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Research Article

Correlation, path analysis and genetic diversity in *Nerium oleander* L. accessions for morphological, yield and quality traits

G. Ashok Kumar[1], S.T. Bini Sundar[1*], A. Jayajasmine[2], C. Indu Rani[3] and S. Vasanth[1]

[1]HC&RI, TNAU, Coimbatore-641003, Tamil Nadu, India.
[2]Horticultural Research Station, Pechiparai, Kaniyakumari-629161,Tamil Nadu, India.
[3]Department of Vegetable Science, HC&RI, TNAU, Coimbatore-641003, Tamil Nadu, India.
***E-Mail:** stbinisundar@gmail.com

Abstract
Character association and genetic diversity analyses were performed in the present study for the morphological and yield traits of *Nerium oleander* L. accessions to find out the major contributing traits towards flower yield. A panel of 20 diverse nerium accessions were evaluated at the Floriculture Research Station, Thovalai, Kanyakumari, Tamil Nadu during 2018 to 2022. Correlation analysis revealed that number of flowers per spikes had highly significant and positive correlation with flower yield. From the path analysis, the number of flowers per spike, days for bud initiation, flower weight, plant height and number of shoots/plants were identified to have high positive direct effect on flower yield. Clustering of nerium germplasm, revealed two distinct groups. Cluster I, comprising NI-1 to NI-19, suggested shared genetic traits among them, while Cluster II, represented by NI-20, showcases unique attributes. High inter-cluster distance between Cluster I and Cluster II suggested that the genotypes in these clusters had a significant degree of genetic diversity between them and that crossings between the genotypes in the cluster I with NI-20 would produce desirable transgressive segregants.

Keywords: Nerium , correlation, path analysis, cluster analysis

INTRODUCTION

Nerium (*Nerium oleander* L., 2n = 22), a member of the Apocynaceae family, is a small perennial shrub that thrives in various climates, from tropical to temperate regions (Kiran and Prasad, 2014; Yadav *et al*., 2013). Its origin remains uncertain, but it is extensively cultivated in South-West Asia and widely distributed throughout India (Barrios and Koptur, 2011). It is renowned for its drought tolerance and stunning blooms and is favored in urban landscaping for its ornamental value. It is used as screens, highway hedges, coastal planting, and urban landscaping since it can be made into extremely little trees by cutting off the suckers and leaving only a few stems (Portis *et al*., 2004). It holds significant demand in the floriculture industry, particularly among landscape architects, due to its aesthetic appeal, pollution control attributes and its role in gardening and religious ceremonies. It commands higher economic value in view of its usage in various religious events and is a remunerative floriculture crop. Tamil Nadu is endowed with rich genetic diversity of nerium (Kumar *et al*., 2024), which warrants systematic research to fully explore and comprehend the diversity.

Yield is a polygenically controlled, complexly inherited trait. Genetic gains through selection for yield have been considerably very low, as the genotype x environment interactions play a major role and it is influenced, either directly or indirectly, by a wide range of component traits (Dhandapani *et al*., 2023). Evaluation of different nerium genotypes for the proportion and pattern of genetic diversity are extremely helpful for the identification of diverse parents to be utilized in future breeding programmes to develop high flower yielding nerium lines. Plant breeders could select superior genotypes with desired traits linked with flower yield by using correlation studies where selection in favour of one component may positively impact linked traits concurrently (Shanmugam *et al*., 2024). Thus, the present study aims to investigate the character association and genetic diversity of nerium accessions of Tamil Nadu, focusing on traits related to flower yield.

MATERIALS AND METHODS

The investigation was conducted from 2018 to 2022 at the Floriculture Research Station in Thovalai, located in the Kanyakumari district of Tamil Nadu (Latitute 8.2312° N, longitude 77.5060° E and altitude 81 m). A total of 20 distinct accessions collected based on variations in flower colour from various zones across Tamil Nadu were used for this study (**Table 1)**. The primary field was prepared, with pits measuring 30 cm length × 30 cm width × 30 cm length x 30 cm depth dug at 2 m between rows × 2 m between plants spacing and filled with FYM, red earth and top soil, and the rooted cuttings of the accessions were planted and maintained for performance evaluation. The experiment was laid out in Randomized Block Designs with three replications for each treatment. Observations on plant height, number of shoots per pit, East-West spread, North-South plant spread, inter nodal length, leaf length, leaf width, flower bud initiation, number of flowers per spike, flower length and weight, flower yield per plant per year and duration of flower retention on the plant were evaluated at the appropriate stage.

The observed characters were subjected to various statistical analyses such as correlation, path and cluster analysis. Correlation analysis among all the observed characters with flower yield as dependent trait was computed by adopting the method suggested by Johnson *et al.* (1955). Path analysis which is helpful to figure out the direct and indirect relationships of variables on independent variables was determined as per Wright (1921) and Dewey and Lu, (1959). Genetic divergence was assessed as per D^2 analysis proposed by Mahalanobis, (1936).

RESULTS AND DISCUSSION

Analysis of variance (ANOVA): In the present study, 20 nerium genotypes were subjected to pooled analysis of variance for 13 morphological traits (**Table 2**). Results of the pooled ANOVA revealed that variations due to years and genotypes examined were highly significant ($p < 0.01$) for all the traits studied, suggesting substantial variability for the studied traits among the genotypes studied. Genotypes and year interactions were highly significant ($p < 0.01$) for plant height, number of shoots, East-West plant spread, leaf length, days to bud initiation and number of flowers per spike while all other traits were identified as significant ($p < 0.05$). Significant

Table 1. List of Nerium accessions, source and salient features used for the study.

Acc. No.	Source	Leaf color	Leaf shape	Leaf texture
NI 1	Beemanahari	Green	Linear	Leathery
NI 2	Beemanahari	Green	Linear	Leathery
NI 3	Beemanahari	Greyish Green	Narrow oblong	Leathery
NI 4	Santhavilai	Green	Narrow oblong	Leathery
NI 5	Thirupathisaram	Green	Linear	Leathery
NI 6	Aralvaimozhi	Green	Linear	Leathery
NI 7	Aralvaimozhi	Green	Narrow oblong	Leathery
NI 8	Kumarapuram	Green	Linear	Leathery
NI 9	Kumarapuram	Green	Linear	Leathery
NI 10	Kumarapuram	Green	Linear	Leathery
NI 11	Thazhakudy	Green	Linear	Leathery
NI 12	Thazhakudy	Grayish Green	Oblong	Leathery
NI 13	Rasipuram	Grayish Green	Oblong	Leathery
NI 14	Rasipuram	Green	Linear	Leathery
NI 15	Rasipuram	Green	Linear	Leathery
NI 16	Salem	Green	Linear	Leathery
NI 17	Salem	Green	Linear	Leathery
NI 18	Azhaganapuram	Grayish Green	Narrow oblong	Leathery
NI 19	Azhaganapuram	Green	Linear	Leathery
NI 20	Kulasekaran pudhur	Grayish Green	Linear	Leathery

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Table 2. Pooled analysis of variance for the morphological traits studied

Traits	Replication	Genotypes	Year	Y× G	Error
PH	10.20	5056.87**	75631.16**	139.14**	10.62
NS	5.88	2262.47**	30072.35**	64.87**	4.9
EW	2.77	1533.55**	31877.59**	51.29**	4.82
NS	0.01	10.18**	109.77**	0.31*	0.01
INL	0.00	2.05**	47.34**	0.08*	0.00
LL	0.16	67.49**	1490.31**	2.05**	0.17
LW	0.00	0.82**	22.69**	0.02*	0.00
DBI	21.54	2576.88**	43791.48**	85.64**	6.12
NFS	0.01	69.45**	402.33**	1.94**	0.04
FW	0.00	0.87**	0.79**	0.02*	0.00
FL	0.00	0.35*	61.28**	0.02*	0.00
FY	0.00	1.44**	35.67**	0.06*	0.00
FR	0.00	0.36**	30.32**	0.01*	0.00

(*-Significant at p<0.05, **-Significant at p<0.01, PH-Plant height, NS-No. of shoots/plant, EW-East –West plant spread, NS- North-South Plant spread, INL- inter nodal length, LL-Leaf length, LW-Leaf width, DBI –Days for bud initiation, NFS-No of flowers/spike, FL-Flower length, FW-Flower weight, FY- Flower yield, FR- Flower retentivity)

interactions between genotype and years for the studied traits indicated that genotypes had varied response for different environments. This is similar to the findings of Mohammadi *et al*. (2017), who reposted significant variation for most of the morphological traits in nerium genotypes.

Correlation coefficient among agro-morphological and yield component traits of nerium accessions: Correlation analysis (**Table 3**) revealed significant relationships among various morphological and agronomic traits studied. Internode length had significant positive correlation with plant height (r = 0.488, p < 0.05) and flower weight (r = 0.520, p < 0.05). Plant spread East-West, North-South and leaf length were found to have positive correlation with number of shoots per plant. Days to bud initiation had negatively significant correlation with plant height (r = -0.684, p < 0.010), plant spread East-West (r = -0.554, p < 0.05) and plant spread North-South (r = -0.445, p < 0.05). This revealed a potential trend where taller plants with more spreading type may exhibit delay in flowering. Number of flowers per spikes exhibited positive significant correlation with leaf length (r = 0.450, p < 0.05), flower retention (r = 0.650, p < 0.01) and flower yield (r = 0.794, p < 0.01). Similar results were shown in chrysanthemum (Prakash *et al*., 2018), gladiolus (Raj *et al.,* 1998) and in African marigold (Karuppaiah and Kumar, 2010). The results indicated that plants with more spreading nature might have greater number of flowers coupled with greater proportion of flower retention. Flower yield also had a positive correlation with flower retention (r = 0.528, p < 0.05) which indicated the importance of flower retention in plant in determining overall yield.

Path analysis among agro-morphological, yield and quality traits of nerium accessions: Path analysis was performed to explore the direct and indirect relationships among various plant characteristics studied (**Table 4)**. Among the various traits studied number of flowers per spike (1.425) expressed high positive direct effect towards flower yield followed by days for bud initiation (0.741), flower weight (0.701), plant height (0.528) and number of shoots/plant (0.301). Inter node length (-0.278) exhibited high negative direct effect followed by leaf width (-0.260) and East West plant spread (-0.112). Similar research findings were observed in Dahlia by Gupta *et al*. (2015). Number of flowers per spike expressed high positive indirect effect through flower retention (0.977) followed by East-West plant spread (EW) (0.723) and leaf length (0.647) towards plant yield. It showed high negative indirect effect through days for bud initiation (-0.590). Flower retention had high positive indirect effect through plant height (0.528) and negative indirect effect through days for bud initiation (-0.360). These findings showed that late blooming genotypes could be more likely to enter the vegetative phase, which led to high proportion of flower yield. This is in line with the reports of Shanmugam *et al*. (2023). Plant height (-0.505), East-West plant spread (-0.399) and North-South plant spread (-0.336) expressed high negative indirect effect through days for bud initiation towards flower yield. Flower weight exhibited high positive and negative indirect effect through inter node length (0.372) and number of shoots/plant (-0.315) respectively.

Residual effect indicates the proportion of variance in the dependent variables that is not explained by the independent variables included in the model. In current

Table 3. Pearson's correlation coefficient among agro-morphological, yield and quality traits of nerium accessions

Characters	PH	NS	EW	NS	INL	LL	LW	DBI	NFS	FL	FW	Yield	FR
PH	1.000	-.089	.353	.239	**.488***	-.288	.048	**-.684****	.105	.182	.341	.183	.224
NS		1.000	**.745****	**.707****	-.097	**.490***	.135	-.206	.419	.400	-.433	.383	.243
EW			1.000	**.689****	.152	.400	.140	**-.554***	**.515***	.387	-.186	.441	.392
NS				1.000	-.044	.376	.257	**-.445***	.423	.349	-.327	.403	.153
INL					1.000	-.315	.034	-.094	-.070	.038	**.520***	.079	.031
LL						1.000	.408	.151	**.450***	.109	-.438	.361	.100
LW							1.000	.087	.072	-.199	.216	.110	-.041
DBI								1.000	-.418	-.331	-.088	-.220	-.433
NFS									1.000	.140	-.343	**.794****	**.650****
FL										1.000	-.111	.217	.242
FW											1.000	-.090	.088
yield												1.000	**.528***
FR													1.000

(*= Significant at p<0.05, **=Significant at p<0.01**,** PH-Plant height, NOS-No. of shoots/plant, EW-East –West plant spread, NS- North-South Plant spread, INL- inter nodal length, LL-Leaf length, LW-Leaf width, DBI –Days for bud initiation, NFS-No of flowers/spike, FL-Flower length, FW-Flower weight, FR- Flower retentivity)

Table 4. Path analysis among agro-morphological, yield and quality traits of nerium accessions

Traits	PH	NS	EW	NS	INL	LL	LW	DBI	NFS	FL	FW	FR
PH	**0.528**	-0.021	-0.043	0.056	-0.137	0.015	-0.007	-0.505	0.131	0.015	0.239	-0.142
NS	-0.038	**0.301**	-0.085	0.152	0.037	-0.022	-0.036	-0.168	0.634	0.046	-0.315	-0.125
EW	0.201	0.229	**-0.112**	0.145	-0.043	-0.018	-0.039	-0.399	0.723	0.041	-0.127	-0.202
NS	0.142	0.219	-0.078	**0.209**	0.02	-0.015	-0.076	-0.336	0.597	0.038	-0.229	-0.091
INL	0.261	-0.04	-0.017	-0.015	**-0.278**	0.013	-0.018	-0.077	-0.09	-0.015	0.372	-0.047
LL	-0.168	0.142	-0.045	0.07	0.082	**-0.046**	-0.103	0.105	0.647	0.014	-0.292	-0.057
LW	0.015	0.042	-0.017	0.062	-0.019	-0.018	**-0.26**	0.051	0.078	-0.027	0.138	0.039
DBI	-0.36	-0.068	0.06	-0.095	0.029	-0.007	-0.018	**0.741**	-0.59	-0.029	-0.068	0.22
NFS	0.048	0.134	-0.057	0.088	0.018	-0.021	-0.014	-0.307	**1.425**	0.028	-0.235	-0.311
FW	0.072	0.127	-0.042	0.072	0.037	-0.006	0.065	-0.193	0.365	**0.11**	-0.195	-0.118
FL	0.18	-0.136	0.02	-0.068	-0.147	0.019	-0.051	-0.072	-0.477	-0.031	**0.701**	-0.043
FR	0.165	0.083	-0.05	0.042	-0.029	-0.006	0.022	-0.359	0.977	0.029	0.066	**-0.454**

Residual effect square-0.0948
(*= Significant at p<0.05, **=Significant at p<0.01; PH-Plant height, NS-No. of shoots/plant, EW-East –West plant spread, NS- North-South Plant spread, INL- inter nodal length, LL-Leaf length, LW-Leaf width, DBI –Days for bud initiation, NFS-No of flowers/spike, FL-Flower length, FW-Flower weight and FRP - Flower retentivity)

study, the residual effect is 0.0948, suggesting that approximately 9.48% of the variance in the dependent variables remains unexplained by the variables included in the path analysis model.

Selecting genotypes with higher yield potential in Nerium could be achieved successfully by taking in to consideration the traits that contribute indirectly. In the present study, the correlation and path study revealed that the traits number of flowers per spike, flower weight, days for bud initiation, leaf length were directly associated with flower yield and the traits plant spread East-West, plant spread North-South and plant height had an indirect association with flower yield. This implied that these traits might be important for determining flower yield in nerium.

Cluster analysis:Cluster analysis grouped the 20 nerium accessions into two clusters (**Table 5**). Cluster 1 comprise a diverse range of members, including NI-1 to NI-19, suggesting shared genetic traits or phenotypic

Table 5. Clustering in Nerium germplasm

Cluster	Cluster Membership
I	NI-9, NI-17, NI-19, NI-7, NI-14, NI-10, NI-2, NI-11, NI-6, NI-8, NI-4, NI-5, NI-12, NI-18, NI-1, NI-15, NI-16, NI-3, NI-13,
II	NI-20

characteristics among these genotypes. Meanwhile, Cluster 2 was a solitary one with the genotype NI-20, indicating unique attributes that set it apart from the rest of the germplasm. This clustering provides valuable insights into the genetic diversity within Nerium species, aiding researchers in understanding the relationships between different germplasm and facilitating targeted breeding strategies for desired traits. Intra-cluster distance measures the average distance between members within the same cluster, while the inter-cluster distance signifies the distance between different clusters. Cluster 1 was observed to record an intra-cluster distance of 1894.79 while Cluster 2 had a distance of 0. The inter-cluster distance between Cluster 1 and Cluster 2 was 11604.57, indicating a considerable separation between these two clusters. These distance metrics provide quantitative insights into the clustering structure, aiding in understanding the cohesion within clusters and the separation between them. These results are in accordance with Kumar *et al.* (2017), Prakash *et al.* (2017) and Henuka *et al.* (2015). Enormous genetic diversity exists in nerium accessions and its utilization mainly rely on the way of finding variation in a population. Accessions falling under cluster I and NI-20 could be utilized for the future breeding programmes to obtain higher heterotic expression in F_1s as they were found to be more divergent. Correlation and path analysis has been used to identify the major characteristics that contribute to maximum divergence. Traits namely, number of flowers per spike, flower weight, days for bud initiation, plant spread East-West, plant spread North-South and plant height were the major contributing traits towards total diversity as explained by variability analysis. Selection based on these traits would be ideal way to improve the flower yield in nerium breeding programmes.

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