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Ex-situ evaluation of genetic diversity in indigenous *Nerium* accessions

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ABSTRACT

In the current investigation, 22 *Nerium* accessions gathered from different places in Tamil Nadu were evaluated. Regarding the assessment of accessions, a higher plant height of 209.25 cm was recorded in NI-13, and the greatest number of shoots per plant (7.40), plant spread in East-West direction (118.15 cm) and plant spread in North-South direction (123.85 cm) occurred in NI-16. The highest average leaf length (28.60 cm) was seen in Accession NI-1, whereas Accession NI-6 had the largest average leaf width (3.25 cm). Among the accessions, NI-13 recorded earliness in bud initiation (66.60). Accession NI-1 had the most flowers per spike (18.15), whereas accession NI-16 had the longest blooms (4.70) and highest individual flower weight (0.96 g) was recorded in the accession NI-3. Flower yield was highest in the accession NI-15 (4.10 kg) and the retentivity of the flowering rate were noted to be elevated in accession NI-1 (3.25 days). The PCA analysis revealed that four principal components showed 75.44% of total variation. From this, we identified that plant height, No. of shoots, plant spread (East-West) and plant spread (North-South), internode length, No. of spikes yield/plant/year, flower weight, and leaf width in different principal components are highly contributing traits for total variation. The clustering pattern was very effective, with a cophenetic correlation coefficient 0.705. The cluster analysis was displayed in four major clusters based on their specific geographical locations. The above-found accessions and traits could be utilized in the *nerium* varietal improvement programmes.

Key words: *Nerium oleander* L., Phenotypic Coefficient of Variation, Heritability, Cluster analysis.

INTRODUCTION

Nerium (*Nerium oleander* L.) is a small tree or evergreen shrub belonging to the Apocynaceae family, which is a part of the dogbane family (Kiran and Prasad, 9; Yadav *et al*., 20). This botanical family, comprising both tropical and temperate varieties, exhibits a widespread distribution (Barrios and Koptur, 2). *Nerium* has been extensively developed across South-West Asia, even though its precise origin is unknown. It usually happens near dry creek bottoms. *Nerium* is widely dispersed over India.

Nerium propagates well from stem cuttings. *Nerium* has upright stems that extend outward as plants age, reaching heights of 2 to 6 m. The leaves often emerge in groups of three from the stem and are 10 to 22 cm long, thin, sharp, and possess a strong midrib. They have a “leathery” feel. The plant yields terminal, typically white or pink flower heads. *Nerium* is widely planted because it is a drought-tolerant ornamental plant that is utilized in urban landscaping because of its amazing blooms, which vary in colour according to the type (Albornoz *et al*., 1). Recent days, the floriculture industry is dynamic and requires new products. *Nerium* is in high demand among landscape architects for its aesthetic value, pollution control properties, gardening, and worshipping. The flowering season coincides with festivals and religious functions and fetches high prices in the market (Rs. 200/kg), and a farmer can earn a net profit of Rs. 2,37,000 to 2,56,500/- per hectare. Tamil Nadu is endowed with a rich genetic diversity of nerium. However, more systematic research is needed to explore and understand the genetic diversity of Nerium. Therefore, the current investigation has been initiated to delve into the genetic diversity of nerium accessions, focusing on yield and quality traits.

MATERIALS AND METHODS

The study was conducted at the Floriculture Research Station in Thovalai, Kanyakumari district (8.2312° N longitude and 77.5060° E latitude at 81 m above mean sea level). The experiment was laid out in a randomized block design with three replications. Twenty-two different accessions were used for this study. The planting was done in pits measuring (30 × 30 cm) with farm yard manure, red earth and topsoil. Twenty plants were planted for each accession in each replication, and ten randomly selected plants in each accession were used for recording the observations. Data on plant height (cm), number of shoots per plant, plant spread (East-West; cm), plant spread (North-South; cm), internodal length (cm), average leaf length (cm), average leaf width (cm), leaf colour, shape, texture, number of flower

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bud initiations, number of flowers per spike, flower length (cm), individual flower weight (g), flower yield per plant per year (kg), flower retention in the plant (days), and flower colour were recorded at the profuse blooming stage (5 months after planting).

The principal component analysis utilized STAR software, and genetic variability analysis was conducted using R software, as outlined by Burton *et al.* (3). Following the approach of Johnson *et al.* (8), distinct classifications were assigned (Table 4) to the phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV).

RESULTS AND DISCUSSION

Twenty *Nerium* sp. accessions were gathered from various locations in Kanyakumari, Salem, and Namakkal districts (Table 1). They underwent evaluations for vegetative parameters, and the results are presented in Table 2. Accession NI-16 had the most branches per plant (7.40), while accession NI-13 exhibited the maximum plant height (209.25 cm) among the accessions. NI-16 also demonstrated the greatest plant spread in the East-West direction (118.15 cm) and the North-South direction (123.85 cm). The maximum internodal length (4.70 cm) was reported for accession NI-20, comparable to accessions NI-5 (4.60 cm) and NI-3 (4.50 cm). Additionally, the internodal length (2.60 cm) in accession NI-6 and the number of shoots per plant (3.40) in accessions NI-12 and NI-17 were noted (Table 3). Fig. 3 highlights the variability in different *Nerium* accessions.

Variations in plant height among cultivars may be attributed to the genetic composition of these cultivars (Sharova *et al*., 16). Previous studies in related areas on Nerium by Herrera *et al.* (6), chrysanthemum by Henny *et al*. (7), China aster by Zosiamliana (21) and marigold by Choudhary *et al.* (4) reinforce the idea that genetic factors play a significant role in determining plant height differences among cultivars. Regarding plant distribution, oleander ecotypes exhibit substantial variations, ranging from 1.4 to 5.0 m. Similar findings were observed in bougainvillea, where stems tend to be multi-trunked or clumpy (Griffis *et al*., 10), aligning with observations in nerium (Samanta *et al*., 14). The average leaf length, leaf width, leaf colour, leaf shape, and leaf texture of the collected accessions were also recorded (Table 2). The highest average leaf length (28.60 cm) was noted in accession NI-1, while the average leaf width was higher in accession NI-6 (3.25 cm). The leaf colour of single-flowered accessions was

Table 1. List of *Nerium* sp. accessions used for evaluation and variability analysis.

Accession No.	Source	Leaf colour	Leaf shape	Leaf texture	Flower type
NI-1	Beemanahari	Green	Linear	Leathery	White single
NI-2	Beemanahari	Green	Linear		Red single
NI-3	Beemanahari	Greyish-green	Narrow oblong		Pink double
NI-4	Santhavilai	Green	Narrow oblong		White single
NI-5	Thirupathisaram		Linear		Red single
NI-6	Aralvaimozhi		Linear		White single
NI-7	Aralvaimozhi		Narrow oblong		Red single
NI-8	Kumarapuram		Linear		White single
NI-9	Kumarapuram		Linear		Ivory single
NI-10	Kumarapuram		Linear		Red single
NI-11	Thazhakudy		Linear		Red single
NI-12	Thazhakudy	Greyish-green	Oblong		Red double
NI-13	Rasipuram	Greyish-green	Oblong		Pink double
NI-14	Rasipuram	Green	Linear		White single
NI-15	Rasipuram		Linear		Red and Pink mix single
NI-16	Salem		Linear		Pink single
NI-17	Salem		Linear		Ivory single
NI-18	Azhaganapuram	Greyish-green	Narrow oblong		Pink double
NI-19	Azhaganapuram	Green	Linear		Red single
NI-20	Kulasekaran pudhur	Greyish-green	Linear		Red and Pink mix single

Table 2. Evaluation of vegetative parameters in *Nerium* sp. accessions.

Accession No.	Plant height (cm)	No. of shoots/ plant	Plant spread in E-W (cm)	Plant spread in N-S (cm)	Inter-nodal length (cm)	Av. leaf length (cm)	Av. leaf width (cm)
NI-1	148.15	6.55	108.60	110.65	3.05	28.60	2.60
NI-2	123.60	5.15	97.85	76.65	3.25	18.40	2.05
NI-3	199.35	3.55	102.65	88.25	4.50	18.60	2.30
NI-4	143.25	6.50	103.50	111.50	3.30	21.60	2.70
NI-5	175.10	6.50	97.15	117.30	4.60	19.15	2.50
NI-6	137.15	6.50	103.80	105.50	2.60	25.35	3.25
NI-7	144.35	5.60	87.85	77.15	3.40	20.60	2.15
NI-8	129.50	7.00	107.85	115.40	3.60	24.15	3.00
NI-9	102.15	4.60	77.00	82.50	3.40	22.60	2.60
NI-10	132.60	6.00	100.40	71.75	4.30	24.60	2.60
NI-11	134.50	7.00	104.65	99.50	3.60	19.15	2.60
NI-12	149.50	3.40	59.50	74.65	3.10	17.40	2.40
NI-13	209.25	5.15	100.50	97.25	4.00	17.85	3.00
NI-14	137.50	6.40	92.85	91.35	3.15	19.15	2.05
NI-15	190.40	4.40	97.00	84.85	4.10	19.15	2.60
NI-16	162.25	7.40	118.15	123.85	4.00	19.60	2.10
NI-17	112.35	3.40	67.65	77.25	3.10	17.85	2.40
NI-18	139.15	4.85	77.40	58.65	4.00	17.85	2.40
NI-19	133.35	5.15	79.85	94.65	4.00	21.85	2.70
NI-20	140.50	4.85	88.65	80.65	4.70	18.85	3.00
Mean	140.37	5.42	90.46	87.88	3.73	20.44	2.56
SE d	0.35	0.24	0.15	1.23	0.11	0.10	0.10
CD at 5%	0.72	0.49	0.32	2.55	0.23	0.22	0.21
CD at 1%	0.98	0.67	0.44	3.47	0.31	0.29	0.29

NI-1, NI-2, NI-3 - Beemanahari; NI-4 - Santhavilai; NI-5 - Thirupathisaram; NI-6, NI-7 - Aralvaimozhi; NI-8, NI-9, NI-10 - Kumarapuram; NI-11, NI-12 - Thazhakudy; NI-13, NI-14, NI-15 - Rasipuram; NI-16, NI-17 - Salem; NI-18, NI-19 - Azhaganapuram; NI-20 – Kulasekaranpudur

green, whereas double-flowered accessions were greyish-green. The leaf shapes include narrow oblong (NI-3, NI-4, NI-7, NI-18), oblong (NI-12 and NI-13), and leaf shape (NI-1, NI-2, NI-5, NI-6, NI-8, NI-9, NI-10, NI-11, NI-14, NI-15, NI-16, NI-17, NI-19, NI-20). The leaf texture was found to be leathery in all the accessions, consistent with observations in rose (Singh *et al*., 18) and hibiscus (Seeruttum and Ranghoo-Sanmukiya, 15).

The genetic composition of the cultivar and the influence of agroclimatic conditions highlighted in Table 3 likely contribute to the variation in yield characteristics. The additive impact of genes may explain the varietal differences in yield potential. Improved morphological features, such as increased plant height, leaf count, and expanded leaf area, could be the underlying factors driving higher yields. This observation aligns with findings in other plant species, including Dahlia (Gupta *et al*., 5), China aster (Tirakannanavar *et al*., 19), chrysanthemum (Rajiv *et al*., 12), crossandra (Ramachandrudu and Thangam, 11), and rose (Shahrin *et al*., 17).

The study evaluated 20 *nerium* accessions across 13 characteristics, noting wide variations in traits like plant height (102.15-209.25 cm), spread (East-West) (59.50-118.15 cm), and flower yield (2.50-4.10) (GCV: 4.95 to 73.31%, PCV: 5.55 - 73.41%). Phenotypic coefficients varied widely; individual flower weight (73.41%), spikes per plant (30.42%), and shoots per plant (22.63%) showed high variability. Moderate variability appeared in traits like plant spread (North-South), plant height, and flowering initiation days. Flower retentivity and length displayed the lowest variability (7.29 and 5.55%,

Table 3. Evaluation of yield parameters of *Nerium* sp. accessions.

Accession No.	Days for flower bud initiation	No. of flowers/ spike	Flower length (cm)	Individual flower weight (g)	Flower yield/ plant/year (kg)	Flower retentivity on plant (days)
NI-1	95.50	18.15	4.30	0.26	4.05	3.25
NI-2	105.85	12.15	4.00	0.36	3.10	2.75
NI-3	99.15	5.60	4.20	0.96	2.55	2.75
NI-4	92.85	14.15	4.30	0.33	3.35	3.05
NI-5	110.50	12.15	3.90	0.31	3.35	2.75
NI-6	115.50	10.60	4.00	0.26	3.15	2.75
NI-7	117.35	9.60	4.50	0.36	3.15	3.05
NI-8	129.85	8.60	4.10	0.30	3.10	2.75
NI-9	130.50	10.60	4.00	0.21	2.50	2.75
NI-10	142.75	12.15	4.10	0.33	3.05	3.05
NI-11	125.35	10.25	4.40	0.33	3.15	3.05
NI-12	137.15	6.85	4.10	0.76	3.05	2.75
NI-13	66.60	10.15	4.25	0.90	2.50	3.05
NI-14	106.00	8.15	4.00	0.29	2.65	3.00
NI-15	95.50	16.60	4.00	0.35	4.10	3.20
NI-16	78.25	14.15	4.70	0.33	3.60	3.15
NI-17	126.50	9.15	3.90	0.33	2.50	3.00
NI-18	118.00	6.60	4.10	0.75	2.60	2.70
NI-19	130.75	8.00	4.40	0.32	3.00	2.50
NI-20	120.75	10.40	4.00	1.66	3.55	3.15
Mean	112.23	10.70	4.16	0.48	3.10	2.92
SE d	0.35	0.20	0.02	0.01	0.07	0.06
CD at 5%	0.73	0.41	0.03	0.01	0.16	0.13
CD at 1%	1.00	0.56	0.05	0.02	0.21	0.18

NI-1, NI-2, NI-3 - Beemanahari; NI-4 - Santhavilai; NI-5 - Thirupathisaram; NI-6, NI-7 - Aralvaimozhi; NI-8, NI-9, NI-10 - Kumarapuram; NI-11, NI-12 - Thazhakudy; NI-13, NI-14, NI-15 - Rasipuram; NI-16, NI-17 -Salem; NI-18, NI-19 - Azhaganapuram; NI-20 - Kulasekaranpudhur

respectively). Heritability estimates were notably high (79.64 to 99.74%) for several traits, suggesting robust genetic control with limited environmental influence (Fig. 1).

Traits exhibiting high heritability also demonstrated substantial genetic advances as a percentage of the mean, ranging from 26.53 to 62.20%. However, traits with low genetic advances despite high heritability implied the presence of non-additive gene effects, making the selection process less rewarding. Conversely, traits with low heritability yet significant genetic advances suggested cumulative gene effects, indicating the potential for effective selection. These findings align with prior research conducted on various plants, including China aster (Tirakannanavar *et al*., 19), crossandra (Ramachandrudu and Thangam, 11), rose (Shahrin *et al*., 17), and nerium (Rajiv *et al*., 13).

Principal Component Analysis (PCA) of 20 entries predicated on 13 growth and yield traits delineated four principal components (PCs), cumulatively explaining 75.44% of the total variation. PC1 (34.08%) was influenced by traits like yield/plant/year, spikes, shoots, and plant spread. PC2 (19.81%) featured plant height, internode length, and flower weight. PC3 (11.16%) was shaped by leaf dimensions and flower weight, while PC4 (10.40%) was defined by shoots and plant spread. The analysis reveals high genetic diversity among accessions, with traits like plant height, shoots, spread, spikes, yield, and leaf dimensions contributing to total variation and PCA serves as an accurate measure (Table 5).

The field performance of 20 *Nerium* sp. accessions was depicted in cluster analysis using 13 vegetative and yield traits, resulting in four main groups (Fig. 2).

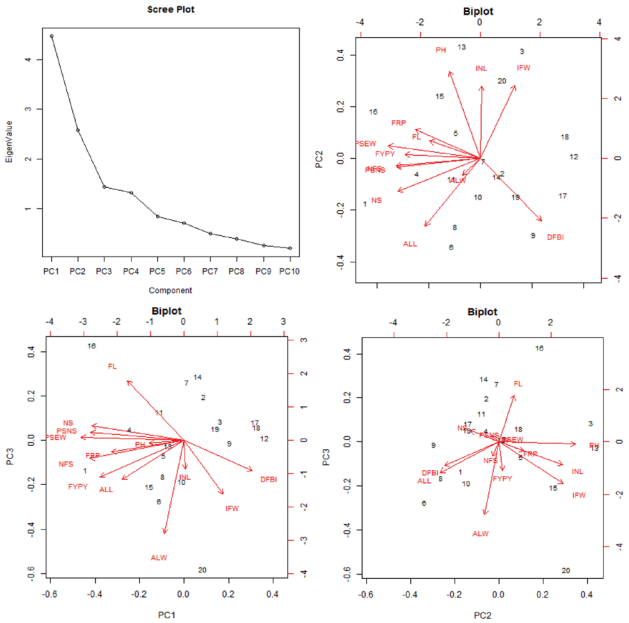

Fig. 1. Screen plot and Biplots for PCA of agro-morphological and yield traits in *Nerium* sp. accessions.

Cluster II had the maximum number of accessions (10), followed by Cluster III (4), Cluster IV (4), and Cluster I (2). Cluster means of various traits in Nerium accessions are shown in (Table 6 and Fig. 2). Grouping for several characteristics, Cluster I showed greater mean values, including plant height, shoots per plant, spread (E-W and N-S), internode length, average leaf length, spikes per flower, flower length, yield, and flower retention. Cluster II lacked predominant mean trait values, while Cluster III excelled in internode length and individual flower weight. Cluster IV showcased superior mean traits in average leaf width and flowering initiation days. The analysis indicated strong clustering (cophenetic correlation value: 0.705), offering insights into creating crops with higher mean values by utilizing respective germplasms. This clustering approach aids in selecting

Table 4. Performance of different *Nerium* sp. accessions based on genetic parameters.

Genetic parameter	PCV	GCV	h^2	GAM
Plant height (cm)	18.85	18.68	98.17	38.13
No. of shoots/ plant	22.63	22.49	98.79	46.05
Plant spread in E-W (cm)	16.02	15.79	97.14	32.06
Plant spread in N-S (cm)	19.44	19.23	97.80	39.17
Inter-nodal length (cm)	16.06	15.86	97.44	32.24
Av. leaf length (cm)	14.93	14.67	96.53	29.69
Av. leaf width (cm)	13.39	13.13	96.19	26.53
Days for flower bud initiation	17.86	17.60	97.12	35.72
No. of flower/ spike	30.42	30.31	99.27	62.20
Flower length (cm)	5.55	4.95	79.64	9.10
Individual flower weight (g)	73.41	73.31	99.74	50.83
Flower retentively in plant (days)	7.29	6.99	92.12	13.83
Flower yield/ plant/ year (kg)	15.54	15.34	97.45	31.19

PCV: Phenotypic Coefficient of Variation; GCV: Genotypic Coefficient of Variation; H2: Heritability; GAM: Genetic Advance as Per cent of Mean

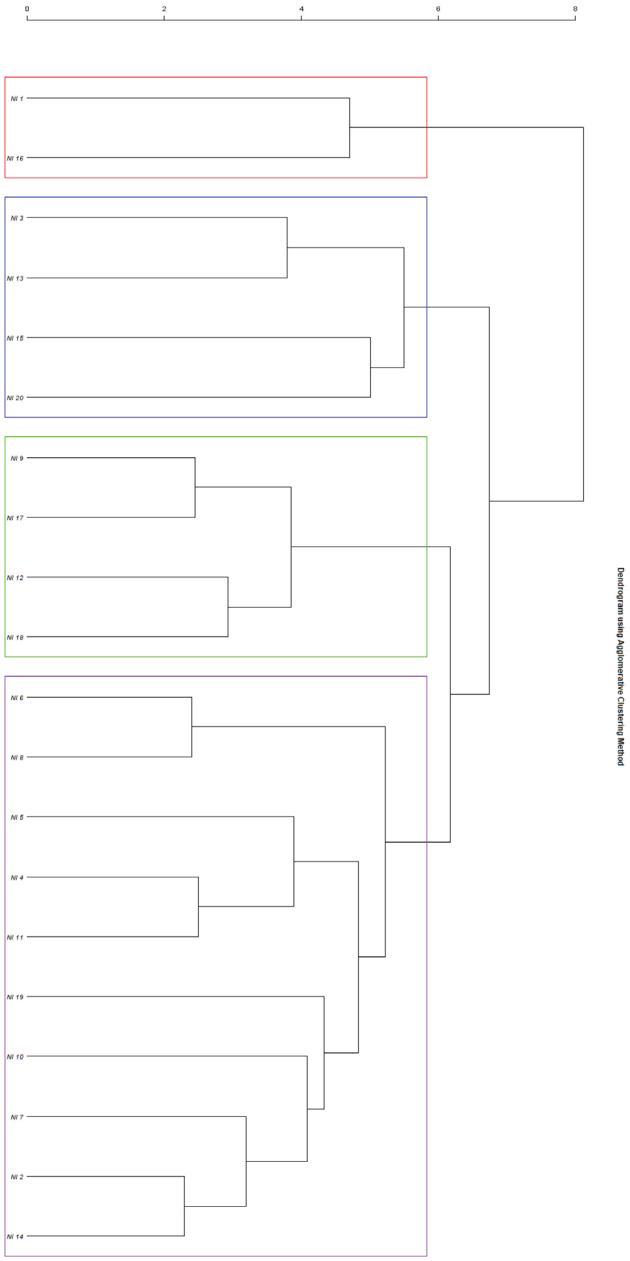

Fig. 2. Cluster analysis dendrogram based on agglomerative for *Nerium* sp. accessions.

Table 5. Eigen vectors for the four principal components from PCA of agro-morphological and yield traits in *Nerium* sp. accessions.

Trait	PC1	PC2	PC3	PC4
Plant height	0.282	0.818	0.043	0.161
No. of shoots	0.769	-0.304	-0.041	0.324
Plant spread (E-W)	0.857	0.127	0.033	0.273
Plant spread (N-S)	0.780	-0.069	0.053	0.426
Internode length	-0.025	0.686	0.291	0.136
Leaf length	0.521	-0.622	0.347	0.001
Leaf width	0.159	-0.108	0.872	0.196
Days taken for flower bud initiation	-0.566	-0.582	0.259	-0.075
No of spikes	0.795	-0.062	0.045	-0.519
Flower length	0.471	0.137	-0.447	0.272
Flower weight	-0.334	0.694	0.413	-0.052
Yield/ plant/ year	0.709	0.046	0.186	-0.463
Retentivity	0.575	0.281	-0.062	-0.585
Eigenvalues	4.430	2.575	1.451	1.351
% total variance	34.08	19.81	11.16	10.40
% cumulative variance	34.08	53.89	65.04	75.44

Table 6. Clustering in *Nerium* sp. germplasm.

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

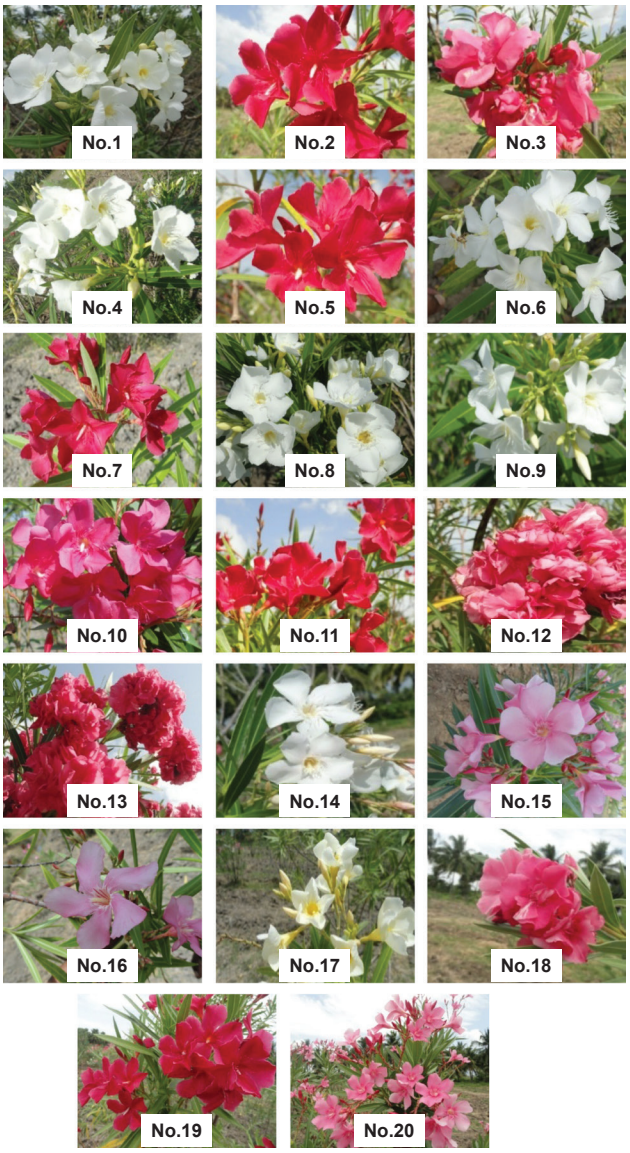

Fig. 3. Variability in *Nerium* sp. accessions evaluated.

optimal accessions for nerium breeding programs, leveraging natural mutations and location effects influencing vegetative and yield parameters. Breeders can choose nerium parents by examining the colour and usage classifications of twenty accessions. Due to low environmental impact, high genetic progress in thirteen traits was observed in accessions NI-1, NI-6, NI-13, NI-15, and NI-16.

The investigation delves into the variation in nerium accessions by colour and focuses on growth and yield performance. The genetic variability of these accessions is crucial for genetic improvement and high-yielding accessions. The study found that accessions with high coefficients of variation, heritability, and genetic advance showed better performance in all quantitative traits. The PCA analysis identified plant height, shoot number, plant spread, internode length, spike number, yield, flower weight, and leaf width as highly contributing traits for total variation. Further molecular characterization is essential for *nerium* crop improvement programs.

AUTHORS' CONTRIBUTION

Conceptualization of research (AK); Designing of the experiments (AK, JJ); Contribution of experimental materials (AK, JJ); Execution of field/lab experiments and data collection (AK, BS); Analysis of data and interpretation (BS, KE, SV); Preparation of the manuscript (KE, SV).

DECLARATION

The authors declare that they do not have any conflict of interest.

REFERENCES

1. Albornoz, A., Fernandez, M., Vilchez, J., Fernandez, C. and Martinez, L. 2014. Effect of paclobutrazol on growth oleander (*Nerium oleander* L.) plant in nursery. *Rev. Fac. Agron. Jun*. **31**: 301-11.
2. Barrios, B. and Koptur, S. 2011. Floral biology and breeding system of *Angadenia berteroi* (Apocynaceae). *Int. J. Plant Sci.* **172**: 378-85.
3. Burton, G.W. 1952. Quantitative inheritance in grasses. *Proc. VI Int. Grassland Congress,* 1952, pp. 277-283.
4. Choudhary, M., Beniwal, B.S. and Kumari, A. 2014. Evaluation of marigold genotypes under semi-arid conditions of Haryana. *Ann. Hortic.* **7**: 30-35.
5. Gupta, A.K., Jaiswal, N.K. and Saravanan, S. 2015. Varietal evaluation of different hybrids of dahlia (*Dahlia variabilis* L.) under Allahabad agro-climatic conditions. *Int. J. Agric. Sci. Res.* **5**: 55-58.
6. Herrera, J. 1991. The reproductive biology of a riparian Mediterranean shrub, *Nerium oleander* L. (Apocynaceae). *Bot. J. Linn.* **106**: 147-72.
7. Henny, T., Palai, S.K., Beura, S., Chongloi, L., Devi, O.B. and Mishra, S. 2021. Evaluation and selection of spray chrysanthemum (*Chrysanthemum morifolium* Ramat.) genotypes suitable for commercial cultivation under coastal plain zone of Odisha. *Pharma Innov.* **10**: 124-26.
8. Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybeans. *Agron. J.* **47**: 314-18.
9. Kiran, C. and Prasad, D.N. 2014. A review on: *Nerium oleander* Linn. (Kaner). *International Int. J. Pharmacogn. Phytochem.* **6**: 593-97.
10. Kobayashi, K.D., McConnell, J. and Griffis, J. 2007. Bougainvillea. Honolulu (HI): University of Hawaii, USA, 12 p.
11. Ramachandrudu, K. and Thangam, M. 2010. Characterization and evaluation of local germplasm of crossandra (*Crossandra undulaefolia* Salisb.). *J. Orn. Hortic.* **3**: 138-41.
12. Rajiv, K. 2014. Evaluation of chrysanthemum genotypes for flowering traits under open grown condition. *HortFlora Res. Spec.* **3**: 388-89.
13. Rajiv, G., Allen, J.J. and Ganesh, S. 2022. Diversity assessment of *Nerium* accessions for growth and flower yield. *J. Hortic. Sci.* **17**: 543-48.
14. Samanta, D., Lahiri, K., Mukhopadhyay, M.J. and Mukhopadhyay, S. 2015. Karyomorphological analysis of different varieties of *Tabernae montana coronaria*. *Cytologia*, **80**: 67-73.
15. Seeruttum, B. and Ranghoo-Sanmukiya, V.M. 2013. Molecular characterization of some *Hibiscus* species cultivated in Mauritius. *Int. J. Life Sci. Biotechnol.* **2**: 358-66.
16. Sharova, N.L., Rybak, Y.G. and Marins, W.E. 1977. Development of gladiolus under the influence of micronutrients. *Kishinev, Moldavian SSR, Stiinca*, 11-17.
17. Shahrin, S., Roni, M.Z.K., Taufique, T., Mehraj, H. and Uddin, A.F.M. 2015. Study on flowering characteristics and categorization of rose cultivars for color, fragrance and usage. *J. Biosci. Agric. Res.* **4**: 20-30.
18. Singh, A.K. 2006. Effect of farmyard manure, *Azotobacter* and nitrogen on leaf nutrient composition, growth, flowering and yield in rose. *Indian J. Hortic.* **63**: 62-65.
19. Tirakannanavar, S., Katagi, A., Jagadeesha, R.C. and Halesh, G.K. 2015. Studies on genotypic evaluation and correlation studies in China aster (*Callistephus chinensis* (L.) Nees). *Indian Res. J. Genet. Biol.* **7**: 179-86.
20. Yadav, C.S.P.D., Bharadwaj, N.S.P., Yedukondalu, M., Methushala, C.H. and Kumar, R. 2013. Phytochemical evaluation of *Nyctanthes arbor tristis*, *Nerium oleander* and *Catharathnus roseus*. *Ind. J. Res. Pharm. Biotechnol*. **1**: 333-38.
21. Zosiamliana, J.H., Reddy, G.S.N. and Rymbai H. 2013. Study on the performance of some varieties of China aster (*Callistephus chinensis* Ness.) in Andhra Pradesh. *Prog. Hortic.* **45**: 312-16.

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