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EFFECT OF NITROGEN RATE AND HARVESTING TIME ON FLAX YIELD AND ITS COMPONENTS

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ABSTRACT

The flax cultivar "Sakha 1" was grown on a clay soil at the Experimental Farm, Faculty of Agriculture, Kafr El-Sheikh, Tanta University during 2000/2001 and 2001/2002 seasons. The aim was to study the effect of four nitrogen rates (30, 40, 50 and 60 kg N/fed.) and four harvesting times (140, 150, 160 and 170 days after sowing) on flax yield and its attributes. Two field experiments were laid out in a split plot design with four replications. The main findings of this study can be summarized as follows:

Increasing nitrogen rate from 30 to 60 kg N/fed. significantly increased straw and fiber yields and its related characters, i.e., technical stem length, main stem diameter, straw yield/plant, total fiber percentage and fiber length as well as seed yield and its attributes, i.e., upper branching zone length, number of capsules and seeds/plant, seed yield/plant and 1000- seed weight. On the contrary, seed oil content was significantly decreased by increasing nitrogen rate. There was no significant difference between 50 and 60 kg N/fed. in most studied traits.

The oblained results reveal that harvesting date significantly affected all studied characters, except main stem diameter in both seasons. There was a continuous increase in straw, fiber and seed yields as well as their attributes with delaying harvesting time from 140 to 170 days after sowing, except technical stem length and fiber length, which decreased significantly with delaying harvesting time from 160 to 170 days after sowing. On the other hand, there was no significant difference between the third and fourth harvesting time (160 and 170 days after sowing) in all studied traits, except technical stem length and fiber length.

It could be concluded that application of 60 kg N/fed. and harvesting flax plants at 170 DAS could be recommended for optimum straw, fiber and seed yields/fed. Under the conditions of this investigation.

INTRODUCTION

Flax (*Linum usitatissimum*, L.) is one of the important double purpose crop in Egypt. Increasing flax production is an important goal since it is used widely as main source for fibers and oil. Also, it plays an important role in Egyptian national economy through export as well local industry. Therefore, several attempts were carried out to increase the yield of flax per unit area. This could be achieved by improving the agronomic practices such as the optimum rate of nitrogen fertilizer and the suitable harvesting time.

Nitrogen plays an important role in plant growth and yield and it is considered as an indispensable element for several vital functions. It should be applied at the optimum rate to meet the crop requirements. Several investigators under Egyptian conditions, reported that increasing N- rate significantly increased technical stem length, main stem diameter, straw yield per plant and per feddan, fiber length, fiber percentage and fiber yield/fed. as well as upper branching zone length, number of capsules/plant, 1000-seed

weight, seed yield per plant and per feddan but decreased seed oil content. [Mohamed (1996); Badr *et al.* (1998); Kineber *et al.* (1998); Mostafa *et al.* (1998); El-Gazzar (2000); El-Gazzar and El-Kady (2000); El-Shimy and Moawed (2000); Abou-Zaied (2001); El-Gazzar and Abou-Zaied (2001) and El-Gazzar and Kineber (2002)].

With respect to harvesting time, Esmail and Moursy (1994); Nimje and Gandhi (1994); El-Sweify *et al.* (1996) and Mosalem *et al.* (1999) showed that the harvesting time of 155 days after sowing significantly out- yielded the highest seed and straw yields as well as its components with best quality in comparison to harvesting after 145 and 165 days from sowing. They observed also that the highest value of seed oil content pulled at the harvest time of 165 days after sowing. Also, Shafshak *et al.* (1992) and Mohamed *et al.* (1998) reported that there was a significant increase in straw and seed yields and its related characters with delaying harvesting time from 140 to 160 days after sowing.

The aim of this investigation is to study the effect of nitrogen fertilizer rate and harvesting time on yield and yield attributes of flax.

MATERIALS AND METHODS

Two field trials were carried out at the Experimental Farm, Faculty of Agriculture, Kafr El-Sheikh, Tanta University, Egypt during 2000/2001 and 2001/2002 seasons. The soil of the experimental fields was clay in texture with pH value of 8.1 and 1.63% organic matter. It is having 18.75, 13.50 and 286 ppm available N, P and K, respectively. The preceding crop was rice in both seasons. The experiments were laid out in a split plot design with four replications. Each experiment included sixteen treatments, which were the combinations of four nitrogen rates i.e., 30, 40, 50 and 60 kg N/fed. as main plots and four harvesting times i.e., 140, 150, 160 and 170 days after sowing (DAS) as sub plots. The sub plot area was 9 m^2 (3x3m). Sowing of "Sakha 1" flax cultivar seed took place on Nov. 15th and 20th in the first and second seasons, respectively. The broadcasting method was used at seeding rate of 60 kg seed/fed. Calcium super phosphate (15.5% P_2O_5) at the rate of 100 kg/fed. was applied during seed bed preparation. Nitrogen fertilizer at the above mentioned levels was fully given just before the first irrigation as urea (46.5% N). The other recommended cultural practices for growing flax were followed.

At harvest, ten guarded plants were randomly selected from each sub plot to recording yield components. Straw and seed yields of flax/fed. were estimated from an area of 4 m^2 from the central area of each sub plot. Data collected included:

I- Straw and fiber yields and their related characters:

1- Technical stem length in (cm)
2- Main stem diameter in (mm).
3- Straw yield (g/plant).
4-Straw yield (t/fed.).
5- Fiber length in (cm).
6- Total fiber percentage.
7- Fiber yield (kg/fed.).

II- Seed yield and its related characters:

1- Upper branching zone length in (cm).
2- Number of capsules/plant.
3- Number of seeds/plant.
4- Seed yield (g/plant).
5- 1000-seed weight in (g).
6- Seed yield (kg/fed.).
7- Seed oil content: Oil was extracted using solvent ether in a soxhlet apparatus on the dry weight basis as mentioned by A.O.A.C. (1980).

All data were subjected to the analysis of variance according to procedures out lined by Snedecore and Cochran (1980). Treatment means were compared by Duncan's multiple range test (Duncan, 1955). All statistical analysis were performed using analysis of variance technique by means of "IRRISTAT" computer software package.

RESULTS AND DISCUSSION

I. Straw and fiber yields and their related characters:

Means of straw and fiber yields and their attributes of flax cv. Sakha 1 as affected by nitrogen rate and harvesting time in 2000/2001 and 2001/2002 seasons are presented in Tables 1 and 2.

I.1. Effect of nitrogen level:

Technical stem length and main stem diameter were significantly increased by increasing nitrogen rate from 30 to 50 kg N/fed. in the two seasons. Meanwhile, increasing nitrogen rate from 50 to 60 kg N/fed. caused insignificant increase in both traits. It is well known that nitrogen is an essential element for flax growth to build up protoplasm and proteins, which induce cell division, cell elongation and merastimic activity and furtherly increase flax growth, i.e., plant height (technical length + upper branching zone length) and stem diameter. The present results are in full agreement with those of Mohamed (1996); El-Gazzar (2000); and El-Gazzar and Kineber (2002).

Straw yield per plant and per feddan were significantly affected by nitrogen rate in both seasons in favor of 60 kg N/fed. compared to 30 and 40 kg N/fed. The rate of 50 kg N/fed. did not significantly differ from the rate of 60 kg/fed. in straw yield. Thus, the highest two nitrogen rates increased straw yield through increasing technical length and stem diameter. Many investigators came to similar conclusion such as Mohamed (1996); Mostafa *et al.* (1998); El-Shimy and Moawed (2000) El-Gazzar and Abou-Zaied (2001).

Total fiber percentage and fiber length at 50 and 60 kg N/fed. being insignificant, exceeded those at 30 and 40 kg N/fed. in the two seasons. Nitrogen rate exerted a significant effect on fiber yield/fed. in both seasons. Fiber yield/fed. at 50 or 60 kg N/fed. was significantly higher than at 30 and 40 kg N/fed. This may be attributed to the considerable increase in straw yield, fiber percentage and fiber length at the highest two nitrogen rates. These results are similar to those reported by Badr *et al.* (1998). El-Shimy and Moawed (2000); Abou-zaied (2001) and El-Gazzar and Abou-Zaied (2001).

Table (1): Straw and fiber yields and their attributes as affected by N-rate and harvesting time during 2000/2001 season.

Factor	Technical length, (cm)	Stem diameter, (mm)	Straw yield (g/plant)	Straw yield (t/fed.)	Total fiber %	Fiber length, (cm)	Fiber yield (kg/fed.)
N- rate (kg N/fed.):							
30	92.40c	1.55c	2.60c	3.273c	34.00b	90.50c	270.73c
40	95.55b	2.59b	3.11b	3.619b	35.83ab	94.35b	301.99bc
50	98.06a	3.18a	3.43ab	3.823ab	37.64a	97.06a	343.78ab
60	99.02a	3.25a	3.77a	3.948a	37.67a	98.22a	372.10a
F- test	**	**	**	**	**	**	**
Harvesting time (DAS):							
140	93.01c	2.50	2.85c	3.449c	33.05c	91.11c	289.27b
150	95.94b	2.60	3.11bc	3.610bc	36.05b	94.74b	306.37ab
160	99.27a	2.67	3.52a	3.732ab	38.25a	98.27a	343.34a
170	96.81b	2.79	3.43ab	3.872a	37.87ab	96.01b	349.62a
F-test	**	NS	**	**	**	**	*
Interaction	NS	NS	**	*	NS	NS	*

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.
Means followed by the same letter within columns are not significantly different at the 5% level, using Duncan's multiple range test.

Table (2): Straw and fiber yields and their attributes as affected by N-rate and harvesting time during 2001/2002 season.

Factor	Technical length, (cm)	Stem diameter, (mm)	Straw yield (g/plant)	Straw yield (t/fed.)	Total fiber %	Fiber length, (cm)	Fiber yield (kg/fed.)
N- rate (kg N/fed.):							
30	93.40c	1.48c	2.77c	3.157c	33.98c	91.60c	270.05c
40	96.08b	2.58b	3.06bc	3.351bc	35.67bc	94.96b	329.33bc
50	98.55a	3.30a	3.42ab	3.545ab	37.64ab	97.75a	383.48ab
60	99.34a	3.42a	3.82a	3.723a	37.80a	98.74a	437.59a
F- test	**	**	**	**	**	**	**
Harvesting time (DAS):							
140	93.34c	2.56	3.00b	3.262b	34.33b	91.54c	308.56b
150	96.63b	2.68	3.20ab	3.389ab	36.15ab	95.53b	341.38ab
160	99.75a	2.75	3.46a	3.510ab	37.27a	98.95a	373.28ab
170	97.62b	2.81	3.41a	3.595a	37.25a	97.02ab	397.23a
F-test	**	NS	*	*	*	**	*
Interaction	NS	NS	*	*	NS	NS	*

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.
Means followed by the same letter within columns are not significantly different at the 5% level, using Duncan's multiple range test.

I.2. Effect of harvesting time:

As shown in Tables (1 and 2), harvesting time affected significantly straw and fiber yields as well as their attributes, except main stem diameter in both seasons. The obtained results indicate that delaying harvesting time from 140 to 160 DAS resulted in a significant increase in technical stem length, straw yield/plant, total fiber percentage and fiber length. However, delaying harvesting time from 160 to 170 DAS caused a significant decrease in technical stem length and insignificant decrease in the other mentioned traits in both seasons. Meanwhile, delaying harvesting time to 170 DAS gave a continuous increase in straw and fiber yields/fed. without significant difference between the two late harvesting times (160 and 170 DAS). These results might be due to an incase in metabolites synthesized by flax plants owing to prolonged growth period and that was more pronounced, especially during the 3rd harvesting time, which in turn increased dry matter accumulation in plant organs till it reached full maturity stage (160 DAS). After this period, the reduce in straw yield components could be due to a reduction in moisture content of flax plants. In addition, delayed harvesting time exposed flax plants to over maturity stage, which often accompanied by a reduction in dry matter content owing to translocation of organic compounds to be stored in seeds. The previous results are in good accordance with these reported by Shafshak *et al.* (1992) and Mohamed *et al.* (1998).

I.3. Interaction effect:

Data in Tables (1 and 2) reveal that there were significant effects for the interaction between nitrogen rate and harvesting time on straw yield/plant as well as straw and fiber yields/fed. in the two seasons. Data in Table (3) reveal herein that the highest values of straw yield/plant (4.03 and 4.02 g) were obtained from the 3rd harvesting time (160 DAS) under the highest N-rate (60 kg N/fed.) in both seasons, respectively. Meanwhile, the highest values of straw yield/fed. (4.170 and 3.880 tons) and fiber yield/fed. (408.6 and 472.6 kg) were recorded with the 4th harvesting time (170 DAS) and when flax plants received the higher N- rate (60 kg N/fed.) in the two seasons of this study, respectively.

II. Seed yield and its related characters:

Means of seed yield and its attributes of flax cv. Sakha 1 as affected by nitrogen rate and harvesting time in 2000/2001 and 2001/2002 seasons are presented in Tables 4 and 5.

II.1. Effect of nitrogen level:

Data in Tables (4 and 5) show that the increase of nitrogen rate from 30 to 50 kg N/fed. had a significant effect on seed yield and its components, i.e., upper branching zone length, number of capsules and seeds/plant, seed yield/plant and 1000- seed weight, while increasing nitrogen rate from 50 to 60 kg N/fed. caused insignificant increase in all characters under study. Nitrogen applications enhanced vegetative growth and increasing translocation of metabolisms from source to sink and prolonging duration of seed fill, which was reflected in higher seed yield and its components.

Table (3): Effect of interaction between nitrogen rate and harvesting time on straw and fiber yields during 2000/2001 (1st) and 2001/2002 (2nd) seasons.

N- rate (kg N/ fed.)	Harvest-ing time (DAS)	Straw yield (g/plant)		Straw yield (t/fed.)		Fiber yield (kg/fed.)	
		1st	2nd	1st	2nd	1st	2nd
		Season		Season		Season	
30	140	2.06j	2.41j	2.91i	2.96k	234.7j	229.3o
	150	2.34i	2.66i	3.32h	3.10j	264.7i	258.3n
	160	3.03g	3.03fgh	3.43gh	3.24hi	284.7h	287.1L
	170	2.98g	2.97gh	3.43gh	3.32g	298.9g	305.5k
40	140	2.76h	2.89h	3.45gh	3.20i	271.5i	275.3m
	150	3.05g	3.04fg	3.55fg	3.29gh	290.9gh	312.3j
	160	3.36de	3.19e	3.73de	3.42f	313.3f	248.5h
	170	3.27ef	3.12ef	3.75de	3.50e	332.2cd	381.2f
50	140	3.17f	3.14ef	3.66ef	3.39f	315.1ef	337.0i
	150	3.34de	3.37d	3.72de	3.50e	326.6de	365.3g
	160	3.64bc	3.60c	3.80de	3.61d	366.7b	402.0d
	170	3.54c	3.55c	4.11ab	3.68c	366.8b	429.6c
60	140	3.42d	3.55c	3.80de	3.57d	335.8cd	392.7e
	150	3.71b	3.74b	3.85cd	3.67c	343.3c	429.6c
	160	4.03a	4.02a	3.97bc	3.78b	400.7a	455.5b
	170	3.93a	3.99a	4.17a	3.88a	408.6a	472.6a

Means followed by the same letter within columns are not significantly different at the 5% level, using Duncan's multiple range test.

Also, the superiority in seed yield/plant at higher nitrogen rate could be due to the increase in upper branching zone length, number of capsules and seeds/plant and seed index and in turn increased seed yield/fed. These results are supported by those of Mohamed (1996); Mostafa *et al.* (1998); El-Gazzar and El-Kady (2000) and El-Gazzar and Kineber (2002).Nitrogen fertilizer significantly and negatively affected seed oil content in both seasons, (Tables 4 and 5). Each nitrogen increment up to 50 kg N/fed. resulted in a significant decrease in seed oil content, while increasing nitrogen rate from 50 to 60 kg N/fed. caused insignificant decrease in seed oil content. At the low nitrogen rate, the oil content was higher but seed yield and seed size were depressed. This beneficial effect of the lower level of N nutrition on the oil content probably resulted because the earlier senescence of leaves, observed in this treatment, reduced the rate of seed filling during seed maturation. The present results are in full agreement with those of Mohamed (1996); Badr *et al.* (1998); El-Shimy and Mcawed (2000) and About-Zaied (2001).

II.2. Effect of harvesting time:

With regard to the effect of harvesting time on seed yield and its components, data in Tables 4 and 5 show that there was a significant increase in upper branching zone length, number of capsules and

seeds/plant, seed yield/plant, 1000- seed weight, seed oil content as well as seed yield/fed. with delaying harvesting time until 160 DAS. The results indicate also that delaying the time of harvesting from 160 to 170 DAS failed to exert any significant effect in all these traits.

Table (4): Seed yield and its related characters as affected by N- rate and harvesting time during 2000/2001 season.

Factor	Upp.br. zone length (cm)	No. of capsul-es/plant	No. of seeds/ plant	Seed yield		Seed index (g)	Seed oil content
				(g/plant)	(kg/fed.)		
N- rate (kg N/fed.):							
30	15.68c	10.12c	64.26c	0.90c	466.10c	8.67b	40.42a
40	18.02b	11.82bc	82.36b	1.20bc	624.79b	9.13a	39.38b
50	20.13a	13.76ab	89.92ab	1.42ab	753.72ab	9.29a	38.29c
60	20.75a	14.35a	91.96a	1.49a	761.68a	9.39a	38.12c
F- test	**	**	**	*	**	*	**
Harvesting time (DAS):							
140	16.15b	9.91c	68.05c	0.83b	585.05c	8.69b	38.19b
150	17.96b	11.99b	79.56b	1.25a	642.67bc	9.01b	38.85ab
160	19.97a	13.77ab	89.24a	1.46a	668.84ab	9.36a	39.54a
170	20.50a	14.37a	91.65a	1.47a	709.74a	9.40a	39.63a
F-test	**	**	*	*	*	*	*
Interaction	NS	NS	NS	NS	*	NS	NS

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.
Means followed by the same letter within columns are not significantly different at the 5% level, using Duncan's multiple range test.

Table (5): Seed yield and its related characters as affected by N- rate and harvesting time during 2001/2002 season.

Factor	Upp.br. zone length (cm)	No. of capsul-es/plant	No. of seeds/ plant	Seed yield		Seed index (g)	Seed oil content
				(g/plant)	(kg/fed.)		
N- rate (kg N/fed.):							
30	15.54c	9.92b	62.89c	0.93b	531.19c	8.80b	40.63a
40	17.88b	11.83b	81.78b	1.26a	587.97bc	9.28a	39.52b
50	20.06a	14.03a	88.95ab	1.46a	639.6ab	9.44a	38.31c
60	20.48a	14.63a	92.78a	1.52a	731.65a	9.49a	38.20c
F- test	**	**	**	*	**	*	**
Harvesting time (DAS):							
140	16.00b	9.77c	69.64b	0.88c	575.23b	8.83b	37.21b
150	17.76b	11.86b	80.70a	1.20b	607.66ab	9.30ab	39.48a
160	19.85a	14.07a	87.65a	1.51a	638.82ab	9.41a	39.89a
170	20.33a	14.68a	88.40a	1.56a	668.71a	9.44a	40.11a
F-test	**	**	*	**	*	*	*
Interaction	NS	NS	NS	NS	**	NS	NS

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.
Means followed by the same letter within columns are not significantly different at the 5% level, using Duncan's multiple range test.

The increase in the traits previously noted with delaying the time of harvesting might be attributed to the progressive development of the tissues and the increase in dry matter content of flax plants owing to the progressive building of tissues and accumulation of metabolites in the different organs of flax plants. Many investigators came to similar conclusion such as Esmail and Moursy (1994); El-Sweify *et al.* (1996); Mohamed *et al.* (1998) and Mosalem *et al.* (1999).

II.3. Interaction effect:

Data presented in Tables (4 and 5) reveal that the interaction between nitrogen rate and harvesting time had no significant effect on all studied characters, except seed yield/fed. in both seasons. Data in Table (6) show clearly that the highest values of seed yield/fed. (813.5 and 786.7 kg) were achieved at the 4th harvesting time (170 DAS) with the higher nitrogen rate under study (60 kg N/fed.) in both seasons, respectively, without significant difference between this combination (60 kg N X harvesting time at 170 DAS) and (50 kg N X harvesting time at 160 or 170 DAS) or (60 kg N X harvesting time at 160 DAS) in the first season.

Table (6): Effect of interaction between nitrogen rate and harvesting time on seed yield/fed. during 2000/2001 and 2001/2002 seasons.

N- rate (kg N/fed.)	Harvesting time (DAS)			
	140	150	160	170
		2000/2001 season		
30	416.3g	433.4fg	445.3f	569.5e
40	602.0d	602.6d	642.4c	652.2c
50	658.1c	765.1b	788.0ab	803.7a
60	663.9c	769.6b	799.7a	813.5a
		2001/2002 season		
30	507.8k	519.7k	534.6j	562.7i
40	541.0j	566.9i	606.5g	637.5f
50	585.6h	626.7f	658.1e	687.9d
60	666.5e	717.3c	756.1b	786.7a

Means followed by the same letter within columns are not significantly different at the 5% level. using Duncan's multiple range test.

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تأثير معدل السماد الأزوتى وميعاد الحصاد على محصول الكتان ومكوناته

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تم زراعة صنف الكتان سخا ١ فى أرض طينية بالمزرعة البحثية لكلية الزراعة بكفرالشيخ – جامعة طنطا خلال موسمى الزراعة ٢٠٠٠/٢٠٠١، ٢٠٠١/٢٠٠٢م. وكان الهدف هو دراسة تأثير أربع معدلات من الأزوت (٣٠، ٤٠، ٥٠، ٦٠ كجم أزوت/فدان) وأربع مواعيد للحصاد (١٤٠، ١٥٠، ١٦٠، ١٧٠ يوم من الزراعة) على محصول الكتان ومكوناته. ولهذا أجريت تجربتان حقليتان فى تصميم القطع المنشقة فى أربع مكررات. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

أدت زيادة معدل السماد الأزوتى من ٣٠ الى ٦٠كجم أزوت للفدان الى زيادة معنوية فى كل من محصولى القش والألياف للفدان ومكوناتهما وهى الطول الفعال، قطر الساق الرئيسى، محصول القش/ نبات، النسبة المئوية للألياف الكلية، طول الألياف وكذلك فى محصول البذرة للفدان ومكوناته وهى طول المنطقة الثمرية، عدد الكبسولات والبذور للنبات، محصول البذرة/نبات، وزن الـ ١٠٠٠ بذرة. ومن ناحية أخرى فقد نقص محتوى البذور من الزيت معنويا بزيادة مستويات التسميد الأزوتى. ولم يكن هناك فروقا معنوية بين معدلى التسميد الأزوتى (٥٠، ٦٠ كجم أزوت/فدان) فى معظم الصفات المدروسة.

أظهرت النتائج المتحصل عليها أن ميعاد الحصاد أثر معنويا على كل الصفات المدروسة فيما عدا صفة قطر الساق الرئيسى بكلا موسمى الدراسة. وقد كانت هناك زيادة مستمرة فى محصول القش والألياف والبذرة ومكوناتها بتأخير ميعاد الحصاد من ١٤٠ الى ١٧٠ يوم من الزراعة فيما عدا صفتى الطول الفعال وطول الألياف واللتان نقصتا معنويا بتأخير ميعاد الحصاد من ١٦٠ الى ١٧٠ يوم من الزراعة. ومن ناحية أخرى لم تظهر أى فروق معنوية بين ميعادى الحصاد الثالث والرابع تحت هذه الدراسة (١٦٠، ١٧٠ يوم من الزراعة) فى كل الصفات المدروسة فيما عدا صفتى الطول الفعال وطول الألياف.

ويمكن أن نستخلص من نتائج هذه الدراسة أنه بإضافة معدل الأزوت ٦٠ كجم أزوت/فدان وحصاد نباتات الكتان بعد ١٧٠ يوم من الزراعة يمكن الحصول على أقصى محصول من القش والألياف والبذرة.