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Character Association and Path coefficient Analysis for Yield and Yield Components in Linseed (*Linum usitatissimum* L.)

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ABSTRACT: Demand for linseed is increases day by day, globally due to its health benefits and industrial uses. Although, the availability of high yielding cultivars of linseed is limited. So, the present study has been conducted to determine genetic variability, heritability and character association among 47 linseed genotypes using eleven agro-morphological traits for yield and yield component. It was carried out at Agricultural Farm of BAU, Sabour, Bhagalpur (Bihar) during the *Rabi* 2019-20. The experimental material was evaluated in RBD design with three replications. Analysis of variance indicated that the presence of sufficient amount of variability among the genotypes for all the characters studied. High to moderate values of PCV and GCV were obtained for traits plant height, bud fly infestation, number of primary branches per plant, number of capsules per plant, 1000-seed weight and seed yield per plant. High heritability along with high to moderate genetic advance has been estimated for plant height, bud fly infestation, number of primary branches per plant, number of capsules per plant, 1000 seed weight and seed yield per plant. Thus, plant height and the number of capsules per plant are suitable for direct selection of the genotypes. Correlation study showed the significant and positive correlation of seed yield with flower diameter, number of primary branches per plant, number of capsules per plant, number of seeds per capsule and 1000-seed weight, whereas, days to 50% flowering, days to 50% maturity, plant height and bud fly infestation were found to be significant and negative correlation with seed yield per plant Path coefficient analysis indicated that the number of capsules per plant and flower diameter exhibited high and medium positive direct effect on seed yield, respectively. Hence, flower diameter, number of capsules per plant and bud fly resistance would be utilised for improvement of linseed cultivars.

Keywords: Linseed, Correlation, Path coefficient, Variability, Heritability, Genetic Advance.

INTRODUCTION

Linseed (*Linum usitatissimum* L., 2n = 30) is the third most important *Rabi* oilseed crop after rapeseed and mustard. Linseed is a self-pollinated, oilseed crop which comes under genus *Linum* and family *Linaceae* of the order *Geraniale*. It is commonly known as flax or flaxseed. Each part of the flaxseed crop is utilises, either directly or indirectly. Linseed has approximately 33 to 45 % oil and 24 % protein, both of which are used commercially for a variety of purposes. Linseed oil contains a high amount of unsaturated fatty acids, including oleic acid (16-24%), linoleic acid (18-24%), and linolenic acid (36-50%). Linseed oil is a rich source of ω-3 fatty acid: α-linolenic acid (ALA) and short-chain polyunsaturated fatty acids (PUFA) (Konreddy *et al*., 2022). Approximately 80% of the oil produced is used as a drying oil in the production of stickers, linoleum, oil cloth, patent leather, paints, varnish, printer ink, enamels, tarpaulins, and soaps. The fine grade fibre extracted from the stem is used to make strong yarns, linen fabrics, linen threads, and the coarser grades are used to make strings, canvas bags, and quality papers, etc (Kumari *et al*., 2017).

Despite these nutritional benefits, linseed is the most underutilised oilseed crop in developing countries, where it is mostly grown on marginal land under rainfed conditions. Although, the linseed crop has maintained its increasing productivity trend, while the area are declining gradually, resulting in stagnant production. The lack of improved cultivars to suit the diverse agro-climatic conditions is attributed to the low yield of the linseed crop. Therefore, developing high yielding cultivars becomes the top priority in order to overcome low yield levels (Leelaathi and Mogali 2018).

Studies on genetic variation increase selection possibilities and support the development of superior cultivars. Understanding of genotypic potential for future breeding programs requires a thorough knowledge of the extent of heritable variation in the traits under study. It is crucial to evaluate variability for yield along with its component traits before deciding on a suitable breeding strategy for genetic improvement. The relationship between variables, known as correlation, which helps scientists to choose the most appropriate techniques for genotype selection. A path coefficient is a standardized partial regression coefficient that breaks down a correlation coefficient into components of direct and indirect effects for a set of a priori cause-and-effect relationships. It measures the direct impact of one trait on another trait. Correlation coupled with path coefficient analysis is the best method for estimating the interdependence of important yield components. To determine the direct and indirect effects of seed yield components on seed yield, correlations between yield components and seed yield must be computed. In order to increase linseed productivity and create high yielding improved varieties, these methods are used in the breeding program.

MATERIALS AND METHODS

The present investigation, which included 47 linseed genotypes, was carried out at the Bihar Agricultural College Farm of BAU during *Rabi*, 2019-20. The experiment location is situated at an altitude of 52.73 metres above mean sea level in the Middle Gangetic Plain of Bihar's agro-climatic zone III A, at 25°50' N latitude and 87°19' E longitude. Each genotype was grown in a Three meter long plot using a Randomized Block Design (RBD) with three replications, maintaining a 10 cm plant-to-plant distance. The experiment was conducted in an appropriate environment on loam soil. The analysis of variance for individual characters was performed using the mean values of each plot, as described by Panse and Sukhatme (1967). The genotypic and phenotypic coefficients of variation (GCV and PCV) were calculated using the Burton and Devane (1953) method. Heritability was calculated in the broad sense as a ratio of genotypic variance to phenotypic variance. The expected genetic advance under selection for the various characters was estimated using the method proposed by Johnson *et al.* (1955). The correlation coefficients were calculated to determine the degree of association of various characters with yield and also among the yield components. Fisher (1918) formula was used to calculate the correlation. The direct and indirect effects were estimated using path coefficient analysis, which was proposed by Wright (1921).

RESULTS AND DISCUSSION

Developing high-yielding, superior genotypes by genetic manipulation is the ultimate goal of most of the plant breeding programmes. Linseed is an important oilseed crop cultivated in India and other countries. In this context, the current investigation was undertaken tostudy various genetic parameters, namely, genetic variability, heritability, genetic advance, correlation and path coefficient. The findings of the current investigation has been discussed below.

In this investigation highly significance mean differences were found in the analysis of variance for all the eleven traits under consideration namely, days to 50 per cent flowering, flower diameter (mm), Days to 50% maturity, Plant height(cm), Bud fly infestation (%), Number of primary branches per plant, Number of capsules per plant, Number of seeds per capsule, 1000 Seed weight(g), Oil content (%) and seed yield per plant (g) (Table 1). It indicates that the linseed genotypes chosen for study had significant variability and were appropriate for further analysis.

The findings of genetic variability studies showed that PCV estimates were greater than GCV estimates for all the traits under study (Table 2). It indicates that the existing variation is caused not only by genotypes but also by environmental influences. PCV and GCV values were found to be high for traits such as bud fly infestation, number of capsules per plant, and seed yield per plant. Moreover, plant height (cm), number of primary branches per plant, and 1000 seed weight have moderate PCV and GCV (10-20%) values (g). Similar trends of finding for GCV and PCV were reported by Kumari *et al.* (2017); Upadhyay *et al.* (2019). Low GCV and PCV were estimation for days to 50% flowering, flower diameter (mm), days to 50% maturity, number of seeds per capsule, and oil content. Earlier worker Kaur *et al.* (2018); Dhirhi and Mehta (2019) were supported above findings.

Knowledge of a trait's heritability is an important tool that can be used to select the trait under specific conditions. In the current study, high heritability was observed for all traits except days to 50% maturity (Table 2). Similar findings were reported by Choudhary *et al*. (2017); Meena *et al*. (2018); Singh *et al*. (2019); Shiva *et al.* (2021) for plant height, number of seeds per Capsule, days to 50 % flowering, 1000 seed weight and seed yield per plant. However, high estimate of genetic advance as percentage of the mean was computed for buf fly infestation Followed by the number of capsules per plant, Seed yield per plant, Plant height, number of primary branches per plant, and 1000 seed weight, Number of seeds per capsule, Flower diameter and Days to 50% flowering. These findings were supported by work of earlier workers such as Ahmed (2017); Kumari *et al.* (2017); Shiva *et al*. (2021). This indicates that these traits could be influenced by additive gene effects. Therefore, selection based on these traits would thus be effective. Oil content had a high heritability with a low genetic advance as a percentage of the mean.

Table 1: Analysis of variances for eleven quantitative traits in linseed.

Source of variation	D.F.	Days to 50% flowering	Flower diameter	Days to 50% maturity	Plant height	Bud fly infestation	Number of primary branches	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content	Seed yield per plant
Replication	2	6.156	1.091	12.149	28.702	0.504	0.521	8.041	0.025	0.03	2.115	0.039
Treatments	46	55.209**	10.693**	49.455**	537.304**	94.27**	1.236**	1,046.340**	1.753**	1.983**	9.634**	1.995**
Error	92	3.982	0.244	9.627	11.64	2.759	0.102	26.468	0.164	0.043	1.518	0.074

Table 2: Estimate of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (H), genetic advance (GA) and genetic advance as per cent of mean (GAM) for fourteen quantitative characters in linseed.

Characters	Days to 50% flowering	Flower diameter	Days to 50% maturity	Plant height	Bud fly infestation	Number of primary branches per plant	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content	Seed yield per plant
GCV	5.53	7.82	3.17	19.53	30.06	16.24	25.29	9.03	12.85	4.68	22.68
PCV	6.14	8.09	4.16	20.17	31.39	18.30	26.25	10.34	13.27	5.85	23.96
H	81.09	93.44	57.97	93.77	91.70	78.72	92.78	76.30	93.79	64.06	89.60
GA	7.67	3.72	5.72	26.41	10.90	1.12	36.59	1.31	1.60	2.71	1.56
GAM	10.26	15.57	4.97	38.97	59.30	29.67	50.18	16.25	25.63	7.71	44.23

Correlation coefficient analysis revealed a significant and positive correlation of seed yield per plant with flower diameter, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, and 1000 seed weight at both the genotypic and phenotypic levels (Table 3). So, direct selection for above traits may be beneficial in improving linseed accessions (Table 3). Similar finding was reported by Kumari *et al.* (2017); Patial *et al.* (2018); Meena *et al.* (2018) for primary branches per plant, capsules per plant and Ankit *et al.* (2019) for 1000 seed weight. On the basis of association studies, it can be suggested that the genotypes with higher values for above traits *viz*., flower diameter, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, and 1000 seed weight can be used for improvement of linseed. Bud fly infestation, days to 50% flowering, days to 50% maturity, and plant height, on the other hand, had a significant and negative correlation with seed yield. These results are supported by Kasana *et al.* (2016); Kumari *et al*. (2017). Thus, selecting bud fly resistant genotypes will be advantageous for achieving high seed yield in linseed.

Yield is directly and indirectly influenced by a number of independent traits. So, the relation among different yield contributing traits give better means for the selection. Path coefficient analysis employed for this purpose as it divides correlation into direct and indirect effect. In the present study, path coefficient analysis showed a significant and high positive direct effect of the number of capsules per plant on seed yield in the current study. Similar finding was reported by Patial *et al.* (2018); Meena *et al*. (2018); Shiva *et al.* (2021). Flower diameter had a moderately direct positive effect on seed yield. This result is also consistent with the findings of Kasana *et al.* (2016). However, plant height, number of primary branches per plant, Number of capsules per plant, Number of seeds per capsule, 1000 Seed weight and oil content had a low direct positive effect on seed yield (Table 4). Similar trends of findings is reported by Ibrar *et al.* (2016); Kasana *et al.* (2016); Ankit *et al*. (2019). Hence, desirable improvements may be achieved by selecting genotypes with a higher number of capsules per plant, a higher number of seeds per capsule, and a higher 1000 seed weight. However, days to 50% flowering, days to 50% maturity, and bud fly infestation all had a negative direct effect on seed yield. This is consistent with the results of Sahu *et al.* (2016); Kumari *et al.* (2017), who found a negative direct effect for above traits.

In the present study number of seeds per capsule and 1000 seed weight found to have highest positive indirect effect on seed yield via the number of capsules per plant. All these indirect effects resulted in a positive correlation between respective characters and seed yield per plant, which is consistent with the findings of Kumari *et al*. (2017); Kasana *et al.* (2016), who reported indirect effects of 1000 seed weight on seed yield. These traits also played an important role in the improve of linseed genotypes for seed yield. Therefore, these characters should be considered as important selection criteria for improving seed yield. Low residual effects (R^2= 0.325) has been suggested that there were no significant characters left in the present study.

Table 3: Phenotypic and genotypic correlation coefficient between pairs of fourteen quantitative characters in linseed.

	Flower diameter	Days to 50% maturity	Plant height	Bud fly infestation	Primary branches per plant	Capsules per plant	Seeds per capsule	1000-seed weight	Oil content	Seed yield per plant
Days to 50% flowering	0.005 **0.026**	0.372** **0.562**	0.187* **0.206**	0.101 **0.120**	0.236** **0.283**	-0.027 **0.062**	0.022 **0.069**	-0.159 **-0.177**	-0.217** **-0.310**	-0.226** **-0.295**
Flower diameter		0.192* **0.270**	0.120 **0.127**	-0.169* **-0.186**	-0.066 **-0.082**	0.012 **0.004**	0.145 **0.133**	0.374** **0.396**	0.203* **0.245**	0.249** **0.279**
Days to 50% maturity			0.265** **0.360**	0.291** **0.350**	-0.181* **-0.241**	-0.198* **-0.275**	-0.080 **-0.084**	-0.108 **-0.153**	-0.033 **-0.035**	-0.318** **-0.389**
Plant height				0.114 **0.108**	-0.248** **-0.283**	-0.302** **-0.328**	-0.304** **-0.359**	-0.271** **-0.293**	-0.060 **-0.089**	-0.310** **-0.348**
Bud fly infestation					-0.124 **-0.184**	-0.238** **-0.255**	0.086 **0.113**	-0.071 **-0.079**	-0.116 **-0.192**	-0.309** **-0.337**
Primary branches per plant						0.146 **0.187***	0.288** **0.385**	-0.137 **-0.161**	-0.113 **-0.174**	0.189* **0.206**
Capsules per plant							0.269** **0.326**	0.240** **0.265**	-0.016 **0.013**	0.712** **0.790**
Seeds per capsule								0.217** **0.262**	-0.168* **-0.261**	0.376** **0.457**
1000-seed weight									0.294** **0.368**	0.349** **0.382**
Oil content										0.104 **0.131**

Note: *, ** significant at 5% and 1 % level of probability, respectively. Genotypic correlation coefficients are shown in bold.

Table 4: Direct (digonal) and indirect phenotypic effect of different characters on seed yield in linseed.

Characters	Days to 50% flowering	Flower diameter	Days to 50% maturity	Plant height	Bud fly infestation	Primary branches per plant	Capsules per plant	Seeds per capsule	1000-seed weight	Oil content	Seed yield per plant
Days to 50% flowering	**-0.166**	0.001	-0.046	0.001	-0.007	0.021	-0.016	0.003	-0.008	-0.010	-0.226
Flower diameter	-0.001	**0.210**	-0.023	0.000	0.012	-0.006	0.007	0.023	0.018	0.009	0.249
Days to 50% maturity	-0.062	0.040	**-0.123**	0.001	-0.021	-0.016	-0.119	-0.013	-0.005	-0.002	-0.318
Plant height	-0.031	0.025	-0.032	**0.004**	-0.008	-0.022	-0.181	-0.048	-0.013	-0.003	-0.310
Bud fly infestation	-0.017	-0.035	-0.036	0.000	**-0.072**	-0.011	-0.143	0.013	-0.003	-0.005	-0.309
Primary branches per plant	-0.039	-0.014	0.022	-0.001	0.009	**0.090**	0.088	0.045	-0.007	-0.005	0.189
Number of capsules per plant	0.005	0.002	0.024	-0.001	0.017	0.013	**0.599**	0.042	0.012	-0.001	0.712
Number of seeds per capsule	-0.004	0.031	0.010	-0.001	-0.006	0.026	0.161	**0.157**	0.010	-0.008	0.376
1000-seed weight	0.026	0.078	0.013	-0.001	0.005	-0.012	0.144	0.034	**0.048**	0.013	0.349
Oil content	0.036	0.043	0.004	0.000	0.008	-0.010	-0.010	-0.026	0.014	**0.046**	0.104

CONCLUSION AND FUTURE SCOPE

The current study found adequate genetic variability within and among genotypes, indicating the possibility of further genetic enhancement in linseed.Plant height and the number of capsules per plant are two traits with high heritability and genetic advance that are suitable for selection as they have direct positive effects at phenotypic and genotypic level. Furthermore, According to a study that used correlation and path coefficients, the number of capsules per plant showed a significant direct correlation with seed yield. As a result, this trait may be prioritised in the improvement programme to genetic yield potential in linseed. As a result, improve genetic variability can be successfully used to develop new linseed cultivars.

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Conflict of Interest. None.

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