

**“EVALUATION OF ROSE VARIETIES FOR LOOSE FLOWER
PRODUCTION”**

by

Miss. Kute Rani Suresh

(Reg. No. 018/314)



**DIVISION OF HORTICULTURE
COLLEGE OF AGRICULTURE, PUNE-411 005**

**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722, DIST-AHMEDNAGAR
MAHARASHTRA, INDIA**

2020

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A Thesis submitted to the

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MAHARASHTRA, INDIA**

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (HORTICULTURE)

in

FLORICULTURE AND LANDSCAPING



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APPROVED BY

Dr. G. M. Idate

(Chairman and Research Guide)

Dr. Ganesh B. Kadam
(Committee Member)

Dr. A. A. Bhagat
(Committee Member)

Prof. B. B. Meher
(Committee Member)

**DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, PUNE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413 722 DIST- AHMEDNAGAR
MAHARASHTRA, INDIA**

2020

Dedication



**This thesis is
Respectfully and affectionately
Dedicated to
My beloved mother and father,
Miss. Maina and Mr. Suresh
And my
Lovely family and friends
To whom
My success is their success.....!!!**

.....Rani

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma

Place: Pune

(Miss. Rani Suresh Kute)

Date: / /2020

Dr. G. M. Idate

Assistant Professor of Horticulture,
AICRP on AZF, (Fig and Custard apple),
Jadhav wadi, Pune.
Maharashtra State, India

CERTIFICATE

This is to certify that the thesis entitled, **“EVALUATION OF ROSE VARIETIES FOR LOOSE FLOWER PRODUCTION”**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FLORICULTURE AND LANDSCAPING**, embodies the result of a piece of bonafide research work carried out by **Miss. KUTE RANI SURESH** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place : Pune

Date : / /2020

(G. M. Idate)

Dr. S. D. Masalkar

Principal and Associate Dean,
College of Horticulture, Pune-05,
Maharashtra State, India.

CERTIFICATE

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Place : Pune

Date : / /2020

(S. D. Masalkar)

Dr. S. D. Masalkar

Associate Dean,

College of Agriculture, Pune-05,

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Place : Pune

Date :

(S. D. Masalkar)

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Place: Pune

(Miss. Kute Rani Suresh)

Date: / /2020

Reg. No: 018/314

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LIST OF ABBREVIATIONS

@	:	At the rate
/	:	Per
%	:	Percent
+	:	Plus
C.D.	:	Critical difference
Cm	:	Centimeters
<i>et al.</i>	:	et all (and others)
etc.	:	Ecetra
G	:	Gram
ha.	:	Hectare
i.e.	:	That is
Kg	:	Kilo gram
Mg	:	Milligram
No.	:	Number
S.E.	:	Standard error
<i>viz.,</i>	:	Videlicent (namely)
ml	:	Milligram
T	:	Tone
L	:	Liter
DAB	:	Days after budding
RHS	:	Royal Horticulture Society
hrs	:	Hours
Fig	:	Figure
°C	:	Celcius
MSL	:	Mean Sea Level
Ft	:	Feet

ABSTRACT

“EVALUATION OF ROSE VARIETIES FOR LOOSE FLOWER PRODUCTION”

By

Miss. KUTE RANI SURESH

A candidate for the degree

of

MASTER OF SCIENCE

in

HORTICULTURE**(FLORICULTURE AND LANDSCAPING)****DEPARTMENT OF HORTICULTURE****COLLEGE OF AGRICULTURE****PUNE – 411005****2020**

Research Guide:**Dr. G. M. Idate****Department:****Horticulture**

The present investigation entitled, “Evaluation of rose varieties for loose flower production” was carried out at experiment unit Directorate of Floriculture Research, Pune during 2019-20 to evaluate the performance of ten rose varieties in open field condition, viz., Charishma, Kashmir Velvet, Abhisarika, Paradise, Sophia, Folklore, Peter Frankelfeld, Tenacious, Strawberry and Rose Sherbet. Observations were recorded for various growth, flower, yield and pollen attributes including shelf life.

The experiment was conducted in Randomized Block Design with ten rose genotype as treatment and replicated thrice spaced at 60 x 90 cm.

Among the ten varieties evaluated, maximum plant height (213.67 cm), plant spread (188.34 cm) and duration of flowering (132.67 days) were recorded in Folklore. The variety Paradise produced maximum number of flowers per plant (82.67), flower diameter (9.67 cm), chlorophyll content (1.85 mg/g), shelf life (55.13 hr.) and pollen fertility (31.24 %). Maximum number of petals per flower (57.00) and pollen viability (95.69%) were recorded in Tenacious.

Among the ten varieties studies, maximum flower weight (7.60 g), hundred flower weight (663.7g), days required for flower opening after bud initiation (13.67 days), were recorded in Peter Frankelfeld. The maximum number of days taken to flowering after pruning (115.33 days) and days required for flower bud initiation (102 days) were recorded in Rose Sherbet. The maximum days required for colour break (11 days) was recorded in Sophia and maximum anthocyanin content (6.5 mg/L) was recorded in Abhisarika.

Present study revealed that among the varieties evaluated viz., Folklore, Paradise, Tenacious, Peter Frankelfeld and Rose Sherbet emerged as promising varieties for loose flower production in open field condition.

1. INTRODUCTION

Flowers are symbolic of beauty, love and tranquility. They form the soul of a garden and convey the message of nature to mankind, especially the rose, since it is the most favorite gift on special occasions. The rose rightly called “Queen of Flowers” is the most beautiful among all the flowers. It is one of the best known commercial cut flower that has become an integral part of our daily life. Variety in sizes, colours, shapes and versatility has made it the queen of flowers. It belongs to the family Rosaceae and native of temperate region of Northern hemisphere. Flowers are used both as cut flower and loose flower for floral arrangement, garland making, in landscape gardening and also for making various products such as rose oil, rose water, garland, rose attar, etc.

Rose (n=7) is one of the oldest flowers under cultivation and most popular of all garden flowers throughout the world. The genus *Rosa* consists of about 120 species out of which only eight species are cultivated viz., *R. multiflora*, *R. luciae*, *R. moschata*, *R. damascene*, *R. gallica*, *R. chinensis*, *R. gigantean*, and *R. foetida*. Rose have been classified into different classes like Hybrid Teas, Polyanthus, Floribundas, Grand flora, Damask Roses, Miniatures etc. on the basis of their mode of origin and blooming pattern. Each variety is unique in one or more characteristics. The cut flowers with long stem belonging to Hybrid Tea and commonly cultivated by the farmers for cut flower purpose. For loose flower purpose, Floribunda possess the character of producing flowers in cluster and few varieties of Floribunda are highly suitable for garland preparation, poojas and other social functions.

Rose ranks first among the top ten cut flowers in the international flower market, followed by carnation and chrysanthemum. Top ten major flower producing countries in the world during 2018 are the Netherland (52%), Columbia (15%), Ecuador (9%), Keniya (7%), Belgium (3%), Ethiopia (2%), Malaysia, Italy and Germany, (1%) of global market share.

India “Flower power” continues to bloom with the country emerging as the second largest grower of flowers around the world, surpassed only by China. The National Horticulture Board said that India produced 17 lakh MT of loose flowers and Andhra Pradesh leads in loose flowers production with 2, 24,410 MT cultivated over 34,850 hectares, followed by Karnataka at 2, 07,500 MT cultivated in 29,700 hectares and Tamilnadu with 3, 12,970 MT grown in 28,700 hectares in 2012 – 13.

Roses can be grown throughout the year in India. In fact the vast Indian sub-continent with its varied climate provides such diverse ecological niches that roses spread their year round charm

almost without a pause. Rose is grown in almost all parts of the world from a tropical to temperate climate in variable ranges of humidity and rainfall. Its best performance is however seen in temperate climate where there is a market period of rest. Much of the area under cut flower production in Northern India is concentrated around Delhi and they produce cut flowers during winter months from November to March. In the South, rose for cut flower and loose flower production is extensively grown for domestic and export market in and around Bangalore. In the Western region extensive export oriented cut flower cultivation is taken up in Pune, Nasik and Sangli districts of Maharashtra.

Rose is the strongest compound of domestic cut flowers production and market. In seeking the best combination of price and domestic quality requirement and preference, rose flower production can be found at the most primitive and most advanced levels depending on environmental conditions, production costs, market demand and distance. The main competition occurs between local primitive and advanced growing to take advantage of growing domestic demand. This competition will continue for the foreseeable futures permitting a more economical product to be marketed but requiring continued focus on improved production efficiency and more effective quality maintenance. Recently in many districts and towns, many retail florists (traditional flower sellers) require local supply of roses from their own area around to meet the local growing demand. There has been a distribution network allows the state, where in flowers move long distances from the production sites to the retail florist.

Most of the existing Indian rose cultivars are released for garden display and for loose flowers production. Hence, an attempt was made to evaluate the varieties for open field conditions which will not only help the consumer to get better quality flowers but also fetches higher income to growers. Evaluation and test was carried out in the performance of varieties in open field condition with the following objectives.

- 1) To evaluate the rose varieties in open field condition for loose flower production.
- 2) To study the pollen viability in rose.

2. REVIEW OF LITERATURE

The area under cultivation of rose for both as cut flower and loose flower production is increasing to meet domestic as well as export market. The demand for rose flowers still tops the list among the flowers. Most of the rose cultivars grown for loose flower production are region specific and commercially only few cultivars are popular which are mostly loose bud type, opens quickly and petals are loosely arranged. The growers are not aware of new varieties and their performance. It is worth testing new cultivars for their adoptability and performance in the different region. Attempts to be made with respect to introduction and evaluation to know the performance of new varieties under different climatic condition with respect to their yield and quality aspects. Rose have been classified into different classes like Hybrid Perpetual, Tea Roses, Hybrid Teas, Polyanthus, Floribundas, Grand flora, Damask Roses, Miniatures etc. on the basis on their mode of origin and blooming pattern. In recent years there has been a remarkable development of the Floribunda roses, and in some parts of the world they are now considered to be as important as the Hybrid Teas.

The literature pertaining to the present investigation is reviewed and presented under the following headings. Wherever the literature on rose is limited, information on other related flower crop is also reviewed here under.

2.1 Varietal performance

2.2 Effect of climate

2.3 Effect of preservatives on shelf life

2.4 Economics of rose cultivation

2.5 Pollen viability, pollen fertility and pollen colour

2.1 Varietal performance

Post (1952) classified rose cut flowers into different grades based on length of shoot. According to Hussein (1955) straight stem over 50 cm long with clean and healthy leaves evenly distributed along the stem is one of the most important characteristics of ideal rose cut flowers. Weak stem and neck are often a sign of variety rather than sign of poor culture. In general bloom must be well set upon a stem of sufficient strength to hold it firmly erect.

Lundstad (1962a) reported experimental findings of varietal trials with 31 Floribunda roses during the period 1954-60. They were evaluated for different characteristics like height of the

plant, colour and size of the flower. Based on the evaluation results, two cultivars Border King and Schweizer Crruss were recommended for cultivation.

Lundstad (1962b) reported the result of varietal trials with 25 cultivars of shrub roses during the period 1955-61. Based on the plant vigor and flowering period, six cultivars were recommended being of outstanding value. The cultivars were Marigold, Moje, Hammerberg, Nevda, Schmeezweg and Splendius.

Balasubramanian (1963) pointed out that a good rose variety should have sufficient petals held firmly erect on the stalk for number of days.

Lundstad (1964) used plant vigor and number of flowers as important characters for the selection of a variety and recommended 'Ama', 'Korona', 'Lady Muysee', 'Robinson', 'Moulin Rouge', 'Pink', 'Garnette', 'Queen Elizabeth' and 'The Fairy' to be best for cultivation.

Buck (1964) used the relative height of the plant, colour and type of flower for selecting rose variety. Further he took into consideration, the number of blooms per plant for measuring the adaptation of the variety.

Malik (1968) stated that an ideal variety should have long, sharp, erect and pointed buds without excessive petals and a firm texture to withstand bruising during transport and preferred strong flower stems with least density of thorns and have an appreciable fragrance and vase life.

Lundstad (1969) reported the results of varietal trials on 51 Hybrid Tea roses during the period 1965-68. Based on the data recorded on number of flowers, flowering period and colour, cultivar 'Coronado', 'Ena Harkness', 'Hamre Intirmezzo'. 'McGredys', 'Sunset' and 'Superstar' were recommended for cultivation.

Brander (1971) conducted varietal trials with Floribunda and Hybrid Tea roses for growing outdoors. Evaluation was based on production, quality, time and duration of flowering.

Chandrashekaraiah (1973) evaluated eight rose cultivars during rainy and winter seasons and reported that maximum number of flowers per plant (7.28 and 8.32), petals per flower (43.30 and 44.47), total stem length (64.10 and 56.69 cm) and bud length (4.61 and 5.00 cm) were obtained with Superstar and Kings Ramson respectively.

Millia (1974) observed that in a trial of 13 cultivars grafted on *Rosa indica*, the highest yield was obtained from the cultivars Grandmere Jenny, Champs Elysees and Carina with 77, 66 and 62 flowers/m², respectively.

Lundstad (1975) evaluated forty five new cultivars of Floribunda and Polyanthus roses during the period 1968-72. Height of the plant was found to be maximum in the cultivars 'Queen Elizabeth' (84 cm) and minimum in 'Goldschatz' (30 cm). The cultivars 'Goldenrausch' and 'Tip Top' had the maximum flower diameter (9.5 cm) and 'Gartnerreude' and 'Marimba' and minimum (5.5 cm). The number of petals was found to be maximum in the cultivar 'Gold Topaz' (48) and minimum in 'Lampion' (25). The colour of the cultivars recorded was recorded with the Horticulture colour chart. Based on results of evaluation the cultivars 'Janspek' Pernille 'Poilsen' and 'Tip Top' were recommended as best one.

Schoroder (1975) reported that highest yield was recorded with Magic Moment (317 blooms/m²) followed by Illona with 241 blooms/m², whereas least number of flowers was obtained with Cv. Baccara. The longest stem length (50-80cm) was recorded in Baccara and Illona.

Kore *et al.* (1977) evaluated that 56 rose cultivars for resistance to die back caused by *Diplodia rosarum*, out of which 11 were highly resistant including White Christmas, Royal Ascot, Blue moon and Crimson Glory.

Bogamozova (1978) carried out varietal trials with 62 rose cultivars and reported, 'Baccara Rose', 'Guazard' and 'Superstar' were the most suitable cultivars for plastic film houses and 'Bel Ange', Baccara', 'Gloria Dei', 'Memorian', 'Ophelia', Superstar' and 'Alaska' were the most productive.

Gowda *et al.* (1979) reported that rose cv. Eiffel Tower produced highest number of marketable flowers (21.50/plant) followed by Jovencelle (16.50), Summer Queen (10.70), Elida Cardinal, First Prize, Agena and John F. Kennedy. The John F. Kennedy was considered unsuitable for cut flower production.

Lundstad (1979) recommended that Koniginder Rsen, Pescali and Peer Gynt cultivars for cultivation based on flower number, flower size, number of petals, colour and scent.

Gowda *et al.* (1980) evaluated that eight hybrid tea roses for cut flowers. Various characters was evaluated shoot length which was found to be maximum in Mainauperle (36.00cm) and minimum in Red Devil (18.58cm). The total number of well-developed petals was found to be maximum in Red Devil. The density of thorns per 2.5 cm shoot was observed maximum in Mainauperle (6.25) and minimum in Pink Parfait (2.25).

Malik and Singh (1980) described that the flower characters of cultivars, 'Arjun', 'Jawahar', 'PinkMontezuma', (Hybrid Tea Type) 'Chandrama', 'Navasadabahaar', and 'Sindhoor',

and 'Queen Elizabeth' (Floribunda type). Two other Indian cultivars Arjun and Raktagandha were also promising.

Plomacher (1980) assessed that the longest stem length was obtained with cultivars Folklore, Romantica -76, Corso Carlita, whereas least stem length was recorded in Traumeria. There was reduction in number of cut stems (40%) due to frost. The early cultivars fetched the highest price in June whereas late cultivars were less productive but produced high quality flowers with long stems. The Cv. Folklore had the longest stems (90-120 cm), whereas Traumeri had the shorter stems (50-80 cm) but with longest vase life.

Haenchen (1981) assessed that the productivity of 54 rose cultivars grown outdoors for cut flowers. The highest average number of cut stems was with cultivars 'Spartan', 'Crimson Glory' and 'Sutters Gold' being 20.3, 19.3 and 19.1 stems per plant respectively and the lowest yield from cultivars 'Abu', 'Marcelle Gret' and 'Baccara', which gave 5.2, 5.3 and 7.5 stems per plant respectively.

Garica and Mejias (1982) reported that among the rose cultivars evaluated the highest yield was obtained with Cv. Laminuette followed by Sabrina, Goldentimes, Candia, Caste, Blanche, Bettina, Sonia, Mercedes, Visa and Samantha.

Roxas (1982) stated that in a trial using two types of rose cultivars, viz., medium flowered rose and miniroses, the Cv. Prominent produced high quality flowers and Belinda was useful for its high autumn-winter yield among medium flowered roses, whereas in miniroses more number of flowers (1816 flowers/m² in six years) was obtained with Cv. Carol whereas Cv. Zorina produced high quality long lasting flowers.

Ginzburg *et al.* (1983) reported that Cv. Mercedes was more sensitive to low temperature than other cultivars like Sonia and Bingo where flower yield was reduced when the maximum air temperature was 14 °C or less. The cultivar Mercedes and Bingo exhibited higher yields during winter months.

Miske (1983) reported that the Cv. Athena (white), Causana (copper yellow), Mirato (red yellow), Pasandena (orange red) proved superior among nine rose cultivars evaluated.

Vyapari (1985) studied 50 rose cultivars and reported that cultivars Ambassador, Bull's Red, Ferry, Pozssche, Illona, Interflora and Vasavi having stalk length of 85.67, 65.67, 79.17, 61.17, 46.00, 77.17 and 53.23 cm respectively were found to be suitable for cut flower production.

Gelder (1985) reported that among the rose cultivars evaluated, cultivars Darling Ulsteta, Lovely Girl and Ruby were considered the best for cut flower production. Out of 35 rose cultivars evaluated, 19 were found to be outstanding which includes one yellow, three salmon orange, four pink red, ten deep red and one bi-colour cultivar (Larson, 1985).

Eichin and Deiser (1986) studied total yield and its distribution between May and October and stem girth and length of 8 rose cultivars for a period of 3 years in a plastic house. The most productive cultivar 'Alsmer Gold' produced 200stems/m², but they were the shortest, while cultivar Magitta produced 100stems/m², but they were the longest and strongest.

Rejman and Wisniewska (1986) carried out trials with cultivars 'Sonia', 'Carlina' and 'Illona' grafted on '*Rosa canina*' which were grown under unheated plastic tunnel. The variability of bushes of each cultivar was tested. The number of flowers produced by individual bushes showed a high coefficient of variability which rose to 48 per cent. Changes in the number of cut flowers produced on the plant and cultivars, 'Illona' had a higher variability.

Grzeszkie-Wicz and Rejman (1991) carried out the eight rose cultivars evaluated under greenhouse condition, highest yield of cut flower was obtained with cultivars Sonia, Carina and queen of Bermuda (12.40, 9.50, and 8.60flowers/plant respectively). Whereas, Queen of Bermuda, Belle Epoque and Interflora produced longest stem length.

Murugesan and Ramani (1991) studied the performance of 85 rose cultivars. There were evaluated with reference to plant height, number of thorns per 10 cm shoot, flower colour, flower diameter, flower stalk length. Coefficient of variation ranged from 137.8 per cent for number of flowers per plant 22.6 per cent for flower length. The mean plant height ranged from 41.5cm in dwarf Polyanthus cultivar 'Chattion' to 178.8 cm in tall erect hybrid tea cultivar, 'American Heritage' and flower diameter of 30 cm in 'Chattion' and 'Minister' to 13.0 cm in cultivar 'Happiness', 'Duet', 'Sunrise' and 'Sunset'. The variation in stalk length was 2.8 cm in cultivar 'Chandrama', 'Red rose' and 'Cactus blane' had the highest number of flowers/ plant and recommended for garden use. 'Happiness', 'Illona', 'American Heritage', 'Sunrise' and 'Sunset' recommended for quality cut flower.

Bhattacharjee *et al.* (1993) reported longer stem length and highest diameter of shoots in Cv. Sonia Meilland which was earlier to initiate flowering after pruning, the Cv. Raja surrender Singh of Nalagarh recorded maximum vase life (10.60days) followed by Dr. B. P. Pal (9.8days), highest number of petals obtained with Dr. B. P. Pal (47.80) whereas least number of petals was observed in Raja surrender Singh of Nalagarh (18.20).

Singh *et al.* (1994) conducted field experiment for three years and assessed the performance of Indian bred rose in respect of growth and flower production. Among sixteen cultivars, Nurjehan from Hybrid Tea group and Banjaran from Floribunda had performed better.

Sooriannatha *et al.* (1996) studied ninety seven rose cultivars and reported that cultivars Abhisarika, Ambassador, Anurag, Arabian Night, Casino, Duet, Folk Lord, Garden Party, Grandmere Jenny, Happiness, Strawberry and Superstar performed well in respect to floriferousness, stalk length and flower size.

Nagaraj (1996) carried out an experiment to know the influence of growing condition on growth, yield and quality parameters of exotic rose cultivars viz., Kiss, Vivaldi, Yunone, Eternand and Gladiator under polyhouse condition. The cultivar Kiss produced the highest flower yield ($80.96/m^2$), followed by Yunone ($64.16/m^2$) and Vivaldi ($57.79/m^2$) as compared to Gladiator, which produced the least number of flowers ($44.13/m^2$). Quality parameters viz., bud length, bud diameter and total stem length were found to be superior in gladiator followed by Yunone and Vivaldi. Among the cultivars Kiss recorded better growth, yield and highest vase life.

Vandoorn and Vojinovic (1996) carried out petal abscission in rose flowers: effects of water potential, light intensity and light quality.

Sharma and Singh (2002) reported that among 210 rose cultivars, including available Hybrid Teas, Floribundas and Miniatures, Eighty- three cultivars and three rootstocks expressed moderately resistant reaction.

Raheela *et al.* (2002) revealed that among the ten cultivars Angelique produced maximum plant height (139.83 cm) whereas maximum number of flowers per plant (41.00) was observed in the rose variety, Day Dream. The cultivars Alexandra and Paradise had the maximum flower size (7.93 cm) whereas maximum number of petals (59.20) in Yankee Doodle and longest life persistency (17.17days) was in Golden Times was recorded. The maximum vase life of 8.00 days was observed in variety Freesia. Based on the results of evaluation, Alexander and Paradise are recommended for outdoor beautification due to their large flower size and Golden Time is recommended for long flower production. For cut flower production freesia is recommended due to its vase life.

Sharma and Sharma (2003) conducted the experiment on eleven Hybrid Ten and Floribunda rose varieties and reported that HT rose varieties viz., Jwahar and Kasturi Rangan performed best under Tarai conditions of Pantanagar whereas the Chambe-Di-Kali and Kasturi Ranga (HT) and Gene Boerner (Floribunda) produced the maximum marketable flowers.

Dias and Patil (2003) evaluated that the three rose varieties among which marketable yield per bush was highest in Arjun (128.98) followed by Super Star (97.39) and Golden Times (57.81). Arjun followed by Super Star and Golden Times produced maximum flowers with longer and slender stalks per unit area.

Polara *et al.* (2004) evaluated that the nineteen cultivars of hybrid tea rose and 10 cultivars of floribunda group. Based on the results of evaluation, the cultivars Peace, Eiffel Tower, Gladiator in Hybrid Tea group and Samba, Dickson's Flame and Zorina in Floribunda group performed better in summer under South Saurashtra conditions of Gujarat.

Hussain and Khan (2004) evaluated two rose species and reported that *Rosa bourboniana* produced maximum plant height (94.3cm) as compared to *Rosa gruss-an-teplitz* (42.00cm).

Manjula (2005) reported that among ten Dutch rose cultivars evaluated for cut flowers, Grand Gala found to be very vigorous and recorded the maximum stalk length. Cultivar Tineke recorded maximum number of cut flowers per plant (27.84) followed by First Red (27.50) and Grand Gala (26.83). Cultivar Grand Gala produced maximum bud length, bud diameter and neck length, while Ravel showed maximum shoot girth whereas Skyline recorded maximum neck girth. Grand Gala and First Red were found to be early for flower initiation.

Adan and Atif (2005) evaluated three rose cultivars and reported that among the cultivars Kardinal produced maximum number of shoots per plant (2.9) followed by Gold Medal (.7) and Wisky Mac (2.3) and the number of flowers produced per plant was 4.2, 3.0 and 2.7 in case of Gold Medal, Wisky Mac and Kardinal, respectively.

Fascella and Zizzo (2005) evaluated four rose varieties and reported that the cultivar Anastasia produced higher number of stems (18.7/plant) and longest buds (5.8 cm) and the cultivar Fenice produced the maximum stem length (70 cm).

Parbiati and Santoso (2007) evaluated nine rose cultivars and reported that the Pergiwo produced the maximum stem length (49.6 cm) with the more leaves (45.9 leaves/ plant). Akito produced the highest number of petals (56 petals/flower) and Grand Gala had the widest flower diameter (5.4 cm).

Fascella and Zizzo (2007) evaluated the red rose cultivars for vegetative and productive behavior. They reported that among the cultivars, Red France and Dallas gave the highest cut flower yield of 24.8 and 24.1 flowers per plant, respectively and highest stem length was recorded in cultivar Dallas (84.1 cm). The cultivar Maira had the earliest flowering (108 days after planting).

Crofton and Susan (2008) evaluated seventeen cultivars of an outdoor cut flower series from W. KordesSohne and nine cultivars of the Romantica series from Meilland star for cut flower production. Based on 2 years of assessment, the best performing W. Kordes Sohne roses were Fantasia Mondiale, Masquerade and Penguin, averaging 3 to 12 stems per plant per month that were at least 30 cm long and the best Meilland Star cultivars were Frederic Mistral, Michelangelo, McCartney Rose and Traviata, averaging 3 to 20 stems per plant per month that were at least 30 cm long.

Qasim *et al.* (2008) evaluated two rose cultivars Amalia and Anjeeleq. They reported that the cultivar Anjeeleq produced maximum plant height (65.16 cm), higher number of branches per plant (6.55) and maximum number of leaves (217) compared to Amalia.

Mackay *et al.* (2008) reported that the polyanthus rose cultivars exhibited the best overall performance, mean bloom percentage, final vigor and survival. While cultivars in the Hybrid Tea class had the worst performance in all measures. Foliar nutrient content, bloom number and mean percentage of bloom were not good predictors of overall performance. The diseases monitored, black spot was the most severe and was closely correlated to overall performance and final vigor, but was not only factor determining overall performance. The top five cultivars in mean overall performance were RAD razz, Caldwell Pink, Sea Foam, Perled and The Fairy, in descending order.

Mohanty and Binpani (2008) assessed that the performance of three rose varieties viz., Gladiator, Minuparle and Montezuma under polyhouse condition. The result of the study revealed that among three rose varieties Montezuma performed well with respect to plant height, thickness of shoot and flower production.

Bihari and Kumar (2009) concluded that the rose cultivar Rakta local had given maximum bud diameter (6.86 cm), bud length (4.58 cm) and maximum number of leaves per shoot (56.61).

Zlesak *et al.* (2010) observed that nine cultivars viz., Brite Eyes, Grouse, Home Run, Knock Out, Paprika, Peachy Cream, Pink Knock Out, Rainbow Knock Out and Yellow Submarine were resistant to all three races of black spot. Blushing Knock Out, a spot of Knock Out was susceptible to Race 8.

Mohanty *et al.* (2011) reported that rose cv. Montezuma performed very well with respect to several growth characters which recorded maximum plant height (60.94 cm), highest number of secondary laterals (6.69) and maximum plant spread in N-S (53.72 cm) and E-W (35.60 cm) directions.

Rosario (2012) reported that Hybrid tea rose varieties recommended for the low lands are Pilgrin, Tutu Mauve, W. H. Taft, First Federal Gold, Anne Marie Treschlin, Latte Gunthart, Canasta, Credo, Spartan, Woburn Abbey and Confidence. Among the Grand floras, Ginger and Schweizer Gruss performed best.

Akbari (2012) reported that relationship of flower colour parameters and metal ions of petal tissue in fully opened flowers of gerbera.

Kumar *et al.* (2013) identified three rose varieties namely Paradise, Shabnam and Pixie as moderately susceptible to black spot disease. Whereas, eleven varieties viz., Angelica Renae, Atago, Folklore, Granada, Hot Cocoa, Mardigrass, Midas Touch, Mrinalini, Revival, Tipus Flame and Victor Hugo showed susceptible reaction to black spot disease. Twelve varieties viz. Baccardi, Claudia Ribord, Charles Mallerin, Crimson Lace, Dr. Pal, Impatient, Madam, Dulbourde, Marcopolo, Melody, Rainbow End, Sonia and Sugandha were responded highly susceptible reaction at 75 per cent disease severity. Whereas, eleven varieties namely Angelique, Christian Dior, Gemini, Gladiator, Golden Jubilee, Priyadarsini, Sand. Centenary, R. R. M. Roy, Sweet Promise, Unforgotten and Vale of Cloyd were highly susceptible at 95 per cent disease severity.

Singh *et al.* (2013) To evaluated thirty cultivars were planted in RBD, with three replication. Maximum plant height (53.67 cm) was recorded in 'Banjaran', while plant spread, leaf length and leaf breadth were maximum (90.83 cm, 12.73 cm and 9.10 cm, respectively) in 'Brown Velvet'. The cv. 'Iceberg' produced comparatively longer (2.77 cm) buds. Flower size was maximum in 'Charleston' (8.37 cm). Number of petals per flower was higher in 'Arunima'. Thorn density was found to be higher (42.67 per ten cm i.e., decimeter) in cv. 'St. Boniface' whereas, 'Summer Snow' and 'Ahalya' were thorn less. Maximum number of flowers per plant, per unit area were recorded in 'Summer Snow' (367.85/m²), which was no par with 'Arunima' (340.32/cm²), 'First Edition' (32.75/m²) 'Thornless Beauty' (328.24/m²). Flower stalks length 982.33 cm) and flower duration (141.33 days) were higher in cv. Brown Velvet.

Ranzan *et al.* (2014) found that among the different cultivars of hybrid tea roses the highest stalk length (24.6, 24 cm) was recorded in cultivars Double Delight and Signature. Maximum plant height (100 cm) was recorded in Jagua followed by Pink Peace and Honey Perfume (97 cm). While minimum plant height (67.33 cm) was noted in Abby DeCulnry. Maximum number of flowers (52) and Alice Red (34). Supreme flowering percentage (65%) was observed in cultivar Abby De Culnry followed by Julias Rose (60%) and Cendrila (52%). Results of the study suggested that Double Delight, Signature, Honey Perfume and Pink Peace performed better during hot months of May to July.

Ranchana *et al.* (2014) reported that among the cut rose varieties studied, the highest stem length was recorded in the variety Passion followed by Grand Gala. The other growth parameters, days to sprouting, days to flowering, plant height, stem length, neck length, flower diameter, number of petals per flower, number of cut stems/m² and vase life were also higher in the variety Passion. The investigations have led to the identification of the variety Passion as more promising for cut flower production under organic farming system in Nilgiris condition.

Atram *et al.* (2015) evaluated 42 hybrid tea rose varieties. The performances of the varieties were recorded for morphological, yield and yield contributing traits after October pruning. In all respect of morphological traits, Chardoni, Alliance, Kentucky Derby, Roter Champagner, Montreal and Melody varieties were superior. As regards to number of flowers/plant variety Alliance recorded maximum number of flowers/plant (42.50) followed by Melody (44.25). Similar trend was recorded for yield of flowers/plot and total yield of flowers/ha. In all respect of yield and yield contributing traits Alliance, Melody, Roter Champagner and Melame varieties were superior.

Joshna and Mitra (2018) evaluated fifteen hybrid tea rose cultivar under the plains of West Bengal. The varieties viz. Mandelon, Varcelia, Cherry Brandy, John John, Goldstrike, Texas, Teneke, Hollywood, Naranga, Johny Leonida, First Red, Bordo, Passion, Aqua and Pink Dutch were chosen for the study. Among this cultivar Bordo, First Red, Varcelia, Mandelo has emerged as promising cultivars in terms of growth and quality under West Bengal condition.

Saptarini *et al.* (2018) evaluated the total anthocyanin content of petals of red rose and red China rose which extracted by maceration and percolation method.

Soujanya *et al.* (2018) evaluated twenty five hybrid tea rose varieties. Results revealed that there was a significant variation among the varieties for growth, flowering and yield characters. Among the varieties, maximum plant height (118.50 cm) was recorded in var. Claire Chazal. The maximum stem girth, chlorophyll content and individual leaf area were recorded in var. Claire Chazal (10.60 mm, 58.90 SPAD value and 25.07 cm², respectively). Among the varieties, var. Chantre took least number of days for bud initiation, days from bud initiation to tight bud stage and days from bud initiation to full bloom stage (36.00, 13.20 and 15.00 days, respectively). Maximum number of cut flowers per plant and per m² (20.00 and 83.00, respectively) were recorded in var. Cherry Parfair. Maximum stalk length (55.40 cm) was obtained in var. Claire Chazal. Among the varieties, the maximum vase life (11.50 days,) as recorded in var. Eterna.

2.2 Effect of climate

Post and Howland (1946) observed that growth and flower production were controlled by light intensity. Flower production is thus a direct function of sun light.

Ruppercht (1968) and Matson and Widmer (1970) observed that the annual flower yield depended to great extent on weather conditions, especially on sunshine throughout the year.

Moe (1971) concluded that in blindness uppermost four leaves were also missing besides terminal flowers. Various environmental factors such as low temperature and low light intensity favors blind shoot (Moe and Kristofftersen, 1969; Zieslin and Halevy, 1975b). Carpenter and Anderson (1972) observed blind shoots in roses grown in supplementary light. Long days have no effect on blind shoot production (Horridge and Cockshall, 1974).

Moe (1972) reported that increasing temperature and light intensity both decreased eventual shoot length. The growth of the uppermost internodes and especially the neck of the flower shoot were most sensitive to day length, temperature and light intensity.

Moe (1973) reported that number of flower produced by four rose cultivars were improved by increasing the temperature 12°C to 24°C. Stem length and thickness of ‘Garnette’ roses decreased as the temperature rose. Petal size and number were adversely affected at higher temperature.

Zeroni and Gale (1987) reported that rose plants (*Rosa* hybrid ‘Sonia’ = ‘Sweet Promise’) were grown in heated (minimum night temperature 17°C), and unheated greenhouses with or without root heating to 21°C. These trials covered 6 growth cycles extending over two winter seasons. In the heated greenhouse, root heating did not increase yield, flower quality or plant development. In unheated greenhouse, root heated plants grew as well as those in the air heated greenhouse as long as the air temperature did not fall below 6°C. When minimum night temperatures fell below 6°C, Growth, yield and quality were reduced, irrespective of root temperature.

Bhattacharjee (1991) reported that quality rose blooms were obtained only during December to April with approximately 5 to 6 blooms per plant with a stem length of 60 cm and above. He also reported that well-formed, good sized flowers with more number of petals can be obtained during November to April.

Baudino *et al.* (2019) reported that the rose fragrances in garden roses are very diverse and scent has always been an important character in the selection process.

2.3 Effect of preservation on shelf life

Sugars play an important role in flower development and opening either as energy source for respiration or as osmotically active substance, which aid in maintaining turgidity of the expanding corolla. However, sugars also maintain higher fresh weight in shoots or cut flowers by inducing Stomatal closure in the leaves and thus reducing water loss. The optimum concentration of sugar varies with the treatment and the flowers.

Generally, for a given flower the longer exposure to the chemical solution, the lower concentration required and vice versa.

Rogers (1973) reported that the turgidity in plants and flowers is dependent on the rate of absorption and rate of water loss. Increase in fresh weight can occur when the rate of water absorption is more than the rate of transpiration. He also reported that the composition of tap water varies greatly in various locations. This may influence the longevity of the flowers kept in tap water, as well as the efficiency of chemical solutions used for holding, pulsing or bud opening.

Rogers (1973) reported that 8- HQS at the rate of 200 to 600ppm used as germicide.

Mayak *et al.* (1974) stated that sucrose improves water balance in cut flowers.

Li Jen Liao *et al.* (2000) reported that inhibition of ethylene production was greater in sucrose and in combination with HQS than with Silver ThioSulphate (sts) followed by sucrose along with HQS although the effectiveness of the latter for maintaining rose vase life was better than the former.

Ichimura *et al.* (2002) reported that 8-HQS at 200mg/lit +sucrose at 20g/lit markedly promoted petal reflecting and inhibited blueing.

Jain *et al.* (2007) revealed that vase solution of sucrose (1.5 per cent) and 8 - HQC (50ppm) resulted in maximum vase life (14.96 day) and maximum amount of reducing sugars (396.30mg/g) in rose.

Madhubala *et al.* (2008) stated that in case of holding solutions, treatment with 1.5% sucrose +300ppm $\text{Al}(\text{SO}_4)_3$ was found to be the best for improving final stage of bud opening, flower diameter, vase life and volume of solution absorbed/stem.

Gebremedhin *et al.* (2013) stated that vase solution Aluminium + ethanol + sucrose preservative solution treated cut flowers had shown longest vase life, flower opening, solution

uptake, petal fresh weight and TSS on 'Red Sky' and 'Blizzard' cultivars; while the values were significantly higher in 'Red Sky' cultivar.

Most *et al.* (2020) revealed that vase solution 2% sucrose with 50 ppm AgNO₃ solution extended the vase life and improved the quality parameters in rose cv. Lincoln than other preservatives.

2.4 Economics of rose cultivation

Though, greenhouse cultivation results in higher returns by producing higher yield and better quality produce, its initial investment and maintenance cost are much higher than open condition. So, grower should be provided with suitable cultivars for open field conditions. There by, profitability could be increased.

Bhattacharjee and Bose (1973) worked out cost of cultivation of roses for export and estimated that a net income of Rs. 1, 00,441 can be obtained per acre per year.

Manjula (2005) worked out cost economics of ten rose cultivars under naturally ventilated polyhouse. Among the ten rose cultivars, First Red realized maximum net returns (Rs.2, 02, 900 per 560 m² per year) and B: C ratio (2.27) followed by Grand Gala (1, 92, 750 per 560 m² per year) and Skyline (Rs. 1, 80,430 per 560 m² per year) compared to all other cultivars studied.

Tiwari *et al.* (2019) revealed that total cost in gerbera and rose production grown on an average 1200m² were Rs. 909206 and Rs. 882517, respectively. Net profit was to the extent of Rs.529868 and Rs. 345288 and benefit – cost ratio was 1:85 and 1:61 respectively.

Waghmare and Shendage (2019) worked out the average cost of erection of polyhouse (0.24ha.) was around Rs.23.13 lakhs. The average cost of cultivation of cut roses was worked to Rs.5.97 lakh and it was decreased across the size group of polyhouses. The average profit realized was Rs. 10, 2517 with B: C ratio 1.72.

2.5 Pollen viability, pollen fertility and pollen colour

Shahare and Shastry (1963) pointed out multivalent configurations having non- disjunction orientation are responsible for higher pollen sterility in garden roses.

Swarup *et al.* (1972) determined pollen fertility in different cultivars of rose by acetocarmine test while female fertility was judged by the number of hips formed per bush under open pollination.

Jieinska (1976) studied pollen viability and germinability in eight species of roses namely *Rosa pimpinellifolia*, *R. gallica*, *R. jundizillii*, *R. canina*, *R. majalis*, *R. pendulina*, *R. arvensis* and *R. reversa* and observed that some species were predominantly self-fertile, while others were partially or completely sterile.

Visser *et al.* (1977) reported that in rose the staining percentage obtained considerably exceeded germination percentage. On the other hand, he called stainable pollen grains “normal pollen” but considered them as having only the potential to germinate. He reported that seed set was generally in step with pollen viability as determined by the percentage of normal as well as the percentage of viable pollen, being usually lower as both were lower.

Pearson and Harney (1984) reported that there was a significant positive correlation between pollen staining and pollen germination.

Lunau (1995) reported the colour of pollen.

Noor (2004) studied the pollen morphology and pollen fertility of 15 cultivated ornamental plant species and reported that pollen of *Rosa alba* were oblong with 95% pollen fertility.

Ercisli (2007) investigated pollen quantity, viability and germination of four genotypes of *Rosa dwnalis* and *Rosa villosa* and reported that pollen production, viability and germination capacity varied within and between *Rosa* species.

Pipino *et al.* (2010) characterized pollen morphology and in vitro germination of 11 rose genotypes and reported that pollen was either small (mean diameter < 30 micro m), shrunken, and irregular (abnormal), or large (mean diameter > 30 micro m), elliptical and crossed by furrows (normal), among the 11 rose genotypes tested. High correlation was found between the number of seeds produced per hybridization and the pollen diameter ($r = 0.94$) or the percentage of normal pollen ($r = 0.96$). They also reported that using either the mean pollen diameter or the percentage of normal pollen resulted in effective fertility prediction.

Nadeem (2013) investigated pollen morphology and in vitro germination of 9 gardens rose genotypes were selected database as high fertile or low fertile male parents, according to the number of seeds per hybridization. Pollen was either small (mean diameter = 30 um), shrunken, and irregular (abnormal), or large (mean diameter = 30 um), elliptical and crossed by furrows (normal). High correlations were found between the number of seeds produced per hybridization and the pollen diameter ($r = 0.94$) or the percentage of normal pollen ($r = 0.96$).

Anand and Raju (2016) evaluate the effect of seasonal variation on pollen viability, *in vitro* pollen germination and hip set in rose.

Giovanini *et al.* (2017) reported the result of three different trials. In the first, pollen diameter and pollen viability were chosen as fertility predictors of 10 *Rosa hybrida* commercial cultivars. In the second trial, aliquots of dried pollen grains of six *R. hybrida* cultivar were stored under two different temperature (freezer at $T = - 20^{\circ}\text{C}$ and deep freezer at $T = - 80^{\circ}\text{C}$) and after a wide range of conservation period, their viability was measured. In the third trial, the effective fertilization capacity of frozen pollen of 19 pollen donor cultivars was evaluated during 2015 crossing breeding plan, performing 44 hybridizations and correlating the number of seeds and the ratio seeds/crossing, obtained by each cultivar, with *in vitro* pollen germination ability.

3. MATERIAL AND METHODS

The research work entitled “Evaluation of Rose Varieties for Loose Flower Production” was undertaken during the year 2019-20 at ICAR-Directorate of Floricultural Research, Pune. The details of the material used and methods followed are described in this chapter and the techniques adopted during the investigation are presented here under.

3.1 Details of Experimental Research

3.1.1 Geographical location

The present investigation on “Evaluation of rose varieties for loose flower production” was initiated in ICAR- Directorate of Floricultural Research, Pune.

3.1.2 Experimental site

Pune is situated in the mid-west Maharashtra at an altitude of 559 m, above MSL. It is located in tropical region at 18.32° North latitude and 73.95° East longitudes

3.1.3 Climate and weather condition

The meteorological data from October 2019 to March 2020 was collected from meteorological observatory of Agriculture College, Pune and given in the APPENDIX. The average annual rainfall of this area is 650-750 mm and it is normally distributed during June to October.

The maximum temperature ranges between 34°C to 40°C in summer but on the onset of monsoon, it drops down to 27°C. The minimum temperature ranges from 6°C to 10°C prevails in winter season from November to middle of February. The average minimum and maximum temperature ranged between 18.5°C and 32.1°C. The relative humidity during crop growth period ranged between 42 to 82 percent.

3.1.4 Material

The trial was conducted with 10 genotypes of Rose. Uniform, healthy and vigorously growing three months old budded plants of ten rose varieties were procured from reputed rose nursery at Pune. The nomenclature of these genotypes are given in the Table 3.1

3.1.5 Soil

The soil of experimental field was of medium texture with good drainage. The experimental field was leveled before planting

3.1.6 Other equipment

Different type of materials like butter paper bags, tag label, weighing balance, metal tape, scale and other equipment are used from ICAR-Directorate Floricultural Research, Pune.

3.2 Methods

3.2.1 Programme of Research work

The experiment was conducted during 2019-20 at ICAR-Directorate of Floricultural Research, Pune.

Experiment details

The main objective of the experiment was to evaluate the rose varieties for loose flower production in open field condition for their growth, flower yield and quality. The details of the experiment are as follows.

Number of treatment	: 10
Number of replication	: 3
No. of plants/replication	: 3
Date of planting	: 27.12.2017
Date of pruning	: 15.10.2019
Design	: RBD
Spacing	: 60 cm X 90 cm
Fertilizers	: As per the recommendation
Place of research	: ICAR- Directorate of Floricultural Research, Pune.

3.2.3 Design and replication of the experiment

The experiment was laid out in Randomized Block Design (RBD) by the Panse and Sukhatamane (1985) with ten varieties as the treatments with three replications each. Each

replication had three plants and plants were selected for recording biometric observations till harvest.

Table 3.1 Name of Rose genotype

Treatments Number	Varieties
T ₁	Charishma
T ₂	Kashmir Velvet
T ₃	Abhisarika
T ₄	Paradise
T ₅	Sophia
T ₆	Folklore
T ₇	Peter Frankenfeld
T ₈	Tenacious
T ₉	Strawberry
T ₁₀	Rose Sherbet

Statistical Model of RBD

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Where,

Y_{ij} is the value of variate for the i^{th} treatment in the j^{th} replication ($i = 1, 2, t; j = 1, 2, r$)

μ is the general mean effect

α_i is the effect due to i^{th} treatment

β_j is the effect due to j^{th} replication

e_{ij} random error which is assumed to be independently and normally distributed with mean zero and variance σ_e^2

3.3 Details of production technology

3.3.1 Selection of rose varieties

Uniform, healthy and vigorously growing three months old budded plants of ten rose varieties were selected.

3.3.2 Preparation of field

The field was ploughed twice and cleared from weeds and leveled. Pits of 45 cubic centimeter size were dug at 90 cm apart. Farm Yard Manure (FYM) @10 kg per pit was applied and mixed well with the top soil.

3.3.3 Planting

Three months old budded rose plants were planted in the center of pits taking care that the bud union was well placed above the ground surface. The planting was taken up on 27-12-2017 and all the ten varieties were randomly replicated in three blocks accommodating 3 plant of each variety.

3.3.4 Irrigation

The plots were irrigated once in 3-5 days intervals depending upon the weather and growth stage of the crop. Irrigation was provided through flood irrigation method. The beds were irrigated regularly to keep soil moderately moist.

3.3.5 Fertilizer application

Rose is a perennial crop, it require regular nutrient feeding through manures and fertilizers at the time of plant growth and at the end of flowering, besides the nutrients applied during land preparation and planting. The major nutrients (NPK) were provided through soil application as per the recommended package of practices.

3.3.6 Weeding

Weeding was the major problem noticed on field hence the experimental plot kept weed free by hand weeding as and when weeds were noticed.

3.3.7 Other cultural practices

Desuckering, hoeing and removal of water suckers were attended regularly. The flower buds that emerged during first 15 days were pinched off to encourage vegetative frame work and



Plate 3.1: General view of the experimental site

quality of flowers. The shoots or suckers of the rootstock emerging from the base of the plants were removed as soon as they appeared. They could be distinguished from those of the scion by the shape and size of their leaves.

3.3.8 Harvesting

Flowers were harvested early in the morning or evening hours as and when they attained 50 percent opening for loose flower purpose.

3.4. Observations recorded

3.4.1 Growth parameter

The observations on vegetative growth parameters were recorded at 15 days intervals. Five labeled plants which were randomly selected from each replication under each treatment were used for recording the observations.

3.4.1.1 Plant height (cm)

The plant height was recorded by measuring the length of the plant from ground level to the peak growing shoot at 15 days intervals and expressed in centimeter.

3.4.1.2 Plant spread (cm)

The plant spread was measured at 15 days intervals by taking width at two directions (North- South and East -West) at right angle to each other and the mean was calculated and expressed in centimeter.

3.4.2 Flower characters

3.4.2.1 Days taken to flowering after pruning

The number of days taken from pruning to flowering was recorded from the tagged plants in all the varieties.

3.4.2.2 Days required for flower bud initiation after pruning

The number of days taken for emergence of flower bud was recorded from the tagged plants in all the varieties.

3.4.2.3 Days required for flower opening after bud initiation

The number of days taken from pruning to flower opening was recorded from the tagged plants in all the varieties.

3.4.2.4 Duration of flowering

The number of days taken from pruning to flowering was recorded from the tagged plants in all the varieties.

3.4.2.5 Days required for colour break

The number of days taken from pruning to colour break was recorded from the tagged plants in all the varieties.

3.4.2.6 Shelf life of loose flowers (hours)

The flowers were harvested with 2-3 cm stalk length early in the morning and kept open in plastic plates in laboratory at room temperature. Shelf life was expressed in terms of hours taken from the time of harvest till the flowers were found unfit for use i.e. when 50 percent of the petals were showed wilting symptoms.

3.4.3 Yield parameters

3.4.3.1 Number of flowers per plant

The total number of flowers produced per plant during the first year of planting was recorded by counting flowers at every harvest.

3.4.3.2 Number of petals per flower

The number of petals produced in a fully opened flower was counted and recorded.

3.4.3.3 Flower diameter (cm)

The diameter of the fully opened flower at its maximum width was measured and expressed in centimeter.

3.4.3.4 Flower weight (g)

The fully opened flowers were harvested from each of the tagged plants and weighted using physical balance and average weight per flower was worked and expressed in grams.

3.4.3.5 Hundred flower weight (g)

The fully opened flowers were harvested from each of the tagged plants and weighted using physical balance and average weight of hundred flowers were worked and expressed in grams.

3.5 Pollen grain collection, pollen viability, pollen fertility

Pollen grains from each of the varieties under study were collected separately from fully developed unopened flower buds and percentage viability was found out by acetocarmine test (Johansen, 1940). The germination capacity of fresh pollen grains was assessed with the hanging drop technique (Voyiatzi, 1995). One treatment was used for in vitro pollen germination viz., 15% sucrose + 100 ppm boric acid. A drop of germination medium was placed on a cover slip and the pollen was dusted onto the drop. The cover slip then was inverted and placed over a concave depression on a slide, using Vaseline to seal the cover slip and prevent desiccation. Three slides per treatment were prepared, each slide with pollen of a different flower. Unless stated otherwise the pH of the medium was between 5.5 and 6.5, and the pollen grain preparations were incubated at 25°C. After 18-24 hours counts of germination were made on each slide under a compound microscope at 20x magnification.

3.6 Other parameters

3.6.1 Total chlorophyll content

Total chlorophyll content was estimated by Arnon (1949) method.

3.6.2 Total anthocyanin content

Total anthocyanin content in flower petals was estimated by pH differential method.

3.6.3 Petal encourage test

Petal encourage test observed in field and recorded.

3.6.4 Fragrance

Rose flower fragrance present or absent observed by taken smell and recorded.

3.6.5 Petal colour

Petal colour were observed by using RHS colour chart and recorded.

4. RESULTS AND DISCUSSION

The present study was aimed to investigate the performance of different rose varieties with respect to productivity and quality of flowers. In recent years the number of varieties of the rose has increased rapidly, and perhaps one of the reasons in increase in the number of introductions of new varieties year by year. However, the rose market, nursery men, amateurs are interested on varietal performance. Considering the necessity, studying of morphological characters of different varieties is important. Hence an experiment was planned to evaluate different rose varieties for loose flower production. Ten rose varieties were evaluated in open field condition for loose flower production in the experimental unit ICAR-Directorate of Floricultural Research, Pune and College of Agriculture, Pune, MPKV, Rahuri. Apart from the varietal evaluation for yield and quality aspect, vase life, pollen viability and pollen fertility of different rose cultivars were also studied. The result and discussion of the experiments are presented separately under the following heading.

4.1 Growth parameter

Growth parameters like plant height and plant spread were measured at 15 days intervals and results and discussion are presented below.

4.1.1 Plant height (cm)

The data on mean plant height was recorded at different stages of crop growth in all the 10 rose varieties for loose flower production is presented in the Table 4.1 and Fig. 4.1

The ten varieties of rose showed significant variation for plant height at different stages of growth after budding. At all the growth stages, the rose variety Folklore recorded its superiority over the rest of varieties studied for plant height. Significant maximum plant height was recorded by variety Folklore which was 197.67, 202.34, 208.00 and 213.67 cm respectively at 15, 30, 45 and 60 days after budding over the rest.

The variety Sophia was found second best and recorded plant height of 144.84, 148.47, 151.67 and 155.00 cm respectively at 15, 30, 45 and 60 days after budding stage. The least plant height was recorded by variety Kashmir Velvet that is 40, 41.50, 43 and 47.67 cm respectively at 15, 30, 45 and 60 days after budding stage. Similar variation in plant height was reported by Soujanva *et al* (2018).

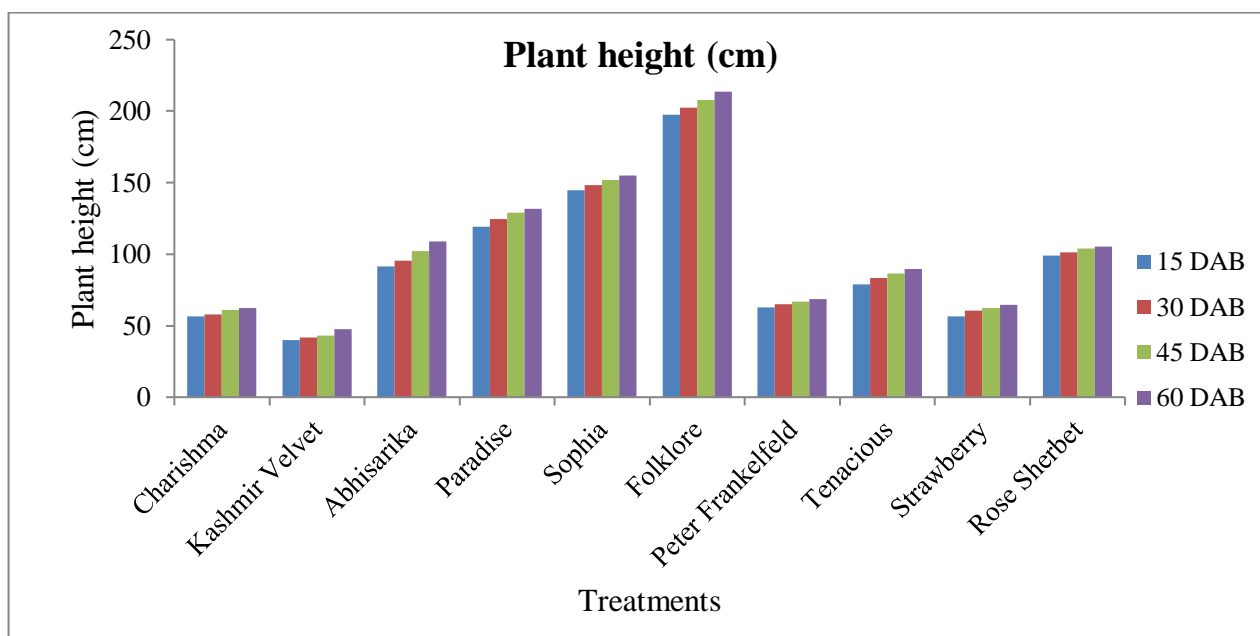
Table 4.1: Plant height (cm) of different rose varieties at different stages of growth

Treatments (Variety)	Plant Height (cm)			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	56.34 ^{ab}	58.00 ^{ab}	61.00 ^{ab}	62.34 ^{ab}
Kashmir Velvet	40.00 ^a	41.50 ^a	43.00 ^a	47.67 ^a
Abhisarika	91.64 ^{de}	95.67 ^d	102.34 ^d	108.67 ^c
Paradise	119.00 ^g	124.34 ^e	128.84 ^e	131.67 ^d
Sophia	144.84 ^h	148.47 ^f	151.67 ^f	155.00 ^e
Folklore	197.67 ⁱ	202.34 ^g	208.00 ^g	213.67 ^f
Peter Frankelfeld	62.84 ^{bc}	64.84 ^{bc}	66.67 ^{bc}	68.80 ^b
Tenacious	79.00 ^{cd}	83.47 ^{cd}	86.50 ^{cd}	89.47 ^c
Strawberry	56.67 ^{ab}	60.47 ^{ab}	62.47 ^{ab}	64.74 ^{ab}
Rose Sherbet	99.00 ^f	101.40 ^d	103.74 ^d	105.30 ^c
S. E \pm(m)	6.54	6.65	6.68	6.73
C.D at 5%	19.59	19.91	20.01	20.15

DAB: Days after budding.

NOTE: 1. Treatment means having common super subscript are statistically non-significant.

2. Treatment means having different super script are statistically significant.

**Fig. 4.1: Plant height (cm) of different rose varieties at different stages of growth**

4.1.2 Plant spread (cm)

The data pertaining to plant spread of different rose varieties grown in open field condition at different growth periods are presented in Table 4.2 and Fig. 4.2

Plant spread varied significantly among the rose varieties evaluated during different growth periods. At 15 days after flower bud initiation the maximum plant spread was observed in Folklore (174.67 cm) which was significantly higher than rest of variety, whereas the minimum plant spread was observed in the variety Charishma (46.50 cm). At 30 days after flower bud initiation the maximum plant spread was observed in Folklore (180.34 cm), which was significantly higher than rest of varieties, whereas the minimum plant spread was observed in the variety Peter Frankelfeld (47.84 cm). At 45 days after flower bud initiation the maximum plant spread was observed in the variety Folklore (186.00 cm) which was significantly higher than rest of varieties, whereas, the minimum plant spread observed in Peter Frankelfeld (49.67 cm). At 60 days after flower bud initiation the maximum plant spread observed in the variety Folklore (188.34 cm), which was significantly higher than rest of varieties, whereas the minimum plant spread observed in Peter Frankelfeld (51.67 cm). Plant spread is an important growth for flower crops. It helps to utilize the sunlight to maximum extent. Similar result was recorded by Mohanty *et al.* (2011) in rose.

Table 4.2: Plant spread (cm) of different rose varieties at different stages of growth

Treatments (Variety)	Plant Spread (cm)			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	46.50 ^a	49.00 ^{ab}	52.17 ^{ab}	54.84 ^{ab}
Kashmir Velvet	70.67 ^{ab}	73.50 ^{bc}	76.50 ^{bc}	78.34 ^{bc}
Abhisarika	80.50 ^{bc}	84.84 ^{cd}	88.50 ^{cd}	93.00 ^{cd}
Paradise	100.84 ^{cd}	105.17 ^d	110.00 ^{de}	112.67 ^{de}
Sophia	112.67 ^d	114.84 ^d	117.17 ^e	119.67 ^e
Folklore	174.67 ^e	180.34 ^e	186.00 ^f	188.34 ^f
Peter Frankelfeld	46.67 ^a	47.84 ^a	49.67 ^a	51.67 ^a
Tenacious	46.67 ^a	49.00 ^{ab}	50.50 ^a	52.84 ^a
Strawberry	66.34 ^{ab}	69.34 ^{ab}	72.17 ^{abc}	75.34 ^{abc}
Rose Sherbet	91.50 ^{cd}	95.17 ^{cd}	97.14 ^{cde}	100.00 ^{cde}
S.E± (m)	8.29	8.38	8.40	8.47
C.D.at 5%	24.83	25.11	25.17	25.38

DAB: Days after budding.

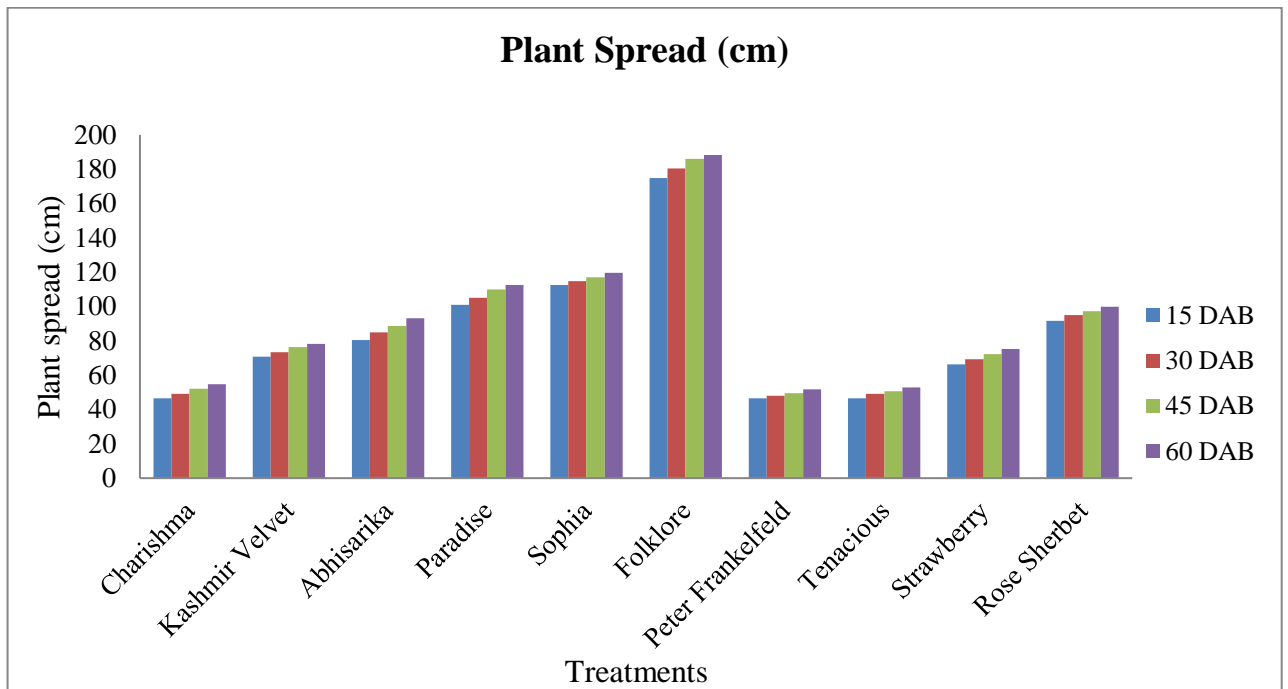


Fig. 4.2: Plant spread (cm) of different rose varieties at different stages of growth

4.2 Flower characters

4.2.1 Days required for flower bud initiation after pruning

Data pertaining to number of days required for flower bud initiation after pruning among ten rose varieties evaluated for loose flower production are presented in Table 4.3

There was significant difference among the rose varieties with respect to the number of days required for flower bud initiation after pruning. The maximum days required for flower bud initiation after pruning was recorded in variety Rose Sherbet (102 day) which was highest variety and significant with all other variety. The minimum days required for flower bud initiation after pruning was recorded in variety Abhisarika (36 day), followed by Tenacious and Kashmir Velvet (37 and 39.67 days respectively). The results are in line with Soujanva *et al.* (2018).

4.2.2 Days taken to flowering after pruning

Data pertaining to number of days taken to flowering after pruning of different rose varieties in open field condition for loose flower production are presented in Table 4.3

There was significant difference among the rose varieties with respect to the number of days taken to flowering after pruning. The maximum days taken to flowering after pruning was recorded in variety Rose Sherbet (115.33 day) which was highest variety and significant with all other variety. Whereas, the minimum days taken to flowering after pruning was recorded in variety Abhisarika (48 day). The similar results are in line with Atram *et al.* (2015).

Table 4.3: Flower characters of different rose varieties

Treatments (Variety)	Days required for flower bud initiation after pruning	Days taken to flowering after pruning	Days required for flower opening after bud initiation	Duration of flowering (days)	Days required for colour break	Shelf life (Hours)
Charishma	41.00 ^{ab}	54.67 ^a	13.33	112.33 ^b	8.00 ^{abc}	45.85 ^d
Kashmir Velvet	39.67 ^{ab}	50.67 ^a	11.33	98.34 ^a	7.00 ^a	32.75 ^a
Abhisarika	36.00 ^a	48.00 ^a	12.33	98.33 ^a	10.00 ^{cd}	53.35 ^e
Paradise	70.00 ^c	82.67 ^b	13.00	113.00 ^b	10.67 ^d	55.13 ^e
Sophia	80.34 ^d	91.67 ^c	11.33	118.00 ^b	11.00 ^d	40.42 ^b
Folklore	43.00 ^b	55.33 ^a	11.33	132.67 ^d	9.67 ^{bcd}	44.80 ^{cd}
Peter Frankenfled	42.00 ^b	55.67 ^a	13.67	131.33 ^c	10.33 ^d	53.83 ^e
Tenacious	37.00 ^{ab}	48.67 ^a	10.67	107.34 ^{ab}	9.33 ^{abcd}	39.83 ^b
Strawberry	43.00 ^b	54.67 ^a	11.67	111.00 ^b	7.67 ^{ab}	41.43 ^{bc}
Rose Sherbet	102.34 ^e	115.33 ^d	13.00	97.34 ^a	7.00 ^a	30.78 ^a
S. E± (m)	2.47	2.64	0.68	3.79	0.76	1.24
C. D at 5%	7.41	7.90	N/S	11.36	2.32	3.72

DAB: Days after budding.

4.2.3 Days required for flower opening after bud initiation

Data pertaining to number of days required for flower opening after bud initiation of different rose varieties in open field condition for loose flower production are presented in Table 4.3.

There was non-significant difference among ten rose varieties for loose flower production with respect to the number of days required for flower opening after bud initiation. All varieties are at par with each other means result is non-significant. The results are line with Soujanva *et al.* (2018).

4.2.4 Duration of flowering

Data pertaining to duration of flowering of different rose varieties in open field conditions for loose flower production are presented in Table 4.3

There was significant difference among the rose varieties with respect to the duration of flowering. The maximum duration of flowering was recorded in variety Folklore (132.67 day) which was highest and significant with all remaining varieties. The minimum duration of flowering was recorded in variety Rose Sherbet (96 day). The results are in line with Singh *et al.* (2013).

4.2.5 Days required for flower colour break

Data pertaining to number of days required for flower colour break of different rose varieties in open field conditions for loose flower production are presented in Table 4.3

There was significant difference among the rose varieties with respect to the number of days required for flower colour break. The maximum days required for flower colour break was recorded in variety Sophia (11 day) which was highest and at par with Paradise (10.67 days), Peter Frankelfeld (10.33 days), Abhisarika (10.00 days), Folklore (9.67 days) and Tenacious (9.33 days). The minimum days required for flower colour break was recorded in variety Rose Sherbet (7 day) and Kashmir Velvet (7 days). The results obtained by Murugesan *et al.* (1991).

4.2.6 Shelf life of loose flower

The observation on shelf life of loose flower of different rose varieties in open field conditions under room temperature are presented in Table 4.3

The shelf life varied from 30.78 to 55.13 hours among the rose varieties. The maximum shelf life of loose flower was recorded in variety Paradise (55.13 hr.) which was highest and at par with Peter Franfelfeld (53.83 hr.) and Abhisarika (53.35 hr.). The minimum shelf life of loose flower was recorded in variety Rose Sherbet (30.78 hr.). Variation in shelf life of fully opened rose may be due to inherent difference in the genotypes. Number of petals also might have played role in shelf life. This was in accordance with the finding of Verma *et al.* (2008).

4.3 Yield parameters

4.3.1 Number of flowers per plant

The data on number of flowers produced per plant was recorded at different stages of crop growth of different rose varieties which is grown in open field condition for loose flower production are presented in Table 4.4 and Fig. 4.3

The data showed highly significant differences among the varieties for number of flowers produced per plant. At 15 days after flower bud initiation the variety Paradise (63.00) was recorded maximum number of flowers per plant, which was significantly higher than rest of variety, whereas the minimum number of flowers were recorded in the variety Tenacious (13.34). At 30 days after flower bud initiation the maximum number of flowers per plant was recorded in the variety Paradise (82.67) which was significantly higher than rest of variety and

Table 4.4: Number of flowers per plant of different rose varieties at different stages of growth

Treatments (Variety)	Number of flowers per plant			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	15.34 ^{ab}	26.67 ^a	25.34 ^a	21.34 ^a
Kashmir Velvet	36.67 ^e	54.00 ^{bc}	53.00 ^{cd}	56.34 ^d
Abhisarika	29.34 ^{de}	55.34 ^c	60.34 ^d	38.67 ^{bc}
Paradise	63.00 ^f	82.67 ^d	84.00 ^e	73.00 ^e
Sophia	26.00 ^{cd}	54.67 ^{bc}	52.00 ^{cd}	45.00 ^{cd}
Folklore	22.67 ^{bcd}	75.67 ^d	79.67 ^e	74.67 ^e
Peter Frankenfeld	18.67 ^{abc}	48.67 ^{bc}	38.00 ^{ab}	33.34 ^{abc}
Tenacious	13.34 ^a	39.34 ^{ab}	36.00 ^{ab}	27.00 ^{ab}
Strawberry	18.34 ^{abc}	39.00 ^{ab}	44.00 ^{bc}	22.67 ^a
Rose Sherbet	24.00 ^{bcd}	58.34 ^c	62.67 ^d	24.00 ^{ab}
S.E ±(m)	3.01	5.31	5.00	4.99
C.D at 5%	8.99	15.89	14.97	14.93

DAB: Days after budding

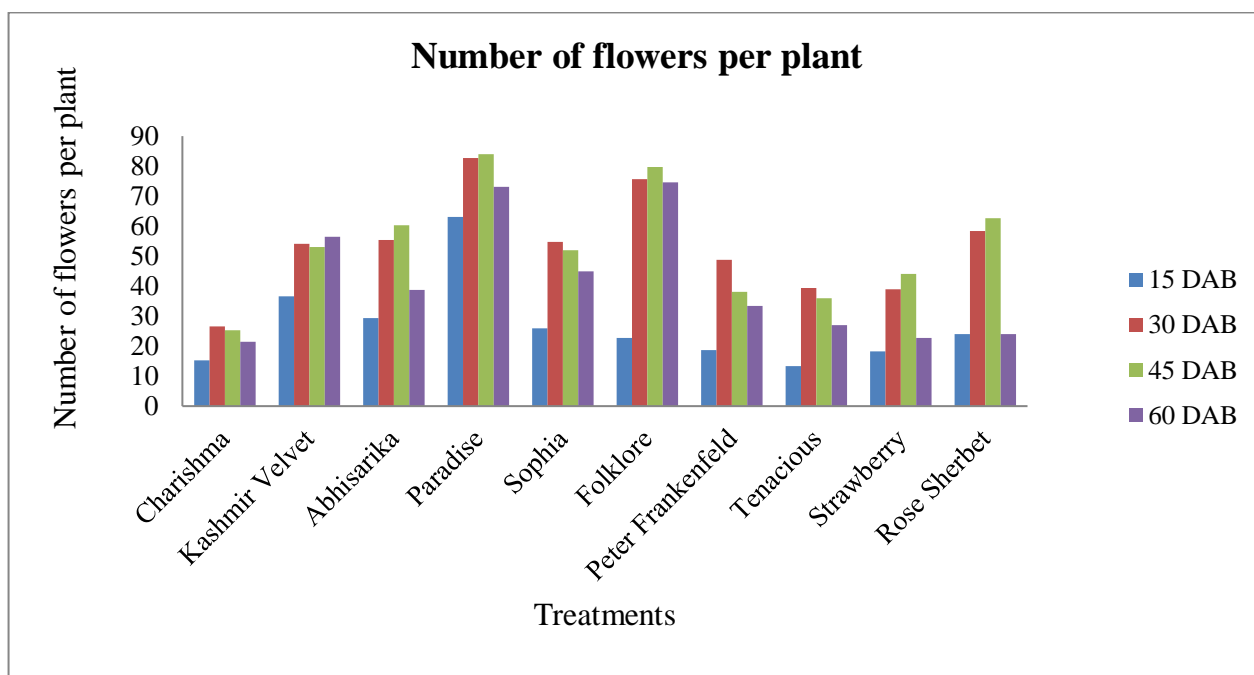


Fig.4.3: Number of flowers per plant of different rose varieties at different stages of growth

at par with variety Folklore (75.67). The minimum number of flowers per plant was observed in variety Charishma (26.67) at 30 days after flower bud initiation. At 45 days after flower bud initiation Paradise (84.00) was recorded maximum number of flowers per plant, which was significantly higher than rest of variety and at par with variety Folklore (79.67). The minimum



Plate 4.1: Varietal view of variety Charishma



Plate 4.2: Varietal view of variety Kashmir Velvet



Plate 4.3: Varietal view of variety Abhisarika



Plate 4.4: Varietal view of variety Paradise



Plate 4.5: Varietal view of variety Sophia



Plate 4.6: Varietal view of variety Folklore



Plate 4.7: Varietal view of variety Peter Frankelfeld



Plate 4.8: Varietal view of variety Tenacious



Plate 4.9: Varietal view of variety Strawberry



Plate 4.10: Varietal view of variety Rose Sherbet

number of flowers per plant was observed in Charishma (25.34). At 60 days after flower bud initiation the maximum number of flowers per plant was recorded in Folklore (74.67) which was significantly higher than rest of variety and at par with variety Paradise (73). The minimum number of flower per plant (21.34) at 60 days after flower bud initiation was recorded in variety Charishma. Ultimate aim of crop improvement is to achieve higher yields with good quality. Among the varieties studied, the var. Paradise, Kashmir Velvet, Abhisarika and Folklore produced maximum number of flowers per plant and can be grouped under high yielders whereas, var. Tenacious and Charishma can be classified as the low yielder in open condition. The greater accumulation of dry matter which is directly or indirectly leads to production of more number of flowers per plant. Variation in flower yield was also observed previously in rose by Ranzan *et al.* (2014) and Atram *et al.* (2015).

4.3.2 Number of petals per flower

The data on number of petals produced per flower was recorded at different stages of crop growth of different rose varieties are presented in Table 4.5 and Fig. 4.4

The data showed highly significant differences among the varieties for number of petals produced per flower. At 15 days after flower bud initiation the variety Rose Sherbet (49.00) was recorded maximum number of petals per flower, which was significantly higher than rest of variety and followed by Tenacious (48.67), Charishma (47.34), Strawberry (45.34) and Sophia (57.21), whereas the minimum number of petals per flower was recorded in the variety Kashmir Velvet (29.00). At 30 days after flower bud initiation the maximum number of petals per flower was recorded in the variety Tenacious (55.67) which was significantly higher than rest of variety and followed by Rose Sherbet (50.34), Charishma (50.34) and Strawberry (49.67). The minimum number of petals per flower was observed in variety Kashmir Velvet (29.67) at 30 days after flower bud initiation. At 45 days after flower bud initiation Tenacious (57.00) was recorded maximum number of petals per flower, which was significantly higher than rest of variety. The minimum number of petals per flower was observed in Kashmir Velvet (27.00). At 60 days after flower bud initiation the maximum number of petals per flower was recorded in Tenacious (55.00) which was significantly higher than rest of variety and followed by Charishma (48.34) and Strawberry (47.34). The minimum number of petals per flower (28.00) at 60 days after

Table 4.5: Number of petals per flower of different rose varieties at different stages of growth

Treatments (Variety)	Number of petals per flower			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	47.34 ^c	50.34 ^{de}	48.67 ^d	48.34 ^{cd}
Kashmir Velvet	29.00 ^a	29.67 ^a	27.00 ^a	28.00 ^a
Abhisarika	29.67 ^a	32.00 ^a	35.67 ^b	29.67 ^a
Paradise	35.00 ^{ab}	36.34 ^{abc}	36.67 ^b	30.67 ^a
Sophia	45.34 ^{bc}	43.34 ^{cd}	45.00 ^{cd}	45.34 ^c
Folklore	29.00 ^a	34.34 ^{ab}	35.34 ^b	35.00 ^{ab}
Peter Freankelfeld	33.67 ^{ab}	39.34 ^{bc}	39.67 ^{bc}	40.00 ^{bc}
Tenacious	48.67 ^c	55.67 ^e	57.00 ^e	55.00 ^d
Strawberry	45.34 ^{bc}	49.67 ^{de}	48.34 ^d	47.34 ^{cd}
Rose Sherbet	49.00 ^c	50.34 ^{de}	48.00 ^d	45.67 ^c
S. E ± (m)	3.96	2.42	2.76	2.97
C. D at 5%	11.87	7.26	8.27	8.90

DAB: Days after budding

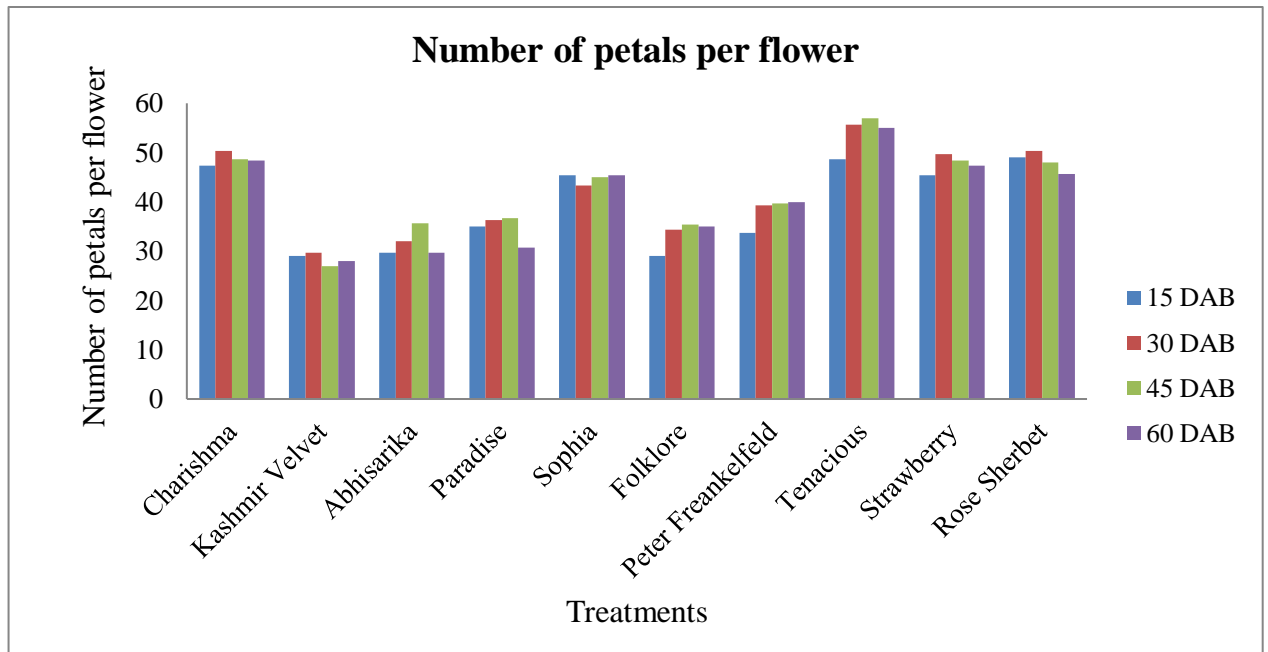


Fig. 4.4: Number of petals per flower of different rose varieties at different stages of growth

flower bud initiation was recorded in variety Kashmir Velvet. Number of petals per flower is another important quality character in a cut flower, as it renders quality and appearance to the flower bud at the time of harvest and after opening. In case of less number of petals, the flower opens quickly showing its open center, which is extremely undesirable, however, if the petals are so many in number of the flowers and does not open at all or opens poorly many times resulting

in bull heads, thus losing its appearance. A good cut flower should not have excessive number of petals. This was in accordance with the finding of Raheela *et al.* (2002).

4.3.3 Flower Diameter (cm)

The data on mean flower diameter was recorded at different stages of crop growth in all the 10 rose varieties for loose flower production is presented in the Table 4.6 and Fig 4.5

The ten varieties of roses showed significant variation for flower diameter at different stages of growth after budding. At all the growth stages, the rose variety Paradise recorded his superiority over the rest of varieties studied for flower diameter. Significant maximum flower diameter was recorded by variety Paradise was 9.67, 9.84, 9.50 and 9.84 cm respectively at 15, 30, 45 and 60 days after budding over the rest. The least flower diameter was recorded by variety Charishma that is 4.67, 5.17, 4.67 and 4.67 cm respectively at 15, 30, 45 and 60 days after budding stage.

Flower quality is based on diameter of flower also. The variation in flower size is mainly due to genetic makeup of the individual cultivar. These results were in conformation with Polara *et al.* (2004) and Ranchana *et al.* (2014) in rose who reported that flower diameters varied among the cultivars

Table 4.6: Flower Diameter (cm) of different rose varieties at different stages of growth

Treatments (Variety)	Flower Diameter (cm)			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	4.67 ^a	5.17 ^a	4.67 ^a	4.67 ^a
Kashmir Velvet	6.59 ^{bc}	6.58 ^{bc}	6.50 ^b	6.50 ^b
Abhisarika	7.84 ^{cd}	8.08 ^{de}	8.08 ^c	8.17 ^c
Paradise	9.67 ^e	9.84 ^f	9.50 ^d	9.84 ^d
Sophia	8.84 ^{de}	8.67 ^{ef}	8.67 ^{cd}	8.67 ^c
Folklore	8.50 ^{de}	8.58 ^{ef}	8.75 ^{cd}	8.75 ^{cd}
Peter Frankelfeld	6.17 ^b	6.41 ^{ab}	6.67 ^b	6.67 ^b
Tenacious	6.34 ^b	7.84 ^{cde}	8.00 ^c	7.84 ^c
Strawberry	5.59 ^{ab}	6.08 ^{ab}	6.08 ^b	6.00 ^b
Rose Sherbet	6.67 ^{bc}	6.75 ^{bcd}	6.75 ^b	6.67 ^b
S.E ± (m)	0.42	0.46	0.35	0.38
C.D at 5%	1.28	1.39	1.06	1.15

DAB: Days after budding

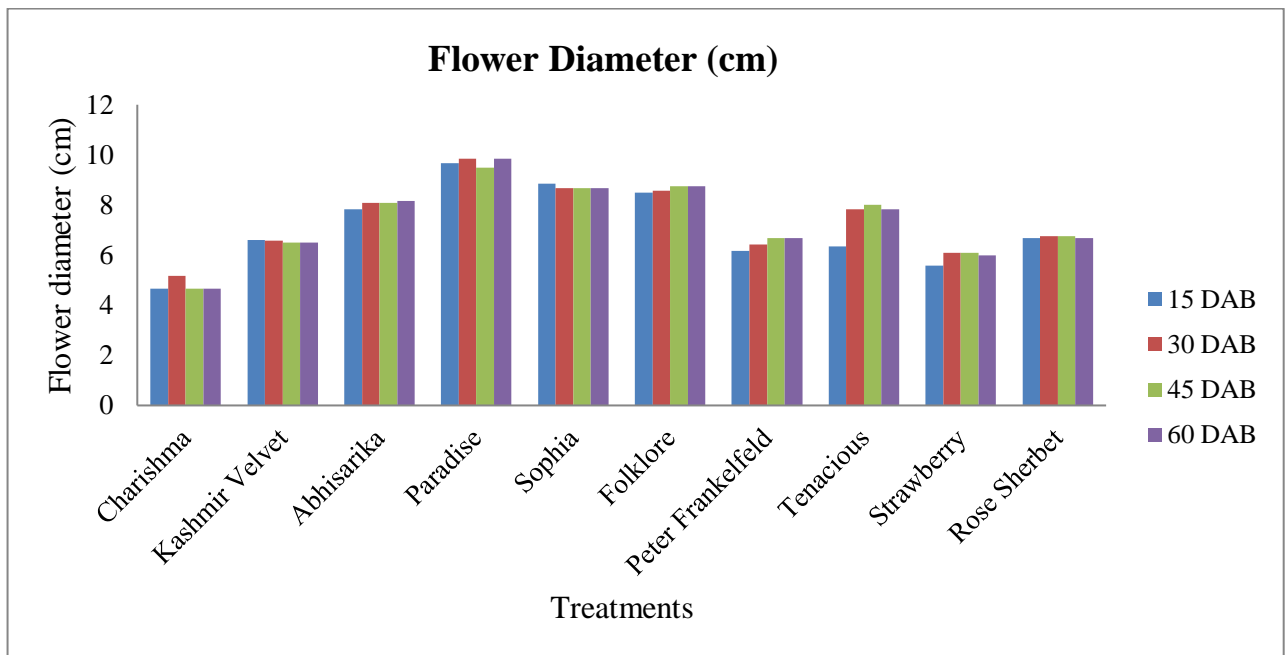


Fig. 4.5: Flower Diameter (cm) of different rose varieties at different stages of growth

4.3.4 Flower weight (g)

The data on mean flower weight was recorded at different stages of crop growth in all the 10 rose varieties for loose flower production is presented in the Table 4.7 and Fig. 4.6

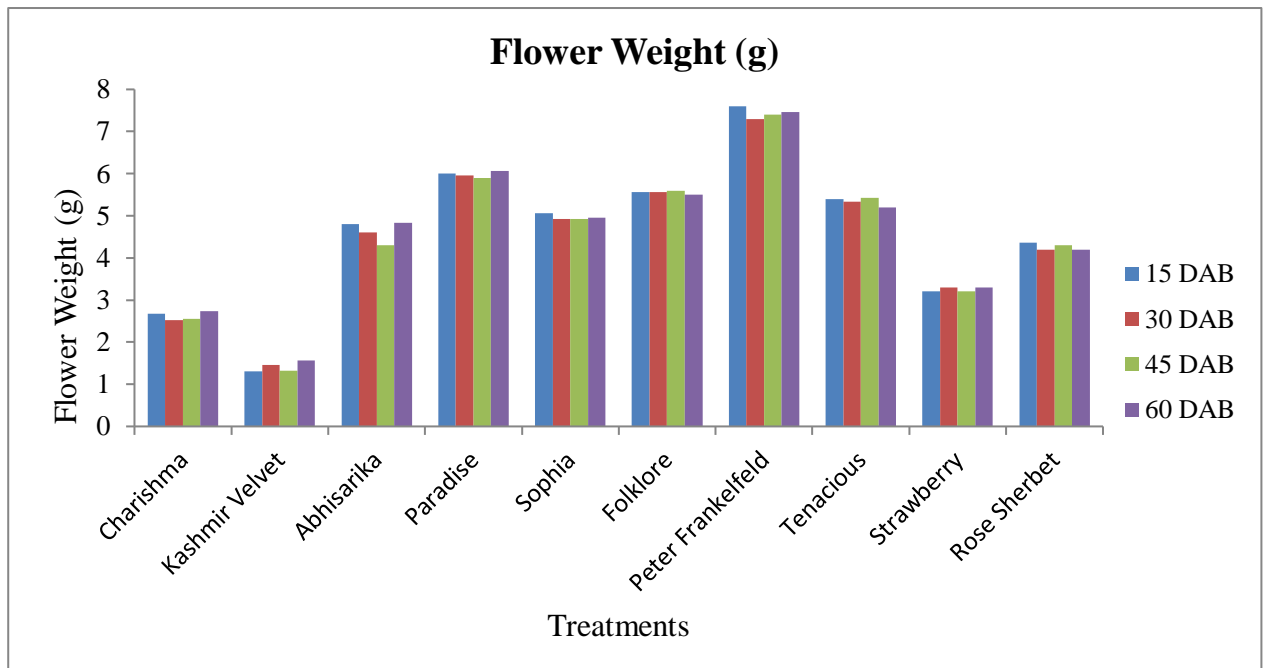
The ten varieties of rose showed significant variation for flower weight at different stages of growth after budding. At all the growth stages, the rose variety Peter Frankelfeld recorded his superiority over the rest of varieties studied for flower weight. Significant maximum flower weight was recorded by variety Peter Frankelfeld was 7.60, 7.30, 7.40 and 7.46 g respectively at 15, 30, 45 and 60 days after budding over the rest.

The variety Paradise was found second best and recorded flower weight of 6.00, 5.96, 5.90 and 6.06g respectively at 15, 30, 45 and 60 days after budding stage. The least flower weight was recorded by variety Kashmir Velvet that is 1.30, 1.46, 1.33 and 1.56g respectively at 15, 30, 45 and 60 days after budding stage. Variation in flower weight among the varieties was mainly because of flower size and also due to presence of fairly more number of well-developed petals. Variations were expected among the varieties of roses. This was in accordance with the findings of Polara *et al.* (2004), Manjula (2005) in rose.

Table 4.7: Flower weight of different rose varieties at different stages of growth

Treatments (Variety)	Flower Weight (g)			
	15 DAB	30 DAB	45DAB	60 DAB
Charishma	2.67 ^b	2.53 ^b	2.56 ^b	2.73 ^b
Kashmir Velvet	1.30 ^a	1.46 ^a	1.33 ^a	1.56 ^a
Abhisarika	4.80 ^e	4.60 ^e	4.30 ^d	4.83 ^e
Paradise	6.00 ^h	5.96 ⁱ	5.90 ^g	6.06 ^h
Sophia	5.06 ^f	4.93 ^f	4.93 ^e	4.96 ^{ef}
Folklore	5.56 ^g	5.56 ^h	5.60 ^f	5.50 ^g
Peter Frankelfeld	7.60 ⁱ	7.30 ^j	7.40 ^h	7.46 ⁱ
Tenacious	5.40 ^g	5.33 ^g	5.43 ^f	5.20 ^f
Strawberry	3.20 ^c	3.30 ^c	3.20 ^c	3.30 ^c
Rose Sherbet	4.36 ^d	4.20 ^d	4.30 ^d	4.20 ^d
S.E ± (m)	0.08	0.07	0.09	0.09
C.D at 5%	0.24	0.21	0.27	0.27

DAB: Days after budding

**Fig. 4.6: Flower weight (g) of different rose varieties at different stages of growth**

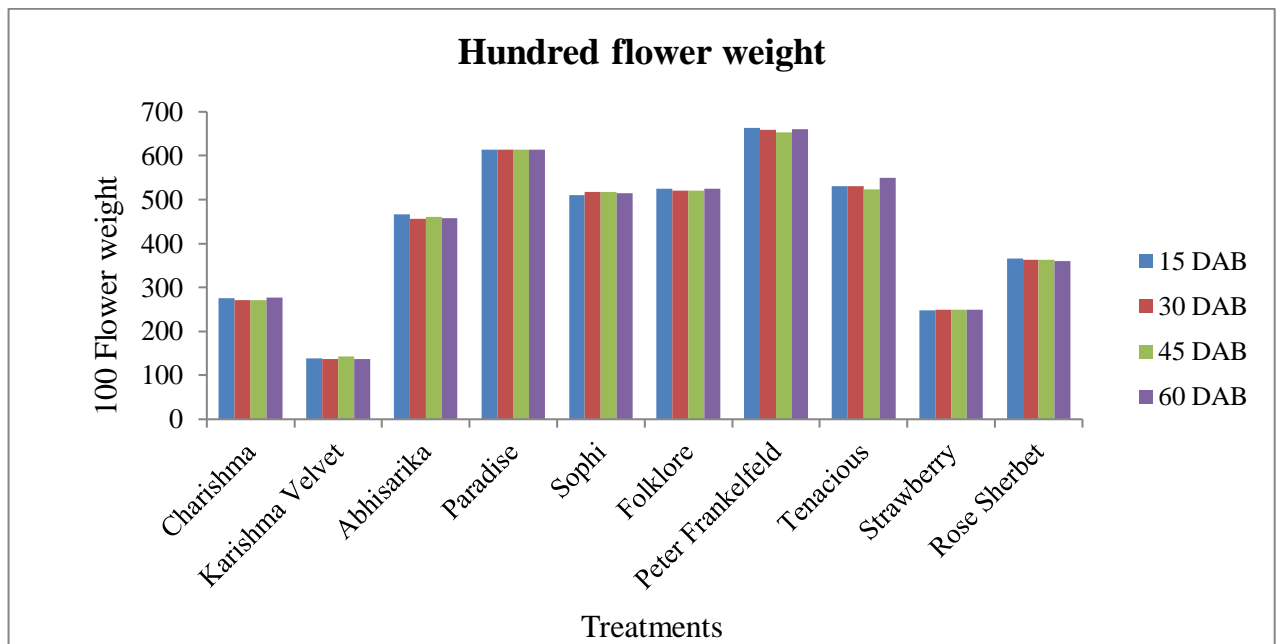
4.3.5 Hundred flower weight

The data on mean hundred flower weight was recorded at different stages of crop growth in all the 10 rose varieties for loose flower production is presented in Table 4.8 and Fig. 4.7

Table 4.8: Hundred flower weight of different rose varieties at different stages of growth

Treatments (Variety)	100 Flowers weight (g)			
	15 DAB	30 DAB	45 DAB	60 DAB
Charishma	275.8 ^c	271.0 ^c	270.8 ^c	277.3 ^c
Karishma Velvet	138.2 ^a	137.4 ^a	142.4 ^a	137.8 ^a
Abhisarika	466.7 ^e	456.3 ^e	461.2 ^e	457.7 ^e
Paradise	613.4 ^h	613.9 ^g	613.9 ^g	614.5 ^h
Sophia	510.7 ^f	517.0 ^f	517.2 ^f	514.5 ^f
Folklore	524.5 ^g	520.8 ^f	520.3 ^f	525.0 ^f
Peter Frankelfeld	663.7 ⁱ	658.5 ^h	653.3 ^h	660.3 ⁱ
Tenacious	531.3 ^g	530.0 ^f	523.4 ^f	549.0 ^g
Strawberry	247.2 ^b	249.8 ^b	249.7 ^b	248.8 ^b
Rose Sherbet	365.3 ^d	363.4 ^d	362.9 ^d	360.6 ^d
S. E ± (m)	4.41	4.60	4.95	4.82
C. D at 5%	13.22	13.79	13.82	13.45

DAB: Days after budding

**Fig. 4.7: Hundred flower weight (g) of different rose varieties at different stages of growth**

The ten varieties of rose showed significant variation for hundred flower weight at different stages of growth after budding. At all the growth stages, the rose variety Peter Frankelfeld recorded its superiority over the rest of varieties studied for hundred flower weight. Significant maximum hundred flower weight was recorded by variety Peter Frankelfeld which was 663.7, 658.5, 653.3 and 660.3 g respectively at 15, 30, 45 and 60 days after budding over the rest. The variety Paradise was found second best and recorded hundred flower weight of 613.4, 613.9, 613.9 and 614.5 g respectively at 15, 30, 45 and 60 days after budding stage.

The least flower weight was recorded by variety Kashmir Velvet that is 138.2, 137.4, 142.4 and 137.8 g respectively at 15, 30, 45 and 60 days after budding stage. Variation in flower weight among the varieties was mainly because of flower size and also due to presence of fairly more number of well-developed petals. Variations were expected among the varieties of roses. This was in accordance with the findings of Polara *et al.* (2004), Manjula (2005).

4.4. Pollen viability, pollen fertility and pollen colour

4.4.1 Pollen viability

The data on pollen viability of rose was presented in Table 4.9

The pollen viability varied among the rose varieties, the pollen viability ranges from 82.39 to 95.69 %. The variety Tenacious registered maximum pollen viability (95.69 %) which was found to be higher than rest of variety. The minimum pollen viability was recorded in the variety Charishma (82.39 %). Pollen viability varied between varieties. This was in accordance with the finding of Giovanini *et al.* (2017).

4.4.2 Pollen fertility

The data on pollen fertility of rose was presented in Table 4.9

The pollen fertility varied among the rose varieties, the pollen fertility ranges from 0.92 to 31.24%. The maximum pollen fertility was recorded in the variety Paradise (31.24 %) which was found to be higher than rest of variety. The minimum pollen fertility was recorded in the variety Folklore (0.92 %). Higher pollen germination capacity depends on the concentration of sugar content. This was in accordance with the finding of Giovanini *et al.* (2017).

4.4.3 Pollen colour

The observations on pollen colour of loose flowers of different rose cultivars grown in open field condition which was shown mostly yellow colour pollen. This was in accordance with the finding of Lunau (1995).

4.5 Other parameters

4.5.1 Total chlorophyll content

The total chlorophyll content was analyzed and the values are presented in Table 4.9

The total chlorophyll content in rose plant was differed. The maximum total chlorophyll content was recorded in variety Paradise (1.85 mg/g). The minimum total chlorophyll content

was recorded in variety Kashmir Velvet (0.94 mg/g). Similar result was recorded by Soujanva *et al.* (2018).

4.5.2 Total anthocyanin content

The total anthocyanin content in rose petals was analyzed and the values are presented in Table 4.9

The pigment anthocyanin content varied among the rose varieties, the anthocyanin content ranges from 0.18 to 6.5 mg/L. The maximum total anthocyanin content in rose petal was recorded in variety Abhisarika (6.5 mg/L) whereas variety Peter Frankelfeld (0.18 mg/L) registered minimum total anthocyanin content among the variety. Anthocyanin was the most important flavonoid pigments widely distributed in nature, dressing the flowers of plants with colours ranging from orange, pink, red, magenta, purple, and blue to blue- black. The attractive colours contributed by anthocyanin facilitate the reproduction of flowering plants, and have long been admired and used by humans to beautify their environment. Colour maintenance is important for the preservation of the market values of most ornamental flowers. Similar results were recorded by Saptarini *et al.* (2018) in rose.

Table 4.9: Total Chlorophyll content, Anthocyanin content, Pollen viability and Pollen fertility of different rose varieties

Treatments (Variety)	Total Chlorophyll content (mg/g)	Anthocyanin content (mg/L)	Pollen viability (%)	Pollen fertility (%)
Charishma	1.03	1.29	82.39	12.42
Kashmir Velvet	0.94	4.23	91.48	9.83
Abhisarika	1.05	6.5	87.59	23.97
Paradise	1.85	0.84	84.9	31.24
Sophia	1.52	0.34	85.5	10.25
Folklore	1.31	4.23	88.53	0.92
Peter Frankenfeld	0.98	0.18	92.3	6.5
Tenacious	1.51	0.47	95.69	4.18
Strawberry	1.31	0.38	94.11	11.68
Rose Sherbet	1.79	5.04	94.81	2.1

4.5.3 Petal encourage test

The observation on petal encourage test of loose flowers of different rose varieties grown in open field conditions are presented in Table 4.10

Table 4.10: Petal encourage test and Fragrance of different rose varieties

Treatments (Variety)	Petal encourage test	Fragrance
Charishma	Yes	Normal present
Kashmir Velvet	Yes	Normal present
Abhisarika	No	Normal present
Paradise	Yes	Absent
Sophia	Yes	Absent
Folklore	No	Absent
Peter Frankenfild	No	Absent
Tenacious	No	Normal present
Strawberry	Yes	Normal present
Rose Sherbet	Yes	Highly present

The petal encourage test is important character for consumer acceptance. Charishma, Paradise, Kashmir Velvet, Sophia, Strawberry and Rose Sherbet in these varieties petal encourage test present whereas, Folklore, Abhisarika, Peter Frankelfeld and Tenacious variety petal encourage test absent. This was in accordance with the finding of Vandoorn and Vojinovic. (1996).

4.5.4 Fragrance

The observation on fragrance of loose flowers of different rose varieties grown in open field conditions are presented in Table 4.10

In variety Charishma, Abhisarika, Kashmir Velvet, Tenacious and Strawberry fragrance was normally present and variety Rose Sherbet fragrance highly present whereas, Paradise, Peter Frankelfeld, Sophia and Folklore fragrance was absent. This was in accordance with the finding of Sylvie Baudino (2019).

4.5.5 Petal colour

The observation on petal colour of fully opened flowers showed differences among the rose varieties grown in open field condition. This was in accordance with the finding of Akbari (2012). These are presented in table 4.11

Table 4.11: Petal colour of different rose varieties

Treatments (Variety)	Flower colour/group	Flower code
Charishma	Orange Group	N25 - C (Tip Orange)
Kashmir Velvet	Red Purple Group	N66 – A
Abhisarika	Yellow Group	9 - B (Pink Spot)
Paradise	Red Purple Group	62 - A (Tip Pink)
Sophia	Red Group	45 – C
Folklore	Green Orange Group	168 – B
Peter Frankenfeld	Red Purple Group	N 67 – A
Tenacious	Orange Red Group	33 – B
Strawberry	Orange Group	G – 29 –C
Rose Sherbet	Red Purple Group	N 57 – A

FUTURE LINE OF WORK

1. More number of rose varieties may be tried in open field conditions for their performance with respect to growth, flower, yield and quality aspects.
2. Promising varieties may be tried at different nutrient levels and plant density in open field conditions to know their growth, yield and quality performance.
3. Need to study their performance over a period of years to know their economic yield levels and yield potential under open field conditions.

5. SUMMARY AND CONCLUSION

The present investigation on “Evaluation of rose varieties for loose flower production” was carried out at experiment unit Directorate of Floriculture Research, Pune during 2019-20 to evaluate the performance of ten rose varieties in open field condition, viz., Charishma, Kashmir Velvet, Abhisarika, Paradise, Sophia, Folklore, Peter Frankelfeld, Tenacious, Strawberry and Rose Sherbet. The trial was laid out in randomized block design with three replications.

The main objectives of the study were to know the performance of rose varieties in open field condition with respect to various growth, flower and yield attributes including pollen viability. The salient features of experimental findings are summarized below.

The ten rose varieties showed great variations among them their growth, flower, yield, pollen and quality parameters in open field condition.

The rose varieties showed significant variations for all the growth parameters studied during the studied. Among the varieties evaluated, variety Folklore, Sophia, Paradise and Rose Sherbet showed superior performance for their growth attributes viz., plant height and plant spread. Hence these varieties are regarded as vigorously growing varieties. The Charishma, Kashmir Velvet, Abhisarika, Peter Frankelfeld, Strawberry and Tenacious were found less vigorous in growth aspects under field conditions.

There was wide variation with respect to days taken to flowering after pruning and days required for flower bud initiation among the rose varieties studied. The variety Abhisarika, Tenacious, Kashmir Velvet and Charishma require minimum days and can be regarded as early flower opening varieties, which is a desirable character for loose flower production

There was no significant difference for number of days required for flower opening after bud initiation in all the varieties which were evaluated. The maximum number of days required for flower opening after bud initiation was observed in variety Peter Frankelfeld, Charishma and Paradise and can be regarded slow flower opening varieties, which is a desirable character for post-harvest handling.

The maximum duration of flowering was observed in variety Folklore, Peter Frankelfeld, Sophia and Charishma which is highly profitable character for loose flower production.

The maximum days required for flower colour break was recorded in variety Sophia followed by Paradise, Peter Frankelfeld and Abhisarika. However, the shelf life of loose flowers was maximum in variety Paradise, Peter Frankelfeld and Abhisarika.

The maximum number of flowers per plant was recorded in Paradise. The other promising varieties are Folklore, Abhisarika and Kashmir velvet for these traits.

Significant variation in petal number per flower was found among the rose varieties studied. The optimum number of petals was observed in variety Rose Sherbet, Tenacious, Charishma and Sophia.

The maximum flower diameter was found in Paradise, Sophia, Folklore and Rose Sherbet and these varieties have the most ideal size for loose flower whereas the minimum flower diameter was observed in Charishma.

Flower weight is an important parameter in rose production. There was wide variation with respect to flower weight and hundred flower weight. The variety Peter Frankelfeld , Paradise, Tenacious and Folklore, minimum flower weight observed in variety Kashmir Velvet.

Among the rose varieties variety Paradise and Rose Sherbet were maximum total chlorophyll content. Among the different rose varieties analyzed for observing anthocyanin content, the variety Abhisarika shown maximum anthocyanin content.

The maximum pollen viability among the rose varieties was recorded in variety Tenacious followed by variety Rose Sherbet, Strawberry and Peter Frankenfeld. The maximum pollen fertility among the rose varieties was recorded in variety Paradise followed by variety Abhisarika, and Charishma.

Among the rose varieties variety Abhisarika, Folklore, Peter Frankelfeld and Tenacious in these variety petal encourage test absent and which is a desirable for post-harvest handling. Whereas variety Charishma, Kashmir Velvet, Paradise, Strawberry, Sophia and Rose Sherbet does not shown petal encourage test

Among the different rose varieties variety Rose Sherbet shown the highly fragrance than rest of the variety. Variety Charishma, Kashmir Velvet, Abhisarika, Tenacious and Strawberry shown normal fragrance present, whereas Paradise, Sophia, Folklore and Peter Frankelfeld in these variety fragrance absent. All the rose variety showed the mostly yellow pollen colour.

CONCLUSION

Among the rose varieties evaluated, Folklore, Paradise, Abhisarika and Peter Frankelfeld can be regarded as better varieties in open field condition for loose flower production.

6. LITERATURE CITED

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7. APPENDICES

(Pune Weekly Weather Data 2019)

Weather Data 2019

MW	T max	T min	R H I	R H II	WS	RAIN	R.D	Epan	B S S
1	30.6	8.7	93	23	1.3	0.0	0	3.0	8.8
2	30.6	9.6	93	25	1.4	0.0	0	3.3	8.8
3	30.9	11.9	92	27	1.4	0.0	0	3.6	8.7
4	28.6	11.0	86	37	3.0	0.0	0	4.1	8.8
5	29.0	11.4	87	30	1.8	0.0	0	3.7	8.6
6	29.7	10.2	86	24	3.2	0.0	0	4.7	9.3
7	33.3	13.5	87	24	2.4	0.0	0	5.2	9.4
8	35.5	15.7	81	20	2.5	0.0	0	5.8	9.6
9	33.0	13.5	80	17	3.8	0.0	0	5.9	10.0
10	33.8	15.0	80	22	4.6	0.0	0	7.0	9.5
11	36.1	15.6	68	15	2.9	0.0	0	7.2	9.1
12	37.3	15.9	65	14	3.4	0.0	0	7.8	9.7
13	39.6	19.8	59	18	3.8	0.0	0	8.4	9.4
14	39.1	19.5	53	14	4.7	0.0	0	9.8	9.5
15	39.7	20.9	57	15	3.6	1.7	0	10.2	9.7
16	37.5	19.6	60	19	5.0	0.0	0	9.2	10.4
17	41.2	23.8	48	18	4.1	0.0	0	10.4	10.1
18	36.8	21.9	62	23	8.3	0.0	0	9.9	10.6
19	37.8	22.8	71	22	7.7	0.0	0	9.7	11.0
20	39.2	21.5	56	15	5.9	0.0	0	10.3	11.2
21	39.8	23.6	63	23	7.0	0.0	0	10.1	10.9
22	39.3	24.2	65	28	8.9	0.0	0	10.7	10.9
23	37.6	24.8	72	40	8.2	32.5	1	8.3	8.0
24	33.7	24.3	76	55	6.0	8.9	1	5.8	7.6
25	33.0	23.9	77	51	8.4	2.2	0	6.9	6.0
26	30.0	22.8	86	78	4.5	158.8	6	3.6	2.6
27	27.8	22.5	87	77	6.7	92.0	4	2.8	0.8
28	28.4	22.9	87	74	5.7	74.7	5	3.3	3.1
29	30.9	23.1	87	59	5.1	34.5	2	4.4	7.2
30	28.0	22.6	84	83	7.1	123.4	5	3.2	1.5
31	25.8	21.8	92	83	7.0	180.1	7	1.5	0.2
32	26.5	22.3	90	80	8.6	55.2	6	1.9	0.8
33	28.4	21.8	88	75	5.0	7.7	1	3.2	3.6
34	29.7	21.2	84	70	5.5	9.2	1	4.5	7.8
35	28.9	21.5	88	70	4.0	7.5	2	3.1	4.4
36	27.2	22.2	91	81	5.1	30.0	5	2.2	0.5
37	27.2	21.7	89	77	5.6	21.5	2	2.7	0.9
38	29.0	21.1	91	72	2.5	36.7	2	2.8	3.7
39	30.1	20.8	92	64	1.6	196.8	3	3.0	5.3

40	31.2	20.6	91	63	1.6	60.5	3	3.9	6.5
41	31.4	21.0	93	59	0.8	39.6	3	3.1	5.5
42	29.	20.0	92	69	2.3	56.4	2	2.9	4.9
43	28.3	20.9	90	72	3.0	65.5	4	1.7	2.2
44	29.8	20.7	93	62	3.0	69.4	4	3.7	6.3
45	30.9	18.5	93	51	1.3	38.6	2	3.5	7.5
46	30.0	17.3	93	50	1.7	0.0	0	3.1	8.0
47	30.2	15.6	94	45	2.0	0.0	0	3.0	8.2
48	30.5	16.0	92	47	2.3	0.0	0	3.3	8.3
49	28.5	17.6	88	50	3.4	0.0	0	3.1	5.8
50	30.3	16.0	94	44	1.3	0.0	0	2.7	8.2
51	28.8	15.7	92	46	2.4	0.0	0	2.6	5.7
52	28.8	17.2	90	54	3.2	0.9	0	2.5	4.9

Weather Data 2020

MW	T max	T min	R H I	R H II	WS	RAIN	R.D	Epan	B S S
1	29.7	12.3	96	43	2.6	0.0	0	2.9	7.6
2	28.2	14.4	94	49	2.8	0.0	0	2.5	6.9
3	29.1	12.2	93	38	2.2	0.0	0	3.2	8.7
4	31.4	14.6	92	41	1.8	0.0	0	3.0	8.7
5	29.1	12.8	94	38	2.8	0.0	0	3.7	9.5
6	29.4	14.2	86	40	3.4	0.0	0	4.4	8.1
7	31.6	15.7	89	34	2.2	0.0	0	4.3	7.5
8	34.3	15.8	83	25	1.8	0.0	0	4.7	9.5
9	32.8	14.3	77	28	2.8	0.0	0	5.4	9.5
10	31.8	15.1	81	27	4.8	0.0	0	6.0	9.5
11	32.7	15.5	75	32	4.4	0.0	0	6.0	9.5
12	35.7	16.6	68	18	3.4	0.0	0	7.2	9.8
13	35.4	20.0	87	36	2.3	12.7	2	4.1	7.3

8. VITAE

MISS. RANI SURESH KUTE
MASTER OF SCIENCE (HORTICULTURE)
IN
FLORICULTURE AND LANDSCAPING

2020

Title of thesis		:	Evaluation of rose varieties for loose flower production
Major field		:	Horticulture (Landscaping and Floriculture)
Biographical information			
Personal	Date of Birth	:	November 17, 1996
	Place of Birth	:	At. Post- Tembhorni, Tal. Madha, Dist. Solapur
	Father's Name	:	Mr. Kute Suresh Sopan
	Mother's Name	:	Mrs. Kute Maina Suresh
Educational	Bachelor Degree Obtained	:	College of Agriculture Kolhapur
	Class	:	First class
	Name of University	:	Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Dist- Ahmednagar, Maharashtra, India.
Address		:	At. Post- Tembhorni, Tal. Madha, Dist. Solapur
	Email – Id	:	ranikute16@gmail.com
	Contact Number	:	9763314771