RESEARCH ARTICLE Agricultural Science Digest, Volume 46 Issue 2: 220-225 (April 2026)

Genetic Variability, Correlation Coefficient and Path Coefficient Analysis among *Perilla frutescens* (L.) Britton Germplasm for Seed Oil Yield Related Traits in Uttarakhand, India

Suman Khanduri[1], Subhdara Khankriyal[1], Neha Kumari[1], Maneesha Singh[1]

10.18805/ag.D-6267

ABSTRACT

Background: *Perilla* [*Perilla frutescens* (L.) Britton] commonly known as Bhangjeera, belongs to family Lamiaceae, is an annual plant contains significant phyto-constituents. This is traditionally used as an herbal medicine to treat various disorders. Despite the *Perilla's* huge potential, no concerted attempts have been undertaken to diversify for selection of parents in genetic improvement programme both globally and in our country.

Methods: The experiment was arranged in a Latin square design with three replications on the experimental farm. Data were collected from five randomly selected plants in each plot, excluding border plants. The mean values were analyzed statistically to determine the analysis of variance for all the traits to decipher the nature and magnitude of genetic variability and other genetic parameters in *Perilla.*

Result: The studies shows significant variation among the studied genotypes for all characters. Among the studied germplasm, PF 7 was found to be superior for most of oil yielding related traits followed by PF4 and PF2. All characters showed high heritability accompanied by low to high genetic advance as percent of mean. These characters showed medium to high GCV and PCV. Genotypic correlation co-efficient were found to be higher than their corresponding phenotypic ones. Path coefficient analysis revealed positive direct effect of plant height, length of petiole, leaf breath, stem girth, length of inflorescence and total phenolic content on seed oil yield. The direct selection for these traits will be beneficial in yield improvement program. Therefore, it was suggested that tall and bushy plants with thick stem with long inflorescence are likely to produce high seed oil yield with unsaturated fatty acids, beneficial for human health.

Key words: Correlation coefficient, Genetic variability, Heritability, Lamiaceae, Oil yield, Path analysis, *Perilla*.

INTRODUCTION

Perilla [*Perilla frutescens* (L.) Britton] commonly known as Bhangjeera, family Lamiaceae is an annual plant, found in China, Korea, Japan, the Himalayan regions of India and Nepal (Bachheti *et al*., 2014). The plant contains significant phytochemicals, including rosmarinic acid, luteolin, quercetin, catechin, caffeic acid and ferulic acid. *Perilla* has been traditionally used as an herbal medicine to treat various conditions, such as depression, anxiety, tumors, cough, oxidative stress, allergies, intoxication, intestinal disorders with several biological potential (Saklani *et al*., 2011; Ueda *et al*., 2002; Takano *et al*., 2004; Khanduri *et al*., 2024; Singh *et al*., 2021; Rongsensusang *et al.,* 2020). In modern days, this plant finds importance for its nutritious cooking seed oil as it contains about 64% linolenic acid, an omega-3 fatty acid (Shin *et al*., 1994; Gwari *et al*., 2015; Engtipi and Raju (2022). Despite the *Perilla's* huge potential, no concerted attempts have been undertaken to diversify it and boost its growth and yield both globally and in our country.

Success in any breeding program relies on the effective management and utilization of the population. It is pertinent to decipher the nature and magnitude of genetic variability and other genetic parameters in the indigenous landraces. Estimation of genetic divergence among available landraces of *Perilla* could provide a rational basis for selection of parents in genetic improvement programme stressed that correlations among progenies should be good indicators of linkage or, pleiotropism within an elite gene pool (Ansari *et al*., 2019 and Sampson, 1971). Association analysis is necessary to understand the relationship between traits and the potential for indirect selection. Path coefficient analysis can provide information on the direct and

[1]Department of Botany, School of Basic and Applied Sciences, Shri Guru Ram Rai University, Patel Nagar, Dehradun-248 001, Uttarakhand, India.

Corresponding Author: Maneesha Singh, Department of Botany, School of Basic and Applied Sciences, Shri Guru Ram Rai University, Patel Nagar, Dehradun-248 001, Uttarakhand, India.
Email: singhmaneesha2@gmail.com
ORCIDs: https://orcid.org/0009-0009-5321-1892; https://orcid.org/0009-0002-2048-1107; https://orcid.org/0009-0001-4031-7876; https://orcid.org/0000-0002-5266-9692

How to cite this article: Khanduri, S., Khankriyal, S., Kumari, N. and Singh, M. (2026). Genetic Variability, Correlation Coefficient and Path Coefficient Analysis among *Perilla frutescens* (L.) Britton Germplasm for Seed Oil Yield Related Traits in Uttarakhand, India. *Agricultural Science Digest.* **46(2):** 220-225. doi: 10.18805/ag.D-6267.

Submitted: 16-12-2024 **Accepted:** 27-02-2025 **Online:** 06-05-2025

indirect effects of specific traits on others and ultimately on yield (Bhakal *et al*., 2017; Bhor *et al*., 2020). This study was conducted to gather information on variability, heritability, genetic advance, trait associations and path coefficients in promising *Perilla* genotypes collected from different region of Uttarakhand, India.

MATERIALS AND METHODS

Material

This study was conducted during the *Kharif* season in 2021-2023 using 10 germplasm collected from Garhwal and Kumaun regions of Uttarakhand.

Methodology

The experiment was conducted in a Latin square design with three replications on the experimental farm of Shri Guru Ram Rai University, Dehradun. Seeds were sown in June at a depth of 1-1.5 cm using line sowing. All standard cultural practices were followed to ensure a good crop. Data were collected from five randomly selected plants in each plot, excluding border plants.

Statistical data analysis

All measured parameters of yield and yield-related traits were submitted to analysis of variance (ANOVA) following the standard procedures of the commands using the R software program version 4.2 to estimate the variation among genotypes (Core Team, 2020 and Abdurezake *et al.,* 2024).

The mean values were analyzed, statistically to determine the analysis of variance for all the traits as suggested by Panse and Sukhatme (1954). The phenotypic, genotypic and environmental coefficients of variation were calculated following the method of Burton and De Vane (1953). Heritability and genetic advance was estimated using the method described by Allard (1960); Falconer and Douglas (1996) and Johanson *et al.* (1955). Phenotypic and genotypic correlations were estimated using the standard procedure suggested by Singh (1985) to study positively and negatively correlated characters with yield and among themselves. Path coefficient analysis was performed using the formula applied by Dewey *et al*. (1959).

RESULTS AND DISCUSSION

Mean performance and analysis of variance of germplasm

The result on analysis of variance (ANOVA) for yield component traits revealed significant mean sum of square for studied genotypes for all traits, indicating the existence of sufficient variation among the genotypes and therefore ample scope for effective selection (Table 1).

Mean performance of morphological and essential oil related traits of all the studied germplasm was presented

Table 1: Analysis of variance (ANOVA) of *Perilla* germplasm.

Characters	Mean sum of square		
	Replication	Genotypes	Errors
	Df=2	Df=9	Df=18
Plant height	0.43	388.24 ***	0.69
Length of petiole	0.07	2.30***	0.02
Leaf length	0.13	7.87***	0.49
Leaf breath	0.11	2.32***	0.12
Stem girth	0.02	0.14***	0.02
Length of inflorescence	0.10	62.53***	0.35
Total phenolic content (µg/ml)	0.0000017	0.018***	0.0000021
Total flavonoid content (µg/ml)	0.0000009	0.014***	0.0000046
Oil yield (%)	1.25***	38.29***	0.03

Table 2: Mean value of ten (10) genotypes of *Perilla* for nine studied characters.

Parents	Plant height	Length of petiole	Leaf length	Leaf breadth	Stem girth	Length of inflorescence	Total phenolic content	Total flavonoid content	Oil yield %
PF1	151.00	8.06	17	9.66	2.43	21	0.12	0.24	24.86
PF2	175.33	7.93	13.66	9.43	2.16	12.33	0.11	0.18	20.00
PF3	161.00	7.7	12.33	8.06	2.16	20.33	0.25	0.20	20.80
PF4	164.00	9.76	14.5	8.5	2.23	22	0.12	0.18	27.73
PF5	151.33	6.73	12.83	7.23	2.5	20.66	0.23	0.22	24.73
PF6	161.00	6.7	12.83	7.9	2.3	32	0.17	0.19	21.33
PF7	192.00	7.6	15.76	9.2	2.7	22.33	0.12	0.15	32.00
PF8	165.00	8.3	13.33	8.2	2.6	20.3	0.12	0.32	21.86
PF9	161.66	7.2	12.5	7.6	1.8	20.6	0.28	0.20	20.53
PF10	161.33	7.4	12	7.2	2.0	22.66	0.32	0.38	25.00
Parental range	151-192	6-10	12-17	7-10	1.8-2.7	12-32	0.11-0.32	0.15-0.38	20-32
Mean	165.46	7.80	13.67	8.32	2.30	21.50	0.18	0.22	24.07
SEM	0.48	0.09	0.40	0.20	0.08	0.34	0.0008	0.0012	0.11
CD at 5%	1.42	0.28	1.20	0.60	0.25	1.02	0.0025	0.0037	0.33

in Table 2. On the basis of morphological, biochemical and oil yield%, PF7 germplasm is superior for most of studied characters followed by PF4 and PF2.

Genetic variability

Genotypic variance (GV), phenotypic variance (PV), genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), environment variance (EV), environment coefficient of variation (ECV), heritability (HT) and genetic advance (GV) for the oil yield and yield component traits were furnished in Table 3. These findings revealed maximum range of variability for the plant height (151-191) while minimum range (0.15-0.38) was recorded for the total phenolic content. In the present study, heritability estimates for the studied traits range from (0.649) in stem girth to (1.00) in total phenolic content and total flavonoid content. High estimates of heritability were recorded for all traits excepts stem girth (0.649) which indicate that these characters were less influenced by environment conditions and phenotypic selection would be effective. Similar results were reported by Zhimoni *et al.* (2019). Higher estimates of heritability coupled with high to moderate estimates of genetic advance as percentage of mean were observed for different traits in *Perilla* by Hussain *et al.* (2014).

Generally the value of PV and PCV was generally higher than that of GV and GCV for all studies traits indicating the role of environmental variance in controlling the characters along with genetic variability. Similar studies was conducted by Zhimomi *et al*. (2019) in landraces collected from Nagaland, India indicating the expression of characters were influenced by the environment factors. The phenotypic variance was partitioned into heritable (genotypic variance and non-heritable-environment variance) components (Table 3). The estimate of genotypic and phenotypic variances in case of plant height were 129.18 and 129.87, respectively and the GCV and PCV were 6.86 and 6.88, respectively (Table 4). The differences between the variances and coefficient of variation quite close indicated that there was a negligible environment influence on plant height of the genotypes. Phenotypic variance and phenotypic coefficient variance was higher than genotypic variance and genotypic coefficient variance in case of length of petiole, stem girth indicating environmental influence (Table 3). In case of leaf length and length of inflorescence, the genotypic and phenotypic variance were 2.46 and 2.95, respectively and the genotypic and phenotypic coefficient of variations were 11.47 and 12.56, respectively. This indicated that a considerable degree of genetic variability prevailed in this character and there was a negligible influence of environment. Estimates of genotypic, phenotypic variance, genotypic coefficient variance and phenotypic coefficient variance indicated that there was moderate environmental influence on leaf breath. For the study of variability in case of total phenolic content and total flavonoid content, the values of genotypic and phenotypic variance (0.006 and 0.006) and genotypic coefficient variance and phenotypic coefficient variance (0.004 and 0.004). These findings indicated that there was no environmental influence on both traits. The genotypic and phenotypic variance of oil yield (%) trait was 12.75 and 12.79, respectively and the genotypic coefficient variance was14.83 and phenotypic coefficient variance was14.85, respectively. These variability values were quite close indicating negligible influence of environment for this trait. Similar results were reported by Hussain *et al.* (2013) and Manggoel *et al*. (2012).

Heritability, genetic advance and genetic advance as % of mean

High value of Heritability in broad sense are helpful in identify the appropriate characters for selection and enabling the breeder to select superior genotypes on the basis of phenotypic expression of quantitative traits. Heritability is considered low if it is less than 30%, moderate between (30-60%) and high if it is more than 60% (Johnson *et al*., 1955). The maximum heritability (broad sense) was observed for oil yield % followed by value of total phenolic content, total flavonoid content, plant height, length of petiole, leaf length, leaf breath, stem girth and length of inflorescence (Table 3). Thus selection for these traits is

Table 3: Estimation of component of variation for nine traits in *Perilla*.

Character	GV	PV	GCV	PCV	EV	ECV	H^2 (%)	GA	GA as % of mean
Plant height	129.18	129.87	6.86	6.88	0.69	0.50	99	23.35	14.11
Length of petiole	0.76	0.78	11.16	11.35	0.02	2.09	96	1.76	22.54
Leaf length	2.46	2.95	11.47	12.56	0.49	5.13	83	2.95	21.57
Leaf breath	0.73	0.85	10.29	11.12	0.12	4.23	85	1.63	19.60
Stem girth	0.04	0.06	8.86	11.00	0.02	6.51	64	0.33	14.70
Length of inflorescence	20.73	21.08	21.17	21.35	0.35	2.78	98	9.28	43.24
Total phenolic content	0.006	0.006	41.63	41.63	0.0000	0.78	100	0.16	85.78
Total flavonoid content	0.004	0.004	30.50	30.50	0.0000	0.93	100	0.14	62.83
Oil yield (%)	12.76	12.79	14.83	14.85	0.03	0.80	99	7.34	30.52

Note: GV- Genotypic variance; PV- Phenotypic variance; GCV- Genotypic coefficient of variation; PCV- Phenotypic coefficient of variation; EV- Environment variance; ECV- Environment coefficient of variation; HT- Heritability; GA- Genetic advance.

likely to accumulate more additive genes leading to further improvement of their performance and might also use as selection criteria in *Perilla* breeding program. Similar results were reported by Hussain *et al*. (2013). Whereas, Johnson *et al*. (1955) have showed that a character exhibiting high heritability may not necessarily give high genetic advance. Accordingly, the highest value of genetic advance as per cent of mean was shown for total phenolic content (85.78) and total flavonoid content (62.83), while plant height had lowest value for this estimate. The characters exhibiting moderate estimates of genetic advance in percent of mean (>25% to <50%) were length of inflorescence (43.24) and oil yield % (30.52). However, the low estimates of genetic advance in percentage of mean (<25%) was observed for plant height (14.11), length of petiole (22.54), leaf length (21.54), leaf breath (19.60), stem girth (14.70). On the basis of both variability parameters, high heritability coupled with high genetic advance as percentage of mean was exhibited for total phenolic content, total flavonoid content, oil yield % and length of inflorescence. Thus, this study revealed that these traits can be improve through direct selection. High heritability coupled with moderate genetic advance as per cent of mean were recorded for plant height, length of petiole, leaf width, stem girth. This finding indicated the

Table 4: Estimation of correlation coefficient for nine traits in *Perilla*.

Characters		Plant height	Length of petiole	Leaf length	Leaf width	Stem girth	Length of inflorescence	Total phenolic content	Total flavonoid content	Oil yield %
Plant height	G	1**	0.3078	0.3511	0.5382	0.2101	-0.1939	-0.4942	-0.3933	0.5092
	P	1**	0.3054	0.3332	0.4879**	0.1787	-0.1899	-0.4929**	-0.3916*	0.5069**
Length of petiole	G		1**	0.3606	0.3967	0.0438	-0.275	-0.4424	0.0817	0.352
	P		1**	0.3422	0.3414	-0.0315	-0.2693	-0.4355*	0.0817	0.3472
Leaf length	G			1**	0.8948**	0.5803	-0.085	0.7605*	-0.3466	0.6228
	P			1**	0.7418**	0.4298*	-0.0778	-0.6963**	-0.3134	0.565**
Leaf width	G				1**	0.391	-0.366-	-0.8557**	-0.441	0.268
	P				1**	0.2151	0.3542*	-0.7901**	-0.4075*	0.2491
Stem girth	G					1**	0.1146	-0.653*	-0.0865	0.5237
	P					1**	0.0935	-0.5234**	-0.0608	0.4191*
Length of inflorescence	G						1**	0.1895	0.0349	0.2197
	P						1**	0.189	0.0353	0.2148
Total phenolic content	G							1**	0.4189	-0.3341
	P							1**	0.4187*	-0.3337
Total flavonoid content	G								1**	-0.183
	P								1**	-0.183
Oil yield %	G									1**
	P									1**

*,** Significant at 5% and 1% level of probability.

G = Genotypic correlation; P = Phenotypic correlation.

Table 5: Path coefficient analysis of morphological, total phenolic and flavonoid content charterers in *Perilla*.

Characters	Plant height	Length of petiole	Leaf length	Leaf breath	Stem girth	Length of inflorescence	Total phenolic content	Total flavonoid content
Plant height	0.2663	0.0819	0.0935	0.1433	0.0559	-0.0516	-0.1316	-0.1047
Length of petiole	0.3794	1.2327	0.4445	0.4890	-0.0539	-0.3389	-0.5456	0.1007
Leaf length	-0.1073	-0.1102	-0.3057	-0.2735	-0.1774	0.0259	0.2326	0.1059
Leaf breath	0.6313	0.4654	1.0497	1.1731	0.4596	-0.4294	-1.0042	-0.5173
Stem girth	0.3660	0.-0763	1.0111	0.6826	1.7422	0.1996	-1.1380	-0.1509
Length of inflorescence	-0.0720	-0.1022	-0.3160	-0.1361	0.0426	0.3718	0.0705	0.0129
Total phenolic content	-1.2125	-1.0857	-1.8662	-2.0998	-1.6021	0.4651	2.4568	1.0265
Total flavonoid content	0.2580	-0.0536	0.2274	0.2893	0.0568	-0.0228	-0.2746	-0.6561
Genotypic correlation with oil yield %	0.5092	0.352	0.6228	0.268	0.5237	0.2197	-0.3341	-0.183

Residual effect = 0.0121

role of additive gene action and hence selection to be effective for improvement program.

Correlation coefficient

The correlation coefficient of the nine characters of *Perilla* were presented in Table 5. In general, phenotypic correlation showed lower values than the corresponding estimate of the genotypic values. Morphological traits such as plant height showed positive significant association with length of petiole, leaf length, leaf width, stem girth and oil yield at phenotypic level. But it showed non-significant association with length of inflorescence, total phenolic content and total flavonoid content. Length of petiole had significant positive association with leaf length, leaf width, total flavonoid content and oil yield. In contrast, it showed negative significant association with stem girth, length of inflorescence and total phenolic content. Leaf length had significant positive association with leaf width, stem girth and oil yield % at phenotypic level. But it showed non-significant association with length of inflorescence, total phenolic content and total flavonoid content. Leaf width showed significant positive association with stem width and oil yield % at phenotypic level and non-significant correlation with length of inflorescence, total phenolic content, total flavonoid content. Stem girth showed significant positive correlation with length of inflorescence and oil yield%. Length of inflorescence had significant positive association with total phenolic content, total flavonoid content and oil yield % at phenotypic level. Total phenolic content showed significant positive correlation with total flavonoid content and showed non-significant correlation with oil yield%. Total flavonoid content showed non- significant correlation with oil yield % at phenotypic level. Ansari *et al*. (2019) studied that seed yield per plant was positively correlated with all studied traits except days to 50% flowering, leaf width, petiole length and seed oil content in *Perilla*. Contrarily, seed oil content had negative association with inflorescence length, number of inflorescence per plant and 100 seed weight. Nam *et al.* (2004) observed positive correlations of seed weight with plant height, flower clusters and inflorescence length.

Path coefficient analysis

Path analysis uses standardized partial regression coefficients to assess the direct and indirect impacts of independent variables on a dependent variable. By separating correlation coefficients into direct and indirect effects, we can better understand the relationship between observable characteristics (Ansari-mahyari *et al.,* 2019). In present investigation, path analysis was done as the procedure given by Dewey *et al*. (1959) to know the direct and indirect effect of various characters on oil yield of *Perilla*. In present study, the characters which has highest positive direct effect on seed yield were due to length of petiole (0.741), leaf width (1.32), stem girth (0.98), length of inflorescence (0.35), total phenolic content (1.69). Similar result were reported by Hussain *et al*. (2013) and Zhimomi *et al.* (2019). Thus, direct selection for these traits will be beneficial in yield improvement program. While, the characters like plant height, leaf length, total flavonoid content exhibited negative direct effect on seed yield per plant. Similar result were reported by Rasheed *et al*. (2008).

CONCLUSION

The present studies revealed high heritability accompanied by low to high genetic advance as percent of mean. In all these cases significant genotypic correlation co-efficient were found to be higher than their corresponding phenotypic ones. Thus, based on the estimates of character association and path coefficient analysis, it was suggested that tall and bushy, thick stem with long inflorescence *Perilla* plants are likely to produce high seed oil yield. Therefore, the present study recommended to utilize high oil yielding germplasm in breeding programme to enhance the seed oil yield with linoleic acid, α-linolenic acid and stearic acid.

ACKNOWLEDGEMENT

Authors are grateful to Prof. (Dr.) Arun Kumar Dean, School of Basic and Applied Sciences, Shri Guru Ram Rai University, Patel Nagar, Dehradun for his kind support and suggestions.

Disclaimers

The views and conclusions expressed in this research article are solely those of the authors and do not necessarily reflect the views of their affiliated institution. The authors are responsible for the accuracy and completeness of the information presented, but they do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

Authors have declared that no competing interests exist.

REFERENCES

Abdurezake, M., Bekeko, Z. and Mohammed, A. (2024). Genetic variability and path coefficient analysis among bread wheat (*Triticum aestivum* L.) genotypes for yield and yield related traits in bale highlands, southeastern Ethiopia. *Agrosystems. Geosciences and Environment.* **7(2):** e20515.

Allard, R.W. (1960). Principles of Plant Breeding. John Willey and Sons.

Ansari-mahyari, S., Ojali, M.R., Forutan, M., Riasi, A. and Brito, L.F. (2019). Investigating the genetic architecture of conception and non-return rates in Holstein cattle under heat stress conditions. *Trop. Anim. Health Prod.* **51(7):** 1847-1853.

Bachheti, R.K., Joshi, A. and Ahmed, T. (2014). A phyto-pharmacological overview on *Perilla frutescens*. *Int. J. Pharm. Sci. Rev. Res.* **26(2):** 55-61.

Bhakal, M. and Lal, G.M. (2017). Estimation of genetic variability, correlation and path analysis in groundnut (*Arachis hypogaea* L.) germplasm. *Chem. Sci. Rev. Lett.* **6(22):** 1107-1112.

Bhor, T.J., Kashid, N.V. and Kadam, S.M. (2020). Genetic variability, character association and path analysis studies for yield components traits in promising rice (*Oryza sativa* L.) genotypes. *Journal of Pharmacognosy and Phytochemistry.* **9(4):** 1953-1956.

Burton, Glenn W. and De Vane, E.H. (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal.* **45(10):** 478-481.

Core Team, R. (2020). R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing. Vienna, Austria. https://www.r-project.org/.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheatgrass seed production. *Agronomy Journal.* **51(9):** 515-518.

Engtipi, M. and Raju, N.L. (2022). Nutritional value and anti-nutritional factor analyses of five indigenous spices used by the karbi group of Assam, India. *Agricultural Science Digest*. **42(2):** 242-245. doi: 10.18805/ag.D-5450.

Falconer, D.S. (1996). Introduction to Quantitative Genetics. Pearson Education India.

Fellahi, Z., Hannachi, A., Guendouz, A., Bouzerzour, H. and Boutekrabt, A. (2013). Genetic variability, heritability and association studies in bread wheat (*Triticum aestivum* L.) genotypes. *Electronic Journal of Plant Breeding.* **4(2):** 1161-1166.

Gwari, G., Lohani, H., Bhanduri, U., Andola, H., Haider, S.Z. and Chauhan, N. (2015). Chemical and nutritional studies of *Perillia* (*Perilla frutescens* L.) accession collected from Uttarakhand. *European Journal of Biomedical and Pharmaceutical Sciences*. **2(4):** 761-769.

Hussain, S., Changkija, S. and Hore, D.K. (2014). Genetic divergence analysis in *Perilla* [*Perilla frutescens* (L.) Britton]. *Indian Journal of Hill Farming.* **27(2):** 10-15.

Hussain, S., Changkija, S. and Hore, D.K. (2013). Variability studies in some Perilla [*P. frutescens* (L.) Britton] accessions of North-east India. *International Journal of Bio-resource and Stress Management.* **4(2):** 230-236.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy Journal.* **47:** 314-318.

Khanduri, S., Khankriyal, S., Kumari, N., Gusai, N., Mathur, S. and Singh, M. (2024). *Perilla frutescens* (L.) Britton: A review on phytochemical profile, biological potential, traditional applications and future prospects. *Eco. Env. and Cons.* **30(3):** 201-215.

Manggoel, W., Uguru, M.I., Ndam, O.N. and Dasbak, M.A. (2012). Genetic variability, correlation and path coefficient analysis of some yield components of ten cowpea [*Vigna unguiculata* (L.) Walp] accessions. *Journal of Plant Breeding and Crop Science.* **4(5):** 80-86.

Nam, S.Y., Hong, S.T., Kim, M.J., Kim, I.J., Lee, C.H. and Kim, T.S. (2004). Growth and yield components of Korean Perilla collections. *Korean Journal of Crop Science.* **49:** 222-226.

Panse, V.G. and Sukhatme, P.V. (1954). Statistical methods for agricultural workers; Publisher Indian Council of Agricultural Research. pp 1-361.

Rasheed, S., Hanif, M., Sadiq, S., Abbas, G., Asghar, M.J. and Haq, M.A. (2008). Inheritance of seed yield and related traits in some lentil (*Lens culinaris* Medik) genotypes. *Pak. J. Agri. Sci.* **45(3):** 49-52.

Rongsensusang, Rao Appa, V., Babu Narendra, R., Karunakaran, R., Dorai Palani, R. and Pandian Saravana Serma, A. (2020). Optimization of *Perilla* roselle and Zanthoxylum levels in pork patties by application of conjoint analysis. *Indian Journal of Animal Research*. **55(7):** 853-859. doi: 10.18805/ijar.B-4118.

Saklani, S., Chandra, S. and Gautam, A.K. (2011). Phytochemical investigation and contribution of *Perilla frutescence* as spices in traditional health care system. *International Journal of Pharmacy Technology*. **3(4):** 3543-3554.

Sampson, D.R. (1971). Additive and non-additive genetic variances and genotypic correlation for yield and other traits in oats. *Can. J. Genet. Cytol.* **13:** 864-872.

Shin, H.S. and Kim, S.W. (1994). Lipid composition of *Perilla* seed. *Journal of the American Oil Chemistry Society*. **71(6):** 619-622.

Singh, M., Bharti, B. and Chauhan, D. (2021). Effect of organic and biofertilizers on seed yield and yield related attributes of *Perilla frutescens* (L.) britton. *Natural Volatile and Essential. Oils*. **8(4):** 2374-2390.

Singh, R.K. (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalyani Pub. Ludhiana. New Delhi, Revised Ed.18.

Takano, H., Osakabe, N., Sanbongi, C., Yanagisawa, R., Inoue, K., Yasuda, A., Natsume, M., Baba, S., Ichiishi, E. and Yoshikawa, T. (2004). Extract of *Perilla frutescens* enriched for rosmarinic acid inhibits seasonal allergic rhino conjunctivitis in humans. *Exp. Biol. Med.* **229:** 247-254.

Ueda, H., Yamazaki, C. and Yamazaki, M. (2002). Luteolin as an anti-inflammatory and anti-allergic constituent of *Perilla frutescens*. *Biol. Pharm. Bull.* **25(9):** 1197-1202.

Zhimomi, H., Seyie, K. and Chaturvedi, H.P. (2019). Genetic variability, correlation and path coefficient studies in *Perilla* [*Perilla frutecens* (L.) Britton] landraces of Nagaland. *Research Review International Journal of Multidisciplinary.* **4(3):** 2259-2263.