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RESPONSE OF SOME FLAX GENOTYPES TO BIO AND NITROGEN FERTILIZATION

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ABSTRACT: Two field experiments in split split plot design were carried out during 2004 /2005 and 2005/ 2006 seasons on a clay soil at the Experimental Farm of Kafr El-Hamam Agricultural Research Station, Sharkia Governorate to study the response of three flax genotypes (Sakha$_1$, Sakha$_2$ and Strain 2419/1) to three levels of mineral nitrogen fertilizer (15,30 and 45kg N/fad) and biofertilizer (0,500 and 1000 gm Microbein/fad) regarding the effects on yield, yield components and its quality as well as economic yield. Moreover, correlation coefficient and path analysis between some straw and seed characters were studied. Results showed significant differences among the three genotypes under study in the two seasons and in their combined . The flax variety Sakha$_1$ surpassed significantly the two other genotypes i.e. Sakha$_2$ and St. 2419/1 in total and technical length / plant, straw yield / plant, fiber yield / plant, fiber yield / fad, fiber length, fiber fineness, biological yield / fad, economic yield / fad and net income of fiber yield / fad. Furthermore, over the two seasons the oil strain 2419 /1 ranked first and surpassed significantly Sakha$_2$ and Sakha$_1$ varieties in number of capsules / plant, 1000 seed weight, seed yield / plant, seed yield / fad, seed oil percentage, oil yield / fad, seed protein percentage and protein yield / fad, in addition to its relative income of seed yield / fad. On the other hand, the differences between the three genotypes did not reach the level of significance for harvest index trait.

Application of 45 kg N / fad resulted the highest values for straw and seed characters as well as economic yield, while adding 15 kg N / fad gave the lowest values for all characters under study.

Inoculating flax seeds genotypes with 1000 gm Microbein /fad as a biofertilizer followed by 500 gm Microbein / fad achieved highest values for all studied characters comparing with the control (uninoculation). Moreover, genotypes × nitrogen levels, genotypes ×

biofertilization, nitrogen levels × biofertilization did not affect significantly most characters under study.

The estimated correlation coefficients (r) were positively and highly significant correlated between straw yield / fad and each of straw yield / plant, fiber yield / fad, fiber yield / plant, technical length/ plant and fiber length . Also seed yield / fad was positively and highly significant correlated with each of seed yield / plant, number of capsules / plant, 1000 seed weight, oil yield / fad and protein yield / fad. Positive and highly significant correlations were found between fiber yield / fad and each of fiber yield / plant, technical length/ plant and fiber length.

Path analysis revealed that the main source of straw yield variation according to their relative importance was straw yield / plant (598,363). However, the main sources of seed yield variation were 1000 seed weight (163,885) and seed yield / plant (57,851).

Key words: Flax genotypes, nitrogen fertilizer, biofertilization.

INTRODUCTION

Flax (*Linum usitatissimum,* L.) is consider as the most important dual purpose type for oil and fiber production in Arab Republic of Egypt and many countries in the world. This crop plays an important role in developing the national economy by its fiber exportation and local fabrication. Fresh linseed oil is used as human food and after boiling as painting and varnish industry. Moreover, after extracting oil from seeds, cake is considered as a rich source of protein for animal feeding (Kozlowski, 2001). The cultivated area by flax in Egypt tended to decrease and the production of fiber and seed from such limited area was insufficient to provide the need of increasing demands for growing Egyptian population. In the same time, it is difficult to increase the cultivated area because the great competition with another winter crops such as wheat, clover and faba bean. So it is necessary to increase flax productivity from the present area to cover the gap between flax production and consumption specially in linseed oil. This could be achieved by growing more productive genotypes or by improvement the agricultural practices i.e. nitrogen and bio fertilizers. Flax genotypes vary widely in yield and its attributes as well as its quality (Momtaz,1965, Momtaz *et al.,* 1989, El-Hariri *et* *al.,* 2002 a,b, El-Azzouni *et al.,* 2003, El-Farouk *et al.,* 2003, Mourad *et al.,* 2003, Zedan, 2004, Nashy, 2005, El-Shimy *et al.,* 2006 and El–Sweify *et al.,* 2006).

Nitrogen is the nutrient element frequently deficient in Egyptian soil. Therefore, adequate supply of nitrogen is essential for optimum yield and quality of flax. Many investigators detected the important role of nitrogen element on flax growth which reflect on the yield, yield components and quality of fibers and seeds, among of them Ghanem (1990), El–Kady *et al.,*(1995), Zedan *et al.,* (1997), Badr *et al.,*(1998), Nassar and El-Taweel (2001) and El–Shimy *et al.,* (2002) who reported that application of 45 kg N / fad gave a significant increase in straw and seed yields as well as their related characters. On the other hand, an excess of nitrogen fertilizer was found to affect negatively on flax yield and its quality because of lodging and development of disease (Trush, 1986). Relatively low flax requirement in nitrogen was the presquisite for the experiments with associative N2–fixing bacteria *Azospirillum braselines*, which also posses a hormonal effect. Biological management allows preventing high concentration of nitrogen in soil excludes lodging and negative effects on flax yield and quality (Mikhailouskaya 2006). Recently, much interest is focused on using biofertilizer to minimize the production cost and environmental pollution. In this respect several investigators indicated the positive response of flax plant to biofertilization and recorded maximum values of the yield, yield components as well as its quality, among of them Afify *et al.,* (1994), Hamed (1998), El–Gazzar (2000),El–Gazzar and El–kady (2000), Ash-Shormillesy, Salwa (2001), Abdel–Samie *et al.,* (2002), El– Azzouni and El–Banna (2002), Mostafa *et al.,* (2003), Abdel–Haleen (2005) and Mikhailouskaya (2006).

Therefore, this work aimed to study the effect of nitrogen fertilizer levels (as mineral N fertilizer) and Microbein (as N–biofertilizer) for increasing yield , yield components and fiber or seed quality characters, in addition to study the interrelationships between straw and seed yields and their related characters, as well as the contribution of yield components in straw and seed yields for some flax genotypes.

MATERIALS AND METHODS

Two field experiments were carried out during 2004/ 2005 and 2005/ 2006 growing seasons in a clay soil at the Experimental Farm of Kafr El–Hamam Agricultural Research Station, Sharkia Governorate, to study the effect of three mineral nitrogen fertilizer levels and biofertilization with Microbein (bio– nitrogen source) on the yield, yield components, fiber or seed quality characters and the interrelationships between straw and seed yields and their related characters, as well as the path analysis study related to straw and seed yields / fad and their components for three flax genotypes. In each season a split–split plot design with four replications was used. The main plots contained three flax genotypes i.e. $Sakha_1$, $Sakha_2$ and St. 2419 /1, the sub- plots included three nitrogen fertilizer levels (15,30 and 45 kg N / fad) and the sub-sub plots were assigned to three biofertilization treatments (0,500 and 1000 gm Microbein / fad). Each experiment included 27 treatments which were the combination of three flax genotypes, three nitrogen fertilizer levels and three treatments of biofertilization with Microbein. Flax genotypes $Sakha_1$, $Sakha_2$ and St.2419/1 were selected from cross between Bombay x 1.1485, 1.2348 x Hira and pure seed of I: Humpata (a Hungarian introduction) respectively. The experimental unit area was $6m^2$. Seeds of flax genotypes were equally drilled in 20 rows 15cm apart at sowing rate of 70 kg seeds / fad. Sowing dates were 16^{th} and 18^{th} November in the first and second seasons, respectively. Mineral phosphorus fertilizer as calcium superphosphate (15.5% P_2O_5) was applied during soil preparation. Other agricultural practices for growing flax were performed as recommended. Physical and chemical analysis of the experimental field are presented in Table 1. Soil of the experimental site was clay in texture. Both physical and chemical analysis were conducted by the following method described by Jackson (1973), while N, P and K nutrients were analyzed by the extractive with DTPA according to Lindsay and Norwell (1978).

Flax was preceded by maize and rice in the first and second seasons, respectively. Nitrogen was applied as ammonium nitrate 33.5% N in a two equal doses, the first dose was added before the first irrigation at 21 days from sowing and the second one at 21 days later. Harvesting took place at 28 April and 1 May for the two growing seasons, respectively. The N_2 fixer inoculation efficient nitrogen was performed by mixing seeds of the studied flax genotypes with the appropriate amount of Microbein at the rate of 500 gm / fad using Arabic gum as adhesive material. The mixed seeds were

Table 1. Some physical and chemical characteristics of the experimental site

Soil analysis	2004/ 2005 season	2005 / 2006 season
I- Physical analysis:		
Clay %	45.60	44.77
Silt %	30.50	29.10
Coarse sand %	2.68	2.43
Fine sand %	21.22	23.70
Organic matter %	2.58	1.97
$CaCo_3$ %	2.50	3.26
EC ds/ cm	1.26	1.45
Texture class	clay	clay
II- Chemical anaysis:		
PH	7.90	8.10
Available N ppm	75.5	68.0
Available P ppm	21.23	19.35
Available K ppm	325.00	300.00

then air dried in the shade for 30 minutes and some immediately in the well prepared drills (rows) of each experimental unit. After sowing the inoculated seeds, the irrigation practices immediately followed. After hand weeding another rate of 500 gm was well mixed with about 20kg / fad fine dust and such mixture was applied between the rows of flax plants before the first irrigation directly i.e. after 21 days from sowing, which corresponding with the first nitrogen dose application. At maturity ten guarded plants were taken randomly from each sub sub plot to determine the yield components of straw and seed as well as their quality. However straw, seed and fiber yields / fad were calculated from the central area of $2m^2$ from the plot area basis . Data recorded incuded:

Straw Yield and its Related Characters

Total length/ plant (cm), technical length / plant (cm), straw yield / plant (gm), straw yield / fad (ton), fiber yield / plant (gm), fiber yield / fad (ton), fiber length (cm) and fiber fineness which estimated according to Radwan and Momtaz (1966) as follows: N. m = N x L / G where: N. m: metrical number, N: number of fibers (20 fibers of 10 cm length, L: length of fiber in mm (2000) and G: weight of fiber in mg.

Seed Yield and its Related Characters

Number of capsules/ plant, 1000 seed weight (gm) , seed yield / plant (gm), seed yield / fad (kg), seed oil percentage determined according to the extraction method described by Horwitz *et al.*, (1965), using soxhlet apparatus and petroleum ether with a boiling range of 60- 80°C as a solvent for six hour, the oil % was calcutated on dry weight basis, oil yield / fad (kg) calculated by multiplying seed oil percentage × seed yield / fad, seed protein percentage determined by using the modified microkgeldahl apparatus according to the method described by A. O. A. C. methods (1990), the obtained values were multiplied by 6.25 as used by Tripathi *et al.*, (1971), protein yield / fad (kg) calculated by multiplying the crud protein content % X seed yield / fad.

Economic Yield

Biological yield/fad (ton) calculated from the summation of straw and seed yields / fad (W), economic yield / fad (ton) (EY) calculated from the summation of seed and fiber yields / fad, harvest index calculated as percentage from the biological yield according to the following formula suggested by Wallaco *et al.*, (1972), HI = E Y/W × 100 where: EY : economic yield /fad, W: biological yield /fad. Net income of fiber yield / fad = total income of fiber yield / fad – fertilization costs / fad (pound). Relative income of seed yield / fad (pound) = total income of seed yield / fad – fertilization costs / fad (pound).

Statistical Analysis

Analysis of variance of split-split plot design was performed in each season according to Snedecor and Cochran (1982). Significance of differences among treatment means Judged with least significant difference (L. S. D) at 5% and 1% levels of significance. Means followed by the same alphabetical letters are not statistically different. Moreover combined analysis of variance over the two seasons was undertaken for each character according to Le Clerg *et al.* (1966). In the interaction Tables computed on the pooled data of both seasons only capital and small letters were used to compare both row and column averages, orderly.

Correlation study

Simple correlation coefficients between different flax characters were calculated according to Svab (1973) to determine the relationship according to the following equation :

$$r_{xy} = \frac{SP_{xy}}{\sqrt{SS_x . SS_y}}$$

Where:

$SP_{xy} = \Sigma x y - \Sigma x . \Sigma y/n,$

$SS_x = \Sigma x^2 - (\Sigma x)^2 / n$

$SS_y = \Sigma y^2 - (\Sigma y)^2 / n$

SP_{XY} is the phenotypic covariance between the two traits, SS_X is the phenotypic standard deviation of the first trait and SS_Y is the phenotypic standard deviation of the second trait. The r test was used the significance of r (value).

Path analysis

The path analysis study was computed by using the method mentioned by Li (1975).

RESULTS AND DISCUSSION

Straw Yield and its Related Characters

Mean values of straw yield and its related characters for three flax genotypes as affected by nitrogen fertilizer levels and biofertilization with Microbein from the combined analysis are presented in Tables 2 and 3. Statistical analysis of variance showed significant differences between flax genotypes and either between nitrogen fertilizer levels or biofertilization with Microbein treatments in all eight straw characters studied.

Response of genotypes

Data in Tables 2 and 3 showed that $Sakha_1$ variety ranked first and surpassed significantly the other two flax genotypes and produced the highest values of total and technical length / plant, straw as well as fiber yields / plant, in addition to per fad, fiber length and fiber fineness, meanwhile the strain 2419/1 gave the lowest values concerning the all previous traits in the combined analysis. These varietal differences in straw yield characters due to differences in genetic potential which in turn on different straw yield characters. Many investigators found varietal differences in straw characters such as Momtaz, (1965), Momtaz *et al.*, (1989), Abo–El- Zahab and Abo–Kaied (2000_I), Ash–Shormillesy, Salwa (2001), Abdel–Samie *et al.*, (2002), El–Hariri *et al.*, (2002a), Azzouni *et al.*, (2003), El–Farouk *et al.*, (2003), Mostafa *et al.*, (2003), Mourad *et al.*, (2003), Zedan (2004), Abdel–Haleem (2005), Nashy (2005), El–El– Shimy *et al.*, (2006) and El–Sweify *et al.*, (2006). Generally, the maximum mean values for the eight characters previously mentioned were obtained by $Sakha_1$ variety followed by $Sakha_2$ variety and the lowest mean values obtained by St. 2419 /1.

Effect of nitrogen fertilizer levels

Nitrogen fertilizer had a marked influence on straw yield and its related characters of flax plant. Data from the combined analysis revealed that there was a gradual increase in all straw yield and its related studied characters i. e. total and technical length / plant, straw yield/ plant, straw yield / fad, fiber yield/ plant, fiber yield / fad and

Table 2. Mean values of total length / plant, technical length / plant, straw yield / plant, and straw yield / fad as affected by nitrogen fertilizer levels(N) and biofertilization (B) of the flax genotypes (G) in 2004/2005 and 2005/2006 seasons and their combined analysis

Main effects and interactions	Total length / plant (cm)			Technical length / plant (cm)			Straw yield / plant(g)			Straw yield / fad (ton)		
	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.
Genotypes:												
G_1: Sakha1	123.79a	114.42a	119.10a	111.51a	100.92a	106.22a	3.409a	3.007a	3.208a	5.370a	4.956a	5.163a
G_2: Sakha2	120.66b	112.24a	116.45b	105.91b	96.94a	101.43b	3.016ab	2.600b	2.808b	4.825b	4.313b	4.569b
G_3: Strain 2419/1	116.29c	107.73b	112.01c	102.15c	88.39b	95.27c	2.683b	2.474b	2.579c	4.553b	4.080c	4.317c
F. test	**	**	**	**	**	**	*	**	**	**	**	**
Nitrogen levels(N):												
N_1:15kg N/ fad	118.33b	107.41b	112.87b	104.24b	91.14c	97.69c	2.563b	2.342b	2.453b	4.413b	4.179c	4.296c
N_2: 30kg N/ fad	120.54a	112.78a	116.66a	106.81a	95.68b	101.24b	3.180a	2.787a	2.983a	4.965a	4.479b	4.722b
N_3: 45kg N / fad	121.86a	114.21a	118.03a	108.52a	99.44a	103.98a	3.365a	2.952a	3.158a	5.369a	4.691a	5.030a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Biofertilization(B):												
B_0: Uninoculation	114.99b	107.69c	111.34c	101.27c	90.20c	95.74c	2.492c	2.193c	2.343c	4.439c	3.967c	4.203c
B_1: 500gm Microbein/ fad	121.57a	112.13b	116.85b	107.55b	95.89b	101.72b	3.067b	2.803b	2.935b	5.011b	4.564b	4.787b
B_2: 1000gm Microbein/ fad	124.16a	114.58a	119.37a	110.75a	100.16a	105.45a	3.549a	3.084a	3.317a	5.299a	4.819a	5.059a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:												
GXN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXB	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
NXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXNXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 3. Mean values of fiber yield / plant, fiber yield / fad, fiber length and fiber fineness as affected by nitrogen fertilizer levels (N) and biofertilization (B) for the flax genotypes (G) in 2004/2005, 2005/2006 and their combined analysis

Main effects and interactions	Fiber yield / plant (gm)			Fiber yield / fad (ton)			Fiber length (cm)			Fiber fineness (N.m)		
	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.
Genotypes:												
G_1: $Sakha_1$	0.568a	0.510a	0.539a	0.899a	0.834a	0.867a	120.62a	110.74a	115.68a	220.85a	219.47a	220.16a
G_2: $Sakha_2$	0.472ab	0.400b	0.436b	0.758ab	0.662b	0.710b	116.32b	107.47a	111.90b	216.20b	213.68b	214.94b
G_3: Strain 2419/1	0.369b	0.342b	0.356c	0.632b	0.562b	0.597b	112.10c	101.18b	106.64c	211.11c	202.05c	206.58c
F. test	*	**	**	*	**	**	**	**	**	**	**	**
Nitrogen levels(N):												
N_1:15kg N/ fad	0.354b	0.321b	0.337c	0.611b	0.573b	0.592b	113.77b	102.16c	107.96c	221.27a	219.89a	220.58a
N_2: 30kg N/ fad	0.523a	0.454a	0.489b	0.816a	0.731a	0.773a	117.02a	107.29b	112.16b	220.44b	216.38b	218.41b
N_3: 45kg N / fad	0.532a	0.478a	0.505a	0.862a	0.754a	0.808a	118.25a	109.94a	114.10a	206.46c	198.94c	202.70c
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Biofertilization(B):												
B_0: Uninoculation	0.348c	0.301c	0.324c	0.638c	0.540c	0.589c	110.98c	102.23c	106.61c	221.34a	218.13a	219.74a
B_1: 500gm Microbein/ fad	0.484b	0.445b	0.465b	0.789b	0.724b	0.756b	117.63b	106.90b	112.26b	220.14a	215.98b	218.06b
B_2: 1000gm Microbcin/ fad	0.577a	0.506a	0.542a	0.863a	0.794a	0.828a	120.43a	110.27a	115.35a	206.68b	201.08c	203.08c
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:												
GXN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	*
GXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
NXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S
GXNXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

fiber length with increasing N levels up to 45 kg N / fad except with fiber fineness which decreased by 8.11% between the highest and the lowest nitrogen rate in this case. The increments between the highest and lowest averages were 4.57, 6.44, 28.74, 17.09, 49.85 , 36.49, 5.69% for the previous traits, respectively. On the other hand, no significant differences among mean values of total length / plant, straw yield / plant and fiber yield / fad occurred as result of added 30 and 45 kg N / fad. These results could be explained according to the favourable effect of the applied nitrogen on metabolic processes i. e. enhanced cell division, building new merstimic cells, cell elongation which resulted in an increase in flax plant growth and productivety. These findings are in accordance with those obtained by Hella *et al.,* (1988), Ghanem (1990), El-Kady *et al.,* (1995), Abdel–Samie and EL-Bially (1996), Abo–Shetia *et al.,* (1996_b), Abdel wahab *et al.,* (1997) ; Zedan *et al.,*(1997), Badr *et al.,* (1998), Hamed (1998), Ash-Shormillesy, Salwa (2001), Nassar and El–Taweel (2001) and El–Azzouni and El – Banna (2002).

Effect of biofertilization

Results obtained indicated that inoculation with 1000 gm Microbein / fad caused a markable increase in total and technical length / plant, straw yield / plant, straw yield / fad, fiber yield / plant, fiber yield / fad and fiber length. The superiority ratios between the maximum dose and the untreated control were 7.21, 11.14, 41.57, 20.37, 67.28, 40.58 and 8.20%. On contrary, fiber fineness was decreased by 7.58%. These results might be attributed to the favourable effect of Microbein as N–biofertilizer in enhanced growth of flax plant. The obtained results are in accordance with those obtained by Trush (1986). Afify *et al.,* (1994), Hamed (1998), El–Gazzar (2000), El-Gazzar and El – Kady (2000), Ash– Shormillesy, Salwa (2001), Abdel– Samie *et al.,* (2002), El– Azzouni and El–Banna (2002), Abdel–Haleem (2005), El-Shimy *et al.,* (2006) and Mikhailouskaya (2006).

Interaction effect

The interaction effect between genotypes and nitrogen levels on straw yield and its related characters did not reach the level of significance, except fiber fineness (Table 4). The highest values of fiber fineness were obtained from $Sakha_1$ variety when fertilized with 15 kg N/fad. The insignificant effect between genotypes and nitrogen levels showed that each of these two

Table 4. Interaction effect of flax genotypes (G) X nitrogen fertilizer levels (N) on fiber fineness (combined analysis of 2004/2005 and 2005/2006 seasons)

Genotypes	Nitrogen fertilizer levels		
	N_1 :15kg N/ fad	N_2 :30 kg N / fad	N_3 :45 kg N/ fad
	Fiber fineness (N.m)		
	A	A	B
G_1 :Sakha$_1$	225.23a	223.87a	211.39a
	A	A	B
G_2 :Sakha$_2$	220.64ab	218.78ab	205.40a
	A	A	B
G_3 :Strain 2419/1	215.87b	212.58b	191.30b

factors acted independently on these traits. These results are in agreement with those reported by El–Kady *et al.,* (1995), Badr *et al.,* (1998), Ash–Shormillesy, Salwa (2001), Nassar and El–Taweel (2001), El–Azzouni and El– Banna (2002) and Abdel Haleem (2005).

Seed Yield and its Related Characters

Mean values of seed yield and its related characters for the flax genotypes as affected by nitrogen fertilizer levels and biofertilization treatments are presented in Tables 5 and 6. Analysis of variance showed significant differences between the three flax genotypes, nitrogen fertilizer levels and biofertilization treatments in all eight seed characters studied.

Response of genotypes

The obtained results revealed that Strain. 2419/1 ranked first and surpassed the two local varieties Sakha$_1$ and Sakha$_2$ in all studied seed characters i.e. number of capsules / plant, 1000 seed weight, seed yield / plant, seed yield/ fad, seed oil percentage, oil yield / fad, seed protein percentage and protein yield / fad. The superiority of St. 2419/1 in seed yield / fad may be attributed to the increase in number of capsules / plant, 1000 seed weight and seed yield / plant. It could be concluded that the previous varietal differences in seed yield characters due to the genetically make- up for each one. Similar results were obtained by Momtaz (1965), Momtaz *et al.,* (1989), Abo–El- Zahab and Abo–Kaied (2000 $_{II}$), El – Azzouni *et al.,* (2003), Zedan (2004), Abdel–Haleem (2005), Nashy (2005), El–Shimy *et al.,* (2006) and El–Sweify *et al.,* (2006).

Effect of nitrogen fertilizer levels

Results revealed that there was a significant increase in all seed yield and its related studied characters i.e. number of capsules / plant, 1000 seed weight, seed yield / plant, seed yield / fad, seed oil percentage, oil yield / fad, seed protein percentage and protein yield / fad with increasing N levels up to 45 kg N/ fad. The superiority percentages between the maximum N level and the corresponding

Table 5. Mean values of number of capsules / plant, 1000 seed weight, seed yield / plant and seed yield / fad as affected by nitrogen fertilizer levels (N) and biofertilization (B) for the flax genotypes (G) in 2004/2005 and 2005/2006 seasons and their combined analysis

Main effects and interactions	Number of capsules / plant			1000 seed weight (gm)			Seed yield / plant (gm)			Seed yield / fad (kg)		
	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.
Genotypes(G):												
G_1: $Sakha_1$	8.03c	7.25c	7.78c	8.73b	8.32b	8.53c	0.382c	0.355c	0.369c	584.60c	424.64c	504.62c
G_2: $Sakha_2$	9.32b	8.82b	9.07b	9.28a	9.01a	9.15b	0.493b	0.426b	0.460b	631.23b	486.63b	558.93b
G_3: Strain 2419/1	10.48a	10.01a	10.25a	9.61a	9.24a	9.42a	0.536a	0.484a	0.510a	676.54a	544.29a	610.42a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Nitrogen levels(N):												
N_1:15kg N/ fad	7.93c	7.45b	7.69c	8.86b	8.46b	8.66c	0.399b	0.361b	0.380b	568.04b	455.49b	511.77c
N_2: 30kg N/ fad	9.66b	9.24a	9.45b	9.30a	8.97a	9.13b	0.497a	0.444a	0.470a	649.82a	487.05a	568.43b
N_3: 45kg N / fad	10.24a	9.65a	9.94a	9.46a	9.14a	9.30a	0.515a	0.461a	0.488a	674.52a	513.03a	593.77a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Biofertilization(B):												
B_0: Uninoculation	7.55c	6.99c	7.27c	8.68c	8.35c	8.52c	0.361c	0.241c	0.351c	581.49b	438.98c	510.24c
B_1 : 500gm Microbein/ fad	9.60b	9.17b	9.39b	9.32b	8.97b	9.15b	0.506b	0.443b	0.475b	649.09a	492.41b	570.75b
B_2: 1000gm Microbein/ fad	10.68a	10.19a	10.43a	9.62a	9.24a	9.42a	0.544a	0.481a	0.512a	661.79a	524.18a	592.99a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:												
GXN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXB	*	N.S	N.S	*	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S
NXB	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	N.S
GXNXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 6. Mean values of seed oil percentage, oil yield / fad, seed protein percentage and protein yield / fad as affected by nitrogen fertilizer levels (N) and biofertilization (B) for flax genotypes (G) in 2004/2005 and 2005/2006 seasons and their combined analysis

Main effects and interactions	Seed oil percentage			Oil yield / fad (kg)			Seed protein percentage			Protein yield /fad(kg)		
	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.
Genotypes(G):												
G_1: Sakha$_1$	39.39b	39.33b	39.55c	230.58c	167.25c	198.91c	25.82b	24.01c	24.92c	152.70c	102.84c	127.77c
G_2: Sakha$_2$	41.17a	40.97a	41.07b	260.27b	199.71b	229.99b	29.69a	27.45b	28.57b	189.06b	134.85b	161.76b
G_3: Strain 2419/1	41.60a	41.39a	41.50a	281.93a	225.67a	253.80a	31.69a	30.19a	30.94a	215.55a	165.35a	190.45a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Nitrogen levels(N):												
N_1:15kg N/ fad	40.21c	39.90c	40.06c	228.86b	182.38c	205.62c	26.92c	24.98c	25.95c	154.14c	115.57c	134.85c
N_2: 30kg N/ fad	40.74b	40.64b	40.69b	265.53a	198.53b	232.03b	29.26b	27.06b	28.16b	192.34b	133.64b	162.99b
N_3: 45kg N / fad	41.21a	41.15a	41.18a	278.39a	211.73a	245.06a	31.02a	29.61a	30.31a	210.83a	153.83a	182.33a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Biofertilization(B):												
B_0: Uninoculation	39.84c	39.71c	39.78c	232.19b	174.73c	203.46c	26.28c	24.73c	25.51c	153.75c	109.76c	131.75c
B_1 : 500gm Microbein/ fad	40.97b	40.86b	40.91b	266.45a	201.68b	234.06b	29.72b	27.64b	28.68b	195.48b	137.82b	166.65b
B_2: 1000gm Microbein/ fad	41.35a	41.12a	41.24a	274.14a	216.23a	245.19a	31.19a	29.28a	30.24a	208.08a	155.45a	181.77a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:												
GXN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	*	*
NXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	*	N.S	*	*
GXNXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

lowest one for each previously characters were 29.26, 7.39 ,28.42, 16.02, 2.79, 19.18, 16.80 and 35.21%, respectively as an average for the two seasons. Many investigators obtained similar conclusions, among of them Hella *et al.,* (1988) , Ghanem (1990), El–Kady *et al.,* (1995), Abdel –Samie and El-Bially (1996), Abo- Shetaia *et al.,* (1996_b), Abdel wahab *et al.,* (1997), Zedan *et al.,* (1997). Badr *et al.,* (1998), Ash- Shormillesy, Salwa (2001), Nassar and El–Taweel (2001), El– Azzoumi and El- Banna (2002) and Mostafa *et al.,* (2003)

Effect of biofertilization

Concerning to biofertilization with Microbein, data showed that there was increase in number of capsules / plant, 1000 seed weight, seed yield / plant, seed yield / fad, seed oil percentage, oil yield / fad, seed protein percentage and protein yield / fad with increasing application amount of Microbein. The increment was 43.47 , 10.56 , 45.87 , 16.22 , 3.67 , 20.51 , 18.54 and 37.97% between the highest Microbein rate and the control (uninoculation) for the previous traits, respectively as average for the two seasons. These findings are in harmony with those reported by Afify *et al.,*(1994), Hamed (1998), El–Gazzar (2000), El–Gazzar and El–Kady (2000), Ash–Shormillesy, Salwa (2001), Abdal–Samie *et al.,* (2002), El-Azzouni and El–Banna (2002). Mostafa *et al.,* (2003), Abdel–Haleem (2005) and El–Shimy *et al.,* (2006) .

Interaction effect

As average for both seasons data presented in Table 7 showed that the interaction between genotypes and biofertilization with Microbein had significant effect on 1000 seed weight and protein yield / fad. The highest values of 1000 seed weight and protein yield / fad were obtained by inoculating strain 2419/1 with 1000gm Microbein /fad. It could be concluded that the strain 2419/1 inferior to the two other local varieties $Sakha_1$ and $Sakha_2$ when inoculated with 1000 gm Microbein / fad. Similar results are in agreement with those obtained by Ash-Shormillesy, Salwa (2001). Abdel–Samie *et al.,* (2002), El–Azzoumi and El–Banna (2002).

Combined analysis of the two seasons indicated that the interaction between nitrogen fertilizer levels and biofertiliztion with Microbein had a significant effect on seed protein percentage and protein yield / fad (Table 8). The maximum values of seed protein percentage and protein yield /fad were obtained by inoculating flax genotypes with 1000 gm Microbein/ fad combined with 45 kg N / fad. This indicate

Table 7. Interaction effect of the flax genotypes (G) X biofertilization (B) in 1000 seed weight and protein yield / fad (combined analysis of 2004/2005 and 2005/2006 seasons)

Genotypes	Biofertilization					
	B_0: uninoculation	B_1: 500gm Microbein / fad	B_2: 1000gm Microbein / fad	B_0: Uninoculation	B_1: 500gm Microbein / fad	B_2: 1000gm Microbein /fad
	1000 seed weight (gm)			Protein yield /fad(kg)		
	B	A	A	C	B	A
G_1:Sakha$_1$	7.82c	8.74b	9.03b	105.73b	133.39b	156.14b
	B	A	A	C	B	A
G_2:Sakha$_2$	8.67b	9.22a	9.55a	130.54a	168.23a	201.19a
	B	B	A	C	B	A
G_3:Strain 2419/1	9.07a	9.48a	9.72a	147.04a	184.24a	214.03a

Table 8. Interaction effect of nitrogen fertilizer levels (N) X biofertilization (B) in seed protein percentage and protein yield / fad (combined analysis of 2004/2005 and 2005/2006 seasons)

Nitrogen fertilizer levels	Biofertilization					
	B_0: Uninoculation	B_1: 500gm Microbein / fad	B_2: 1000gm Microbein / fad	B_0: Uninoculation	B_1: 500gm Microbein / fad	B_2: 1000gm Microbein /fad
	Seed protein percentage			Protein yield/ fad(kg)		
	B	B	A	B	A	A
N_1:15kg N/fad	24.04b	25.30c	27.18c	113.59b	132.85c	148.82b
	C	B	A	C	B	A
N_2 :30 kg N /fad	26.07a	28.56b	31.42b	138.29a	169.09b	192.58a
	B	A	A	C	B	A
N_3 :45kg N / fad	27.75a	30.63a	32.34a	152.68a	187.03a	205.59a

that applying of Microbein compensated partially the requirement of flax crop to mineral nitrogen fertilizer. Similar results were reported by Hamed (1998), El-Gazzar and El-Kady (2000), Ash-Shormillesy, Salwa (2001) and El–Azzouni and El–Banna (2002).

Economic Yield

Mean values of biological yield / fad, economic yield / fad, harvest index, net income of fiber yield / fad, and relative income of seed yield / fad as affected by flax genotypes, nitrogen fertilizer levels and biofertilization with Microbein for combined analysis of the two seasons are presented in Table 9. Analysis of variance showed significant differences between flax genotypes, nitrogen fertilizer levels and biofertilization treatments.

Response of genotypes

Combined data in Table 9 revealed that the differences among flax genotypes reached the level of significance in each of biological yield / fad, economic yield/ fad, net income of fiber yield / fad and relative income of seed yield / fad. Moreover, harvest index trait did not affect significantly with the varietal differences.

Data in the same table revealed that the local variety $Sakha_1$ ranked first and surpassed significantly the two other genotypes in each of biological yield / fad, economic yield / fad and net income of fiber yield/ fad. These results may be due to the genetical make-up. These results are in accordance with those obtained by El-Kady *et al.,* (1995), Ash–Shormillesy, Salwa (2001), El-Azzouni *et al.,* (2003), Zedan (2004) and Abdel –Haleem (2005).

Effect of nitrogen fertilizer levels

Data presented in Table 9 revealed from the combined analysis that there was a gradual increase in biological yield / fad, economic yield/ fad, net income of fiber yield /fad and relative income of seed yield / fad with increasing N level up to 45 kg N / fad. The increment was 16.97, 25.04 , 40.25 and 27.46% for the previous traits, respectively. Also, data showed that the difference between 30 and 45 kg N / fad did not reach to the level of significant for economic yield/ fad and net income of fiber yield / fad traits. On the other hand harvest index trait did not affect significantly with nitrogen application. Similar results were reported by El–kady *et al.,* (1995), El–Azzouni *et al.,* (2003), Zedan (2004),Ash–Shormillesy, Salwa (2001),Nassar and El–Taweel (2001) and Abdel–Haleem (2005).

Effect of biofertilization

Combined analysis for data presented in Table 9 showed that the biofertilization treatments affected significantly all studied economical characters i.e. biological yield / fad, economic yield / fad, harvest index, net income of fiber yield / fad and relative income of seed yield / fad. Inoculating flax genotypes with 1000 gm Microbein caused a significant increases in all economical characters under study. The increments were 19.92 , 27.09, 7.63, 45.58 and 27.73 % respectively between the highest Microbein rate and the control (uninoculation). On the other han there was no significant differences between 500 and 1000 gm Microbein for harvest index trait. These results may be due to the favourable effect of Microbein in fixing nitrogen which helped flax plants to produce higher yield components with best quality of fibers and seeds. These findings are in accordance with those obtained by Afify *et al.,* (1994), Hamed (1998), El–Gazzar (2000), El–Gazzar and El-Kady (2000), Ash–Shormillsey, Salwa (2001) Abdel–Samie *et al.,* (2002), El-Azzouni and El–Banna (2002), Abdel–Haleem (2005) and El–Shimy *et al.,* (2006).

Table 9. Mean values of biological yield / fad , economic yield /fad, harvest index, net income of fiber yield / fad (pound) and relative income of seed yield (pound) as affected by nitrogen fertilizer levels (N) and biofertilization (B) for flax genotypes (G) in 2004/2005 , 2005/2006 and their combined analysis

Main effects and interactions	Biological yield/ fad(ton)			Economic yield /fad(ton)			Harvest index(%)			Net Income of fiber yield/fad (pound)			Relative income of seed yield/ fad (pound)		
	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb	1st Season	2nd Season	Comb.	1st Season	2nd Season	Comb.
Genotypes(G):															
G_1: $Sakha_1$	5.954a	5.381a	5.667a	1.487a	1.273a	1.380a	0.249	0.236	0.242	3881.31a	3583.04a	3732.18a	1122.82c	639.73c	881.27c
G_2: $Sakha_2$	5.467b	4.800b	5.133b	1.395a	1.163b	1.279b	0.259	0.242	0.250	3164.24ab	2743.17b	2953.70b	1260.50b	826.56b	1043.53b
G_3: Strain 2419/1	5.230b	4.624b	4.927c	1.325b	1.117b	1.221b	0.256	0.241	0.248	2607.99b	2230.07b	2419.03c	1396.43a	999.67a	1198.05a
F. test	*	**	**	*	*	**	N.S	N.S	N.S	*	**	**	**	**	**
Nitrogen levels(N):															
N_1:15kg N/ fad	4.981b	4.634c	4.808c	1.204b	1.049b	1.126b	0.254	0.226	0.235	2549.87b	2337.80b	2445.83b	1070.92b	732.27b	901.60c
N_2: 30kg N/ fad	5.626a	4.966b	5.296b	1.466a	1.224a	1.345a	0.265	0.247	0.256	3423.76a	3043.26a	3233.51a	1316.25a	827.94a	1072.09b
N_3: 45kg N / fad	6.043a	5.204a	5.624a	1.537a	1.279a	1.408a	0.244	0.246	0.250	3679.92a	3175.23a	3427.57a	1392.57a	905.75a	1149.16a
F. test	**	**	**	**	**	**	N.S	N.S	N.S	**	*	**	**	**	**
Biofertilization (B):															
B_0: Uninoculation	5.019c	4.406c	4.713c	1.242c	1.002c	1.122b	0.245b	0.227c	0.236b	2673.29c	2181.71c	2427.50c	1111.28b	683.74c	897.51c
B_1: 500gm Microbein /fad	5.671b	5.056b	5.363b	1.440b	1.224b	1.332b	0.259a	0.243b	0.251a	3297.14b	2989.66b	3143.40b	1314.06a	843.87b	1078.97b
B_2: 1000gm Microbein/ fad	5.960a	5.342a	5.652a	1.525a	1.327a	1.426a	0.259a	0.249a	0.254a	3683.12a	3384.91a	3534.02a	1354.40a	938.34a	1146.37a
F. test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interactions:															
GXN	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
NXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
GXNXB	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Yield Analysis

Correlation coefficient

Data of correlation coefficient between straw and seed yields and some of their related characters as affected by nitrogen fertilizer levels and biofertilization treatment with Microbein for three flax genotypes in combined analysis of 2004 / 2005 and 2005/ 2006 seasons are presented in Table 10. Data revealed that straw yield / fad was positively and highly significant correlated with straw yield / plant (r = 0.955), technical length / plant (r = 0.617) and fiber yield / plant (r =0.788) . Positive and highly significant correlation were also found between straw yield / plant and fiber yield / fad (r = 0.922), between straw yield / plant and technical length / plant (r = 0.642), between straw yield / plant and fiber length (r = 0.490). Also positive and significant correlation was found between straw yield / plant and 1000 seed weight. Moreover positive and insignificant correlation was found between straw yield / plant and each of seed yield / fad (r = 0.324), and oil yield /fad (r=0.328). Similar results were obtained by Ghanem (1990). El-Azzouni *et al.,* (2003). Zedan (2004), El-Shimy *et al.,* (2006) andEl-Sweify *et al.,* (2006).

Fiber yield / fad was positively and highly significant correlated with fiber yield / plant (r = 0.992). On the other hand fiber yield / fad was positively and insignificantly correlated with each of seed yield / fad (r = 0.163) and seed yield / plant (r = 0.145).

Fiber yield / plant was positively and highly significant correlated with each of technical length (r = 0.627) and fiber length (r= 0.705).

Seed yield / fad was positively and highly significant correlated with each of seed yield plant (r = 0.961) , number of capsules / plant (r = 0.963) and protein yield / fad (r = 0.960) .

Also positive and highly significant correlation was found between seed yield / plant and each of number of capsules / plant (r = 0.671), 1000 seed weight (r = 0.958) , oil yield / fad (r = 0.963) and protein yield / fad (r = 0.960). Also positive and highly significant correlation was found between number of capsules / plant and each of 1000 seed weight (r = 0.945), oil yield / fad (r = 0.952) and protein yield / fed (r= 0.956) . These results are in agreement with those reported by Momtaz (1965), Momtaz *et al.,* (1977), Zeiton (1992) and Zahana, Afaf (1999).

Table 10. Simple correlation coefficient among straw and seed yields and some of their related characters as affected by nitrogen fertilizer levels (N) and biofertilization (B) for the flax genetypes (G) (Combined analysis of 2004/2005 and 2005/2006 seasons)

	Variables	1	2	3	4	5	6	7	8	9	10	11	12
1	Straw yield/ fad	-	0.960**	0.955**	0.955**	0.617**	0.788**	0.185	0.297	0.354	0.527**	0.157	0.187
2	Straw yield/ plant		-	0.922**	0.973**	0.586**	0.973**	0.324	0.445	0.490**	0.392*	0.299	0.328
3	Fiber yield/ fad			-	0.979**	0.642**	0.992**	0.163	0.259	0.321	0.215	0.133	0.145
4	Fiber yield/ plant				-	0.627**	0.705**	0.251	0.367	0.421*	0.322	0.224	0.241
5	Technical length /plant					-	0.348	-0.228	0.108	-0.087	-0.072	0.237	-0.226
6	Fiber length						-	0.137	0.062	0.316	0.216	0.118	0.134
7	Seed yield / fad							-	0.961**	0.953**	0.934**	0.998**	0.991**
8	Seed yield/ plant								-	0.671**	0.958**	0.963**	0.960**
9	No. of capsules plant									-	0.945**	0.952**	0.956**
10	1000 seed weight										-	0.939**	0.930**
11	Oil yield / fad											-	0.994**
12	Protein yield/ fad												-

Finally positive and highly significant correlation was observed between 1000 seed weight and each of oil yield / fad (r = 0.939) and protein yield / fad (r = 0.930). Similarly oil yield /fad was positively and highly significant correlated with protein yield / fad (r = 0.994). These results are in accordance with those obtained by Ghanem (1990). Al-Kaddoussi and Moawed (2001), El-Azzouni *et al.*, (2003), El-Shimy *et al.*, (2006) and El–Sweify *et al.*, (2006).

Path analysis

The methods of path coefficient was used to analyze the final flax yield components to explore the relative importance of such components to the final flax yield (either fiber or seed) per unit area of the land.

Path analysis study related to straw yield/fad and its components

The results of partitioning simple correlation coefficients among straw yield and its components of flax genotypes as affected by biofertilization and different nitrogen levels are presented in Table 11 and illustrated in Figure 1. The highest direct effect was obtained for fiber yield/fad (1.506) and straw yield/ plant (1.424). Meanwhile fiber yield/plant gave negative value. The highest indirect effect was noticed for fiber yield/plant was through indirect effect via straw yield/plant (1.385) as well as for fiber yield/fad, indirect effect via straw yield/plant (1.312). These results indicated that the increasing alleles played a great role in increasing these characters through straw yield. The other indirect effects were negative, revealing that the decreasing alleles played a great role for these interactions to decrease straw yield.

Direct and joint effects of straw yield components presented as a percentage of yield variations of flax genotypes as affected by biofertilization and different nitrogen levels are given in Table 12. The results clearly revealed that the straw yield/plant , fiber yield/ fad , fiber yield/plant and the interaction between straw yield/ plant and fiber yield/fad are considered the main sources of straw yield variation having the relative contribution of 202.78 , 226.93 , 362.65 and 395.57% respectively.

Table 11. Partitioning of simple correlation coefficients among straw yield and its components of flax genotypes. (combined data of 2004/2005 and 2005/2006 seasons)

Source	Coefficient	
Straw yield/plant via straw yield/fad		
Direct effect	Py_1	= 1.4240
Indirect effect via fiber yield/fad	$r_{12}\,Py_2$	= 1.3889
Indirect effect via fiber yield/plant	$r_{13}\,Py_3$	= - 1.8529
Total	ry_1	= 0.960
Fiber yield/fad via straw yield/fad		
Direct effect	Py_2	= 1.5064
Indirect effect via straw yield/plant	$r_{12}\,Py_1$	= 1.3129
Indirect effect via fiber yield/plant	$r_{23}\,Py_3$	= - 1.8643
Total	ry_2	= 0.955
Fiber yield/plant via straw yield/fad		
Direct effect	Py_3	= - 1.9043
Indirect effect via straw yield/plant	$r_{13}\,Py_1$	= 1.3855
Indirect effect via fiber yield/fad	$r_{23}\,Py_2$	= 1.4748
Total	ry_3	= 0.956

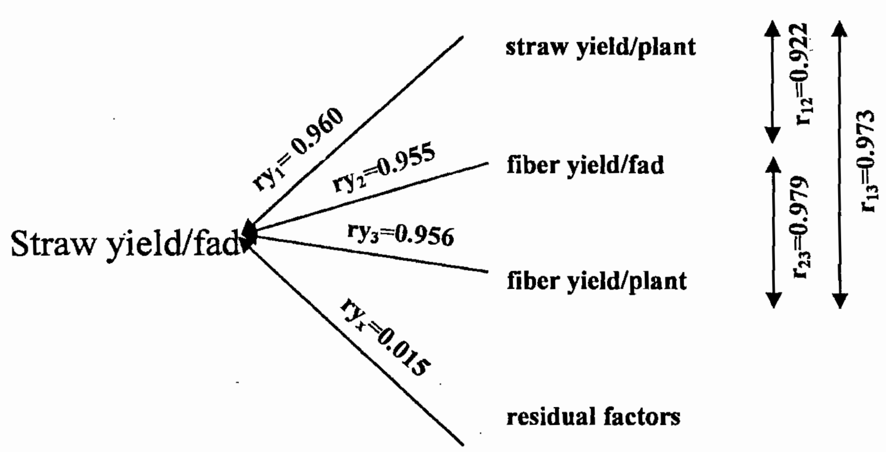

Fig. 1: A path coefficient diagram of factors influencing straw yield (ton/ fad) of flax genotypes $Sakha_1$, Sakha $_2$ and St. 2419/1 (combined data of 2004/2005 and 2005/2006 seasons).

Table 12. Direct and joint effects of straw yield plant , fiber yield/fad and fiber yield/plant as well as their interactions recorded as % of straw yield/fad variation of flax (combined data of 2004/2005 and 2005/2006 seasons)

Source of variation	C.D	%
Straw yield/plant	2.02788	202.78871
Fiber yield/fad	2.26929	226.92995
Fiber yield/plant	3.62648	362.64849
Straw yield/plant × fiber yield/fad	3.95574	395.57451
Straw yield/plant × fiber yield/plant	- 5.27724	- 527.72499
Fiber yield/fad × fiber yield/plant	- 5.61695	- 561.69573
R^2	0.98520	98.52510
RE^2	0.01479	1.47449
Total	1.00000	100.00000

Table 13. Total contribution of straw yield components

	Direct	Indirect	Total
Straw yield/plant	202.78871	395.57451	598.36322
Fiber yield/fad	226.92952	- 561.69573	- 334.76621
Fiber yield/plant	362.64849	- 527.72499	- 165.0765
Total	792.36672	- 693.84621	98.52051

Also, R^2 recorded herein reached 98.525% of the total yield variation. However the residual effect of the other straw yield components included in the present study was 1.48%. This residual variation could be attributed to other yield contributing characters. Finally, according to the relative importance , the studied characters could be arranged as follows, straw yield/plant (598.363), fiber yield/ fad (-334.766) and fiber yield/plant (-165.076) (Table 13). These results are in accordance with those reported by Ghanem (1990) , Aly and Awaad (1997), Ash-Shormillesy, Salwa (2001) and Awad *et al.*,(2001).

Path analysis study related to seed yield/fad and its components

Direct and indirect effects of seed yield/plant, number of capsules/plant and 1000 seed weight on seed yield/fad of flax genotypes as affected by biofertilization and different nitrogen levels are presented in Table 14 and illustrated in Figure 2. The results cleared that seed index reflected the highest direct effects on flax seed yield/fad (1.860). But the direct effect of seed yield/plant and number of capsules/plant on seed yield/fad was negative. These results indicated that seed index played an important role in increasing seed yield/fad. The indirect effect of seed yield/plant through seed index and indirect effect of number of capsules/plant through seed index on seed yield variation gave a considerable values (1.782 and 1.758), respectively.

The relative importance contributed to the seed yield/plant, number of capsules / plant , 1000 seed weight as well as their interactions are given in Table 15. The obtained results showed that 1000 seed weight, seed yield/plant, number of capsules/plant and the interaction between seed yield/ plant and number of capsules/plant were the main sources of flax seed yield variation having the relative contribution of 346.15, 26.14, 21.35 and 31.71%, respectively.

It could be concluded that seed index , seed yield/plant , number of capsules/plant and the interaction between seed yield/plant and number of capsules/plant played a great role in flax seed yield/fad determination. Since they mad the most notable direct or indirect effects estimated by 80.59% of the total seed yield alteration. Therefore , the plant breeder could focalize his attention on seed yield/ plant, number of capsules/plant and 1000 seed weight characters to maximize the final flax seed yield per unit area of the land. In addition the residual effects of other seed yield attributes not encompassed in the present study was 19.40% of the total yield variation indicating that the most effective traits contributed appreciably to the final seed yield diversity were actually examined in this study.

Finally, according to the relative importance , the studied traits could be arranged as follows, 1000 seed weight (163.885) , seed yield/plant (57.851) and number of capsules/plant (- 141.139) Table 16. Similar results were expressed by Ghanem (1990), Zeiton (1992) , Ash–Shormillesy, Salwa (2001) and Awad *et al.,* (2001).

Table 14. Partitioning of simple correlation coefficients among seed yield and its components of flax genotypes (combined data of 2004/2005 and 2005/2006 seasons)

Source		Coefficient
Seed yield/plant via seed yield/fad		
Direct effect	Py_1	= - 0.5113
Indirect effect via number of capsules/plant	$r_{12}\ Py_2$	= - 0.3101
Indirect effect via 1000 seed weight	$r_{13}\ Py_3$	= 1.7824
Total	ry_1	= 0.961
Number of capsules/plant via seed yield/fad		
Direct effect	Py_2	= - 0.4621
Indirect effect via seed yield/plant	$r_{12}\ Py_1$	= - 0.3431
Indirect effect via 1000 seed weight	$r_{23}\ Py_3$	= 1.7582
Total	ry_2	= 0.953
1000 seed weight via seed yield/fad		
Direct effect	Py_3	= 1.8605
Indirect effect via seed yield/plant	$r_{13}\ Py_1$	= - 0.4898
Indirect effect via number of capsules/plant	$r_{23}\ Py_2$	= - 0.4367
Total	ry_3	= 0.934

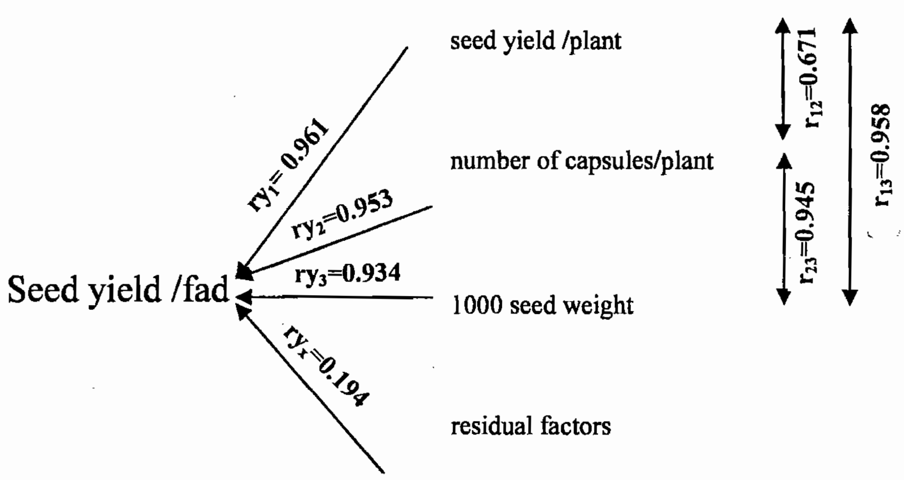

Fig. 2: A path coefficient diagram of factors influencing seed yield (kg/ fad) of flax genotypes $Sakha_1$, Sakha $_2$ and St. 2419/1 (combined data of 2004/2005 and 2005/2006 seasons).

Table 15. Direct and joint effects of seed yield/plant , number of capsules plant and 1000 seed weight as well as their interactions recorded as % of seed yield/fad variation of flax (combined data of 2004/2005 and 2005/2006 seasons

Source of variation	C.D	%
Seed yield/plant	0.26143	26.14311
Number of capsules/plant	0.21353	21.35398
1000 seed weight	3.46152	346.15209
Seed yield/plant × number of capsules/plant	0.31708	31.70813
Seed yield/plant × 1000 seed weight	- 1.82266	- 182.26684
Number of capsules/plant × 1000 seed weight	- 1.62443	- 162.44303
R^2	0.80597	80.59744
RE^2	0.19402	19.40256
Total	1.00000	100.00000

Table 16. Total contribution of seed yield components

	Direct	Indirect	Total
Seed yield/plant	26.14311	31.70813	57.85124
Number of capsules/plant	21.35398	- 162.49303	- 141.13905
1000 seed weight	346.15209	- 182.26684	163.88525
Total	393.64918	- 313.05174	80.59744

CONCLUSION

Under the conditions of the present study for maximizing flax genotypes (Sakha$_1$, Sakha$_2$ and Strain 2419/1) its recommended to inoculate flax seeds with 1000 gm Microbien and fertilized plants with 45 kg N/fed.

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استجابة بعض التراكيب الوراثية من الكتان للتسميد الحيوي والنيتروجينى

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أجريت تجربتان حقليتان في محطة البحوث الزراعية بكفر الحمام محافظة الشرقية (أرض طينية) لدراسة تأثير ثلاثة مستويات من السماد الآزوتي (١٥ ، ٣٠، ٤٥ كجم نيتروجين / فدان) وكذلك ثلاث معاملات من التسميد الحيوى (صفر ، ٥٠٠ ، ١٠٠٠ جرام ميكروبين / فدان) على المحصول ومكوناته وصفات الجودة للألياف والبذور وكذلك المحصول الاقتصادى هذا بالإضافة إلى تقدير قيمة معامل الارتباط بين محصول القش والبذور والصفات المرتبطة بهما وكذلك معامل المرور لثلاثة تراكيب وراثية من الكتان وهم سخا١ ، سخا٢ والسلالة الزيتية ١/٢٤١٩. وفيما يلى أهم النتائج المتحصل عليها :

١- تفوق صنف الكتان سخا١ معنويا على التراكيب الوراثية الاخرى في محصول القش والصفات المرتبطة به وكذلك بعض الصفات الاخرى مثل المحصول البيولوجى والمحصول الاقتصادى وكذلك العائد النقدى من محصول الألياف للفدان بالجنية ، بينما أعطت السلالة الزيتية ١/٢٤١٩ أعلى القيم لمحصول البذرة والصفات المرتبطة بها هذا بالإضافة إلى العائد النقدى من محصول البذرة للفدان بالجنية وكان ذلك واضحا لكلا الموسمين وكذلك للتحليل المشترك لهما .

٢- أدت إضافة ٤٥ كجم نيتروجين /فدان إلى الحصول على أعلى القيم لمحصولى القش والبذور وكذلك الصفات المرتبطة بهما هذا بالإضافة إلى المحصول الاقتصادى الاخرى بينما سجلت إضافة ١٥ كجم نيتروجين / فدان اقل القيم لمحصولى القش والبذور والصفات المرتبطة بهما هذا بالإضافة إلى المحصول البيولوجى للفدان والمحصول الاقتصادى للفدان والعائد النقدى لمحصولى الألياف والبذور للفدان.

٣- أدت إضافة السماد الحيوى بمعدل ١٠٠٠ جرام ميكروبين للفدان إلى الحصول على أعلى القيم لمحصول القش والبذور والصفات المرتبطة بهما هذا بالإضافة إلى المحصول الاقتصادى .

٤- كانت قيم معامل الارتباط (ر) معنوية جدا وموجبة بين محصول القش للفدان وكل من محصول الالياف للنبات والفدان ، الطول الفعال للنبات ، طول الألياف

٥- أيضا كان هناك ارتباط عالى المعنوية وموجبا بين محصول البذور للفدان وكل من محصول البذور للنبات ، عدد كبسولات النبات ، وزن الالف بذرة ، محصول البروتين للفدان ، محصول الالياف للنبات ، محصول القش للنبات ، وطول الالياف . من ناحية أخرى كان هناك إرتباط سالبا وعالى المعنوية ما بين محصول القش / فدان ووزن الالف بذرة .

٦- أوضحت نتائج تحليل معامل المرور أهمية صفة محصول القش للنبات فى زيادة محصول القش للفدان بينما أظهرت صفتي وزن الألف بذرة ومحصول البذور للنبات أهمية كبيرة فى زيادة محصول البذرة للفدان .