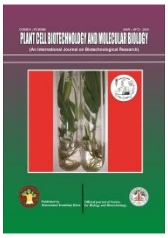

Plant Cell Biotechnology and Molecular Biology

Volume 25, Issue 3-4, Page 54-61, 2024; Article no.PCBMB.12040
ISSN: 0972-2025

Estimates Indirect Selection Parameters Through Correlation and Path Analysis in Linseed (*Linum usitatissimum* L.)

Ankit [a], Shivendra Pratap Singh [b*], Sonali Ambadas Aware [c], Ankaj Tiwari [d], Seetal B. Sindha [e], Sushma Raj Chellem [f], Ramnivas [g] and Dharm Veer Singh [h]

[a] Department of Genetics and Plant Breeding, SVPUA&T, Meerut, Uttar Pradesh, India.
[b] Department of Plant Breeding, Krishi Vigyan Kendra, Belipar, Gorakhpur, Uttar Pradesh, India.
[c] Department of Genetics and Plant Breeding, V.N.M.K.V., Parbhani, India.
[d] Department of Genetics and Plant Breeding, A. N. D. U. A. & T., Kumarganj, Ayodhya, Uttar Pradesh, India.
[e] Department of Biotechnology, Sardar Patel Institute of Applied Science, Sardar Patel University, Gujarat, India.
[f] Department of Genetics and Plant Breeding, Koneru Lakshmaish (Deemed to University), Andhra Pradesh, India.
[g] Maharaja Surajmal Agriculture College Rahinpur, Uchchain Bharatpur, Rajasthan, India.
[h] Department of Genetics and Plant Breeding, B.U.A. & T., Banda, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.56557/PCBMB/2024/v25i3-48652

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.ikprress.org/review-history/12040

Original Research Article

Received: 06/02/2024
Accepted: 10/04/2024
Published: 20/04/2024

**Corresponding author;*

ABSTRACT

An important rabi oilseed crop, linseed (*Linum usitatissimum* L.) has diploid chromosomal number 2n=30. According to Tadesse et al. (2009), L. usitatissimum is a single species in the Linaceae family of commercial value. According to correlation coefficient analyses, there is a strong intrinsic inherent between the different qualities because the genotypic correlation values were larger than the equivalent phenotypic correlation values. The biological yield per plant, 1000 seed weight, and seed yield per plant all shown a highly significant and favorable correlation. It suggested that grain yield might be enhanced under selection by enhancing these features. The results of the genotypic path coefficient analysis of seed yield and its contributing characters showed that harvest index, days to 50% flowering, number of secondary branches per plant, and number of primary branches per plant were the next most important factors that positively influenced grain yield per plant. These findings suggested that selection based on these traits could increase yield. The biological yield per plant, harvest index, number of primary branches per plant, days to maturity, and days to 50% flowering were found to have the greatest positive direct effects on seed yield per plant based on phenotypic path coefficient analysis of grain yield and its contributing features.

Keywords: Genotypic correlation; phenotypic correlation; path coefficient direct; path coefficient indirect.

1. INTRODUCTION

An important rabi oilseed crop, linseed (*Linum usitatissimum* L.) has diploid chromosomal number 2n=30. The genus Linum, which includes more than 200 species, is a member of the linaceae family. Cultivated linseed, among them *Linum usitatissimum* L., is significant economically. Two regions were identified by Vavilov [1] as centers of origin. One focuses on seed varieties in South Western Asia, while the other addresses fiber types in Mediterranean nations. Because of its extensive industrial utility, linseed has a place in the Indian economy. However, the average productivity of linseed across the country is rather poor. However, India (4266 kg/ha) is significantly less productive than the United Kingdom (17778 kg/ha), France (19405 kg/ha), Tunisia (18765 kg/ha), Switzerland (21185 kg/ha), and New Zealand (13069 kg/ ha) (Faostat, 2016).

The area (293000 ha), productivity (4266 kg/ha), and production (125000 tons) of linseed in India. Madhya Pradesh (110.4 thousand ha), Maharashtra (31.0 thousand ha), Chhattisgarh (26.2 thousand ha), Uttar Pradesh (26.0 thousand ha), Jharkhand (25.5 thousand ha), Orissa (22.9 thousand ha), and Bihar (18.7 thousand ha) are the five states that grow the most lentils out of the fifteen. The yearly productivity in Uttar Pradesh is 560 kg/ha [2]. Many Asian, African, European, and American nations plant linseed. It has been cultivated in India from ancient times. The states that cultivate the most linseed in the nation include Madhya Pradesh, Chhattisgarh, Maharashtra, Uttar Pradesh, Orissa, and Jharkhand, which combined account for more than 83 percent of the total area planted with linseed. For common flax, the growing season lasts 90–120 days [3,4,5]. Being a crop for the chilly season, it needs temperatures that are between moderate and cool for it to grow. It grows well in regions with annual rainfall of 48–76 cm and is reasonably resistant to drought. During the growth season, heavy rains and overcast skies are particularly detrimental to the crop. When it reaches maturity, it needs high temperatures, little moisture, and generally dry conditions [6,7].

Linseed, which has an oil content of 33–45%, is mostly used in the agro-based sectors to make paint, varnish, and other products. Linolenic acid, in particular, is abundant in unsaturated fatty acids [8,9]. All parts of the linseed plant are used for commercial purposes, either unprocessed or processed. On a modest scale, the seed and its oil are consumed by humans in the form of bagels, baked and fried goods, and full meals made from flax seeds [10,11,12]. Therefore, when developing the selection criteria, it is crucial to investigate the correlation between yield and its constituent parts. When two desirable qualities have a positive association, plant breeders have an easier time simultaneously improving both traits. But a mere correlation cannot reveal the underlying biological relationship between these features and seed output. The standardized partial regression analysis known as the path coefficient analysis, which was developed by Wright [13,14] and described by Dewey and Lu [15], enables the partitioning of the correlation coefficient into the direct and indirect effects of different traits (independent variables) towards the dependent variable (seed yield). This aids in the assessment of the cause-and-effect relationship and efficient selection. The genuine nature of the association between a character and seed yield is shown if the correlation is the result of the character's direct influence. So, in order to increase seed results, selection can be focused on this trait. In the case that the correlation results from the character's indirect influence on a different component trait, the later trait that the indirect effect is exerted through would be the basis for selection. A character's phenotypic values, which are influenced by both the environment and heritable genotypes, are typically the basis for selection.

2. MATERIALS AND METHODS

The present experiment was carried out during Rabi 2016-17, at Crop Research Centre SVPUA&T Meerut (UP). The site of experiment is at an elevation of about 297 meter above mean sea level with 29º 01'N latitude and 77 º 75' E longitudes, representing the North Western Plain Zone. The experimental material comprised of forty diverse genotypes of linseed, was obtained from Project Coordinating Unit (Linseed), CSAUA&T, Kanpur.

3. RESULTS AND DISCUSSION

In the present investigation, To determine the degree of relationship between eleven traits, all potential genotypic and phenotypic correlation coefficients were evaluated (Tables 1 & 2). When the specific characteristic under selection has low heritability or is difficult to measure accurately, indirect selection is seen to be a more suitable and effective strategy than direct selection. In these situations, the selected breeding program must be justified using a few simple assessment criteria.

The main objective of correlation studies is to determine which features are suitable for indirect selection, as selection for one trait influences other traits [16] and alters the pattern of variation (Waddington and Robertson 1966). Breeders frequently benefit from the establishment of a link between readily detectable traits and quantitative characteristics that are being considered, according to Joshi et al., [17]. Grafius [18] proposed that since yield is the result of multiplicative interactions between the multiple yield components, selection for yield alone would not be beneficial. Therefore, it would be useful to identify key yield components and learn about their relationships in order to produce effective genotypes that increase productivity. The genetic connections were comparable in direction and somewhat greater in amplitude than the phenotypic correlate in every case that was studied. It was inferred indirectly that the main source of the substantial phenotypic relationship between qualities was genetic, possibly as a result of linkage and pleiotropic effects. Plant height, 1000 seed weight, biological yield per plant, number of primary branches per plant, and harvest index all showed a significant positive correlation with seed yield per plant. There was also a significant positive correlation with the number of capsules per plant and the number of secondary branches per plant. It suggested that under selection, grain production could be increased by enhancing these features. Many of the scientists reported same type of result and suggestions viz; Rama Kant et al. [18], Nagaraja et al. [19], Jain et al. [20], Rajanna et al. [21], Chauhan et al. [21], Patel et al. [22] , Dash et al. [23] , Naik et al. [24] , Gul et al. [25] , [26,27] and Kumar et al. (2017). The remaining eight features were either contributing or independent variables in the current study, with grain yield serving as the dependent variable (Tables 3 and 4). The idea of path coefficient analysis was created by Sewall Wright in 1921 [29] as a method to separate the observed correlation coefficient into the direct and indirect impacts of the independent variable on the dependent variable. Path analysis is not the same as simple correlation; the former measures only the mutual association, ignoring the causation, while the latter highlights the causes and their relative importance. Biological yield per plant had the highest positive direct effect on grain yield per plant, followed by harvest index, according to a genotypic path coefficient study of grain yield and its contributing features. This suggested that yield improvement may be accomplished by by selection based on these traits. Many of the scientists reported same type of result and suggestions viz; Nagaraja et al. [19], Dandigadasar et al. [28], Rajanna et al. [21], Patel et al. [22] , Dash et al. [23], Sahu et al. [26] and Kumar et al. (2017). Examined was the contribution of the characteristics through other traits to grain yield. Significant indirect impacts are explored here. The indirect positive effect on grain yield was contributed by days until 50% of the plants were in flower; the indirect positive effect was contributed by days

Table 1. Estimates of genotypic (G) correlation coefficients among eleven characters in linseed (*Linum usitatissimum* L.).

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Capsules per plant	Seeds per capsule	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	G	**1.0000**	0.9024	0.1312	-0.0723	0.2876	0.2114	0.0930	-0.2758	-0.2110	-0.3550	-0.3367
Days to maturity	G		**1.0000**	0.0956	-0.0443	0.3025	0.1628	0.1433	-0.3249	-0.3239	-0.4893	-0.4192
Plant height (cm)	G			**1.0000**	-0.1074	0.4452	0.4327	-0.2965	0.3988	-0.0818	0.1349	0.3171
Primary branches per plant	G				**1.0000**	-0.0500	0.0159	0.2230	0.2497	-0.0957	-0.0435	0.2352
Secondary branches per plant	G					**1.0000**	0.6786	-0.4620	0.1723	0.0002	-0.1845	0.1625
Capsules per plant	G						**1.0000**	-0.3241	0.2774	-0.2477	-0.2301	0.1784
Seeds per capsule	G							**1.0000**	-0.1416	-0.1851	0.1132	-0.1978
Biological yield per plant (g)	G								**1.0000**	-0.1008	0.4542	0.9419
Harvest index (%)	G									**1.0000**	0.1582	0.2313
1000 seed weight (g)	G										**1.0000**	0.4585
Seed yield per plant (g)	G											**1.0000**

Table 2. correlation coefficients among eleven characters in linseed (*Linum usitatissimum* L.).

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Capsules per plant	Seeds per capsule	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	P	**1.0000**	0.6457**	0.1242	-0.0710	0.1809*	0.1678	0.1035	-0.2440**	-0.1711	-0.3335**	-0.2965**
Days to maturity	P		**1.0000**	0.1169	-0.0666	0.1286	0.1208	0.1404	-0.2008*	-0.1385	-0.3254**	-0.2375**
Plant height (cm)	P			**1.0000**	-0.1570	0.1627	0.2730**	-0.1448	0.2386**	-0.0340	0.1016	0.2015*
Primary branches per plant	P				**1.0000**	0.1835*	0.1129	0.1795*	0.2898**	-0.0551	-0.0406	0.2682**
Secondary branches per plant	P					**1.0000**	0.5992**	-0.1706	0.3049**	0.0280	-0.1310	0.2773**
Capsules per plant	P						**1.0000**	-0.2402**	0.3412**	-0.1669	-0.2097*	0.2474**
Seeds per capsule	P							**1.0000**	-0.0359	-0.1399	0.1030	-0.0931
Biological yield per plant (g)	P								**1.0000**	-0.0796	0.3955**	0.9237**
Harvest index (%)	P									**1.0000**	0.1098	0.2856**
1000 seed weight (g)	P										**1.0000**	0.3979**
Seed yield per plant (g)	P											**1.0000**

**, ** significant at 5% and 1% level, respectivel*

Table 3. Estimates of genotypic path coefficient showing direct and indirect effects of component characters on seed yield at genotypic level in linseed (*Linum usitatissimum* L.).

Characters		Days to 50% Flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Capsules per plant	Seeds per capsule	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Correlation with seed yield (g)
Days to 50%flowering	G	**0.0353**	0.0318	0.0046	-0.0026	0.0101	0.0075	0.0033	-0.0097	-0.0074	-0.0125	-0.3367
Days to maturity	G	-0.0335	**-0.0371**	-0.0035	0.0016	-0.0112	-0.0060	-0.0053	0.0121	0.0120	0.0181	-0.4192
Plant height (cm)	G	-0.0070	-0.0051	**-0.0532**	0.0057	-0.0237	-0.0230	0.0158	-0.0212	0.0044	-0.0072	0.3171
Primary branches per plant	G	-0.0003	-0.0002	-0.0005	**0.0047**	-0.0002	0.0001	0.0010	0.0012	-0.0005	-0.0002	0.2352
Secondary branches per plant	G	0.0059	0.0062	0.0091	-0.0010	**0.0205**	0.0139	-0.0095	0.0035	0.0000	-0.0038	0.1625
Capsules per plant	G	-0.0066	-0.0051	-0.0135	-0.0005	-0.0212	**-0.0313**	0.0101	-0.0087	0.0078	0.0072	0.1784
Seeds per capsule	G	-0.0001	-0.0001	0.0002	-0.0001	0.0003	0.0002	**-0.0006**	0.0001	0.0001	-0.0001	-0.1978
Biological yield per plant (g)	G	-0.2828	-0.3331	0.4089	0.2561	0.1767	0.2844	-0.1452	**1.0253**	-0.1034	0.4656	0.9419
Harvest index (%)	G	-0.0692	-0.1062	-0.0268	-0.0314	0.0001	-0.0812	-0.0607	-0.0331	**0.3279**	0.0519	0.2313
1000 seed weight (g)	G	0.0215	0.0296	-0.0082	0.0026	0.0112	0.0139	-0.0069	-0.0275	-0.0096	**-0.0606**	0.4585

Residual Effect = 0.0224
Bold values indicate direct effects

Table 4. Estimates phenotypic of path coefficient showing direct and indirect effects of component characters on seed yield at phenotypic level in linseed (*Linum usitatissimum* L.).

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Secondary branches per plant	Capsules per plant	Seeds per capsule	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Correlation with seed yield (g)
Days to 50%flowering	P	**0.0010**	0.0007	0.0001	-0.0001	0.0002	0.0002	0.0001	-0.0003	-0.0002	-0.0003	-0.2965**
Days to maturity	P	0.0063	**0.0097**	0.0011	-0.0006	0.0012	0.0012	0.0014	-0.0019	-0.0013	-0.0032	-0.2375**
Plant height (cm)	P	-0.0010	-0.0010	**-0.0084**	0.0013	-0.0014	-0.0023	0.0012	-0.0020	0.0003	-0.0009	0.2015*
Primary branches per plant	P	-0.0009	-0.0009	-0.0021	**0.0133**	0.0024	0.0015	0.0024	0.0039	-0.0007	-0.0005	0.2682**
Secondary branches per plant	P	-0.0053	-0.0038	-0.0048	-0.0054	**-0.0295**	-0.0177	0.0050	-0.0090	-0.0008	0.0039	0.2773**
Capsules per plant	P	-0.0034	-0.0025	-0.0056	-0.0023	-0.0122	**-0.0204**	0.0049	-0.0070	0.0034	0.0043	0.2474**
Seeds per capsule	P	-0.0019	-0.0026	0.0027	-0.0034	0.0032	0.0045	**-0.0188**	0.0007	0.0026	-0.0019	-0.0931
Biological yield per plant (g)	P	-0.2392	-0.1969	0.2340	0.2842	0.2990	0.3346	-0.0352	**0.9807**	-0.0781	0.3878	0.9237**
Harvest index (%)	P	-0.0623	-0.0504	-0.0124	-0.0201	0.0102	-0.0607	-0.0509	-0.0290	**0.3639**	0.0400	0.2856**
1000 seed weight (g)	P	0.0104	0.0101	-0.0032	0.0013	0.0041	0.0065	-0.0032	-0.0123	-0.0034	**-0.0312**	0.3979**

Residual Effect = 0.1218
Bold values indicate direct effects
**, ** significant at 5% and 1% level, respectively*

until the plants reached maturity; the plant height contributed the indirect positive effect on the grain yield through biological yield per plant; the primary and secondary branches of each plant contributed the indirect positive and indirect positive effects on the grain yield through biological yield per plant; the capsules per plant contributed the indirect positive effect on the grain yield through biological yield per plant; the seeds per capsule demonstrated the indirect positive effect on the grain yield through plant height; days to maturity via biological yield per plant; harvest index demonstrated the indirect positive effect on grain yield through days to maturity; 1000 seed weight demonstrated the indirect positive effect on grain yield through biological yield and harvest index. Rama Kant et al. [18], Nagaraja et al. [19] and Jain et al. [12] also reported such types of findings. Following harvest index, biological yield per plant had the highest positive direct effect on seed yield per plant according to phenotypic path coefficient analysis of grain yield and its contributing features. Numerous scientists reported similar findings and recommendations viz; Rai et al. [29], Rama Kant et al. [21], Nagaraja et al. [19], Rajanna et al. [20] , Chauhan et al. [30] , Patel et al. [18] , Dash et al. [23] , Sahu et al. [26] and Kumar et al. (2017). Plant height, the number of main and secondary branches on each plant, the number of capsules on each plant, and the weight of 1000 seeds each plant all had a favourable indirect impact on grain yield through biological yield per plant. Plant height, the number of main and secondary branches on each plant, the number of capsules on each plant, and the weight of 1000 seeds each plant all had a favourable indirect impact on grain yield through biological yield per plant. Rama Kant et al. [18], Nagaraja et al. [16] and Jain et al. [12] also observed such types of findings. Based on over all findings of the path analysis, characteristics that have a strong positive direct impact on seed yield, such as biological yield, harvest index, and number of capsules per plant, should be prioritized throughout the selection process in order to maximize yield. Selection could also prioritize those features that increased seed yield through interactions with other traits.

4. SUMMARY AND CONCLUSION

The correlation coefficient was estimated at the genotypic and phenotypic levels in order to examine the relationships between different traits and their relative importance in the selection program. The results are shown in Table 1. Their practical implications are well-founded in the degree of correlation with their corresponding phenotypic values. In general, there was a slight increase in magnitude and similar sign between the genotypic and phenotypic correlations. Here, phenotypic correlation values are used to explain the results.

Table 2 revealed a thorough analysis of the highly significant and positive correlations between various characteristics, including the number of days to 50% flowering and the days to maturity; the number of secondary branches and capsules per plant; the days to maturity with seeds per capsule; the number of secondary branches and capsules per plant; the plant height with capsules per plant; the biological yield per plant; and the seed yield per plant; the number of primary branches per plant with biological yield per plant; the seed yield per plant; the number of secondary branches per plant and seeds per capsule; the number of secondary branches per plant with capsules per plant; the biological yield per plant and seed yield per plant; seeds per capsule with 1000 seed weight, biological yield per plant with seed yield per plant, and 1000 seed weight, harvest index with seed yield per plant, and 1000 seed weight, 1000 seed weight with seed yield per plant. Seed yield per plant showed highly significant and positive association with biological yield per plant and 1000 seed weight.

There were, however, noticed significant negative correlations found between the following: the number of days until 50% flowering and the 1000 seed weight; the number of seeds per plant and the 1000 seed weight; the number of days until maturity and the 1000 seed weight; and the number of capsules per plant and the 1000 seed weight. There were no significant correlations found between any of the other study characters. The direct and indirect effects of the current investigation are shown in Table 3. Following harvest index, days to 50% flowering, number of secondary branches per plant, and number of primary branches per plant, genotypic path coefficient analysis of seed yield and its contributing characters showed that biological yield per plant had the largest positive direct effect on grain yield per plant.

The remaining characters had small and unfavourable direct effects on grain yield per plant. Days to 50% flowering contributed an indirect positive effect on grain yield through 1000 seed weight; Days to Maturity contributed an indirect positive effect on grain yield per plant through 1000 seed weight; Plant height contributed an indirect positive effect on grain yield per plant through biological yield per plant; Primary Branch per Plant: Provided an indirect positive effect on grain yield through biological yield per plant, Secondary Branch per Plant. Provided an indirect positive effect on grain yield through biological yield per plant. capsules per plant. Provided an indirect positive effect on grain yield through biological yield per plant. Seeds per capsule showed an indirect positive effect on grain yield via plant height, biological yield per plant contributed the indirect positive effect on grain yield via days to maturity, harvest index showed the indirect positive effect on grain yield via days to maturity and 1000 seed weight showed the indirect positive effect on grain yield via biological yield per plant. Phenotypic path coefficient analysis (Table 4) of seed yield and its contributing characters revealed that biological yield per plant had the highest positive direct effect on seed yield per plant followed by harvest index, number of primary branches per plant, days to maturity and days to 50% flowering. The direct effects of the remaining characters on seed yield were negative and of low magnitude. Days to 50% flowering contributed the indirect positive effect on grain yield via 1000 seed weight, days to maturity showed the indirect positive effect on grain yield via 1000 seed weight, plant height contributed the indirect positive effect on grain yield via biological yield per plant, primary branches per plant contributed the indirect positive effect on grain yield via biological yield per plant, secondary branches per plant contributed the indirect positive effect on grain yield via biological yield per plant, capsules per plant contributed the indirect positive effect on grain yield via biological yield per plant, seeds per capsule showed the indirect positive effect on grain yield via secondary branches per plant, biological yield per plant contributed the indirect positive effect on grain yield via primary branches per plant, harvest index contributed the indirect positive effect on grain yield via capsules per plant and 1000 seed weight showed the indirect positive effect on grain yield via biological yield per plant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Vavilov NI. Studies on the origin of cultivated plant. Bull Bot. and Pl. Breed. 1926;16:39-145.
2. Anonymous. Area, production and productivity of linseed. Directorate of Economics and Statistics, Ministry of Agriculture and farmers Welfare. 2015; 211212.
3. Allard RW. Principles of plant breeding. John Willy and Sons, Inc. New York; 1960.
4. FAOSTAT. Area, production and productivity of linseed in the world; 2018.
5. Fisher RA. The correlations between relatives on the supposition of Mendelian inheritance. Trans. Yoj. Soc. Edin. 1918; 52:399-433.
6. Galton F. Correlation and their management of child head from antropometric data, Proc. Roy. Soc. 1888; 45:35-44.
7. Kumar N, Paul S, Patial R. Assessment of genetic variability, heritability and genetic advance for seed yield and its attributes in linseed (*Linum usitatissimum* L.). Plant Arch. 2015;15:863-867.
8. Khan ML, Sharif M, Sarwar M, Sameea, Ameen M. Chemical composition of different varieties of linseed. Pak. Vet. J. 2010;30(2):79-82.
9. Grafius JE. Components of yield in oat-a geometrical interpretation. Agron. J. 1956; 48:419-423.
10. Rao CR. Advance statistical methods in biometrical research edt. I. J Willey and Sons, New York; 1952.
11. Searle SR. Phenotypic, genotypic and environmental correlations. Biometrics. 1961;47:474-480.
12. Ward JH Jr. Hierarchical grouping to optimize an objective function. J American Stat. Asso. 1963;48:236- 244.
13. Wright S. Correlation and causation. J Agric. Res. 1921;20:557-587.
14. Wright S. Theory of path coefficient and regression; alternative or complementary concepts. Biometrics. 1960;16:189-202.
15. Dewey D, Lu KH. A correlation and path-coefficient analysis of components of crested heat grass seed production. Agron. J. 1959;51:515-518.
16. Singh SP. Variability in linseed under rainfed condition. Madras Agri. J. 1984; 71(4):255-256.
17. Joshi AB, Dhawan NL. Genetic improvement of yield with special

reference to self-fertilizing crops. Ind. J Gen. 1986;26A:101-113.

18. Rama Kant, Chauhan MP, Srivastava RK, Maurya KN. Correlation and path coefficient analysis of seed yield and yield components of linseed (*Linum usitatissimum* L.). Hind Agri-Horticultural Society, Muzaffarnagar, India. Int. J Plant Sci. 2008;3(2):323-325.
19. Nagaraja TE, Ajit KR, Golasangi BS. Genetic variability, correlation and path analysis in linseed. Journal of Maharashtra Agricultural Universities, College of Agriculture, Pune, India J Mah. Agri. Uni. 2009;34(3):282-285.
20. Jain RJ. Correlation study of flowering performance and flowering pattern with the yield in (*Linum usitatissimum* L.). African J Plant Sci. 2011;5(3):146-151.
21. Rajanna B, Biradar SA, Ajit K. Correlation and path coefficient analysis in linseed (*Linum usitatissimum* L). National Environmentalists Association, Jharkhand, India, The Bio scan. 2014;9(4):1625-1628.
22. Patel DD, Mishra SP, Moitra PK. Genetic studies for seed yield and its components in linseed (*Linum usitatissimum* L.). Green Farming. 2015;6(4):696- 699.
23. Naik BS, Dash J, Mohapatra UB. Path-coefficient analysis of seed yield and its components in linseed (*Linum usitatissimum* L.). A review. Int. J Ad. Res. 2016;4(3):1571-1579.
24. Dash J, Naik BS, Mohapatra UB. Variability, correlation and path coefficient analysis in linseed (*Linum usitatissimum* L.) under late sown conditions in the north central plateau zone of Odisha in India. Int. J Ad. Res. 2016;4(1):799-811.
25. Gul S, Rajper AA, Kalhorol FA, Kalhoro SA, Ali A, Shah FA. Screening Selected Linseed (*Linum usitatissimum* L.) Genotypes for Yield Performance in Sindh, Pakistan. Natural Sci. 2016;8:53-65.
26. Sahu G, Mishra SP, Mishra VK, Sahu T, Solanki RS. Correlation and path analysis in linseed (*Linumu sitatissimum* L.) genotypes under rainfed condition. Envirt. & Eco. 2016;34(1A):288-291.
27. Tadesse T, Singh H, Weyessa B. Genetic divergence in linseed germplasm. J Innov. Dev. Strategy. 2009;3(2):13-20.
28. Dandigadasar B, Tattimani M, Danaraddi CS, Biradar SB, Dandagi MR. Genetic variability, correlation and path analysis in linseed (*Linum usitatissimum* L.). Asian J Bio Sci. 2012;6(2):218-222.
29. Rai M, Kerkhi SA, Naqvi PA, Pandey S, Vashishtha AK. Path analysis for quality components in linseed (*Linum usitatissimum* L). Ind. J Gen. & Pb. 1993; 53(4):381-386.
30. Chauhan MP, Kumar S, Kumar B, Kumar S. Character association analysis in linseed (*Linum usitatissimum* L.). Res. Environ. Life Sci. 2015;8(3):535-537.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.ikprress.org/review-history/12040