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Evaluation, Correlation and Path Coefficient Analysis among Seed Yield and Its Attributes of Oil Flax (*Linum usitatissimum* L.) Genotypes.

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Abstract: In field trials, six flax cultivars of diverse origins were grown during three successive seasons with three sowing dates in each growing season. Mean squares of all traits studied across the three seasons and three sowing dates; exhibited highly significant effects for all traits recorded. The effect of sowing dates was more pronounced than seasons for all traits except No. of fruiting branches / plant, seed index as well as seed yield/ plant, straw and biological yield/ plant which due to the differences of climatic factors prevail in the three sowing dates. The first and second order interaction involving genotypes and seasons or sowing dates were significant for all traits indicating different responses of genotypes under each of variation in environmental condition. In the third order interaction significance for all studied traits were shown for the interaction between genotypes x seasons x sowing dates. Seed yielding capacity for all tested genotypes ranged from 0.53 (g) for G3 in D3 of S3 to 1.95 (g) for G6 in D1 of S2. Results indicated that the magnitude of differences between flax genotypes tested is high for all traits under the experimental conditions. G5, G1 and G6 recorded the highest values (24.40, 26.45 and 22.48, respectively) for number of capsules/plant in the first, second and third season, respectively. The second sowing date was the best one through 1st and 2nd seasons as it recorded the highest values of seed yield / plant for different genotypes under study. Positive and significant associations were found between straw yield/ plant (g) and each of biological yield/ plant (g), seed yield/ plant (g), No. capsules/ plant, technical length (cm) and plant height (cm) and between biological yield/ plant (g) with each of No. capsules/ plant, length of the fruiting zone (cm), technical length (cm) and plant height (cm) and between seed yield/ plant (g) with length of the fruiting zone (cm) and plant height (cm) and between No. capsules/ plant with technical length (cm) and plant height (cm) and finally between both plant height (cm) and technical length (cm). Insignificant negative correlation coefficients were detected between ten pairs out of all combinations of traits studied. The components of seed yield variations determined directly and jointly by each factor are calculated. The main source of plant seed yield variation in order of relative importance was the direct effect of number of capsules / plant (33.15 %) and its negative joint effect with seed index (16.35 %) followed by its joint effect with number of fruiting branches / plant (12.65 %) and its joint effect with length of fruiting zone (3.07 %). Hence, number of capsules/ plant totally contributes seed yield / plant by 49.2 % out of 98.27 % total contribution of the four traits fractionated in this study. Meanwhile the residual effect assumed to be 1.73 % of the total phenotypic variations.

Kew words: Flax (*Linum usitatissimum* L), Evaluation, Path Coefficient, Seed Yield , oil.

INTRODUCTION

Flax (*Linum usitatissimum* L.) belongs to Linaceae family that consists of 9 genera and 150 species. It is the only species in this family that has economic as agronomic values. It is annual and rarely perennial crop and has 2 different forms that are used for fiber and oil production (Kurt, 1996). Flax seeds contain 30-45% oil, making it an important industrial crop. Since flax oil is dried off rapidly, it is quite valuable in dye industry (Copur *et al.*, 2006). Flax is the third largest natural fiber crop and one of the five major oil crops in the world. It is a small size and self pollination herb that has been thought to be the model plant for the bast fiber plants. At present, fiber flax cultivars are mainly grown in some regions of northern Europe, Russia and China, while distinct linseed flax varieties are widely grown in cool temperate regions of Argentina, India, China, Russia, the USA and Canada (Millam *et al*., 2005 and Deng *et al*., 2011). Fiber flax is bred for its long fiber; whereas, line seed was deliberately bred for short and highly branched plants with increased number of flowers for enhanced seed production. Linseed oil originated from the seeds has many industrial applications, e.g. paints, linoleum carpet and ink. 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 and Yermanos, 1987). Divergent selection for fiber flax and linseed in connection with the early dispersion of this crop resulted in a wide range of infraspecific variation.

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The total world area planted with linseed increased to 3.1 million hectares in 2005 (FAOSTAT data, 2006). Linseed oil is obtained from ripe, dried linseed, which contain 35 - 45 % oil. In Egypt, 75 % of industrial oil and 92 % of edible are annually imported to cover the wide gap between production and consumption (FAOSTAT data 2006), the oil percentage of the Egyptian cultivars ranging from 25 to 35 %, whereas it reaches 45 to 47 % in some imported varieties. Therefore, there is a need to develop Egyptian cultivars with high oil content and quality. Flaxseed oil is grown in Egypt as a dual purpose crop, i.e. fibers and seeds. Recently, there is an increase in world requirements from flax fibers and seeds, where the two products has great importance for several industries. Flax fibers are used in manufacturing linen cloth from long fine fibers, tent cloth, twines and best paper. Meanwhile, linseed oil is used as edible for human, medical purpose and flaxseed cakes are used as dairy cattle feeding. Moreover, the boiling seed oil is used in making paints, varnish and printing ink. The cultivated area by flax in Egypt is relatively small and decreased dramatically in last decade. This is due to the strong competition between flax and other strategic winter season crops such as wheat and clover on the limited arable land in Nile valley and Delta. For that, this investigation aimed to study the performance of some local and introduced flax varieties under different environmental conditions. Many investigators reported significant differences among flax varieties concerning straw, seed yield and its components, El-Hariri *et al*. (1998, 2002 and 2004).

This investigation dealt with detailed characterizations of six flax genotypes evaluated by nine quantitative morphological traits under 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 seed yield / plant and four of its attributes in the *Linum usitatissimum* L. genotypes tested using simple correlation and bath coefficient analyses.

MATERIALS AND METHODS

In field trials, six flax cultivars of diverse origins were grown in Kafr El- Amar Village, Kalubia Governorate during three successive growing seasons lasted 2009/2010. 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 sup-plots. Each plot consisted of fifteen rows with 3.5m long and 20cm apart, thus area of the plot was 10.5 m^2 (1/400 fed.). The experimental treatments can be described as follows:

Sowing Dates:

D1- 15^{th} November.
D2- 30^{th} November.
D3- 15^{th} December.

Cultivars:

G1 - Romanian Linseed oil type "Geria"
G2 - Romanian Linseed oil type "Olin"
G3 - Romanian Linseed oil type "Gentiana"
G4 - Romanian Linseed oil type "Midin"
G5 - Romanian Linseed oil type "Deta"
G6 - Egyptian dual purpose type "Giza 7"

Seeding rate was 50 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 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 was 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 Wright (1934) and Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

I- Genotype – 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. 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 prevail in the three sowing dates(Table, 1). The first and second order interaction involving genotypes and seasons or sowing dates were significant for all traits indicating different responses of genotypes under each of variation in environmental condition. In the third order interaction significant for all studied traits were shown for the interaction between genotypes x seasons x sowing dates. These results are in agreement with those obtained by El-Sweify and Mostafa (1996), Kineber (2003) for flax 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).

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

Source of variation	DF	Plant height X1	Technical length X2	Fruiting zone X3	No. fruiting branches/ plant X4	No. capsules/ plant X5	Seed index X6	Seed yield/ plant X7	Straw yield/ plant X8	Biological yield/ plant X9
Seasons (S)	2	521.36**	236.39**	87.39**	23.52**	12.42**	0.092**	0.718**	0.85**	3.41**
Dates (D)	2	1161.38**	727.79**	205.24**	14.45**	116.44**	0.006^{+}	0.507^{+}	3.00**	5.76**
Error (a)	4	6.90	7.55	3.18	0.73	0.439	0.0012	0.083	0.153	0.25
SD	4	320.27**	286.06**	115.83**	4.41**	214.52**	0.014**	0.807**	2.22**	4.56**
Error (b)	12	16.29	11.76	3.11	0.18	1.42	0.0019	0.051	0.121	0.192
Varieties (G)	5	1294.76**	640.10**	723.68**	7.70**	160.97**	0.041**	2.99**	4.46**	13.26**
GS	10	161.26**	41.88**	28.52**	8.18**	91.78**	0.006**	0.412**	2.03**	4.47**
GD	10	194.67**	165.03**	20.90**	3.56**	30.36**	0.007**	0.098**	0.48**	0.74*
GSD	20	53.66**	35.11**	15.97**	3.83**	22.80**	0.005**	0.091**	0.58**	1.15**
Error (c)	90	12.78	5.28	4.47	0.213	2.193	0.0015	0.052	0.184	0.31

+,* and **: denote significant at 0.10, 0.05 and 0.01 levels of probability, respectively.

The interaction between genotypes 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 seed yielding capacity for all tested genotypes ranged from 0.53 (g) for G3 in D3 of S3 to 1.95 (g) for G6 in D1 of S2. Results indicated that the magnitude of differences between flax genotypes tested is high for all traits under the experimental conditions. G5, G1 and G6 recorded the highest values (24.40, 26.45 and 22.48, respectively) for number of capsules/plant in the first, second and third season, respectively. While, G2, G4 and G3 in the first, second and third season, respectively presented the lowest values (16.25, 16.15 and 13.85) of capsules number /plant. The third season seemed to be the best one for all genotypes seed index (0.77g) followed by the first and second seasons, 0.74 and 0.69g, respectively. On the other hand, the second sowing date was the best one through 1st and 2nd seasons as it recorded the highest values for different genotypes under study of seed yield / plant. Similar results were obtained by (Verma and Mahto 1994: Sharaan and Ghallab 1997: Bo Shim *et al.,* 2003: Saravanan *et al.,* 2003: Anuradha and Reddy 2005: and Mohamed *et al.,* 2008). On the other hand, Seed yield is the most important character in oil flax type, Moseman and Sato (1944) pointed out that selection for high seed based on the yield of individual plant would be of little value because of the wide range in yield variation of individual plants due to environmental influences. Varietal differences in number of capsules per plant were found by Blackman and Bunting (1954). Meanwhile, Frank and Hollosi (1985) stated that number of capsules, number of seeds per capsule and 1000-seed weight was all intercorrelated and suitable for use as selection principle for seed yield. Abo El-Zahab *et al*., (1994) reported that the genetic environmental interaction for seed yield was significant magnitude and attributable to the genetic location first order interaction. They added that variability measurements for oil percentage revealed low estimate of the genetic environmental interaction variance.

2- Simple Correlation Coefficient:

As shown in Table (3), positive and significant associations were found between straw yield/ plant (g) and each of biological yield/ plant (g), seed yield/ plant (g), No. capsules/ plant, technical length (cm) and plant height (cm) and between biological yield/ plant (g) with each of No. capsules/ plant, length of the fruiting zone (cm), technical length (cm) and plant height (cm) and between seed yield/ plant (g) with length of the fruiting zone (cm) and plant height (cm) and between No. capsules/ plant with technical length (cm) and plant height (cm) and finally between both plant height (cm) and technical length (cm). Insignificant negative correlation coefficients were detected between ten pairs out of all combinations of traits studied. Agrowal *et al*., (1994) revealed that seed yield was highly and positively correlated with number of capsules / plant. Muduli and

Pantiak (1994) indicated that seed yield had high positive correlation with capsules per plant, but moderate positive correlated with seeds per capsule. Some correlations were worthy of attention between seed yield / plant and fruiting zone length with r value being 0.944**. High association of biological yield and seed 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-Hariri *et al.,* (2002 and 2004) and Copur *et al.,* (2006). The trends of associations in this study are also in line with other findings as number of capsules and seed index were correlated (Frank and Hollosi, 1985), oil content and seed index were positively correlated (Green and Marshell, 1981). Other investigators reported associations among flax seed yield and its attributes (El-Shimy *et al.,* 1997). 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 mean 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 2: Mean performance of all flax genotypes 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
X1 Plant height (cm)												
G1	100.25	96.50	89.75	95.50	78.67	93.78	71.33	81.26	93.78	84.67	75.22	84.56
G2	93.33	73.25	65.83	77.47	80.33	79.44	70.78	76.85	85.22	79.89	72.44	79.18
G3	86.58	78.17	71.08	78.61	69.67	77.56	63.00	70.08	72.45	69.44	58.56	66.82
G4	92.42	71.50	76.67	80.20	76.67	77.00	71.78	75.15	81.56	81.89	74.00	79.15
G5	104.58	79.08	75.08	86.25	82.92	87.55	72.00	80.82	81.89	73.56	67.56	74.34
G6	84.90	94.33	89.62	89.62	91.62	95.90	96.71	94.74	84.00	93.33	88.67	88.67
mean	93.68	82.14	78.01	84.61	79.98	85.21	74.27	79.82	83.15	80.46	72.74	78.79
D. means	D1= 85.60			D2= 82.60		D3= 75.01			Grand Mean= 81.07			
New LSD (0.05)												
S= 1.69	D= 1.40		SD= 2.93		G=1.93		GS= 3.35		GSD= 5.80			
X2 Technical length (cm)												
G1	81.00	73.00	67.67	73.89	61.67	74.11	54.44	63.41	71.00	69.89	62.66	67.85
G2	72.67	54.33	52.75	59.92	66.78	59.89	55.78	60.82	61.44	59.78	56.33	59.18
G3	65.17	57.45	56.67	59.76	59.22	61.89	48.78	56.63	57.78	57.11	47.00	53.96
G4	71.50	51.00	65.00	62.50	61.78	57.22	56.22	58.41	56.56	60.11	59.89	58.85
G5	79.17	54.06	58.08	63.77	65.44	64.66	54.78	61.63	61.78	60.11	54.33	58.74
G6	66.00	73.33	69.67	69.67	63.81	70.90	67.36	67.36	65.10	72.33	68.72	68.72
mean	72.59	60.53	61.64	64.92	63.12	64.78	56.23	61.37	62.28	63.22	58.16	61.22
D. means	D1= 66			D2= 62.84		D3= 58.68			Grand Mean= 62.51			
New LSD (0.05)												
S= 1.44	D= 1.47		SD= 2.49		G=1.24		GS= 2.15		GSD= 3.73			
X3 Fruiting zone (cm)												
G1	19.25	20.92	20.92	20.36	16.89	19.67	17.00	17.85	22.00	15.00	11.56	16.19
G2	20.67	18.17	13.08	17.31	13.44	19.56	15.22	16.07	19.45	20.11	15.78	18.45
G3	21.55	22.58	14.32	19.48	10.45	15.67	15.89	14.00	17.11	12.33	11.56	13.67
G4	20.88	20.58	11.50	17.65	15.00	20.78	15.56	17.11	24.11	16.22	14.33	18.22
G5	25.42	25.03	17.00	22.48	18.33	22.89	17.22	19.48	22.72	13.44	13.56	16.57
G6	28.20	31.33	29.77	29.77	28.50	31.67	30.08	30.08	28.50	31.67	30.08	30.08
mean	22.66	23.10	17.77	21.18	17.10	21.71	18.50	19.10	22.32	18.13	16.15	18.86
D. means	D1= 20.69			D2= 20.83		D3= 17.47			Grand Mean= 19.66			
New LSD (0.05)												
S= 0.74	D= 0.95		SD= 1.28		G=1.14		GS= 1.98		GSD= 3.43			
X4 No. fruiting branches/ plant												
G1	5.08	6.42	9.75	7.08	5.22	7.00	6.33	6.18	6.22	5.89	4.89	5.67
G2	7.00	6.25	4.42	5.89	5.55	6.00	7.22	6.26	6.45	7.00	6.56	6.67
G3	7.50	6.58	10.00	8.03	5.55	6.44	8.11	6.70	5.67	6.78	6.89	6.45
G4	6.42	7.67	8.17	7.42	5.45	7.55	7.00	6.67	7.22	7.78	5.67	6.89
G5	7.42	12.92	9.75	10.03	5.11	6.11	6.22	5.81	6.11	6.22	5.78	6.04
G6	5.70	6.33	6.02	6.02	5.61	6.23	5.92	5.92	5.64	6.27	5.95	5.95
mean	6.52	7.70	8.02	7.41	5.42	6.56	6.80	6.26	6.22	6.66	5.96	6.28
D. means	D1= 6.05			D2= 6.97			D3= 6.93		Grand Mean= 6.65			
New LSD (0.05)												
S= 0.18	D= 0.46		SD= 0.31		G=0.25		GS= 0.43		GSD= 0.75			
X5 No. capsules/ plant												
G1	16.92	24.19	21.67	20.93	22.00	29.00	28.34	26.45	26.56	16.56	13.00	18.71
G2	18.08	15.17	15.50	16.25	12.44	22.00	19.89	18.11	27.11	22.44	14.22	21.26
G3	21.58	17.08	17.67	18.78	18.44	18.55	21.56	19.52	17.44	12.89	11.22	13.85
G4	13.17	22.50	15.75	17.14	10.44	21.22	16.78	16.15	24.00	23.89	12.33	20.07
G5	22.10	27.17	23.92	24.40	16.00	18.89	15.11	16.67	25.33	19.34	14.78	19.82
G6	21.90	24.33	23.12	23.12	23.40	26.00	24.70	24.70	21.30	23.67	22.48	22.48
mean	18.96	21.74	19.61	20.10	17.12	22.61	21.06	20.26	23.62	19.80	14.67	19.36

D. means D1= 19.9 D2= 21.38 D3= 18.45 Grand Mean= 19.91												
New LSD (0.05) S= 0.50 D= 0.35 SD= 0.87 G=0.80 GS= 1.39 GSD= 2.40												
X6 Seed index (g)												
G1	0.63	0.65	0.75	0.68	0.67	0.57	0.58	0.61	0.76	0.73	0.64	0.71
G2	0.71	0.78	0.69	0.73	0.71	0.65	0.59	0.65	0.79	0.79	0.82	0.80
G3	0.81	0.80	0.79	0.80	0.75	0.75	0.65	0.72	0.78	0.78	0.78	0.78
G4	0.68	0.75	0.78	0.74	0.74	0.68	0.62	0.68	0.76	0.82	0.72	0.77
G5	0.78	0.66	0.77	0.74	0.74	0.68	0.73	0.72	0.82	0.78	0.75	0.78
G6	0.74	0.82	0.78	0.78	0.73	0.81	0.77	0.77	0.74	0.83	0.79	0.79
mean	0.73	0.74	0.76	0.74	0.72	0.69	0.66	0.69	0.78	0.79	0.75	0.77
D. means D1= 0.74 D2= 0.74 D3= 0.72 Grand Mean= 0.73												
New LSD (0.05) S= 0.02 D= 0.02 SD= 0.03 G=0.02 GS= 0.04 GSD= 0.06												
X7 Seed yield/ plant (g)												
G1	1.03	1.72	1.60	1.45	1.44	1.65	1.46	1.52	1.27	1.11	0.75	1.04
G2	1.14	1.20	1.02	1.12	0.82	1.04	0.95	0.94	1.40	1.38	0.70	1.16
G3	1.22	1.43	1.66	1.44	0.68	1.11	1.45	1.08	1.05	0.96	0.53	0.85
G4	1.04	1.33	1.03	1.13	0.76	1.21	1.05	1.01	1.66	1.24	0.62	1.17
G5	1.26	1.8	1.76	1.61	0.89	0.87	0.94	0.90	1.36	1.30	1.07	1.24
G6	1.79	1.69	1.89	1.79	1.95	1.87	1.76	1.86	1.81	1.71	1.91	1.81
mean	1.25	1.53	1.49	1.44	1.09	1.29	1.28	1.21	1.43	1.28	0.93	1.23
D. means D1= 1.26 D2= 1.42 D3= 1.25 Grand Mean= 1.31												
New LSD (0.05) S= 0.09 D= 0.15 SD= 0.16 G=0.12 GS= 0.21 GSD= 0.37												
X8 Straw yield/ plant (g)												
G1	3.42	3.39	2.65	3.15	3.23	4.00	2.66	3.30	2.60	2.33	1.72	2.22
G2	2.25	1.75	1.40	1.80	1.13	2.11	1.95	1.73	2.84	3.08	2.09	2.67
G3	3.32	1.87	2.24	2.48	1.46	1.91	2.21	1.86	2.04	2.12	1.29	1.82
G4	2.14	2.34	1.76	2.08	1.18	2.20	2.44	1.94	4.06	2.20	2.13	2.80
G5	3.07	3.31	2.26	2.88	1.76	2.73	1.44	1.98	2.42	2.02	1.67	2.04
G6	2.77	3.08	2.92	2.92	2.85	3.17	3.01	3.01	2.83	3.14	2.98	2.98
mean	2.83	2.62	2.21	2.55	1.94	2.69	2.29	2.30	2.80	2.48	1.98	2.42
D. means D1=2.52 D2= 2.60 D3= 2.16 Grand Mean= 2.43												
New LSD (0.05) S= 0.15 D= 0.21 SD= 0.25 G=0.23 GS= 0.40 GSD= 0.70												
X9 Biological yield/ plant (g)												
G1	4.45	5.11	4.25	4.60	4.67	6.05	4.12	4.95	3.87	3.44	2.48	3.26
G2	3.39	2.95	2.42	2.92	1.94	3.15	2.91	2.67	4.24	4.46	2.79	3.83
G3	5.24	3.31	3.90	4.15	2.14	3.02	3.66	2.94	3.09	3.08	1.82	2.66
G4	3.17	3.67	2.79	3.21	1.94	3.41	3.49	2.95	5.73	3.44	2.75	3.97
G5	4.33	5.33	4.02	4.56	2.65	3.60	2.38	2.88	3.79	3.32	2.74	3.28
G6	4.56	4.77	4.82	4.72	4.80	5.04	4.77	4.87	4.64	4.86	4.90	4.90
mean	4.19	4.24	3.70	4.04	3.02	4.10	3.61	3.57	4.23	3.82	2.91	3.65
D. means D1= 3.81 D2= 4.05 D3= 3.41 Grand Mean= 3.76												
New LSD (0.05) S= 0.18 D= 0.27 SD= 0.32 G=0.30 GS= 0.52 GSD= 0.90												

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

Traits	Plant height X1	Technical length X2	Fruiting zone X3	No. fruiting branches/ plant X4	No. capsules/ plant X5	Seed index X6	Seed yield/ plant X7	Straw yield/ plant X8
X2 Technical length	0.979**							
X3 Fruiting zone	0.800	0.695						
X4 No. fruiting branches/ plant	-0.692	-0.703	-0.582					
X5 No. capsules/ plant	0.914*	0.945**	0.611	-0.467				
X6 Seed index	-0.177	-0.312	0.444	0.149	-0.309			
X7 Seed yield/ plant	0.821*	0.776	0.944**	-0.591	0.731	0.341		
X8 Straw yield/ plant	0.952**	0.976**	0.723	-0.632	0.931**	0.221	0.831*	
X9 Biological yield/ plant	0.933**	0.926**	0.858*	-0.641	0.879*	0.030	0.947**	0.966**

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

3- Path Coefficient Analysis:

The components of seed yield variations determined directly and jointly by each factor are calculated and presented in table (4). The main source of plant seed yield variation in order of relative importance was the direct effect of number of capsules / plant (33.15 %) and its negative joint effect with seed index (16.35 %) followed by its joint effect with number of fruiting branches / plant (12.65 %) and its joint effect with long of fruiting zone (3.07 %). Hence, number of capsules / plant totally contributes seed yield / plant by 49.2 % out of

98.27 % total contribution of the four traits fractionated in this study. Meanwhile the residual effect assumed to be 1.73 % of the total phenotypic variations. It is interest to observe that Eraky *et al.*, (1983) reported after partitioning the direct and joint effects of three yield attributes of maize grain yield that the residual effects was less than 1% of the total contribution. 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).

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 as well as seed, straw and biological yield/ plant which due to the differences of Kalubia governorate climatic factors prevail in the three sowing dates. The second sowing date (30 November) exhibited as a suitable one through first and second seasons as it recorded the highest values of seed yield / plant for different genotypes tested. This mainly attributed to number of capsules per plant specially for the Romanian Linseed oil type two varieties, "Geria" and "Deta" as well as the Egyptian dual purpose type variety "Giza 7". The major selection criteria was number of capsules / plant as it totally contribute seed yield / plant by 49.2 % out of 98.27 % total contribution of the four traits fractionated in this investigation.

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

Source of variation	CD	RI %	Total contribution
Fruiting zone (X3)	0.0031	0.19	3.22
No. fruiting branches/ plant (X4)	0.0909	5.53	14.07
No. capsules/ plant (X5)	0.5447	33.15	49.20
Seed index (X6)	0.3471	21.12	31.80
X3 via X4	0.0196	1.20	
X3 via X5	0.0505	3.07	
X3 via X6	0.0293	1.78	
X4 via X5	0.2079	12.65	
X4 via X6	-0.0530	3.22	
X5 via X6	-0.2687	16.35	
Residual	0.0285	1.73	1.73
Total	1.0000	100.00	100.00

CD: Coefficient of determination RI%: Percentage of relative importance.

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