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Morphological variability and genetic potential of henna (*Lawsonia inermis*) germplasms in semi-arid regions of Rajasthan

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ABSTRACT

Henna (*Lawsonia inermis* L.) is a commercial and export-oriented important perennial shrub used in the ornamentation of palm, feet, dyeing of hair, etc. Developing high-yielding varieties and elite plant materials are the best method to increase the productivity and quality in henna. An experiment was conducted at research farm of ICAR-Central Arid Zone Research Institute, Regional Research Station, Pali-Marwar, Rajasthan during 2018–22 in Randomized block design to assess variability among morphometric traits and genetic parameters for dry leaf yield and attributing characters in Henna. The results indicated that among 19 germplasms maximum dry leaf yield and minimum number of inflorescence was recorded in CZ-RSPH-8 followed by CZ-RSPH-15. The accession CZ-RSPH-9 (2.33%) exhibited the highest lawsone content (%) followed by CZ-RSPH-8 and CZ-RSPH-15. The estimates of phenotypic co-efficient variation (PCV) were higher than the respective genotypic co-efficient variation (GCV). The number of inflorescences registered high heritability with high genetic advance. Path analysis exhibited the direct effect of the number of inflorescence with dry leaf yield. Cluster analysis revealed two major clusters classified into 6 and 13 germplasm which depicts the diverse degree of relatedness among different accessions.

Keywords: Cluster analysis, Genetic advance, Henna germplasms, Heritability, Variability

Henna or Mehndi (*Lawsonia inermis* L.) (Family: Lythraceae) is an important dye-yielding cash crop used for dyeing hair, palm, and feet since ancient times (Singh *et al.* 2015). Its cultivation is profitable under low rainfall conditions and provides assured returns at low-cost investment in drought-prone semi-arid regions. Economic production of leaves starts from the third year onwards that continues up to next 15–30 years (Chand and Jangid 2007). Low use of input and maintenance, easy to regenerate, high rate of success in the establishment, no or very little usage of fertilizers, less or no pest and disease attack etc., promotes henna cultivation among the farmers for the economic and ecological development. Globally, India exported 2,383 tonnes of henna to several countries in 2002–03, indicated high demand in the international export. In India henna occupies about 40,000 ha area out of which 35,000 ha alone is in the Pali district (Sojat and adjoining tehsils) Rajasthan. Sojat (Rajasthan) is the only centre for its processing and trading in India (Chand and Jangid 2007 and Jyotshna *et al.* 2017).

Botanically, two types of henna (based on flower colour) exist i.e. alba (yellow colour flower) and rubra (reddish rose colour flower), among which the former is mostly cultivated in arid and semi-arid regions. At present, there are no released varieties in India and only the population raised from seeds are existing in the farmer's field. However morphological variation and difference in yield and quality exist in field level. Hence considerable scope exists for improvement programme in henna for high yield and lawsone content. Even though it is an economically important promising crop, there is no superior germplasm or quality planting material available to meet the demand and quality. Henceforth, there is an urgent need to give attention to the selection, evaluation and improvement of henna, and utilizing it in the breeding programme for enhancement of productivity and better quality. With this background, the present study was carried out to determine the magnitude of genetic variability, correlation coefficient, path analysis and clustering pattern for achieving higher productivity through the selection of superior germplasms of henna.

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MATERIALS AND METHODS

The study was carried out at ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station, Pali-Marwar (25°47′–25°49′N and 73°17′–73°18′E at 217–220 m MSL), Rajasthan in the hot semi-arid region of India during 2018–22. The annual average rainfall is 460 mm with an annual maximum mean temperature of 42°C and a minimum of 7°C. The soils were shallow in depth (30–45 cm) with sandy clay loam to sandy loam texture, 1.35–1.5 Mg/m bulk density, 7.7–8.4 *p*H, 0.15–0.55 d/Sm electrical conductivity, and a dense underlying layer of murrum (highly calcareous weathered granite fragment coated with lime).

The survey was carried out in predominant henna growing areas of Pali and Jodhpur districts, and 19 superior germplasms were selected based on their morphometric traits, flowering habit and lawsone content (Supplementary Table 1). The cuttings were collected from superior selected mother plants of henna and raised in the nursery. The raised one-year old henna plants were planted in the field with 60 cm × 60 cm spacing for evaluation. The plants were raised purely in rainfed condition and harvested during mid-October, every year. The harvesting of henna was carried out by cutting the plant 10–15 cm above ground level.

The experiment was laid out in a Randomized Block Design (RBD) with 3 replications. The observations, viz. plant height (cm), collar diameter (mm), number of branches, leaf length (cm), leaf width (cm) and number of inflorescence and internodal length (cm) were recorded. Dry leaf weight (g/plant) and dry stem weight (g/plant) were recorded for yield attributes. The lawsone content (%) was estimated by Pratibha and Korwar (1999) method. Estimation of genetic parameters, viz. variability, PCV and GCV (Burton 1952), heritability and genetic advance (Lush 1940 and Johnson *et al.* 1955), correlation coefficient and path analysis (Wright 1921) were calculated.

RESULTS AND DISCUSSION

Growth performance of henna germplasms: Nineteen germplasms raised from cuttings exhibited significant differences in morphological growth parameters (Table 1). Three accessions, viz. CZ-RSPH-8 (181.1 cm), CZ-RSPH-15 (180.6 cm) and CZ-RSPH-16 (177.4 cm) showed significantly higher values for their plant height. The collar

Table 1 Variability in growth attributes of henna germplasm in field condition

Germplasm	Plant height (cm)	Collar dia. (mm)	No. of branches	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)
CZ-RSPH-1	140.8	13.52	5.55	3.05**	1.49**	2.32
CZ-RSPH-2	141.1	15.07	5.63	2.43	1.36	1.68
CZ-RSPH-3	132.0	15.18	5.69	2.47	1.18	1.83
CZ-RSPH-4	142.6	16.86	5.98	2.76	1.36	2.34
CZ-RSPH-5	116.5	16.43	5.16	2.74	1.29	2.17
CZ-RSPH-6	123.1	17.06	5.91	2.92*	1.42*	2.51*
CZ-RSPH-7	133.8	14.98	5.25	2.58	1.19	2.07
CZ-RSPH-8	181.1**	24.29**	10.1**	3.13**	1.37	1.96
CZ-RSPH-9	150.0	17.57	6.87	2.58	1.13	2.16
CZ-RSPH-10	159.1	19.97	7.75	2.77	1.35	2.34
CZ-RSPH-11	147.0	20.39	8.05	2.74	1.41	2.45
CZ-RSPH-12	147.4	18.80	7.56	2.53	1.36	2.54
CZ-RSPH-13	133.3	19.08	8.00	2.83	1.42*	2.67**
CZ-RSPH-14	171.2*	16.81	8.22	2.28	1.21	2.18
CZ-RSPH-15	180.6**	20.90	9.55**	2.32	1.16	2.17
CZ-RSPH-16	177.4**	16.75	9.20*	2.19	1.04	2.07
CZ-RSPH-17	160.5	20.36	8.50	2.33	1.14	2.08
CZ-RSPH-18	135.5	14.70	6.27	2.51	1.06	2.00
CZ-RSPH-19	139.3	14.27	7.08	2.39	1.03	2.11
Mean	148.0	17.53	7.18	2.61	1.26	2.19
SE(m)	7.411	1.200	0.59	0.10	0.05	0.09
CD (0.05)	21.25	3.443	1.70	0.31	0.16	0.28
CD (0.01)	28.50	4.617	2.29	0.42	0.21	0.37

*Significant at 5% level, **Significant at 1% level.

Table 2 Economic and yield attributes of henna germplasm in field condition

Germplasm	No. of inflorescence	Dry leaf yield (g/plant)	Dry leaf yield (kg/ha)	Dry stem yield (g/plant)	Dry stem yield (kg/ha)	Lawsone content (%)
CZ-RSPH-1	12.5	60.70	1686.1	227.8	6330.0	2.14
CZ-RSPH-2	15.6	70.71	1964.3	213.3	5926.5	2.15
CZ-RSPH-3	17.1	74.54	2070.6	200.1	5559.2	1.77
CZ-RSPH-4	15.0	66.19	1838.6	277.0	7696.5	1.97
CZ-RSPH-5	17.9	56.30	1564.0	237.0	6584.6	1.92
CZ-RSPH-6	18.6*	98.66	2740.6	332.8	9244.3	1.98
CZ-RSPH-7	17.0	77.47	2151.9	301.0	8362.4	1.69
CZ-RSPH-8	0.61	129.4**	3594.8**	461.1	12810.6	2.27
CZ-RSPH-9	1.48	81.72	2270.0	281.7	7826.94	2.33*
CZ-RSPH-10	12.7	90.44	2512.2	363.3	10092.3	1.89
CZ-RSPH-11	18.1	79.11	2197.4	424.3	11787.4	1.80
CZ-RSPH-12	19.3*	71.47	1985.2	290.1	8060.7	1.33
CZ-RSPH-13	20.1*	75.75	2104.1	232.4	6456.6	1.74
CZ-RSPH-14	4.95	72.22	2006.1	391.1	10865.4	1.71
CZ-RSPH-15	3.69	112.6	3128.0*	362.9	10081.5	2.25
CZ-RSPH-16	10.9	101.8	2827.8	489.8*	13605.3**	2.03
CZ-RSPH-17	10.0	108.1	3003.0	477.0	13249.6**	2.00
CZ-RSPH-18	15.2	71.39	1983.1	239.1	6641.9	1.85
CZ-RSPH-19	15.8	75.71	2103.0	243.3	6759.7	1.84
Mean	13.0	82.86	2301.6	318.2	8839.0	1.93
SE(m)	1.88	11.48	319.01	55.55	1543.0	0.13
CD (0.05)	5.39	32.94	914.99	159.3	4425.7	0.37
CD (0.01)	7.23	44.17	1226.9	213.6	5934.5	0.50

*Significant at 5% level, **Significant at 1% level.

diameter ranged from 24.29 mm to 13.52 mm. Similar kind of results were obtained for number of branches and higher leaf yield which is contributed due to the presence of more number of branches (Table 1 and Table 2). Maximum leaf length was found in CZ-RSPH-8 followed by CZ-RSPH-1 and minimum was in CZ-RSPH-16. The leaf width ranges between 1.49 cm (CZ-RSPH-1) and 1.03 (CZ-RSPH-19). Singh *et al.* (2005) reported plant height of 99.10 cm and leaf width of 1.30 cm in natural populations of henna which indicates that the henna germplasms in the present study performed better than natural populations. The lowest internodal length (1.68 cm) was registered in CZ-RSPH-2 followed by CZ-RSPH-8 (1.96 cm) while the highest (2.67 cm) in CZ-RSPH-13 followed by CZ-RSPH-6. Three to four leaves were present in each internode of henna. The minimum internodal length produces more number of leaves which in turn increases productivity.

Performance of henna germplasms in yield and economic traits: Considering 19 germplasms, the minimum number of inflorescence was observed in CZ-RSPH-8 (0.61) followed by CZRSPH-9 (1.48) and CZ-RSPH-15 (3.69). The number of inflorescence is related to leaf yield and maximum dry leaf yield was registered in CZ-RSPH-8

Table 3 Genetic parameters of morphometric and yield traits of henna germplasm

Trait	GCV	PCV	Heritability	Genetic advance (%) of mean
Plant height (cm)	11.81	14.65	0.649	19.61
Collar dia. (mm)	14.30	18.58	0.592	22.67
No. of branches	19.64	24.33	0.651	32.65
Leaf length (cm)	9.232	11.73	0.619	14.96
Leaf width (cm)	10.47	12.94	0.654	17.45
Internodal length (cm)	10.40	12.97	0.643	17.19
No. of inflorescence	45.08	51.56	0.764	81.21
Dry leaf weight (g/plant)	18.41	30.25	0.370	23.09
Dry stem weight (g/plant)	23.81	38.49	0.382	30.35
Lawsone content (%)	10.45	15.80	0.437	14.24

(129.4 g/plant, 3584.8 kg/ha) and CZ-RSPH-15 (112.6 g/plant, 3128.0 kg/ha). The highest values registered for dry stem yield was 489.8 g/plant and 13605.3 kg/ha (CZ-RSPH-16). In germplasms with maximum inflorescence, the photosynthates are diverted for the synthesis of secondary metabolites which further reduces lawsone content. However, in the present study, the highest lawsone content (%) was recorded in CZ-RSPH-9 (2.33%) followed by CZ-RSPH-8 (2.27%) and CZ-RSPH-15 (2.25 %) (Table 2).

Genetic variability: The estimates of genetic variability provide the opportunity for selection and it is a useful tool for determining the further improvement and breeding strategies of the species. In the present study, the values of PCV were higher than corresponding GCV. The differences between PCV and GCV were observed narrow except for two traits i.e. Dry leaf and stem weight. It indicates that genotype × environmental interactions play a major role in the manifestation of characters except for dry leaf and stem weight, and high GCV may be attributed to maternal inheritance. The high amount of GCV and PCV was exhibited by the number of inflorescence followed by number of branches. And also, dry leaf weight (g/plant) (30.25) and dry stem weight (g/plant) (38.49) recorded high PCV. On contrary, low PCV and GCV were recorded for plant height, collar diameter, leaf length and width, intermodal length and lawsone content, indicating that variation under these traits was not solely under genetic influence. The performance of these traits is influenced by environmental factors like rainfall, its quantity and distribution. Therefore, these accessions also warrant testing in different locations over the years. Similarly, low GCV and PCV for height and collar diameter were also reported in *Bambusa pallida* (Singh and Beniwal 1993). The variability parameter estimates in the study are in close approximation with the findings of genetic parameters in *Aquilaria malaccensis* (Noor *et al.* 2015), *Juglans regia* (Lalchand *et al.* 2020) and *Melia dubia* (Kumar *et al.* 2013).

Heritability and genetic advance: Heritability in a broad sense may give a useful indication about the related value of the selection, heritability combined with genetic advance would be more reliable for predicting the effect of selection (Sumathi *et al.* 2010). The estimate of heritability ranged from 0.382 (dry stem weight) to 0.764 (number of inflorescence) whereas, genetic advance ranged from 14.24 (Lawsone content %) to 81.21 (number of inflorescence) (Table 3). High heritability coupled with high genetic advance as per cent of mean was observed for the traits, number of inflorescence (0.764) followed by leaf width (0.654), number of branches (0.651) and plant height (0.649) indicating the predominance of additive gene action, hence good response to selection can be obtained from these traits (Table 3). The study results agree with the findings reported

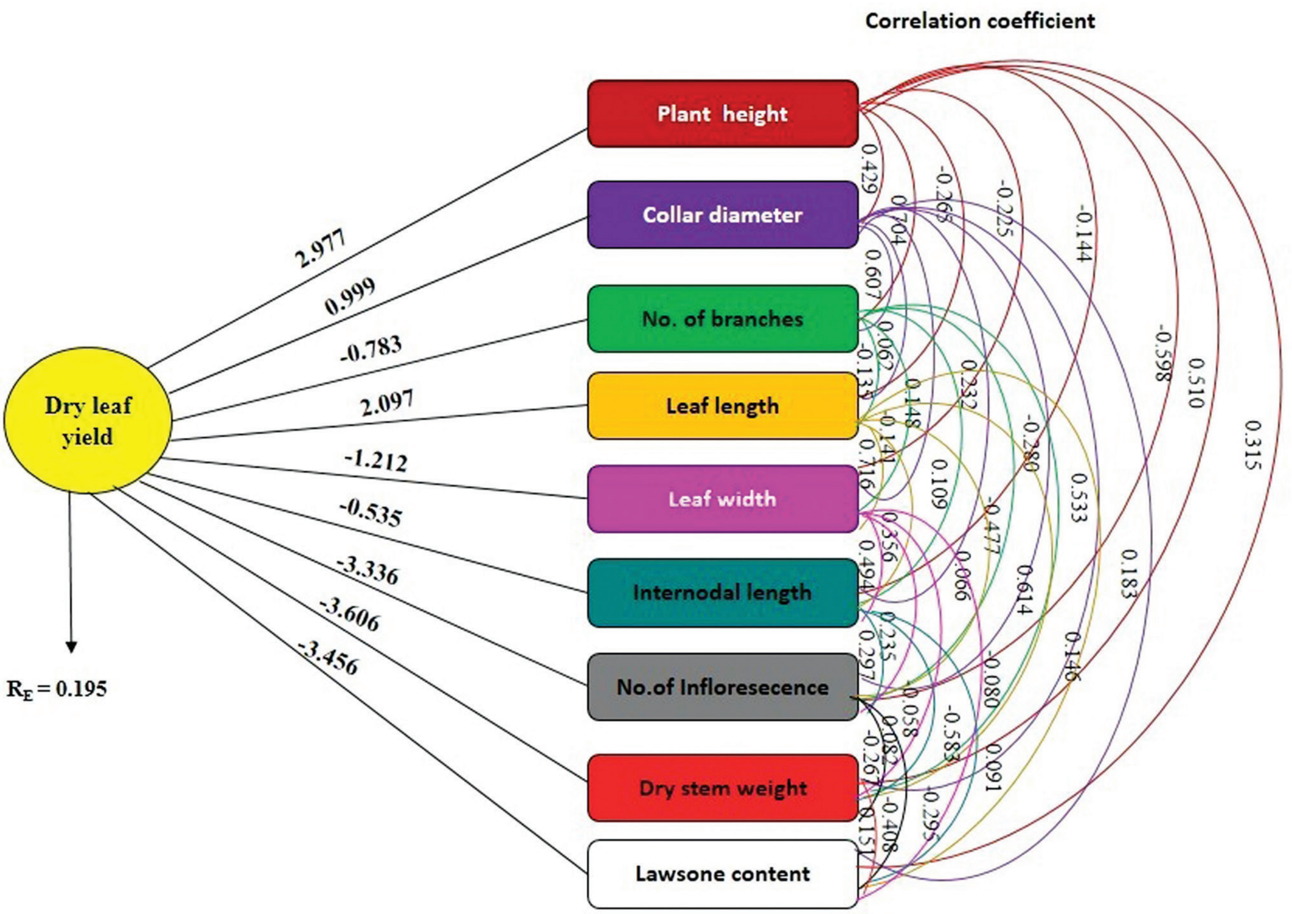

Fig 1 Path correlation analysis among morphometric traits and yield.

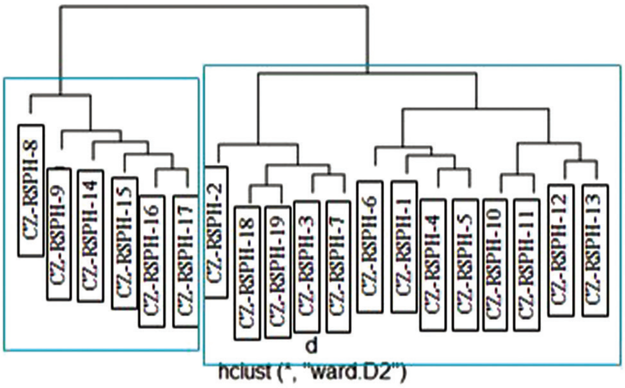

Fig 2 Dendrogram of henna germplasms on the basis of morphometric and yield attributes.

by Umeshkanna *et al.* (2019) in *Ailanthus excelsa* and Singh *et al.* (2001) in poplar.

Correlation coefficient and path analysis: Correlation coefficient cum path analysis helps to identify the magnitude and assign values for cause and effect relationship (Wright 1921). Results of correlation coefficient and path analysis among different morphometric traits and dry leaf yield are given Fig 1. Plant height, collar diameter and number of branches showed a significant and positive genotypic correlation with dry leaf yield (0.877; 0.960; 0.899) and stem yield (0.819; 0.944). This implies, there was a strong inherent relationship among the traits studied which is in consonance with the findings of Majumedar *et al.* (2012). The number of inflorescences exhibited a significant but negative correlation with lawsone content (-0.874) and dry leaf yield (-0.834) which indicates higher the inflorescence, the lower will be dry leaf weight. Similarly, it is noticeable that the number of inflorescence (-3.336), dry stem weight (-3.606), and lawsone content (-3.456) have high direct negative effect on dry leaf yield whereas plant height (2.977) and leaf length (2.097) has a high direct positive effect which infers both these traits can be used for selection in breeding programme. The results indicate that focusing on reducing the number of inflorescence will enhance the dry leaf yield and its negative correlation with yield can be taken as selection criteria in breeding programme. The results obtained from this study are in contrast with other findings reported by Zhao *et al.* 2014 and Dogra *et al.* 2018, where flower density had a significant and positive correlation with fruit set and has a direct positive effect with yield.

Cluster analysis: Clustering methods have the goal of separating a pool of observations in many subgroups to obtain homogeneity within and between the formed subgroups. In the present investigation, the evaluated henna germplasms were grouped into two major clusters which depict the degree of relatedness among accessions. Cluster I was grouped into 6 accessions indicating the relatedness among the progenies within clusters. This may be because even closely related accessions may also have genetic divergence. The cluster closely depicts diverse results in morphological grouping which might be owing to environmental conditions, soil types, temperature and moisture regime. Similarly, cluster II grouped into two clusters which consists of 5 accessions in one group and 8 accessions in another group (Fig 2). Hence the divergent progenies grouped under one cluster might be due to the factor other than the geographical distribution as evidenced in *Santalum album* (Manoj Kumar 1994) and *Prunus armeniaca* (Singh and Chaudhary 1992) which lend support to the results of current findings.

The present study concluded that 4 accessions, viz. CZ-RSPH-8, CZ-RSPH-15, CZ-RSPH-16 and CZ-RSPH-9 performed superior in terms of yield and quality traits among 19 germplasms and further used for multi-location trials which leads to the development of varieties with higher yield potential in henna under arid and semi-arid region of Rajasthan. The high heritability coupled with high or moderate genetic gain for the number of inflorescence, number of branches and dry stem weight in the current study indicated that this character is strongly under genetic control and these traits would have possibilities of selection for further improvement and breeding programme. The clustering patterns of henna germplasms revealed that the tendency of seed sources from diverse geographic regions to be grouped together in one cluster may be due to the similarity of the nature of selection pressure operating under the respective domestic conditions. Further, studying the biochemical analysis to quantify the active principle involved in lawsone dye will help to bring correlation in a better way for the selection of elite germplasm.

REFERENCES

Burton G W. 1952. Quantitative inheritance in grasses. *Proceedings of 6th International. Grassland Congress* **1**: 277–83.

Chand K and Jangid B L. 2007. Economic viability of henna in semi-arid Rajasthan. *Agricultural Economics Research Review* **20**: 137–46.

Dogra R K, Sharma S and Sharma D P. 2018. Heritability estimates, correlation and path coefficient analysis for fruit yield in walnut (*Juglans regia* L.). *Journal of Pharmacognosy and Phytochemistry* **7**(2): 3707–14.

Johnson H W, Robinson H F and Comstock R E. 1955. Estimate of genetic and environmental variability in soybean. *Agronomy Journal* **47**: 314–18.

Jyotshna, Gaur P, Singh D K, Luqman S and Shanker K. 2017. Validated method for quality assessment of henna (*Lawsonia inermis* L.) leaves after postharvest blanching and its cosmetic application. *Industrial Crops and Products* **95**: 33–42

Kumar P, Parthiban K T and Saravanan V. 2013. Genetic variations among open pollinated families of selected better trees in *Melia dubia*. *Research Journal of Recent Sciences* **2**: 189–94.

Lalchand, Singh D B, Kumawat K L, Madhav Rai K, Sharma O C, Sharma A, Pawansaini and Handa A K. 2020. Genetic variability, correlation and path-coefficient studies among Persian walnut (*Juglans regia*) genotypes. *Indian Journal of Agricultural Sciences* **90**(5): 868–73.

Lush K I. 1940. Intrasite correlation and regression of spring on dams as a method of establishing heritability of characters. *Proceedings of the American Society. Animal Production* **33**: 293–301.

Majumder D A N, Hassan L, Rahim M A and Kabir M A. 2012. Correlation and path coefficient analysis of mango (*Mangifera* *indica* L.). *Bangladesh Journal of Agriculture Research* **37**(3): 493–503.

Manoj Kumar K. 1994. 'Genetic divergence, isozyme pattern and micro-propagation studies in sandal (*Santalum album*)'. MSc Thesis, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Noor mohamed M B, Parthiban K T and Ravi R. 2015. Provenances variation in growth traits of *Aquilaria malaccansis* Lam. suitable to south Indian condition. *Electronic Journal of Plant Breeding* **6**(1): 183–90.

Pratibha G and Korwar. 1999. Estimation of lawsone in henna (*Lawsonia inermis*). *Journal of medicinal and Aromatic Plant Sciences* **21**: 658–60.

Singh D K, Luqman S and Mathur A K. 2015. *Lawsonia inermis* L. – A commercially important primaeval dying and medicinal plant with diverse pharmacological activity: A review. *Industrial Crops and Products* **65**: 269–86.

Singh N B and Beniwal B S. 1993.Variability, heritability and genetic gain of some growth characters in *Bambusa balcooa*. *The Indian Forester* **119**(3): 205–10.

Singh N B and Chaudhary V K. 1992. Multivariate analysis of genetic divergence in wild apricot (*Prunus armeniaca* Linn.). *Indian Journal of Forestry* **15**(3): 211–16.

Singh N B, Kumar D, Rawat G S, Gupta R K, Singh K and Negi S S. 2001. Clonal evaluation of poplar (*Populus deltoides* Bartr.) in Eastern Uttar Pradesh II – Estimates of genetic parameters in field testing. *The Indian Forester* **127**(2): 163–72.

Singh M, Jindal S K and Singh D. 2005. Natural variability, propagation, phenology and reproductive biology of henna. *Henna Cultivation, Improvement and Trade,* pp. 13–18. Singh M, Singh Y V, Jindal S K, Narain P (Eds). Published by Director, CAZRI, Jodhpur, India.

Sumathi P, Sumanth M and Veerabadhiran P. 2010. Genetic variability for different biometrical traits in pearl millet genotypes (*Pennisetum glaucum* L. R. BR.). *Electronic Journal of Plant Breeding* **1**(4): 437–40.

UmeshKanna S, Krishnakumar N and Md. Mohideen Abdul Kather Jailani K. 2019. Variability, heritability and genetic advance of *Ailanthus excelsa*. *International Journal of Current Microbiology and Applied Sciences* **8**(7): 1508–17.

Wright S. 1921. Correlation and causation. *Journal of Agricultural Research* **20**: 557–85.

Zhao B J, Gong Y H and Liu F. 2014. Multiple regression and path analysis between agronomic characteristics and yield in laterally fruitful individual walnut. *Acta Horticulturae* **1050**: 235–40.