



Assessment of variability in water lily (*Nymphaea* spp.)

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Abstract

Twelve accessions of water lily (*Nymphaea* spp.) differing in flower colour and opening time were selected from diverse locations of the water lily growing tracts of Thrissur district. These accessions were evaluated based on the width as well as length of leaf lamina, length of notch on lamina, length of mature flower bud, circumference of mature flower bud, diameter of fully opened flower, number of petals and number of stigmatic appendages in the flower. The study revealed that there was significant variability among the accessions for all the characters evaluated. DMRT was carried out and the accessions were grouped taking diameter of fully opened flower as well as the size of mature flower bud as the decisive characters for grouping. Significant correlations were observed between flower size and leaf size as well as flower size and length of mature flower bud. Hence, leaf size can be taken as an indicator of the flower size of the accession. Selection programmes based on length of lamina will be effective in improving the population, since PCV, GCV, H^2 and GG were the highest for this character.

Keywords: Variability, *Nymphaea*, Water lily

Nymphaea, commonly known as water lily, is the largest and most diverse genus in the family Nymphaeaceae. There are about seventy species in this genus and are distributed in all the continents except Antarctica (Lohne *et al.*, 2008). Water lily, important in aquatic landscaping, is ornamentally valued and economically viable as a vegetable as also a source of medicinal compounds (Huang *et al.*, 1997). The members of this genus are aquatic perennials with erect or horizontal underground stems. They are also characterized by the presence of floating, elliptic to orbicular leaf blades with a saggitate base. The solitary flowers are emergent with many sepals, petals, stamens and carpels. Anthesis is diurnal or nocturnal depending on the species (Lima *et al.*, 2012). A combination of characters like flower bud size, flower size, flower colour, frequency of flowering and periodicity of flowering are considered to be decisive in the selection of water lily as an ornamental plant (Dassanayake, 1996). It was in this background the present study was undertaken to assess the variability among twelve accessions of water lily.

Twelve accessions of water lily (*Nymphaea* spp.) differing in flower colour and opening time, collected from diverse locations of the water lily growing tracts of Thrissur district (Fig 1a to 1f) formed the material for the study. All the selected accessions were grown

in cement tanks of uniform size. Uniform water level was also maintained in all the tanks. The experiment was carried out in completely randomized design (CRD) with five replications each. These accessions were evaluated based on leaf and floral characters. The width as well as length of lamina and length of notch on the lamina were the leaf characters considered for evaluation. The leaf width was measured at the widest point of lamina across the notch. The leaf length was taken as the length from the notch to the tip of leaf. The floral characters considered for evaluation were length of mature flower bud, circumference of mature flower bud, diameter of fully opened flower, number of petals and number of stigmatic appendages. Observations on the various biometric characters of leaf were taken from five fully developed leaves in each replication of each accession. Five flower buds from each replication of each accession were observed for recording floral characters.

Data collected were subjected to ANOVA (CRD) and Duncan's Multiple Range Test was used for mean comparison and grouping. The phenotypic and genotypic variance were estimated according to the methods suggested by Burton and De Vane (1953) and these components of variance were used for the estimation of coefficients of variation (PCV, GCV) as described by Singh and Chaudhary (1977). Heritability and expected genetic advance ($K=2.06$ at 5% selection intensity) were computed for each

character based on the formula developed by Allard (1960).

The analysis of variance was done for each of the characters observed in different accessions. The post hoc test *viz.*, Duncan's Multiple Range Test (DMRT) was also carried out and the subgroups obtained for the different characters are presented in Table 1. From Table 1, it is evident that the accessions differed significantly for all the characters evaluated. A character wise review reveals that the subgroups for the different characters under study were more or less uniform as regards their composition.

Grouping of the accessions were done based on the results of the post hoc test, DMRT, for the two most decisive characters of water lily in ornamental gardening i.e. diameter of fully opened flower as well as the size of mature flower bud as indicated by its length and circumference. With these decisive characters, a rationale for the exclusive identification and reconstruction of the subgroups without overlapping was achieved. Whenever there was an ambiguity regarding the assignment of an accession into a particular subgroup *i.e.*, when the same fell in another subgroup also, assignment was made with respect to the remaining characters. The groups formed in such a way, along with the accessions falling in each subgroup, are presented in Table 2. The groups I and II included only one accession each. The group IV was the biggest one with six members. The summary statistics *viz.*, range, mean, standard deviation and coefficient of variation (CV) were computed group wise and the results are presented in Tables 3a to 3h.

The flower size as indicated by the mean diameter of the flower was the highest in group I and the lowest in group V. The mean diameter of the flowers ranged from 12 to 15 cm with a standard deviation of 1.26 cm in group I and the same decreased to a range of 5 to 6.1 cm with a respective standard deviation of 0.36 cm in group V (Table 3a). The length of flower bud ranged from 6.20 to 7.00 cm in group I with a mean value of 6.56 cm and 3.10 to 6.70 cm in group V with a mean value of 5.11 cm (Table 3b). The circumference of flower bud was ranging from 7.20 to 8.20 cm in group I. The range was the lowest in group II (6.50 to 7.00 cm). The intra group variability for length of flower bud was the highest (29.5%) in group V (Table 3b).

With respect to circumference of flower bud, the highest intra group variability (10.7%) was exhibited by group IV (Table 3c). The group I recorded the highest mean petal number of 23 and group IV recorded the lowest value of 17 (Table 3d). The mean number of stigmatic appendages was the highest in group II and the lowest in group V (Table 3e). The highest intra group variability for number of petals was exhibited by group III and for number of stigmatic appendages was exhibited by group II (Table 3e).

The width of lamina ranged from 22.40 to 25.00 cm in group I, 17.70 to 18.70 in group II, 14.40 to 21.20 cm in group III, 5.60 to 21.00 cm in group IV and 12.10 to 16.40 in group V (Table 3f). The length of lamina showed a range of 13.20 to 14.50 cm in group I, 9.50 to 11.40 cm in group II, 8.20 to 12.00 cm in group III, 4.20 to 13.20 cm in group IV and 7.80 to 10.50 cm in group V with the highest mean value in group I (Table 3g). The width and length of lamina were the highest in group I and the lowest in group IV (Table 3f and 3g). The range observed for notch length was 11.00 to 12.40 cm in group I, 8.00 to 9.50 cm in group II, 6.50 to 9.30 cm in group III, 3.30 to 10.50 cm in group IV and 5.00-6.60 cm in group V. The notch length was the highest in Group I and the lowest in group V (Table 3h). The intra group variability for width and length of lamina as well as length of notch were the highest in group IV.

The ratio of flower diameter to length of mature flower bud as well as circumference of mature flower bud in the five different groups is presented in Table 4. There was a steady decline in the flower diameter : bud length ratio from group I to group V. Similar pattern was observed in the ratio of flower diameter to width as well as length of lamina (Table 5). From the results it can be seen that there is correlation between leaf size (width and length of lamina) and flower size as well as flower bud length and flower size. This points to the fact that lamina size is indicative of flower size in water lily.

The descriptive statistics *viz.*, mean, range, standard deviation (SD), heritability (H^2), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), genetic advance (GA) and genetic gain (GG) were also computed and are presented in Table-6. From the Table, it is clear that all the characters evaluated expressed high heritability indicating that proportion of genetic component is high for these characters and selection

can be safely exercised. PCV and GCV were high for the character lamina length. Moderate PCV and GCV were observed for lamina width, notch length, diameter of flower and number of stigmatic appendages. The circumference of bud and petal number exhibited low PCV and GCV. The bud length recorded moderate PCV and low GCV. Genetic gain was high for the characters like lamina width, lamina length, notch length, diameter of flower bud and number of stigmatic appendages. Moderate genetic gain was observed for the characters bud length, circumference of bud and number of petals. Among

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the characters considered for evaluation, length of lamina showed the highest GCV (28.53%), heritability (99%) and genetic gain (58.55%) indicating its scope in selection programmes (Table 6). This can bring about more than 50% improvement in the population.

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Table 1. Mean values of various characters in different accessions of water lily

Accession No.	Lamina width (cm)	Lamina length (cm)	Notch length (cm)	Flower bud length (cm)	Flower bud circumference (cm)	Flower bud diameter (cm)	Petal number	Number of stigmatic appendages
1	14 (3.8 ^{fg})	8.82 (3.05 ^{ef})	6.44 (2.63 ^d)	3.66 (2.04 ^e)	4.448 (2.23 ^{ef})	6.12 (2.57 ^{def})	17.20 (4.28 ^{bc})	17.80 (4.20 ^d)
2	19.56 (4.48 ^c)	12.26 (3.57 ^b)	9.34 (3.14 ^b)	4.26 (2.18 ^{cd})	4.84 (2.31 ^{de})	6.62 (2.67 ^d)	13.60 (4.11 ^c)	16.40 (3.74 ^{ef})
3	14.66 (3.89 ^{efg})	9.56 (3.17 ^{de})	6.56 (2.65 ^d)	4.12 (2.15 ^{cd})	5.16 (2.38 ^{cd})	6.16 (2.58 ^{def})	19.20 (4.00 ^c)	17.00 (4.44 ^{cd})
4	23.68 (4.92 ^a)	13.98 (3.80 ^a)	11.82 (3.51 ^a)	6.56 (2.66 ^a)	7.82 (2.88 ^a)	14.16 (3.83 ^a)	23.00 (4.32 ^{bc})	18.20 (4.85 ^a)
5	18.06 (4.31 ^d)	10.72 (3.35 ^c)	8.82 (3.05 ^b)	5.28 (2.40 ^b)	6.70 (2.68 ^b)	9.50 (3.16 ^b)	20.40 (5.06 ^a)	25.20 (4.57 ^{bc})
6	6.10 (2.57 ^c)	4.24 (2.18 ^h)	3.58 (2.02 ^f)	3.96 (2.11 ^{de})	4.24 (2.18 ^f)	5.98 (2.54 ^{def})	13.00 (3.94 ^c)	15.00 (3.67 ^f)
7	12.040 (3.54 ^h)	7.46 (2.82 ^g)	5.42 (2.43 ^e)	4.14 (2.15 ^{cd})	4.50 (2.24 ^{ef})	6.42 (2.63 ^{de})	18.60 (4.28 ^{bc})	17.80 (4.37 ^{cd})
8	20.70 (4.60 ^b)	11.18 (3.42 ^c)	9.10 (3.09 ^b)	5.12 (2.37 ^b)	5.50 (2.45 ^c)	8.20 (2.95 ^c)	20.20 (4.76 ^{ab})	22.20 (4.55 ^{bc})
9	14.96 (3.93 ^{efg})	8.52 (3.00 ^f)	6.64 (2.67 ^d)	4.42 (2.22 ^c)	5.32 (2.41 ^c)	7.52 (2.83 ^c)	15.20 (4.32 ^{bc})	18.20 (3.96 ^c)
10	15.16 (3.96 ^e)	9.76 (3.20 ^d)	7.32 (2.80 ^c)	3.62 (2.03 ^e)	5.36 (2.42 ^c)	6.32 (2.61 ^{def})	20.40 (4.30 ^{bc})	18.00 (4.57 ^{bc})
11	15.68 (4.02 ^e)	9.60 (3.18 ^{de})	6.52 (2.65 ^d)	6.52 (2.65 ^a)	5.46 (2.42 ^c)	5.60 (2.47 ^f)	21.80 (3.11 ^d)	9.20 (4.72 ^{ab})
12	13.74 (3.77 ^g)	9.30 (3.12 ^{de})	5.54 (2.45 ^e)	3.70 (2.05 ^e)	5.22 (2.40 ^{cd})	5.74 (2.50 ^{ef})	23.40 (3.11 ^d)	9.20 (4.89 ^a)

*(Values in parenthesis indicate square root transformed values)

Table 2. Groups obtained and members in each group

Groups	Accessions
Group I	Accession 4
Group II	Accession 5
Group III	Accession 8, Accession 9
Group IV	Accession1, Accession 2, Accession 3, Accession 6, Accession 7, Accession 10
Group V	Accession 11, Accession12

Table 3a. Descriptive statistics for flower diameter in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	12.00	15.00	14.16	1.26	8.90
Group II	8.00	10.00	9.50	0.87	9.10
Group III	7.30	8.60	7.86	0.42	5.30
Group IV	5.00	7.50	6.27	0.55	8.80
Group V	5.00	6.10	5.67	0.36	6.30

Table 3b. Descriptive statistics for length of flower bud in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	6.20	7.00	6.56	0.33	5.00
Group II	5.10	5.50	5.28	0.16	3.00
Group III	4.10	5.40	4.77	0.46	9.60
Group IV	3.20	4.70	3.96	0.37	9.30
Group V	3.10	6.70	5.11	1.51	29.50

Table 3c. Descriptive statistics for circumference of flower bud in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	7.20	8.20	7.82	0.41	5.24
Group II	6.50	7.00	6.70	0.19	2.83
Group III	5.00	6.00	5.41	0.28	5.20
Group IV	3.90	5.60	4.76	0.51	10.70
Group V	5.10	5.90	5.34	0.22	4.10

Table 3d. Descriptive statistics for petal number in different groups of water lily

Groups	Range		Mean	Standard deviation	CV (%)
	Minimum	Maximum			
Group I	22	24	23	1.00	4.30
Group II	17	24	20.4	2.51	12.50
Group III	13	21	17.70	2.79	15.70
Group IV	12	22	17	0.32	1.90
Group V	20	24	22.60	1.51	6.70

Table 3e. Descriptive statistics for number of stigmatic appendages in different groups of water lily

Groups	Range		Mean	Standard deviation	CV (%)
	Minimum	Maximum			
Group I	16	19	18.20	1.30	7.10
Group II	19	28	25.20	3.70	14.70
Group III	16	23	20.20	2.53	12.50
Group IV	15	22	17.63	2.04	11.60
Group V	8	10	9.20	0.63	6.80

Table 3f. Descriptive statistics for lamina width in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	22.44	25.00	23.68	1.08	4.56
Group II	17.70	18.70	18.06	0.39	2.20
Group III	14.40	21.20	17.83	3.05	17.10
Group IV	5.60	21.00	13.59	4.17	30.70
Group V	12.10	16.40	14.71	1.43	9.72

Table 3g. Descriptive statistics for lamina length in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	13.20	14.50	13.98	0.60	4.30
Group II	9.50	11.40	10.72	0.74	6.90
Group III	8.20	12.00	9.85	1.46	16.20
Group IV	4.20	13.20	8.68	2.54	29.30
Group V	7.80	10.50	9.45	0.80	8.46

Table 3h. Descriptive statistics for notch length in different groups of water lily

Groups	Range (cm)		Mean (cm)	Standard deviation (cm)	CV (%)
	Minimum	Maximum			
Group I	11.00	12.40	11.82	0.60	5.10
Group II	8.00	9.50	8.82	0.61	6.90
Group III	6.50	9.30	7.87	1.31	16.60
Group IV	3.30	10.50	6.44	1.84	28.60
Group V	5.00	6.60	6.03	0.72	11.90

Table 4. Ratio of flower diameter to bud length and circumference in different groups

Groups	D/BL ratio	D/BC ratio
Group I	2.16	1.81
Group II	1.80	1.42
Group III	1.65	1.45
Group IV	1.58	1.31
Group V	1.11	1.06

D - Diameter of flower BL - Bud length BC – Circumference of bud

Table 5. Ratio of flower diameter to width and length of lamina in different groups

Groups	D/WL	D/LL
Group I	0.60	1.01
Group II	0.53	0.89
Group III	0.44	0.80
Group IV	0.46	0.72
Group V	0.39	0.60

D - Diameter of flower WL – Width of lamina LL – Length of lamina

Table 6. Descriptive statistics for various characters of water lily accessions

Character	Mean	Range		SD	PCV (%)	GCV (%)	H ² (%)	GG (%)
		Minimum	Maximum					
Lamina width (cm)	3.98	2.57	4.92	0.58	15.12	14.91	97	30.25
Lamina length (cm)	3.16	2.18	3.81	0.40	28.67	28.53	99	58.55
Notch length (cm)	2.76	2.02	3.51	0.39	14.54	14.17	95	28.37
Length of flower bud (cm)	2.25	2.03	2.66	0.22	10.23	9.83	93	19.49
Circumference of flower bud (cm)	2.42	2.18	2.88	0.20	8.47	8.06	91	15.80
Diameter of flower (cm)	2.78	2.47	3.83	0.39	14.34	13.84	93	27.54
Petal number	4.38	3.67	4.89	0.42	9.95	9.07	83	17.07
No. of stigmatic appendages	4.13	3.11	5.06	0.67	16.53	12.93	61	20.81

*PCV & GCV (Sivasubramanian and Menon, 1973) - Low: less than 10%, Moderate: 10-20%, High: more than 20%

*H² (Johnson *et al.*, 1955) - Low: less than 30%, Moderate: 30-60%, High: more than 60%

*GG (Johnson *et al.*, 1955) - Low: less than 10%, Moderate: 10-20%, High: more than 20



Fig. 1a. Accession 1 and 2

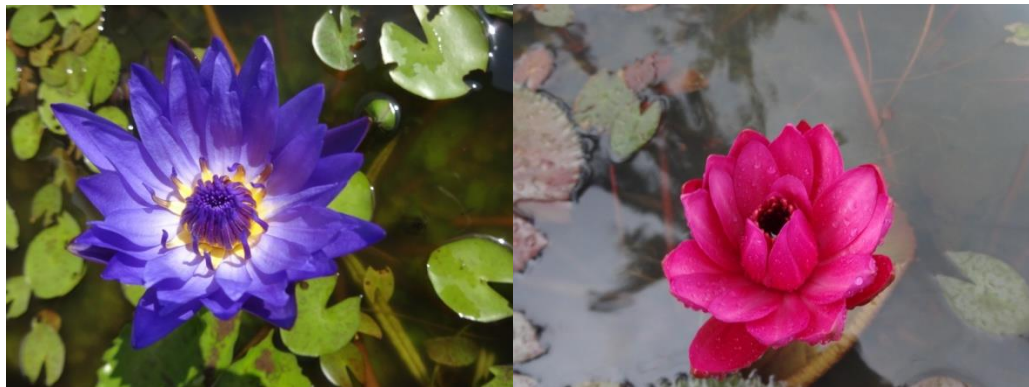


Fig. 1b. Accession 3 and 4



Fig. 1c. Accession 5 and 6



Fig. 1d. Accession 7 and accession 8



Fig. 1e. Accession 9 and accession 10

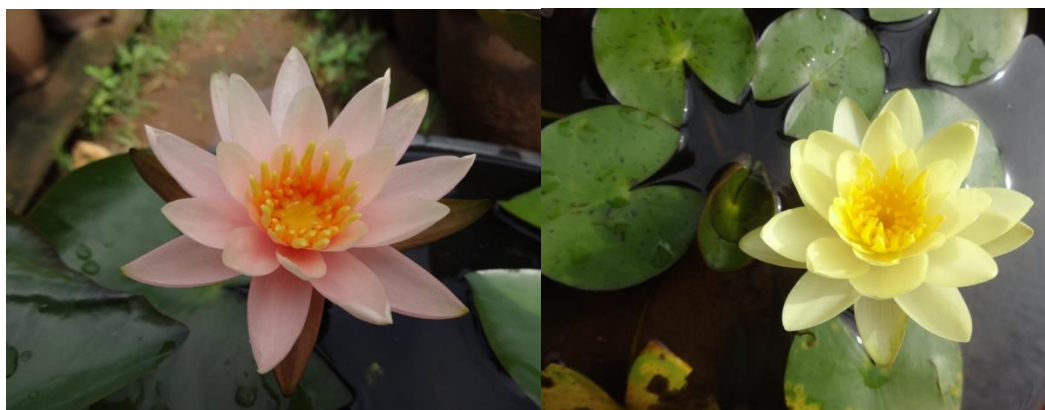


Fig. 1f. Accession 11 and accession 12