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EVALUATION OF GROWTH AND FLOWERING POTENTIAL OF *ROSA HYBRIDA* CULTIVARS UNDER FAISALABAD CLIMATIC CONDITIONS

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Exotic cultivars of hybrid roses respond uncertainly to new habitat. It is necessary to explore the potential of the introduced cultivars to judge the suitability in a new habitat. In the present study, nine *Rosa hybrida* cultivars including Autumn Sunset, Ice Berg, Paradise, Angel Face, Louise Odier, Casino, Grand Margina, Handel and Gruss-an-Teplitz were evaluated for growth and yield attributed under the climatic conditions of Faisalabad. Results indicated that there was decreasing trend in the growth and flowering of the bushes as the temperature increased above 32 ^{o}C and humidity decreased to 29 %. Number of flowers per bush and diameter of flower decreased as the temperature increased and humidity decreased in contrast to increment in height of the plant and number of primary branches per plant in succeeding months. Interaction between yield traits and months was also significant. Overall, significant variations were observed in each cultivar for length and number of petals per flower, number of prickles, fragrance, flower persistence life and color, bush shape and overall performance with respect to climatic conditions of Faisalabad. It is concluded that the cultivars 'Autumn Sunset' and Gruss-an-Teplitz performed better in climatic conditions of Faisalabad.

Keywords: *Rosa hybrida*, climate, growth, flowering, morphology

INTRODUCTION

Roses are grown in landscape premises and gardens for aesthetic gratification, as cut flower and for essential oil production as in case of Rosa centifolia. These are used in today's landscape as they have many advantages over other shrubs. It blooms for long period and the effect and range of the flower is remarkable. The autumn coloring of the foliage, the shape and color of the hips (fruits), sometime supplemented by decorative thorns make the rose important to be used in the landscape. In large parks, housing developments, city green areas, along with highways and community gardens the rose has a spiritual palace in formal beds. Most of the cultivars of hybrid roses have been developed in the cool climate of the world hence most of the cultivars fail to respond well under ho climate like Faisalabad. It is the nature of the roses that they are endemic to Northern hemisphere of the world hence they respond well to relatively low temperature, rainfall and moderate relative humidity. Among all the climatic factors temperature is main determinant of growth and yield of roses followed by relative humidity considerations. A moderate temperature ranging from 15^{o}C to 28^{o}C with humid conditions is suitable for the growth and flower production. If the temperature is less than 15^{o}C then there is production of malformed flowers followed by blind shoot and poor flower color in hybrid tea cultivars (Moe, 1988). During low temperature "bullheads" flowers are produced characterized by flat-topped appearance instead of pointing tips (Chimonidou, 2003). High temperature on the other hand is also worst for growth and flowering of *Rosa hybrida* cultivars whereas, humid environment leads to the prevalence of bacterial and fungal diseases. Water borne diseases are highly prevalent in more humid environment as disease spores are easily attracted by cuticle of leaves surfaces. Humidity is also related to the rose plant internal water contents where, browning of edges of leaves and leaflet may occur at low humidity. Water transportation is reduced through damaged flowers and hence emits ethylene (Bhattacharjee and De, 2005). High relative humidity is favorable for the mildew diseases. Present study was aimed to investigate the potential of the hybrid rose cultivars grown for landscape premises in the response of temperature, humidity and rainfall for the suitability under Faisalabad climatic conditions

MATERIALS AND METHODS

Selected hip bearing *Rosa hybrida* cultivars viz. Autumn Sunset, Ice berg, Paradise, Angel Face, Louise Odier, Casino, Grand Margina, Handel and Gruss-an-Teplitz, were collected from nurseries of district Kasur and planted in March, 2007 at Institute of Horticultural sciences by adopting RCBD layout plan. They were allowed to grow during the year to get full acclimatization and vigor. In the month of November, all cultivars were headed back to a height of 9" from the ground level leaving 4 main canes on the trunk in all bushes. Equal amount of farm yard manure

and potash fertilizers were applied to all bushes after pruning and before the start of new flushes. The field was irrigated at 15 days interval by canal water.

***Data Collection*:** Data regarding qualitative traits were collected for leaf color which was recorded by comparing the color of the flowers with color chart simply to know the tone of colors. Leaf margins were recorded as unserrated or serrated showing symptoms' of corrugated leaf margins. Leaf hairiness was recorded by visual observations. If it is present, was regarded as positive (+), if absent then negative (-). Petiole pubescence was observed by touching the petiole surface and presence was mentioned as positive (+) or negative (-). Flower color was also estimated by comparing the color of the flowers with color chart. It was estimated when flowers were fully opened. On the basis of variations in inflorescence type, flowers were classified into solitary or clustered on a common stalk.

On the basis of the quantitative traits, cultivars were evaluated for number of flowers bush^{-1} which was recorded from March to October on the 3 randomly selected bushes of each cultivar during each month along with total number of flowers. Number of petals flower^{-1} was also considered as important parameter which was recorded by selecting three flowers from different bushes of the same cultivars during the early blooming period. Length of petal (mm) was recorded by measuring the length of five randomly selected petals with three replications. Leaf (Pinnate) length (cm) was recorded from base of the leaf to the apex. Leaflet length (cm) was computed from base of leaflet to the terminal portion. Flower persistence life in the field (days) was recorded as the field shelf life of flower by recording the days from opening of the flower to the start of the senescence on the tagged plants. Flower diameter (cm) was measured by vernier caliper with three replicates for each flower. Plant height (m) was measured on monthly basis to estimate the increment in growth per month by using meter rod. Bush shape was considered as compact and regular, open and scattering with intermediate rating levels. Rating consisted of the following levels: 1= well developed, compact and regular bush shape having uniformity in branching, 2= good compact shape having few irregular branches, 3= with semi- compact shape having irregular branching patterns. 4= open scattering framework of branches. To investigate overall performance of the bushes of the selected cultivars also the scale the same scale was used. The scale consisted of the following rating: 1= with good healthy, compact shape and more recurrent flowering intensity, 2= with average growth, semi-compact shape and good flowering intensity, 3= with reasonable growth and bush shape and flowering intensity, 4= with stunted growth, irregular bush shape and few flowering intensity. Fragrance was evaluated by judge with rating scale as follows: 1= highly fragrant, 2= Medium fragrant, 3= Less fragrant and 4= No fragrance. Amount of prickles present on the branches and canes was calculated by using rating scale having 1 = with no prickles, 2= Very few prickles, 3= Medium number of prickles and 4= High number of prickles.

Data were analyzed using standard ANOVA techniques by using statistical software SPSS-15. Means were compared by LSD to check the significance of the results.

Table 1. Description of qualitative traits of selected cultivars

Plant traits/ Cultivar	Autumn Sunset	Ice Berg	Paradise	Angel Face	Casino	Louise Odier	Grand Margina	Handel	Gruss-Anteplitz
Leaf color	Dark green glossy	Pale green, glossy	Dark green, semi glossy	Dull green	Pale green, glossy	Light green,	Dull green	Dark green glossy	Light green, pink blush, glossy
Leaf Margins	Partially Serrated	Un-Serrated	Serrated	Serrated	Partially Serrated	Serrated	Serrated	Serrated	Serrated
Leaf hairiness	+	-	-	+	+	-	-	+	+
Petiole pubescence	+	-	+	+	+	-	+	-	+
Flower color	Yellow with pink blush	Snow	Lavender	Plum	Yellow	Hot pink	Yellow	Hot	Deep
Flower color	Yellow with pink blush	white	Lavender	mauve	Yellow	Hot pink	With pink bush	pink	pink
Inflorescence type	Clustered	Clustered	Solitary	Clustered	Solitary	Clustered	Clustered	Clustered	Clustered
Inflorescence type	Clustered	Clustered	Solitary	Clustered	clustered	Clustered	Clustered	Clustered	Clustered

+ = Present - = Absent

RESULTS AND DISCUSSION

Data regarding qualitative traits of foliage and flowers is presented in Table 1. Foliage characters varied visually among all cultivars. Foliage color of cvs. 'Autumn Sunset' and 'Handel' was same as dull green and glossy. Foliage of other cultivars varied from pale green to dull green. Most attractive foliage was exhibited by cultivar 'Ice Berg' with excellent light green and glossy foliage with sharp apices. Leaf margins of all cultivars varied from un-serrated to highly serrated. Leaves in cvs. Casino and Autumn Sunset were slightly serrated as compared to cultivars Paradise, Angel Face, Louise Odier, Grand Margina and Gruss-an-Teplitz having highly serrated leaves, while it was present in the cultivars Autumn Sunset, Angel Face, Casino and Gruss-an-Teplitz. Leaf hairiness and petiole pubescence was absent in the cultivars Ice berg and Louise Odier. Similar variations were observed in other cultivars as well. Observation on flowers color resulted in a lot of variation. Most of the cultivars exhibited clustered inflorescence showing bunches of flowers on a peduncle including Autumn Sunset, Ice Berg, Angle Face, Casino, Louise Odier Grand Margina, Handel and Gruss-an-Teplitz. In cultivar Paradise solitary inflorescence was recorded. The findings are similar to Hortus Third (1976) who stated that Hybrid Tea and Floribunda roses are the predominant garden and greenhouse cut-flower production roses with glossy foliage, recurrent blooming habit showy colors as described by Lammerts 1945).

Data regarding quantitative traits in the form of flower number per bush each month showed that there were significant variations. Maximum number of flowers per bush (40) were produced by the cultivar Ice Berg flowed by cultivar Angel Face (31). Minimum number of flowers (9) was produced by the cultivar Autumn Sunset, however, great variations were observed each month with respect to flower production. Maximum number of flowers per bush was produced in the month of March with a mean value of 19 followed by April with mean flowers per bush of 17 as shown in the Table 2. The interaction of cultivars and month was also significant ($P<0.001$) as maximum number of flower per bush were produced by the cultivar Ice Berg in the month of March followed by the cultivar Angel Face, however the performance of Ice Berg in most of the months except June and July was excellent. Performance of cultivar Paradise was not satisfactory as in the month of June it

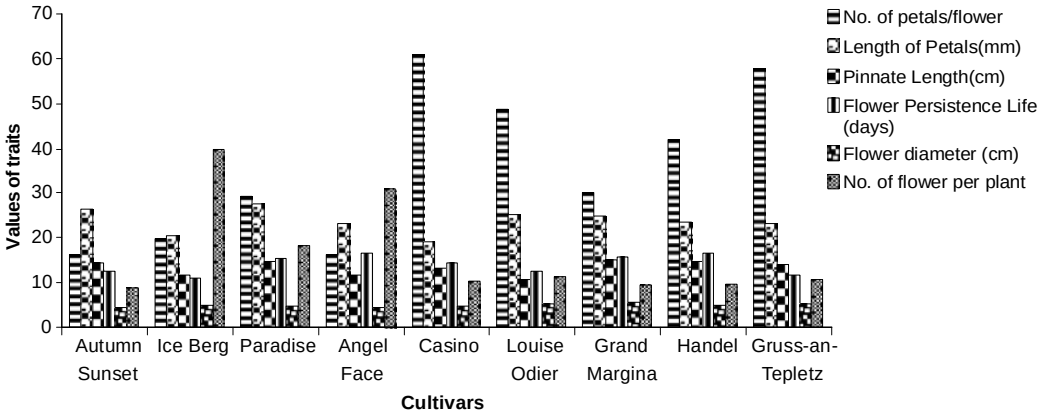

Figure 1. Mean values of the yield traits of cultivars

Table 2. Comparison of performance of cultivars with respect to environmental factors (2008)

Months	Environmental Factors			Growth parameters			
	Temp. ^{o}C	R. H%	Rainfall (mm)	NOFPP	DOF (cm)	NOPB	HOP (m)
March	22.7	37.8	0.0	19.69a	5.381a	8.64f	0.639f
April	26.0	33.6	16.0	18.86ab	4.835bc	10.08e	0.760e
May	30.8	30.2	75.5	15.61cd	4.599c	12.08d	0.925d
June	32.9	29.0	41.7	9.92e	4.59c	12.66cd	0.941d
July	32.9	53.0	81.6	14.88d	4.77bc	13.16bc	0.979cd
August	30.9	65.0	204.5	17.80abc	4.863b	13.50ab	1.026bc
September	29.0	59.3	28.8	18.75ab	5.150a	13.91abc	1.051b
October	26.7	57.6	0.0	17.25bc	5.273a	14.44ab	1.030c
November	19.7	58.9	0.0	17.25bc	5.204a	14.81a	1.132a

NOFPP= Number of flowers per plant **DOF**= Diameter of flower (cm) Alpha= 0.05
HOP= Height of the plant (M) **NPBP**= Number of Primary branches/plant

produced only 5 flowers per bush. Similar results has been reported by Singh *et al.*, (1994) who observed that hybrid tea rose cv. Nurjehan produced maximum flowers per plant (58.8), largest flower diameter (9.3 cm), had deep flower bud (4.2 cm) and were most fragrant. According to Mulla *et al.* (1995) number of flowers per plant was maximum in cv. Nania followed by cv. Devotion from the hybrid tea group. Variations in number of flowers per plant are related to recurrent blooming habit due to their genetic makeup (Manjula, 2005). It was also observed that as the temperature increased humidity decreased and number of flowers per bush decreased in the month of June and again increased in the month of July showing that temperature is a determinant factor for flower yield as Khatak *et al.* (1995) while working on hybrid tea roses for field evaluation stated that maximum flower per bush was obtained in cv. Paradise in the month of March and April as compared to June-July due to 7-17^{o}C increment in temperature. Data regarding flower diameter in each month is presented in the Table 2. Diameter of flower varied significantly ($P<0.001$) among all cultivars and according to each month variations in flower diameter were observed in each cultivar as presented in the Figure 1. Maximum mean flower diameter was exhibited by the cultivar Grand Margina (5.75 cm) followed by the cultivar Louise Odier (5.37 cm). Minimum flower diameter (4.33 cm) was observed in the cultivar Autumn Sunset as presented in figure 1. Diameter of flower also varied according to each month as maximum flower diameter was calculated in the month of March (5.38 cm) followed by October (5.27 cm) however minimum diameter of flower was calculated in the month of May and June (4.59 cm) as presented in the table 2. Interaction of moths and cultivars was not significant. Decreasing trends in diameter from the month of June to August can be attributed to high temperature stress (Khatak *et al.*, 1995). Moreover, reduction in number of flowers and diameter of flower from April to onward seems to be affected by the increase in temperature and decrease in relative humidity. Pettersen *et al.* (2006) argued that number of flowers/ plant can be increased by 34% due to diurnal variations in air humidity under continuous period from 18 to 24h day^{-I} and decrease the number of days until flowering by 12% in roses. The transport of photosynthetic assimilates to the developing floral buds may seems to be triggered by the amount of endogenous growth regulators in the flower (Halevy, 1987). Height of the Plant (m) exhibited seasonal variations. Data regarding height of the plant collected on monthly basis revealed that the cultivars and months exhibited significant differences in height of the bush as shown in the table 2. The interaction between cultivars and months was also significant ($P<0.001$). Height of the plant of all cultivars varied with respect to months. Maximum mean height (1.7261 m) was observed in the cultivar Handel followed by Gruss-an-Teplitz (1.51 m) and Ice Berg (0.89 m). Minimum bush height (0.5917 m) was yielded in cultivar Louise Odier (Table 2). Maximum height (1.13 m) on average basis was recorded in the month of November and minimum (0.64 m) in the month of April. However on overall all basis interaction between cultivars and months revealed that maximum plant height (2.12 m) was observed in cultivar Handel in the month of November and minimum (0.48 m) was yielded by cultivar Louise Odier in the month of March. Possible cause of the variation in response of cultivars is due to environmental, genetic and management factors as Bernier *et al.*, (1993) explained that environmental factors (e.g. irradiance, photoperiod, temperature, water availability) are important for the purpose of controlling the transition to flowering in plants. These factors also interact with each other. Light intensity is the most important climatic factor affecting rose plant growth and flowering (Zieslin and Mor, 1990).

For number of primary branches per plant results of ANOVA indicated that cultivars and months showed highly significant ($P<0.001$) results with respect to number of primary branches per plants. However the interaction between cultivars and months did not revealed highly significant results ($P>0.001$). Maximum numbers of primary branches (18) were yielded in the cultivar Gruss-an-Teplitz followed by Ice Berg. Minimum primary branches (9) were yielded by the cultivar Casino. Data regarding the response of all cultivars in different months showed that maximum average numbers of primary branches (15) were yielded in the month of November as shown in the Table 2. Number of petals per flower also varied in all cultivars. Results regarding number of petals per flower are presented in the table which revealed highly significant differences among all cultivars ($P< 0.001$). Maximum number of petals (61) was exhibited by the cultivar "Casino" followed by "Gruss-an-Teplitz" (57). Minimum number of petals per flower was recorded in the cultivar "Autumn Sunset" and "Angel Face" (16). This correlates with the assumption of Lammerts (1945) that there is variation in number of petals among different Rosa species and number of petals (doubleness) is controlled by dominant gene and has quantitative inheritance. The degree of dominant gene with more alleles contributes to more flowers petals i.e dddd having five petals and DDdd having medium number of petals and DDDD having maximum number of petals. Double-flowered cultivars have more petals or "petaloids" than the basic five petals and this increment in number of petals seems to be due to conversion of pistil and stamens into petals and petaloids. Furthermore, increased vigor of scion due to contribution of rootstock and numer of floral initials can affect the number of petals in flowers (Morey, 1959; Zlesak, 2006). These results are in accordance with Bhattacharjee *et al.* (1993) obtained maximum petals with Cv. Dr. B.P. Pal (47.80), whereas minimum number of petals was recorded in Cv. Raja Surrender Singh of Nalagarh.

Flower persistence life was recorded in the month of April. It varied significantly (P<0.001) for all cultivars. Maximum flower persistence life (17 days) was recorded in the "Handel" followed by the cultivar "Angel face" (16 days). Minimum flower persistence life (11 days) in the field was exhibited by the cultivar "Ice Berg". Flower shelf life depends on the senescence of the tissues as Farrante *et al.* (2010) revealed that flower shelf life (aesthetic value) is related to genes that control senescence process and as a result of senescence discoloration and death of tissues takes place leading to the abscission of petal. Further, flower senescence is due to accumulation of ethylene, Abscisic Acid (ABA) and Calcium (Farrante *et al.,* 2010). According to Van Doorn (2002) roses are very sensitive to ethylene and its sensitivity differs from specie to specie and with in cultivars. Kondo *et al.* (2005) and Torre *et al.* (1999) claimed that flower color, size, flower shelf life and pigmentation are directly affected by soil pH and Calcium level. Other factors that affect flower shelf life are relative humidity (Plaut et al, 1979), light and temperature (Farrante *et al*., 2010) as temperature affects the anthocyanin biosynthesis path ways (Dela *et al.,* 2003; Plaut *et al*., 1979). Results regarding length of petals are presented in the Figure 1. There were not significant differences with respect to length of petals (P>0.001). The results regarding pinnate length for all cultivars in terms of statistical analysis of variance are presented in the Figure 1. Maximum pinnate length (15.1 cm) was yielded in the cultivar Grand Margina (14.7 cm) followed by the cultivar Paradise. Minimum pinnate length (10.5 cm) was recorded in Louise Odier. Leaf (pinnate) size, whether measured as leaf width, leaf area, or leaflet number was found to be quantitative in nature (Lammerts, 1945; Zhang, 2003; Shupert *et al.,* 2007).

Bush shape varied significantly among all cultivars. Comparison of means revealed that excellent bush shape was exhibited in the cultivar "Ice Berg" with compact, regular and dense growing habit getting 1.75 scores followed by Cultivar "Autumn Sunset" (2.25). Performance of cultivar "Handel" with respect to Bush shape was not satisfactory as it got 4.75 scores leading to irregular, scattering and creeping growth habit as presented in the Table 3. Fragrance was also recorded in the form of rating scale in between 1 and 4 having value 1 with maximum fragrance and 4 with minimum. Results of ANOVA showed highly significant results (P<0.001) for varying amount of fragrance in all cultivars. Maximum amount of fragrance was recorded in the cultivar Grand Margina with a mean value of (1.5) followed by Gruss-an-Teplitz (1.75) and Paradise (2.00). Very less amount of fragrance (3.5) was recorded in the cultivar Casino. According to Verhoeven *et al.* (2003) fragrance is very important factor which is under the control of multitude pathways and environmental factors. Lammerts (1945) suggested that this trait seems to be quantitative but according to the recent work of Cherri-Martin *et al.* (2007) it is clear there is also a major gene that is responsible for turning the pathway of scent production on and off. In addition, certain enzymes are responsible for the creation and regulation of various fragrance components (Vainstein *et al.,* 2003). Data for prickles was also calculated by using rating scale. ANOVA showed that the performance of all cultivars with respect to prickles did not vary significantly. However maximum prickles (scoring 3.5) were present in the cultivar Grand Margina. All other cultivars behaved in a similar fashion with respect to amount of prickles scoring between 2 and 2.5. Inheritance of each cultivar as thornless seems to be controlled by single recessive gene (Debener, 1999) however the inheritance of thornless found in tetraploid cultivars seems to be complicated as Rajapakese *et al.* (2001) while working on tetraploid cultivars revealed that thornlessness may be controlled by multiple gene. Over all performance was estimated for considering novel traits of growth and performance.

Results from ANOVA indicated that all the cultivars showed highly significant differences (P<0.001) with respect to overall performance. It was also estimated by using rating scale, i.e. rating 1 with excellent performance and 4 with poor performance with stunted growth. Better performance on overall basis was shown by the cultivar Autumn Sunset and Gruss-an-Teplitz (2.5). Poor performance was exhibited

Table 3. Quality parameters of cultivars as rated by scale

Cultivar	Fragrance	Prickles	Bush Shape	Overall Performance
Autumn Sunset	2.75bc	2.25bc	2.25de	2.50b
Ice Berg	2.75bc	2.00c	1.75e	2.75ab
Paradise	2.00de	2.75b	2.5cd	3.00ab
Angel Face	2.75bc	2.5bc	2.5cd	2.75ab
Casino	3.50a	2.75b	3.00bc	3.25ab
Louise Odier	3.00ab	2.75b	3.00bc	3.75a
Grand Margina	1.50e	3.50a	2.75cd	3.00ab
Handel	2.25cd	2.25bc	4.75a	3.25ab
Gruss-an-Teplitz	1.75de	2.75b	4.50a	2.50b

Alpha= 0.05 Standard Error for Comparison= 0.0879

by the cultivar Louise Odier (3.75) (Table 3). Variations in the performance to all the cultivars can be attributed to fluctuations in temperature, humidity and low rainfall as in the present study for almost every trait decreasing trends were observed as the temperature increased and humidity decreased (Tabassum *et al.*, 2002; Khattak, 1991).

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