

Varietal Performance and Correlation Studies in Hybrid Tea Roses

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Abstract- The present investigation was undertaken to evaluate environmental correlation studies among important growth, flowering and yield characters in thirty varieties of hybrid tea roses (*Rosa hybrida* L.) at the Horticulture Research Farm, DSN College, Unnao, Uttar Pradesh. The experiment was laid out in Randomised Block Design (RBD) with thirty treatments (varieties) replicated three times during the years 2022–23 and 2023–24. Observations were recorded on six quantitative characters, namely: plant height, days to first bud appearance, flower diameter, number of petals per flower, stem length, and number of flowers per plant per year. Analysis of variance revealed highly significant differences among varieties for all traits under study, confirming the existence of sufficient genetic variability. Correlation studies indicated that plant height exhibited highly significant positive correlations with flower diameter ($r = 0.71^{**}$), number of petals ($r = 0.58^{**}$), and number of flowers per plant ($r = 0.55^{**}$). Flower diameter showed a strong positive correlation with the number of petals ($r = 0.78^{**}$) and number of flowers per plant per year ($r = 0.69^{**}$). Days to first bud appearance registered a significant negative correlation with flower diameter and flower yield, suggesting that early budding genotypes tend to produce higher flower counts. Varieties Peace, Queen Elizabeth, Oklahoma, Crimson Glory, and Perfume Delight emerged as the most promising based on their superior performance across multiple characters. The study concludes that environmental conditions at Unnao, characterised by sub-tropical climate, significantly influence inter-trait associations in hybrid tea roses, and that selection based on plant height and flower diameter may lead to indirect improvement in overall flower yield.

Keywords: Hybrid Tea Roses, Correlation, Flower Yield, *Rosa Hybrida*

I. INTRODUCTION

Rose (*Rosa hybrida* L.) is universally regarded as the queen of flowers and occupies an unrivalled position in the ornamental horticulture industry. It belongs to the family Rosaceae and is commercially cultivated across the globe for its diverse utility in cut flower

trade, essential oil extraction, perfumery, cosmetics, and landscape gardening. India ranks among the leading producers of rose flowers in Asia, with states like Karnataka, Tamil Nadu, Maharashtra, West Bengal, and Uttar Pradesh contributing significantly to national production.

Hybrid tea roses represent the most commercially important group within the genus *Rosa*, prized for their large, high-centred blooms, extensive colour range, long stems, and extended vase life. The group originated from crosses between hybrid perpetual roses and tea roses in the nineteenth century and has since been developed into thousands of named cultivars through intensive breeding programmes worldwide. In India, varieties such as Arjun, Pusa Gaurav, Rajhans, Queen Elizabeth, First Prize, and Maharani have been developed or recommended for commercial cultivation in different agroclimatic regions.

The performance of rose varieties is strongly governed by the interaction between genotype and environment. Uttar Pradesh, particularly the Unnao district, presents a sub-tropical climate with hot summers, cold winters, and moderate monsoon rainfall. Understanding how environmental factors at this location influence morphological and yield-related traits and how these traits correlate with each other is essential for developing effective selection strategies for plant breeders and for advising commercial growers on variety selection.

Correlation analysis is a powerful biometrical tool that quantifies the degree of association between two variables. In crop improvement programmes, knowledge of inter-character correlations helps breeders identify traits that can be used as indirect selection criteria for improving complex quantitative characters such as flower yield. Several workers have conducted correlation studies in rose, including Singh and Nath (2001), Gupta et al. (2005), Mishra and

Verma (2010), Arya (2018) and Sharma et al. (2019), but there remains a paucity of systematic studies under the specific agroclimatic conditions of Unnao, Uttar Pradesh.

Keeping the above considerations in view, the present investigation was designed to: (i) evaluate thirty varieties of hybrid tea roses for growth, flowering, and yield characters under the agroclimatic conditions of D.S.N. College, Unnao; (ii) determine the nature and magnitude of correlations among important quantitative traits; and (iii) identify superior varieties for commercial cultivation in this region.

II. REVIEW OF LITERATURE

A comprehensive understanding of the work done by earlier researchers forms the backbone of any new scientific investigation. The following review encompasses studies relevant to varietal evaluation and correlation analysis in hybrid tea roses.

2.1 Varietal Evaluation

Singh and Nath (2001) evaluated twenty-five varieties of hybrid tea roses at Lucknow under north Indian plains conditions and reported significant differences among varieties for plant height, number of leaves per plant, flower diameter, and flower yield. They identified varieties Mr. Lincoln, Queen Elizabeth, and Crimson Glory as high-performing genotypes. Gupta et al. (2005) assessed thirty rose varieties at Pantnagar and documented a wide range of variability for growth parameters, with plant height ranging from 62.4 to 96.8 cm and flower diameter from 7.2 to 11.4 cm. Their study highlighted that varieties adapted to temperate conditions may not always perform optimally in sub-tropical environments.

Kumar and Prasad (2008) studied the performance of fifteen hybrid tea rose varieties at Varanasi and noted that Fragrant Cloud and Double Delight performed consistently well for cut flower production under UP agroclimatic conditions. Mishra and Verma (2010) evaluated twenty rose varieties at CISH, Lucknow, and found that local varieties such as Maharani and Pusa Gaurav showed better heat tolerance and more consistent yield during summer months compared to imported European varieties.

2.2 Correlation Studies in Rose

Bose and Yadav (2003) reported highly significant positive correlations between plant height and flower diameter ($r = 0.68^{**}$) in hybrid tea roses, suggesting that taller plants tend to produce larger blooms. Sharma and Kaur (2007) found that number of petals per flower was positively and significantly associated with flower diameter ($r = 0.72^{**}$) and vase life ($r = 0.54^{**}$). They suggested that petal count could serve as a useful indirect selection criterion for vase life improvement.

Tripathi et al. (2011) conducted correlation studies in thirty rose genotypes at Allahabad and reported that days to first bud appearance had a significant negative association with total flower yield per plant ($r = -0.49^*$), implying that early-flowering varieties tend to produce more flowers over the season. Patel and Singh (2014) observed that stem length was positively correlated with flower diameter ($r = 0.61^{**}$) and plant height ($r = 0.58^{**}$), reinforcing the importance of stem length as a cut flower quality parameter.

More recently, Verma et al. (2020) conducted a multivariate analysis including correlation and path coefficient analysis in twenty-five rose varieties at Kanpur. Their study confirmed that flower diameter exerted the highest direct positive effect on flower yield per plant, and its positive correlation with yield was the most consistent finding across years and locations. These findings are broadly consistent with similar studies conducted in Iran (Ahmadi et al., 2015) and Turkey (Korkut and Babaoglu, 2017). Arya and Sachan (2023) reported that insect pest and nematodes play a significant role in plant growth.

III. MATERIALS AND METHODS

3.1 Experimental Location

The experiment was conducted at the Botanical garden of D.S.N. College, Unnao, Uttar Pradesh (26.55°N, 80.49°E; altitude 126 m above mean sea level) during two consecutive years: 2022–23 and 2023–24. The climate of Unnao is characterised as sub-tropical with hot, dry summers (April–June), monsoon season (July–September), mild autumn (October–November), and cold winters (December–February). Mean annual rainfall is approximately 870 mm, largely concentrated during the monsoon months.

Summer temperatures range from 38°C to 45°C, while winter temperatures can fall to 4°C–8°C. The soil of the experimental site is loamy with a pH of 7.2–7.6, moderate organic matter content (0.58%), and good water-holding capacity.

3.2 Experimental Material

Thirty varieties of hybrid tea roses constituted the experimental material. These varieties were procured from National Botanical Research Institute (NBRI), Lucknow; Indian Agricultural Research Institute (IARI), New Delhi; and reputable commercial nurseries. The selected varieties represent a wide spectrum of flower colour, petal configuration, growth habit, and commercial importance. Details of all thirty varieties are presented in Table 1.

Table 1: Varieties of Hybrid Tea Roses Used in the Experiment

S.No.	Variety	Flower Colour	Key Characteristics
1	Arjun	Red	Vigorous, high bud count
2	Rajhans	Deep Pink	Excellent fragrance, long stem
3	Pusa Gaurav	Pink	High yielding, disease resistant
4	Love	Scarlet Red	Compact growth, prolific bloomer
5	Gladiator	Orange-Red	Heat tolerant, firm petals
6	Super Star	Orange	Bright colour, strong fragrance
7	Crimson Glory	Crimson	Classic variety, velvety petals
8	Queen Elizabeth	Pink	Large blooms, disease resistant
9	Mr. Lincoln	Dark Red	Vigorous, highly fragrant
10	Montezuma	Salmon	Upright growth, high yield
11	Sonia	Salmon-Pink	Fine texture, long vase life
12	Gold Crown	Yellow	Bright colour, medium fragrance
13	Golden Days	Golden Yellow	Heat tolerant, long stem
14	Pascali	White	Disease resistant, long petals
15	Iceberg	White	Excellent bloomer, sturdy
16	Blue Moon	Lavender	Unique colour, strong scent
17	Perfume Delight	Deep Pink	Intense fragrance, large blooms
18	Peace	Yellow-Pink	Classic bicour, large flower
19	First Prize	Pink	Perfectly formed buds
20	Double Delight	Red-White	Bicour, highly fragrant
21	Tropicana	Orange-Red	Glossy leaves, strong growth
22	Garden Party	Creamy White	Excellent form, mild fragrance
23	Chrysler Imperial	Crimson	Rich fragrance, velvety

S.No.	Variety	Flower Colour	Key Characteristics
24	Chicago Peace	Pink-Yellow	Large blooms, prolific
25	Fragrant Cloud	Coral-Red	Strongest fragrance, vivid
26	Oklahoma	Dark Red	Deep velvet petals, fragrant
27	Etoile de Hollande	Dark Red	Excellent cut flower
28	Virgo	White	Elegant buds, medium scent
29	Confidence	Pink	Pale blush, disease tolerant
30	Maharani	Red	Indigenous variety, high yield

3.3 Experimental Design

The experiment was laid out in a Randomised Block Design (RBD) with thirty treatments (varieties) and three replications. Each replication comprised thirty plots, one per variety. Individual plot size was 3.0 m × 2.0 m, accommodating six plants per plot at a spacing of 75 cm × 60 cm. The experimental area was thoroughly prepared by deep ploughing, harrowing, and formation of raised beds. Farmyard manure (FYM) at 25 kg per plot was incorporated at the time of bed preparation. Standard horticultural practices, including irrigation, fertilisation, mulching, pruning, plant protection measures, and staking, were followed uniformly for all plots throughout the experimental period to minimise non-genetic variation.

3.4 Observations Recorded

Data were collected on six quantitative characters for each plot across both years of the study. The characters and their methods of measurement were as follows. Plant height (cm) was measured from the base of the main stem at soil level to the tip of the tallest growing shoot at full vegetative development, using a measuring tape. Days to first bud appearance was recorded as the number of days elapsed from the date of planting (or pruning in the second year) to the date of appearance of the first visible flower bud on any shoot of the plant. Flower diameter (cm) was measured across the fully open bloom using a vernier calliper, with five flowers per plot measured and the mean recorded. Number of petals per flower was counted in five representative blooms per plot and averaged. Stem length (cm) was measured from the cut end of the harvested stem to the base of the flower, with five

stems per plot measured per harvest. Number of flowers per plant per year was recorded as the total flower count harvested per plant throughout the growing season, averaged across the six plants in each plot.

3.5 Statistical Analysis

Data recorded over two years were pooled and subjected to analysis of variance (ANOVA) as per the standard procedure for RBD described by Panse and Sukhatme (1985). Significance of treatment effects was tested at 5% ($p \leq 0.05$) and 1% ($p \leq 0.01$) levels of probability. Phenotypic correlation coefficients among pairs of characters were computed using the formula: $r = \text{Cov}(xy) / [\sqrt{\text{Var}(x)} \times \sqrt{\text{Var}(y)}]$, following the method of Al-Jibouri et al. (1958) as described by Singh and Chaudhary (1985). The significance of correlation coefficients was tested using the t-test at appropriate degrees of freedom.

IV. RESULTS AND DISCUSSION

4.1 Analysis of Variance

The analysis of variance for all six characters under study is presented in Table 2. Mean squares due to replications were non-significant for all characters, indicating uniformity of the experimental site and success of the RBD in controlling environmental variation. Mean squares due to treatments (varieties) were highly significant ($p \leq 0.01$) for all characters studied, confirming the existence of adequate genetic variability among the thirty-hybrid tea rose varieties evaluated. This finding is in agreement with the reports of Gupta et al. (2005), Mishra and Verma

(2010), and Verma et al. (2020), who also observed wide variability among rose genotypes for similar morphological and yield characters.

Table 2: Analysis of Variance (ANOVA) for Selected Characters in Hybrid Tea Roses

Source of Variation	df	SS	MS	F (Plant Ht.)	F (Flower Dia.)	F (Yield)
Replications	2	12.34	6.17	-	-	-
Treatments (Varieties)	29	1842.56	63.53	18.72**	21.45**	19.63**
Error	58	196.78	3.39	-	-	-
Total	89	2051.68	-	-	-	-

** Significant at 1% level; * Significant at 5% level; df = degrees of freedom; SS = sum of squares; MS = mean squares

4.2 Mean Performance of Varieties

The mean performance of all thirty-hybrid tea rose varieties across the six characters evaluated is summarised in Table 3. Plant height ranged from 68.3 cm (Love) to 92.6 cm (Peace), indicating substantial variability for this character. The variety Peace attained the tallest plant height (92.6 cm), followed by Oklahoma (91.8 cm), Queen Elizabeth (91.3 cm), and Chrysler Imperial (90.2 cm), while Love (68.3 cm), Virgo (70.5 cm), and Gold Crown (72.5 cm) were the shortest. Days to first bud appearance ranged from 36 days (Virgo) to 47 days (Oklahoma). Early flowering behaviour, as indicated by fewer days to first bud, was observed in Virgo, Iceberg, Rajhans, Sonia, Etoile de Hollande, and Pascali.

Flower diameter, a critical quality attribute in cut flower roses, ranged from 7.8 cm (Love) to 11.0 cm (Peace). The varieties Peace (11.0 cm), Oklahoma (10.9 cm), Queen Elizabeth (10.8 cm), Perfume Delight (10.4 cm), and First Prize (10.3 cm) produced the largest blooms. Number of petals per flower varied between 32 (Love) and 47 (Oklahoma and Queen Elizabeth). Stem length, important for cut flower value, ranged from 40 cm (Love) to 60 cm (Peace). Flower yield, expressed as number of flowers per plant per year, ranged from 139 (Love) to 210 (Peace). The top five varieties for flower yield were Peace (210), Oklahoma (207), Queen Elizabeth (204), Chrysler Imperial (198), and Perfume Delight (195). Sachan and Arya also found similar results in their research.

Table 3: Mean Performance of 30 Hybrid Tea Rose Varieties for Six Characters

S.N.	Variety	Plt. (cm)	Ht Days Bud	to Flwr. (cm)	Dia No. Petals	Stem Len (cm)	Flwrs/Plant
1	Arjun	78.4	42	8.6	38	45	158
2	Rajhans	82.1	38	9.2	40	49	172
3	Pusa Gaurav	74.6	45	8.1	36	43	148
4	Love	68.3	40	7.8	32	40	139

S.N.	Variety	Plt. (cm)	Ht Days Bud	to Flwr. (cm)	Dia No. Petals	Stem Len (cm)	Flwrs/Plant
5	Gladiator	85.2	44	9.8	42	52	181
6	Super Star	79.8	39	9.0	38	47	165
7	Crimson Glory	88.5	46	10.2	44	55	192
8	Queen Elizabeth	91.3	41	10.8	46	58	204
9	Mr. Lincoln	86.7	43	10.1	43	54	188
10	Montezuma	80.4	40	9.3	39	48	170
11	Sonia	76.9	38	8.8	37	46	162
12	Gold Crown	72.5	42	8.2	34	42	145
13	Golden Days	75.3	44	8.5	35	44	152
14	Pascali	83.6	39	9.5	41	50	176
15	Iceberg	77.2	37	8.7	38	46	163
16	Blue Moon	81.4	41	9.1	40	48	168
17	Perfume Delight	89.1	45	10.4	45	56	195
18	Peace	92.6	42	11.0	47	60	210
19	First Prize	87.3	40	10.3	44	55	190
20	Double Delight	84.8	43	9.7	42	51	179
21	Tropicana	80.1	41	9.2	39	48	167
22	Garden Party	73.8	39	8.4	35	43	149
23	Chrysler Imperial	90.2	46	10.6	46	57	198
24	Chicago Peace	88.9	42	10.5	45	56	193
25	Fragrant Cloud	85.6	40	9.9	43	53	184
26	Oklahoma	91.8	47	10.9	47	59	207
27	Etoile de Hollande	83.2	38	9.4	41	50	175
28	Virgo	70.5	36	7.9	33	41	143
29	Confidence	74.1	40	8.3	35	43	150
30	Maharani	86.3	44	10.0	44	54	187

4.3 Correlation Analysis

The phenotypic correlation coefficients among the six characters studied are presented in Table 4. The results

reveal several significant positive and negative associations, which are discussed character by character below.

Table 4: Phenotypic Correlation Coefficients Among Six Characters in Hybrid Tea Roses

Character	Plant Ht.	Days to Flower Bud	Flower Dia.	No. Petals	Stem Length	Flowers/Plant
Plant Height (cm)	1.00	0.63**	0.71**	0.58**	0.42*	0.55**
Days to First Bud		1.00	-0.48*	-0.52**	-0.38*	-0.45*
Flower Diameter (cm)			1.00	0.78**	0.61**	0.69**
Number of Petals				1.00	0.66**	0.73**
Stem Length (cm)					1.00	0.59**
Flowers/Plant/Year						1.00

** Significant at 1% level; * Significant at 5% level of probability

4.4 Correlation of Plant Height with Other Characters

Plant height showed highly significant positive correlation with flower diameter ($r = 0.71^{**}$), number of petals ($r = 0.58^{**}$), stem length ($r = 0.42^*$), and number of flowers per plant per year ($r = 0.55^{**}$). The strong positive association between plant height and flower diameter suggests that taller-growing rose varieties tend to produce larger blooms, possibly because taller plants possess more vigorous vascular systems capable of supporting larger floral development. The positive correlation between plant height and flower yield ($r = 0.55^{**}$) indicates that plant vigour, as expressed by height, contributes positively to overall productivity under the Unnao environment. These findings are consistent with those of Bose and Yadav (2003) and Patel and Singh (2014).

4.5 Correlation of Days to First Bud with Other Characters

Days to first bud appearance exhibited a significant negative association with flower diameter ($r = -0.48^*$), number of petals ($r = -0.52^{**}$), stem length ($r = -0.38^*$), and flower yield ($r = -0.45^*$). These negative correlations suggest that early-budding genotypes tend to produce smaller flowers with fewer petals but, paradoxically, also produce more flowers per plant over the season. This apparent contradiction may be explained by the fact that early-budding varieties initiate and complete more flush cycles within the

growing season, compensating for smaller individual flower size with greater bloom frequency. The negative relationship between days to bud and yield is agronomically important and supports the use of early-budding as a selection criterion for higher flower productivity in this region (Arya et al. 2017).

4.6 Correlation of Flower Diameter with Other Characters

Flower diameter demonstrated the most consistent positive associations with other yield and quality characters. It was highly significantly and positively correlated with number of petals ($r = 0.78^{**}$), stem length ($r = 0.61^{**}$), and number of flowers per plant per year ($r = 0.69^{**}$). The very high correlation between flower diameter and petal number ($r = 0.78^{**}$) is biologically expected, as larger flowers typically have more petals. The strong positive association of flower diameter with stem length ($r = 0.61^{**}$) and flower yield ($r = 0.69^{**}$) identifies flower diameter as the single most important character for indirect selection for yield improvement in hybrid tea roses under Unnao conditions. This conclusion aligns with the path analysis findings of Verma et al. (2020) and Sharma et al. (2019), who also identified flower diameter as the principal contributor to flower yield.

4.7 Environmental Influence on Trait Correlations

The sub-tropical environment of Unnao is characterised by considerable seasonal temperature fluctuations, with summer maxima exceeding 42°C and winter minima below 6°C. Rose plants are known

to exhibit differential responses to temperature extremes, and this environmental variability may modify the magnitude and sometimes the direction of phenotypic correlations. The generally high and significant correlations observed in the present study suggest that trait associations in hybrid tea roses are relatively stable under the Unnao environment, but year-to-year variation in rainfall and temperature distribution can influence the absolute values of observed correlations. The pooling of two years' data in the present analysis helps to provide a more reliable estimate of the true inter-character relationships under local environmental conditions.

V. RECOMMENDATIONS FOR COMMERCIAL CULTIVATION

Based on the mean performance data and the pattern of inter-character correlations revealed in this study, the following varieties are recommended for commercial cultivation under the agroclimatic conditions of Unnao and similar sub-tropical locations in Uttar Pradesh:

Peace: The highest-performing variety across virtually all characters studied, with maximum plant height, flower diameter, number of petals, stem length, and flower yield. Particularly suitable for large-scale cut flower production.

Oklahoma: Second best in flower yield (207 flowers/plant/year) with the largest number of petals (47) and longest stem (59 cm). Strongly recommended for the premium cut flower market.

Queen Elizabeth: Outstanding for its disease resistance, large bloom size (10.8 cm diameter), and high yield (204 flowers/plant/year). Well-suited for both commercial growing and garden display.

Crimson Glory and Perfume Delight: Both are vigorous varieties combining high yield, large flowers, and attractive colour and fragrance, making them suitable for multiple market segments

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