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MORPHO-PHYSIOLOGICAL COMPARISON OF CUT ROSE CULTIVARS GROWN IN TWO PRODUCTION SYSTEMS

IFTIKHAR AHMAD*, M. SHAFIQUE KHALID, M. ASLAM KHAN AND M. SALEEM

Institute of Horticultural Sciences, University of Agriculture, Faisalabad-38040, Pakistan

Abstract

A study was conducted to compare the growth and yield of five promising cut rose (*Rosa hybrida* L.) cultivars in two production systems viz. greenhouse and field under agro-ecological conditions of Faisalabad, Pakistan. All plant growth and physiological indices of the study except total leaf chlorophyll contents were higher in greenhouse grown plants as compared with field cultivated. Among cultivars, 'Rosy Cheeks' and 'Whisky Mac' had vigorous vegetative growth while 'Amalia' and 'Anjlique' produced higher flower yield of best quality than other cultivars compared in the study. Therefore, 'Amalia' and 'Anjlique' are preferred cultivars for commercial production than 'Rosy Cheeks', 'Whisky Mac' and 'Kardinal'.

Introduction

Cut roses are one of the most famous and popular cut flowers in global floriculture trade. Roses have deep relationship with human sentiments and have high demand in international markets on account of their use in almost every event. Currently, major cut rose producers are Netherlands, Colombia, Kenya, Israel, Ecuador, and Japan. In Dutch flower auctions; 3,243 million rose stems were marketed in 2007 while 3,415 million rose stems were marketed as cut flower during 2008 with a value of US $ 10 billion (Evans, 2009). Pakistan being an agricultural economy with diverse agro climatic conditions has a great potential for cut rose production. According to a survey, roses are being grown as cut flowers on 1,300 acres in Punjab (Khan, 2005).

Roses enjoy superiority over all other flowers being extensively used for decorative purposes and are praised for their decorative nature, beauty, charm and fragrance. Rose cut flower cultivation is gaining popularity among the farmers in different areas of Pakistan and has recently been considered as a lucrative enterprise. In the last few years, an increased awareness, recognition of high return on investments, rapid growth rate, improved living standards, increased desire to live and work in an environment friendly atmosphere and increase in hotel and restaurant business has led to more demanding and choosy clients. Favorable agro-climatic conditions of the country clearly indicate that wide range of cut rose cultivars can be grown, which can uplift the economic status of the growers. As rose is being grown in rural and peri-urban areas, its potential to generate employment is an added advantage to improve economic livelihood of the weaker section of our society. For export quality cut rose production, modern technology has to be adopted in order to optimize the growing conditions essential for plant growth and development under local climatic and edaphic conditions.

Climatic and edaphic factors play vital role in the production of quality roses. These factors not only influence the growth and production but also influence the quality. Among these, temperature, light and relative humidity directly influence the plant growth. The ideal temperature for rose production is 20-25°C during the day and 13-16°C at night alongwith 8 h of sunlight (Shin *et al*., 2001) and <75% relative humidity. Below 15°C, roses can be grown but interval between flushes becomes longer and bull heads, a physiological problem which results in flat-topped unmarketable buds, are produced. While at higher temperatures above 30°C, poor quality flowers with lesser petals are produced (Lerner & Dana, 2003).

Elenes & Hanan (1987) studied the effect of greenhouse cover and shading on rose yield and found that 76.7 flowers plant^{-1} were produced over a 15.5 month period under the double layer polyvinyl fluoride structure. Khattak *et al*., (1995) evaluated performance and adaptability of ten exotic rose cultivars in D.I. Khan and found that cv. Paradise was the tallest and produced large sized flowers without fragrance. Jawaharlal *et al*. (1999) reported that optimum conditions for large sized flower production were 15-21^{o}C mean temperature, 55-80% relative humidity and 5-8 h photoperiod while according to Damake & Bhattacharjee (2000) maximum flower production occurred at 21-31^{o}C mean temperature, 60-80 % relative humidity and 6.5-8 h photoperiod. It was observed that roses grown at moderate R.H. had a longer vase life than high R.H., irrespective of the K/Ca ratio of the nutrient solution. At high R.H. only, bent neck was resulted but changes in the K/ Ca ratio had no adverse effect (Torre *et al.,* 2001). Flower yield is increased by 34% due to diurnal variations in air humidity under continuous period from 18 to 24 h day^{-1} and decrease the number of days until flowering by 12% in roses (Pettersen *et al*., 2006). Shin *et al*., (2001) observed that the number of days from bud to flowering increased from 21.6 to 63.0 days as temperature decreased from 30 to 15^{o}C in *Rosa hybrida* cv. 'Kardinal'. Leaf area, stem length, chlorophyll contents and stem diameter generally increased with decreasing temperature, but the best quality stems were observed at 18^{o}C. With decrease in temperature from 30 to 15^{o}C, flower dry weight was increased from 0.7 to 3.0 g. It was observed that when plants were moved to lower temperature at visible bud stage, flower dry weight was increased. Maximum flower yield, stem length and flower quality has been reported in plants grown at 23.9^{o}C day temperature (Holocomb & Tsinaraki, 1987). Growing conditions also affect the postharvest quality of cut roses which may be partially related to the carbohydrate balance of the plants. Long photoperiod, high air humidity and low temperature may reduce vase life (Slootweg & van Meeteren, 1991; Mortensen & Fjeld, 1998).

At present, very little information is available on effects of climatic factors on growth, yield and quality of cut roses under local conditions. Keeping in view the socio economic value of cut roses and emerging needs to standardize the production technology for commercial rose cultivation, this study was conducted with the specific objective to compare the performance of five most popular *Rosa hybrida* L. cultivars grown in greenhouse and open field conditions.

*Corresponding author's e-mail: iftikharahmadhashmi@gmail.com; Tel. & Fax. 92 41 9201085, Cell: 92 333 8417286

Materials and Methods

This study was conducted at Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Two years old plants of five hybrid rose cultivars viz. 'Amalia', 'Anjlique', 'Kardinal', 'Whisky Mac' and 'Rosy Cheeks' were selected growing in both greenhouse and open field. The experiment was set up in a randomized complete block design with factorial combination of two growing conditions and five cultivars. All treatments were replicated thrice and each replicate consisted of ten plants. For uniformity, all plants were pruned at equal height (15 cm from bud union). The plants in the field were grown in natural environment, whereas, in greenhouse were grown under controlled conditions viz. 27 ± 3°C mean temperature and 60 ± 10% R.H. Data regarding different environmental factors, e.g. temperature, R.H. etc. were collected twice a day both in open field and greenhouse (Figs. 1 & 2). All other cultural practices like fertilization, irrigation, weeding, plant protection etc. were similar for all treatments during entire period of study. Data regarding plant height (cm), number of leaves per branch^{-1}, leaf area (cm^2), leaf total chlorophyll contents (mg g^{-1}), days to flower, number of flowers plant^{-1}flush^{-1}, bud diameter (cm), flower diameter (cm), fresh and dry weight of a flower (g), stem length (cm) and diameter (cm) were collected. Flower quality was also estimated according to Cooper & Spokas (1991) and Dest & Guillard (1987). Analysis of variance (ANOVA) on data was performed using the GLM program of the STATISTICA 5.6 and means were separated using Tukey's test at $p \leq 0.05$ (Steel *et al*., 1997).

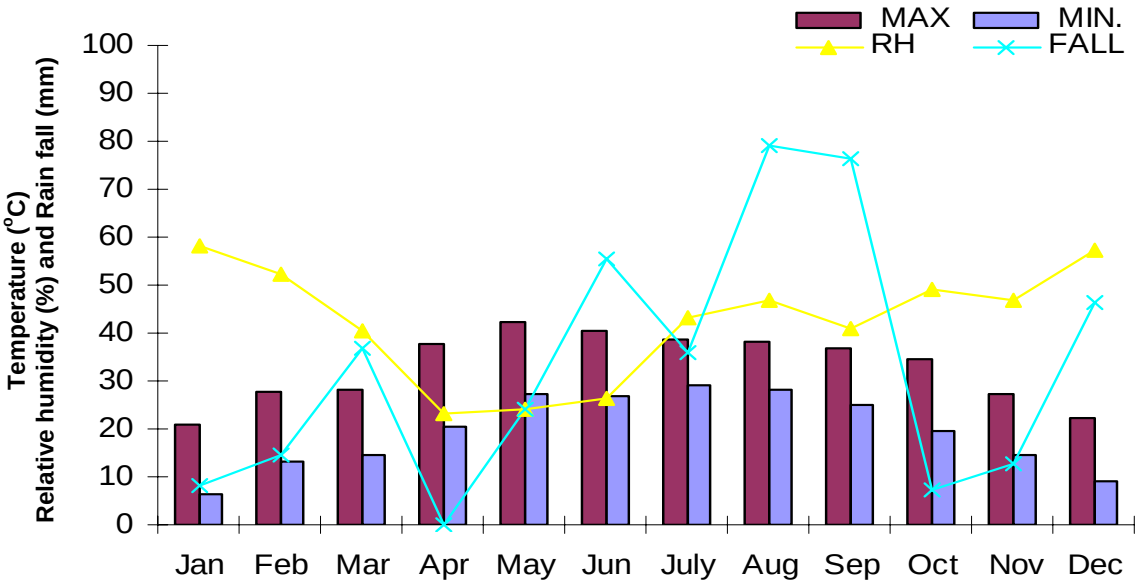

Fig. 1. Meteorological data of the experimental site during study period.
Max. = Maximum temperature; Min. = Minimum temperature; RH = Relative humidity; RF = Rain fall

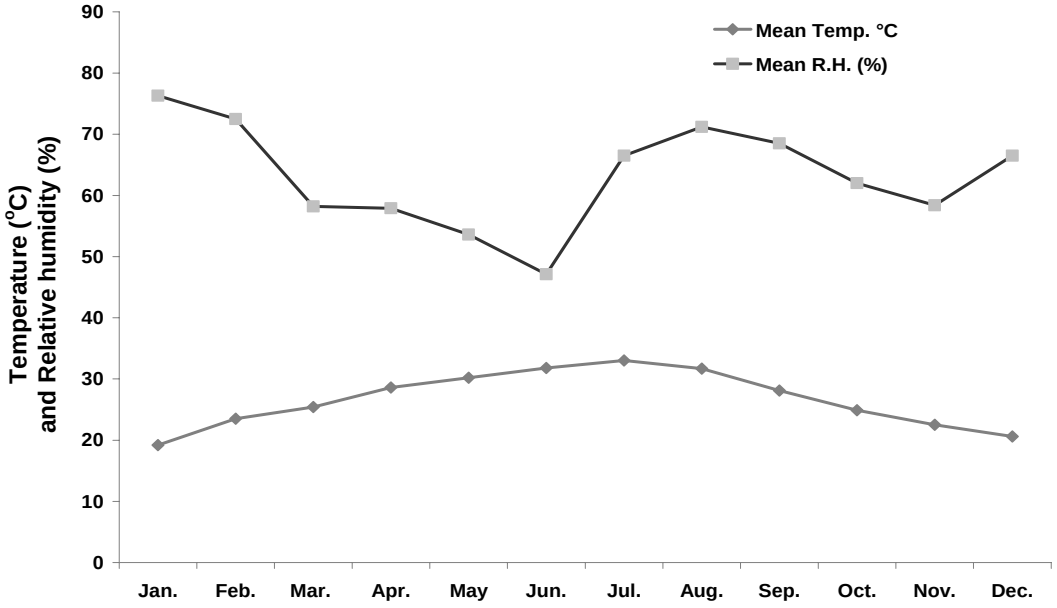

Fig. 2. Greenhouse temperature °C and relative humidity (%) during study period.

Results

Roses grown in greenhouse produced taller plants (80.6 cm) than grown in the field (68.7 cm). Among cultivars, 'Rosy Cheeks' attained maximum plant height (88.5 cm) followed by 'Whisky Mac' (86.4 cm), 'Anjlique' (78.3 cm) and 'Amalia' (70.2 cm), whereas, 'Kardinal' got minimum plant height (49.7 cm). In greenhouse, 'Whisky Mac' produced maximum height (95.5 cm) followed by 'Rosy Cheeks' (94.0 cm) while 'Kardinal' produced shortest plants with 52.7 cm height (Table 1). In open field, 'Rosy Cheeks' had maximum height (83.0 cm) followed by 'Whisky Mac' (77.3 cm) while 'Kardinal' produced minimum plant height (46.7 cm). These results suggested that roses can be best grown in greenhouse due to controlled environmental conditions particularly temperature and relative humidity which triggered plant growth as compared with those grown in open field. Plant foliage was increased by growing plants under controlled conditions in greenhouse. Greenhouse cultivation produced higher number of leaves per branch^{-1} (13.6) than open field grown (10.1 leaves branch^{-1}). Among cultivars, 'Rosy Cheeks' produced maximum leaves branch^{-1} (16.5 in greenhouse while 10.8 in open field) followed by 'Whisky Mac' and 'Anjlique' which were statistically at par (13.9 and 13.8 in greenhouse and 10.6 and 10.5 leaves branch^{-1} in open field, respectively; Table 1). 'Kardinal' and 'Amalia' produced minimum leaves branch^{-1} and were statistically similar. Foliage growth revealed higher photosynthetic activity in greenhouse by producing maximum leaves.

Greenhouse grown plants had larger leaf area as compared with field grown plants. All cultivars grown in greenhouse produced large sized leaves (89.95 cm^2) as compared with open field grown plants (81.26 cm^2). Among cultivars, 'Whisky Mac' produced large-sized leaves (116.63 cm^2) in greenhouse while minimum leaf area (65.2 cm^2) was produced by 'Anjlique' grown in open field followed by 'Amalia' and 'Rosy Cheeks' which were statistically similar, whereas, 'Anjlique' produced leaves with minimum leaf area (Table 1). Plants grown in open field had higher leaf total chlorophyll contents (53.43 mg g^{-1}) than greenhouse grown plants (46.74 mg g^{-1}) as shown in Table 2. All cultivars exhibited similar results for leaf total chlorophyll contents which were statistically non-significant.

Table 1. Plant height, number of leaves branch^{-1} and leaf area of *Rosa hybrida* L. 'Amalia', 'Anlique', 'Kardinal', Whicky Mac' and 'Rosy Cheeks' grown in two production systems viz. greenhouse and field.

Cultivars	Plant height (cm)		Number of leaves branch^{-1}		Leaf Area (cm^2)	
	Greenhouse	Field	Greenhouse	Field	Greenhouse	Field
Amalia	73.7 ± 2.1	66.6 ± 1.8	10.5 ± 1.0	9.6 ± 1.7	96.26 ± 4.6	85.53 ± 4.5
Anjlique	86.8 ± 4.3	69.8 ± 1.1	13.8 ± 0.9	10.5 ± 0.3	76.46 ± 3.1	65.20 ± 3.7
Kardinal	52.7 ± 3.3	46.7 ± 1.5	13.1 ± 1.9	8.8 ± 0.8	73.00 ± 3.5	71.36 ± 3.2
Whisky Mac	95.5 ± 4.8	77.3 ± 1.1	13.9 ± 0.7	10.6 ± 0.9	116.63 ± 2.8	104.86 ± 2.2
Rosy Cheeks	94.0 ± 3.8	83.0 ± 3.4	16.5 ± 0.1	10.8 ± 0.9	87.40 ± 2.2	79.36 ± 3.6
Mean	**80.5 ± 3.6**	**68.7 ± 1.8**	**13.6 ± 0.9**	**10.1 ± 0.9**	**89.95 ± 3.2**	**81.26 ± 3.4**

Values are means ± S.E. of three replicates of 10 plants

Table 2. Total leaf chlorophyll contents, days to flower and bud diameter of *Rosa hybrida* L. 'Amalia', 'Anlique', 'Kardinal', Whicky Mac' and 'Rosy Cheeks' grown in two production systems viz. greenhouse and field.

Cultivars	Total leaf chlorophyll contents (mg g^{-1})		Days to flower (Days)		Bud diameter (cm)	
	Greenhouse	Field	Greenhouse	Field	Greenhouse	Field
Amalia	50.84 ± 0.7	54.78 ± 3.3	66.1 ± 0.8	69.7 ± 0.1	4.4 ± 0.1	3.1 ± 0.1
Anjlique	49.30 ± 2.4	54.84 ± 2.6	72.7 ± 1.2	75.1 ± 0.4	3.4 ± 0.2	2.7 ± 0.1
Kardinal	47.13 ± 3.2	49.60 ± 1.4	67.3 ± 0.4	72.7 ± 0.5	4.4 ± 0.1	2.9 ± 0.1
Whisky Mac	43.04 ± 2.1	58.12 ± 3.1	80.5 ± 0.6	88.0 ± 1.6	4.2 ± 0.1	3.1 ± 0.0
Rosy Cheeks	43.41 ± 1.3	49.80 ± 2.6	81.2 ± 0.4	85.4 ± 1.3	3.7 ± 0.1	2.6 ± 0.1
Means	**46.74 ± 2.0**	**53.43 ± 2.6**	**73.5 ± 0.7**	**78.2 ± 0.8**	**4.0 ± 0.1**	**2.9 ± 0.1**

Values are means ± S.E. of three replicates of 10 plants

Analysis of variance for days to flower revealed significant ($p \leq 0.01$) differences among growing conditions as well as cultivars. Greenhouse grown plants produced earlier flowering (73.5 days) as compared with field grown plants which flowered after 78.2 days. Among cultivars, 'Amalia' produced earlier flowers (after 66.1 days in greenhouse and 69.7 days in field) followed by 'Kardinal' (67.3 and 72.7 days). However, 'Whisky Mac' produced late flowering (80.5 and 88.0 days in greenhouse and open field, respectively). These results revealed that 'Amalia', 'Kardinal' and 'Anjlique' were more suitable cultivars to be grown in greenhouse for getting higher yield than 'Whisky Mac' and 'Rosy Cheeks'. Greenhouse production resulted higher yield (18.6 flowers plant^{-1} flush^{-1}) than field production (12.9 flowers plant^{-1} flush^{-1}). Regarding cultivars, 'Whisky Mac' produced more flowers (21.2) followed by 'Rosy Cheeks' and 'Anjlique' (16.0 and 15.8, respectively) and were statistically similar. 'Amalia' and 'Kardinal' had less flowers plant^{-1} flush^{-1} (13.4 and 12.3, respectively). In greenhouse, 16.2, 18.1, 14.9, 31.1 and 18.9 flowers were produced flush^{-1} while in field, 10.5, 13.6, 9.7, 30.7 and 15.9 flowers flush^{-1} were produced by 'Amalia', 'Anjlique', 'Kardinal', 'Whisky Mac' and 'Rosy Cheeks', respectively (Fig. 3). The results revealed that greenhouse production can increase flower yield as compared with field cultivation. Among cultivars, 'Whisky Mac', 'Rosy Cheeks' and 'Anjlique' proved floriferous cultivars which produced higher yield than 'Amalia' and 'Kardinal'.

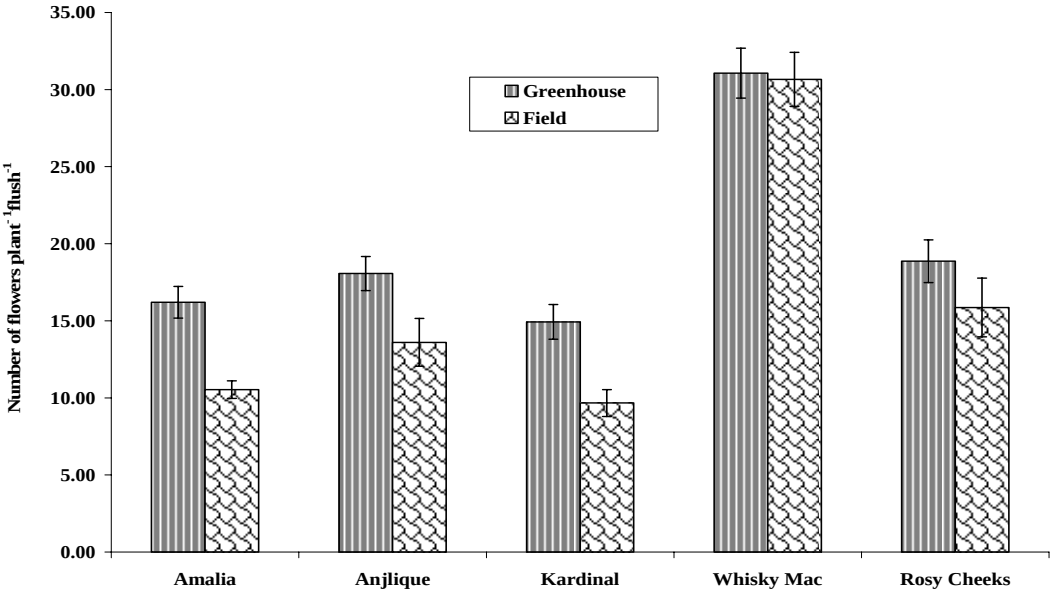

Fig. 3. Number of flowers plant^{-1} flush^{-1} of *Rosa hybrida* L. cultivars grown in two production systems viz. greenhouse and field.

Greenhouse grown plants produced greater bud diameter (4.0 cm) than field grown (2.9 cm). Among cultivars, 'Amalia', 'Kardinal' and 'Whisky Mac' grown in greenhouse produced large sized buds with 4.4, 4.4 and 4.2 cm diameter, respectively, and were statistically similar. Whereas, in field, 'Amalia' and 'Whisky Mac' produced maximum bud diameter (3.1 cm each) and were statistically at par. However, 'Rosy Cheeks' and 'Anjlique' had smaller buds in both production regimes (Table 2). Results showed that protected rose cultivation increased bud diameter, a major quality parameter for export quality cut rose flower production. Similarly, greenhouse grown plants produced larger flowers (7.3 cm) while field grown plants had 5.4 cm diameter. Among cultivars, 'Amalia' and 'Rosy Cheeks' had greater flower diameter (8.5 and 7.5 cm in greenhouse and 5.8 and 5.7 cm in field, respectively) which were statistically similar. However, 'Kardinal' produced minimum flower diameter in both production regimes (Table 3).

Table 3. Flower diameter and fresh and dry weight of a flower of *Rosa hybrida* L. 'Amalia', 'Anlique', 'Kardinal', Whicky Mac' and 'Rosy Cheeks' grown in two production systems viz. greenhouse and field.

Cultivars	Flower diameter (cm)		Fresh weight of a flower (g)		Dry weight of a flower (g)	
	Greenhouse	Field	Greenhouse	Field	Greenhouse	Field
Amalia	8.5 ± 0.6	5.8 ± 0.1	5.7 ± 0.0	5.2 ± 0.1	1.32 ± 0.0	1.11 ± 0.0
Anjlique	6.7 ± 0.1	4.8 ± 0.1	5.6 ± 0.0	5.1 ± 0.1	1.26 ± 0.1	0.99 ± 0.0
Kardinal	6.4 ± 0.3	5.0 ± 0.2	4.5 ± 0.1	4.3 ± 0.0	1.11 ± 0.0	0.87 ± 0.0
Whisky Mac	7.4 ± 0.1	5.6 ± 0.2	6.4 ± 0.0	5.2 ± 0.1	1.41 ± 0.0	1.21 ± 0.0
Rosy Cheeks	7.5 ± 0.5	5.7 ± 0.6	5.9 ± 0.1	5.4 ± 0.2	1.20 ± 0.0	1.06 ± 0.0
Mean	**7.3 ± 0.3**	**5.4 ± 0.3**	**5.6 ± 0.1**	**5.0 ± 0.1**	**1.26 ± 0.0**	**1.05 ± 0.0**

Values are means ± S.E. of three replicates of 10 plants

Greenhouse grown plants had higher flower fresh weight (5.6 g) than field grown (5.0 g). Regarding cultivars, 'Whisky Mac' produced flowers with 6.4 g fresh weight in greenhouse while 5.2 g in field followed by 'Rosy Cheeks' (5.9 and 5.4 g) and 'Amalia' (5.7 and 5.2 g) in greenhouse and open field, respectively (Table 3). As greenhouse grown plants produced flowers with higher fresh weight than field grown plants, similar trend was observed regarding dry weight of a flower. Greenhouse grown plants had 1.3 g dry weight while field grown plants had 1.0 g dry weight. Among cultivars, 'Whisky Mac' produced higher dry weight of a flower in both growing conditions (1.4 and 1.2 g), while 'Kardinal' produced less dry weight (1.1 and 0.9 g) in greenhouse and open field, respectively (Table 3).

Regarding flower quality, best quality flowers (6.6) were produced in greenhouse while in field, average quality flowers (with 5.6 quality rating) were harvested. Among cultivars, 'Anjlique', 'Rosy Cheeks' and 'Amalia' had better quality blooms with proper bud development, color, free of blemishes and attractive appearance (7.0 each in greenhouse while 6.5, 6.1 and 5.8 in open field, respectively) and were statistically similar, while 'Kardinal' had poor flower quality with poor color and bud development irrespective of the production system (Fig. 4).

Stem length is one of key factor for quality evaluation of cut roses. Analysis of variance for stem length revealed significant ($p \leq 0.01$) differences among growing conditions as well as cultivars. Greenhouse grown plants produced longer stems (56.0 cm) than field grown (36.7

cm long). Among cultivars, 'Whisky Mac' and 'Rosy Cheeks' produced longer stems in greenhouse and were statistically at par, while in field, 'Rosy Cheeks' and 'Anjlique' produced longer stems (47.7 and 39.2 cm, respectively) as shown in Fig. 5. Stem diameter, another variable to estimate the mechanical strength and thereby quality of cut roses, was greater in greenhouse grown plants (0.44 cm) than field grown (0.33 cm). Among cultivars, 'Amalia', 'Rosy Cheeks' and 'Whisky Mac' produced greater stem diameter (0.50, 0.49 and 0.49 cm, respectively) in greenhouse and were statistically similar. While in field, 'Rosy Cheeks' and 'Amalia' had greater diameter (0.41 and 0.39 cm, respectively). 'Kardinal' had minimum stem diameter irrespective of the production system (Fig. 6).

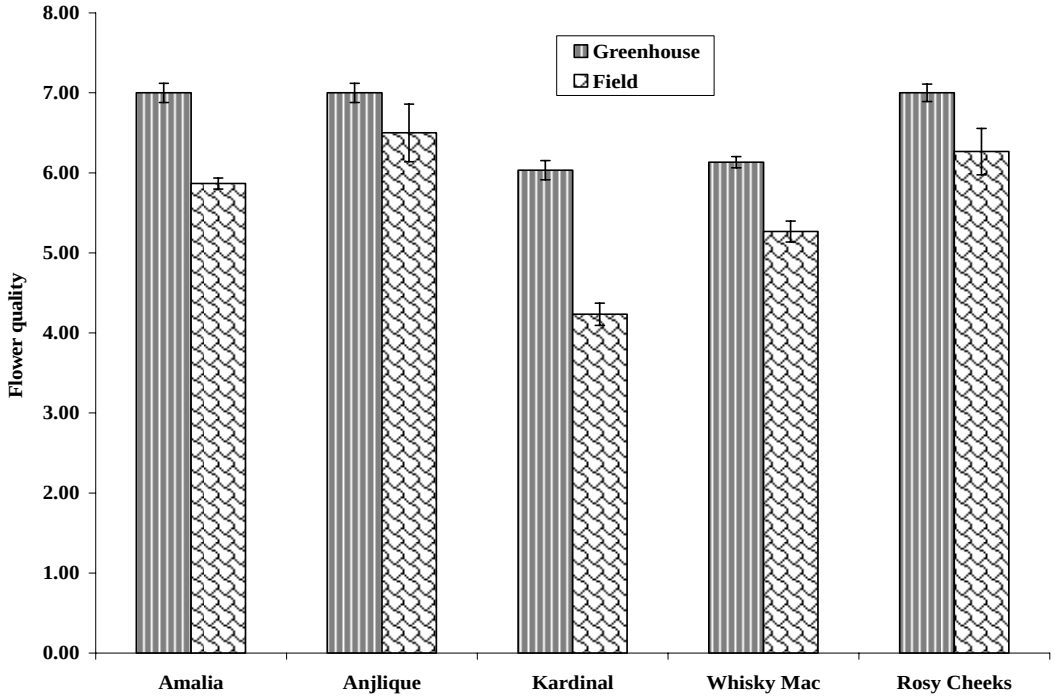

Fig. 4. Flower quality of *Rosa hybrida* L. cultivars grown in two production systems viz. greenhouse and field.

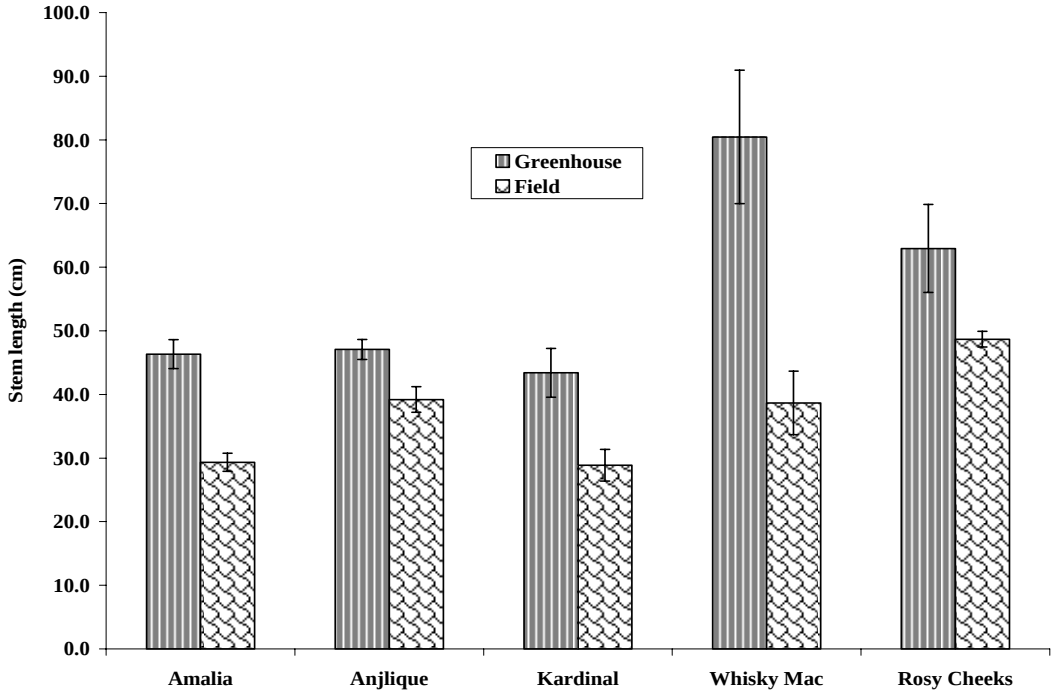

Fig. 5. Stem length (cm) of *Rosa hybrida* L. cultivars grown in two production systems viz. greenhouse and field.

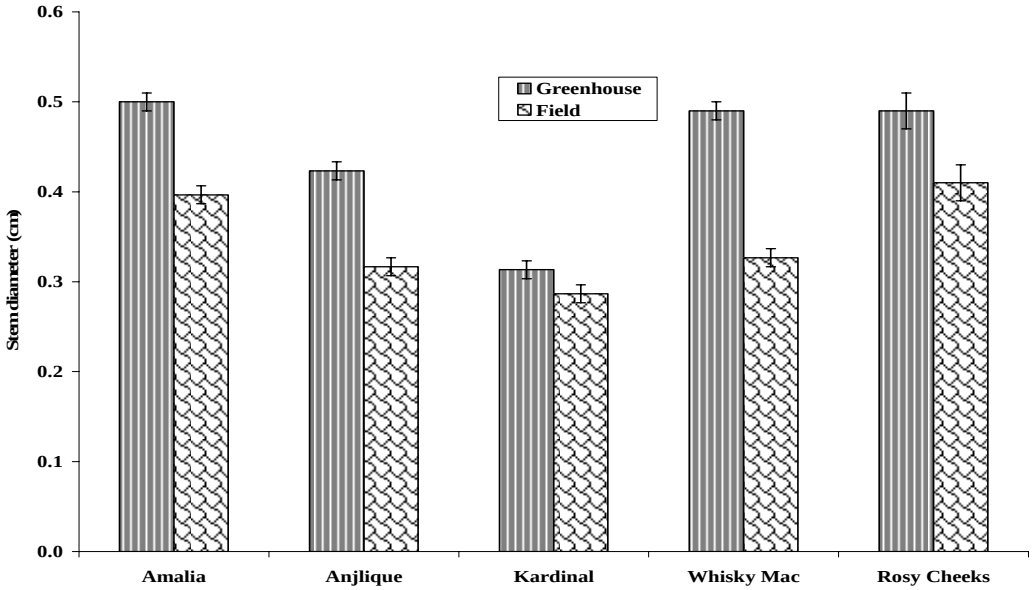

Fig. 6. Stem diameter (cm) of *Rosa hybrida* L. cultivars grown in two production systems viz. greenhouse and field.

Discussion

Year-round greenhouse production of cut roses is yet not explored commercially in Pakistan due to several reasons. Growing of *Rosa hybrida* cultivars in greenhouse produced vigorous growth as well as higher yield of better quality as compared with field production which suggested the superiority of greenhouse cultivation over traditional open field production in order to produce year round cut roses. Higher number of leaves with large area was recorded in greenhouse which indicated large surface area for assimilation of photosynthates as in greenhouse; comparatively less light was available as compared with field. Therefore, leaves with larger area had overall higher chlorophyll on account of their larger area than field grown plants which enhanced photosynthetic efficiency and helped produce more carbohydrates for growth and development of the plants. These results confirmed the findings of Damake & Bhattacharjee (2000); Torre *et al.,* (2001); Pettersen *et al*. (2006) and Qasim *et al.,* (2008) who argued that greenhouse rose cultivation enhances growth, yield as well as flower quality. Open field cultivation only produced marketable flowers during October, November and February, March as during rest of the time, too high or low temperatures reduce flower yield and quality. Among cultivars, 'Rosy Cheeks' and 'Whisky Mac' proved vigorously growing cultivars while 'Amalia' and 'Anjlique' produced higher yield of better quality.

In summary, greenhouse production is better option for commercial production than field cultivation as it not only enhances growth and yield of the plants but also quality. In addition, more flushes per annum can be harvested in greenhouse than in open field which in turn helps in increasing profitability. Among cultivars, 'Amalia' and 'Anjlique' proved best for greenhouse production in terms of growth, development and quality.

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