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Assessment of variability, heritable components and grouping of Indian rose (*Rosa × hybrida)* genotypes based on DUS guidelines

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ABSTRACT

Thirty-two genotypes of rose were evaluated for various vegetative and floral traits to ascertain genetic parameters such as variability, heritability, genetic (GCV) and phenotypic (PCV) coefficient of variation and genetic advance. Further, these genotypes were grouped into five categories, i e plant growth type, flower type, flower diameter, number of colours on inner side of petal and flower colour group on basis of DUS (Distinctness, Uniformity and Stability) guidelines. Analysis of variance for all traits showed highly significant differences among genotypes for all the vegetative and floral traits studied. Phenotypic coefficient of variation (PCV) for all traits was higher than the genotypic coefficient of variation (GCV). High estimates of PCV and GCV were observed for weight per flower, number of petals per flower, number of flowers per plant and prickle density. Moreover, high heritability (>80%) were noticed for plant height, internodal length, neck length, flower diameter, weight per flower, number of petals per flower and number of flowers per plant. High genetic advance was observed for weight per flower followed by number of petals per flower and number of flowers per plant. High coefficient of variation both at the genotypic and phenotypic level along with high heritability and genetic advance was observed for weight per flower, number of petals per flower and number of flowers per plant. The diverse genotypes with peculiar characteristics, identified in the present study may be used as parents in the crop improvement programme for evolving elite genotypes.

Key words: DUS, GCV, Grouping, Heritability, PCV, Rose, Variability

Rose (*Rosa × hybrida*) is universally known as "Queen of Flowers". It is one of the most important members of Rosaceae. Roses are recognized highly valuable for economical benefits, being the best source of raw material to be used in agro-based industry especially in the cosmetics and perfumery. The assessment of variability is the pre requisite step in any crop improvement programme. The greater the variability more will be the scope for improvement by selection. Hence, insight into the magnitude of variability present in various biometric traits in the gene pool of crop species is of utmost importance to a breeder for planning a systematic breeding programme. Selection of genetically diverse parents is the primary requirement for the success of any hybridization programme. Hence, understanding of genetic variability among the genotypes is of prime importance. The genotypic coefficient of variation alone does not provide reliable estimation of variation that is heritable and therefore, estimation of heritability becomes imperative. The heritable value represents a measure of genetic relationship between parent and progeny, and thus is of fundamental importance in selection because it acts as a predictive instrument in expressing the reliability of a phenotypic value. Information on mean performance and variability parameters like coefficient of variation, heritability and genetic advance are essential for selection of genetically superior genotypes. With the background in view, the present study was undertaken to assess and estimate the magnitude and nature of variation among 32 Indian rose genotypes with respect to various vegetative and floral characteristics that would be further utilized in crop improvement programme.

MATERIALS AND METHODS

The present investigation was carried out during 2008–09, at Research Farm, Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi. The experimental material consisted of 32 genotypes of rose (Table 1). The genotypes were planted in randomized block design (RBD) with three replications. The experiment was conducted in open field where plants were planted at spacing

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Table 1 Details of rose genotypes, source and parentage used for variability estimation

Genotype	Source	Parentage
Raktima	IARI, New Delhi	Pink Parfait × Sugandha
Raktagandha	IARI, New Delhi	Christian Dior × Seedling of Carrousel
Lalima	IARI, New Delhi	Picture × Jour
Pusa Arun	IARI, New Delhi	Queen Elizabeth × Jantar Mantar
Pusa Mohit	IARI, New Delhi	Suchitra × Christian Dior
Indian Princess	IARI, New Delhi	Super Star × Granada
Dr. S.S. Bhatnagar	IARI, New Delhi	Oklahoma × White Christmas
Jantar Mantar	IARI, New Delhi	
Jawahar	IARI, New Delhi	Sweet Afton × Delhi Princess
Mrs. K.B. Sharma	IARI, New Delhi	White Masterpiece × Michele Meilland
Shabnam	IARI, New Delhi	Seedling of Baby Sylvia
Navneet	IARI, New Delhi	Prelude × Africa Star
Himangini	IARI, New Delhi	Seedling of Saratoga
Ganga	IARI, New Delhi	Seedling of Sabine
Raja Ram Mohan Roy	IARI, New Delhi	
Pusa Pitambar	IARI, New Delhi	Jantar Mantar × Banjaran
Haseena	IARI, New Delhi	Youki San × Balinese
Dr. Benjamin Pal	IARI, New Delhi	Sweet Afton × First Prize
Pusa Ajay	IARI, New Delhi	Pink Parfait × Queen Elizabeth
Sadabahar	IARI, New Delhi	Seedling of Frolic
Pusa Barahmasi	IARI, New Delhi	Seedling of Sadabahar
Pusa Ranjana	IARI, New Delhi	Pink Parfait × Iceberg
Surkhab	IARI, New Delhi	
Chingari	IARI, New Delhi	Seedling of Charleston
Lahar	IARI, New Delhi	Pink Parfait × Ganga
Pusa Manhar	IARI, New Delhi	Jantar Mantar × Lahar
Raja Surendra Singh of Nalagarh	IARI, New Delhi	Scarlet Knight × Montezuma
Jawani	IARI, New Delhi	Scarlet Queen Elizabeth × Louisiana
Suryodaya	IARI, New Delhi	Seedling of Orangeade
Suryakiran	IARI, New Delhi	
Deepak	IARI, New Delhi	
Shola	IARI, New Delhi	Seedling of Anna Wheatcroft

of 60 × 60 cm. All the selected genotypes were given uniform management practices for healthy growth and development. The biometrical observations were recorded on 10 random competitive plants from each replication after discarding side plants. The observations were recorded on various vegetative and floral traits, viz. plant height (cm), number of primary branches, number of secondary branches, stem girth (cm), prickle density (number per 5 cm stem length), internodal length (cm), leaf area (cm^2), days to flowering, bud length (cm), stalk length (cm), neck length (cm), flower diameter (cm), weight per flower (g), number of petals per flower, number of flowers per plant. The analysis of variance was done as per the procedure described by Panse and Sukhatme (1967). The genotypic and phenotypic coefficient of variation was estimated according to the methods of Burton and de Vane (1953). Heritability (broad sense) in per cent was estimated as per the formula given by Johnson *et al*. (1955). Genetic advance and genetic gain were calculated using formula suggested by Lush (1949) and Johnson *et al*. (1955). The mean and standard error (SE) were worked out as per standard methods (Panse and Sukhatme 1967) and coefficient of variation was calculated using the following formula:

CV= S/X*100 where S is the standard deviation and X is the mean.

RESULTS AND DISCUSSION

Analysis of variances revealed highly significant differences among genotypes for all the growth and flowering traits under study. This concluded the existence of wide range of variability for different traits which revealed that considerable improvement can be made in this crop. Mean performance of the genotypes revealed that a single genotype was not superior for all traits (Table 2). Hence, in our study

Table 2 Mean performance of 32 rose genotypes for various vegetative and floral traits

Genotype	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Stem girth (cm)	Prickle density (No./5 cm stem length)	Internodal length (cm)	Leaf area (cm^2)	Days to flowering	Bud length (cm)	Stalk length (cm)	Neck length (cm)	Flower diameter (cm)	Weight per flower (g)	No. of petals/ flower	No. of flowers/ plant
Raktima	104.20	7.33	19.67	2.27	11.33	4.03	13.47	43.00	2.67	30.73	7.47	9.87	5.57	24.00	11.00
Raktagandha	66.63	4.67	18.67	1.80	10.67	7.83	12.45	52.00	3.03	33.40	6.87	9.30	6.58	40.67	17.33
Lalima	67.30	3.33	13.00	1.37	12.33	3.93	16.96	54.00	2.50	27.97	6.03	8.83	14.63	36.67	11.00
Pusa Arun	77.17	3.67	12.33	2.13	11.67	3.43	12.28	41.67	2.50	20.97	4.50	7.97	12.65	32.00	12.00
Pusa Mohit	58.10	6.00	16.00	1.80	2.67	3.17	15.95	56.33	2.40	25.37	6.10	8.87	12.01	54.67	14.00
Indian Princess	89.00	5.33	11.33	1.73	16.67	4.10	15.58	53.00	2.30	29.87	6.87	9.45	7.29	32.67	10.33
Dr S S Bhatnagar	59.13	4.67	16.33	1.73	9.67	3.67	14.10	56.33	2.10	21.07	8.97	8.70	4.86	21.33	14.67
Jantar Mantar	74.17	6.33	17.33	1.53	10.00	3.40	15.53	51.33	2.70	25.47	7.17	9.10	4.58	28.00	13.67
Jawahar	65.43	6.67	20.33	1.33	6.67	4.30	13.85	54.00	2.90	24.87	6.63	9.27	7.57	42.00	14.67
Mrs K B Sharma	86.33	4.33	14.00	1.60	11.33	3.67	10.58	49.00	2.83	25.33	7.77	9.60	5.18	22.00	13.33
Shabnam	61.40	3.33	8.00	1.13	7.00	3.57	8.02	50.33	2.03	19.83	4.47	5.92	2.60	56.33	9.67
Navneet	57.30	4.00	12.00	1.90	12.33	3.50	8.15	57.67	2.50	21.23	4.53	7.38	4.22	20.33	9.00
Himangini	56.93	4.00	14.67	1.43	7.33	3.10	9.10	48.33	1.97	23.17	4.73	6.95	2.25	28.00	50.00
Ganga	59.60	3.33	17.67	1.60	5.67	3.77	9.58	43.67	2.27	31.03	5.97	8.60	4.54	20.33	9.00
Raja Ram Mohan Roy	71.50	4.33	16.00	1.57	6.67	3.40	13.00	47.00	2.87	31.80	8.77	9.12	10.54	48.00	10.67
Pusa Pitambar	83.90	4.67	12.00	1.93	6.33	3.50	14.74	47.33	2.30	24.03	4.50	7.52	6.06	35.00	16.67
Haseena	68.60	4.00	14.67	1.17	10.00	2.60	11.64	55.00	2.10	26.50	5.97	9.42	6.69	48.00	11.00
Dr Benjamin Pal	64.63	2.67	10.33	2.07	13.00	3.23	10.06	46.67	2.47	27.83	7.57	11.18	20.23	34.67	12.67
Pusa Ajay	101.87	5.67	22.00	2.23	12.67	3.10	10.63	44.33	2.37	24.00	5.70	8.38	5.93	22.33	21.00
Sadabahar	80.83	5.00	15.33	1.67	10.00	4.63	10.24	43.67	2.40	28.73	3.53	7.07	2.93	40.00	47.33
Pusa Barahmasi	74.57	4.67	15.00	1.67	7.67	4.50	8.81	51.00	2.00	15.37	3.53	5.92	1.39	25.00	27.00
Pusa Ranjana	61.50	6.33	15.67	1.13	10.33	3.17	10.61	53.33	2.10	18.93	2.37	5.65	1.04	10.00	44.67
Surkhab	101.33	3.67	13.00	1.90	8.67	3.73	16.57	52.67	2.17	34.67	7.77	8.62	9.30	75.33	11.00
Chingari	66.43	6.33	16.00	1.37	8.33	2.53	8.60	45.33	2.30	27.17	3.73	6.53	1.61	9.67	20.67
Lahar	62.80	3.33	10.33	1.57	8.33	3.07	13.41	53.33	2.10	22.10	3.43	8.20	5.25	30.33	23.33
Pusa Manhar	63.90	6.33	14.00	1.43	8.67	5.07	17.08	49.67	2.40	24.00	5.10	7.13	3.54	89.33	21.67
Raja Surender Singh of Nalagarh	90.07	5.33	14.33	2.17	9.00	3.80	13.36	46.67	2.00	31.73	7.00	9.58	9.38	40.67	14.33
Jawani	71.20	5.00	16.67	2.43	22.00	2.20	15.43	50.67	2.07	28.77	4.67	8.28	14.80	120.33	13.33
Suryodaya	50.07	5.00	13.67	1.37	11.00	3.10	13.55	52.00	2.20	19.30	6.50	7.90	3.32	13.33	7.67
Suryakiran	37.83	3.33	9.00	1.27	11.33	2.77	16.59	50.67	2.50	20.27	5.13	7.73	3.24	14.67	8.00
Deepak	60.77	4.00	19.67	1.37	5.67	2.70	6.01	50.33	1.60	16.50	5.20	6.93	2.05	35.00	18.67
Shola	46.30	4.00	14.00	1.57	10.00	3.43	7.53	51.67	2.17	24.50	3.20	6.08	2.52	20.00	22.00
Mean	70.02	4.71	14.78	1.66	9.84	3.63	12.30	50.06	2.34	25.20	5.68	8.16	6.39	36.58	17.54
Range	37.83-104.20	2.67-7.73	8.00-22.00	1.13-2.43	2.67-22.00	2.20-7.83	6.01-17.08	41.67-57.67	1.60-3.03	15.37-34.67	2.37-8.97	5.65-11.18	1.04-20.23	9.67-120.33	7.67-50.00
SE	4.29	0.90	2.15	0.30	1.41	0.33	1.30	1.74	0.12	2.65	0.32	0.27	0.76	3.22	4.11

different genotypes were identified to be superior for various vegetative and floral traits, which may be due to varied growth rate and their genetic make-up. The maximum plant height was recorded in genotype Raktima (104.20 cm), followed by Pusa Ajay (101.87 cm) and Surkhab (101.33 cm). These were significantly superior over other genotypes. However, minimum plant height was recorded in Suryakiran (37.83 cm). Number of days taken to flowering is an important trait in garden roses because early or late flowering genotypes may be useful for regular availability of flowers. The desirable genotypes for early flowering were Pusa Arun (41.67 days), followed by Raktima (43.00 days) and Ganga (43.67 days). Besides cut flower, roses are also utilized as loose flower. Weight per flower is an important trait for loose flowers as loose flowers are sold on weight basis and our study revealed maximum weight per flower for genotype Dr Benjamin Pal (20.23 g) followed by Jawani (14.80 g) while Pusa Ranjana recorded lowest weight per flower (1.04 g). The prickle density in all genotypes under study ranges from 2.67 (Pusa Mohit) to 22.00 (Jawani). The maximum number of petals per flower was found in Jawani (120.33) followed by Pusa Manhar (89.33) and Surkhab (75.33). However, minimum number of petals per flower was observed in genotype Chingari (9.67). The significantly highest number of flowers per plant was recorded in genotype Sadabahar (47.33) followed by Pusa Ranjana (44.67) whereas lowest number of flowers was observed in Suryodaya (7.67) followed by Suryakiran (8.00). Since different genotypes were identified to be performing differently for qualitative and quantitative traits, hence, these diverse genotypes with superior traits could be involved in the hybridization programme for assembling of desirable traits in single genotype.

From Table 3 it is concluded that the phenotypic coefficient of variation (PCV) estimates were greater than genotypic coefficient of variation (GCV) in respect of all attributes under observation which indicates that the variability in these traits is not only due to the genotypes but also environmental factors. The results are in close conformity with the work done by Verma *et al*. (2008) in rose and Srivastava *et al*. (2012) in *Malus domestica*. The PCV was highest for weight per flower (71.98%) followed by number of flowers per plant (66.34%) and number of petals per flower (64.20%), whereas the lowest value was observed for days to flowering (9.06%).

Highest GCV was recorded for weight per flower (70.46%) followed by number of petals per flower (63.29%) and number of flowers per plant (59.78%). The lowest GCV was observed for days to flowering (7.99%). Low GCV and PCV were obtained for days to flowering, whereas highest GCV and PCV were observed for traits like weight per flower, number of petals per flower and number of flowers per plant. Punetha *et al*. (2011) in chrysanthemum and Kumar *et al.* (2012) in snapdragon also reported lower values of GCV and PCV for days to flowering indicating that these genotypes do not have much variation for this particular trait. The high estimates of PCV and GCV for various traits indicating that the selection for these traits would be effective. The genotypic coefficient of variation alone does not provide reliable estimation of variation that is heritable and therefore, estimation of heritability becomes imperative. The heritable value represents a measure of genetic relationship between parent and progeny and thus is of fundamental importance in selection because it acts as a predictive instrument in expressing the reliability of a phenotypic value. Burton and de Vane (1953) suggested that genotypic coefficient of

Table 3 Estimates of genetic parameters for vegetative and floral traits in rose genotypes

Trait	Genotypic coefficient variation (%)	Phenotypic coefficient variation (%)	Heritability (%)	Genetic advance	Genetic advance as per cent of mean
Plant height (cm)	22.08	23.32	89.60	30.16	43.07
Primary branches (no.)	21.21	31.61	45.10	1.38	29.31
Secondary branches (no.)	19.68	26.56	54.90	4.44	30.04
Stem girth (cm)	16.38	27.75	34.80	0.33	19.83
Prickle density (no./5 cm stem length)	34.23	38.51	79.00	6.17	62.68
Internodal length (cm)	26.51	28.83	84.60	1.82	50.21
Leaf area (cm^2)	24.28	27.52	77.80	5.42	44.08
Days to flowering	7.99	9.06	77.70	7.27	14.52
Bud length (cm)	12.93	14.59	78.50	0.55	23.52
Stalk length (cm)	17.95	22.11	66.00	7.57	30.04
Neck length (cm)	29.42	30.24	94.60	3.35	58.98
Flower diameter (cm)	16.20	16.71	93.90	2.64	32.36
Weight per flower (g)	70.46	71.98	95.80	9.07	142.03
Number of petals/flower	63.29	64.20	97.20	47.01	128.50
Number of flowers/plant	59.78	66.34	81.20	19.47	110.99

variation accompanied with heritability estimates would give the best picture of the extent of genetic advance to be expected from selection.

In this study, the heritability in broad sense was high for all traits except stem girth and number of primary branches suggesting that the selection based on phenotype would be more effective. There is every possibility to transmit traits into the off-springs. Heritability (broad sense) estimates ranged from 34.80% for stem girth to 97.20% for number of petals per flower. The high value of heritability was also observed for traits like weight per flower, neck length, flower diameter, plant height, internodal length and number of flowers per plant which revealed that these traits were least influenced by environmental changes. However, low values were observed for stem girth (34.80%) followed by number of primary branches (45.10%) indicated that these traits were highly influenced by environmental changes. This was supported by Palai *et al*. (2003) who suggested similar trend in Hybrid Tea roses for plant height and total petal number per flower. Ghimiray *et al*. (2005) also reported high heritability for number of flowers per plant and flower diameter in chrysanthemum. Genetic advance is an improvement in the mean genotypic value of the selected plants over the base population and is generally expressed as percentage of mean (expected genetic gain). Johnson *et al.* (1955) reported that heritability estimates together with expected genetic gain are more reliable than either of these parameters alone in predicting the resultant effects of selecting the best individuals and therefore, the genetic advance should be considered along with heritability in streamlining the coherent selection in breeding programme. Genetic advance was estimated at 5% selection intensity and converted into expected genetic gain as per cent of mean. The genetic advance as per cent of mean ranged from 14.52% for days to flowering to 142.03% for weight per flower. In the present study, weight per flower, number of petals per flower, number of flowers per plant and prickle density exhibited high genetic gain. Our findings are in accordance with Palai *et al*. (2003) who reported high genetic gain in Hybrid Tea roses for prickle density and petal number and Namita *et al.* (2008) who reported high genetic gain for weight per flower and number of flowers per plant in marigold.

Heritability along with genetic gain is more useful criteria in predicting the resultant effect for selecting the best individual. High heritability with high genetic advance as per cent of mean tells that the trait is governed by the additive gene action and for this, simple selection is advocated. High heritability with high genetic advance as per cent of mean was reported for weight per flower, number of petals per flower and number of flowers per plant. Baskaran *et al*. (2009) also reported high heritability associated with high genetic advance as the per cent of mean in chrysanthemum for number of flowers per plant, indicating the presence of additive gene action. High heritability with low genetic gain tells that the trait is governed by the non-additive gene action and for this selection with adequate progeny testing is practiced. High heritability with low genetic gain was reported for days to flowering. High heritability with medium genetic gain tells that trait is governed by the dominant and epistatic gene action and for this hybridization is done. High coefficient of variation both at the genotypic and phenotypic level along with high heritability and genetic advance was observed for weight per flower, number of petals per flower and number of flowers per plant. Palai *et al*. (2003) reported similar results in Hybrid Tea roses for petal number.

Grouping of rose genotypes on basis of distinctness, uniformity and stability guidelines

The rose genotypes were grouped on the basis of DUS guidelines developed by PPV&FRA, New Delhi. Plant growth type was divided into six categories and the maximum (24) genotypes were covered under bed rose category. The dwarf rose included Ganga, Shola, Dr S S Bhatnagar, Suryodaya, Himangini, Pusa Mohit and Navneet, whereas miniatures included only Suryakiran. Flower type was categorised into three groups. Single flower type included only one genotype Chingari, whereas semi-doubles type included nine genotypes, viz Pusa Barahmasi, Pusa Ranjana, Sadabahar, Shola, Suryakiran, Suryodaya, Deepak, Pusa Ajay and Navneet. The remaining genotypes belonged to double flower category. Flower diameter was divided into three groups and genotypes Pusa Barahmasi, Shabnam, Pusa Ranjana grouped under small flower diameter type. The medium flower diameter type includes genotypes Pusa Manhar, Pusa Pitambar, Chingari, Sadabahar, Pusa Arun, Shola, Suryakiran, Suryodaya, Himangini, Deepak, Pusa Mohit and Navneet and the remaining 17 genotypes belonged to large flower diameter type. Number of colours on inner side of petals included three categories, i e one (single), two (double) and more than two (multiple). Maximum genotypes (29) were of single colour, whereas Pusa Manhar, Lahar and Surkhab were included under double category. Flower colour was divided into thirteen categories based on flower colour groups mentioned in the DUS guidelines. The white or near white category included genotypes Jawahar, Himangini, Navneet, Shabnam, Pusa Manhar and Mrs K B Sharma. The light to medium yellow included Ganga. The yellow blend included Pusa Pitambar and Lahar. The apricot blend included Raja Ram Mohan Roy. The orange and orange blend included Raja Surendra Singh of Nalagarh, Suryakran, Chingari and Jawani. The orange-red included Suryodaya, Deepak and Shola. The light pink included Sadabahar, Dr Benjamin Pal and Pusa Ranjana. The medium red included Pusa Barahmasi. The deep pink included Haseena. The pink blend included Pusa Mohit and Pusa Ajay. The light red and deep pink included Indian Princess, Dr S S Bhatnagar and Jantar Mantar. The medium red included Lalima, Raktagandha, Raktima and Surkhab and dark red included Pusa Arun. These different

Table 4 Grouping based on DUS guidelines

Group	Parameter					
Plant growth type (cm)	Ground covers (< 30)	Miniature (30-45)	Dwarf rose (46-60)	Bed rose (61-150)	Shrub rose (151-200)	Climbing rose (> 200)
Number of genotype (s)		1	7	24		
Flower type		Single		Semi-double		Double
Number of genotype (s)		1		9		22
Flower diameter (cm)		Small (4.0-6.0)		Medium (6.1- 8.0)		Large (8.1-10.0)
Number of genotypes		3		12		17
Number of colour(s) on inner side of petals		One		Two		Multiple
Number of genotypes		29		3		
Flower colour	White or near white	Light to medium yellow	Yellow blend	Apricot blend	Orange and orange blend	Orange-red
Number of genotype(s)	6	1	2	1	4	3
Flower colour	Light pink	Medium pink	Deep pink	Pink blend	Light red and deep pink	Medium red	Dark red
Number of genotype(s)	3	1	1	2	3	4	1

groups and respective number of genotypes were presented in Table 4.

The present investigation concluded that the existence of wide variations for various vegetative and floral traits in 32 genotypes offered a good scope of selecting the suitable genotypes for all the economic traits. Further, these identified diverse genotypes with peculiar characteristics may be used as parents in the crop improvement programme for evolving elite genotypes.

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REFERENCES

Baskaran V, Jayanthi R, Janakiram T and Abirami K. 2009**.** Studies on genetic variability, heritability and genetic advance in chrysanthemum. *Journal of Horticultural Sciences* **4**: 174–6.

Burton G W and de Vane E H. 1953. Estimating heritability in tall fescue *(Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* **54**: 478–81.

Ghimiray T S, Sarkar I and Roy A. 2005. Variability studies in chrysanthemum grown over two environments. *Research on Crops* **6**(3): 514–6.

Johnson H W, Robinson H F and Comstock R E. 1955. Estimate of genetic and environmental variability in soybean. *Agronomy Journal* **46**: 314–8.

Kumar R, Kumar S and Singh A K. 2012. Genetic variability and diversity studies in snapdragon (*Antirrhinum majus*) under tarai conditions of Uttarakhand. *Indian Journal of Agricultural Sciences* **82** (6): 535-7.

Lush J L. 1949. *Animal Breeding Plans*, pp 443, Edn 3. College Press, Iowa State.

Namita, Singh K P, Raju D V S, Prasad K V and Bhardwaj C. 2008. Studies on genetic variability, heritability and genetic advance in French marigold (*Tagetes patula*). *Journal of Ornamental Horticulture* **12**(1): 30–4.

Palai S K , Mishra M , Bhuyan, S and Mishra H N. 2003. Genetic variability in hybrid tea roses. *Journal of Ornamental Horticulture* **6**(1): 29–33.

Panse V G and Sukhatame P V. 1967. *Statistical Methods for Agriculture Workers*, p 381, edn 2. Indian Council of Agricultural Research, New Delhi.

Punetha P, Rao V K and Sharma S K. 2011. Evaluation of different chrysanthemum (*Chrysanthemum morifolium*) genotypes under mid hill conditions of Garhwal Himalaya. *Indian Journal of Agricultural Sciences* **81**(9): 830–3.

Srivastava K K, Das B, Ahmed N, Singh S R, Rather J A and Bhat S K. 2012. Correlation and co-heritability studies of yield and yield-associating characters in apple (*Malus domestica*). *Indian Journal of Agricultural Sciences* **82** (3): 270–6.

Verma S, Kumar S and Singh D. 2008. Studies on variability for various quantitative traits in rose (*Rosa* spp). *Journal of Ornamental Horticulture* **11**(1): 27–31.