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ORIGINAL ARTICLES

Evaluation, Correlation and Path Coefficient Analysis among Straw Yield and Its Attributes of Fiber Flax (*Linum usitatissimum* L.) Cultivars

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ABSTRACT

In field trials, eight flax fiber cultivars of diverse origins were grown during three successive seasons with three sowing dates in each growing season. Mean squares of all quantitative characters estimates across the three seasons and three sowing dates; exhibited highly significant effect for most traits recorded. The effect of sowing dates was more pronounced than seasons for most traits. In the third order interaction significant for all studied traits were shown for the interaction between cultivars x seasons x sowing dates. Straw yield / plant and biological yield /plant capacity for all tested cultivars ranged from 1.19 (g) and 1.92 (g) for G1 in D3 of S2 to 4.21 (g) and 5.54 (g) for G4 in D1 of S1 and G8 in D2 of S2, respectively. G2, G6 and G7 recorded the highest values (95, 95 and 89.8 cm, respectively) for plant height in the three seasons. Also, G2, G6 and G2 recorded the highest values (79.9, 74.8 and 74.8 cm respectively) of technical length in the three seasons. The first sowing date was the best one through 1st and 3rd seasons as it recorded the highest values for different cultivars under study of plant height, straw yield / plant and biological yield / plant. Positive and significant associations were found between straw yield/ plant (g) and each of fruiting zone length / plant (cm),number of capsules/ plant , seed index (g),and seed yield/ plant (g) and between biological yield/ plant (g) with each of fruiting zone length/ plant (cm),No. capsules/ plant, seed index (g),seed yield / plant(g),and straw yield / plant (g). The components of straw yield variations determined directly and jointly by each factor are calculated. The main source of straw yield variation in order of relative importance was the joint effect of number of capsules / plant with seed index (21.89 %), followed by its joint effect with fruiting zone length (16.60%). Number of capsules / plant gave also the main direct effect (12.36%) and achieved the highest totally contributes straw yield / plant (34.58%).

Key words: Cultivars, Evaluation, Correlation, Path Coefficient Straw Yield, Fiber Flax.

Introduction

The dual purpose of flax was already known in ancient times. Ancient Egypt, linen (derived from the fiber) was used for wrapping the royal mummies and additionally linseed oil which was used to embalm the bodies of deceased Pharaohs (Dewilde 1983). For a long time flax has been cultivated as a dual-purpose crop, but nowadays fiber flax and linseed represent different gene pools. Fiber flax has been cultivated in the Netherlands and most likely in Belgium and Northern France since ancient times. The quality and fineness of the linen has been proven ever since (Bostock and Riley 1856; Stokkers *et al.* 2004). The application of flax is not restricted to the production of linen yarn. In fact almost the whole plant is used, justifying the name given by Linnaeus, *L. usitatissimum*, which means useful flax. The short fibers are used in paper, isolation material, matrix composites and linen painting textile. The wooden shives which are released during the scotching of flax can serve as an energy source, litter in cattle farming or as source material for pressurized wooden bricks (Stokkers *et al.* 2004). The seeds of fiber flax are mainly used as sowing seeds for the next year. Generally Flax plants coud be considered an industerial crop newadays.

Linseed oil also offers important nutritional benefits because of the high levels of omega-3 fatty acids. Animal experiments and clinical intervention studies indicate that omega-3 fatty acids have anti-inflammatory properties, and therefore, might be useful in the management of inflammatory and autoimmune diseases, including coronary heart disease, major depression, aging, rheumatoid arthritis, Chrohn's disease and cancer (Simopoulos 2002). Recent breeding achievements are in the development of a new flax type called 'Solin'. This name is used for flax cultivars with low (<5%) linolenic acid content in the oil (Dribnenki and Green 1995). Solin, which is agronomically not different from regular linseed, is being developed for the edible oil market, which in turn helps to narraw the gab in edible oils commadity.

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Flax was already grown 6000 – 8000 years ago in Egypt and Sumaria, and belongs (together with barley and wheat) to the oldest of cultivated plants. The distribution of flax from the Near East into Europe is well documented (Zohary and Hopf 2000). It is considered that flax cultivation in Western Europe (the Netherlands, Northern France, Belgium and Switzerland) started about 7000-3000 BC when semi-nomads, originating from the Middle East settled in Flanders and introduced flax cultivation (Dewilde 1983). Since the domestication of flax, there has been a preference for growing flax either for its fiber or oil. In the Western region of Eurasia, flax is mainly grown for its fiber, whereas in the Eastern region of Eurasia flax is grown for its oil (Gill 1987). Fiber flax has a long unbranched growth habit, whereas linseed (oil flax) is much shorter and highly branched. Throughout this thesis the distinction between fiber flax and linseed is made.

Breeding for fiber yield can be divided into two components, straw yield and fiber content (Popescu *et al.* 1998). The low heritability found for fiber yield suggests a considerable environmental influence. Contrary, fiber content (ratio of fiber weight on the stem) is more heritable and easier to determine. However, in order to calculate fiber content, large numbers of stems are necessary and consequently large trial plots and big quantities of seeds (Fouilloux 1988). Furthermore, it is known that both additive and dominant effects of genes are involved in the heredity of fiber content and both effects are influenced by environmental conditions (Popescu *et al.* 1998). However, it is still uncertain how many genes are involved in the heredity of fiber content. Likewise, the inheritance of straw yield is poorly understood. Straw yield is supposed to be controlled by several genes as well. A modest gain is to be expected from breeding for straw yield as heritabilities were shown to be low (Mourad and Abo-Kaied 2003). Considering the genetic basis of both straw yield and fiber content, breeding for fiber yield should be mainly focused on the more heritable fiber content. Oil yield is the most important quantitative trait in linseed. Oil yield is dependent on the seed yield and linseed oil content. Low heritability was observed for seed yield in early generations. Contrary, selection on oil content, a character with comparatively high heritability, in an early stage, should be feasible and successful in linseed (Salas and Friedt 1995).

This investigation dealt with detailed characterizations of eight flax cultivars evaluated by nine quantitative morphological traits fewer than nine environmental conditions (3 growing seasons X 3 sowing dates). The other aim of this study was to determine the direct and indirect relationships between straw yield / plant and four of its attributes in the *Linum usitatissimum* L. cultivars tested using simple correlation and bath coefficient analyses.

Materials And Methods

In field trials, eight flax cultivars of diverse origins were grown in Experimental Station of National Research Center at Shalakan, Kaluobia, Governorate during three successive growing seasons lasted 2006/2007. The experimental design was split plot design with three replications. Three sowing dates in each growing season were allocated in the main plots, flax cultivars were allocated in the sub-plots. Each plot consisted of fifteen rows with 3.5m long and 20cm apart, thus area of plot was 10.5 m^2 (1/400 fed.). The experimental treatments can be arranged as follows:

Sowing dates:

D1- 15th November.
D2- 30th November.
D3- 15th December.

Cultivars:
G1 - Romanian fiber flax type "ICA6"
G2 - Romanian fiber flax type "INA"
G3 - Romanian fiber flax type "Emilin"
G4 - Romanian fiber flax type "Daniela"
G5 - Romanian fiber flax type "Madaras"
G6 - Romanian fiber flax type "Rolin"
G7 - Romanian fiber flax type "Istru"
G8 - Egyptian dual purpose type "Giza 8"

Seeding rate was 60 Kg seeds /feddan. The normal cultural practices of growing flax were followed till symptoms appearance of full maturity, then harvest was carried out. Representative random samples of 20 plants from every plot were chosen to estimate flax yield attributes, i.e. plant height (cm), technical stem length/plant (cm), fruiting zone length/plant (cm), number of fruiting branches/plant, number of capsules/plant, seed index (g), seed yield/plant (g), straw yield/plant (g) and biological yield/plant (g). Comparison between means of each of the traits reported was practiced by new LSD according to Waller and Duncan (1969). Simple correlation coefficient for all possible pairs of seed yield/plant and its attributes were practiced according to Gomez and Gomez (1984).

Simple correlation of course does not permit the estimation of direct effect of particular yield factors such as plant height, technical length and fruiting zone length, or any other factors, since the variable is in some way associated with yield. Therefore, the path coefficient analysis, which measures the direct influence of one variable upon another and permits the separation of the simple correlation coefficient into components of direct and indirect effects, was done according to Wright (1934) and Snedecor and Cochran (1989).

Results And Discussion

I- Cultivar – Environment interaction analysis:

Mean squares of all traits studied across the three seasons and three sowing dates; exhibited highly significant effect for all traits recorded except the seasons for number of capsules / plant was insignificant. The effect of sowing dates was more pronounced than seasons for all traits except No. of fruiting branches / plant, seed index and seed yield/ plant which due to the differences of climatic factors prevailing in the three sowing dates(Table, 1). The first and second order interaction involving cultivars and seasons or sowing dates were significant for all traits indicating different responses of cultivars under each of variation in environmental condition. In the third order interaction significant for all studied traits were shown for the interaction between cultivars x seasons x sowing dates. These results are in agreement with those obtained by Abo El Zahab *et al*. (1994) who obtained significant GY, GL and GLY interactions for plant height , straw yield/ plant in flax and El-Sweify and Mostafa (1996), Kineber (2003) for straw and fiber yield / m^2, straw, fiber and seed yield per plant. Concerning straw yield components and plant height were reported by Badr *et al*. (1998), Casa *et al*. (1999), Hassan and Leitch (2000) and Kandil *et al.* (2009) in flax.

Table 1: Mean squares of all fiber flax cultivars tested (G) through three growing seasons (S) and three sowing dates (D).

Source of variation	DF	Plant height	Technical length	Fruiting zone	No. fruiting branches/ plant	No. capsules/ plant	Seed index	Seed yield/ plant	Straw yield/ plant	Biological yield/ plant
Seasons (S)	2	658.08**	423.36**	62.617**	18.227**	0.956	0.0823**	1.912**	0.781**	3.851**
Dates (D)	2	3846.51**	2096.9**	320.83**	3.267*	538.59**	0.0221$^+$	0.678**	8.414**	10.549**
Error (a)	4	16.60	8.78	1.863	0.231	0.922	0.0033	0.0042	0.1172	0.0924
SD	4	1360.17**	995.46**	324.25**	9.674**	411.81**	0.0169**	0.966**	5.742**	7.863**
Error (b)	12	9.26	5.79	3.018	0.5897	3.288	0.0009	0.0192	0.0993	0.1303
Varieties (G)	7	1211.07**	1288.4**	257.38**	4.965**	172.59**	0.1578**	7.633**	8.744**	31.750**
GS	14	64.005**	53.496**	30.311**	2.477**	40.371**	0.0073**	0.0936**	0.583**	0.7897**
GD	14	251.18**	166.28**	54.582**	5.553**	90.802**	0.007**	0.090**	0.9011**	1.212**
GSD	28	80.50**	77.361**	23.869**	1.568**	56.491**	0.005**	0.0648*	0.814**	1.106**
Error (c)	126	7.087	9.493	2.737	0.422	1.3772	0.0013	0.0369	0.1596	0.2491

+,* and **: denote significant at 0.001, 0.05 and 0.01 levels of probability, respectively.

The interaction between cultivars tested and seasons prevailed at various sowing dates are designated as means of the nine characteristics in table (2). From such data, it is quite obvious that straw yield / plant and biological yield /plant capacity for all tested cultivars ranged from 1.19 (g) and 1.92 (g) for G1 in D3 of S2 to 4.21 (g) and 5.54 (g) for G4 in D1 of S1 and G8 in D2 of S2, respectively. Results indicated that the magnitude of differences between flax cultivars tested is high for all traits under the experimental conditions. G2, G6 and G7 recorded the highest values (95, 95 and 89.8 cm, respectively) for plant height in the first, second and third season. Also, G2, G6 and G2 recorded the highest values (79.9,74.8 and 74.8 cm respectively) of technical length in the first, second and third season. While, G1, G1 and G2 in the first, second and third season, respectively presented the lowest values (80.1, 78.2 and 63.6 cm) of plant height, as well as,G8, G1 and G1 in the first, second and third season, respectively which gave the lowest values (62.5, 58.4 and 57 cm) for technical length. The first season seemed to be the best one for all cultivars technical length, fruiting zone length, number of fruiting branches/plant, seed yield / plant straw yield / plant and biological yield / plant (69.8cm,21.3cm,7.1, 1.2g,2.5g and 3.6g respectively. On the other hand, the first sowing date was the best one through 1st and 3rd seasons as it recorded the highest values for different cultivars under study of plant height, straw yield / plant and biological yield / plant.

It could be concluded that these varietal differences in flax yield components might be due to differences in cultivars genetic potential which in turn reflected on yield components. In addition, differences between cultivars concerning partition of dry matter accumulation as well as glucose required for plant synthesis, carbon equivalents yield energy /plant and coefficient of energy for crop harvest indices (Ahmed *et al.* 1992). Similar results were obtained by El- Shimy *et al*. (1993),El- Sweify (1993), Abo El – Zahab *et al*. (1994), El-Hariri (1995), El-Hariri *et al.* (1996), El-Sweify and Mostafa (1996), Abo Zaid (1997), El-Hariri *et al*. (1998), Zahana (1999) and El-Hariri *et al*. (2004).

Table 2: Mean performance of all fiber flax cultivars tested (G.) through three growing seasons (S) and three sowing dates (D).

G.	Season 1				Season 2				Season 3			
	D1	D2	D3	mean	D1	D2	D3	mean	D1	D2	D3	mean
Plant height (cm)												
G1	96.3	74.1	70	80.1	86.2	82.3	66	78.2	84	75	64.7	74.6
G2	95	96.8	93.3	95	86.3	98	82.3	88.9	99.7	9.7	81.3	63.6
G3	90	86.7	92.7	89.8	84.7	102.6	84	90.4	100	91.3	77	89.4
G4	82	87.7	77	82.2	88.3	91.7	83.3	87.8	97.1	88.7	72.3	86.0
G5	85	88	84	85.7	96.7	99	87.7	94.5	86	92	75.7	84.6
G6	88	92.3	90	90.1	93	103.3	88.7	95.0	85	88.7	83.7	85.8
G7	90	87.3	91	89.4	88	102.7	89.7	93.5	92	90.7	86.7	89.8
G8	84.8	94.2	89.5	89.5	85.8	95.3	90.6	90.6	84	93.3	88.7	88.7
mean	88.9	88.4	85.9	87.7	88.6	96.9	84.0	89.8	90.98	78.7	78.8	82.8
D. means D1=89.5 D2= 88 D3= 82.9 Grand Mean=86.8												
New LSD (0.05) S= 1.11 D= 1.89 SD= 1.91 G=1.43 GS=2.48 GD=2.48 GSD= 4.3												
Technical length (cm)												
G1	77.67	54.33	55.67	62.6	68.67	61.33	45.33	58.4	61.67	57.67	51.67	57.0
G2	80	80	79.67	79.9	73	79.33	64.67	72.3	75	84.67	64.67	74.8
G3	75	62	78.67	71.9	70.33	83	64.67	72.7	74.33	74.67	65	71.3
G4	66	61.67	64.33	64	71.67	72.33	64.33	69.4	72.33	73	59.67	68.3
G5	68	65.67	72.33	68.7	72.33	75.67	68.67	72.2	76.67	75	60.33	70.7
G6	80	64.33	85.67	76.7	77.67	81.67	65	74.8	73	72.33	72	72.4
G7	72	68	75	71.7	72.33	77.33	69.33	73.0	69.33	73.33	70.33	71.0
G8	59.19	65.77	62.48	62.5	59.46	66.07	62.76	62.8	59.10	65.67	62.38	62.4
mean	72.2	65.2	71.7	69.8	70.7	74.6	63.1	69.5	70.2	72.0	63.3	68.5
D. means D1= 71.03 D2= 70.6 D3= 66.03 Grand Mean=69.22												
New LSD (0.05) S=0.87 D= 1.37 SD= 1.51 G=1.66 GS=2.87 GD=2.87 GSD= 4.98												
Fruiting zone length (cm)												
G1	24	19.67	14.33	19.3	17	21	20.33	19.4	22	16.67	12.33	17.0
G2	22.67	16.33	14.33	17.8	15	19	16.33	16.8	24.67	15	16	18.6
G3	23	25	14.33	20.8	15	20.33	17.33	17.6	24.67	16	11.67	17.4
G4	26.33	25.67	14.33	22.1	16	19	19	18.0	24.67	17.67	12.33	18.2
G5	19.33	21.67	12	17.7	24.67	23.33	19	22.3	29	16.33	15	20.1
G6	24.33	27	15.67	22.3	15.33	21	24	20.1	28.33	16.67	12	19.0
G7	24.33	18.6	26.33	23.1	16	24.67	29.33	23.3	19.33	17	16.67	17.7
G8	25.59	28.43	27.01	27.0	26.58	29.53	28.06	28.1	26.10	29	27.55	27.6
mean	23.7	22.8	17.3	21.3	18.2	22.2	21.7	20.7	24.8	18.0	15.4	19.4
D. means D1=22.23 D2= 21 D3= 18.13 Grand Mean=20.45												
New LSD (0.05) S=0.63 D=0.63 SD=1.09 G=0.89 GS=1.54 GD=1.54 GSD=2.67												
No. fruiting branches/ plant												
G1	7.83	8.60	6.53	7.7	5.87	7.43	7.10	6.8	9	7.43	6.90	7.8
G2	7.67	8.93	7.10	7.9	5.43	6.67	5.47	5.9	7.13	6.43	5.57	6.4
G3	6.33	7.83	7.27	7.1	4.77	6.33	6.43	5.8	6.23	5.53	5.67	5.8
G4	6.33	7.60	7.70	7.2	5.33	7.70	6.80	6.6	6.80	6.67	5.77	6.4
G5	7	5.63	7.77	6.8	5.67	6.53	5.67	6.0	6.77	6.23	4.80	5.9
G6	6.33	5.87	6.93	6.4	5.47	5.67	6.37	5.8	6.67	6.60	5.23	6.2
G7	7.20	4.97	10.8	7.7	4.03	6.23	8.90	6.4	5	4.90	5.90	5.3
G8	5.71	6.34	6.03	6.0	6	6.67	6.33	6.3	5.94	6.60	6.27	6.3
mean	6.8	7.0	7.5	7.1	5.3	6.7	6.6	6.2	6.7	6.3	5.8	6.3
D. means D1=6.27 D2= 6.45 D3=6.63 Grand Mean=6.45												
New LSD (0.05) S= 0.28 D=0.22 SD= 0.48 G= 0.35 GS=0.61 GD=0.61 GSD=1.05												
No. capsules/ plant												
G1	18.23	20.27	11.27	16.6	12.63	23.33	15.67	17.2	10.70	29.53	11.77	17.3
G2	17.67	17.27	11.60	15.5	9.10	20.57	13.57	14.4	23.63	11.87	8.43	14.6
G3	14.57	25.50	12.67	17.6	11	23.43	18.57	17.7	30.33	16.77	11.90	19.7
G4	17.83	25.70	19	20.8	10.10	26.80	11.10	16.0	24.37	20.57	11.33	18.8
G5	11.10	17.93	10.17	13.1	14.30	25	20.13	19.8	24.33	15.23	9	16.2
G6	15.33	15.53	13.33	14.7	12.23	24.33	12.10	16.2	25.62	16.10	9.13	17.0
G7	27	11.87	24.37	21.1	13.33	17.90	22.67	18.0	18.13	12.53	12.67	14.4
G8	21.99	24.43	23.21	23.2	22.14	24.60	23.37	23.4	21.84	24.27	23.05	23.1
mean	18.0	19.8	15.7	17.8	13.1	23.2	17.1	17.8	22.4	18.4	12.2	17.6
D. means D1=17.83 D2= 20.47 D3=15 Grand Mean=17.77												
New LSD (0.05) S=0.66 D=0.44 SD=1.14 G=0.63 GS=1.09 GD=1.09 GSD= 1.90												

Table 2: Continue

G.	Season 1				Season 2				Season 3			
	D1	D2	D3	mean	D1	D2	D3	mean	D1	D2	D3	mean
Seed index (g)												
G1	0.61	0.57	0.62	0.6	0.63	0.51	0.64	0.59	0.72	0.65	0.61	0.66
G2	0.55	0.51	0.57	0.54	0.52	0.47	0.42	0.47	0.55	0.56	0.52	0.54
G3	0.58	0.60	0.61	0.6	0.59	0.52	0.57	0.56	0.65	0.58	0.55	0.59
G4	0.68	0.62	0.61	0.64	0.59	0.51	0.53	0.54	0.68	0.66	0.56	0.63
G5	0.65	0.49	0.55	0.56	0.51	0.48	0.48	0.49	0.58	0.71	0.56	0.62
G6	0.51	0.50	0.55	0.52	0.49	0.51	0.47	0.49	0.59	0.64	0.49	0.57
G7	0.62	0.61	0.65	0.63	0.70	0.64	0.53	0.62	0.74	0.72	0.68	0.71
G8	0.71	0.79	0.75	0.75	0.73	0.81	0.77	0.77	0.71	0.78	0.74	0.74
mean	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.65	0.66	0.6	0.63

D. means D1=0.63 D2=0.63 D3=0.60 Grand Mean=0.62												
New LSD (0.05) S= 0.01 D=0.03 SD=0.02 G=0.02 GS=0.03 GD= 0.03 GSD=0.06												
Seed yield/ plant (g)												
G1	1.04	1.19	1.10	1.1	0.76	1.20	0.72	0.89	0.86	1.10	0.70	0.89
G2	0.93	1.20	1.06	1.1	0.52	0.71	0.86	0.7	0.86	0.67	0.7	0.74
G3	0.86	1.27	1.15	1.1	0.69	0.70	0.83	0.74	0.90	0.81	0.8	0.84
G4	1.10	1.38	1.44	1.3	0.52	0.89	0.97	0.79	1.11	1.11	0.9	1.04
G5	0.76	1.09	0.91	0.9	0.62	0.82	0.67	0.7	1	1	0.9	0.97
G6	0.86	1.14	1.07	1.0	0.53	0.95	1	0.83	0.93	0.91	0.8	0.88
G7	1.43	1.10	1.47	1.3	0.76	0.99	1.54	1.1	1.12	0.84	0.63	0.9
G8	1.26	1.51	1.39	1.4	1.36	1.62	1.49	1.49	1.17	1.41	1.29	1.3
mean	1.0	1.2	1.2	1.2	0.72	0.99	1.0	0.91	1.0	1.0	0.84	0.95
D. means D1=0.91 D2= 1.06 D3=1.01 Grand Mean= 0.99												
New LSD (0.05) S=0.05 D=0.03 SD=0.09 G=0.10 GS=0.18 GD=0.18 GSD=0.31												
Straw yield/ plant (g)												
G1	2.73	1.20	1.93	2.0	1.88	2.53	1.19	1.9	2.22	2.46	1.71	2.1
G2	2.48	2.17	1.31	2.0	1.40	2.09	1.95	1.8	2.85	2.18	1.71	2.2
G3	2.66	2.95	2.07	2.6	1.42	3.17	1.43	2.0	2.67	2.53	1.87	2.4
G4	4.21	2.07	1.89	2.7	1.45	2.70	2.44	2.2	3.90	2.57	1.75	2.7
G5	2.17	2.57	1.31	2.0	2.39	2.82	2.20	2.5	2.21	2.18	1.65	2.0
G6	3.53	1.76	2.08	2.5	1.85	2.26	2.55	2.2	2.57	2.36	1.61	2.2
G7	2.93	1,76	1.97	2.5	1.84	2.79	1.71	2.1	2.39	2.21	2.30	2.3
G8	3.55	3.95	3.75	3.8	3.53	3.92	3.73	3.7	3.49	3.88	3.68	3.7
mean	3.0	2.4	2.0	2.5	2.0	2.8	2.2	2.3	2.8	2.5	2.0	2.5
D. means D1=2.60 D2=2.57 D3= 2.07 Grand Mean= 2.41												
New LSD (0.05) S=0.11 D=0.16 SD=0.20 G=0.22 GS=0.37 GD= 0.37 GSD=0.65												
Biological yield/ plant (g)												
G1	3.76	2.39	3.03	3.1	2.63	3.73	1.92	2.8	3.08	3.56	2.40	3.0
G2	3.42	3.37	2.37	3.1	1.92	2.80	2.82	2.5	3.71	2.86	2.41	2.99
G3	3.53	4.22	3.22	3.7	2.11	4.24	2.26	2.9	3.57	3.38	2.67	3.21
G4	5.30	3.44	3.33	4.0	1.98	3.59	3.41	3.0	5	3.68	2.65	3.78
G5	2.93	3.66	2.22	2.9	3.02	3.63	2.87	3.2	3.21	3.18	2.55	2.98
G6	4.39	2.90	3.14	3.5	2.38	3.21	3.56	3.1	3.49	3.27	2.41	3.06
G7	4.36	2.86	3.45	3.6	2.60	3.77	3.25	3.2	3.52	3.05	2.93	3.2
G8	4.82	5.46	5.14	5.1	4.88	5.54	5.21	5.2	4.66	5.29	4.97	5.0
mean	4.1	3.5	3.2	3.6	2.7	3.8	3.2	3.2	3.8	3.5	2.87	3.40
D. means D1=3.53 D2=3.6 D3= 3.09 Grand Mean=3.41												
New LSD (0.05) S=0.13 D= 0.14 SD= 0.23 G=0.27 GS=0.47 GD= 0.47 GSD= 0.81												

2- Simple correlation coefficient:

As shown in Table (3), positive and significant associations were found between straw yield/ plant (g) and each of fruiting zone length / plant (cm),number of capsules/ plant , seed index (g),and seed yield/ plant (g) and between biological yield/ plant (g) with each of fruiting zone length/ plant (cm),No. capsules/ plant, seed index (g),seed yield / plant(g),and straw yield / plant (g) and between seed yield/ plant (g) with length of the fruiting zone (cm),number of capsules / plant and seed index (g) and between seed index(g) with fruiting zone length/ plant (cm)and number of capsules / plant and between number of capsules/ plant with fruiting zone length/ plant (cm) and finally between both plant height (cm) and technical length (cm). On the contrary, negative and significant correlation coefficients was found between number of fruiting branches / plant and plant height (cm). Insignificant negative correlation coefficients were detected between seventeen pairs out of all combinations of traits studied. It could be concluded that such results correlated highly positive significant and /or positive significant with straw yield and yield components would lead to increase in flax yield and then these characters must be taken in selection program to achieve high flax yield.

Al-Kordy *et al*. (2003) revealed that biological yield was high significant and positive correlation with plant height (cm), technical length (cm) and straw yield / plant (g) of Egyptian cultivars. Also, high significant and positive correlation between biological yield and each of number of capsules / plant and straw yield / plant was detected in Polish cultivars.

Some correlations were worthy of attention between biological yield / plant and straw yield / plant with value being 0.986**. High association of biological yield and straw yield / plant is of interest to the plant breeder because it is relatively easily identifiable characteristic in the field. These results are in agreement with those previously obtained by El-Shimy *et al*.(1990), Abo El – Zahab *et al*. (1994) , Zahana (1999) and El-Hariri *et al*. (2004). It is apparent that many possible combinations of traits under consideration were correlated because of a mutual association, positive or negative, with others but these could not be of absolute validity, since simple correlation coefficient did not put direct and indirect effects in the point of view. While, path coefficient analysis provides an effective means of separating causes of associations and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each causal factor.

Table 3: Simple correlations coefficients between all pairs of the traits studied.

Traits	Plant height	Technical length	Fruiting zone	No. fruiting branches/ plant	No. capsules/ plant	Seed index	Seed yield/ plant	Straw yield/ plant
Technical length	0.905**							
Fruiting zone	0.080	-0.351						
No. fruiting branches/ plant	-0.785*	-0.547	-0.442					
No. capsules/ plant	-0.212	-0.564	0.856**	-0.229				
Seed index	-0.274	-0.614	0.829*	-0.027	0.924**			
Seed yield/ plant	-0.141	-0.532	0.943**	-0.230	0.923**	0.891**		
Straw yield/ plant	0.083	-0.317	0.938**	-0.459	0.923**	0.811*	0.941**	
Biological yield/ plant	-0.026	-0.427	0.954**	-0.354	0.937**	0.862**	0.984**	0.986**

* and **: denote significant at 0.05 and 0.01 levels of probability, respectively.

3- Path coefficient analysis:

The components of straw yield variations determined directly and jointly by each factor are calculated and presented in table (4). The main source of straw yield variation in order of relative importance was the joint effect of number of capsules / plant with seed index (21.89 %), followed by its joint effect with fruiting zone length (16.60%). Number of capsules / plant gave also the main direct effect (12.36%) and achieved the highest totally contributes straw yield / plant (34.58%). The second important character, seed index presented high jointly effect (9.70%) with fruiting zone length and moderate direct effect (7.15%) with (24.17%) of total contribution. These results cleared that number of capsules / plant and seed index had significant participate for straw yield variation. Meanwhile, the residual effect assumed to be 7.26% of total phenotypic variation higher than the foundence of Eraky *et al*. (1983) who reported that the residual effects was less than 1% of the total contribution after partitioning the direct and joint effects of three yield attributes of maize grain yield.

From above, it is evident that the correlations between yield on one hand and the various characters on the other have been partitioned into direct and indirect effects. As a guideline for interpretation of path analysis results, the following broad points may be kept in view:

(1) If the correlation coefficient between a causal factor and the effect is almost equal to its direct effect, then correlation explains the true relationship and a direct selection through this trait will be effective.

(2) If the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be cause of correlation. In such situations, the indirect causal factors are to be considered simultaneously.

(3) Correlation coefficient may be negative but the direct effect is positive and high. Under these circumstances, a restricted simultaneous selection model is to be followed, i e. restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effects (Singh and Kakar, 1977).

Table 4: Direct and joint effects of some yield attributes presented as percentage of straw yield variation in flax.

Source of variation	CD	RI %	Total contribution
Plant height (X1)	0.1972	2.31	6.945
Fruiting zone length (X2)	0.4093	4.79	19.69
No. fruiting branches/ plant (X3)	0.2011	2.36	7.34
No. capsules/ plant (X4)	1.055	12.36	34.58
Seed index (X5)	0.6108	7.15	24.17
X1 via X2	0.0455	0.53	
X1 via X3	-0.3127	3.66	
X1 via X4	-0.2437	2.85	
X1 via X5	0.1902	2.23	
X2 via X3	-0.2537	2.97	
X2 via X4	1.4177	16.60	
X2 via X5	-0.8281	9.70	
X3 via X4	-0.2659	3.11	
X3 via X5	0.0189	0.22	
X4 via X5	-1.869	21.89	
Residual	0.6203	7.26	7.26
Total	0.993	100	99.99

CD: Coefficient of determination

RI%: Percentage of relative importance

Finally, it could be concluded that the effect of sowing dates was more pronounced than seasons for all traits except No. of fruiting branches / plant, seed index and seed yield/ plant which due to the differences of Kalubia governorate climatic factors prevailing in three sowing dates. The first sowing date (15 November) exhibited as a suitable one through first and third seasons as it recorded the highest values of plant height, straw yield / plant and biological yield /plant for different cultivars tested. The major selection criteria was number of capsules / plant as it totally contribute straw yield/ plant by 34.58% out of 92.73% total contribution of the five traits fractionated in this investigation.

References

Abo El-Zahab, A.A., N.K.M. Mourad and H.M. Abo Kaied, 1994. Genotype-environment interaction and evaluation of flax genotypes.1-Straw yield. Proc. 6th Conf. Agron., Al-Azhar univ., Cairo, Egypt, I: 129-152.

Abo Zaid, T.A., 1997. Comparative study of yield and technological characters of some flax varieties. Ph.D. Thesis, Fac. Agrc. Mansoura Univ., Egypt.

Ahmed, M.A., El-Gazzar, M. and N.M. Zaki, 1992. Partition of photosynthates in some soybean cultivars grown in Egypt. Egypt. J. App. Sci., 7(3): 113-123.

Al-Kordy, M.A., M.A. Ahmed and M.S. Hassanein, 2003. Correlation and Path coefficient analysis of some quantitative traits in flax (*Linum usitatissimum* L.). Annals of Agric. Sci., Moshtohor, 41(2): 579-597.

Badr, A., S. Mehasen, S.H.A. Mostafa and T.A. Omer, 1998. Flax yield and quality as affected by row spacing and nitrogen fertilization. Proc.8th Conf. Agron., Suez Canal Univ., Ismailia, Egypt 28-29 Nov 513-521.

Bostock, J. and H.T. Riley, 1856. The history of Pliny. IV. London: 523 pp.

Casa, R., G. Russell, B. Locascio and F. Rossini, 1999. Environmental effects on linseed (*Linum usitatissimum* L.) yield and growth of flax at different stand densities. European J. of Agronomy, 11: 267-278.

Dewilde, B., 1983. 20 eeuwen vlas in Vlaanderen: 439 pp.

Dribnenki, J.C.P. and A.G. Green, 1995. Linola TM '947' low linolenic acid flax. Canadian Journal of Plant Science, 75: 201-202.

El-Hariri, D.M., 1995. Effect of flax cultivars on yield and quality in relation to flax processing. Modern flax Proc.,1st workshop of the extraction and processing of flax of the FAO Eur. Coop. Res. Network of flax, March, 15-16, Poznan, Poland.

El-Hariri, D.M., A.H. El-Sweify and S.H. Mostafa, 1996. Response of flax yield to cultivars, phytohormone levels and pulling dates. Proc.4th Europ. Reg. Workshop on flax, First General Consul. of the FAO Eur. Coop. Res. Network on flax, Rouen, France, September 25-28.

El-Hariri, D.M., M.S. Hassanein and M.A. Ahmed, 1998. Evaluation of different flax genotypes under Egyptian conditions. Proc. Bast fibrous plants today and tomorrow, N. I. Vavilov Res. INS. Industry (VIR) St. Petersburg, Russia.

El-Hariri, D.M., M.S. Hassanein and H. Amna El-Sweify, 2004. Evaluation of some flax Genotypes, straw yield, yield components and technological characters, J. of Natural fibers, 1(2): 1-12.

El-Shimy, G.H., M. Abd El-Hamed and L.M. Zaky, 1990. Comparative analysis of certain genotypes of flax (*Linum usitatissimum* L.). J. Agric.Sci. Moshtohor, 28: 879-904.

El-Shimy, G.H., E.A. El-Kady and N.K. Mourad, 1993. Effect of seeding rate and nitrogen fertilizer levels on yield and anatomical manifestation on some, flax genotypes. J. Agric. Res. Tanta Univ., 19(1): 92-104.

El- Sweify, A.H.H., 1993. Evaluation of some promising flax strains in relation to growth, yield and quality. Ph.D. Thesis, Fac. Agrc. Moshtohor, Zagazig Univ., Egypt.

El-Sweify, A.H. and S.H.A. Mostafa, 1996. Growth, yield and quality of flax as affected by genotypes, potassium fertilizer and plant densities. Egypt J. Appl. Sci., 11(7): 116-133.

Eraky, A.G., A.H. Salem and A.S.A. Gauda, 1983. Path coefficient and regression analysis for yield attributes in maize. Proc. of the first Conf. of Agron, 1(A): 111-126.

Fouilloux, G., 1988. Breeding flax methods. In Flax: Breeding and Utilisation, 14-25.

Gill, K.S., 1987. Linseed. Indian Council of Agricultural Research, New Dehli, 186 pp.

Gomez, K.A. and A.A. Gomez, 1984. "Statistical Procedures for Agricultural Research". 2nd Ed., John Wiley and Sons, New York, pp: 361-381.

Hassan, F.U. and M.H. Leitch, 2000. Influence of seeding density on contents and uptake of N,P and K in linseed (*Linum usitatissimum* L.). J. Agronomy and Crop Sci., 185, 193, 199.

Kandil, A.A., A.A. Hob Allah, D.M. El-Hariri, M.S. Zeidan and A.B. Bakri, 2009. Effect of seeding rate on yield and quality traits of some flax varieties (*Linum usitatissimum* L.) grown in newly reclaimed sandy soils. Scientific Bulletin of Escorena, 1: 16-21.

Kineber, M.E.A., 2003. Flax plants performance as influenced by planting methods and seeding rate. J. Agric. Res. Tanta Univ., 1: 64-73.

Mourad, N.K.M. and H.M.H. Abo-Kaied, 2003. Genetic analysis of yield and yield components in flax (Linum usitatissimum L.). Egyptian Journal of Agricultural Research, 81: 595-608.

Popescu, F., I. Marinescu and I. Vasile, 1998. Heredity and stability of flax fiber content. Romanian Agricultural Research, 9: 15-24.

Salas, G. and W. Friedt, 1995. Comparison of pedigree selection and single seed descent for oil yield in linseed (Linum usitatissimum L). Euphytica, 83: 25-32.

Simopoulos, A.P., 2002. Omega -3 fatty acids in inflammation and autoimmune diseases. Journal of the American College of Nutrition, 21: 495-505.

Singh, R.K. and S.N. Kakar, 1977. Control on individual trait means during index selection. Proc. 3rd Congr. SABRAO (Canberra), 3(d): 22-25.

Snedecor, G.W. and W.G. Cochran, 1989. "Statistical Methods". 8th Ed., Ames, Iowa, USA: Iowa State Univ. Press, Iowa, USA., pp: 503.

Stokkers, R., S.R.M. Janssens and B.H.C. Vvan der Waal, 2004. Vezelvlassector in opmars. Lei, Wageningen University, Den Haag, 66 pp.

Waller, R.A. and D.B. Duncan, 1969. A bays role for the symmetric multiple comparison problem. Amer. Stat. Assoc. J., 91: 1485-1503.

Wright, S., 1934. The methods of path coefficient. Ann. Math. Stat., 5: 161-215.

Zahana, A.S.A., 1999. Correlation and regression studies in flax. Ph.D. Thesis, Fac. Agrc. Moshtohor, Zagazig Univ., Egypt.

Zohary, D. and M. Hopf, 2000. Domestication of plants in the Old World: the origin and spread of cultivated plants in West Asia, Europe and the Nile Valley. Oxford University Press, Oxford, pp: 316.