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Genetic variability, Correlation and Path analysis studies in thirty *Hibiscus rosa-sinensis* L. genotypes for yield and its attributes

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Abstract
Thirty *Hibiscus rosa-sinensis* L. genotypes were evaluated for their morphological and yield attributes. Mean, Range, Co-efficient of variation (Phenotypic and Genotypic), heritability, correlation (Phenotypic and Genotypic), path analysis (Direct and indirect) were calculated for vegetative, flowering and yield parameters for all *Hibiscus rosa-sinensis* L**.** 30 accessions. Similarly, High heritability was observed for the characters, plant height (cm), number of primary and secondary branches/plant, leaf area (cm^2), chlorophyll (SPAD value), days to bud initiation, days taken for flowering, flower longevity(Hrs.), pedicel length (cm), petal length (cm), petal width (cm), style length (cm) and shelf life (Hrs.). In the correlation, flower yield was positive and significantly correlated with plant height, number of primary branches, number of secondary branches, chlorophyll, petal length. Whereas, in path co-efficient analysis plant height, number of primary branches, petal length showed the positive direct effect on flower yield per plant per year.

Keywords: Hibiscus, Co-efficient of variation, heritability, correlation, path analysis

Introduction

The plant Japa kusuma botanically identified as *Hibiscus rosa-sinensis* Linn. of the family Malvaceae is a glabrous shrub widely cultivated in the tropics as an ornamental plant and has several forms with varying colors of flowers and grouped under minor flower crops. Accordingly, in Hindu Mythology Hibiscus grabbed the top position as they widely used in the worship of Hindu deities, especially Goddess Durga / Kali (Jijji *et al.*, 2019). In this day and age, flowers are not mere confined to the literature and worship, instead they ruling the international flower market. It may be cut flowers or loose flowers; they both have got immense value for their aesthetic value.

Besides all its mythological and historical views, Hibiscus is one of the most important indigenous flower and medicinal plant. It is one of the few flower crops which used as loose flower, hedge planning, pot culture, specimen planting, shrubbery, anthocyanins extraction, shampoo preparation, sweet and confectionary usages. Hibiscus cultivation has started in some parts of Tamilnadu due its immense value for its dried flower from international market. Hence, the variability existing in the Hibiscus genotypes has been assessed for their vegetative, flowering and flower yield traits, which would help the farmers to identify potential cultivars for commercial cultivation based on the market demand. A systematic planned cultivation and breeding programme would play a key role in solving some of the problems in the current breeding process, such as the need for the commercial exploitation of hybrid vigor, various morphological characters including vegetative and floral characters. This approach aimed to improve the selection process in diversified genetic pool for further breeding programme or would help in selecting the desirable parents for other breeding strategies. Considering all these points, the present investigations were taken up in thirty *H. rosa-sinensis* L. genotypes to measure the genetic variability, correlation between flower yield components and to know the extent to which they are associated with each other (path analysis).

Material and Methods

This study was carried out using three years old well developed Hibiscus plants. Thirty genotypes were selected, which were grown in open field condition at the Department of Floriculture and Landscape Architecture, College of Horticulture Bengaluru.

The experimental design used is Completely Randomized Block Design with two replications. In each replication treatments were randomly allotted. Plants were pruned back before starting the experiment. Weeding and fertilization were done regularly. Plant protection measures were followed when required during the crop growth period. Vegetative, flowering, flower yield and flower quality parameters were observed at regular interval and averages was worked out. The obtained data phenotypic coefficient of variation and genotypic coefficient of variation were calculated as suggested by Burton (1952). The heritability (h_2) in broad sense was calculated according to Webber and Moorthy (1952) [12] and expressed as percentage (%). And coefficient of correlation was estimated by as suggested by Al – Jibouri *et al.* (1958) [1]. Also, the direct and indirect effects of the important components, which are the standardized partial regression were followed from Dewey and Lu (1959) [3].

Result and Discussion

Significant treatment difference indicated appreciable amount of variability for all character studied in present investigation and all the genotypes used in the experiment differed with respect to vegetative, flowering, flower yield and flower quality parameters. There was a wide variation in thirty Hibiscus genotypes for their characters *viz.*, plant height (58.27-211.34 cm), number primary (5.22-22.30) and secondary (6.87-75.73) branches/plant, plant spread (N-S (56.83-167.20 cm) and E-W (55.74-179.90 cm) direction), leaf length (4.84-11.26 cm), leaf width (3.23-10.09cm), leaf area (9.61-86.26cm), chlorophyll content (36.99-86.42 SPAD value), Days to bud initiation (44.83-88.54 days), Days taken for flowering (60.59-114.99 days), flower longevity on plant (7.77-33.10 hrs.), pedicel length (2.63-10.50cm), petal length (4.81-7.06cm), petal width (3.53-8.20cm), flower diameter (6.65-16.75cm), length of style (4.79-10.10cm), shelf life (9.90-47.65hrs.), individual flower weight (3.80-17.84g), flower yield (10.33-485.20 kg/plant/year). Similar results were found in Jijji *et al.*, 2019 who also a found a wide variability in vegetative and flowering parameters studied in 12 *Hibiscus rosa-sinensis* accessions.

High genotypic and phenotypic co-efficient of variations were recorded for plant height, number primary and secondary branches/plant, plant spread (N-S and E-W direction), leaf length, leaf width, leaf area, chlorophyll content, flower longevity on plants, pedicel length, petal width, flower diameter, length of style, shelf life, individual flower weight, flower yield (kg/plant/year). As also reported by Jiji *et al.* (2019); Mohini (2018) [9]; Gaikwad (2018) [7] and Pascual *et al.* (2017) [10] in Hibiscus. The estimates of GCV and PCV was medium for days to bud initiation, days to flowering and petal length. The results indicated wide diversity is existing among the genotypes and the selection based on these traits would be effective as well as high scope for improvement.

Heritability is an important genotypic parameter, which serves as an index for effectiveness of selection based on phenotypic performance (Table 01). The characters with high genetic gain may be attributed to the additive gene effects (Pans, 1957) which can easily be improve by simple selection. High heritability in broad sense was observed for all the characters under the study. The plant height, number of primary and secondary branches/plant, plant spread (E-W), leaf area, chlorophyll, days to bud initiation, days to flowering, flower yield (kg/plant/year) recorded high heritability (99.44%. 99.59%, 99.85%, 91.61%, 93.41%, 98.28%, 92.00%, 93.30%, 99.96%, 99.94%, 99.96% and 99.86%, respectively). The characters *viz.*, plant height, number of primary and secondary branches/plant, plant spread in East-West and North -South direction, leaf area, longevity of flower on plant, shelf life, individual flower weight, flower yield (kg/plant/year) recorded high heritability due to environment. It may therefore, be suggested that plant height, number of primary and secondary branches/plant, plant spread in East-West and North -South direction, leaf area, longevity of flower on plant, shelf life, individual flower weight, flower yield (kg/plant/year) in present study are likely to be operated by additive gene action on the other hand characters like leaf length, leaf width, chlorophyll content, days to bud initiation, days taken for flowering, pedicel length, petal length, petal width, flower diameter and length of style were operated by non-additive gene action. High heritability estimates for most of the traits studied have also been reported by *Salih et al.* (2014) [11], *and Ibrahim et al.* (2013) [6] in *Hibiscus sabdariffa* L.

Table 1: Mean, range, variance (genotypic and phenotypic), co-efficient of variation (genotypic and phenotypic), heritability, for vegetative parameters in *Hibiscus rosa-sinensis* L. genotypes

Character	Mean	Range	GV	PV	GCV (%)	PCV (%)	Heritability (%)
Plant height (cm)	115.44	58.27-211.34	2051.59	2063.24	39.24	39.35	99.44
No. Primary branches/plant	9.76	5.22-22.30	14.83	14.89	39.47	39.55	99.59
No. Secondary Branches/plant	34.89	6.87-75.73	503.84	504.59	64.33	64.38	99.85
Plant spread E-W (cm)	90.06	56.83-167.20	851.64	929.64	32.40	33.85	91.61
Plant spread N-S (cm)	95.53	55.74-179.90	1216.24	1363.14	36.51	38.65	89.22
Leaf length (cm)	7.72	4.84-11.26	2.33	5.43	19.78	30.18	42.94
Leaf width (cm)	5.98	3.23-10.09	1.72	5.10	21.92	37.74	33.75
Leaf Area (cm^2)	39.11	9.61-86.26	477.49	511.18	55.88	57.82	93.41
Chlorophyll (SPAD value)	56.32	36.99-86.42	172.86	175.89	23.35	23.55	98.28
Days to bud initiation	67.12	44.83-88.54	146.14	158.85	18.01	18.78	92.00
Days taken for flowering	86.70	60.59-114.99	219.45	235.20	17.09	17.69	93.30
Flower longevity on plant (hr.)	18.77	7.77-33.10	69.06	80.00	44.27	47.65	86.32
Pedicel length (cm)	5.55	2.63-10.50	2.25	3.79	27.01	35.06	59.36
Petal length (cm)	9.50	4.81-7.06	1.24	1.70	15.76	18.47	72.77
Petal width (cm)	5.53	3.53-8.20	1.55	2.09	22.53	26.14	74.34
Flower Diameter (cm)	11.01	6.65-16.75	3.90	9.66	17.93	28.22	40.37
Style length (cm)	6.79	4.79-10.10	1.69	3.01	19.13	25.55	56.03
Shelf life (hr.)	25.02	9.90-47.65	3.37	4.76	40.36	44.62	81.82
Individual Flower weight (g)	10.70	3.80-17.84	17.20	23.27	38.75	45.08	73.89

No. of flowers/plant/Month	60.64	10.30-485.20	9658.87	9662.73	162.08	162.11	99.96
Flower yield (kg/plant/year)	60.64	10.33-485.20	9658.87	9662.73	162.08	162.11	99.96

GV-Genotypic variance, GCV- Genotypic co-efficient of variation, PV-Phenotypic variance, PCV- Genotypic co-efficient of variation

Heritability	**GAM**	**GCV and PCV**
Low = 0-30%	Low = 0-30%	Low = 0-30%
Moderate = 30-60%	Moderate = 30-60%	Moderate = 30-60%
High = >60%	High = >60%	High = >60%

Correlation

Good amount of variation in quantitative characters provide basis for the selection in the breeding programme. The phenotypic correlation coefficient helps in determining selection index, whereas genotypic correlation provide a close measure of association between characters, give an indication of usefulness of characters in overall improvement of the crops (Johnson *et al.* 1955) [5]. This may also help to identify the characters that have little or no importance in the selection programme and are presented in Table 02.

In the present study, the magnitude of correlation coefficient at genotypic level was found higher than the corresponding correlation at phenotypic level. It indicates that there is a strong inherent association between various characters under studied. In the genotypic correlation, Flower yield was positive and significantly correlated with plant height (0.604), number of primary branches (0.705), number of secondary branches (0.466), chlorophyll (0.331), petal length (0.273) and in the phenotypic correlation, flower yield per plant per yield was observed to be positive and significant with plant height (0.602), number of primary branches (0.704), number of secondary branches (0.466) and chlorophyll (0.328).These results are in line with Jiji *et al.* (2019); Mohini (2018) [9]; Gaikwad (2018) [7] and Pascual *et al.* (2017) [10] in Hibiscus.

Table 2: Correlation coefficient among the different characters in different accessions of Hibiscus rosa-sinensis

Characters		PH	PB	SB	LA	CH	FI	FL	FD	PL	PW	FW	SL	FY
PH	G	1	0.660**	0.470**	0.257*	0.256*	-0.360*	-0.393*	0.038	0	-0.179	-0.156	-0.131	0.604**
PH	P	1	0.6575 ***	0.4681 ***	0.2528	0.2531	-0.3467 **	-0.3795 **	0.0153	-0.0028	-0.153	-0.1358	-0.1174	0.602**
PB	G		1	0.704**	0.1138	0.287*	-0.472**	-0.476**	-0.0455	-0.1109	-0.310*	-0.271*	-0.359*	0.705**
PB	P		1	0.7014 ***	0.109	0.2857*	-0.4544 ***	-0.4599 ***	-0.0328	-0.0866	-0.2641 *	-0.242	-0.3296 *	0.704**
SB	G			1	0.1489	0.198	-0.307*	-0.328*	-0.0403	0.014	-0.2068	-0.2084	-0.171	0.466**
SB	P			1	0.1448	0.196	-0.2919 *	-0.3158 *	-0.031	0.0131	-0.1832	-0.1763	-0.1497	0.466**
LA	G				1	0.673**	0.0.604	0.0761	0.793**	0.614**	0.682**	0.500**	0.298*	0.0917
LA	P				1	0.6362***	0.0596	0.0828	0.4826 ***	0.4863 ***	0.5369 ***	0.4506 ***	0.2756 *	0.0886
CH	G					1	-0.014	0.0196	0.698**	0.584**	0.375*	0.374*	0.304*	0.331*
CH	P					1	-0.0278	0.008	0.4290 ***	0.5073 ***	0.3319 **	0.3056 *	0.2525	0.328*
FI	G						1	0.993**	0.1562	0.0269	0.323*	0.428**	0.325*	-0.728**
FI	P						1	0.9778 ***	0.1057	0.0364	0.2411	0.3454 **	0.2983 *	-0.698**
FL	G							1	0.2542	0.0902	0.391*	0.468**	0.352*	-0.715**
FL	P							1	0.1414	0.0572	0.2981 *	0.3853 **	0.3043 *	-0.690**
FD	G								1	0.966**	0.892**	1.1504	0.786**	0.242
FD	P								1	0.6563 ***	0.6743 ***	0.4850 ***	0.4019 **	0.1537
PL	G									1	0.741**	0.960**	0.544**	0.273*
PL	P									1	0.7066 ***	0.5244 ***	0.3821 **	0.2328
PW	G										1	0.942**	0.493**	-0.0878
PW	P										1	0.5670 ***	0.3148 *	-0.0757
FW	G											1	0.376*	-0.0727
FW	P											1	0.3688 **	-0.0625
SL	G												1	-0.286*
SL	P												1	-0.259*
FY	G													1
FY	P													1

Path analysis

Path coefficient are important tools for the selection of desirable genotype. Path coefficient analysis is simply a standardized partial regression coefficient, which splits the correlation coefficients into direct and indirect effects and to estimate the magnitude and direction of direct and indirect effects of yield and yield contributing characters. Path analysis provides the information about characters and their relative importance. The direct and indirect effects of yield components studied in 30 genotypes of Hibiscus and are presented in Table 03. Path analysis of yield and yield contributing characters showed that plant height, number of primary and petal length had positive direct effect on flower yield at both genotypic and phenotypic levels. On the other side, number of secondary branches and leaf area had negative direct effect on flower yield at both phenotypic and genotypic level. But at the genotypic level, days taken for bud initiation, days taken for flowering, petal length, petal width and shelf life had positive direct effect on flower yield and negative direct effect was observed by chlorophyll, flower diameter and flower weight.

At the phenotypic level, positive direct effect was observed by chlorophyll, flower diameter and flower weight. Days taken for bud initiation, days taken for flowering, petal length, petal width and shelf life had negative direct effect on flower yield. The finding of Jijji *et al.* (2019); Gaikwad (2018) [7] in *Hibiscus rosa-sinensis* and Salih *et al.* (2014) [11] are in agreement with the above results.

Table 3: Path co-efficient analysis among the different characters in different accessions of Hibiscus rosa-sinensis L

Characters		PH	PB	SB	LA	CH	FI	FL	FD	PL	PW	FW	SL	FY	Rg
PH	G	0.3266	1.4712	-0.479	-0.1805	-0.0163	-0.0292	-0.2015	-0.1343	0.0001	-0.4289	0.3269	-0.0512	0.604**	0.3266
PH	P	0.2553	0.2092	-0.0043	-0.0687	0.0396	0.1271	0.043	0.0018	-0.0007	0.0089	-0.0255	0.0165	0.602**	0.2553
PB	G	0.2155	2.229	-0.717	-0.079	-0.0183	-0.0383	-0.2444	0.1589	-0.4821	-0.7444	0.5672	-0.141	0.705**	0.2155
PB	P	0.1678	0.3182	-0.0064	-0.0296	0.0447	0.1666	0.0521	-0.0039	-0.0219	0.0154	-0.0454	0.0464	0.704**	0.1678
SB	G	0.1535	1.569	-1.019	-0.104	-0.0126	-0.0249	-0.1681	0.1409	0.0608	-0.4969	0.4356	-0.0671	0.466**	0.1535
SB	P	0.1195	0.2232	-0.0092	-0.0394	0.0306	0.107	0.0358	-0.0036	0.0033	0.0107	-0.0331	0.0211	0.466**	0.1195
LA	G	0.084	0.2537	-0.1518	-0.7022	-0.0429	0.0049	0.039	-2.7721	2.6683	1.6387	-1.0447	0.1168	0.0917	0.084
LA	P	0.0645	0.0347	-0.0013	-0.2719	0.0995	-0.0219	-0.0094	0.0567	0.1232	-0.0313	0.0846	-0.0388	0.0886	0.0645
CH	G	0.0836	0.64	-0.2019	-0.4728	-0.0638	-0.0011	0.01	-2.4395	2.537	0.901	-0.7811	0.1191	0.331*	0.0836
CH	P	0.0646	0.0909	-0.0018	-0.173	0.1563	0.0102	-0.0009	0.0504	0.1285	-0.0194	0.0574	-0.0356	0.328*	0.0646
FI	G	-0.1176	-1.0525	0.313	-0.0424	0.0009	0.0812	0.5095	-0.5459	0.1167	0.7765	-0.8945	0.1273	-0.728**	-0.1176
FI	P	-0.0885	-0.1446	0.0027	-0.0162	-0.0043	-0.3666	-0.1108	0.0124	0.0092	-0.0141	0.0648	-0.042	-0.698**	-0.0885
FL	G	-0.1283	-1.0622	0.334	-0.0534	-0.0012	0.0806	0.513	-0.8885	0.3919	0.9392	-0.9776	0.1379	-0.715**	-0.1283
FL	P	-0.0969	-0.1463	0.0029	-0.0225	0.0013	-0.3585	-0.1134	0.0166	0.0145	-0.0174	0.0723	-0.0428	-0.690**	-0.0969
FD	G	0.0125	-0.1013	0.0411	-0.5569	-0.0445	0.0127	0.1304	-3.4953	4.1962	2.1431	-2.4045	0.3086	0.242	0.0125
FD	P	0.0039	-0.0104	0.0003	-0.1312	0.0671	-0.0388	-0.016	0.1175	0.1663	-0.0393	0.0911	-0.0566	0.1537	0.0039
PL	G	0.00	-0.2474	-0.0143	-0.4312	-0.0372	0.0022	0.0463	-3.3756	4.345	1.779	-2.0072	0.2134	0.273*	0.00
PL	P	-0.0007	-0.0275	-0.0001	-0.1322	0.0793	-0.0133	-0.0065	0.0771	0.2533	-0.0412	0.0985	-0.0538	0.2328	-0.0007
PW	G	-0.0583	-0.6908	0.2108	-0.479	-0.0239	0.0262	0.2006	-3.1183	3.2177	2.4022	-1.9684	0.1934	-0.0878	-0.0583
PW	P	-0.039	-0.084	0.0017	-0.146	0.0519	-0.0884	-0.0338	0.0792	0.179	-0.0584	0.1065	-0.0443	-0.0757	-0.039
FW	G	-0.0511	-0.605	0.2124	-0.3509	-0.0238	0.0347	0.2399	-4.0211	4.1727	2.2623	-2.0901	0.1473	-0.0727	-0.0511
FW	P	-0.0347	-0.077	0.0016	-0.1225	0.0478	-0.1266	-0.0437	0.057	0.1328	-0.0331	0.1878	-0.0519	-0.0625	-0.0347
SL	G	-0.0426	-0.8014	0.1743	-0.209	-0.0194	0.0263	0.1803	-2.7487	2.3625	1.184	-0.7848	0.3924	-0.286*	-0.0426
SL	P	-0.03	-0.1049	0.0014	-0.0749	0.0395	-0.1094	-0.0345	0.0472	0.0968	-0.0184	0.0692	-0.1408	-0.259*	-0.03

G-Residual effect: 0.218; rg: Genotypic correlation coefficient with flower yield per plant per year; Diagonal values indicate the direct effect. P-Residual effect: 0.399; rg: Genotypic correlation coefficient with flower yield per plant; Diagonal values indicate the direct effect

Conclusion

From this variability study, it can be concluded that there exists a high amount variability, with high GV, PV, Heritability with high genotypic and phenotypic correlation. This helps in the further breeding programme in selection of parents. Also this finding gave an ample amount of opportunity for selection of varieties for both commercial cultivation and landscape gardening. Also, Identification and characterization of germplasm is essential for the conservation and utilization of plant genetic resources. The highest phenotypic co-efficient of variation indicates the influence of environment over the character observed. Heritable traits of yield and flower quality are complex characters and are known to be collectively influenced by various polygenically inherited traits which are highly vulnerable to the environment effects. In plant breeding, correlation co-efficient analysis measures the mutual relationship between various characters and determine the component characters on which selection can be base for genetic improvement in yield.

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