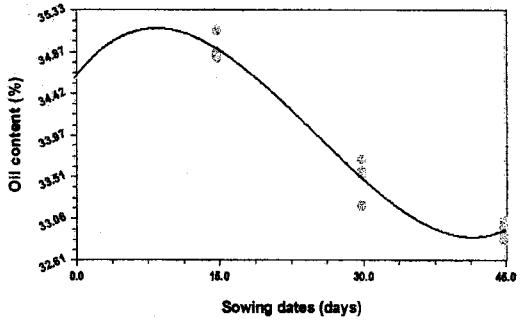
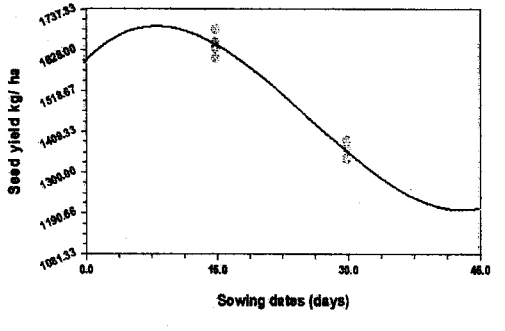
Table (3): Cont.:

Factor	Seed yield/ plant (g)			Oil content (%)			Seed yield (kg/ ha)		
	2004	2005	comb.	2004	2005	comb.	2004	2005	comb.
	Sowing Date								
D_1	13.11 a	12.3 ab	12.72a	35.47 a	34.58 a	35.03a	1411.0 b	1593.6 ab	1502.3b
D_2	12.62 a	13.0 a	12.80a	35.70 a	34.90 a	35.30a	1601.2 a	1642.4 a	1621.8a
D_3	9.08 b	10.9 bc	9.98b	34.60 b	33.50 b	34.05b	1333.7 b	1355.8 bc	1344.7bc
D_4	7.16 b	8.90 c	8.00b	33.94 c	32.93 c	33.43c	1196.5 c	1202.7 c	1199.5c
	Nitrogen patterns								
N_1	7.74 c	9.20 c	8.48c	34.53 c	33.09 c	33.81c	1256.5 c	1373.1 c	1314.8c
N_2	10.91 b	11.1 b	10.99b	34.89 b	33.97 b	34.43b	1412.0 b	1454.4 b	1433.2b
N_3	12.82 a	13.5 a	13.16a	35.36 a	34.88 a	35.12a	1488.2 a	1518.4 a	1503.3a
	Sowing Date * Nitrogen patterns								
$D_1 * N_1$	9.90	9.70	9.79	36.00	33.70	34.85	1111.5	1500.3	1305.9
$D_1 * N_2$	14.25	12.30	13.29	35.20	34.53	34.86	1528.5	1649.0	1588.8
$D_1 * N_3$	15.18	15.0	15.08	35.20	35.53	35.36	1593.0	1631.8	1612.4
$D_2 * N_1$	8.98	10.2	9.59	35.08	33.88	34.48	1505.8	1563.5	1534.6
$D_2 * N_2$	12.50	12.5	12.48	35.70	35.05	35.38	1598.0	1634.3	1616.1
$D_2 * N_3$	16.38	16.3	16.35	36.33	35.78	36.05	1699.8	1729.5	1714.6
$D_3 * N_1$	6.45	9.2	7.80	34.28	32.65	33.46	1283.0	1308.8	1295.9
$D_3 * N_2$	9.33	11.0	10.18	34.58	33.53	34.05	1327.0	1333.3	1330.1
$D_3 * N_3$	11.45	10.5	11.96	34.95	34.33	34.64	1391.0	1425.3	1408.1
$D_4 * N_1$	5.65	7.8	6.74	32.78	32.15	32.46	1125.8	1119.8	1122.8
$D_4 * N_2$	7.55	8.5	8.04	34.10	32.78	33.44	1194.5	1201.0	1197.8
$D_4 * N_3$	8.28	10.2	9.25	34.95	33.88	34.41	1269.0	1287.3	1278.1
$LSD_{0.01}$	1.68	2.45	1.7	-(2)	0.848	0.525	-	-	-

(1) Means followed by the same letter(s) are not significant, but different letters are not significant

(2) The ignored L.S.D. indicates that (D×N) interaction was not significant.

Figure (1): Relationship between sowing date* and number of fruiting branches per plant, oil content (%) and seed yield/ ha (kg) in 2004 and 2005 winter seasons:

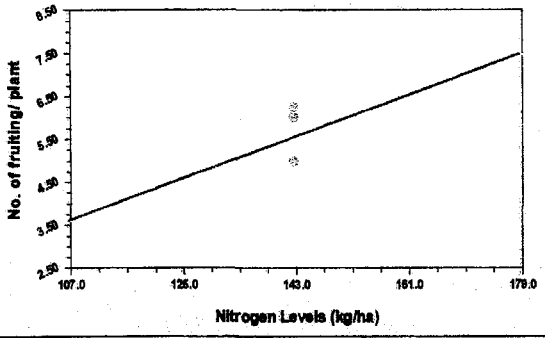
Season	(a) Number of fruiting branches per plant	(b) Oil content (%)	(c) Seed yield/ ha (kg)
2004	S.E= 2.783 R^2 = 0.8836 $\hat{y}$ = 34.31- 0.437X**	S.E= 0.2906 R^2 = 0.9177 $\hat{y}$ = 35.46+ 0.099X**-0.0069 X^{2}** +8.765 X^{3}**	S.E= 130.313 R^2 = 0.552 $\hat{y}$=1440.37 + 10.296 X** - 0.3638X^{2}*
			
2005	S.E= 1.779 R^2 = 0.93 $\hat{y}$ = 34.3- 0.387X**	S.E= 0.1818 R^2 = 0.96361 $\hat{y}$ = 34.58+ 0.1349X**-0.0094 X^{2}** +0.0001 X^{3}**	S.E= 48.11 R^2 = 0.9467 $\hat{y}$=1593+ 24.85X** -1.787X^{2}** + 0.0231X^{3}**
			

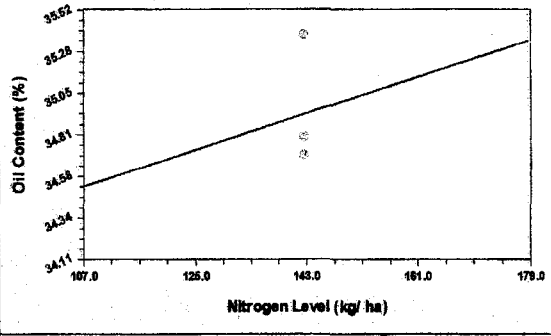
* On X-axis:

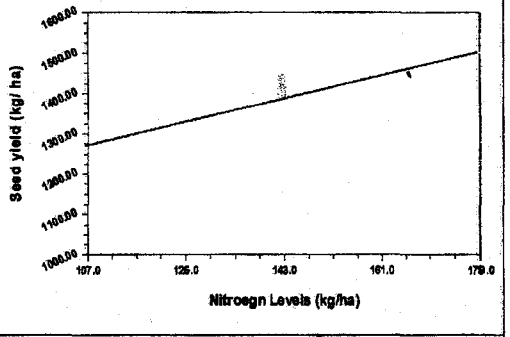
0.0 = November 1 (D_1) 15 = November 15 (D_2) 30 = December 1(D_3) 45 = December 15 (D_4)

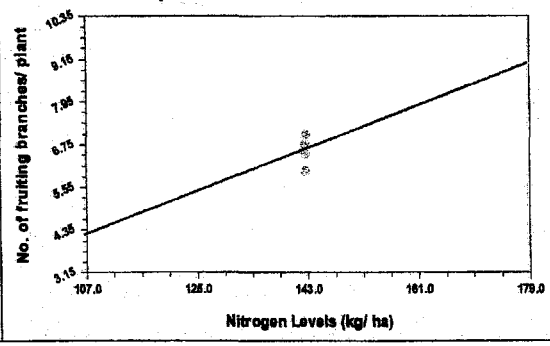
Figure (2): Relationship between nitrogen level and number of fruiting branches per plant, oil content (%) and seed yield/ ha (kg) in 2004 and 2005 seasons.

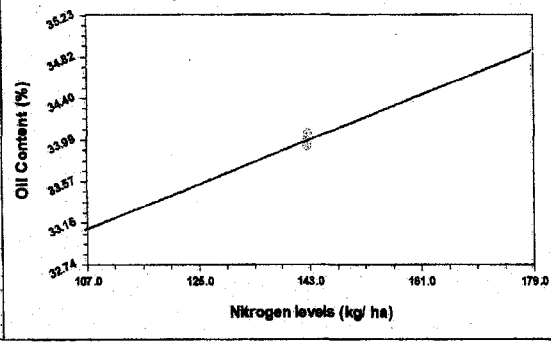
Season	(a) Number of fruiting branches per plant	(b) Oil content (%)	(c) Seed yield/ ha (kg)
2004	S.E= 0.608 R^2 = 0.890 $\hat{y}$ = -2.154+ 0.0538X**	S.E= 0.2498 R^2 = 0.683 $\hat{y}$ = 33.288+ 0.01145X**	S.E= 96.27 R^2 = 0.5358 $\hat{y}$=925.3+3.21X**
2005	S.E= 0.547 R^2 = 0.938 $\hat{y}$ = -2.933+ 0.0668X**	S.E= 0.1032 R^2 = 0.98 $\hat{y}$ = 30.44+ 0.024X**	S.E= 39.765 R^2 = 0.7225 $\hat{y}$=1159.8+2.01X**

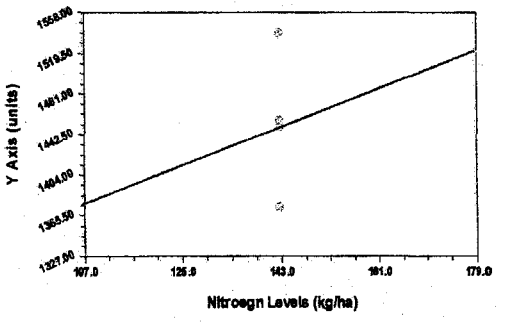












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الملخص العربى

تأثير ميعاد الزراعة ومستويات التسميد النيتروجينى على محصول البذور وبعض مكوناته ونسبة الزيت فى محصول الكتان

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية - بكلية الزراعة- جامعة الإسكندرية فى موسمى ٢٠٠٣/٢٠٠٤ و ٢٠٠٤/٢٠٠٥ لدراسة تأثير أربعة مواعيد زراعة (أول نوفمبر و ١٥ نوفمبر وأول ديسمبر و ١٥ ديسمبر) وثلاثة مستويات من التسميد النيتروجينى (١٠٧، ١٤٣، ١٧٩ كجم ن/ هكتار) على محصول البذور وبعض مكوناته ومحتوى الزيت فى صنف الكتان" جيزة ٨ ".

وقد أمكن وصف العلاقة ما بين كمية المحصول وبعض مكوناته وبين ميعاد الزراعة بمعادلة من الدرجة الثانية . و أظهرت النتائج أن التأخير فى ميعاد الزراعة عن ١٥ نوفمبر أدى إلى انخفاض معنوى فى محصول البذرة ومكوناته المدروسة بالإضافة إلى محتوى الزيت حيث أن الزراعة المتأخرة قد تودى إلى قصر فترة نمو النبات وبالتالى عدم إكتمال تكوين الكبسولات وقصر فترة تكوين وإمتلاء البذور.

وقد أدت الزيادة فى معدل التسميد الآزوتى من ١٠٧ إلى ١٧٩ كجم نيتروجين/ هكتار إلى زيادة محصول البذرة ومكوناته المدروسة وزيادة نسبة الزيت فى البذور، بينما أنخفض ارتفاع النبات فوق مستوى ١٤٣كجم نيتروجين/ هكتار. وقد أمكن وصف العلاقة ما بين كمية المحصول/ هكتار ومعدل التسميد النيتروجينى بمعادلة خطية من الدرجة الاولى مما يقترح أن زيادة مستوى النيتروجين فوق ١٧٩ كجم_تحت ظروف محطة البحوث الزراعية بجامعة الإسكندرية- قد يحتاج إلى مزيد من البحث.