DUS CHARACTERIZATION AND GENETIC STUDIES IN ROSE (*Rosa hybrida*)

Thesis

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CERTIFICATE-I

This is to certify that the thesis titled, **"DUS characterization and Genetic studies in Rose (*Rosa hybrida*)"** submitted in partial fulfillment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY FLORICULTURE AND LANDSCAPE ARCHITECTURE** in the discipline of **HORTICULTURAL SCIENCES** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) - 173230 is a bonafide research work carried out by **Ms Roshni Agnihotri (H-2015-04-D)** daughter of Sh. Kumar Shashikant under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

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

Place: Nauni, Solan
Date : , 2019

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CERTIFICATE-II

This is to certify that the thesis titled, **"DUS characterization and Genetic studies in Rose (*Rosa hybrida*)"**, submitted by **Ms Roshni Agnihotri (H-2015-04-D)** daughter of Sh. Kumar Shashikant to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 India in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY FLORICULTURE AND LANDSCAPE ARCHITECTURE** in the discipline of **HORTICULTURAL SCIENCES** has been approved by the student's advisory committee after an oral examination of the same in collaboration with the external examiner.

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ABBREVIATIONS

%	:	Percentage
@	:	At the rate of
>	:	Less than
<	:	Greater than
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimetre
d.f.	:	Degrees of freedom
dSm^{-1}	:	Deci Siemens per metre
EC	:	Electrical conductivity
et al.	:	*et alli* (and others)
etc.	:	*et cetera*
FYM	:	Farm Yard Manure
GA_3	:	Gibberellic acid
g	:	Gram
g/m^2	:	Gram per meter square
ha	:	Hectare
i.e.	:	*id est* (that is to say)
kg	:	Kilogram(s)
kg/ha	:	Kilogram per hectare
KOH	:	Potassium hydroxide
l	:	Litre
m	:	Metre
m^2	:	Metre square
mm	:	Millimeter
°C	:	Degree Celsius
ppm	:	Parts per million
RBD	:	Randomized Block Design
RH	:	Relative humidity
SSP	:	Single Super Phosphate
sp.	:	Species
v/v	:	volume by volume
viz.	:	*videlicet* (namely)
VAM	:	Vescicular arbuscular mycorrhizae

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Chapter-1

INTRODUCTION

Roses have contributed to our social, economic and religious life hence they are called "Index of Civilization". Rose is more than 90 million years old and has figured in the myths and legends. The fossils of roses recovered from Oregon and Colorado in USA are dated back to 30 million years. As early as 2800 BC, during the Minoan period, motifs of rose flowers and leaves were used in designing ornaments. In ancient Rome and India, roses were widely used by the royal and effluent people as well as by the saints. Ayurveda has also mentioned about the different uses of roses for the benefit of the mankind. Among all the commercially important flowers, rose is occupying the supreme position for their exquisite beauty, attractive shapes, exhilarating hues, excellent vase life, delightful fragrance and wide choice of varieties.

Rose is popularly known as queen of flowers. Garden roses (*Rosa hybrida* L.) are some of the most economically important flowering shrubs in the world. It is a woody perennial of genus *Rosa*, belongs to family Rosaceae. It is well known that roses have been domesticated since the origin of civilization and constituted first non-edible crop. About more than 100 species of roses that can be erect shrubs, climbing or trailing often armed with sharp prickles and accompanied by attractive flowers.

Roses can be grown throughout the year in India. In fact the vast Indian sub-continent with its varied agro-climate provides such diverse ecological niches that roses spread their year round charm almost without a pause. Roses are grown in almost all parts of the world from a tropical to temperate climate in variable ranges of humidity and rainfall. However, it grows better in temperate climate where there is a significant period of rest.

Roses are grouped into classifications based on the botanical characteristics: hybrid teas, grand floras, polyanthas, floribundas, miniatures, climbing, shrub, old roses, but only a few species are scented (Gudin, 2000). Garden roses are uniquely different from cut-roses on account of production of higher number of flowers per stem. Therefore, a greater number of flowers produced per unit area fulfills the criteria for garden display. Although breeders have developed several miniature rose cultivars having desirable characters, the growth and flowering is known to be influenced by several factors like climatic conditions, nutrient management, irrigation, pruning, plant protection measures etc. Among all these factors most

important is prevailing climate and thus evaluating the new genotypes in a given climate holds significant value.

Most of the miniature Roses are mainly found to be triploid or tetraploid (Zlesak, 2007) and were primarily bred by Modern landscape planners hardly utilize the available diversity of roses in landscaping although exclusive rose gardens have been established in various cities. Landscaping with roses is one way of adding beauty to gardens.

In Roses, different species hybridizes easily, and this has been used in the development of a wide array of rose cultivars (garden as well as cut flower purpose). The existence of numerous species and the large area of geographical distribution, together with the high level of interspecific and intersectional hybridization favored by the long breeding history, makes genetic relationships within the genus confusing. In most cases, the thousands of existing cultivars have a complex hybrid origin. Thus, the assessment of variability is the pre-requisite step in any crop-improvement programme. The scope of improvement increases with greater variability. The heritable value represents a measure of genetic relationship between parent and progeny, thus acts as a predictive instrument in expressing the reliability of a phenotypic value.

Hence insights into the magnitude of variability of different bio-metric traits present in the gene pool of a crop species is of utmost importance for planning a systematic breeding programme.

In nature, the occurrence of genotype-environmental interaction has long provided a major challenge for obtaining complete understanding of the genetic control of variability, which plays important role, related to production problems of agriculture in general and plant breeding in particular.

Due to their complex origin and complex genetics, it is very difficult to draw a boundary between different rose classes, thus morphological categorization and classification is only feasible way to classify different new varieties. Garden Rose, as a category, covers any variety intended for outdoor, garden or amenity planting, including rootstocks and stem builders. Although, a large number of new varieties are being released worldwide, but not all of these, have been widely accepted, as many of them have been considered to be merely forms of acknowledged varieties. If these varieties are actually genetically distinct, conservation and purity of these varieties is needed for which a reliable and robust fingerprinting is absolutely required.

With the implementation of Protection of Plant Varieties and Farmer's Right Act (PPV & FRA) 2001, it is pertinent that plant breeders reorient and fine tune their crop improvement programmes. It is therefore, mandatory to maintain complete record of the information of the materials/germplasm used in the breeding programmes, which would be required at the time of protection of a variety.

Conventionally morphological descriptors are routinely used for establishing the Distinctiveness, Uniformity and Stability (DUS) owing to its fast and ease of observation. The above three technical criteria must be determined before registration and release of any new variety so that to protect right and efforts of a breeder doesn't goes in vain and he gets to defend his legitimate interest. Now a day, this is renamed as NDUS, adding novelty to it. DUS is carried out by approved centres according to the descriptor laid out by PPV & FRA, Government of India for Rose. The new variety for which the testing and consequent protection is to be done needs to be different and distinct than all currently existing varieties. Uniformity is determined by looking at plants of a variety and checking for signs of any mutation, reversion or non-trueness of characters. Stability is determined by observing the plants of a variety over a range of period for maintenance of same character throughout. The variety should also have a single and distinct denomination. A major challenge facing those involved in the testing of new plant varieties for Distinctness, Uniformity and Stability (DUS) is the need to compare them against all those of 'common knowledge' and roses have innumerable number of hybrids.

The test guidelines are given in the descriptor which covers 61 different specific characteristics from growth habit, flower characteristics (covering shape size to pigmentation) to spine and hips characteristics. The trial should be laid out in such a way as to give appropriate space to each growth type, and to allow adequate access to the plants for assessment procedures. The plants must be vegetatively propagated, visually healthy and not treated in any way that will affect subsequent development. They must be suitable for planting at the period the applicant submits them, and of sufficient size and maturity to flower and show their representative characteristics in the first year. Plants should be on their own roots or a hardy rootstock. For distinctiveness and stability assessment observation has to be done on 9 plants or parts each derived from 9 different plants. For uniformity, upto 95% acceptance probability has to be applied.

Morphological markers are the phenotypic traits of any organism and are the earliest markers used to describe the observable characters of an organism. Because each species of

the genus *Rosa* has a wide and overlapping range of morphological variations that are influenced by environmental conditions, classification based on morphology alone is not suffice.

Despite the impressive number of rose cultivars and hybrids currently available worldwide, breeders are continuously seeking to increase and improve the range on commercial cultivars thus characterization, systematic documentation and conservation of germplasm are important for its utilization in crop improvement programmes. Critical evaluation of the genotypes through parameters of variability and genetic divergence studies gives a fair idea of the extent of improvement in a character under study. Multivariate statistical methods have been successfully used to assess the extent of genetic diversity in available genotypes. Besides variability and genetic divergence, characterization of Rose germplasm for morphological traits through DUS technique is also important in which there is considerable breeding activity and production of new varieties. Rose comes under top ornamental plant to be protected under Community Plant Variety Office (CPVO, 2009). In order to qualify for plant breeder's right, a variety must be novel, distinct, uniform and stable. A variety is distinct if it differs from all other known varieties by one or more important botanical characteristics, is uniform if plant characteristics are consistent from plant to plant within the variety and stable if plant characteristics are genetically fixed after a cycle of reproduction. Testing for DUS of varieties of Rose involves comparison of candidate and existing variety by the recording of a number of phenotypic characters in tests in which all varieties are grown side by side.

With the passage of time, Intellectual Property Right (IPR) in plant varieties will gain strength and thus more breeders will get involved in breeding and registering of their varieties. As more new players claim IPR for their newly bred varieties thus more number of new high yielding improved varieties will become available in the market and both public and private sector will generate revenues for further investment in R&D and for the rapid growth of agricultural community.

Miniature roses range in size from the micro-minis which grow to about five inches, up to a height four feet or more. They are excellent performers, both in pots and in the garden. Growing of roses on beds is ideal for small gardens especially where space is limited, such as on a patio or terrace of the multistorey buildings. The miniature, polyantha and floribunda roses having compact growth habit, hardy to diseases, recurrent blooming with variety of colours can be used for decoration in multistorey buildings and small gardens. As

other classes have been utilized therefore, rose varieties in miniature, types are needed to be evaluated for garden decoration and landscaping too.

However, there is dearth of literatures available regarding this aspect, so present study is planned to evaluate the performance of different genotypes of Rose with the following objectives:

i. To evaluate the growth performance of different miniature Rose Genotypes.
ii. To assess the genetic variability and association studies in miniature Rose genotypes.
iii. To study the genetic divergence of different genotypes in miniature Rose genotypes.
iv. Morphological characterization of miniature Rose genotypes for Distinctness, Uniformity and Stability (DUS).

Chapter-2

REVIEW OF LITERATURE

Roses are one of the most important ornamental crops being grown worldwide. The popularity of rose, both as a garden plant and in the cut flower industry, allied to its use in perfumery industry, makes it the most important among the ornamental crops thus, is rightly called as Queen of flowers. Normally, performance of genotypes depends upon genetic constitution, whereas, expression of genotypes depends upon climatic conditions of the region under which they are growing. Thus, characterization and identification of Rose genotypes based on set standards and guidelines of PPVFRA is a pre-requisite before introducing new varieties in industry and old varieties for proper naming and identification for use as example varieties in future researches. Besides varietal evaluation, variability studies help in crop improvement programme. The existence of genetic variability in any crop is a pre-requisite for an effective breeding programme therefore the magnitude of variability present in the gene pool of crop is of utmost importance to a breeder for planning a systematic breeding programme. For a sound breeding programme, critical assessment of genetic variability, heritability and genetic advance of the important characters in a germplasm are essential.

Hence, the present study was conducted to generate basic information on qualitative and quantitative characters of different genotypes of roses and to study the morphological variation among the genotypes and yield attributing components and its related characters, their heritability and genetic advance.

The information available in the literature pertaining to Rose germplasm for yield and quality traits have been reviewed here under the following sub heads:

2.1 Evaluation of Flowers for landscape usage
2.2 Genetic variability and association studies
2.2 Genetic divergence studies
2.3 DUS characterization studies

2.1 VARIETAL EVALUATION OF FLOWERS FOR LANDSCAPE USAGE

The performance of Rose varieties for garden as well as Cut-flower purpose varies with region, season, genotypes and growing environment but the garden types varieties are more influenced by growing environment as they are not grown under protected or controlled conditions. Therefore, it is very important to evaluate the varieties for suitability and adaptability with respect to flowering, flower quality and yield parameters. Roses are among the most popular garden ornamentals in temperate and subtropical zones, but they have a reputation of being very difficult to grow (Manners, 1999). Roses have long been an important landscape plant and there is growing interest in low-maintenance roses that do not require heavy pruning or spraying (Anella *et al.*, 2004). A systematic study of vegetative and floral characters would facilitate the breeders to select suitable genotypes for planned breeding programme for landscape rose cultivars which require less maintenance.

Soujanya *et al.* (2018) studied rose (*Rosa hybrida* L.) varieties for growth, yield and quality under eastern dry zone of Karnataka and revealed that there was significant variations 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 cm^2, 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 m^2 (20.00 and 83.00, respectively) were recorded in *var.* Cherry Parfait. Maximum stalk length (55.40 cm) was obtained in *var.* Claire Chazal.

Hosur *et al.* (2015) recorded performance of Dutch roses under naturally ventilated polyhouse in K rishna command area Among the twelve varieties tried, number of shoots (5.89) and bud diameter (3.19 cm) was highest in variety Avalench. Number of leaves per plant (115), leaf area per plant (1276.22 cm), chlorophyll 'b' (0.362 mg/gm) and total chlorophyll (0.418 mg/gm) was highest in variety Karvette. Days taken to first flower bud initiation (16.40 days) and flower stalk length (79.51 cm) were recorded highest in variety Grandgala. Chlorophyll 'a' (0.118 mg/gm), days taken to first flower harvest (36.36 days), flower stalk girth (1.08 cm), vase life (8.12 days) and overall acceptability by the consumers (4.08) was recorded highest in variety Samurai. Number of flower stalks per plant per year (29.49), number of flower stalks per meter square (206.43), flower diameter (8.85 cm) and

number of petals per flower (39.56) was recorded maximum in variety Tineke and the variety Goldstrike has recorded the maximum bud length (5.11 cm).

Owings and Bogren (2013) reported new crosses between miniature and floribunda roses are called minifloras. Among 46 cultivars Abby's Angel showed deep yellow, Déjà Blu-mauve, Dr. Troy Garret – medium red, Focal Point – pink blend, Foolish Pleasure – pink blend, Memphis Blues – mauve, Rocky Top – orange, Shameless – red blend, Show Stopper – apricot blend and Whirlaway showed white colour. These cultivars were suited for ground cover purpose at Hammond Research Station, Louisiana State University, USA.

Ramzan *et al.* (2014) evaluated the performance of 19 *Rosa hybrida* cultivars under agro-climatic conditions of Islamabad, The highest stalk length (24.6, 24 cm) was recorded in cultivars Double Delight and Signature. Maximum plant height (100cm) was recorded in Jagua followed by Pink Peace and Honey Perfume (97 cm). While minimum plant height (67.33 cm) was noted in Abby De Culnry. Maximum number of flowers (52) were produced by cultivar Honey Perfume followed by Pink Peace (50) and Allice 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 suggest that Double Delight, Signature, Honey Perfume and Pink Peace performed better during hot months of May to July and these are best suited cultivars for further research work

Francis Meilland is the 2013 AARS winner. This tall hybrid tea rose with a very large bloom, good exhibition form and strong fragrance is a multiple award winner in Europe. It is named to commemorate the centenary of Francis Meilland's birth and to honor Conard-Pyle Co.'s historic relationship with Meilland International, the breeder behind the historic Peace rose and Drift series (Owings and Bogren, 2013).

Singh *et al.* (2013) evaluated 30 floribunda rose (*Rosa hybrida* L.) cultivars for landscape use under Punjab condition. 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 thornless. Thorn shape was that of a hook in all the cultivars. Maximum number of flowers per plant, per unit area were recorded in 'Summer Snow' (367.85/m^2), which was on par with

'Arunima' (340.32/m^2), 'First Edition' (320.75/m^2) and 'Thornless Beauty' (328.24/m^2). Flower stalk length (82.33 cm) and flower duration (141.33 days) were higher in cv. Brown Velvet. The cultivars were also evaluated for their fragrance.

Singh *et al.* (2013) in the same experiments recommended varieties for pots which contained more plant spread with less plant height; Parfait, Sexy Rexy, Valentine, Spartan, First Edition, Bordure Vive, longer flowering duration Hemangini and Ahalya. For bedding purposes more number of flowers per unit area, the recommended varieties are Banjaran, Parfait, Gold Cup, Junior Miss, Brown Velvet, Sexy Rexy, with long flowering duration Valentine, Rumba, Red Gold, Charleston, Sparton, Thornless Beauty, Hot Cocoa, Show Bizz, Neelambari, Princess de Monaco, Nimes, Iceberg, Summer Snow, First Edition, Charisma, Bordure Vive, John John, Saratoga, St. Boniface, Hemangini, Arunima, Nordia, Lenturner, Ahalya.

Singh *et al.* (2013) recommended varieties for cut-flowers which contained long flower shoot (at least 35cm) spray roses viz., Neelambari, Princess de Monaco, Nimes, Iceberg, Summer Snow, and considerably long vase-life First Edition, Banjaran, Parfait, Gold Cup, Junior Miss, Brown Velvet, Sexy Rexy, Valentine, Rumba, Red Gold, Charleston, Sparton, Thornless Beauty, Saratoga.

Nadeem (2012) conducted morpho-genetic analysis among hip bearing hybrid roses cultivars including "Autumn Sunset", "Iceberg", "Paradise", "Angel Face", "Casino", "Louise Odier", "Grand Margina", "Handel" and "Gruss an Teplitz" where, over all better performance was exhibited by the cultivars Iceberg and Gruss an Teplitz scoring 2.5 points each. Poor performance was exhibited by the cultivar Louise Odier.

Owings and Bogren (2012) reported that Popcorn Drift to be the newest addition to the Drift groundcover series by company Conard-Pyle. Drift roses have many of the same great characteristics as the Knock Out family of roses but are much smaller in habit. Popcorn Drift is has excellent disease resistance and floriferousness. Look-A-Like Hydrangeful is a unique new hybrid shrub rose with dense flower clusters of small red blooms with a white eye that almost look like a hydrangea. This variety is low-growing and easy to maintain. The Eyeconic series of Hulthemia roses of Conard-Pyle's line up for 2013, the two new varieties — Eyeconic Pomegranate Lemonade and Eyeconic Melon Lemonade grows best in the western United States. Cinnamon Dolce has brick-red petals dusted with pink spots and is

very fragrant. This variety needs the dry heat to thrive. Raspberry Cream Twirl is the first striped climber to have a true modern rose exhibition type flower.

Panwar *et al.* (2010) evaluated 32 genotypes of rose (*Rosa x hybrida*) to assess the nature and magnitude of genetic diversity during 2008-09, at the Research Farm of the Division of Floriculture and Landscapin, Indian Agricultural Research Institute, New Delhi

Harshavardhan *et al.* (2011) evaluated flower yield and quality of rose cultivars in open field conditions which revealed that cultivars Avalanche, Bianca and Noblesse recorded maximum number of flowers per plant in first year (208.6, 171.2 & 149.1 respectively). Cultivars Avalanche, Bordeaux and Bianca recorded maximum flower yield per plant (1.3, 0.6 & 0.6 kg respectively), flower yield per hectare (12.9, 6.4 & 6.3 tonne, respectively) and marketable flower yield per hectare (12.3, 6.0 & 5.8 tonne respectively) during first year of investigation.

Mackay *et al.* (2008) studied the performance of 116 Garden Roses in North-Central Texas under Minimal Input Conditions for three years and as a class, the Polyantha 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. Of the diseases monitored, black spot was the most severe and was closely correlated to overall performance and final vigor, but was not the only factor determining overall performance. The top five cultivars in mean overall performance were RADrazz (Knock OutTM), Caldwell Pink, Sea Foam, Perle d'Or, and The Fairy, in descending order.

Hagan *et al.* (2005) reported that 'RADrazz' did not appear to be seriously damaged by black spot.

Fascella and Zizzo (2005) conducted a two-year trial of open-cycle soilless cultivation of four rose (*Rosa hybrida*) cultivars, i.e. Anastasia, Fenice, New Fashion and Gold Strike with the objective of evaluating the quantitative and qualitative parameters of cut flower production. Significant differences were also recorded among all cultivars, however, cv. Anastasia produced the highest number of stems (18.7 per plant) and the longest buds (5.8 cm). The rose cultivar Fenice recorded with flowers with the maximum average length (70 cm) and cv. New Fashion resulted in the highest number of leaves per stem (55.8).

Chandragiri *et al.* (2004) reported that 20 exotic spay varieties of chrysanthemum evaluated for their performance under naturally ventilated greenhouse. Among all, Solomon Impala recorded with highest plant height (132.16 cm) at harvesting stage. Rafel recorded least number of flowers per plant (6.93), while Variety Shuttle and Require recorded maximum flower diameter (7.39 cm). Caymen recorded the highest number of ray florets per flower head (314.27). Maximum vase life was observed in varieties Linekar and Linekar Amber. The study found that all the exotic varieties produced good quality cut flowers and can be grown successfully around Bangalore under protected structure.

Modern shrub roses hold the promise of being better plants for today's landscapes and identified cultivars best suited for the northern midwestern United States. (Jull, 2004).

Polara *et al.* (2004) evaluated performance of 19 hybrid tea roses under Saurashtra conditions. The result revealed that cultivar 'Peace' had maximum flower yield (35 per plant). The variety 'Gladiator' had maximum flower diameter (6.79 cm) and maximum flower weight (5.66 g).

Sindhu and Rameshkumar (2004) laid out an experiment to study the performance of four commercial cut flower rose varieties *viz.*, Konfetti, Novajo, Grandprin and Rakathagandha under unheated polyhouse, Maximum number of flowers/m^2 (10.42) was produced by Novajo followed by Konfetti (8.60) and Rokatgandha (8.22). Length of the cut stem was minimum (47.64 cm) in Novajo, Konfetti, Gradprin and Rakthagandha were at par with each other. Size of the flower and number of petals/flower were observed to be maximum (7.15cm and 21.60 cm, respectively) in Grandprin resulting in the longest vase life. Variations for plant height was a varietal character as studied by Behera *et al.* 2002.

Pascale and Paradiso (1999) conducted a study on Rose cv. Dallas, the cut flower yields were highest in spring.

Manners (1999) reported that only a few own-root rose cultivars performed well in the sandy soils of central Florida.

Nagaraja *et al.* (1999) evaluated five exotic rose cultivars ('Kiss', 'Vivaldi', 'Yunone', 'Eterna' and 'Gladiator') under Bangalore conditions and found that cv. 'Kiss' performed best for yield.

The cultivar Kiss produced the highest flower yield (80.96/m^2) fallowed 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 fallowed by Yunone and Vivaldi. The cv. kiss had better vase life (9.37 days). Gladiator recorded 9.0 days and Yunone 8.25 days' vase life, whereas Eterna recorded the least vase life (7.25 days) (Nagaraja,1996).

Khattak *et al.* (1995) evaluated performance of ten exotic cultivars in D.I. Khan and found that cv. Paradise was the tallest and produced large sized flowers.

Tasker (1995) found that hybrid tea favours warm climate and is susceptible to low temperature.

Mulla *et al.* (1994) reported the performance of 32 exotic rose cultivars and found that cv. 'Jania' produced the maximum number of flowers (187.66) and was recommended for garden purpose.

Singh *et al.* (1994) reported that hybrid tea rose cv. 'Nurjehan' produced the maximum number of flowers per plant (58.18). He also recommended hybrid tea rose cv. 'Nurjehan' on the basis of flower diameter (9.30 cm) out of 16 rose cultivars.

[a]Bhattacharjee *et al.* (1993) evaluated performance of 11 rose cultivars and recorded maximum flower diameter (10.7 cm) in cv. 'Arjun'.

[b]Bhattacharjee *et al.* (1993) reported longer stem length, highest diameter of shoots in cv. Eiffel Tower, whereas highest diameter was recorded with Raktha Gandha, The cv. Sonia Meilland was earliest to initiate flowering after pruning, the cv. Raja surrender Singh of Nalagarh recorded maximum vase life of (10.60 days) fallowed by Dr. B.P. Pal (9.8 days) 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.

Murugesan *et al.* (1991) conducted a study to determine the performance of 85 rose cultivars. The plant height, number of thorns/10 cm stem length, flower colour, floriferousness, flower diameter, flower length and stalk length were recorded. The coefficient of variation ranged from 137.8% for number of flowers/plant to 22.6% for flower length. The mean plant height ranged from 41.5 cm in the dwarf polyantha cv. Chattlion to 178.8 cm in the tall erect Hybrid Tea cv. American Heritage and flower diameter from 3.0 cm in cvs. Chattlion and Minister to 13.0 cm in the cultivars Happiness, Duet and Sunrise Sunset. The variation in stalk length was from 2.8 cm in cv. Chattlion to 9.5 cm in Sunrise Sunset and Illona. The cultivars Safarno, St. Boniface, Iceberg, Chandrama, Red Rose and Cactus Blanc had the highest number of flowers/plant and were recommended for garden use. The cultivars

Happiness, Illona, American Heritage and Sunrise Sunset were recommended for quality cut flowers. True black and true blue roses were not found in the colour spectrum.

Denchev and Groshkov (1989) studied the cost effectiveness of growing 7 cultivars *viz.,* 'Baccara', 'Standard', 'Carina', 'Illona', 'Mount shasta', 'Pascali', Peer Gynt' and 'Sonia' on *Rosa canina* cultivars Plovdiv-1 root stock in unheated houses was compared. The highest yield of cut flowers were produced by 'Carina' Sonia' and 'Pascali' respectively.

Anonymous (1986) reported that the highest intensity of thorns per 10 cm stem (92.0) were found in cv. 'Banjaran' followed by 'Sindoor' (67.4), 'Prema' (34.2), 'Dr. Homibhabha' (24.8), 'Delhi Princess' (23.7), 'Chandrama' (14.0), 'Bhim' (12.6) and 'Poornima' (8.0).

Gelder (1985) reported that rose 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 including one yellow, three salmon orange, four pink red, ten deep red and one bi-colour cultivars.

Vypari (1985) studied fifty rose cultivars and reported that cultivars Ambassador. Bul's Red, Ferry, Pozssche, Illona, Interflora and Vasavi having stalk length of 85.67, 65.67, 79.50, 61.17, 46.00, 77.17 and 53.25 cm respectively were found to be suitable for cut flower production.

Wagenknecht *et al.* (1984) evaluated the performance of 7 rose cultivars under open field conditions and observed that among the early cultivars 'Iketha speeathan' produced more flowers (22.5/plant) while the lowest were in 'Citrina' (14.2). In late flowering cultivars, 'Komet' gave the highest and cv. 'Respono' resulted in the lowest yield.

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 degree C or less. The cultivar Mercedes and Bingo exhibited higher yields during winter months.

Miske (1983) reported that the cv. Athena (white), Cauana (copper yellow), Mirato (red yellow), Pasandena (orange red) proved superior among mini rose cultivars evaluated.

Garica and Mejias (1982) reported that highest yield was obtained with cv. Laminuette (551 flowers/335 plants) followed by Sabrina, Golden time, Candida Caste, Blanche, Bettina, Sonia, Mercedes, Visa and Samantha of 479, 477, 35, 291, 254 199, 129 and 39 flowers per 313-347 plants.

In a trial using two types of rose cultivars, *viz.,* medium flower roses and mini roses, the cv. Prominent produced high quality flowers and Belinda was useful for its high autumn winter yield, among medium flowered roses, whereas in mini roses more number of flowers (1816 flowers/m^2 in six years) was obtained with cv. Carol and cv. Zorina produced high quality long lasting flowers (Roxas, 1982).

Henchen (1981) reported that highest average number of cut stems per plant was obtained with Spartan, Crimson Glory, Sutter's Gold of 20.30, 19.30 and 19.10 respectively. The longest average stem length was obtained with Banjour and Raokete of 46.70 cm and 49.00 cm, respectively.

Gowda *et al.* (1980) evaluated eight hybrid tea roses for cut flowers. The character evaluated was shoot length which was found to be maximum in Mainauperle (36.00 cm) and minimum in Red Devil (18.58 cm). The Christian Dior variety had maximum stem length (47.09cm). The total numbers of well-developed petals were found to be maximum in Red Devil. The density of thorns per 2.5 cm shoot was observed to be maximum in Mainauperle (6.25) and minimum in Pink Parafait (2.25).

Malik and Singh (1980) reported that tea roses are highly resistant to high temperature.

The longest stem length was obtained with cultivars Folkore, Romantica-76, Corso and 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. Folkore had the longest stems (90-120cm), whereas Traumerei had the shorter stems (50-80 cm) but with longest vase life out of 24 new roses evaluated (Plomacher, 1980).

Van (1980) recommended four best cultivars, namely Sandokan, Candida, Elvira and Ramco for cut flowers.

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 Jhon F. Kennedy (4.00).

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

Bogamzova (1978) studied 62 rose cultivars and reported that Baccara rose, Guazard and Superstar were found to be the most suitable cultivars for Plastic film houses and 'Bel Ange', 'Baccara', 'Gloria Dei', 'Mamorion', 'Ophelia', 'Superstar', 'Alska' were found to be most productive cultivars.

Swarup *et al.* (1978) described three hybrids 'Rajkumari', 'Mridula' and 'Neelambri'. It was observed that cultivar 'Rajkumari' was having light green foliage, 'Mridula' rich green and soft foliage and 'Neelambri' with dark green and clean foliage.

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

Gill and Atwal (1976) indicated that the experimental plants inside the tent flowered three weeks earlier than those grown outside and they produced 166 per cent more flowers and had stem length between 80.40 cm and 100.20cm. The uniform height and bloom and absolute freedom from any blemish or frost bite on the flowers grown inside the tent. Increase in yield and good quality of cut flower ascribed to the higher maximum temperature inside the polythene tent.

In another test conducted by Plomacher (1976) among the nine cultivars, Marina produced highest cut flower yield of 4.80 blooms/plant and 34 blooms/m^2 gross area.

Lundstad (1975) evaluated 45 new cultivars of Floribunda and Polyantha roses during the period 1968-1972. He found maximum plant height in cultivar Scarlet Elizabeth (84cm). The cultivars Gold Rausch and Tiptop produced flowers with high diameter (9.50 cm). The number of petals was maximum in cultivar. Based on the results of evaluation the cultivars Janspeck, Pernille, Pouisen and Tiptop were recommended as best.

Schroder (1975) reported that highest yield was recorded with Magic Moment (31.7 blooms/m^2) fallowed by Illona with 24 blooms/m^2, whereas least number of flowers was obtained with Cv. Baccara. The longest stem length (50-80 cm) was recorded in Baccara and Illona.

In a trial of 13 cultivars grafted on Rosa indica, the highest yield was obtained from the cultivars Grandmere, Jenny, Camps, Elysees and Carina with 77.40, 66.90 and 62.19 flowers/m^2, respectively (Millia, 1974).

Kallio (1972) evaluated twenty-seven rose cultivars for flowering and it was observed that cultivar 'Fanal' flowered most heavily followed by 'Letkis' and 'Feurwerk'.

Lundstad (1962a) reported experimental findings of varietal trials with 31 floribunda roses during the period 1954-60. They were evaluated for different characterstics like height of the plant, colour, size of the flower. Based on the evaluation results two cultivars 'Border king' and 'Schweizer Cruss' were recommended for cultivation.

Chandrashekaraiah (1973) evaluated eight rose cultivars during rainy and winter season 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, Kings Ramson, Fountain Beau and White Christmas, respectively.

2.2 GENETIC VARIABILITY AND ASSOCIATION STUDIES

A wide range of variability in any crop provides the better chance of selecting desirable types. The extent of improvement expected by selection in any population depends upon the genetic variability present in the population. Genetic variability forms the basis for crop improvement. Genotypic and phenotypic coefficients of variation are useful in detecting the amount of variability present in the available genotypes. The main purpose of estimating heritability and the genetic parameters that compose the heritability estimate is to compare the expected gains from selection based on alternative selection strategies.

Vavilov (1951) discovered the genetic variability for the first time, who advocated that the wide range of variability provide better scope of selecting desirable genotypes. Broad based germplasm resources are imperative for sound and successful crop improvement programme. Effective selection is dependent upon the existence of genetic variability in the population.

Fisher (1918) partitioned the continued variation exploited by quantitative traits into heritable and non-heritable components. The heritable are attributed to genotype and non-heritable to environmental factors.

According to studies made by Sirohi and Behera (2000) on genetic variability in 57 cultivars of chrysanthemum, high genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) was observed for number of flowers, numbers of branches per

plant and yield of flowers per plant, while it was low for duration of flowering, days to first flower opening, days to first bud initiation, plant height and vase life.

Syamal and Kumar (2002) carried out an investigation on the genetic variability of dahlia. Variability analysis revealed high GCV and PCV for durability of flower, diameter of flower, number of flowers and plant height, whereas, it had lower value for the internodal length, number of branches and number of leaves.

Misra and Gupta (2003) examined the 20 varieties of carnation with respect to 15 characters under four locations i.e., RHRS Bajaura, HRS Kandaghat, RHRS Mashobra and experimental farm of Department of Floriculture and Landscaping, Nauni-Solan to ascertain the genetic parameters of variability and identify the promising genotypes. They revealed that phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) for all the characters studied. However, higher PCV and GCV estimates were found for incidence of disease, followed by stem strength and vase life. High heritability with high genetic advance was observed for flowering duration followed by stem strength and vase life.

Nair and Shiva (2003) studied the genetic variability, correlation and path coefficient analysis among the 25 genotypes of gerbera at IIHR, Hessarghatta, Bangalore during 1998-2001. Variability estimates revealed that the PCV was higher than GCV for all the characters indicating the role of environment in the expression of genotype. Whereas, estimate of GCV was recorded for leaf area followed by flower yield.

Ravikumar and Patil (2003) evaluated the eleven genotypes of China aster for fourteen quantitative characters in a randomized block design during 2001 at the Floriculture Unit of New Orchard, Division of Horticulture, U.A.S., Dharward. They observed that the phonotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were high for spread of plant, leaf area/plant, average weight of fresh flower and flower yield/plant, whereas, medium for characters like number of flowers/plant, stalk length and vase life. High heritability with medium genetic advance was observed for number of leaves/plant and number of flowers/plant.

Nazir *et al.* (2004) studied the genetic variability in among 22 diverse genotypes of gladiolus for 20 characters at two locations, i.e., Baraut (Meerut) and Jammu during 1998-99 and 1999-2000. They observed that the PCV were higher than GCV for all the characters studied, indicating thereby high degree of environment influence. Higher GCV and PCV

estimates were found for number of cormels produced per plant and average weight of cormels per plant. Heritability estimates were high (>80%) for days for 50% heading, first floret colour showing and complete opening of first floret. Whereas, number of cormels per plant, average weight of cormels per plant and propagation coefficient showed moderate to high heritability along with genetic advance as percentage of mean showing additive gene effects.

Patil and co-workers (2004) studied the coefficient of variation, heritability and genetic advance in gladiolus hybrids at Floriculture unit, Department of Horticulture, University of Agricultural Sciences, Dharwad during 2003-04. The estimates of variability revealed that the PCV and GCV were found high for average weight of corm, weight of the spike, weight of the daughter corm and number of cormels per plant. The characters with low PCV and GCV were plant height, number of leaves, number of days taken for first floret to open length of floret and number of days taken for spike initiation. However, high heritability with medium genetic gain was observed for number of days taken for spike initiation, days taken for first floret to open, number of florets per spike, spike length and rachis length.

Sestras *et al.* (2004) analysed the seven varieties of greenhouse carnation, both *in vivo* and *in vitro*, to estimate the variability for several traits of growth. The highest intervarietal variability, under *in vivo* conditions, was recorded for the number of flowers per plant and number of petals per flower, while under *in vitro* conditions all analysed characters showed an extremely large span of variability values (26.50-109.10). The heritability in broad sense showed high values for the analysed characters, both *in vivo* (0.54-0.99) and *in vitro* (0.68-0.95) conditions. The variability for all experiments was higher than intervarietal variability, both in *vivo* conditions (5.4 for flower diameter and 40.1 for number of internodes/plant) and *in vitro* conditions (43.9 for number of internodes/plant and 211.2 for number of shoots/plant).

Pratap and Rao (2006) conducted an experiment on assessment and variability studies among 10 genotypes of gladiolus at AICRPF, ARI, ANGRAU, Rajendranagar, Hyderabad during 2003-04 and 2004-05. They observed that the PCV was higher than GCV for all the characters studied indicating the apparent variance was not only due to genotypes but also due to the influence of environment in the expression of genotype. The GCV was recorded maximum for the characters like, plant height, number of florets/spike, followed by days to flowering and number of florets/spike, whereas, it was low for vase life and spike length.

Rao and Pratap (2006) also evaluated the 10 varieties of chrysanthemum (*Dendranthema grandiflora* Tzvelev) and studied the variability estimates among them at AICRPF, ARI, ANGRAU, Rajendranagar, Hyderabad during 2003-04 and 2004-05. They found that the PCV was higher than GCV for all the characters indicating the apparent variance is not only due to genotypes, but also due to the influence of the environment in the expression of genotype. The genotypic covariance was maximum for characters like 100 flower weight followed by number of stems per plant and length of spray, whereas, it was low for duration of flowering.

Singh and Saha (2006) estimated genetic variability, heritability and genetic advance for various vegetative and floral characters in 30 genotypes of French marigold (*Tagetes patula*). The studies showed high range for total yield per plant, weight per flower and number of flowers per plant. The coefficient of variation (PCV and GCV) was maximum for weight per flower (PCV=59.75, GCV=59.49) and minimum for duration of flowering (PCV=11.08, GCV=10.84). The phenotypic coefficients of variations were higher than those of genotypic coefficient of variation, which indicate greater G x E interaction. The highest value of heritability was obtained for weight of flower per plant, plant-spread, and plant height.

Singh and Misra (2007) evaluated nine parents of marigold and its 36 F_1s to ascertain genetic parameters of variability, heritability and genetic advance. Highest range of variation was reported with number of leaves/plant followed by leaf biomass, whereas, coefficient of variation was maximum for seed yield/plant. High heritability with high genetic advance was found with number of flowers/plant, number of petals/flower, flower yield/plant and seed yield/plant.

Singh and Singh (2007) conducted a study on genetic variability and heritability in 69 genotypes of balsam. Phenotypic and genotypic coefficients were higher for seed yield/plant followed by number of flowers/plant, 1000 seed weight and number of primary branches/plant, whereas, it was less for stem diameter, days taken to flowering and duration of flowering. However, heritability estimates were observed higher for all the characters studied except flower longevity.

Sharma and Srivastava (2008) evaluated sixteen genotypes of carnation (*Dianthus caryophyllus* L.) to assess genetic variability with respect to vegetative and floral traits. They reported that plant height of full flowering stage and stem length was maximum in var.

‘Master’, whereas, maximum number of leaf pairs per stem were found maximum in var. ‘Firato’. For flowering characters, var. ‘Piax Dover’ took minimum days taken to bud opening, while maximum flower diameter, flower duration and minimum percentage of incidence of insect pest damage was observed in var. ‘Tabor’ and minimum percentage of incidence of disease was found for var. ‘Firato’. The coefficient of variation, both at genotypic and phenotypic levels, was maximum for per cent of incidence of disease, incidence of insect pest damage, flower yield/m^2 and leaf pair/stem. Higher values for genetic advance as per cent mean were recorded for incidence of disease (53.85%), flower yield/m^2 (39.20%) and leaf pair/stem (35.16%).

Balaram and Janakiram (2009) studied the genetic Variability among 35 gladiolus genotypes (11 Indian and 24 exotic) for seven corm characters conducted at the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore during 1998-99. The study revealed that, all the genotypes exhibited wide range of number of cormels per corm. For all the seven characters studied, the differences between phenotypic and genotypic co-efficients of variation were narrow indicating less environmental influences on their expression. High phenotypic and genotypic co-efficients of variations, heritability and genetic advance recorded for number of daughter corm, number of cormels per corm and 25 cormel weight and therefore, suggested the selection of genotypes based on these traits for further improvement through effective breeding programmes.

Bihari *et al.* (2009) carried out an investigation to study the variability among 50 genotypes of canna at C.S.A University of Agriculture and Technology, Kanpur during 2004-06. The study revealed a considerable variation among vegetative parameters. Flowering span, flower parameters length and diameters were found to have considerable variation which indicated potential for making improvement through breeding.

Vijaylaxami and co-workers (2010) conducted an experiment under Hyderabad conditions of Andhra Pradesh to evaluate variability among seven single cultivars of tuberose (*Polianthes tuberosa* L.) during the year 2008-09. The estimates of PCV and GCV were recorded high in case of leaf area, yield of flowers per plant and the weight of bulb in decreasing order of their magnitude, whereas, low estimates were recorded for plant height, number of leaves per plant, duration of flowering and number of florets per spike.

Kumar *et al.* (2011) conducted an experiment to estimate genetic variability, heritability and genetic advance of 15 quantitative characters in forty four gladiolus cultivars

and concluded that the estimated phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV). The characters, days to 50% sprouting, number of leaves per plant, length of leaves, number of florets per spike, diameter of corm, weight of corms per plant, number of cormels per plant and cormels weight per plant exhibited high heritability along with high genetic advance which indicated that there was additive gene action in expression of these traits and thereby further improvement could be made by selection.

Roychowdhary and Tah (2011), studied the nine genotypes including a normal (control) and mutant of *Dianthus caryophyllus* L. to estimate various genetic parameters like critical difference (CD), phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain in order to assess the magnitude of variability for various agro-metrical characters. The study revealed highly significant differences for all the studied characters, indicating the presence of substantial genetic variability. The phenotypic coefficient of variation (PCV) was higher than its corresponding genotypic counterpart (GCV) for all characters studied. The highest PCV and GCV were evident in total branches per plant; and their lowest values for total number of flowers per plant along with plant height taken at 50% flowering phase. Broad sense heritability ranged from 33.33 (days to seed germination) to 95.30 (plant height at 50% flowering) per cent. These characters may serve as effective selection parameter in breeding programme for crop improvement.

Roychowdhary *et al.* (2011) conducted a study to evaluate mutant carnation (*Dianthus caryophyllus* L.) genotypes in order to assess the magnitude of genetic variability and to pick up the heritable component of variation for selection response of metrical traits. The phenotypic and genotypic co-efficient of variation (PCV & GCV) value shows the influence of the environmental effect on the characters. Highest PCV and GCV were noticed for total leaves per plant, total branches/plant, and seeds per inflorescence, whereas, lowest for plant height, days to branching and total flowers per plant. Thus, these traits may serve as an effective selection parameter and screening of promising mutant line (s) for crop improvement.

Akaneme and Ani (2013) evaluated the five accessions of the *Amaranthus hybridus* for the morphological assessment of genetic variability in 10 quantitative and 9 qualitative traits at the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Nigeria. Analysis of variance revealed the highly significant differences ($P < 0.001$) for leaf

width, hypocotyls length, days to 50% flowering, 500 seed weight ($P<0.01$) and leaf length ($P<0.05$). The range, coefficient also revealed high variability for each of the quantitative traits. The highest broad sense heritability (h^2b), GCV, PCV and GA were obtained for days to 50% flowering which was also positively correlated with leaf length and stem diameter.

Senapati *et al.* (2013) carried out an investigation on twelve genotypes of tissue cultured plantlets *viz.*, 'Stanza', 'Fana', 'CF Gold', 'Diego', 'Cherany', 'CF Orange', 'Lion', 'Venezia', 'Torbin', 'Jaffana', 'Kento' and 'Ice Queen' of gerbera (*Gerbera jamesonii)* to determine the genetic variability, heritability, genetic advance, and genetic advance as percent of mean for 13 contributing characters conducted at Green house Complex, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Gujarat during 2010-2012. The study revealed that the phenotypic and genotypic coefficients of variation were highest for the number of leaves per plant, number of clumps per plant and leaf area index, indicating presence of sufficient genetic variability for selection in these traits. High heritability and high genetic advance for number of leaves per plant, leaf area index and fresh weight indicated the presence of additive gene effects in these traits and their amicability for direct selection. The non additive gene effects were evident in petal thickness, hollowness of the stalk, fresh weight, flower diameter, stalk diameter and neck diameter thus, warranting use of heterosis breeding for these characters. Hence they concluded that the selection on the basis of number of leaves per plant, number of clumps per plant and leaf area index will be more effective for further breeding programme.

Amrutha *et al.* (2014) estimated the genetic variability among twenty cultivars of gladiolus at Horticultural Research Station (HRS), Venkataramannagudem, West Godavari District. They observed significant variations for various characters studied. Phenotypic and genotypic coefficients of variations were highest for number of leaves per plant, number of spikes per plant and corm weight and these characters are the most suitable characters for selection.

Singh *et al.* (2014) evaluated the twenty-one genotypes of African marigold (*Tagetes erecta* L.) to study their genetic variation for 11 vegetative and floral traits. They found that analysis of variance for all the traits showed significant differences among genotypes for all the growth and flowering related traits. They observed higher genotypic and phenotypic coefficient of variation for traits such as fresh flower weight per plant, flower fresh weight per 10 flowers, number of flowers per plant, stem girth, flowering duration etc. The high value (>90%) of heritability was observed for all traits except plant height, plant spread and

stem girth. The genetic advance was found ranged from 1.23 for flower diameter to 288.69 for fresh flower weight per plant. High values of genetic advance as per cent of mean was recorded for number of flowers (59.79%) followed by fresh flower weight per plant (59.32%) and flower fresh weight per 10 flowers (58.09%).

Kadam *et al.* (2014) conducted an experiment with 26 gladiolus cultivars to assess their performance and the genetic variability among cultivars at the Research Farm of Directorate of Floricultural Research, New Delhi. The data analysis revealed higher values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for cormel weight (104.36 and 67.26, respectively) and number of cormels per plant (99.82 and 71.58, respectively). Maximum heritability was recorded for days to first floret opening (87.23%) followed by rachis length (82.07%) and days to spike initiation (78.26%). In case of genetic advance, highest values were recorded for plant height (26.35) and spike length (23.36), however, low genetic advance was observed for days to sprouting (0.04) followed by number of corms (0.32) and number of leaves per plant (0.59).

Yuvraj and Dhatt (2014) studied the variability, heritability and genetic advance in twenty three marigold genotypes for plant growth and flower yield at the experimental farm area of Floriculture and Landscaping Department, PAU, Ludhiana, during 2011-2012. They observed that the highest value of PCV and GCV was recorded for number of flowers per plant (117.95 and 116.50, respectively), whereas, high heritability was observed for days to bud initiation (98.48) followed by days to first flower opening (98.36), number of flowers per plant (97.55), plant height (96.44), flower diameter (94.08), flower yield per plant (90.66).The estimates of genetic advance were comparatively maximum for number of flowers per plant (237.02%) followed by flower yield (105.37% per plant and 104.66% per m^2).

Kumar (2015) conducted a study to ascertain the extent of genotypic variability, heritability and genetic advance among 10 gerbera genotypes for 13 quantitative traits during 2011-13 at the Division of Ornamental Crops, IIHR, Hessaraghatta, Bengaluru. They observed the high heritability coupled with high genetic advance as per cent of mean for number of leaves/ plant, leaf breadth, number of suckers/plant, disc diameter, flower stalk length and number of flowers/ plant, indicating the presence of additive gene action and consequently a distinct possibility of improving these traits through selection.

Panwar *et al.* (2012) evaluated 32 genotypes of Rose for various vegetative and floral traits to ascertain genetic parameters such as GCV, PCV, heritability and genetic advance and found that PCV for all traits were higher than GCV. High estimates of both coefficient of variance was observed for weight of flower, No. of petal per flower, no of flower per plant and prickle density. High estimates of heritability was noticed for plant height, internodal length, neck length, flower diameter, weight per flower, no. of petals per flower and no. of flowers per plant.

Misra and Gupta (2002) studied the variability and stability estimates of 20 varieties of carnation and revealed that the magnitude of genotypic correlation coefficients were always above the phenotypic correlation coefficients. Strong positive association was recorded for number of flower buds per plant, plant height, stem length and days to flower bud opening with number of flowering stems per plant. Improvement of any of these characters will contribute towards total number of flowering stems. Path coefficient analysis of pooled data showed that number of flower buds per plant, plant height, stem length and days to flower bud opening recorded positive direct effect towards total number of flowering stems.

Nair and Shiva (2003) carried out the correlation and path coefficient analysis for 25 genotypes of gerbera for 11 characters at IIHR, Bangalore during 1998-2001. They observed positive and direct correlation of number of leaves/plant with cut flower yield which revealed that flower production can be increased by directly selecting for increased number of leaves. Number of ray florets had high direct correlation with flower yield but the correlation is negligible due to undesirable indirect effect, hence restricted selection have to be imposed in order to exploit direct effect.

Ravikumar and Patil (2003) evaluated the 11 genotypes of China aster for the genetic variability and character association studies at the Division of Horticulture, U A S, Dharwad during 2001. The correlation studies revealed that flower yield was positively and significantly correlated with diameter of flower and number of flowers/plant during selection of genotypes for improvement in yield.

Baskaran *et al.* (2004) studied the correlation and path coefficient analysis among the 10 genotypes of chrysanthemum at the Horticultural Research Station, Department of Horticulture, Gandhi Krishi Vigyan Kendra, University of Agricultural Sciences, Bangalore during the year 1999-2000. The study revealed that the number of branches per plant showed

positive and significant association with number of flowers at genotypic (0.845) as well as phenotypic (0.778) level. Plant spread showed negative and significant correlation with disc diameter at genotypic level (-0.648). Number of flowers per plant showed positive and non-significant association with number of ray florets, while flower weight and length of ray floret recorded negative and non-significant association at both levels (-0.493, -0.356, -0.169 and -0.163).

Naik *et al.* (2004) conducted an experiment on correlation analysis among 15 diverse genotypes of African marigold to understand the association between component characters and their relative contribution to xanthophylls yield during the year 2002-03. The study revealed that the genotypic and phenotypic correlation of xanthophylls yield per hectare was found to be positively significant with petal meal yields per hectare (0.949 G; 0.939 P), flower yield per plant (0.943 G; 0.919), number of flowers per plant (0.930 G; 0.909P) and total dry matter production (0.865G; 0.853P), flower size (0.884 G; 0.865 P), flower yield per hectare (0.876G; 0.72P), xanthophyll content per kilogram of petal meal (0.864G; 0.862P), number of petals per flower (0.561G;0.522P) during kharif season. Whereas, in the rabi season also majority of them showed significant and positive association with xanthophylls yield except days to 50% flowering and ten fresh flower weight at both the genotypic and phenotypic levels.

Radhakrishna *et al.* (2004) carried out the correlation analysis among eight tuberose single genotypes and six double genotypes for 10 quantitative characters at IIHR, Bangalore during 2001-02. Analysis of variances in case of single genotypes revealed loose flower yield exhibiting positively significant response at genotypic and phenotypic levels with spike length, number of flower per spike, flower length, flower diameter, 100 flower weight and spike weight. Number of flowers per spike showed significant positive correlation with loose flower yield, spike length, rachis length at both levels. In double genotypes, spike yield showed positive and significant correlation with number of leaves per plant, rachis length, flower length and flower diameter. Rachis length also showed positively significant correlation with plant height, spike length, flower length, spike weight and spike yield at both genotypic and phenotypic levels.

Patil *et al.* (2004) carried out an experiment with 10 cultivars of carnation to study the contribution of different parameters to flower yield and quality parameters. The experiment revealed that number of flowers per plant was positively and significantly correlated with number of branches, whereas, plant height was positively and significantly correlates with

stalk length, number of leaves, number of branches, leaf area, total chlorophyll content, stem girth and leaf length. Vase life was positively and significantly correlated with plant height, stem girth, number of leaves and number of branches.

Sestras *et al.* (2004) had noted a strong positive and negative correlation among a lot of the traits of plants, both *in vivo* and *in vitro*. Under *in vivo* conditions, the strong positive correlation has been identified between the plant height and length of stem (0.803), number of internodes per plant and number of leaves per stem (0.877), number of internodes per plant and number of shoots per plant (0.877), number of internodes per plant and plant height (0.918) and under *in vitro* between length of roots and plant height (0.947), length of roots and number of internodes per plant (0.926), length of roots and number of roots per plantlet (0.873). However, strong negative correlation has been identified between the number of internodes per plant and height of flower bud (-0.903), number of leaves per stem and height of flower bud (-0.907), number of leaves per stem and number of petals per flower (-0.738), flower diameter and number of flowers per plant (-0.768) under *in vivo* conditions.

Shiragur and his co-workers (2004) carried out the correlation studies among the various component characters of nine cultivars of carnation (*Dianthus caryophyllus* L.) at Belgaum, Karnataka during the year 2000-2001. The association study revealed that plant height was positively and significantly correlated with stalk length, flower diameter, bud diameter, leaf area and leaf length, whereas, stalk length was positively and significantly correlated with plant height, days for bud appearance, leaf area, bud diameter, flower diameter. Vase life was positively and significantly correlated with number of leaves, leaf area, stalk girth and flower diameter, however, yield in terms of number of flowers per plant was positively and significantly correlated with number of shoots and number of petals per flower.

Sheela *et al.,* (2006) studied the association between various characters and the direction and magnitude of different characters among 12 genotypes of heliconia. Correlation studies revealed that number of flowering shoots per year had a strong positive correlation with vase life, number of flowers/bract and size both at genotypic and phenotypic levels. Plant height was positively correlated with days to first flowering, duration of flowering, spike length, bract number, number of flowers/bract, leaf area and bract size.

Karuppaiah and Kumar (2010) carried out an investigation with 34 genotypes of African marigold to assess the association of yield components and their direct and indirect

effects on flower yield. Results of correlation analysis indicated that the flower yield per plant was found to be significantly and positively correlated with number of branches per plant, flower size, flower weight, number of flowers per plant and xanthophylls content, while, days to first flowering showed a negative association with flower yield per plant. Path analysis revealed that number of flowers per plant and xanthophylls content showed high positive direct effects, whereas, medium level of direct effect was recorded by flower diameter. Thus, this study indicated that flower diameter, number of flowers per plant and xanthophylls content are important characters in deciding the flower yield per plant. Hence these characters may be considered as selection indices in marigold breeding programme.

Roychowdhary *et al.* (2011) evaluated mutant carnation (*Dianthus caryophyllus* L.) genotypes to assess the magnitude of genetic variability and to pick up the heritable component of variation for selection response of metrical traits. The experiment revealed that branches per plant, total number of leaves per plant and number of flower per plant correlated positively with plant height while, seeds per inflorescence and weight of seeds showed negatively correlation with plant height. Similarly, there were positive and significant relationship between number of branches per plant and days to branching, total leaves per plant and total number of branches per plant. Partial correlation was significant for only total leaves per plant.

Kumar *et al.* (2012) carried out an experiment to assess the extent of correlation coefficient and path analysis in 12 gladiolus genotypes, *i.e.*, 'True Love', 'Pacifica', 'Rigency', 'Yellow Stone', 'Sagun', 'Tiger Flame', 'Praha', 'Snow Princess', 'Picardy', 'Eurovision', 'Aldebran' and 'Promise'. The experiment was conducted at the Horticulture Research Farm, Department of Applied Plant Science (Horticulture), B B A U, Lucknow during 2009-10. From the analysis of data, they found that maximum phenotypic variation was recorded for corm weight per plant (180.75) followed by number of days taken full spike emergence (117.18). Significant positive correlation of corm weight plot was recorded with corm size (0.906), spike length (0.764), plant height (0.669).

Akaneme and Ani (2013) assessed the morphological variability among the five accessions of *Amaranthus hybridus*. The study revealed that, of all the correlation coefficients, eleven pairs of characters were positively and highly significantly correlated at $p<0.05$ and $p<0.01$ while one pair was negatively and significantly correlated at $p<0.05$. The highest correlation was between 500 seed weight and leaf width ($r= 0.619$), coefficient of determination ($r = 0.383$ or 38%). The 500 seed weight was also moderately correlated with

hypocotyls length (r = 0.417, r^2 = 0.174 or17.4%). Other moderate correlation coefficients were between canopy cover and plant height (r= 0.595, r^2 = 0.35 or 35%), stem diameter and leaf length (r= 0.593, r^2=0.352 or 35%), internode length and leaf length (r= 0.554, r^2 = 0.301 or 30%), days to 50% flowering and stem diameter (r= 0.542, r^2 = 0.294 or 29%), days to 50% flowering and leaf length (r= 0.533, r^2 = 0.284 or 28%). The only significant but negative correlation was between hypocotyl length and plant height (r= -0.488, r^2 = 0.24 or 24%).

Twenty-one genotypes of African marigold (*Tagetes erecta* L.) were evaluated by Singh *et al.* (2014) to determine the genetic parameters such as correlation and path coefficient analysis for 11 growth and flowering related traits. They found that fresh flower weight per plant is significantly and positively correlated both at genotypic and phenotypic level for plant spread, flower fresh weight per flower, number of flowers per plant and flower diameter. Whereas, path coefficient analysis at genotypic level revealed that the number of primary branches per plant contributed highest and significantly positive direct effect on fresh flower weight per plant followed by number of flowers per plant, flower diameter, flower fresh weight per flower, days required for flowering and stem girth.

Kumar (2015) estimated the correlation and path coefficient analysis among 10 genotypes of gerbera for 13 quantitative traits to identify potential economic traits for selection. The experiment was carried out in randomized block design with three replications under naturally ventilated polyhouse at the Division of Ornamental Crops, IIHR, Hessaraghatta, Bengaluru during 2011-13. They found that the number of leaves per plant was highly significant and positively correlated with number of suckers per plant, whereas, leaf length was highly significant and positively correlated with leaf breadth, plant spread, days to bud burst, days to first flower opening, flower stalk length, flower stalk diameter and number of flowers per plant. Days to first flower opening were positive and highly significant with leaf length, days to bud burst and number of flowers per plant. Flower diameter was positive and highly significant with number of suckers per plant and flower stalk length.

2.2 GENETIC DIVERGENCE STUDIES

The genetic diversity of species is a valuable natural resource and the basis for survival. The greater the genetic diversity of a species and the more complex its genetic background, the stronger its evolutionary potential and ability to withstand adversity, and the

more easily it will expand its distribution range and adapt to new environments (Templeton, 1998; Martins *et al.*, 2003).

Rai *et al.* (2015) analyzed genetic diversity among different species of rose (*Rosa* species) using morphological and molecular markers (RAPD) which indicated high degree of variation in the rose germplasm and thus the species included in the research *viz., Rosa moschata, R. damascene, R.tomentosa, R. indica, R. chinensis* and *R. bourboniana* prove to be invaluable source of genetic diversity for rose improvement.

Crespel *et al.* (2013) identified the relevant morphological, topological and geometrical variables of rose bushes in relation to plant shape. Five bush rose cultivars, 'Baipome', 'Blush Noisette', 'Old Blush', 'Perle d'Or', 'Fairy and three hybrids, their architecture was digitized and 35 variables were measured, the digitzed version was verified with UPOV descriptor and the result of both were similar.

Riaz *et al.* (2011) collected endemic wild rose based on morphological differences from 5 different sites of Pakistan. Morphological features of flowers, leaves, branches and hips were recorded for genetic studies.

Deshraj and Misra (2000) studied genetic divergence for 20 quantitative characters in 25 cultivars of gladiolus under three environments. Based on cluster means, characters like days to 50% heading, first floret colour showing, first floret opening, last floret opening, number of florets per spike, average weight of a corm and propagation coefficient were the major factors for differentiation among 25 cultivars. Maximum genetic distance was observed between clusters IV & V (E1 and E3), II & V (E2) and III and IV (pooled). The study also revealed that clustering behaviour and mean performance of cultivars of individual cluster were not consistent over the environments because of larger genotype x environment interaction.

Mishra and Mohanty (2003) assessed genetic divergence among 18 dahlia varieties through multivariate analysis following Mahalanobsis D^2 statistic, canonical analysis and numerical taxonomic approach. Analysis of variance showed significant differences among the test entries for all the characters except bloom life of flower and tuber number per plant. The characters having major contribution to genetic divergence were stalk diameter of secondary flower, number of ray florets in main flower, petal length and number of ray florets in secondary flower in order of merits.

Dhiman *et al.* (2006) characterized and evaluated 47 genotypes of buckwheat to study the sufficient diversity for 6 important agro- morphological traits. Agro-morphological traits like plant height, primary branches/plant, days to maturity and 100-seed weight were found important in distinguishing buckwheat genotypes. Cluster analysis grouped genotypes in 13 clusters with a maximum of 20 genotypes in cluster I, followed by 13 in cluster II, 3 in cluster XIII, 2 in cluster X and others ungrouped. Clustering pattern did not corroborate geographical distribution of the genotypes.

Pal *et al.* (2006) employed Mahalanobis D^2 analysis to study the genetic diversity of 30 gladiolus genotypes. The clustering pattern indicated that the geographic diversity need not necessarily be related to the genetic diversity. Genotypes from different eco-geographic regions were identified in one cluster. The inter-cluster distance was found maximum between cluster III and VIII followed by VI and VII. The genotypes in these clusters may possibly be utilized for hybridization through suitable breeding system for the successful exploitation of heterosis in gladiolus.

Nimbalkar and his co-workers (2006) evaluated twenty five genotypes of dahlia (*Dahlia variabilis*) to assess the genetic diversity and variability during the year 2000. The genotypes were studied and grouped into 10 clusters in which cluster-I, II and III were largest with five genotypes in each cluster, followed by cluster-IV, V and VI having two genotypes in each cluster. The cluster VII, VIII, IX and X were monogenotypic clusters. The maximum intra-cluster distance was exhibited by genotypes of the cluster VI, while the lowest by the genotypes of the cluster IV. The inter-cluster distance was highest between the cluster VI, while the lowest between the cluster I and II.

Bihari *et al.* (2009) evaluated the fifty genotypes of gladiolus to assess the nature and magnitude of genetic divergence using Mahalanobis D2 statistics in the Department of Botany, D.A.V. College, Kanpur, during 2004-2005. The population was grouped into six clusters in which, cluster-I was the largest one with 26 genotypes followed by cluster-V with seven and cluster-Ill and VI with five genotypes, whereas, cluster-II had four and cluster-IV had three genotypes. The cluster-I recorded maximum intra-cluster distance (16431.619) followed by cluster-V (1986.137), III (1754.896) and II (1114.541). With respect to inter cluster distance, it was found maximum between cluster-IV & V (1239.864) followed by I & IV (887.138), IV and VI (768.188) and I & V (725.470). Cluster-I retained maximum number of treatments which showed genetic similarities. Remaining clusters retained 4 or 3 varieties

which had considerable differences in their parents. Therefore, selection for divergent parents based on these traits is recommended for getting desirable hybrids or segregates in gladiolus.

Kavitha and Anburani (2009) studied the nature and magnitude of genetic divergence assessed on thirty African marigold genotypes assembled from different geographical locations showed the presence of wide genetic diversity. The clustering pattern of genotypes revealed that the genetic diversity was independent of the geographical diversity. Among the eight clusters, maximum number of genotypes were found in cluster IV and cluster VIII was mono genotypic. The maximum inter cluster distance was observed between cluster IV and III (D^2=30.76), closely followed by cluster IV and VI (D^2=2.16). The cluster I revealed the least distance relationship with cluster III (D^2=2.16).

Panwar *et al.* (2010) evaluated 32 genotypes of rose (*Rosa x hybrida*) to assess the nature and magnitude of genetic diversity. According to Mahalanobis D^2 analysis, the entire germplasm was classified into seven distinct clusters in which larger clusters (I, II and V) composed of seven genotypes while cluster III, IV, VI and VII have five, two, three and one genotypes, respectively. The divergence at inter and intra cluster level revealed the highest inter cluster distance between V and VII (D^2 = 7.863), whereas, the lowest was found between II and VI (D^2 = 2.885). Cluster VII had the minimum intra cluster distance (D^2=0.25) while cluster III had the maximum intra cluster distance (D^2=2.889).

Swaroop and Janakiram (2010) carried out an investigation with twenty eight genotypes of gladiolus (*Gladiolus hybridus*) which were evaluated to assess the genetic diversity at the Research Farm of Floriculture and Landscaping, IARI, New Delhi during 2006-07 to 2009-10 for three years in a completely randomized block design with three replications. Studies revealed that the mean performance of gladiolus data were highly significant for all the twelve traits for growth, flowering and corms parameters studied indicating the presence of variability. The genotypes were grouped into 8 clusters, among which, cluster-VIII was largest with twelve genotypes, followed by cluster-I having 4 genotypes and the remaining cluster had 2 genotypes each. The maximum intra cluster distance was exhibited by genotypes of cluster VIII, whereas, lowest by the genotypes of cluster-II. The inter-cluster distance was highest between the cluster VI and VIII and lowest between cluster I and VI, and II and V. The different clusters have higher mean values for different traits, the genotypes ‘Anjali’ from cluster-I, ‘Dhanvantari’ and ‘Her Majesty’ from cluster VIII, ‘American Beauty’ from cluster-III and ‘Sylvia’ from cluster-VI deserve to be considerably to divergence.

Akaneme and Ani (2013) evaluated the ten accessions of *Amranthus hybridus* in the field for the morphological assessment of genetic variability in ten quantitative and nine qualitative traits. Data from the ten quantitative traits were used to perform a cluster analysis using Ward's method based on squared Euclidean distance. The dendrogram divided the accessions into distinct clusters, in which, cluster I comprising accessions 3 and 5 and cluster II comprising accessions 1, 2 and 4. The qualitative traits differed among the accessions with the exception of growth habit, branching index and leaf shape. Accessions 3 and 5 had small dissimilarity between them just as accessions 1 and 4. The most dissimilar were accessions 5 and 1. The cophenetic correlation coefficient value of 0.8 was obtained.

Srivastava and Sharma (2013) studied the genetic divergence among 16 carnation genotypes grown under polyhouse through Mahalanobis D^2 analysis. A wide genetic diversity was observed among 16 genotypes which were grouped into eight clusters in first year and six clusters in second year. The clustering pattern indicated that the geographic diversity need not necessarily be related to the genetic diversity. The pattern of distribution of these entries in various clusters showed considerable amount of genetic divergence among these genotypes for all the vegetative and flowering characters studied in the both years. The inter-cluster distance was found maximum between cluster VI and cluster VIII in first year, while in second year it was maximum between cluster I and cluster II.

Singh and his co-workers (2014) carried out a genetic diversity analysis in snapdragon (*Antirrhinum majus*) to study the genetic structure of 10 different genotypes through RAPD markers. The study revealed that the genotypes 'Vilmorin' and 'AG-5' were closely related as they showed high value of similarity coefficient (0.735), followed by genotype 'SA-1' with 0.696 of similarity coefficient. 'AG-2' showed least similarity (0.475) with other genotypes.

2.3 DUS CHARACTERIZATION STUDIES

The requirement of distinctness, uniformity and stability are assessed on the basis of characteristics. The characteristics are a feature of whole plant or part of plant. The testing of DUS characters is useful in four main ways, identification of varieties, (ii) for registration of varieties and plant variety protection (PVP) Act, (iii) for varietal information system and classification of varieties into different groups, and (iv) for creating data base for plant viz. (i) for genetic resources (Singh *et al.*, 2005). For characterization, differentiation and protection of varieties specific descriptors are used in each species. A descriptor is a characteristic that

refers to the form, structure or behavior of an accession in a germplasm collection. Descriptors must satisfy with three technical requisites of distinctness (D), uniformity (U) and stability (S) (UPOV, 2002). As per the DUS guidelines, only morpho-physiological descriptors are used for establishing distinctness of the varieties (Anonymous, 2007). Use of morphological descriptors in sequential fashion is useful and convenient to distinguish different varieties.

To promote the encouragement for the development of new varieties of chrysanthemum and to protect the rights of the farmers and breeders, the PPV and FR Authority (2010) proposed a DUS testing guidelines applied to all varieties, parental lines of *Chrysanthemum* x *morifolium* Ramat (*Chrysanthemum* x *grandiflorum* Ramat.), *Chrysanthemum pacificum* Nakai and hybrids between them. The purpose of these guidelines is to provide detailed practical guidance for the harmonized examination of DUS of the candidate variety and, in particular, to identify appropriate characteristics for the examination of DUS.

Before a variety is registered as a cultivar and/or granted Plant Breeder's Rights, its distinctness, uniformity and stability (DUS) is tested using morphological characters (descriptors). In India, the Protection of Plant Varieties and Farmers Rights Authority conducted evaluation trials for identifying the DUS descriptors for rose (PPV and FR Authority, 2011).

To characterize the crop cultivars morphologically, the specific DUS test guidelines for three species of Orchid namely C*ymbidium* Sw., *Dendrobium* Sw. and *Vanda* Jones ex R.Br. have been developed by PPV and FRA, (2011). Under this act, a new cultivar will be registered based on its DUS test**.**

Banerji *et al.* (2012) evaluated ten large flowered chrysanthemum cultivars, viz., 'Beat Rice May', 'Beauty', 'Casa Grande', 'Jet Snow', 'John Weber' , 'Miss Maud Jeffries', 'Penny Lane', 'Shanker Dayal', 'Snow Ball' and 'S.S. Arnold' for morphological and biochemical characterization at National Botanical Research Institute (NBRI), Lucknow. Morphological data were recorded on vegetative and floral characters. Biochemical characterization included analysis of anthocyanins, carotenoides, chlorophyll content (chlorophyll a, b and total) and flavonoids. Results on morphological and biochemical parameters clearly indicated distinctness among cultivars with reference to differences in morphological characters and chemical composition of pigments.

Nadeem (2012) studied varieties like “Autumn Sunset”, “Iceberg”, “Paradise”, “Angel Face”, “Casino”, “Louise Odier”, “Grand Margina”, “Handel” and “Gruss an Teplitz” for their morphological description which revealed various blends of color of flowers, foliage and leaf hairiness, petiole pubescence and inflorescence types.

Choudhary *et al.* (2014) conducted an expriment on the characterizarion of marigold genotypes using morphological characters at the Research Farm of Department of Horticulture, CCS Haryana Agricultural University, Hisar during the years 2011-12 and 2012-13. They selecte thirty genotypes of marigold and their different morphological characters both at vegetative and flowering stages were studied and the categorization was done on the basis of their plant characters. The results revealed the significant variations for different growth, flowering and yield parameters among all the genotypes.

De *et al.* (2014) studied the morphological characterization of eight species of *Paphiopedilum viz., Paphiopedilum concolor, P. fairrieanum, P. godefroyae, P. hirsutissimum, P. insigne, P. spicerianum, P. venustum* and *P. villosum* for the development of morphological descriptors based upon UPOV guidelines and accordingly total 76 morphological descriptor of *Paphiopedilum* were developed. The morphological characterizations were done used for all vegetatively propagated species of *Paphiopedilum* and alliance of the family *Orchidaceae*.

De *et al.* (2014) evaluated 40 hybrids of *Oncidium* for development of DUS test guidelines using common descriptors. Out of 60 common descriptors developed, plant type, basal leaf number/ pseudobulb, flower width in front view, petal predominant colour, petal colour pattern, lip predominant colour and lip colour pattern were used for grouping of hybrids.

De *et al.* (2015) carried out an investigation on morphological characterization of 30 *Dendrobium* spp. for the development of morphological descriptor of *Dendrobium* based on UPOV guidelines and accordingly total 62 morphological descriptors were developed. Out of 62 descriptors, plant height, internode number, inflorescence number per shoot per year, flower width, flower predominant colour, lip main colour, lip ornamentation and flowering time were used for grouping characteristics of species.

De *at al*. (2015) studied the morphological characterization of all vegetatively propagated species of *Vanda* of family Orchidaceae. They studied 11 *Vanda* species viz. *Vanda alpina, V. cristata, V. coerulea, V. parviflora, V. coerulescens, V. stangeana,*

Papilionanthe (Vanda) teres, V. bicolor, V. tassellata, V. pumila, and *V. parishii* for the development of morphological descriptors based upon UPOV guidelines and accordingly total 65 morphological descriptors of *Vanda* were developed.

Distinction of cultivars based on morphological characters is the criterion being followed internationally for assigning Plant Breeders Rights. However, the time and environmental influence being constant problems in morphological evaluation has forced for looking at feasible alternative. Keeping in view the inherent problem of the morphological characters related to their limited number, the precision required in recording, and high genotype × environment interaction, the use of biochemical and molecular markers for DUS testing of varieties has been suggested (Law *et al.* 1999; Wouters and Booy 2000; Jones *et al.* 2003; Cook *et al.* 2003). Of the physiological, biochemical and molecular methods; molecular method had always emerged as time saving and most reliable alternative. Therefore, complementary approaches, such as the use of microsatellite markers, are being evaluated and molecular databases are being constructed. Among several molecular markers, microsatellites are highly polymorphic and preferred for their co-dominant nature, and for abundance.

Smulders *et al.*, (2003) carried out microsatellite genotyping of carnation (*Dianthus caryophyllus*) varieties. They developed a set of 11 sequence-tagged microsatellite markers for carnation using a DNA library enriched for microsatellites. Supplemented with three markers derived from sequence database entries, these were used to genotype carnation varieties using a semi-automated fluorescence based approach. In a set of 82 cultivars, the markers amplified 4–16 alleles each and effective number of alleles varied from 1.9 to 6.0. For the eight best scorable markers, heterozygosity was between 0.51 and 0.99. The markers were able to distinguish all cultivars with a unique combination of alleles, except for sport mutants, which were readily grouped together with the original cultivar. These research workers had developed a set of highly discriminatory microsatellite markers that can be used for genotyping carnation varieties and grouping mutants with the original variety, in a semi-automated, medium-throughout procedure.

Arens *et al.* (2009) carried out an investigation to study the identification of carnation varieties using microsatellite markers for the characterization of carnation varieties as well as the construction and evaluation of a molecular database. In total, 172 samples were analysed of which 133 samples were sent in by breeding companies and 12 samples were reference varieties from the carnation DUS test of 2005. The 15 polymorphic microsatellite markers

available were supplemented with 28 newly developed markers. The set of 12 reference varieties was used for pattern quality assessment. Thirteen markers were selected on the basis of pattern quality (quality 1 or 2), using the standards described by Smulders *et al.* (1997). The selected markers were used for fingerprinting the set of 172 samples. The numbers of allelic marker phenotypes varied from 3 to 20 and, in total, 163 marker phenotypes were found.

Panwar *et al.* (2012) characterised thirty two Indian roses using DUS based morphological descriptors. Plant growth type was divided into six categories and the maximum genotypes (24) were covered under bed rose category. Similarly, flower colour was divided into thirteen categories based on colour groups mentioned in the DUS guidelines. The study concluded that the existence of wide variation for various vegetative and floral traits in all the genotypes provides good scope for selecting suitable genotypes for all the economic traits.

Tejaswini and her co-workers (2014) carried out an investigation to identify a potential set of microsatellite markers for discrimination of carnation cultivars. Microsatellite markers extracted genetic differences between clones indicating the problem of uniformity criterion that is considered as fundamental in DUS testing. On the contrary the set of primers that expressed uniformity across clones failed to extract the maximum difference between cultivars required to establish the distinctness. Primers with high value of power of discrimination were found to be more appropriate for establishing the distinctness of cultivars. Microsatellite markers were to able cluster genetically similar genotypes together that are morphologically separated into distant clusters.

Asha *et al.* (2016) studied characterization and establishment of distinctiveness among thirty chrysanthemum genotypes for 41 essential traits, among which six characters were monomorphic, five dimorphic and thirty were polymorphic. Out of thirty genotypes studied, eight were found to be distinctive on the basis of ten essential characters while the rest of twenty two genotypes remained in groups of two or three without being differentiated for similar traits, therefore it was suggested to use other biological markers/DNA fingerprinting.

Rai *et al*. (2015) characterized genetic diversity among different species of Rose (Rosa species) using morphological markers viz., plant growth habit, young shoot anthocynin coloration, plant height, prickles, colour of prickles, leaf, intensity of green colour on leaf,

glossiness, pubescence and serration of leaf, type of stipule etc, which showed high degree of variation in rose germplasm.

Panwar *et al.* (2012) assessed variability, heritability and grouping of 32 Indian rose (*Rosa x hybrida*) genotypes based on DUS guidelines and found wide variations for various vegetative (plant height, primary branches, secondary branches, stem girth, prickle density, internodal length, leaf area etc) and floral traits (days to flowering, bud length, stalk length, neck length, flower diameter, weight per flower, no of petals/flower, no. of flowers per plant), which offered a scope of selecting the suitable genotypes for all economic traits.

Chapter-3

MATERIALS AND METHODS

The present investigation entitled **"DUS Characterization and Genetic studies in Rose (*Rosa hybrida*)"** was carried out to study the performance of miniature Rose genotypes under open field condition at the Rose Garden, Experimental Farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the years 2017-2018.

The experimental farm is located at 1276 m above mean sea level at the latitude of 30˚51'0" N and longitude of 77˚11'30" E. The climate of the area is sub-temperate characterized by mild summers and cool winters. The maximum temperature during the study period ranged between 17.1˚C to 31.3˚C and minimum 2.6˚C to 20.2˚C (Appendix I).

3.1 Plant Material

Forty five genotypes of miniature or cascade roses were procured from a certified nursery of Bengaluru, Karnataka and selected for undertaking the present investigation as named in the Table No. 3.1. The crop was raised in open field.

Table 3.1 : Name of miniature rose genotypes used in the experiment.

1	Bharani	16	String of pearls	31	Babe
2	China 65	17	Fairy Gold	32	Mirabel
3	Golden Century	18	Lavender Midnette	33	Flamboyant
4	Frothy	19	Young Mistress	34	Roxy
5	Zwergkonig	20	Gourmet Popcorn	35	Graine De Beaute
6	Royal Midnette	21	Giggles	36	Cup Cake
7	Simply Marvelous	22	Ruby Star	37	Mr. Blue Bird
8	Chandrika	23	Wild Fire	38	Amber Star
9	Flash Dance	24	The Fairy	39	Fire Flash
10	Kayla	25	Red Figurine	40	Hoot & Howler
11	Sunday Brunch	26	Aishwarya	41	Leila Laird
12	Vanessa	27	Don Don	42	Painter's Palette
13	Maigold Sweet Dream	28	Lemon Sweet Dream	43	Nine
14	Blue Blood	29	Rise n Shine	44	Dazzler
15	Scarlet Gem	30	Swinger	45	Priti

3.2 GENERAL PROCEDURES

3.2.1 Preparation of Beds and Planting

The field was treated with non-selective pre-emergence weedicide and was ploughed with the help of moldboard plough and kept for solarization one month before planting. Afterwards the field was leveled and pits were dug before the arrival of plants. The pit soil was mixed with well rotten farm yard manure @ 1 Kg per pit and kept for few days. The planting was done on date 18-02-17. The budded plants on *Rosa indica var. odorata* rootstock arrived in a healthy condition with 4-5 branches and 15-20 cm length in leafless condition. The plants were planted in the pits where row to row distance was maintained as 1 m x 1 m; plant to plant distance as 0.5 m x 0.5 m. It was ensured to keep the budded portion well above ground level and the budded portion faced the path side. At the time of planting, recommended basal dose of fertilizer (10 g each of NPK in the form of Urea, SSP and MOP) was applied in each pit After planting. The irrigation was given to help the plant cope with transportation and transplanting shock. The preventive spray of Cu as well as Dithane and Bavistin was done to check the spread of fungal diseases if any on 19th Feb 2017.

3.2.2 Fertigation Irrigation and cultural practices

After planting irrigation was done on every 3 days for 3 months and in the vegetative growth stage soil drenching of Calcium Nitrate @ .1 g /L was done and each plant was applied 2 liter of solution every 10 days for 3 months. The weeding was done regularly every fort night for first 3 months and later the duration was increased to as and when required. The root suckers emerging from base of the plants were removed from time to time. Hoeing was done at a monthly interval and before fertilizer application so as to remove weeds and incorporate proper aeration, water and nutrients in root zone.

Uniform cultural practices regarding pruning, fertilization was given to all the plants well in time. After establishment, plants were given irrigation as and when required depending upon the climatic conditions and season. The frequency of irrigation during summer months were twice a week whereas in winter it was once a week. Manual weeding was done once a week.

3.3 EXPERIMENT DETAILS:

The experiment was laid out in Randomized Block Design (RBD) with three replications in open conditions.

The details of the experiment were as follows:

A.	**Genotypes**	:	45
B.	**Replications**	:	3
C.	**Total No. of plants per genotype**	:	9
D.	**Spacing : Plant to plant**	:	0.5m x 0.5m
	Row to Row	:	1m x 1m
E.	**Design**	:	Randomized Block Design (RBD)
F.	**Location**	:	Experimental farm, Department of Floriculture and Landscape Architecture
G.	**Year of Experiment**	:	February 2017-October 2018

3.4 EXPERIMENT 1: Genetic evaluation of miniature rose (*Rosa hybrida*) genotypes for landscape usage.

The following observations were recorded for 2 years and the data was analyzed for studying the mean performance of genotypes and parameters of variability and drawing the conclusions accordingly.

3.4.1 Plant height (cm) : Plant height (cm) was measured at the peak of flowering. The height of plant was measured from base to tip of longest stem using measuring scale.

3.4.2 Primary branches (no.): The number of primary branches were counted before pruning. Primary branches are the branches originating directly from the bud union and this excluded the root stock as well as suckers.

3.4.3 Secondary branches (no.): The branches origination from the primary branches are considered as secondary branches and the observation was taken by counting the numbers before pruning for both years.

3.4.4 Main stem girth (mm): The main stem girth of 3 marked primary stems were taken and averaged per plant with the help of Vernier calliper before pruning.

3.4.5 Plant Spread (cm): Spread of plant was taken for two directions East-West and North-South at peak flowering with help of measuring scale. The plant spread was averaged and the data was analysed as such.

3.4.6 Internodal length (cm): Internodal length was recorded with the help of measuring scale in the middle third of the primary stem at peak flowering.

3.4.7 Prickle density (No./15 cm stem length): The number of prickles were counted in new growth of primary stem from middle portion measuring 15 cm the data was recorded from 3 stems per plant which were selected randomly and averaged.

3.4.8 Leaf area (cm^2): The leaf area of 3 compound leaves per plant were recorded with the help of Leaf Area Meter (CI-202, PORTABLE LASER LEAF AREA METER, CID Bio-Science) and averaged. The compound leaves were matured fully expanded leaves excised from middle third of the stem.

3.4.9 Days taken for first flowering: Number of days taken for first flowering was recorded from the date of transplanting to the appearance of first flower during the first year. However, during 2018, days for first flowering were recorded after the date of pruning in December, till the appearance of first flower.

3.4.10 Days taken for peak flowering: The peak flowering stage is when the flowers show more than 50 % bloom. The number of days to peak flowering was calculated from the data table of number of flowering stem per plant.

3.4.11 Duration of flowering (days): The duration of flowering was calculated from counting the days between days to first flowering and the rest number of days from weekly data recorded for the purpose of number of flowering stem per plant. Likewise in the second year the day to first flowering was considered after annual pruning. As the flowering plant had recurring flowers there was no last date to flower as such.

3.4.12 Bud length (mm): Flower bud length was measured by using Vernier calliper when one of the petals was unwhorled and sepals were fully opened (Petal Separation Stage).

3.4.13 Bud width (mm): Flower bud width was measured by using Vernier calliper when one of the petals was unwhorled and sepals were fully opened (Petal Separation Stage).

3.4.14 Flower diameter (cm): Flower diameter was recorded at full bloom stage by averaging the lengths from north to south and east to west directions with help of Vernier calliper. The flower picked for data recording at anthesis. The top/apical flower was excluded from recording of observation.

3.4.15 Petal length (mm): Petal length was recorded with the help of Vernier calliper from longest tip of the petal till base. The petal was taken from 3rd whorl counted from outer side in .

3.4.16 Petal Width (mm): Petal length was recorded with the help of Vernier calliper from longest tip of the petal till base.

3.4.17 Length of Pedicel (cm): The length of pedicel was recorded at full bloom stage by measuring the length of pedicel from base of flower to the point where flower gets attached to the flowering stem.

3.4.18 Number of flower/bunches: The data was recorded at full bloom stage by counting the total number of flowers per bunch/flowering stem.

3.4.19 Number of petals per flower: The data was recorded by counting the number of petals

3.4.20 Number of flowering stems per plant: Total numbers of flowering stems per plant per year were counted by taking the observation on each plant on weekly basis and averaging the plant yield of replication.

3.4.21 Size of seed vessel (mm): The size of seed vessel was recorded at petal fall stage by averaging the length and diameter of hips with the help of Vernier calliper.

3.4.22 Incidence of disease (%):

The disease incidence was calculated by using the formula:

$$\text{Disease incidence \%} = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

NOTE:

1. **No incidence of disease or pest was found in the genotypes thus the observation was dropped from analysis of results.**
2. **The observation days to last flowering was not taken in present research as all of the varieties were recurrent blooming thus showed no last flowering date as such. The blooming was completely absent only when pruned at the end of year.**

3.5 STATISTICAL ANALYSIS

The data in respect of different characters studied were subjected to the following analysis.

3.5.1 Analysis of variance

Analysis of variance was done as per design of experiment as suggested by Gomez and Gomez (1984). For estimation of different statistical parameters, following procedure and formulae were adopted:

3.5.2 Analysis of variance

Source of variance	Degree of freedom	Sum of squares	Mean sum of squares	Variance ratio (V.R.)
Replication (r)	r-1	Sr	Sr/(r-1) = Mr	Mr/Me
Genotypes (g)	g-1	Sg	Sg/(g-1) = Mg	Mg/Me
Error (e)	(r-1) (g-1)	Se	Se/(r-1) (g-1) = Me	

Where,

r = Number of replications

g = Number of genotypes

Sr = Sum of squares due to replications

Sg = Sum of squares due to genotypes

Se = Sum of squares due to error

Mr = Mean sum of squares due to replications

Mg = Mean sum of squares due to genotypes

Me = Mean sum of squares due to error

The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one entry over the others.

The standard error and critical differences were calculated as follows:

$$SE\ (m) \pm = \sqrt{Me/r}$$

$$SE\ (d) \pm = \sqrt{2\ Me/r}$$

$$CD_{0.05} = S.E.\ (d) \times t_{(0.05)}\ (r-1)\ (g-1)\ df$$

Where,

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of difference

$CD_{0.05}$ = Critical difference at 5 per cent level of significance

All the traits, which differed significantly, were utilized further for estimation of following genetic parameters:

3.5.2 Mean performance and genetic variability

The extent of variability is measured by genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) which provides information about relative amount of variation in different characters. The genotypic and phenotypic coefficients of variation were calculated as per formulae given by Burton and De-Vane (1953).

A) Genotypic Coefficient of variability (GCV)

$$GCV\ (\%) = \frac{\sqrt{Genotypic\ variance\ (Vg)}}{General\ mean\ of\ population\ (\bar{x})} \times 100$$

B) Phenotypic Coefficient of variability (PCV)

$$\text{PCV (\%)} = \frac{\sqrt{\text{Phenotypic variance (Vp)}}}{\text{General mean of population } (\bar{x})} \times 100$$

3.5.3 Heritability (in broad sense)

Heritability in broad sense was calculated by the formula as suggested by Allard (1960).

$$\text{Heritability (\%)} = \frac{Vg}{Vp} \times 100$$

Where,

Vg = Genotypic variance [Vg = (Mg - Me) / r]

Vp = Phenotypic variance [Vg + Ve]

3.5.4 Genetic advance (GA)

The expected genetic advance (GA) resulting from selection of five per cent superior individuals was worked out as suggested by Allard (1960).

Genetic advance = H x σ p x K

Where,

K = 2.06 (Selection differential at 5 per cent selection index)

σ p = Phenotypic standard deviation

H = Heritability in broad sense

3.5.5 Genetic gain (GG)

Genetic gain expressed as per cent ratio of genetic advance and population mean was calculated by the method given by Johanson *et al.* (1955).

$$\text{Genetic gain (\%)} = \frac{\text{Genetic advance}}{\text{General mean of population } (\bar{x})} \times 100$$

For categorizing the magnitude of different of different parameters, the following limits were used:

GENETIC PARAMETERS	PCV AND GCV	HERITABILITY	GENTIC ADVANCE AND GENETIC GAIN
HIGH	>30%	>80%	> 50 %
MODERATE	15-30%	50-80%	25-50%
LOW	<15%	< 50%	<25 %

3.5.6 Genetic divergence (D^2 analysis)

The genetic divergence among genotypes was computed by following Mahalanobis D^2 technique (1936) and the grouping of genotypes into different clusters was done by following Tochers method (Singh and Chaudhary, 1979). The calculation of D^2 analysis involved following steps:

i) A set of uncorrelated linear combination linear (y's) was obtained by pivotal condensation of the common dispersion matrix Rao (1952) of the set of correlated variable (x's).

ii) Using the relationship between y's and x's the mean value of different genotypes for different characters (x_1 to x_{15}) were transformed into the mean values of an uncorrelated linear combination (y_1 to y_{15}).

iii) The D^2 values between i^{th} and j^{th} genotype for K characters were calculated as:

$$D^2 ij = \sum_{i=1}^{K} (yit - yjt)$$

Group constellation

Treating D^2 as the generalized statistical distance between a pair of populations (genotypes), all populations were grouped into number of clusters according to method described by Rao (1952). The criterion used in clustering by this method was that, any two genotypes belonging to the same cluster, at least on an average, show a small D^2 value than those belonging to two different clusters. In other words, if genotypes V_1 and V_2 are close

together and genotypes V_3 is distant from both as shown by their generalized distance then V_1 and V_2 will be grouped, in same the cluster.

3.6 Morphological characterization of genotypes

The morphological features are the key points for identification of plants in plant species. The knowledge of morphological characters of genotypes is also very helpful in maintaining the genetic purity of the plants. In order to ascertain the morphological description and their classes that can be reliable used for DUS testing of Rose (*Rosa hybrida*).

EXPERIMENT No. 2: DUS Characterization of miniature rose (*Rosa hybrida*) genotypes.

**DUS characterization of rose genotypes was done for various characters as per the PPV&FRA guidelines for DUS testing in *Rosa sp*. (PPVFR, 2009).

3.6.1 Plant Material:

I. Young and healthy plants (free of any disease, pest incidence) of 45 miniature rose genotypes budded on a uniform rootstock (*Rosa indica var. odorata*).

II. Minimum quantity of garden type varieties was 9.

3.6.2 Conduct of Test:

I. The duration recording of data was 2 years i.e. 2 growing cycles in one test location.

II. The observation on flower buds was made before sepal separation stage, while for observation on flowers was made at full flowering stage.

III. Observation on flower was made at anther dehiscence at first flush of flower and the terminal flower was excluded from observation.

3.6.3 Methods and Observations:

1. The characteristics described in the Table of characteristics shall be used for the testing of varieties for their DUS.

2. For the assessment of Distinctiveness and Stability, observations shall be made on nine plants or parts taken from each of nine plants.

3. For the assessment of Uniformity, a population standard of 1% and an acceptance probability of at least 95 % shall be applied.

4. For the assessment of colour characteristics, the latest Royal Horticultural Society (RHS) colour chart shall be used. Because daylight varies, colour determinations made against colour chart shall be made either in a suitable cabinet providing artificial daylight or in the middle of the day in a room without direct sunlight..These determinations shall be made with the plant part placed against a white background.

5. Unless otherwise indicated, all observations of vegetative characteristics shall be made during the first flush of flower in the central third of a flowering shoot.

3.6.4 Grouping of varieties

1. The candidate varieties for DUS testing shall be divided into groups for facilitate the assessment of Distinctiveness. Characteristics which are known from experience not to vary or to vary only slightly with in a variety and which in their various states are fairly evenly distributed across all varieties in the collection are suitable for grouping purpose.

2. The following characteristics shall be used for grouping of rose varieties:

(a) Plant: Growth type (Characteristic. 1) [G] and [P] only

(b) Flower: Type (Characteristic. 23)

(c) Flower: Colour group (Characteristic. 25)

(d) Flower: Diameter (Characteristic. 26)

(e) Petal: Number of colours on inner side (basal spot excluded) (characteristic 41)

(f) Petal: Main colour on the outer side with the following groups, only if clearly different from inner side (Characteristic. 52)

Group 1: Green

Group 2: Light yellow

Group 3: Medium yellow

Group 4: Orange

Group 5: Pink

Group 6: Red

Group 7: Purple red

Group 8: Brown red

3.6.5 Characteristics and symbols

1. To assess Distinctiveness, Uniformity and Stability, the characteristics and their states as given in the Table of characteristics (section VII) shall be used.

2. Notes 1-9 (except flower colour group, ch.no 25) shall be used to describe the state of each character for the purpose of digital data processing.

3. Legend (*) Characteristics that shall be observed during every growing season on all varieties and shall always be included in the description of the variety, except when the state of expression of any of these characters is rendered impossible by a preceding phenological characteristic or by the environment conditions of the testing region. Under such exceptional situation, adequate explanation shall be provided.

4. Characteristics containing the following key in the first column of the Table of characteristics shall be examined as indicated below:

QL: Qualitative characteristic

QN: Quantitative characteristic

PQ: Pseudo-qualitative characteristic

(a): Observations on the leaves and the leaflets shall be made on the middle third of the stem.

(b): Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

(c): Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

(+): See explanations on the Table of characteristics

(C): To be examined in cut-flower type trial

(G): To be examined in garden type trial

(P): To be examined in pot type trial

5. Type of assessment of characteristics indicated in column six of the Table of characteristics are as follows:

MG : Measurement by a single observation of a group of plants or parts of plants

MS : Measurement of a number of individual plants or parts of plants

VG : Visual assessment by a single observation of a group of plants or parts of plants

VS : Visual assessment by observations of individual plants or parts of plants

Table No. 3.2: TABLE OF CHARACTERISTICS FOR DUS CHARACTERIZARION:

S. No.	Characteristics	State of expression	Notes	Type of assessment
1. (*) (G) (P) PQ	Plant: Growth type	Ground cover	1	VG
		Miniature	2	
		Dwarf	3	
		Bed	4	
		Shrub	5	
		Climb	6	
2. (*) (+) QN (G) (P)	Plant growth habit (excluding climbing varieties)	Upright	1	VG
		Semi-upright	3	
		Intermediate	5	
		Moderately spreading	7	
		Strongly spreading	9	
3. QN (C) (G)	Plant: Height (during second flush) (cm)	Very short (<30)	1	MS
		Short (<60)	3	
		Medium (60-100)	5	
		Tall (>100)	7	
		Very tall (>150)	9	
4. (+) QL	Young shoot: Anthocyanin colouration (shoot about 20 cm long)	Absent	1	VG
		Present	9	
5. (+) QN	Young shoot: Intensity of anthocyanin colouration	Very weak	1	VG
		Weak	3	

		Medium	5	
		Strong	7	
		Very strong	9	
6. QN	Stem: Number of prickles (excluding very small and hair like prickles)	Absent	1	VG
		Few	3	
		Medium	5	
		Many	7	
7. PQ	Prickles: Predominant colour (as for 6)	Greenish	1	VG
		Yellowish	2	
		Reddish	3	
		Brown	4	
		Purplish	5	
8. (+)	Prickle: Shape of lower side	Deep concave	1	VS
		Concave	3	
		Flat	5	
		Convex	7	
		High convex	9	
9. (*) QN (a)	Leaf: Size	Small	1	MS
		Medium	3	
		Large	5	
10. QN (a)	Leaf: Intensity of green colour on upper side (at the time of first flowering)	Very light	1	VG
		Light	3	
		Medium	5	
		Dark	7	

		Very dark	9	
11. (G) (P) QL (a)	Leaf: Anthocyanin colouration	Absent	1	VG
		Present	9	
12. (*) QN (a)	Leaf: Glossiness of upper side	Absent	1	VG
		Weak	3	
		Medium	5	
		Strong	7	
13. (*) QN (a)	Leaflet: Undulations of margin	Absent	1	VG
		Weak	3	
		Medium	5	
		Strong	7	
14. (*) QN	Leaflet: Serration of the margin	Absent	1	VG
		Fine	3	
		Medium	5	
		Dense	7	
15. (*) PQ (a)	Terminal leaflet: Shape of blade	Narrow elliptic	1	MS
		Medium elliptic	2	
		Ovate	3	
		Circular	4	
16. (C) (+) PQ	Terminal leaflet: Shape of base of blade	Acute	1	MS
		Obtuse	3	
		Rounded	5	
		Cordate	7	

(a)				
17. (+) PQ (a)	Terminal leaflet: Shape of apex of blade	Acuminate	1	VG
		Acute	2	
		Obtuse	3	
		Rounded	4	
18. (G) (P) (+) QL	Flowering shoot: Flowering laterals	Present	1	VS
		Absent	9	
19. (G) (P) (+) QN	Flowering shoot: Number of flowering laterals	Few	1	MG
		Medium	3	
		Many	5	
20. (+) (G) (P)	Flowering shoot: Number of flowers (for varieties with no flowering laterals)	Few	1	MG
		Medium	3	
		Many	5	
21. (+) (G) (P) QN	Flowering shoot: Number of flowers per lateral (for varieties with flowering laterals)	Few	1	MG
		Medium	3	
		Many	5	

22. (+) (G) (P) PQ	Flower bud: Shape of longitudinal section (just before separation of sepals)	Elliptic	1	VG
		Round	2	
		Ovate	3	
		Broad Ovate	4	
23. (*) (+) (G) (P) QN (b)	Flower: Type	Single	1	VG
		Semi-double	2	
		Double	3	
24. (*) QN (b)	Flower number of petals	Few (<20)	1	MS
		Medium (20-30)	3	
		Many (>30)	5	
25. (*) (+) PQ (b)	Flower: Colour group	i. White or near white	1	VG
		ii. White blend	2	
		iii. Green	3	
		iv. Yellow	4	
		v. Yellow blend (includes varieties that are primarily yellow, but yet show some tones	5	

		of pink-red)		
		vi. Orange	6	
		vii. Orange blend (includes varieties primarily orange or orange with some other hues)	7	
		viii. Pink	8	
		ix. Pink blend	9	
		x. Red	10	
		xi. Red blend	11	
		xii. Red purple	12	
		xiii. Purple	13	
		xiv. Violet blend	14	
		xv. Brown blend	15	
		xvi. Multicoloured	16	
		xvii Pink blend (v a r i e t i e s primarily pink, but show tones of other hues, yellow, orange, etc.)	17	
		xviii. Mauve (varieties primarily lavender	18	

		and purple)		
26. (*) QN (b)	Flower: Diameter (cm)	Small (4.0-6.0) 1	1	MS
		Medium (6.1-8.0)	3	
		Large (8.1-10.0)	5	
27. (G) (+) PQ (b)	Flower: Colour of the center	Green	1	VG
		Yellow	2	
		Orange	3	
		Pink	4	
		Red	5	
		Purple	6	
28. QN (G) (P) (b)	Flower: Density of petals	Very loose	1	MG
		Loose	3	
		Medium	5	
		Dense	7	
29. (*) (+) PQ (b)	Flower shape: View from above	Round	1	VG
		Irregularly round	2	
		Star shaped	3	
30. (+) (C) (G) PQ (b)	Flower: Side view of upper part (fully opened flower)	Flat	1	VG
		Flattened convex	2	
		Convex	3	

31. (+) (*) (C) (G) PQ (b)	Flower: Side view of lower part (fully opened flower)	Concave	1	VG
		Flat	2	
		Flattened convex	3	
		Convex	4	
32. (*) QN (b)	Flower: Fragrance (recorded during early morning)	Absent	1	
		Weak	3	
		Medium	5	
		Strong	7	
33. (*) (+) QN (b)	Sepal: Extensions	Absent	1	VG
		Few	3	
		Medium	5	
		Many	7	
34. (+) QL (b) (c)	Petal : Reflexing of petals one by one	Absent	1	VG
		Present	9	
35. (*) PQ (b) (c)	Petal shape	Elliptic	1	VG
		Obovate	2	
		Rounded	3	
36.	Petal incisions	Absent	1	VG
		Weak	3	

QN (b) (c)		Medium	5	
		Strong	7	
37. QN (b) (c)	Petal: Reflexing of margin	Absent	1	VG
		Weak	3	
		Medium	5	
		Strong	7	
38. QN (b) (c)	Petal: Undulation of margin	Absent	1	VG
		Weak	3	
		Medium	5	
		Strong	7	
39. (*) (C QN (b) (c)	Petal: Length	Very short	1	VG
		Short	3	
		Medium	5	
		Long	7	
		Very long	9	
40. (C) (*) QN (b) (c)	Petal: Width	Very narrow	1	VG
		Narrow	3	
		Medium	5	
		Broad	7	
		Very broad	9	
41. (*) QL (b) (c)	Petal: Number of colours on inner side (basal spot excluded)	One (Single)	1	VG
		Two (Double)	2	
		More than two (Multiple)	3	
42.	Varieties with one colour on inner side of petal:	Lighter towards the base	1	VG

(*) QN (b) (c)	Intensity of colour excluding the basal spot	Uniform	2	
		Lighter towards the top	3	
43. (*) PQ (b) (c)	Petal : Colour of the majority portion of the petal	RHS colour chart (indicate reference number)		VG
44. (*) PQ (b) (c)	Varieties with two or more colours on inner side of petal: Secondary colour of petal (basal spot excluded)	RHS colour chart (indicate reference number)		VG
45. PQ (b) (c)	Varieties with two or more colours on inner side of petal: Tertiary colour of petal (basal spot excluded)	RHS colour chart (indicate reference number)		VG
46. (*) (+) PQ (b) (c)	Varieties with two or more colours on inner side of petal: Petal distribution of secondary colour on inner side (basal spot excluded)	At base	1	VG
		At apex	2	
		At marginal zone	3	
		As a flush	4	
		As a segment or stripes	5	
		As speckles	6	
47. (+) PQ (b)	Varieties with two or more colours on inner side of petal: Petal distribution of tertiary colour on inner side (basal spot excluded)	At base	1	VG
		At apex	2	
		At marginal zone	3	
		As a flush	4	
		As a segment or stripes	5	

(c)		As speckles	6	
48. (*) QL (b) (c)	Petal: Spot at base of inner side	Absent	1	VG
		Present	9	
49. (*) (+) QN (b) (c)	Petal: Size of spot at base of inner side	Small	3	VG
		Medium	5	
		Large	7	
50. (*) PQ (b) (c)	Petal: Colour of spot at base of inner side	RHS colour chart (indicate reference number)		VG
51. (*)	Petal: Colour of spot at base of outer side	RHS colour chart (indicate reference number)		VG
52. (*) PQ (b) (c)	Petal : Main colour on the outer side (only if clearly different from inner side)	RHS colour chart (indicate reference number)		VG
53.	Petal spot at base of the outer side	Absent	1	VG
		Present	9	
54. (*)	Petal: Size of spot at base of outer side	Small	3	VG
		Medium	5	
		Large	7	
55. PQ (b)	Outer stamen: Predominant colour of the filament	White	1	VG
		Green	2	
		Light yellow	3	

		Medium yellow	4	
		Orange	5	
		Pink	6	
		Red	7	
		Brown red	8	
		Purple	9	
56. (G) QN	Seed vessel: Size (at petal fall)	Very small	1	VG
		Small	3	
		Medium	5	
		Large	7	
		Very large	9	
57. (G) (+) PQ	Hip: Shape of longitudinal section	Funnel shaped	1	VG
		Pitcher shaped	2	
		Pear shaped	3	
58. (G) (+) PQ	Hip: Colour (at mature stage, for varieties grown for hip only)	Yellow		VG
		Orange		
		Rogue		
		Brown		
		Black		
59. (C) (G) (*)	Flower: Length of pedicle	Short	3	MS
		Medium	5	
		Long	7	
60. (*) (C) (G)	Flower: Venation of petals	Absent	1	VG
		Weak	3	
		Medium	5	
		Strong	7	

Chapter-4

RESULTS AND DISCUSSION

The experimental results of the studies on **"DUS Characterization and Genetic studies in Rose (*Rosa hybrida*)"** under open cultivation during 2017-18 in the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh have been presented and discussed in this chapter under the following headings:

4.1 Variability studies

4.1.1 Mean performance of genotypes

4.1.2 Parameters of variability

4.3 Genetic Divergence (D^2 Analysis)

4.4 DUS Characterization and Grouping of varieties

4.1 VARIABILITY STUDIES

4.1.1 Mean performance of genotypes

The analysis of variance for all the characters under study indicated significant difference among the genotypes (Appendix-II & III). The mean performance of 45 miniature rose genotypes for various growth and flowering characters has been described separately.

4.1 VARIABILITY STUDIES

4.1.1 Mean performance of genotypes

The analysis of variance for all the characters under study indicated significant difference among the genotypes (Appendix – II & III). The mean performance of 45 miniature rose genotypes for various growth and flowering characters is described. The growth parameters decide the final yield of crops, which include plant height, number of leaves, leaf length, leaf area, leaf area index and number of shoot etc. The performance of garden roses have been studied extensively by many workers like Singh (2016), Dadhwal (2016), Gaurav *et al.* (2018).

4.1.1.1 Plant height (cm)

The variation in plant height of different genotypes during different years varied significantly. During first year (2017), the range for plant height was observed from 22.06 to 81.22 cm (Table 4.1.1). It was recorded maximum (81.22 cm) in genotype 'China 65'. However, minimum plant height i.e. 22.06 cm was observed in genotype 'Priti' which was found statistically at par with genotypes 'Cup Cake' (25.44 cm), 'Mirabel' (29 cm) and 'Golden Century' (29.56 cm), 'Don Don' (29.89 cm), 'Gourmet Popcorn' (30.67 cm), 'Mr. blue Bird' (31.11 cm),'Bharani' (31.22 cm) and 'Amber Star' (31.72 cm).

During second year (2018) also significant differences for plant height were obtained among different genotypes of miniature rose. Maximum plant height (123.89 cm) was recorded in genotype 'Royal Midnette' whereas, minimum plant height (32.33 cm) was recorded in genotype 'Mirabel' which was found statistically at par with genotypes 'Priti' (32.67 cm), 'Rise n Shine' (35.56 cm), 'Simply Marvelous' (37.11 cm), 'Blue Blood' (37.44 cm), 'Ruby Star' (39.78 cm), 'Babe' (40.11 cm), 'Bharani' (42 cm), 'The Fairy' (42 cm), 'Golden Century' (42.33 cm), 'Cup Cake' (42.78 cm), 'Sunday Brunch' (43.22 cm), 'String of Pearls' (43.22 cm), 'Giggles' (43.78 cm), 'Scarlet Gem' (43.78 cm), 'Amber Star' (43.89 cm), 'Red Figurine' (44.11 cm), 'Don Don' (44.33 cm), 'Fire flash' (44.78 cm), 'Mr. Blue Bird' (45.67 cm) and 'Roxy' (46.44 cm).

On pooling the data of two years, it was revealed that the genotype 'Royal Midnette' recorded the maximum plant height (96.67 cm), whereas, minimum plant height (27.36 cm) was recorded in genotype 'Priti' which was statistically at par with genotypes 'Mirabel' (30.67 cm), 'Bharani' (31.61 cm), 'Cup Cake' (34.11 cm), 'Golden Century' (35.94 cm), 'Rise n Shine' (36.78 cm), 'Don Don' (37.11 cm) and 'The Fairy' (37.61 cm).

The differences with respect plant height among the cultivars might be due to the genetic makeup of variety in conformity with the findings of Murugesan et al (1991), Sing *et al* (2004) and Singh *et al (*2016).

The data pertaining to plant height was found maximum in the year 2018 (56.32 cm).

In interaction among different years, maximum plant height (123.89 cm) was recorded during second year i.e. 2018, in 'Royal Midnette', whereas, minimum plant height (22.06 cm) was observed during 2017 in 'Priti', which was found statistically at par with genotypes 'Cup Cake' (25.44 cm), 'Mirabel' (29 cm) and 'Golden Century' (29.56 cm), 'Don Don' (29.89 cm),

Table 4.1.1: Plant height (cm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	31.22	42.00	36.61
2	**China 65**	81.22	94.33	87.78
3	**Golden Century**	29.56	42.33	35.94
4	**Frothy**	59.89	63.11	61.50
5	**Zwergkonig**	49.11	60.00	54.56
6	**Royal Midnette**	69.44	123.89	96.67
7	**Simply Marvelous**	38.11	37.11	37.61
8	**Chandrika**	47.89	55.56	51.72
9	**Flash Dance**	48.22	55.67	51.94
10	**Kayla**	48.00	50.33	49.17
11	**Sunday Brunch**	39.22	43.22	41.22
12	**Vanessa**	38.78	79.89	59.33
13	**Maigold Sweet Dream**	53.33	51.44	52.39
14	**Blue Blood**	46.00	37.44	41.72
15	**Scarlet Gem**	38.22	43.78	41.00
16	**String of pearls**	42.44	46.22	44.33
17	**Fairy Gold**	51.11	57.78	54.44
18	**Lavender Midnette**	48.56	93.78	71.17
19	**Young Mistress**	55.56	74.22	64.89
20	**Gourmet Popcorn**	30.67	63.78	47.22
21	**Giggles**	47.67	43.78	45.72
22	**Ruby Star**	42.11	39.78	40.94
23	**Wild Fire**	61.22	98.22	79.72
24	**The Fairy**	33.22	42.00	37.61
25	**Red Figurine**	39.22	44.11	41.67
26	**Aishwarya**	36.33	51.00	43.67
27	**Don Don**	29.89	44.33	37.11
28	**Lemon Sweet Dream**	46.22	84.44	65.33
29	**Rise n Shine**	38.00	35.56	36.78
30	**Swinger**	39.00	60.89	49.94
31	**Babe**	35.22	40.11	37.67
32	**Mirabel**	29.00	32.33	30.67
33	**Flamboyant**	39.78	56.44	48.11
34	**Roxy**	36.28	46.44	41.36
35	**Graine De Beaute**	37.11	50.56	43.83
36	**Cup Cake**	25.44	42.78	34.11
37	**Mr. Blue Bird**	31.11	45.67	38.39
38	**Amber Star**	31.72	43.89	37.81
39	**Fire Flash**	35.44	44.78	40.11
40	**Hoot & Howler**	59.94	93.22	76.58
41	**Leila Laird**	39.89	64.89	52.39
42	**Painter's Palette**	35.67	69.78	52.72
43	**Nine**	43.06	58.56	50.81
44	**Dazzler**	34.17	52.22	43.19
45	**Priti**	22.06	32.67	27.36
	Mean	42.12	56.32	**Year:** 2.15
	CD $_{0.5}$	10.46	17.64	**Genotype:** 10.18
				G X Y: 14.40

‘Gourmet Popcorn’ (30.67 cm), ‘Mr. Blue Bird’ (31.11 cm),‘Bharani’ (31.22 cm) and ‘Amber Star’ (31.72 cm), ‘The Fairy’ (33.22 cm), ‘Aishwarya’ (36.33 cm), ‘Babe’ (35.22 cm), ‘Roxy’ (36.28 cm), ‘Fire Flash’ (35.44 cm), ‘Painter’s Palette’ (35.67 cm). ‘Dazzler’ (34.17 cm) in 2017 and ‘Rise n Shine’ (35.56 cm), ‘Mirabel’ (32.33 cm) and ‘Priti’ (32.67 cm) in 2018.

As rose is a perennial plant and the energy taken in formation of roots in first year might have been diverted to other plant growth aspects. The result is in conformity with the earlier findings of Murusegan *et al*. (1991) and Malhotra (1997) in roses and Dadlani (2016) in miniatures.

4.1.1.2 Primary branches (no.)

In year 2017, primary branches varied from 2.78 to 14 among different genotypes of miniature rose as shown in Table 4.1.2. Maximum primary branches (14) was recorded in genotype ‘String of Pearls’. However, minimum primary branches (2.78) was recorded in genotype ‘Flash Dance’ which was found statistically at par with genotypes ‘Chandrika’ (3.56), ‘Ruby Star’ (3.78), ‘Blue Blood’ (4), ‘Roxy’ (4), ‘Nine’ (4.22), ‘The Fairy’ (4.44), ‘Painter’s Palette’ (4.56), ‘Lavender Midnette’ (4.67), ‘Babe’ (4.67), ‘Simply Marvelous’ (4.78), ‘Fire Flash’ (5), ‘Bharani’(5.11), ‘Lemon Sweet Dream’ (5.11), ‘Aishwarya’ (5.22), ‘Red Figurine’ (5.44) and ‘Dazzler’ (5.44).

During 2018, the range for primary branches varied from 4.44 to 17. The data presented in the table clearly shows that maximum primary branches (17) was recorded in genotype ‘String of Pearls’ which was statistically at par with ‘Royal Midnette’ (14.67) and Mr. Blue Bird’ (13.89) , whereas, minimum primary branches (4.44) was observed in genotype ‘Flash Dance’ which was statistically at par with genotype ‘’Chandrika’ (4.56), ‘Blue Blood’ (5.22), ‘Ruby Star’ (5.22), ‘Simply Marvelous’ (5.56), ‘The Fairy’ (5.67), ‘Roxy’ (5.78), ‘Nine’ (6), ‘Painter’s Palette’ (6.44), ‘Maigold Sweet Dream’ (6.56), ‘Lemon Sweet Dream’ (6.56), ‘Bharani’ (6.67), ‘Lavender Midnette’ (6.78), ‘Vanessa’ (6.89), ‘Red Figurine’ (6.89), ‘Rise n Shine’ (7.22), ‘Babe’ (7.22), ‘Graine De Beaute’ (7.22), ‘Sunday Brunch’ (7.44), ‘Fire Flash’ (7.44), ‘Fairy Gold’ (7.56), ‘Young Mistress’ (7.67), ‘Amber Star’ (7.67), ‘Lella Laird’ (7.78), ‘Dazzler’ (7.78), ‘Aishwarya’(7.89) and ‘Zwergkonig’ (8).

Pooled analysis for two years revealed maximum number of primary branches (15.50) in genotype ‘String Of Pearls’ and it was found to be statistically at par with genotypes ‘Royal Midnette’ (12.50) and ‘Mr. Blue Bird’ (12.39). In contrast, minimum number of

primary branches (3.61) observed in genotype 'Flash Dance' was found to be statistically *at par* with genotypes 'Chandrika' (4.06), 'Ruby Star' (4.50), 'Blue Blood'(4.61), 'Roxy' (4.89), 'The Fairy' (5.06) , 'Nine' (5.11), 'Simply Marvelous' (5.17), 'Painter's Palette' (5.50), 'Lavender Midnette' (5.72), 'Lemon Sweet Dream' (5.83), 'Bharani' (5.89), 'Babe'(5.94), 'Maigold Sweet Dream' (6.11), 'Red Figurine' (6.17), 'Fire Flash' (6.22), 'Vanessa' (6.33), 'Rise n Shine' (6.50), 'Aishwarya' (6.56), 'Dazzler' (6.61), 'Young Mistress' (6.78), 'Graine de Beaute' (6.83), 'Amber Star' (6.83) and 'Priti' (7.17).

Significant differences in the number of primary branches were also obtained between years. Maximum number of primary branches (17) was recorded in 2018, whereas, minimum primary branches in 2017.

The result is in conformity with the earlier findings of Murusegan *et al* (1991) and Malhotra (1997) in roses Singh (2016) in floribunda and Dadlani (2016) in miniatures. The number of primary branches increased for most of the varieties with age.

4.1.1.3 Secondary branches (number)

In year 2017, there was no significant difference in number of secondary branches among tested miniature rose genotypes.

Significant differences were observed among different miniature rose genotypes in consideration to number of secondary branches in 2018. The range of 4.56 to 185.56 was recorded for number of secondary branches (Table 4.1.3). The genotype 'Gourmet Popcorn' had maximum number of secondary branches (185.56) whereas, genotype 'Babe' (4.56) had the minimum number of secondary branches and found to be statistically at par with genotypes 'Simply Marvelous' (6), 'Flash Dance' (7.44), 'Ruby Star' (8.50) and 'Bharani' (10.22).

Pooled analysis for the two years revealed that maximum number of secondary branches was observed in genotype 'Gourmet Popcorn' (95). However, genotype 'Simply Marvelous' (6.50) had the minimum number of secondary branches and found to be at par with genotypes 'Babe' (6.78), 'Flash Dance' (8.06), 'Bharani' (8.67), and 'Ruby Star' (8.92).

The differences in number of shoots per plant of the varieties have also been reported earlier by Zeinalov (1978), Malik (1980) and Singh (2016). The result is also in conformity with the earlier findings of Murusegan et al (1991) and Malhotra (1997) in Garden roses, Singh (2016) in floribunda and Dadlani (2016) in miniatures. The number of Secondary branches increased for most of the varieties with age as the plant spread increased that might have resulted into more area for production of photosynthates thus contributing to growth.

Table 4.1.2: Primary branches of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
	Bharani	5.11	6.67	5.89
2	**China 65**	8.33	8.67	8.50
3	**Golden Century**	7.56	8.89	8.22
4	**Frothy**	8.78	9.22	9.00
5	**Zwergkonig**	6.56	8.00	7.28
6	**Royal Midnette**	10.33	14.67	12.50
7	**Simply Marvelous**	4.78	5.56	5.17
8	**Chandrika**	3.56	4.561	4.06
9	**Flash Dance**	2.78	4.44	3.61
10	**Kayla**	10.56	12.56	11.56
11	**Sunday Brunch**	6.78	7.44	7.11
12	**Vanessa**	5.78	6.89	6.33
13	**Maigold Sweet Dream**	5.67	6.56	6.11
14	**Blue Blood**	4.00	5.22	4.61
15	**Scarlet Gem**	10.33	11.33	10.83
16	**String of pearls**	14.00	17.00	15.50
17	**Fairy Gold**	6.44	7.56	7.00
18	**Lavender Midnette**	4.67	6.78	5.72
19	**Young Mistress**	5.89	7.67	6.78
20	**Gourmet Popcorn**	7.11	9.44	8.28
21	**Giggles**	7.78	10.44	9.11
22	**Ruby Star**	3.78	5.22	4.50
23	**Wild Fire**	7.56	8.56	8.06
24	**The Fairy**	4.44	5.67	5.06
25	**Red Figurine**	5.44	6.89	6.17
26	**Aishwarya**	5.22	7.89	6.56
27	**Don Don**	7.11	10.67	8.89
28	**Lemon Sweet Dream**	5.11	6.56	5.83
29	**Rise n Shine**	5.78	7.22	6.50
30	**Swinger**	6.78	8.56	7.67
31	**Babe**	4.67	7.22	5.94
32	**Mirabel**	7.22	9.56	8.39
33	**Flamboyant**	7.44	10.33	8.89
34	**Roxy**	4.00	5.78	4.89
35	**Graine De Beaute**	6.44	7.22	6.83
36	**Cup Cake**	6.78	8.89	7.83
37	**Mr. Blue Bird**	10.89	13.89	12.39
38	**Amber Star**	6.00	7.67	6.83
39	**Fire Flash**	5.00	7.44	6.22
40	**Hoot & Howler**	8.89	12.78	10.83
41	**Leila Laird**	6.22	7.78	7.00
42	**Painter's Palette**	4.56	6.44	5.50
43	**Nine**	4.22	6.00	5.11
44	**Dazzler**	5.44	7.78	6.61
45	**Priti**	5.67	8.67	7.17
	Mean	6.48	8.32	**Year:** 0.48
	CD $_{0.5}$	2.85	3.61	**Genotype**: 2.29 **G X Y:** NS

Interaction data of genotypes were found significant and the data revealed same pattern as in 2018.

4.1.1.4 Main stem girth (mm)

In the present studies, miniature rose genotypes varied significantly with respect to main stem girth (mm).

Perusal of data presented in Table 4.1.4 reveals that the range for main stem girth during 2017, was varied from 1.85 to 10.57 mm. Genotype 'Young Mistress' (10.57 mm) reported maximum main stem girth among all the genotypes of miniature rose which was statistically at par with 'Wild Fire' (10.18 mm), whereas, minimum main stem girth (1.85 mm) as recorded in genotype 'String of Pearls' which was found statistically at par with genotypes 'Flamboyant' (1.89 mm), 'Mr. Blue Bird' (2.23 mm), 'The Fairy' (2.49 mm), 'Roxy' (2.58 mm), 'Red Figurine' (2.61 mm), 'Mirabel' (2.61 mm), 'Fire Flash' (2.93 mm), 'Graine de Beaute' (2.97 mm), 'Aishwarya' (3.25 mm), 'Priti' (3.29 mm), 'Simply Marvelous' (3.26 mm) 'Golden Century' (3.30 mm), 'China 65' (3.83 mm) and 'Don Don' (3.89 mm) .

During 2018, main stem girth in different genotypes varied from 6.77 to 22.88 mm. Maximum main stem girth was observed in genotype 'Zwergkonig' (22.88 mm), whereas minimum main stem girth was observed in genotype 'Priti' (6.77 mm), which was statistically found at par with 'Flamboyant' (8.11 mm), 'Mr. Blue Bird' (6.42 mm), 'The Fairy' (9.17 mm), 'Roxy' (8.15 mm), 'Red Figurine' (8.66 mm), 'Mirabel' (9.73 mm), 'Fire Flash' (9.51 mm), 'Graine de Beaute' (8.38 mm), 'Aishwarya' (8.05 mm), 'Dazzler' (8.89 mm)'Simply Marvelous' (9.61 mm), 'China 65' (6.17 mm) and 'Bharani' (8.30 mm), 'Kayla' (8.47 mm), 'Sunday Brunch' (8.64 mm), 'Blue Blood' (9.75 mm), 'Scarlet Gem' (8.90 mm), 'Giggles' (9.90 mm), (Ruby Star' (8.51 mm).

On pooling the data of two year, it was found that maximum main stem girth was recorded in genotype 'Zwergkonig' (15.14 mm) which was found to be statistically at par with genotypes 'Leila Laird' (13.19 mm), ''Young Mistress' (13.09 mm), 'Wild Fire' (13.08 mm), and 'Chandrika' (12.57 mm). However, genotype 'Mr. Blue Bird' recorded minimum main

stem girth (4.33 mm) and found to be statistically at par with genotypes 'China 65' (5 mm), 'Flamboyant'(5 mm), 'Priti' (5.03 mm), 'Roxy' (5.37 mm), 'Red Figurine' (5.64 mm), 'Aishwarya' (5.65 mm), 'Graine De Beaute' (5.67 mm) , 'The Fairy' (5.83 mm), 'Mirabel' (6.17 mm), ''Bharani' (6.18 mm), 'Fire Flash' (6.22 mm).

Table 4.1.3: Secondary branches of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	7.11	10.22	8.67
2	**China 65**	3.67	24.89	14.28
3	**Golden Century**	5.33	28.00	16.67
4	**Frothy**	6.89	45.78	26.33
5	**Zwergkonig**	6.00	24.11	15.06
6	**Royal Midnette**	6.11	117.11	61.61
7	**Simply Marvelous**	7.00	6.00	6.50
8	**Chandrika**	4.56	143.78	74.17
9	**Flash Dance**	8.67	7.44	8.06
10	**Kayla**	8.00	59.56	33.78
11	**Sunday Brunch**	6.56	33.00	19.78
12	**Vanessa**	6.00	33.89	19.94
13	**Maigold Sweet Dream**	7.56	24.11	15.83
14	**Blue Blood**	4.56	25.33	14.94
15	**Scarlet Gem**	7.33	57.00	32.17
16	**String of pearls**	4.89	154.67	79.78
17	**Fairy Gold**	6.67	41.22	23.94
18	**Lavender Midnette**	6.33	36.33	21.33
19	**Young Mistress**	6.67	54.78	30.72
20	**Gourmet Popcorn**	4.44	185.56	95.00
21	**Giggles**	7.67	78.22	42.94
22	**Ruby Star**	9.33	8.50	8.92
23	**Wild Fire**	5.67	59.78	32.72
24	**The Fairy**	3.67	24.89	14.28
25	**Red Figurine**	4.56	56.33	30.44
26	**Aishwarya**	8.22	15.33	11.78
27	**Don Don**	5.67	38.22	21.94
28	**Lemon Sweet Dream**	5.78	32.67	19.22
29	**Rise n Shine**	6.67	54.44	30.56
30	**Swinger**	3.56	37.89	20.72
31	**Babe**	9.00	4.56	6.78
32	**Mirabel**	8.89	52.00	30.44
33	**Flamboyant**	7.11	55.44	31.28
34	**Roxy**	5.78	41.22	23.50
35	**Graine De Beaute**	5.33	64.22	34.78
36	**Cup Cake**	5.33	42.89	24.11
37	**Mr. Blue Bird**	5.67	48.22	26.94
38	**Amber Star**	6.56	68.56	37.56
39	**Fire Flash**	5.22	18.11	11.67
40	**Hoot & Howler**	6.33	77.67	42.00
41	**Leila Laird**	6.67	80.33	43.50
42	**Painter's Palette**	5.00	22.56	13.78
43	**Nine**	4.78	20.44	12.61
44	**Dazzler**	5.78	104.78	55.28
45	**Priti**	4.22	34.78	19.50
	Mean	6.15	50.11	**Year:** 1.05
	CD $_{0.5}$	NS	9.28	**Genotype:** 4.96 **G X Y:** 7.02

In general, within two years, maximum main stem girth (22.88 mm) was recorded during second year i.e. 2018, whereas, minimum main stem girth (1.85 mm) was observed during 2017.

Interaction between genotypes and year revealed maximum main stem girth (22.88 cm) ‘Zwergkonig’ during 2018, whereas, minimum main stem girth (1.85 cm) was recorded in genotype ‘String of Pearls’ during 2017 which was statistically at par with genotypes Flamboyant’ (1.89 mm), ‘Mr. Blue Bird’ (2.23 mm), ‘The Fairy’ (2.49 mm), ‘Roxy’ (2.58 mm), ‘Red Figurine’ (2.61 mm), ‘Mirabel’ (2.61 mm), ‘Fire Flash’ (2.93 mm), ‘Graine de Beaute’ (2.97 mm), ‘Aishwarya’ (3.25 mm), ‘Priti’ (3.29 mm), ‘Simply Marvelous’ (3.26 mm) ‘Golden Century’ (3.30 mm), ‘China 65’ (3.83 mm) and ‘Don Don’ (3.89 mm), ‘Bharani’ (4.05 mm), ‘Blue Blood’ (4.15 mm) and ‘Nine’ (4.46 mm) in 2017.

4.1.1.5 Plant spread (cm)

Being a genetically controlled character, during 2017, plant spread was recorded ranged from 20.75 to 80.83 cm (Table 4.1.5). It was observed maximum in genotype ‘Wild Fire’ (80.83 cm). However, minimum plant spread was observed in genotype ‘Priti’ (20.75 cm) which was found to be statistically at par with genotypes ‘Mirabel’ (23.17 cm), ‘Lemon Sweet Dream’ (24.33 cm), ‘Rise n Shine’ (25.50 cm), ‘Scarlet Gem’(25.58 cm), ‘Babe’ (27 cm), ‘Don Don’ (27.50 cm), ‘’Kayla’ (28.92 cm) , ‘Nine’ (29.33 cm), ‘Chandrika’ (29.58 cm), ‘Flash Dance’ (30.33 cm) and ‘Mr. Blue Bird’ (30.58 cm).

In 2018, range for plant spread was observed between 108.42 cm to 19.92 cm as shown in Table 4.15. Maximum plant spread (108.42 cm) was found in genotype ‘Royal Midnette’ which was found to be statistically at par with genotype ‘Wild Fire’ (99.58 cm), whereas, minimum plant spread (19.92 cm) was observed in genotype ‘Priti’ which was found to be statistically at par with genotype ‘Scarlet Gem’ (28.58 cm).

On pooling the data of two years, maximum plant spread (90.21 cm) obtained in genotype ‘Wild Fire’ was found to be statistically at par with genotype ‘Royal Midnette’ (83.38 cm), whereas, minimum plant spread (20.33 cm) was obtained in genotype ‘Priti’ was found to be statistically at par with genotype ‘Scarlet Gem’ (27.08 cm). The varieties with less plant spread exihibited upright growth and thus, suitable for high density plantation. The differences in plant

spread among the varieties might be due to their differences in genetic make up in conformity with the earliar findings of Haenchen (1980) and Malhotra (1997).

Table 4.1.4: Main Stem Girth (mm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	4.06	8.30	6.18
2	**China 65**	3.83	6.17	5.00
3	**Golden Century**	3.30	15.65	9.48
4	**Frothy**	4.75	12.87	8.81
5	**Zwergkonig**	7.39	22.88	15.14
6	**Royal Midnette**	7.42	13.23	10.32
7	**Simply Marvelous**	3.26	9.61	6.43
8	**Chandrika**	7.69	17.46	12.57
9	**Flash Dance**	7.27	11.59	9.43
10	**Kayla**	8.32	8.47	8.40
11	**Sunday Brunch**	5.39	8.64	7.01
12	**Vanessa**	4.95	10.59	7.77
13	**Maigold Sweet Dream**	5.77	16.42	11.09
14	**Blue Blood**	4.15	9.75	6.95
15	**Scarlet Gem**	4.93	8.90	6.92
16	**String of pearls**	1.85	10.66	6.26
17	**Fairy Gold**	4.91	12.27	8.59
18	**Lavender Midnette**	5.10	12.60	8.85
19	**Young Mistress**	10.57	15.62	13.09
20	**Gourmet Popcorn**	5.74	13.46	9.60
21	**Giggles**	5.56	9.90	7.73
22	**Ruby Star**	6.12	8.51	7.32
23	**Wild Fire**	10.18	15.98	13.08
24	**The Fairy**	2.49	9.17	5.83
25	**Red Figurine**	2.61	8.66	5.64
26	**Aishwarya**	3.25	8.05	5.65
27	**Don Don**	3.89	10.91	7.40
28	**Lemon Sweet Dream**	5.10	11.34	8.22
29	**Rise n Shine**	5.00	11.84	8.42
30	**Swinger**	7.69	10.11	8.90
31	**Babe**	5.17	11.98	8.57
32	**Mirabel**	2.61	9.73	6.17
33	**Flamboyant**	1.89	8.11	5.00
34	**Roxy**	2.58	8.15	5.37
35	**Graine De Beaute**	2.97	8.38	5.67
36	**Cup Cake**	5.23	11.28	8.26
37	**Mr. Blue Bird**	2.23	6.42	4.33
38	**Amber Star**	8.12	11.59	9.85
39	**Fire Flash**	2.93	9.51	6.22
40	**Hoot & Howler**	7.72	15.42	11.57
41	**Leila Laird**	8.31	18.07	13.19
42	**Painter's Palette**	6.72	12.87	9.80
43	**Nine**	4.46	12.12	8.29
44	**Dazzler**	4.83	8.89	6.86
45	**Priti**	3.29	6.77	5.03
	Mean	5.15	11.31	**Year:** 0.40
	CD $_{0.5}$	2.06	3.24	**Genotype:** 1.91 **G X Y:** 2.70

In general, between the years, maximum plant spread (55.36 cm) was recorded during 2018.

The data of interactions between genotypes and years showed, maximum plant spread (108.42 cm) in genotype ‘Royal Midnette’ during 2018 which was found statistically at par with genotype ‘Wild Fire’ (99.58 cm) in 2018, whereas, genotype ‘Priti’ recorded minimum plant spread (19.92 cm) during 2018 which was found statistically at par with genotypes ‘Priti’ (20.75 cm), ‘Mirabel’ (23.17 cm), ‘Lemon Sweet Dream’ (24.33 cm), ‘Rise n Shine’ (25.50 cm),‘Scarlet Gem’(25.58 cm), ‘Babe’ (27 cm), ‘Don Don’ (27.50 cm), ‘’Kayla’ (28.92 cm) , ‘Nine’ (29.33 cm), ‘Chandrika’ (29.58 cm) in 2017 and ‘Scarlet Gem’ (28.58 cm) in 2018.

Maximum plant spread was found in 2nd year as the rose plant shows more vigorous growth and yield character with age in garden roses (Singh, 2016) and Dadlani (2016) as rose being a perennial plant.

4.1.1.6 Internodal length (cm)

During 2017, there was a significant difference among all the genotypes for internodal length and the range varied from 7.63 to 1.84 cm. It is evident from the Table 4.1.6 that the significantly maximum internodal length was recorded in genotype ‘Fire Flash’ (7.63 cm). In contrast, it was registered minimum in genotype ‘Maigold Sweet Dream’ (1.84) and was closely followed by genotypes ‘Young Mistress’ (1.96 cm) , ‘Royal Midnette’ (2.28 cm), ‘Lavender Midnette’ (2.30 cm), ‘Wild Fire’ (2.34 cm), ‘Giggles’(2.35 cm), ‘Nine’ (2.39 cm), ‘Zwegkonig’ (2.43 cm), ‘Amber Star’ (2.45 cm) and ‘Simply Marvelous’ (2.60 cm)

Data recorded for 2018 shows the significant differences among different genotypes for the internodal length and this ranged between 7.72 to 1.15 cm. Maximum internodal length observed in genotype ‘Fire Flash’, whereas, minimum internodal length (1.15 cm) was recorded in genotype ‘Sunday Brunch’ which was statistically at par with genotype ‘Fairy Gold’ (1.18 cm).

Pooled analysis for internodal length showed that it was observed highest (7.68) in genotype ‘Fire Flash’ In contrast, minimum internodal length was recorded in genotype ‘Fairy Gold’ (1.88 cm) which was found to be statistically at par with genotypes ‘Sunday Brunch’ (1.97 cm), ‘Zwergkonig’ (2.30 cm), ‘Wild Fire’ (2.32 cm), ‘Royal Midnette’ (2.38 cm), ‘Giggles’ (2.40 cm) and ‘Amber Star’ (2.48 cm).

The data pertaining to years was found non-significant.

Table 4.1.5: Plant spread (cm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	32.33	39.00	35.67
2	**China 65**	34.83	72.08	53.46
3	**Golden Century**	40.75	72.50	56.63
4	**Frothy**	36.33	60.42	48.38
5	**Zwergkonig**	38.17	58.83	48.50
6	**Royal Midnette**	58.33	108.42	83.38
7	**Simply Marvelous**	31.33	49.25	40.29
8	**Chandrika**	29.58	55.00	42.29
9	**Flash Dance**	30.33	59.92	45.13
10	**Kayla**	28.92	44.75	36.83
11	**Sunday Brunch**	36.50	45.58	41.04
12	**Vanessa**	32.92	32.50	32.71
13	**Maigold Sweet Dream**	50.25	78.17	64.21
14	**Blue Blood**	31.00	42.50	36.75
15	**Scarlet Gem**	25.58	28.58	27.08
16	**String of pearls**	40.50	60.75	50.63
17	**Fairy Gold**	35.50	47.50	41.50
18	**Lavender Midnette**	39.33	74.33	56.83
19	**Young Mistress**	34.83	46.17	40.50
20	**Gourmet Popcorn**	34.08	57.42	45.75
21	**Giggles**	37.25	60.67	48.96
22	**Ruby Star**	33.17	37.17	35.17
23	**Wild Fire**	80.83	99.58	90.21
24	**The Fairy**	43.17	66.50	54.83
25	**Red Figurine**	30.92	40.58	35.75
26	**Aishwarya**	30.75	41.17	35.96
27	**Don Don**	27.50	33.92	30.71
28	**Lemon Sweet Dream**	24.33	64.25	44.29
29	**Rise n Shine**	25.50	38.33	31.92
30	**Swinger**	56.75	71.58	64.17
31	**Babe**	27.00	39.83	33.42
32	**Mirabel**	23.17	42.17	32.67
33	**Flamboyant**	37.92	39.33	38.63
34	**Roxy**	52.83	61.50	57.17
35	**Graine De Beaute**	42.58	64.08	53.33
36	**Cup Cake**	41.83	66.00	53.92
37	**Mr. Blue Bird**	30.58	67.17	48.88
38	**Amber Star**	63.58	61.67	62.63
39	**Fire Flash**	42.17	43.33	42.75
40	**Hoot & Howler**	52.67	80.92	66.79
41	**Leila Laird**	54.83	56.00	55.42
42	**Painter's Palette**	60.75	66.33	63.54
43	**Nine**	29.33	44.92	37.13
44	**Dazzler**	42.83	50.58	46.71
45	**Priti**	20.75	19.92	20.33
	Mean	38.54	55.36	**Year:** 1.46
	CD $_{0.5}$	9.96	9.72	**Genotype:** 6.91 **G X Y:** 9.77

Interaction studied among the genotypes and years showed, maximum internodal length (7.72 cm) in genotype ‘Fire Flash’ during 2018 which was found statistically at par with same genotype in 2017 (7.63 cm) whereas, genotype ‘Sunday Brunch’ recorded minimum internodal length (1.15 cm) during 2018 which was found statistically at par with genotypes ‘Fairy Gold’ (1.18 cm) in 2018.

The differences in internodal length might be due to varietal characteristics of the cultivars in conformity with the findings of Murugesan *et al*. (1991), Bhattacharjee *et al.* (1993) and Sundram *et al.* (1996). The variation in stem length might be due to the retarded growth of the plants, low temperature and low light intensity in winter as reported earlier by Gill and Atwal (1976), Gill *et al*. (1988) and Terfa *et al*. (2014).

4.1.1.7 Prickle Density (no./15cm stem length)

As regards prickle density, during 2017, the range was recorded from 49.89 to 0.00 days as shown in Table 4.1.7. Genotype ‘Painter’s Palette’ recorded the maximum prickle desnity (49.89), whereas, prickle density was recorded minimum (0.00) in genotype ‘Blue Blood’, ‘Babe’ and ‘Mirabel’.

In 2018 also, perusal of the data revealed significant differences among the genotypes for prickle density. Maximum prickle density (49.67) was recorded in genotype ‘Painter’s Palette’, whereas, minimum prickle density recorded minimum (0.00) in genotype ‘Blue Blood’, ‘Babe’ and ‘Mirabel’ which was found statistically at par with genotype ‘Lavender Midnette’ (2.89).

In pooled analysis, the perusal of the data revealed significant differences among the genotypes for prickle density. Maximum prickle density (49.78) was recorded in genotype ‘Painter’s Palette’, whereas, minimum prickle density recorded minimum (0.00) in genotype ‘Blue Blood’, ‘Babe’ and ‘Mirabel’. The thorn density per 10 cm of stem length varied from 0 to 49.78, thus showing wide variations among the cultivars. For landscape use, cultivars with fewer thorns are normally preferred. Keeping this in view cultivars, ‘Blue Blood’, ‘Babe’ and ‘Mirabel had been rated to be better than the other cultivars. The variation in number of thorns might be attributed to genetic make up of the cultivar (Singh, 2016) in conformity with findings of Murugesan *et al.* (1991) and Sundram *et al.* (1996).

Year and interaction were found to be non-significant.

Table 4.1.6: Internodal Length (cm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	4.22	4.94	4.58
2	**China 65**	4.01	4.68	4.35
3	**Golden Century**	5.23	5.75	5.49
4	**Frothy**	3.39	3.50	3.45
5	**Zwergkonig**	2.43	2.17	2.30
6	**Royal Midnette**	2.28	2.47	2.38
7	**Simply Marvelous**	2.60	3.72	3.16
8	**Chandrika**	3.50	2.97	3.23
9	**Flash Dance**	3.30	2.63	2.97
10	**Kayla**	2.86	2.18	2.52
11	**Sunday Brunch**	2.79	1.15	1.97
12	**Vanessa**	2.55	4.65	3.60
13	**Maigold Sweet Dream**	1.84	3.24	2.54
14	**Blue Blood**	4.25	3.31	3.78
15	**Scarlet Gem**	3.33	2.32	2.83
16	**String of pearls**	3.62	2.49	3.05
17	**Fairy Gold**	2.57	1.18	1.88
18	**Lavender Midnette**	2.30	2.84	2.57
19	**Young Mistress**	1.96	3.41	2.68
20	**Gourmet Popcorn**	3.13	2.76	2.95
21	**Giggles**	2.35	2.46	2.40
22	**Ruby Star**	3.56	3.52	3.54
23	**Wild Fire**	2.34	2.30	2.32
24	**The Fairy**	3.50	3.14	3.32
25	**Red Figurine**	2.77	2.61	2.69
26	**Aishwarya**	3.07	3.96	3.52
27	**Don Don**	3.37	3.82	3.60
28	**Lemon Sweet Dream**	3.04	3.24	3.14
29	**Rise n Shine**	4.63	3.57	4.10
30	**Swinger**	4.17	4.98	4.57
31	**Babe**	3.78	3.66	3.72
32	**Mirabel**	5.29	5.82	5.56
33	**Flamboyant**	2.87	2.18	2.53
34	**Roxy**	3.82	3.51	3.67
35	**Graine De Beaute**	3.83	3.41	3.62
36	**Cup Cake**	3.21	3.48	3.35
37	**Mr. Blue Bird**	3.78	3.13	3.46
38	**Amber Star**	2.45	2.52	2.48
39	**Fire Flash**	7.63	7.72	7.68
40	**Hoot & Howler**	3.33	3.58	3.46
41	**Leila Laird**	5.01	5.24	5.12
42	**Painter's Palette**	3.16	3.21	3.19
43	**Nine**	2.39	3.00	2.70
44	**Dazzler**	2.71	2.43	2.57
45	**Priti**	3.50	3.27	3.38
	Mean	3.37	3.38	**Year:** NS
	CD $_{0.5}$	0.61	0.62	**Genotype:** 0.43 **G X Y:** 0.61

Table 4.1.7: Prickle Density (no./15 cm stem length) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	6.78	7.55	7.17
2	**China 65**	7.55	7.56	7.56
3	**Golden Century**	11.67	11.89	11.78
4	**Frothy**	18.89	20.55	19.72
5	**Zwergkonig**	25.11	24.33	24.72
6	**Royal Midnette**	5.22	5.11	5.17
7	**Simply Marvelous**	17.00	15.11	16.06
8	**Chandrika**	6.67	7.22	6.95
9	**Flash Dance**	12.78	14.11	13.44
10	**Kayla**	6.00	6.44	6.22
11	**Sunday Brunch**	29.44	23.89	26.67
12	**Vanessa**	11.22	12.45	11.83
13	**Maigold Sweet Dream**	21.33	17.44	19.39
14	**Blue Blood**	0.00	0.00	0.00
15	**Scarlet Gem**	17.67	15.78	16.72
16	**String of pearls**	11.44	11.55	11.50
17	**Fairy Gold**	31.56	32.11	31.83
18	**Lavender Midnette**	3.56	2.89	3.22
19	**Young Mistress**	14.11	13.56	13.83
20	**Gourmet Popcorn**	6.55	5.55	6.05
21	**Giggles**	23.56	28.33	25.94
22	**Ruby Star**	14.00	12.67	13.33
23	**Wild Fire**	34.22	34.33	34.28
24	**The Fairy**	5.78	4.22	5.00
25	**Red Figurine**	11.89	11.78	11.83
26	**Aishwarya**	13.78	13.67	13.72
27	**Don Don**	9.00	10.22	9.61
28	**Lemon Sweet Dream**	16.89	14.67	15.78
29	**Rise n Shine**	6.11	5.89	6.00
30	**Swinger**	23.11	23.00	23.06
31	**Babe**	0.00	0.00	0.00
32	**Mirabel**	0.00	0.00	0.00
33	**Flamboyant**	5.67	5.00	5.33
34	**Roxy**	11.56	12.78	12.17
35	**Graine De Beaute**	5.22	6.11	5.67
36	**Cup Cake**	11.78	12.11	11.95
37	**Mr. Blue Bird**	7.11	6.00	6.56
38	**Amber Star**	16.00	15.55	15.78
39	**Fire Flash**	3.56	3.67	3.61
40	**Hoot & Howler**	30.44	30.56	30.50
41	**Leila Laird**	6.89	9.34	8.11
42	**Painter's Palette**	49.89	49.67	49.78
43	**Nine**	15.22	15.33	15.28
44	**Dazzler**	8.67	9.22	8.95
45	**Priti**	6.00	8.44	7.22
	Mean	13.35	13.28	**Year:** NS
	CD $_{0.5}$	2.62	3.61	**Genotype:** 2.21 **G X Y:** NS

4.1.1.8 Leaf area (sq. cm)

The observations recorded for leaf area revealed significant differences among the genotypes and the mean values of genotypes for this character, during 2017, ranged from 32.79 to 3.75 (sq. cm) (Table 4.1.8). Maximum leaf area (32.79 sq. cm) recorded in genotype 'Vanessa' which was statistically at par with 'Flash Dance' (32.43 sq. cm) and 'Swinger' (28.74 sq. cm). However, lowest leaf area was recorded in 'String of Pearls' (3.75 sq. cm) which was found statistically at par with genotypes 'Sunday Brunch' (5.66 sq. cm), 'Scarlet Gem' (5.84 sq. cm), 'Red Figurine' (5.91 sq. cm), 'Kayla' (6.03 sq. cm), 'Mirabel' (7.47 sq. cm), 'Priti' (7.52 sq. cm), 'Ruby Star' (7.81 sq. cm) and 'Simple Marvelous' (8.14 sq. cm).

During year 2018, the range for leaf area varied between 37.45 to 4.12 sq. cm. It was recorded maximum (37.45) in genotype 'Vanessa', whereas, minimum (4.12 sq. cm) was recorded in genotype 'Scarlet Gem' which was found statistically at par with genotypes 'Sunday Brunch' (6.14 sq. cm) and 'Red Figurine' (6.53 sq. cm)

On pooling the data for two years, maximum leaf area (35.12 sq. cm) recorded in genotype 'Vanessa' was found to be statistically at par with genotypes 'Flash Dance' (32.69 sq. cm), 'Babe' (28.29 sq. cm) and 'Swinger' (27.95 sq. cm). In contrast, lowest leaf area (4.98 sq. cm) was observed in genotype 'Scarlet Gem' was found to be statistically at par with genotypes 'String of Pearls' (5.73 sq. cm), 'Sunday Brunch' (5.90 sq. cm), 'Red Figurine' (6.22 sq. cm) and 'Kayla' (6.78 sq. cm). The bigger size of the leaf is a better character as it increases the photosynthetic area and thus, positively affected the plant growth and productivity. The differences in leaf size of the varieties might be due to genetic make-up of the variety as reported earlier also by Singh (2009) and Singh (2016). But for miniature roses the leaf area is supposed to be small for attractiveness of the plant as a whole.

Year and interaction were found to be non-significant.

4.1.1.9 Days taken for first flowering

During 2017, there was a significant difference among the genotypes for days taken for first flowering and the range varied from 82.89 to 27.67 days. It is evident from the Table 4.1.9 that the significantly maximum number of days taken for first flowering was recorded in genotype 'Graine De Beaute' (82.89) which was found statistically at par with 'Lemon Sweet Dream' (82.33), 'Chandrika' (81.33), 'String of Pearls' (80.78), 'China 65' (79.11), 'Ruby

Table 4.1.8: Leaf Area (cm^2) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	11.82	11.17	11.50
2	**China 65**	10.36	11.31	10.84
3	**Golden Century**	11.22	10.71	10.96
4	**Frothy**	12.28	10.51	11.40
5	**Zwergkonig**	13.07	11.04	12.06
6	**Royal Midnette**	20.14	19.66	19.90
7	**Simply Marvelous**	8.14	7.89	8.01
8	**Chandrika**	14.80	14.49	14.65
9	**Flash Dance**	32.43	32.94	32.69
10	**Kayla**	6.03	7.53	6.78
11	**Sunday Brunch**	5.66	6.14	5.90
12	**Vanessa**	32.79	37.45	35.12
13	**Maigold Sweet Dream**	16.14	18.02	17.08
14	**Blue Blood**	11.37	11.67	11.52
15	**Scarlet Gem**	5.84	4.12	4.98
16	**String of pearls**	3.75	7.72	5.73
17	**Fairy Gold**	9.01	8.05	8.53
18	**Lavender Midnette**	19.84	18.63	19.23
19	**Young Mistress**	14.79	14.80	14.79
20	**Gourmet Popcorn**	8.63	11.71	10.17
21	**Giggles**	13.25	13.75	13.50
22	**Ruby Star**	7.81	9.74	8.ś77
23	**Wild Fire**	18.98	20.95	19.96
24	**The Fairy**	9.44	11.52	10.48
25	**Red Figurine**	5.91	6.53	6.22
26	**Aishwarya**	9.82	10.80	10.31
27	**Don Don**	11.22	11.45	11.34
28	**Lemon Sweet Dream**	11.64	9.25	10.44
29	**Rise n Shine**	8.63	11.83	10.23
30	**Swinger**	28.74	27.15	27.95
31	**Babe**	24.95	31.64	28.29
32	**Mirabel**	7.47	9.43	8.45
33	**Flamboyant**	19.08	20.86	19.97
34	**Roxy**	11.57	10.76	11.16
35	**Graine De Beaute**	9.58	9.39	9.49
36	**Cup Cake**	9.69	9.54	9.61
37	**Mr. Blue Bird**	24.93	22.79	23.86
38	**Amber Star**	12.48	12.60	12.54
39	**Fire Flash**	15.42	15.06	15.24
40	**Hoot & Howler**	12.60	14.44	13.52
41	**Leila Laird**	22.24	22.47	22.36
42	**Painter's Palette**	13.42	13.07	13.25
43	**Nine**	12.71	12.59	12.65
44	**Dazzler**	11.51	12.30	11.90
45	**Priti**	7.52	8.29	7.91
	Mean	13.53	14.08	**Year:** NS
	CD $_{0.5}$	4.68	3.02	**Genotype:** 2.26 **G X Y:** NS

Star' (78.78) and 'Nine' (78.67). In contrast, it was registered minimum in genotype 'Red Figurine' (24.89) and was closely followed by Giggles (27.67), Gourmet Popcorn (2.89), Leila Laird (28) and Amber Star (28.34).

Data recorded for 2018 shows the significant differences among different genotypes for number of days taken for first flowering and this ranged between 43.56 to 22.11. Maximum number of days taken for first flowering was observed in genotype 'Golden Century' (43.56) which was found statistically at par with 'Hoot & Howler' (43.22), 'String of Pearls' (42.78), 'Lemon Sweet Dream' (42.78), 'Aishwarya' (42.67), 'Grande De Beaute' (42.11). 'China 65' (40.89), 'The Fairy' (40.78) and 'Don Don' (39.44). However, minimum number of days taken for first flowering was observed in 'Red Figurine' (21.11 days) which was followed by 'Kayla' (23 days), 'Wild Fire' (24 days), 'Simple Marvelous' (24.44 days), 'Giggles' (25 days) and 'Gourmet Popcorn' (25.11 days).

Pooled analysis for number of days taken for first flowering showed that it was observed maximum (62.56 days) in genotype 'Lemon Sweet Dream' which was found statistically at par with 'String of Pearls' (61.78 days), 'China 65' (60 days), 'Chandrika' (59.06 days) and 'Golden Century' (58.89 days). In contrast, minimum number of days taken for first flowering was recorded in genotype 'Red Figurine' (23 days), which was found to be statistically at par with genotypes 'Leila Laird' (26.17 days), 'Giggles' (26.33 days) and 'Gourmet Popcorn' (26.50 days).

Between the years, days taken for first flowering was observed to be maximum in year 2017 i.e. 54.50 days.

The data of interactions between genotypes and years showed, maximum number of days taken for first flowering (82.89) in genotype 'Graine De Beaute' during 2017 which was found statistically at par with 'Lemon Sweet Dream' (82.33), 'Chandrika' (81.33), 'String of Pearls' (80.78), 'China 65' (79.11), 'Ruby Star' (78.78) and 'Nine' (78.67) in 2017, whereas, genotype 'Red Figurine' recorded minimum number of days taken for first flowering (21.11) during 2018 which was found statistically at par with genotypes 'Red Figurine' (24.89) in 2017 and 'Kayla' (23 days), 'Wild Fire' (24 days), 'Simple Marvelous' (24.44 days), 'Giggles' (25 days) and 'Gourmet Popcorn' (25.11 days) in 2018.

The variation in time taken for visible bud of the varieties might be due to genetic make up of the variety in conformity with the results reported by Gill and Atwal (1976) and Singh (2016). The varieties which take less number of days to reach the flowering were consider better than those which takes more time but this has to interpreted along with the

data of duration of flowering. Similar results have been reported by Bhattacharjee (1993) and Malhotra (1997) in roses.

4.1.1.10 Days taken for peak flowering

During 2017, there was a significant difference among the genotypes for days taken for peak flowering and the range varied from 201.45 to 56.67 days. It is evident from the Table 4.1.10 that the significantly maximum number of days taken for peak flowering was recorded in genotype 'Maigold Sweet Dream' (201.45 days), whereas, it was registered minimum in genotype 'The Fairy' (56.67 days) which was found statistically at par with 'Aishwarya' (62.22 days), 'Red Figurine' (63 days) and 'String of Pearls' (69.22 days).

Data recorded for 2018 shows the significant differences among different genotypes for number of days taken for peak flowering and this ranged between 231.33 to 54.89. Maximum number of days taken for peak flowering was observed in genotype 'Maigold Sweet Dream' (231.33 days). However, minimum number of days taken for peak flowering was observed in 'Priti' (54.89 days) which was found statistically at par with 'Amber Star' (55.44 days), 'Gourmet Popcorn' (56 days), 'Kayla' (57.89 days), 'Golden Century' (58.11 days), 'Flamboyant' (58.55 days), 'China 65' (59 days), 'Scarlet Gem' (60.22 days), 'Bharani' (60.89 days), 'Graine De Beaute' (61.22 days), 'Sunday Brunch' (62.33 days), 'Fire Flash' (63.11 days), 'Flash Dance' (63.55 days) and 'Frothy' (67.11 days).

Pooled analysis for number of days taken for peak flowering showed that it was observed maximum (216.39 days) in genotype 'Maigold Sweet Dream'. In contrast, minimum number of days taken for peak flowering was recorded in genotype 'Aishwarya' (70.83 days), which was found to be statistically at par with genotypes 'Priti' (72.55 days), 'Amber Star' (72.89 days), 'Golden Century' (75.67 days), 'Vanessa' (78.56 days), 'Gourmet Popcorn' (79.67 days) and 'Sunday Brunch' (82.61 days).

Between the years, days taken for peak flowering was observed to be maximum in year 2017 i.e. 129.55 days.

The data of interactions between genotypes and years showed, maximum number of days taken for peak flowering (231.33) in genotype 'Maigold Sweet Dream' during 2018, whereas, genotype 'Priti' recorded minimum number of days taken for peak flowering (54.89) during 2018 which was found statistically at par with genotypes 'The Fairy' (56.67 days), 'Aishwarya' (62.22 days), 'Red Figurine' (63 days), 'String of Pearls' (69.22 days), 'Young Mistress' (76.33 days), 'Mirabel' (80.55 days), 'Simply Marvelous' (83 days) and

Table 4.1.9: Days taken for First flowering of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	63.67	31.44	47.56
2	**China 65**	79.11	40.89	60.00
3	**Golden Century**	74.22	43.56	58.89
4	**Frothy**	54.22	32.33	43.28
5	**Zwergkonig**	63.11	34.78	48.94
6	**Royal Midnette**	50.11	32.11	41.11
7	**Simply Marvelous**	38.67	24.44	31.56
8	**Chandrika**	81.33	36.78	59.06
9	**Flash Dance**	56.11	26.44	41.28
10	**Kayla**	43.00	23.00	33.00
11	**Sunday Brunch**	49.67	28.55	39.11
12	**Vanessa**	57.00	34.67	45.83
13	**Maigold Sweet Dream**	46.33	29.44	37.89
14	**Blue Blood**	41.00	28.78	34.89
15	**Scarlet Gem**	42.78	31.78	37.28
16	**String of pearls**	80.78	42.78	61.78
17	**Fairy Gold**	58.34	32.66	45.50
18	**Lavender Midnette**	56.11	26.78	41.44
19	**Young Mistress**	53.56	30.78	42.17
20	**Gourmet Popcorn**	27.89	25.11	26.50
21	**Giggles**	27.67	25.00	26.33
22	**Ruby Star**	78.78	36.89	57.83
23	**Wild Fire**	42.00	24.00	33.00
24	**The Fairy**	46.00	40.78	43.39
25	**Red Figurine**	24.89	21.11	23.00
26	**Aishwarya**	65.67	42.67	54.17
27	**Don Don**	75.67	39.44	57.56
28	**Lemon Sweet Dream**	82.33	42.78	62.56
29	**Rise n Shine**	73.11	31.78	52.45
30	**Swinger**	46.33	31.78	39.05
31	**Babe**	53.56	30.66	42.11
32	**Mirabel**	51.89	28.78	40.33
33	**Flamboyant**	38.56	26.00	32.28
34	**Roxy**	62.78	32.78	47.78
35	**Graine De Beaute**	82.89	42.11	62.50
36	**Cup Cake**	41.00	32.44	36.72
37	**Mr. Blue Bird**	74.00	36.11	55.06
38	**Amber Star**	28.34	32.56	30.45
39	**Fire Flash**	35.55	30.33	32.94
40	**Hoot & Howler**	72.34	43.22	57.78
41	**Leila Laird**	28.00	24.33	26.17
42	**Painter's Palette**	54.22	36.89	45.56
43	**Nine**	78.67	34.89	56.78
44	**Dazzler**	31.00	26.37	28.69
45	**Priti**	35.89	23.11	29.50
	Mean	54.40	32.31	**Year:** 0.77
	CD $_{0.5}$	5.25	5.21	**Genotype:** 3.68 **G X Y:** 5.20

Roxy' (83 days) in 2017 and Amber Star' (55.44 days), 'Gourmet Popcorn' (56 days), 'Kayla' (57.89), 'Golden Century' (58.11 days), 'Flamboyant' (58.55 days), 'China 65' (59 days), 'Scarlet Gem' (60.22 days), 'Bharani' (60.89 days), 'Graine De Beaute' (61.22 days), 'Sunday Brunch' (62.33 days), 'Fire Flash' (63.11 days), 'Flash Dance' (63.55 days), 'Frothy' (67.11 days) and 'Vanessa' (69.78 days), 'Chandrika' (70.33 days), 'Aishwarya' (79.44 days) and 'Leila Laird' (81.22 days).

The variation in time taken for peak flowering could be attributed to genetic make up of the variety as well as prevailing environment and adaptation of genotype in such environment. The above data is in conformity with the findings of Bhattacharjee (1993), Malhotra (1997) and Terfa *et al* (2014).

4.1.1.11 Duration of flowering

The data presented in the Table 4.1.11 shows that during 2017, the range of duration of flowering varied from 162.78 to 77.89 days. Maximum duration of flowering was observed in genotype 'Gourmet Popcorn' (162.78 days) which was statistically at par with genotypes 'Ruby Star' (155.11 days), 'Lemon Sweet Dream' (154.33 days), 'Nine' (153.67 days), 'Bharani' (153 days) and 'Red Figurine' (150.89 days), whereas, minimum duration of flowering was observed in genotype 'Mirabel' (77.89 days) which was statistically at par with genotype 'Swinger' (92.33 days).

During 2018, the range of duration of flowering varied from 211.44 to 132.11 days. Maximum duration of flowering was observed in genotype 'Sunday Brunch' (211.44 days) which was statistically at par with genotypes 'Zwergkonig' (210.22 days), 'Golden Century' (202.89 days), 'Maigold Sweet Dream' (201.89 days), 'Frothy' (198 days), 'Royal Midnette' (197.89 days), 'Swinger' (197.34 days), 'String of Pearls' (194.67 days), 'Red Figurine' (188.56 days), 'Roxy' (188.11 days), 'Aishwarya' (184.22 days), 'Flamboyant' (183.11 days), and 'Amber Star' (182.89 days), whereas, minimum duration of flowering was observed in

On pooling the data for two years, maximum duration of flowering was found in 'Maigold Sweet Dream' (173.61 days) , which was found statistically at par with genotype 'Red Figurine' (169.72 days), 'Royal Midnette' (169.50 days), 'Nine' (168.17 days), 'Bharani' (167.61 days), 'Frothy' (165.28 days), 'Zwergkonig' (165 days), 'Scarlet Gem' (159.89 days), 'Roxy' (158.17 days), 'Babe' (156.11 days), 'Golden Century' (155.89 days), 'Ruby Star' (155.39 days), 'Fairy Gold' (152.17 days), 'Amber Star' (151.28 days) and

Table 4.1.10: Days taken for Peak Flowering of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	179.33	60.89	120.11
2	**China 65**	174.33	59.00	116.67
3	**Golden Century**	93.22	58.11	75.67
4	**Frothy**	186.55	67.11	126.83
5	**Zwergkonig**	181.67	119.22	150.45
6	**Royal Midnette**	173.22	115.11	144.17
7	**Simply Marvelous**	83.00	115.78	99.39
8	**Chandrika**	106.33	70.33	88.33
9	**Flash Dance**	172.89	63.55	118.22
10	**Kayla**	118.11	57.89	88.00
11	**Sunday Brunch**	102.89	62.33	82.61
12	**Vanessa**	87.33	69.78	78.56
13	**Maigold Sweet Dream**	201.45	231.33	216.39
14	**Blue Blood**	180.22	162.00	171.11
15	**Scarlet Gem**	111.55	60.22	85.89
16	**String of pearls**	69.22	110.89	90.05
17	**Fairy Gold**	89.55	117.89	103.72
18	**Lavender Midnette**	185.33	120.89	153.11
19	**Young Mistress**	76.33	115.22	95.78
20	**Gourmet Popcorn**	103.33	56.00	79.67
21	**Giggles**	177.67	118.55	148.11
22	**Ruby Star**	181.55	113.67	147.61
23	**Wild Fire**	167.00	119.11	143.06
24	**The Fairy**	56.67	165.67	111.17
25	**Red Figurine**	63.00	115.67	89.33
26	**Aishwarya**	62.22	79.44	70.83
27	**Don Don**	140.33	110.44	125.39
28	**Lemon Sweet Dream**	102.22	110.33	106.28
29	**Rise n Shine**	181.11	93.22	137.17
30	**Swinger**	178.11	110.22	144.17
31	**Babe**	185.55	210.00	197.78
32	**Mirabel**	80.55	155.22	117.89
33	**Flamboyant**	112.67	58.55	85.61
34	**Roxy**	83.00	168.11	125.56
35	**Graine De Beaute**	108.33	61.22	84.78
36	**Cup Cake**	175.22	108.33	141.78
37	**Mr. Blue Bird**	86.89	205.22	146.05
38	**Amber Star**	90.33	55.44	72.89
39	**Fire Flash**	185.22	63.11	124.17
40	**Hoot & Howler**	102.22	107.55	104.89
41	**Leila Laird**	164.78	81.22	123.00
42	**Painter's Palette**	99.00	78.33	88.67
43	**Nine**	109.00	109.22	109.11
44	**Dazzler**	171.22	110.55	140.89
45	**Priti**	90.22	54.89	72.55
	Mean	129.55	103.49	**Year:** 2.15
	CD $_{0.5}$	14.65	14.35	**Genotype:** 10.18 **G X Y:** 14.40

‘Simple Marvelous’ (151.17 days). However, among different genotypes, minimum duration of flowering was observed in ‘Mirabel’ (106.67 day), which was statistically at par with ‘Mr. Blue Bird’ (118.61 days) and ‘Dazzler’ (120.06 days).

In general, between different years, maximum duration of flowering was recorded in year 2018 (173.46 days) and minimum was in 2017 (123.84 days).

The data of interactions between genotypes and years showed, maximum duration of flowering (211.44 days) in 2018 in genotype ‘Sunday Brunch’, which was statistically at par with ‘Zwergkonig’ (210.22 days), ‘Golden Century’ (202.89 days), ‘Maigold Sweet Dream’ (201.89 days), ‘Frothy’ (198 days), ‘Royal Midnette’ (197.89 days), ‘Swinger’ (197.34 days), ‘String of Pearls’ (194.67 days) and ‘Red Figurine’ (188.56 days) in 2018. However, minimum duration of flowering was observed in 2017 in ‘Mirabel’ (77.89 days) which was statistically at par with genotypes ‘Swinger’ (92.33 days), ‘Giggles’ (98.45 days), ‘Flamboyant’ (98.78 days) and ‘Dazzler’ (99 days) in 2017.

Duration of flowering varied from 31 to 41 days among the 20 cultivars of floribunda rose by a study conducted at Punjab (Singh, 2016). The duration of flowering was exceptionally high in miniature roses due to their recurrent flowering behavior. The longest duration of flowering in the cultivars was suitable for garden display and growing in open conditions. The variation in duration of flowering could be attributed due to genotype of the plant together under the influence of environment and other management factors in conformity with the finding of Singh *et al* (1995).

4.1.1.12 Bud length (mm)

Perusal of data presented in Table 4.1.12 revealed that during 2017, the range of bud length varied from 26.37 to 8.44 mm. Maximum bud length was recorded in genotype ‘Fire Flash’ (26.37 mm) which was found to be statistically at par with ‘Hoot & Howler’ (25.75 mm), ‘Flash Dance’ (23.50 mm), ‘Young Mistress’ (23.39 mm), ‘Leila Laird’ (23.24 mm) and ‘Maigold Sweet Dream’ (23.23 mm), whereas, minimum bud length was found in ‘Chandirka’ (8.44 mm) followed by ‘Gourmet Popcorn’ (9.60 mm), ‘Lavender Midnette’ (9.92 mm), ‘China 65’ (10.67 mm), ‘Dazzler’ (10.86 mm), ‘Roxy’ (11.98 mm), ‘Priti’ (12.64 mm), ‘Graine de Beaute’ (12.65 mm) and ‘Frothy’ (12.68 mm).

During 2018, the range of bud length varied from 25.55 to 8.46 mm. Maigold Sweet Dream’ (25.55 mm), which was followed by ‘Leila Laird’ (22.08 mm), ‘Ruby Styar’ (21.37 mm), ‘Flash Dance’ (21.20 mm), ‘Don Don’ (21.01 mm), ‘Aishwarya’ (20.43 mm), whereas,

Table 4.1.11: Duration of Flowering (days) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	153.00	182.22	167.61
2	**China 65**	110.11	162.33	136.22
3	**Golden Century**	108.89	202.89	155.89
4	**Frothy**	132.56	198.00	165.28
5	**Zwergkonig**	119.78	210.22	165.00
6	**Royal Midnette**	141.11	197.89	169.50
7	**Simply Marvelous**	127.34	175.00	151.17
8	**Chandrika**	139.67	144.89	142.28
9	**Flash Dance**	118.22	169.56	143.89
10	**Kayla**	105.67	160.33	133.00
11	**Sunday Brunch**	134.78	211.44	173.11
12	**Vanessa**	133.78	164.22	149.00
13	**Maigold Sweet Dream**	145.34	201.89	173.61
14	**Blue Blood**	117.22	166.33	141.78
15	**Scarlet Gem**	139.55	180.22	159.89
16	**String of pearls**	105.22	194.67	149.95
17	**Fairy Gold**	122.56	181.78	152.17
18	**Lavender Midnette**	119.11	172.56	145.83
19	**Young Mistress**	111.22	169.11	140.17
20	**Gourmet Popcorn**	162.78	161.56	162.17
21	**Giggles**	98.45	165.22	131.84
22	**Ruby Star**	155.11	155.66	155.39
23	**Wild Fire**	112.00	156.67	134.33
24	**The Fairy**	126.00	170.22	148.11
25	**Red Figurine**	150.89	188.56	169.72
26	**Aishwarya**	105.00	184.22	144.61
27	**Don Don**	133.33	161.78	147.56
28	**Lemon Sweet Dream**	154.33	137.33	145.83
29	**Rise n Shine**	117.45	182.44	149.95
30	**Swinger**	92.33	197.34	144.83
31	**Babe**	132.89	179.33	156.11
32	**Mirabel**	77.89	135.44	106.67
33	**Flamboyant**	98.78	183.11	140.95
34	**Roxy**	128.22	188.11	158.17
35	**Graine De Beaute**	139.78	154.67	147.22
36	**Cup Cake**	118.67	173.11	145.89
37	**Mr. Blue Bird**	105.11	132.11	118.61
38	**Amber Star**	119.67	182.89	151.28
39	**Fire Flash**	128.55	170.33	149.44
40	**Hoot & Howler**	114.67	168.00	141.34
41	**Leila Laird**	117.67	169.33	143.50
42	**Painter's Palette**	115.89	182.44	149.17
43	**Nine**	153.67	182.66	168.17
44	**Dazzler**	99.00	141.11	120.06
45	**Priti**	129.56	156.45	143.00
	Mean	123.84	173.46	**Year:** 3.45
	CD $_{0.5}$	16.50	28.56	**Genotype:** 16.36 **G X Y:** 23.14

minimum bud length was found in ‘Graine de Beaute’ (8.46 mm) which was followed by ‘Chandrika’ (8.93 mm), ‘Dazzler’ (9.78 mm), ‘Priti’ (11.34 mm), ‘Lavender Midnette’ (11.50 mm), ‘Forthy’ (12.18 mm), ‘Roxy’ (12.78 mm), ‘Fairy Gold’ (12.95 mm), ‘Bharani’ (13.07 mm), ‘Mirabel’ (13.27 mm), ‘The Fairy’ (13.63 mm), ‘China 65’ (13.69 mm) and ‘Babe’ (13.70 mm).

On pooling the data for two years, maximum bud length was found in ‘Maigold Sweet Dream’ (24.39 mm), which was found statistically at par with genotype ‘Fire Flash’ (22.82 mm), ‘Leila Laird’ (22.66 days), ‘Flash Dance’ (22.35 mm), ‘Hoot & Howler’ (22.08 mm) and ‘Ruby Star’ (22.71 mm). However, among different genotypes, minimum bud length was observed in ‘Chandrika’ (8.69 mm), which was statistically at par with ‘Dazzler’ (10.32 mm), ‘Graine de Beaute’ (10.56 mm), ‘Lavender Midnette’ (10.71 mm), ‘Gourmet Popcorn’ (11.83 mm) and ‘Priti’ (11.99 mm).

Year and interaction were found to be non-significant.

The differences among the cultivars might be attributed to genetic makeup of the same. Similar variations in bud length and diameter were observed by Singh (2009) in roses and Singh (2016) in floribunda.

4.1.1.13 Bud Width (mm)

Perusal of data presented in Table 4.1.13 revealed that during 2017, the range of bud length varied from 14.30 to 3.41 mm. Maximum bud width was recorded in genotype ‘Mirabel’ (14.30 mm) which was found to be statistically at par with ‘Leila Laird’ (12.67 mm), ‘Young Mistress’ (12.63 mm), ‘Painter’s Palette’ (12.55 mm), ‘Fire Flash’ (12.48 mm), ‘Gourmet Popcorn’ (12.42 mm), ‘Red Figurine’ (12.15 mm) and ‘Vanessa’ (12.10 mm), whereas, minimum bud length was found in ‘Priti’ (3.41 mm) followed by ‘Blue Blood’ (5.04 mm).

During 2018, the range of bud width varied from 12.45 to 4.74 mm. Maximum bud length was observed in genotype ‘Zwergkonig’ (12.45 mm), followed by ‘Hoot & Howler’ (12.42 mm), ‘Leila Laird’ (12.41 mm), ‘Painter’s Palette’ (11.93 mm), ‘Fire Flash’ (11.90 mm), ‘Gourmet Popcorn’ (11.88 mm), ‘Vanessa’ (11.79 mm), ‘Red Figurine’ (11.66 mm), ‘Maigold Sweet Dream’ (11.64 mm), ‘Mirabel’ (11.64 mm), ‘Wild Fire’ (11.23 mm), ‘;Aishwarya’ (11.07 mm), ‘Fairy Gold’ (10.94 mm), ‘Kayla’ (10.76 mm), ‘Lemon Sweet Dream’ (10.67 mm), ‘Sunday Brunch’ (10.52 mm), ‘Rise n Shine’ (10.49 mm), ‘Don Don’ (10.45 mm) and ‘Yound Mistress’ (10.44 mm), whereas, minimum bud width was found in ‘China 65’ (4.74 mm) which was followed by ‘Blue Blood’ (4.89 mm), ‘Priti’ (5.02 mm),

Table 4.1.12: Bud Length (mm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	13.98	13.07	13.52
2	**China 65**	10.67	13.69	12.18
3	**Golden Century**	13.08	14.33	13.71
4	**Frothy**	12.68	12.18	12.43
5	**Zwergkonig**	16.16	15.65	15.90
6	**Royal Midnette**	18.99	18.77	18.88
7	**Simply Marvelous**	16.82	18.34	17.58
8	**Chandrika**	8.44	8.93	8.69
9	**Flash Dance**	23.50	21.20	22.35
10	**Kayla**	15.83	18.16	17.00
11	**Sunday Brunch**	16.66	18.82	17.74
12	**Vanessa**	20.75	15.96	18.36
13	**Maigold Sweet Dream**	23.23	25.55	24.39
14	**Blue Blood**	16.64	16.63	16.64
15	**Scarlet Gem**	14.64	17.89	16.26
16	**String of pearls**	15.50	17.02	16.26
17	**Fairy Gold**	12.94	12.95	12.95
18	**Lavender Midnette**	9.92	11.50	10.71
19	**Young Mistress**	23.39	16.00	19.69
20	**Gourmet Popcorn**	9.60	14.05	11.83
21	**Giggles**	17.25	16.37	16.81
22	**Ruby Star**	22.04	21.37	21.71
23	**Wild Fire**	20.31	18.39	19.35
24	**The Fairy**	12.91	13.63	13.27
25	**Red Figurine**	13.93	15.09	14.51
26	**Aishwarya**	18.90	20.43	19.66
27	**Don Don**	19.62	21.01	20.32
28	**Lemon Sweet Dream**	20.91	18.43	19.67
29	**Rise n Shine**	16.73	17.80	17.26
30	**Swinger**	15.86	15.32	15.59
31	**Babe**	15.63	13.70	14.66
32	**Mirabel**	15.18	13.27	14.22
33	**Flamboyant**	14.35	15.92	15.13
34	**Roxy**	11.98	12.78	12.38
35	**Graine De Beaute**	12.65	8.46	10.56
36	**Cup Cake**	18.71	17.81	18.26
37	**Mr. Blue Bird**	17.87	18.71	18.29
38	**Amber Star**	17.02	16.84	16.93
39	**Fire Flash**	26.37	19.28	22.82
40	**Hoot & Howler**	25.75	18.41	22.08
41	**Leila Laird**	23.24	22.08	22.66
42	**Painter's Palette**	20.29	19.52	19.91
43	**Nine**	17.75	15.64	16.70
44	**Dazzler**	10.86	9.78	10.32
45	**Priti**	12.64	11.34	11.99
	Mean	16.72	16.27	**Year:** NS
	CD $_{0.5}$	4.24	5.44	**Genotype:** 3.43 **G X Y:** NS

‘Bharani’ (5.75 mm), ‘Chandrika’ (5.77 mm), ‘Ruby Star’ (6.27 mm), ‘Frothy’ (6.38 mm), ‘Cup Cake’ (6.60 mm) and ‘Babe’ (6.64 mm).

On pooling the data for two years, maximum bud width was found in ‘Mirabel’ (12.97 mm), which was found statistically at par with genotype ‘Leila Laird’ (12.54 mm), ‘Painter’s Palette’ (12.24 mm), ‘Fire Flash’ (12.19 mm), ‘Gourmet Popcorn’ (12.15 mm), ‘Vanessa’ (11.95 mm), ‘Hoot & Howler’ (11.94 mm), ‘Red Figurine’ (11.91 mm), ‘Zwergkonig’ (11.67 mm), ‘Young Mistress’ (11.54 mm), ‘Kayla’ (11.13 mm), ‘Wild Fire’ (11.11 mm), ‘Aishwarya’ (11.11 mm), ‘Fairy Gold’ (10.88 mm) and ‘Sunday Brunch’ (10.45 mm). However, among different genotypes, minimum bud width was observed in ‘Priti’ (4.21 mm) which was statistically at par with ‘Blue Blood’ (4.97 mm), ‘China 65’ (5.20 mm), ‘Chandrika’ (6.05 mm), ‘Bharani’ (6.23 mm), ‘Babe’ (6.45 mm) and ‘Cup Cake’ (6.65 mm). Year and interaction was found to be non-significant.

The differences among the cultivars might be attributed to genetic makeup of the same. Similar variations in bud length and diameter were observed by Singh (2009) in roses and Singh (2016) in floribunda.

4.1.1.14 Flower diameter (cm)

During 2017, there was a significant difference among the genotypes for flower diameter and the range varied from 5.80 to 2.21 cm. It is evident from the Table 4.1.14 that the significantly maximum flower diameter (5.80 cm) which was found statistically significant with genotypes ‘Leila Laird’ (5.47 cm), ‘Amber Star’ (5.42 cm), ‘Royal Midnette’ (5.29 cm), ‘Aishwarya’ (5.23 cm), ‘Cup Cake’ (5.07 cm) and ‘Wild Fire’ (5 cm). In contrast, it was registered minimum in genotype ‘Dazzler’ (2.21 cm) and was closely followed by genotypes China 65’ (2.27 cm), ‘The Fairy’ (2.33 cm), ‘Gourmet Popcorn’ (2.41 cm), ‘Graine de Beaute’ (2.60 cm), ‘String of Pearls’ (2.65 cm), ‘Frothy’ (2.69 cm), ‘Blue Blood’ (2.72 cm), ‘Red Figurine’ (2.83 cm), ‘Flamboyant’ (2.94 cm), ‘Scarlet Gem’ (3 cm), ‘Priti’ (3.08 cm), and ‘Chandrika’ (3.19 cm).

Data recorded for 2018 shows the significant differences among different genotypes for the flower diameter and this ranged between 5.90 to 1.80 cm. Maximum flower diameter observed in genotype ‘Hoot & Howler’ (5.90 cm) which was statistically significant with ‘Swinger’ (5.69 cm) and ‘Royal Midnette’ (5.16 cm), whereas, minimum flower diameter (1.80 cm) was recorded in genotype ‘China 65’ which was statistically at par with genotype ‘Blue Blood’ (2.06 cm), ‘Flamboyant’ (2.07 cm), ‘Dazzler’ (2.16 cm), ‘The Fairy’ (2.31 cm),

Table 4.1.13: Bud width (mm) of different miniature rose genotypes

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	6.72	5.75	6.23
2	**China 65**	5.66	4.74	5.20
3	**Golden Century**	7.57	7.24	7.41
4	**Frothy**	6.93	6.38	6.66
5	**Zwergkonig**	10.88	12.45	11.67
6	**Royal Midnette**	8.43	7.24	7.83
7	**Simply Marvelous**	11.08	10.38	10.73
8	**Chandrika**	6.33	5.77	6.05
9	**Flash Dance**	7.91	7.84	7.88
10	**Kayla**	11.50	10.76	11.13
11	**Sunday Brunch**	10.37	10.52	10.45
12	**Vanessa**	12.10	11.79	11.95
13	**Maigold Sweet Dream**	9.38	11.64	10.51
14	**Blue Blood**	5.04	4.89	4.97
15	**Scarlet Gem**	10.47	9.82	10.15
16	**String of pearls**	9.18	9.30	9.24
17	**Fairy Gold**	10.82	10.94	10.88
18	**Lavender Midnette**	9.21	8.54	8.88
19	**Young Mistress**	12.63	10.44	11.54
20	**Gourmet Popcorn**	12.42	11.88	12.15
21	**Giggles**	9.04	8.46	8.75
22	**Ruby Star**	6.84	6.27	6.56
23	**Wild Fire**	11.00	11.23	11.11
24	**The Fairy**	10.32	10.07	10.20
25	**Red Figurine**	12.15	11.66	11.91
26	**Aishwarya**	11.16	11.07	11.11
27	**Don Don**	10.48	10.45	10.46
28	**Lemon Sweet Dream**	10.79	10.67	10.73
29	**Rise n Shine**	10.47	10.49	10.48
30	**Swinger**	9.81	9.53	9.67
31	**Babe**	6.25	6.64	6.45
32	**Mirabel**	14.30	11.64	12.97
33	**Flamboyant**	8.07	7.59	7.83
34	**Roxy**	8.95	10.21	9.58
35	**Graine De Beaute**	7.62	7.34	7.48
36	**Cup Cake**	6.70	6.60	6.65
37	**Mr. Blue Bird**	9.26	7.35	8.31
38	**Amber Star**	9.29	9.44	9.37
39	**Fire Flash**	12.48	11.90	12.19
40	**Hoot & Howler**	11.45	12.42	11.94
41	**Leila Laird**	12.67	12.41	12.54
42	**Painter's Palette**	12.55	11.93	12.24
43	**Nine**	10.62	9.09	9.85
44	**Dazzler**	6.63	6.99	6.81
45	**Priti**	3.41	5.02	4.21
	Mean	9.49	9.22	**Year:** NS
	CD $_{0.5}$	2.24	2.04	**Genotype:** 1.51 **G X Y:** NS

‘Graine de Beaute’ (2.34 cm), ‘String of Pearls’ (2.34cm), ‘Priti’ (2.37 cm), ‘Scarlet Gem’ (2.47 cm), ‘Chandrika’ (2.51 cm) and ‘Gourmet Popcorn’ (2.53 cm).

Pooled analysis for flower diameter showed that it was observed highest (5.85 cm) in genotype ‘Hoot & Howler’ followed by ‘Swinger’ (5.74 cm), ‘Royal Midnette’ (5.22 cm), ‘Leila Laird’ (5.02 cm) and ‘Aishwarya’ (4.98 cm). In contrast, minimum internodal length was recorded in genotype ‘China 65’ (2.03 cm) and was closely followed by genotypes ‘Dazzler’ (2.19 cm), ‘The Fairy’ (2.32 cm), ‘Blue Blood’ (2.39 cm), ‘Gourmet Popcorn’ (2.47 cm), ‘Graine de Beaute’ (2.47 cm), ‘Flamboyant’ (2.50 cm), ‘String of Pearls’ (2.50 cm), ‘Red Figurine’ (2.71 cm), ‘Priti’ (2.73 cm), ‘Scarlet Gem’ (2.74 cm), ‘Frothy’ (2.81 cm), and ‘Chandrika’ (2.85 cm).

In between the years, flower diameter was found maximum (3.85 cm) in 2017 and minimum (3.43 cm) in 2018.

The data of interactions between genotypes and years was found to be non-significant.

The cultivars with smaller flower size were recorded to be good for garden display considering miniatures. The differences of conformity with the findings of Bhattacharjee *et al*. (1993), Malhotra (1997) and Terfa *et al* (2014). flower size might be due to genetic make up of the cultivars. It may also be related to carbohydrate reserves in plants during plant growth process. The similar differences in flower size of the cultivars had been reported by Singh *et al* (1988), Murugesan *et al* (1991), Bhattacharjee (1994), Singh *et al* (1994), Singh *et al* (2002) and Malik *et al* (2007), Hazarika *et al* (2010) in roses. Dadlani (2016) also found variation in flower diameter in miniature rose genotypes.

4.1.1.15 Petal Length (mm)

Perusal of data presented in Table 4.1.15 revealed that during 2017, the range of petal length varied from 30.06 to 6.62 mm. Maximum petal length (30.06 mm) was recorded in genotype ‘Amber Star’, whereas, minimum petal length was found in ‘Dazzler’ (6.62 mm) followed by ‘China 65’ (6.80 mm), ‘Scarlet Gem’ (9.86 mm), ‘Priti’ (10.33 mm), ‘Maigold Sweet Dream’ (10.68 mm), ‘Grain de Beaute’ (10.74 mm), ‘Frothy’ (10.85 mm) and ‘The Fairy’ (10.92 mm).

During 2018, the range of petal length varied from 30.39 to 7.08 mm. Maximum petal length (30.39 mm) was found in ‘Hoot & Howler’, whereas minimum (7.08 mm) was found in ‘China 65’ which was statistically at par with ‘Dazzler’ (7.90 mm), ‘Chandrika’ (8.63 mm), and ‘Flamboyant’ (9.72 mm).

On pooling the data for two years, maximum petal length (27.75 mm) was found in ‘Hoot & Howler’, whereas minimum (6.94 mm) was found in ‘China 65’ which was statistically at par with ‘Dazzler’ (7.26 mm).

The data of interactions between genotypes and years showed, maximum petal length genotype ‘Hoot & Howler’ (30.39 mm) in 2018 which was at par with ‘Amber Star’ (30.06 mm) in 2017, whereas minimum (6.62 mm) was found in ‘Dazzler’ in 2017 which was statistically at par with ‘China 65’ (6.80 mm) in 2017 and ‘China 65’ (7.80 mm) and ‘Dazzler’ (7.90 mm) in 2018.

Data on petal length was found to be non-significant for years. The differences among the cultivars might be attributed to genetic makeup of the same. Similar variations in bud length

and diameter were observed by Singh (2009) in roses and Dadlani (2016) and Singh (2016) in floribunda.

4.1.1.16 Petal width (mm)

Perusal of data presented in Table 4.1.16 revealed that during 2017, the range of petal width varied from 21.68 to 2.23 mm. Maximum petal width (21.68 mm) was recorded in genotype ‘Hoot & Howler’, which was found at par with ‘Painter’s Palette’ (21.04 mm), whereas, minimum petal length was found in ‘Frothy’ (2.23 mm).

During 2018, the range of petal width varied from 21.47 to 2.73 mm. Maximum petal width (21.47 mm) was found in ‘Hoot & Howler’, whereas minimum (2.73 mm) was found in ‘Frothy’ which was statistically at par with ‘Scarlet Gem’ (4.33 mm), ‘Fairy Gold’ (5.16 mm) and ‘China 65’ (5.68 mm).

On pooling the data for two years, maximum petal width (21.58 mm) was found in ‘Hoot & Howler’, whereas minimum (2.48 mm) was found in ‘Frothy’.

The data of interactions between genotypes and years showed, maximum petal width genotype ‘Hoot & Howler’ (21.47 mm) in 2018 which was at par with ‘Hoot & Howler’ (21.68mm), ‘Painter’s Palette’ (21.04 mm) and ‘Swinger’ (19.19 mm) in 2017. In contrast, minimum petal width was recorded in ‘Frothy’ (2.23 mm) in 2017 which was at par with ‘Scarlet Gem’ (4.20 mm) in 2017, ‘Frothy’ (2.73 mm), ‘Scarlet Gem’ (4.33 mm) in 2018.

Data on petal width was found to be non-significant for years.

The differences among the cultivars might be attributed to genetic makeup of the same.

Table 4.1.14: Flower Diameter (cm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	3.97	4.52	4.24
2	**China 65**	2.27	1.80	2.03
3	**Golden Century**	3.53	3.45	3.49
4	**Frothy**	2.69	2.92	2.81
5	**Zwergkonig**	4.67	3.87	4.27
6	**Royal Midnette**	5.29	5.16	5.22
7	**Simply Marvelous**	3.28	2.94	3.11
8	**Chandrika**	3.19	2.51	2.85
9	**Flash Dance**	4.01	3.17	3.59
10	**Kayla**	3.66	3.47	3.57
11	**Sunday Brunch**	4.31	3.71	4.01
12	**Vanessa**	3.29	2.66	2.98
13	**Maigold Sweet Dream**	3.58	3.61	3.60
14	**Blue Blood**	2.72	2.06	2.39
15	**Scarlet Gem**	3.00	2.47	2.74
16	**String of pearls**	2.65	2.34	2.50
17	**Fairy Gold**	3.93	3.68	3.81
18	**Lavender Midnette**	4.00	3.71	3.85
19	**Young Mistress**	4.65	4.04	4.34
20	**Gourmet Popcorn**	2.41	2.53	2.47
21	**Giggles**	4.70	3.96	4.33
22	**Ruby Star**	3.98	3.67	3.83
23	**Wild Fire**	5.00	4.10	4.55
24	**The Fairy**	2.33	2.31	2.32
25	**Red Figurine**	2.83	2.59	2.71
26	**Aishwarya**	5.23	4.73	4.98
27	**Don Don**	3.74	3.43	3.58
28	**Lemon Sweet Dream**	4.22	3.78	4.00
29	**Rise n Shine**	3.80	3.44	3.62
30	**Swinger**	5.80	5.69	5.74
31	**Babe**	4.30	3.88	4.09
32	**Mirabel**	3.41	3.20	3.30
33	**Flamboyant**	2.94	2.07	2.50
34	**Roxy**	3.48	3.39	3.43
35	**Graine De Beaute**	2.60	2.34	2.47
36	**Cup Cake**	5.07	4.16	4.61
37	**Mr. Blue Bird**	3.28	2.72	3.00
38	**Amber Star**	5.42	3.94	4.68
39	**Fire Flash**	4.76	3.57	4.17
40	**Hoot & Howler**	5.80	5.90	5.85
41	**Leila Laird**	5.47	4.56	5.02
42	**Painter's Palette**	4.37	4.14	4.25
43	**Nine**	4.27	3.62	3.95
44	**Dazzler**	2.21	2.16	2.19
45	**Priti**	3.08	2.37	2.73
	Mean	3.85	3.43	**Year:** 0.13
	CD $_{0.5}$	1.02	0.76	**Genotype:** 0.63 **G X Y:** NS

4.1.1.17 Length of pedicel (mm)

Perusal of data presented in Table 4.1.17 revealed that during 2017, the range of length of pedicel varied from 40.29 to 8.81 mm. Maximum length of pedicel (40.29 mm) was recorded in genotype 'Flash Dance', which was found at par with 'Cup Cake' (39.41 mm), whereas, minimum length of pedicel was found in 'Ruby Star' (8.81 mm) which was found at par with with 'Blue Blood' (9.01 mm), 'China 65' (9.72 mm), 'Flamboyant' (9.80 mm), 'Babe' (10.25

Table 4.1.15: Petal Length (mm) of different miniature rose genotypes.

mm), 'Rise n Shine' (11.03 mm), 'Young Mistress' (12.86 mm), 'Golden Century' (12.99 mm) and 'Swinger' (13.10 mm).

During 2018, the range of length of pedicel varied from 37.86 to 9.53 mm. Maximum length of pedicel (37.86 mm) was recorded in genotype 'Cup Cake', which was found at par with 'Flash Dance' (35.31 mm) and 'Leila Laird' (33.54 mm), whereas, minimum length of pedicel was found in 'Babe' (9.53 mm) which was found at par with 'Flamboyant' (10.02 mm), 'Rise n Shine' (10.64 mm), 'China 65' (10.45 mm), 'Blue Blood' (11.22 mm), 'Ruby Star' (11.27 mm), 'Swinger' (11.41 mm), 'Golden Century' (12.01 mm), 'Maigold Sweet Dream' (12.71 mm), 'Fairy Gold' (13.03 mm) and 'Young Mistress' (13.19 mm).

On pooling the data for two years, maximum length of pedicel (38.63 mm) was recorded in genotype 'Cup Cake', which was found at par with 'Flash Dance' (37.80 mm) and 'Leila Laird' (34.64 mm), whereas, minimum length of pedicel was found in 'Babe' (9.89 mm) which was found at par with 'Flamboyant' (9.91 mm), 'Ruby Star' (10.04 mm), 'China 65' (10.09 mm), 'Blue Blood' (10.12 mm), 'Rise n Shine' (10.83 mm), 'Swinger' (12.26 mm) and 'Young Mistress' (13.03 mm).

The data of interactions between genotypes and years was found to be non-significant.

4.1.1.18 Number of flowers per bunch

Perusal of data presented in Table 4.1.18 revealed that during 2017, the range of number of flowers per bunch varied from 119.45 to 3.55. Maximum number of flowers per bunch (119.45) was recorded in genotype 'Dazzler', whereas, minimum number of flowers per bunch (3.55) was found in 'Leila Laird', which was found statistically at par with 'Mirabel' (3.76), 'Swinger' (4.33), 'Babe' (4.44), 'Young Mistress' (4.67), 'Cup Cake' (5.11), 'Maigold Sweet Dream' (5.11), 'Wild Fire' (5.22), 'Sunday Brunch' (5.56), 'Kayla' (6.11), 'Golden Century' (6.22), 'Fire Flash' (6.33), 'Rise n Shine' (6.33), 'Amber Star' and 'Hoot & Howler' (6.44), 'Ruby Star' (6.67), 'Fairy Gold' (7.44) and Flash Dance' (9.22),

'Aishwarya' (9.78) and 'Lemon Sweet Dream' (10.66).

Table 4.1.16: Petal Width (mm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	12.72	14.34	13.53
2	**China 65**	6.80	7.08	6.94
3	**Golden Century**	12.49	14.63	13.56
4	**Frothy**	10.85	11.48	11.17
5	**Zwergkonig**	19.15	15.51	17.33
6	**Royal Midnette**	20.68	17.88	19.28
7	**Simply Marvelous**	13.00	13.12	13.06
8	**Chandrika**	12.80	8.63	10.72
9	**Flash Dance**	12.90	13.52	13.21
10	**Kayla**	14.12	14.20	14.16
11	**Sunday Brunch**	12.61	13.43	13.02
12	**Vanessa**	13.64	10.08	11.86
13	**Maigold Sweet Dream**	10.68	14.28	12.48
14	**Blue Blood**	13.02	12.23	12.63
15	**Scarlet Gem**	9.86	10.84	10.35
16	**String of pearls**	13.35	11.73	12.54
17	**Fairy Gold**	12.90	14.43	13.66
18	**Lavender Midnette**	15.95	18.73	17.34
19	**Young Mistress**	16.26	15.76	16.01
20	**Gourmet Popcorn**	11.83	12.13	11.98
21	**Giggles**	13.60	19.70	16.65
22	**Ruby Star**	12.68	14.23	13.46
23	**Wild Fire**	18.21	20.63	19.42
24	**The Fairy**	10.92	11.43	11.17
25	**Red Figurine**	12.25	10.76	11.51
26	**Aishwarya**	21.68	23.41	22.54
27	**Don Don**	12.13	15.32	13.72
28	**Lemon Sweet Dream**	19.36	19.69	19.52
29	**Rise n Shine**	13.06	14.44	13.75
30	**Swinger**	22.74	20.77	21.75
31	**Babe**	16.95	15.46	16.21
32	**Mirabel**	18.23	14.01	16.12
33	**Flamboyant**	17.56	9.72	13.64
34	**Roxy**	13.63	13.30	13.47
35	**Graine De Beaute**	10.74	10.77	10.76
36	**Cup Cake**	23.40	17.44	20.42
37	**Mr. Blue Bird**	13.48	11.49	12.49
38	**Amber Star**	30.06	17.47	23.76
39	**Fire Flash**	11.80	14.60	13.20
40	**Hoot & Howler**	25.11	30.39	27.75
41	**Leila Laird**	20.11	22.37	21.24
42	**Painter's Palette**	18.17	16.65	17.41
43	**Nine**	11.91	14.26	13.09
44	**Dazzler**	6.62	7.90	7.26
45	**Priti**	10.33	11.41	10.87
	Mean	14.90	14.70	**Year:** NS
	CD $_{0.5}$	4.73	2.65	**Genotype:** 0.96 **G X Y:** 1.36

Table 4.1.17: Length of Pedicel (mm) of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	12.80	12.02	12.41
2	**China 65**	6.24	5.68	5.96
3	**Golden Century**	7.33	7.72	7.52
4	**Frothy**	2.23	2.73	2.48
5	**Zwergkonig**	15.73	14.32	15.03
6	**Royal Midnette**	12.99	12.11	12.55
7	**Simply Marvelous**	10.63	10.86	10.74
8	**Chandrika**	6.22	6.38	6.30
9	**Flash Dance**	11.88	12.60	12.24
10	**Kayla**	12.22	11.94	12.08
11	**Sunday Brunch**	8.79	8.63	8.71
12	**Vanessa**	8.70	8.59	8.64
13	**Maigold Sweet Dream**	13.09	12.68	12.89
14	**Blue Blood**	7.48	6.66	7.07
15	**Scarlet Gem**	4.20	4.33	4.27
16	**String of pearls**	9.67	10.34	10.01
17	**Fairy Gold**	5.39	5.16	5.27
18	**Lavender Midnette**	12.28	11.69	11.99
19	**Young Mistress**	14.57	14.30	14.43
20	**Gourmet Popcorn**	8.04	7.77	7.91
21	**Giggles**	9.75	9.02	9.39
22	**Ruby Star**	13.12	11.92	12.52
23	**Wild Fire**	12.89	11.23	12.06
24	**The Fairy**	7.60	6.00	6.80
25	**Red Figurine**	5.98	6.24	6.11
26	**Aishwarya**	10.91	12.09	11.50
27	**Don Don**	6.80	6.56	6.68
28	**Lemon Sweet Dream**	12.65	12.44	12.54
29	**Rise n Shine**	8.53	8.64	8.58
30	**Swinger**	19.19	13.80	16.50
31	**Babe**	15.71	15.87	15.79
32	**Mirabel**	12.82	18.27	15.55
33	**Flamboyant**	8.39	12.92	10.65
34	**Roxy**	10.94	9.82	10.38
35	**Graine De Beaute**	8.49	8.70	8.60
36	**Cup Cake**	12.50	12.72	12.61
37	**Mr. Blue Bird**	11.35	10.15	10.75
38	**Amber Star**	11.60	12.65	12.12
39	**Fire Flash**	17.93	18.43	18.18
40	**Hoot & Howler**	21.68	21.47	21.58
41	**Leila Laird**	14.33	17.04	15.68
42	**Painter's Palette**	21.04	15.30	18.17
43	**Nine**	5.59	13.31	9.45
44	**Dazzler**	9.35	12.81	11.08
45	**Priti**	11.57	11.59	11.58
	Mean	10.92	11.01	**Year:** NS
	CD $_{0.5}$	1.94	3.02	**Genotype:** 1.78 **G X Y:** 2.52

During 2018, the range of number of flowers per bunch varied from 165.33 to 3.67. Maximum number of flowers per bunch (165.33) was recorded in genotype ‘China 65’, whereas, minimum number of flowers per bunch (3.67) was found in ‘Mirabel’, which was found statistically at par with ‘Leila Laird’ (4), ‘Wild Fire’ (4.33), ‘Young Mistress’ (4.67), ‘Maigold Sweet Dream’ (4.67), ‘Swinger’ (5), ‘Cup Cake’ (5), ‘Golden Century’ (5.78), ‘Hoot & Howler’ (6.33), ‘Fire Flash’ (6.67), ‘Babe’ (6.78), ‘China 65’ (10.45 mm), ‘Aishwarya’ (10.67), Flash Dance’ (11.22), and ‘Blue Blood’ (11.22 mm), ‘Vanessa’ (11.67), ‘Amber Star’ (11.89) ‘Sunday Brunch’ (12.33), ‘Kayla’ (12.78), ‘Ruby Star’ (13.22), ‘Fairy Gold’ (13.67) ‘Rise n Shine’ (15.67), and Simply Marvelous’ (15.67).

On pooling the data for two years, maximum number of flowers per bunch (124.11) was found in ‘Dazzler’, whereas, minimum number of flowers per bunch (3.72) was found in ‘Mirabel’, which was found statistically at par with ‘Leila Laird’ (3.78), ‘Swinger’ (4.67), ‘Young Mistress’ (4.67), ‘Wild Fire’ (4.78), ‘Maigold Sweet Dream’ (4.89), ‘Cup Cake’ (5.06), ‘Babe’ (5.61), ‘Golden Century’ (6), ‘Hoot & Howler’ (6.39), ‘Fire Flash’ (7), ‘Sunday Brunch’ (8.95), ‘Amber Star’ (9.17), ‘Kayla’ (9.44), ‘Ruby Star’ (9.94), Flash Dance’ (10.22), ‘Aishwarya’ (10.22), ‘Fairy Gold’ (10.56), ‘Rise n Shine’ (11) and ‘Vanessa’ (13).

Maximum number of flowers per bunch (34.98) was recorded in year 2018.

The data of interactions between genotypes and years showed, Maximum number of flowers per bunch (165.33) was recorded in genotype ‘China 65’ in 2018, whereas, minimum number of flowers per bunch (3.55) was found in ‘Leila Laird’ in 2017, which was found statistically at par with ‘Mirabel’ (3.78), ‘Swinger’ (4.33), ‘Babe’ (4.44), ‘Young Mistress’ (4.67), ‘Cup Cake’ (5.11), ‘Maigold Sweet Dream’ (5.11), ‘Wild Fire’ (5.22), ‘Sunday Brunch’ (5.56), ‘Kayla’ (6.11), ‘Golden Century’ (6.22), ‘Fire Flash’ (6.33), ‘Rise n Shine’ (6.33), ‘Amber Star’ and ‘Hoot & Howler’ (6.44), ‘Ruby Star’ (6.67), ‘Fairy Gold’ (7.44), Flash Dance’ (9.22), ‘Aishwarya’ (9.78) and ‘Lemon Sweet Dream’ (10.66), ‘Don Don’ (12.89), ‘Lavender Midnette’ (13) and ‘Simply Marvelous’ (13.33) in year 2017 and ‘Mirabel’ (3.67), ‘Leila Laird’ (4), ‘Wild Fire’ (4.33), ‘Young Mistress’ (4.67), ‘Maigold Sweet Dream’ (4.67), ‘Swinger’ (5), ‘Cup Cake’ (5), ‘Golden Century’ (5.78), ‘Hoot & Howler’ (6.33), ‘Fire Flash’ (6.67), ‘Babe’ (6.78), ‘China 65’ (10.45 mm), ‘Aishwarya’ (10.67), Flash Dance’ (11.22), and ‘Blue Blood’ (11.22 mm), ‘Vanessa’ (11.67), ‘Amber Star’ (11.89), ‘Sunday Brunch’ (12.33), ‘Kayla’ (12.78), ‘Ruby Star’ (13.22) and ‘Fairy Gold’ (13.67) in 2018.

Table 4.1.18: Number of Flower per Bunch of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	22.59	20.94	21.77
2	**China 65**	9.72	10.45	10.09
3	**Golden Century**	12.99	12.01	12.50
4	**Frothy**	22.49	19.98	21.23
5	**Zwergkonig**	16.32	15.13	15.73
6	**Royal Midnette**	21.73	23.14	22.44
7	**Simply Marvelous**	26.27	27.69	26.98
8	**Chandrika**	15.95	16.32	16.14
9	**Flash Dance**	40.29	35.31	37.80
10	**Kayla**	23.13	17.27	20.20
11	**Sunday Brunch**	15.89	16.13	16.01
12	**Vanessa**	17.89	19.86	18.88
13	**Maigold Sweet Dream**	14.36	12.71	13.54
14	**Blue Blood**	9.01	11.22	10.12
15	**Scarlet Gem**	24.34	22.82	23.58
16	**String of pearls**	19.33	16.41	17.87
17	**Fairy Gold**	13.98	13.03	13.50
18	**Lavender Midnette**	16.50	16.39	16.44
19	**Young Mistress**	12.86	13.19	13.03
20	**Gourmet Popcorn**	14.20	15.48	14.84
21	**Giggles**	21.16	19.88	20.52
22	**Ruby Star**	8.81	11.27	10.04
23	**Wild Fire**	14.63	16.06	15.35
24	**The Fairy**	19.44	18.37	18.90
25	**Red Figurine**	23.25	24.19	23.72
26	**Aishwarya**	24.16	23.22	23.69
27	**Don Don**	21.63	21.90	21.76
28	**Lemon Sweet Dream**	30.76	30.06	30.41
29	**Rise n Shine**	11.03	10.64	10.83
30	**Swinger**	13.10	11.41	12.26
31	**Babe**	10.25	9.53	9.89ss
32	**Mirabel**	14.07	16.05	15.06
33	**Flamboyant**	9.80	10.02	9.91
34	**Roxy**	22.35	22.63	22.49
35	**Graine De Beaute**	19.37	20.49	19.93
36	**Cup Cake**	39.41	37.86	38.63
37	**Mr. Blue Bird**	21.46	21.00	21.23
38	**Amber Star**	22.43	21.62	22.03
39	**Fire Flash**	22.06	18.85	20.46
40	**Hoot & Howler**	22.23	20.24	21.23
41	**Leila Laird**	35.73	33.54	34.64
42	**Painter's Palette**	31.99	26.20	29.09
43	**Nine**	32.82	31.77	32.30
44	**Dazzler**	22.58	23.47	23.03
45	**Priti**	15.63	15.02	15.32
	Mean	20.00	19.35	**Year:** NS
	CD $_{0.5}$	4.49	5.19	**Genotype:** 3.41 **G X Y:** NS

4.1.1.19 Number of petals per flower

Perusal of data presented in Table 4.1.19 revealed that during 2017, the range of number of petals per flower varied from 82.44 to 5. Maximum number of petals per flower (82.44) was recorded in genotype 'Nine', which was at par with 'Frothy' (75.56), whereas, minimum number of petals per flower (5) was found in 'China 65' and 'Dazzler' which was at par with 'Mirabel' (8.22).

During 2018, the range of number of petals per flower varied from 92.33 to 5. Maximum number of petals per flower (92.33) was recorded in genotype 'Nine', which was at par with 'Frothy' (91), whereas, minimum number of petals per flower (5) was found in 'China 65' and 'Dazzler' which was at par with 'Mirabel' (6.67).

On pooling the data for two years, maximum number of petals per flower (87.39) was recorded in genotype 'Nine', which was at par with 'Frothy' (83.28), whereas, minimum number of petals per flower (5) was found in 'China 65' and 'Dazzler' which was at par with 'Mirabel' (7.45).

Number of petals per flower was found non-significant in both the years.

The data of interactions between genotypes and years showed, maximum number of petals per flower (92.33) was recorded in genotype 'Nine' in 2018, which was at par with 'Frothy' (91) in 2018, whereas, minimum number of petals per flower (5) was found in 'China 65' and 'Dazzler' in both years which was at par with 'Mirabel' in both the years. The result was in conformity with Singh (2016).

4.1.1.20 Number of flowering stems per plant

Perusal of data presented in Table 4.1.20 revealed that during 2017, the range of number of flowering stems per plant varied from 267.67 to 29.11. Maximum number of flowering stems per plant (267.67) was recorded in genotype 'Gourmet Popcorn', which was at par with 'Royal Midnette' (260.55), whereas, minimum number of flowering stems per plant (29.11) was found in 'Simply Marvelous', which was found statistically at par with 'Flamboyant' (29.56),
'Mirabel' (30.56), 'Aishwarya' (35.44), 'Scarlet Gem' (35.78), 'Flash Dance' (36), 'Rise n Shine' (36.33), 'Fairy Gold' (36.56) and 'Zwergkonig' (37.55).

During 2018, the range of number of flowering stems per plant varied from 1120.56 to 41.67. Maximum number of flowering stems per plant (1120.56) was recorded in genotype 'Royal Midnette', whereas, minimum number of flowering stems per plant (41.67) was found in 'Mirabel', which was found statistically at par with 'Babe' (68.22), 'Ruby Star' (69.44),

‘The Fairy’ (78.78), ‘Flash Dance’ (83.22), ‘Cup Cake’ (84.44), ‘Flamboyant’ (84.56), ‘Fire Flash’ (89.89) and ‘Scarlet Gem’ (91).

On pooling the data for two years, maximum number of flowering stems per plant (690.56) was found in ‘Royal Midnette’, whereas, minimum number of flowering stems per plant (36.11) was found in ‘Mirabel’, which was found statistically at par with ‘Babe’ (56.33), ‘Flamboyant’ (57.56), ‘Flash Dance’ (59.61), ‘Ruby Star’ (62.94) and ‘Scarlet Gem’ (63.39). Maximum number of flowering stems per plant (178.17) was recorded in year 2018. The data of interactions between genotypes and years showed, Maximum number of flowering stems per plant (1120.56) was recorded in genotype ‘Royal Midnette’ in 2018, whereas, minimum number of flowering stems per plant (29.11) was found in ‘Simply Marvelous’, which was found statistically at par with ‘Flamboyant’ (29.56), ‘Mirabel’ (30.56), Aishwarya’ (35.44), ‘Scarlet Gem’ (35.78), ‘Flash Dance’ (36), ‘Rise n Shine’ (36.33), ‘Fairy Gold’ (36.56) and ‘Zwergkonig’ (37.55), ‘Roxy’ (42.55), ‘Cup Cake’ (43.67), ‘Babe’ (44.45), ‘Vanessa’ (45.11), ‘Fire Flash’ (46.11), ‘Don Don’ and ‘Swinger’ (47.22), ‘Priti’ (48.11). ‘Kayla’ (48.56), ‘Nine’ (49.78), ‘Amber Star’ (51.22), ‘Leila Laird’ (52.22), ‘Sunday Brunch’ (52.44), ‘Lavender Midnette’ (54.78), ‘Ruby Star’ (54.64), ‘Painter’s palette’ (59.89), ‘Blue Bird’ (64.89) and ‘Graine De Beaute’ (68) in 2017.

The character showed wide variations among the cultivars which is in conformity with the findings of Wisniewska *et al* (1994) and Bhattacharjee (1994) Rezaee *et al* (2013) in Roses, and Singh (2016) in floribunda and Dadlani (2016) in miniature rose.

Table 4.1.19: Number of Petal per Flower of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	22.67	20.44	21.56
2	**China 65**	5.00	5.00	5.00
3	**Golden Century**	71.11	81.00	76.06
4	**Frothy**	75.56	91.00	83.28
5	**Zwergkonig**	25.67	34.78	30.22
6	**Royal Midnette**	25.11	22.56	23.83
7	**Simply Marvelous**	26.33	27.00	26.67
8	**Chandrika**	36.00	30.56	33.28
9	**Flash Dance**	35.78	33.33	34.56
10	**Kayla**	20.00	17.89	18.95
11	**Sunday Brunch**	72.11	65.33	68.72
12	**Vanessa**	28.33	28.11	28.22
13	**Maigold Sweet Dream**	16.33	18.00	17.17
14	**Blue Blood**	65.45	62.33	63.89
15	**Scarlet Gem**	52.44	45.33	48.89
16	**String of pearls**	26.33	28.00	27.17
17	**Fairy Gold**	34.22	34.11	34.17
18	**Lavender Midnette**	45.67	54.44	50.06
19	**Young Mistress**	25.44	29.89	27.67
20	**Gourmet Popcorn**	26.89	29.44	28.17
21	**Giggles**	25.11	35.67	30.39
22	**Ruby Star**	37.56	40.44	39.00
23	**Wild Fire**	14.89	20.89	17.89
24	**The Fairy**	32.78	34.67	33.72
25	**Red Figurine**	25.56	30.22	27.89
26	**Aishwarya**	63.67	58.56	61.11
27	**Don Don**	64.89	65.11	65.00
28	**Lemon Sweet Dream**	19.67	15.78	17.72
29	**Rise n Shine**	74.00	55.33	64.67
30	**Swinger**	45.89	38.56	42.22
31	**Babe**	47.67	43.67	45.67
32	**Mirabel**	8.22	6.67	7.45
33	**Flamboyant**	43.33	58.33	50.83
34	**Roxy**	38.00	38.33	38.17
35	**Graine De Beaute**	52.67	24.78	38.72
36	**Cup Cake**	35.11	44.89	40.00
37	**Mr. Blue Bird**	35.11	27.67	31.39
38	**Amber Star**	34.56	35.78	35.17
39	**Fire Flash**	22.44	29.00	25.72
40	**Hoot & Howler**	32.56	41.67	37.11
41	**Leila Laird**	28.44	34.00	31.22
42	**Painter's Palette**	57.89	48.56	53.22
43	**Nine**	82.44	92.33	87.39
44	**Dazzler**	5.00	5.00	5.00
45	**Priti**	18.33	21.33	19.83
	Mean	37.40	37.91	**Year:** NS
	CD $_{0.5}$	7.77	7.03	**Genotype:** 5.20 **G X Y:** 7.36

Table 4.1.20: Number of Flowering Stem per Plant of different miniature rose genotypes.

Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	89.67	173.45	131.56
2	**China 65**	83.89	232.22	158.06
3	**Golden Century**	75.11	213.11	144.11
4	**Frothy**	74.33	261.89	168.11
5	**Zwergkonig**	37.55	221.89	129.72
6	**Royal Midnette**	260.55	1120.56	690.56
7	**Simply Marvelous**	29.11	124.56	76.84
8	**Chandrika**	152.78	343.55	248.17
9	**Flash Dance**	36.00	83.22	59.61
10	**Kayla**	48.56	113.00	80.78
11	**Sunday Brunch**	52.44	163.00	107.72
12	**Vanessa**	45.11	177.78	111.45
13	**Maigold Sweet Dream**	112.22	179.22	145.72
14	**Blue Blood**	64.89	201.56	133.22
15	**Scarlet Gem**	35.78	91.00	63.39
16	**String of pearls**	77.11	131.11	104.11
17	**Fairy Gold**	36.56	154.11	95.33
18	**Lavender Midnette**	54.78	186.11	120.44
19	**Young Mistress**	85.11	168.56	126.83
20	**Gourmet Popcorn**	267.67	374.67	321.17
21	**Giggles**	72.33	96.00	84.17
22	**Ruby Star**	56.44	69.44	62.94
23	**Wild Fire**	141.22	208.33	174.78
24	**The Fairy**	110.11	78.78	94.45
25	**Red Figurine**	121.22	167.67	144.45
26	**Aishwarya**	35.44	116.44	75.94
27	**Don Don**	47.22	111.34	79.28
28	**Lemon Sweet Dream**	93.67	212.33	153.00
29	**Rise n Shine**	36.33	164.56	100.45
30	**Swinger**	47.22	116.22	81.72
31	**Babe**	44.45	68.22	56.33
32	**Mirabel**	30.56	41.67	36.11
33	**Flamboyant**	29.56	85.56	57.56
34	**Roxy**	42.55	119.44	81.00
35	**Graine De Beaute**	68.00	159.56	113.78
36	**Cup Cake**	43.67	84.44	64.06
37	**Mr. Blue Bird**	161.11	242.78	201.94
38	**Amber Star**	51.22	197.44	124.33
39	**Fire Flash**	46.11	89.89	68.00
40	**Hoot & Howler**	77.56	171.22	124.39
41	**Leila Laird**	52.22	134.67	93.45
42	**Painter's Palette**	59.89	143.56	101.72
43	**Nine**	49.78	177.55	113.67
44	**Dazzler**	72.44	118.11	95.28
45	**Priti**	48.11	128.00	88.06
	Mean	74.61	178.17	**Year:** 5.80
	CD $_{0.5}$	12.80	53.93	**Genotype:** 27.52 **G X Y:** 38.92

4.1.1.21 Size of seed vessel (mm)

Perusal of data presented in Table 4.1.21 revealed that during 2017, the range of size of seed vessel varied from 6.95 to 2.13 mm. Largest seed vessel size (6.95 mm) was recorded in genotype ‘Wild Fire’, which was found statistically at par with ‘Golden Century’ (6.77 mm), ‘Flash Dance’ (6.44 mm), ‘Young Mistress’ (6.43 mm), ‘Don Don’ (6.29 mm), ‘Lemon Sweet Dream’ (6.23 mm) Frothy’ (75.56 mm), whereas, smallest seed vessel size was found in ‘Painter’s Palette’ (2.13 mm) followed by ‘Priti’ (2.17 mm), ‘Gourmet Popcorn’ (2.32 mm), ‘China 65’ (2.73) and ‘Dazzler’ (2.85 mm).

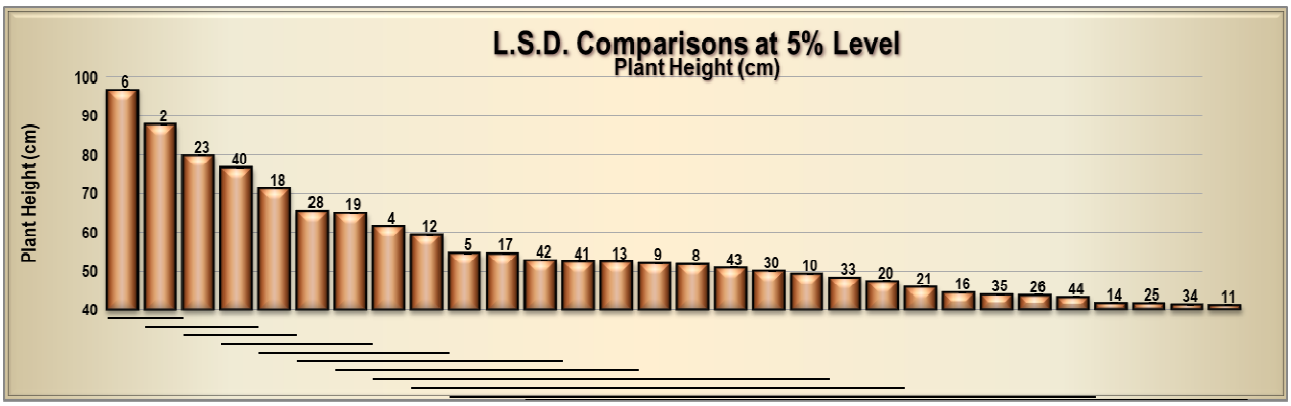
During 2018, the range of size of seed vessel varied from 7.05 to 2.20 mm. Largest seed vessel size (7.05 mm) was recorded in genotype ‘Wild Fire’, which was found statistically at par with ‘Young Mistress’ (6.58 mm), ‘Flash Dance’ (6.50 mm), whereas, smallest seed vessel size was found in ‘Painter’s Palette’ (2.20 mm) followed by ‘Gourmet Popcorn’ (2.20 mm), ‘Priti’ (2.38 mm), ‘Dazzler’ (2.48 mm) and ‘China 65’ (2.51 mm).

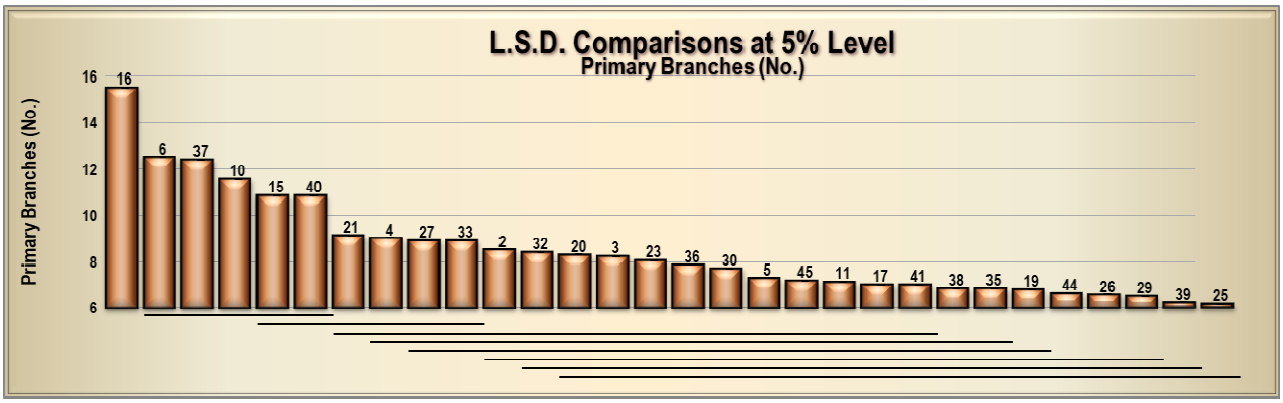
On pooling the data for two years, largest seed vessel size (7 mm) was recorded in genotype ‘Wild Fire’, which was found statistically at par with ‘Young Mistress’ (6.50 mm), ‘Golden Century’ (6.55 mm), whereas, smallest seed vessel size was found in ‘Painter’s Palette’ (2.17 mm) followed by ‘Gourmet Popcorn’ (2.26 mm), ‘Priti’ (2.28 mm), ‘China 65’ (2.62 mm) and ‘Dazzler’ (2.66 mm). Seed vessel size was found non-significant in both the years as well as interaction between genotype and year. The results were similar to findings of Singh (2016).

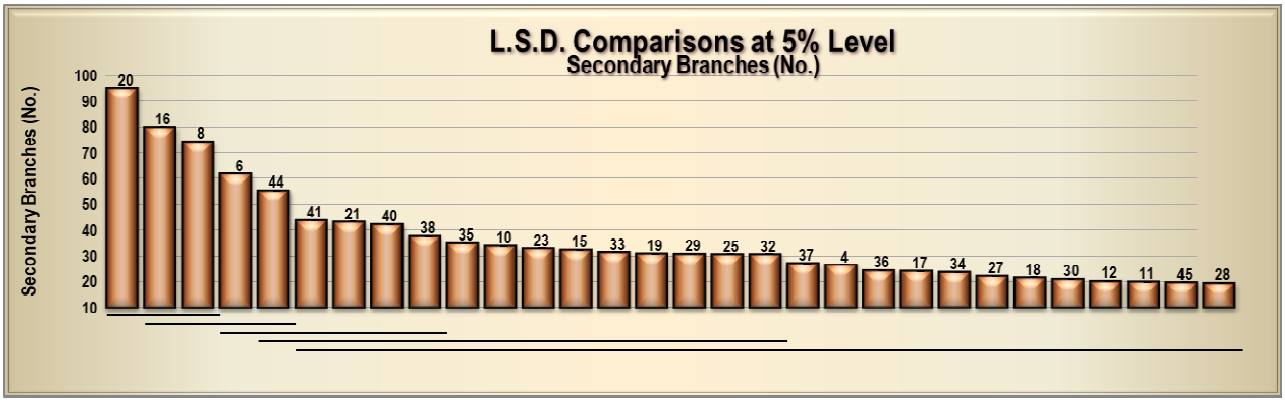
Table 4.1.21: Size of seed vessel (mm) of different miniature rose genotypes.

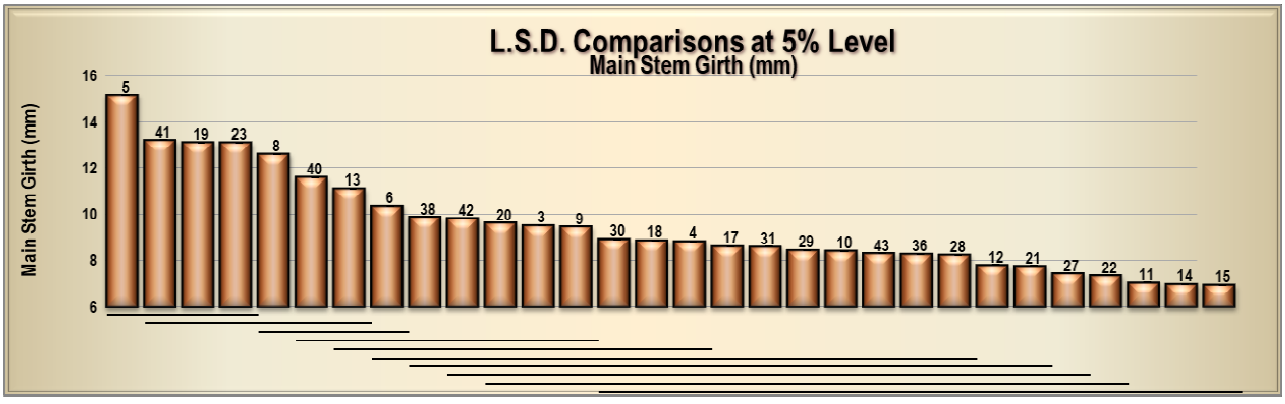
Sl. No.	Variety	2017	2018	Pooled
1	**Bharani**	3.55	3.35	3.45
2	**China 65**	2.73	2.51	2.62
3	**Golden Century**	6.77	6.32	6.55
4	**Frothy**	3.93	3.65	3.79
5	**Zwergkonig**	5.17	5.18	5.17
6	**Royal Midnette**	4.71	4.87	4.79
7	**Simply Marvelous**	5.63	5.29	5.46
8	**Chandrika**	3.50	3.76	3.63
9	**Flash Dance**	6.44	6.50	6.47
10	**Kayla**	3.37	3.46	3.42
11	**Sunday Brunch**	5.75	5.55	5.65
12	**Vanessa**	3.70	3.33	3.51
13	**Maigold Sweet Dream**	5.34	5.27	5.31
14	**Blue Blood**	4.38	4.28	4.33
15	**Scarlet Gem**	4.09	4.31	4.20
16	**String of pearls**	3.90	3.36	3.63
17	**Fairy Gold**	5.43	5.23	5.33
18	**Lavender Midnette**	5.58	5.35	5.46
19	**Young Mistress**	6.43	6.58	6.50
20	**Gourmet Popcorn**	2.32	2.20	2.26
21	**Giggles**	5.59	5.31	5.45
22	**Ruby Star**	4.99	4.75	4.87
23	**Wild Fire**	6.95	7.05	7.00
24	**The Fairy**	3.62	3.28	3.45
25	**Red Figurine**	3.85	3.60	3.73
26	**Aishwarya**	5.93	5.44	5.69
27	**Don Don**	6.29	5.90	6.10
28	**Lemon Sweet Dream**	6.23	6.17	6.20
29	**Rise n Shine**	5.43	5.23	5.33
30	**Swinger**	3.36	3.22	3.29
31	**Babe**	5.62	5.33	5.47
32	**Mirabel**	4.12	4.22	4.17
33	**Flamboyant**	5.36	5.47	5.42
34	**Roxy**	3.19	4.04	3.62
35	**Graine De Beaute**	3.64	3.57	3.61
36	**Cup Cake**	4.73	4.56	4.65
37	**Mr. Blue Bird**	4.59	4.47	4.53
38	**Amber Star**	5.36	5.29	5.32
39	**Fire Flash**	5.42	5.39	5.41
40	**Hoot & Howler**	5.05	5.15	5.10
41	**Leila Laird**	4.19	4.37	4.28
42	**Painter's Palette**	2.13	2.20	2.17
43	**Nine**	5.28	5.47	5.38
44	**Dazzler**	2.85	2.48	2.66
45	**Priti**	2.17	2.38	2.28
	Mean	4.64	4.55	**Year:** NS
	CD $_{0.5}$	0.80	0.66	**Genotype:** 0.52 **G X Y:** NS

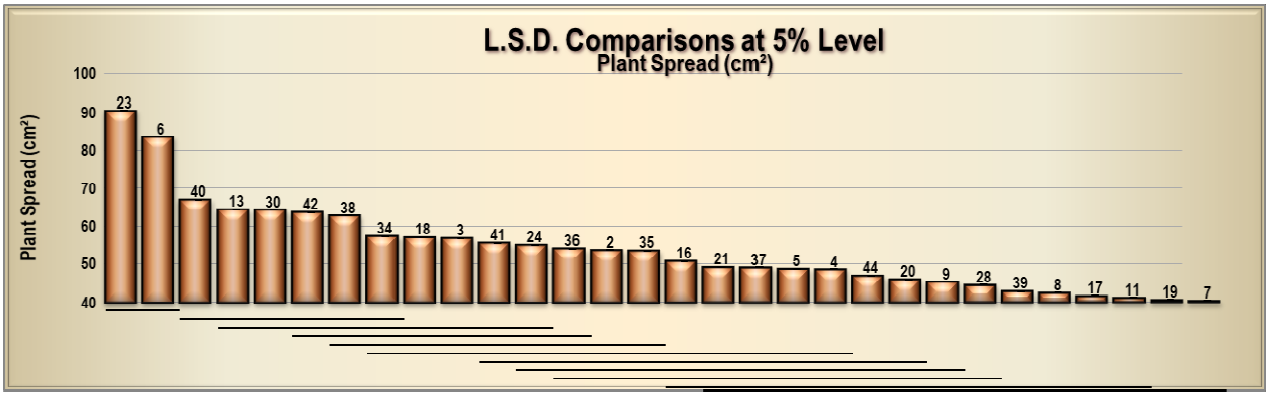
Figure 1. Least Significant Difference Comparison of various characters for pooled data

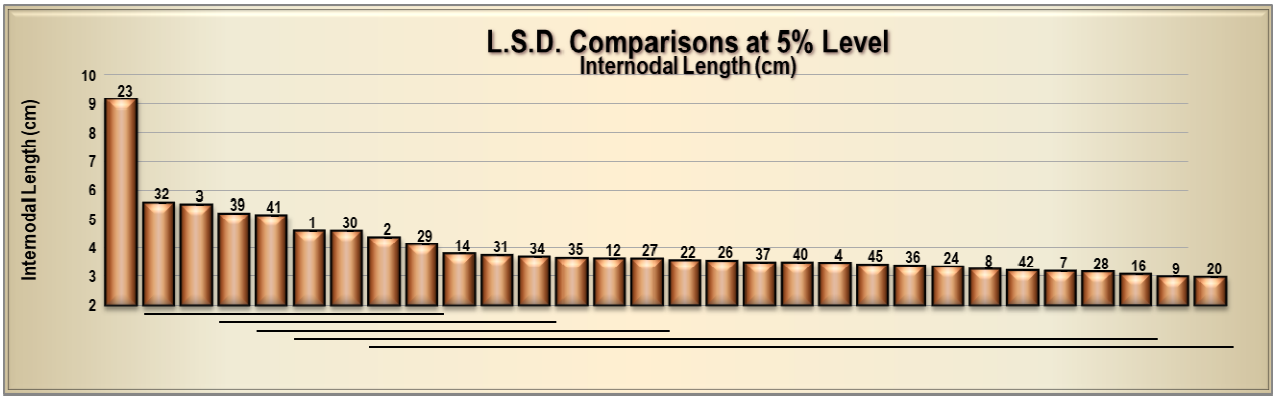


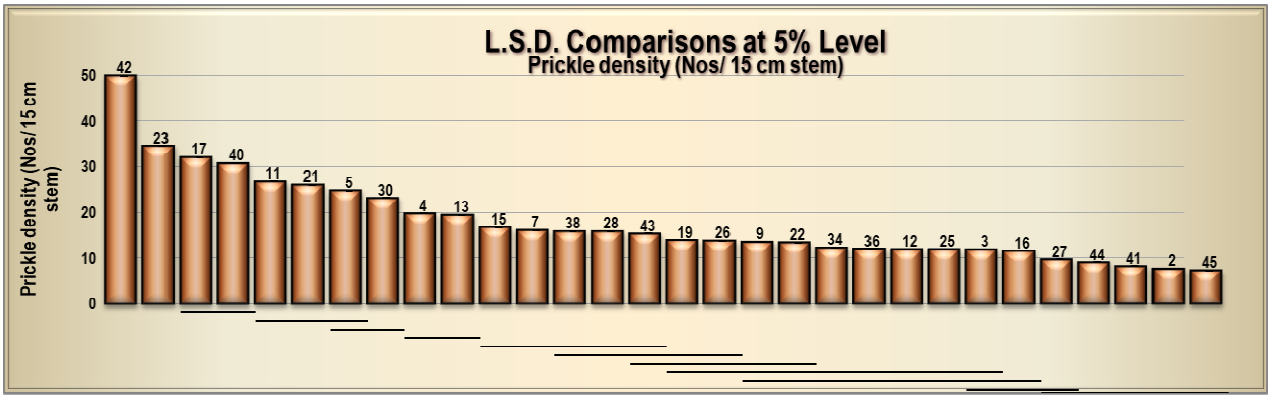


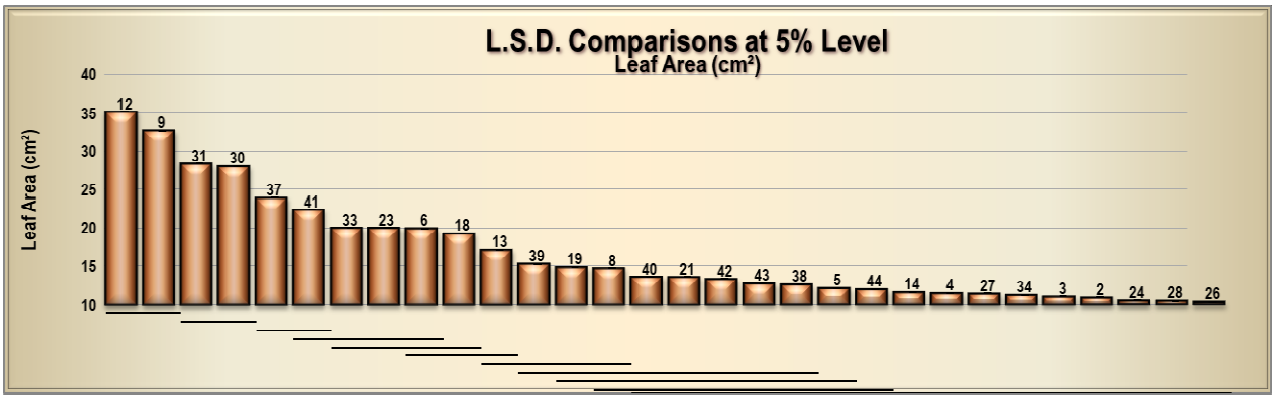


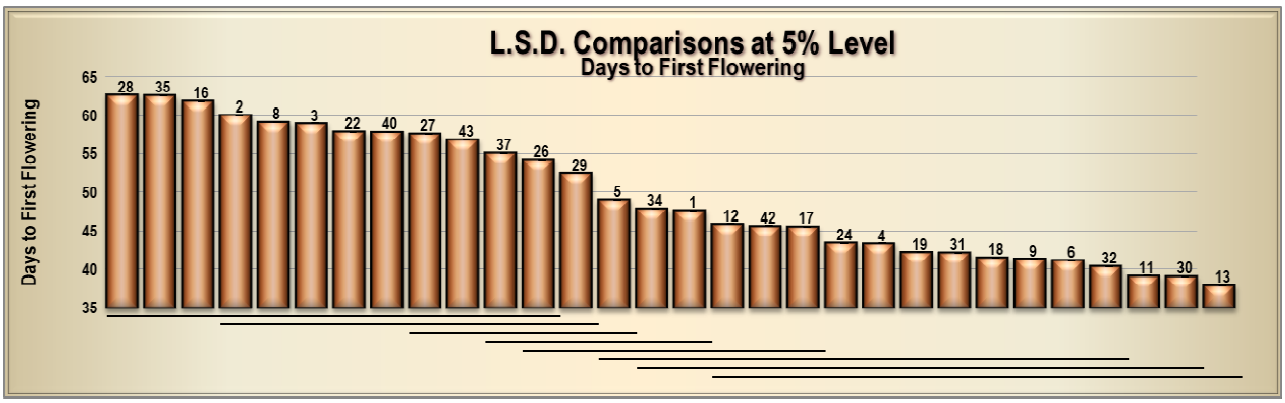


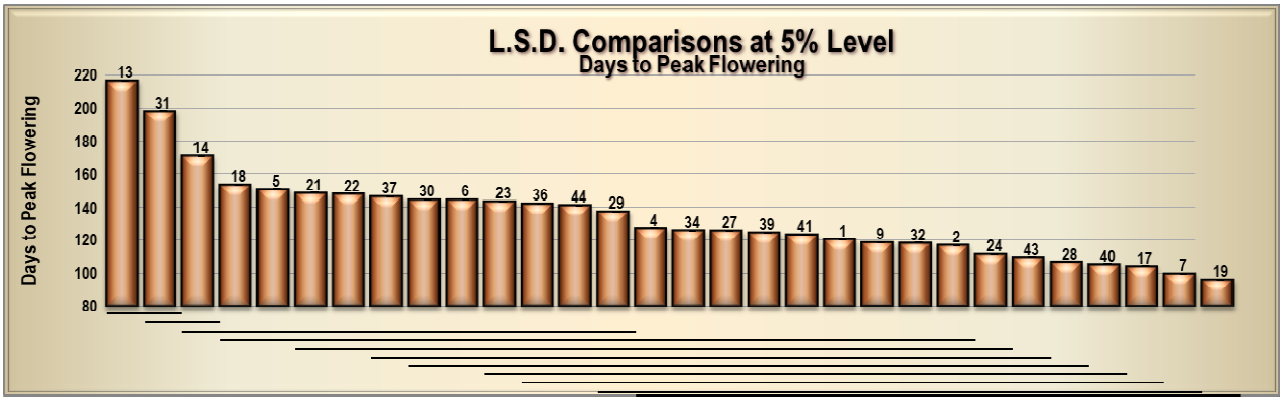

L.S.D. Comparisons at 5% Level
Plant Spread (cm²)
Plant Spread (cm²)
100
90
80
70
60
50
40
23 6 40 13 30 42 38 34 18 3 41 24 36 2 35 16 21 37 5 4 44 20 9 28 39 8 17 11 19 7

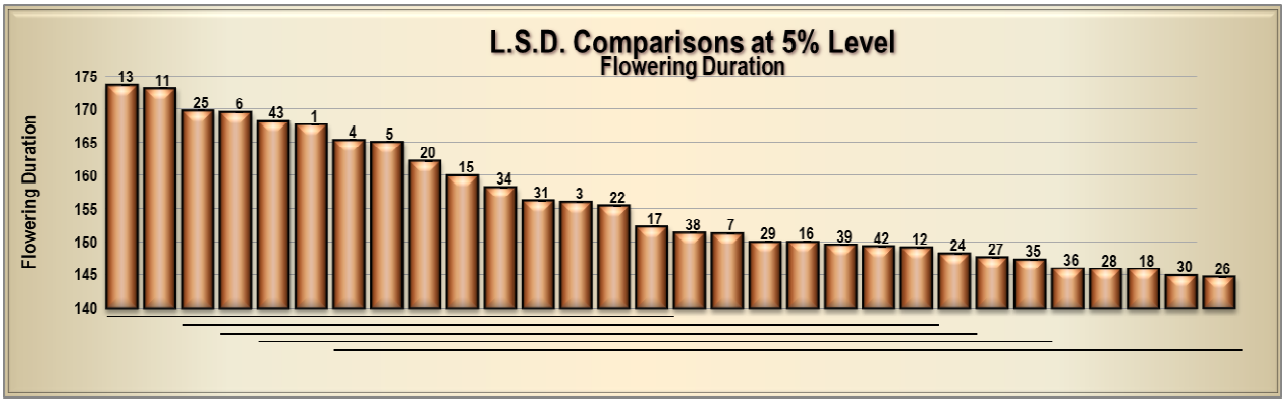

L.S.D. Comparisons at 5% Level
Internodal Length (cm)
Internodal Length (cm)
10
9
8
7
6
5
4
3
2
23 32 3 39 41 1 30 2 29 14 31 34 35 12 27 22 26 37 40 4 45 36 24 8 42 7 28 16 9 20

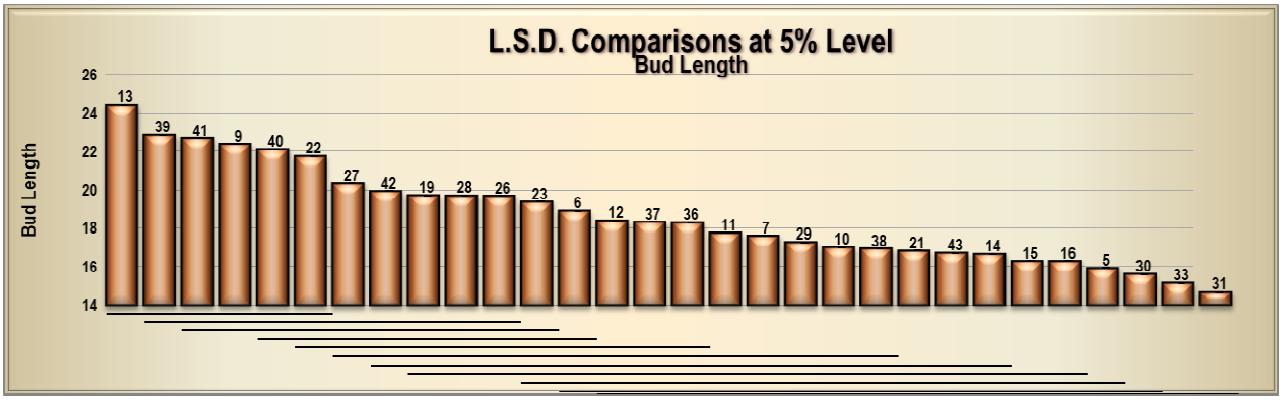

L.S.D. Comparisons at 5% Level
Prickle density (Nos/ 15 cm stem)
Prickle density (Nos/15 cm stem)
50
40
30
20
10
0
42 23 17 40 11 21 5 30 4 13 15 7 38 28 43 19 26 9 22 34 36 12 25 3 16 27 44 41 2 45

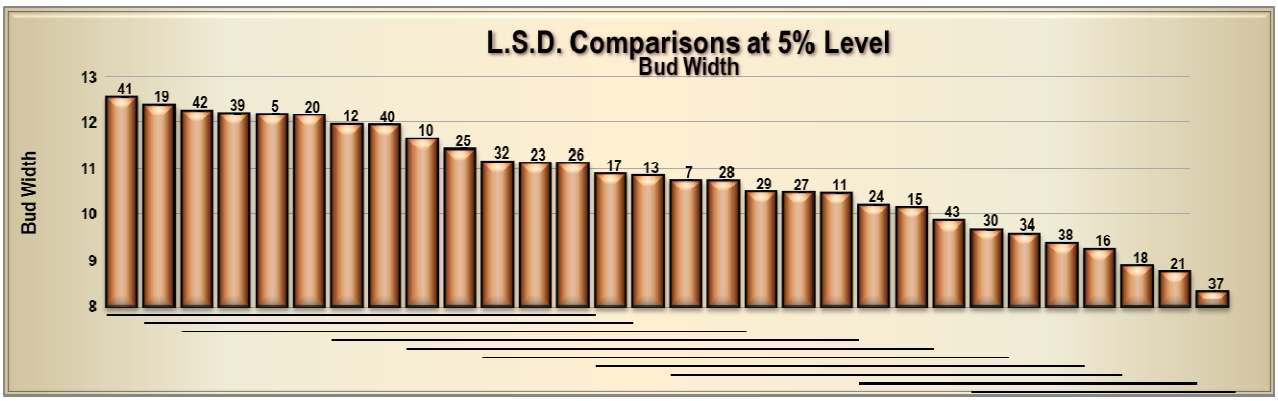

L.S.D. Comparisons at 5% Level
Leaf Area (cm²)
Leaf Area (cm²)
40
35
30
25
20
15
10
12 9 31 30 37 41 33 23 6 18 13 39 19 8 40 21 42 43 38 5 44 14 4 27 34 3 2 24 28 26

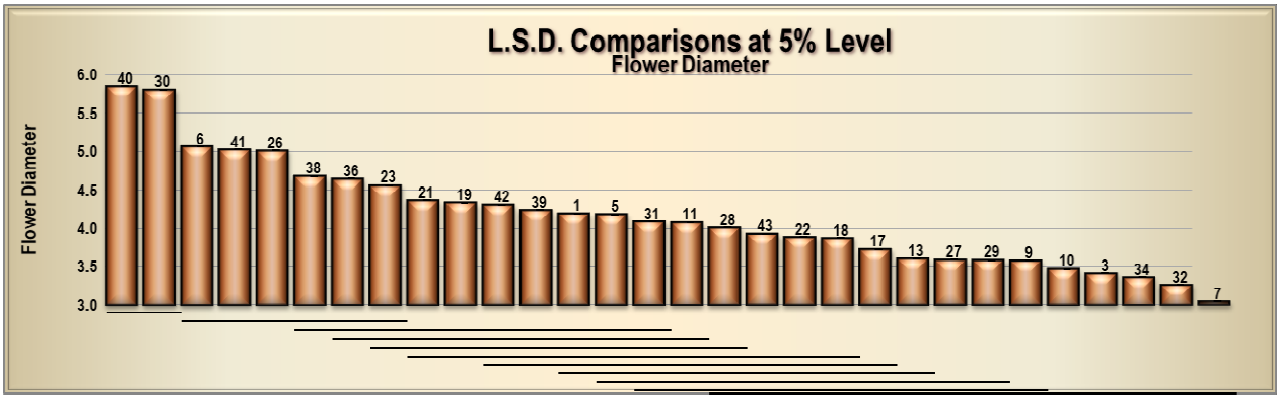

L.S.D. Comparisons at 5% Level
Days to First Flowering
Days to First Flowering
65
60
55
50
45
40
35
28 35 16 2 8 3 22 40 27 43 37 26 29 5 34 1 12 42 17 24 4 19 31 18 9 6 32 11 30 13

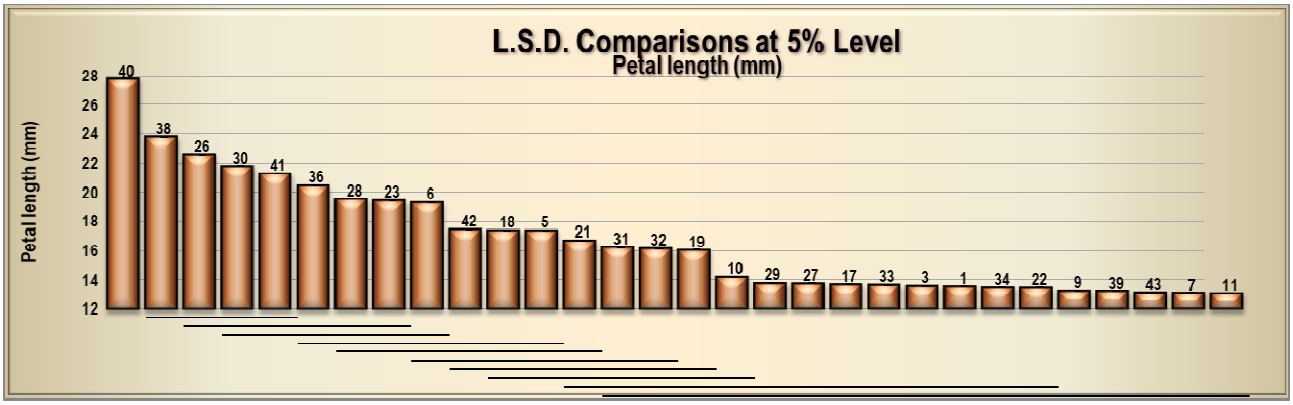

L.S.D. Comparisons at 5% Level
Days to Peak Flowering
Days to Peak Flowering
220
200
180
160
140
120
100
80
13 31 14 18 5 21 22 37 30 6 23 36 44 29 4 34 27 39 41 1 9 32 2 24 43 28 40 17 7 19

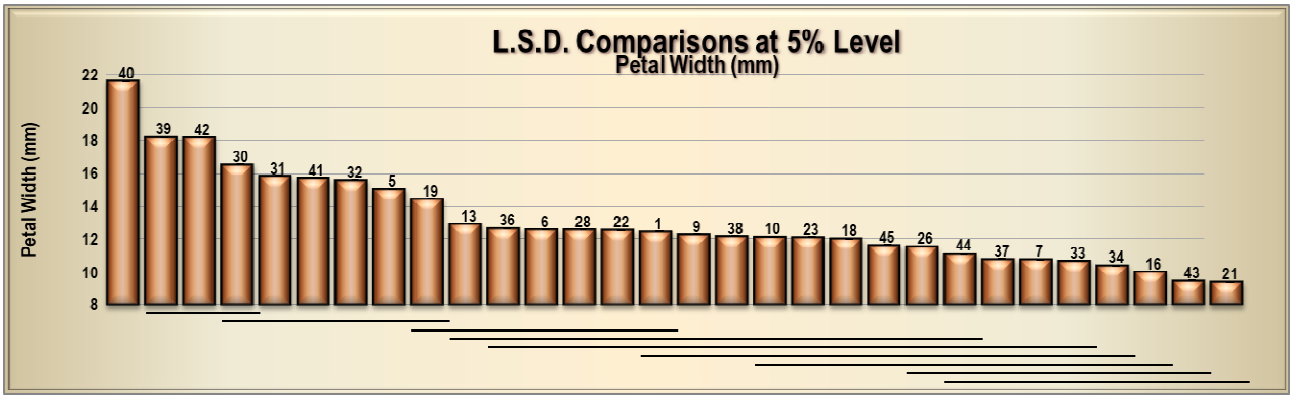

L.S.D. Comparisons at 5% Level
Flowering Duration
Flowering Duration
175
170
165
160
155
150
145
140
13 11 25 6 43 1 4 5 20 15 34 31 3 22 17 38 7 29 16 39 42 12 24 27 35 36 28 18 30 26

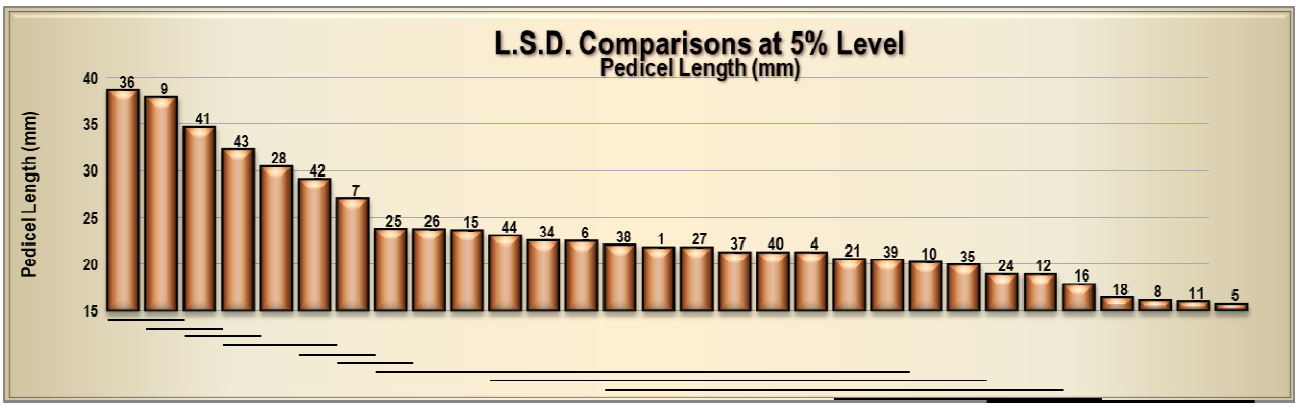

L.S.D. Comparisons at 5% Level
Bud Length
Bud Length
26
24
22
20
18
16
14
13 39 41 9 40 22 27 42 19 28 26 23 6 12 37 36 11 7 29 10 38 21 43 14 15 16 5 30 33 31

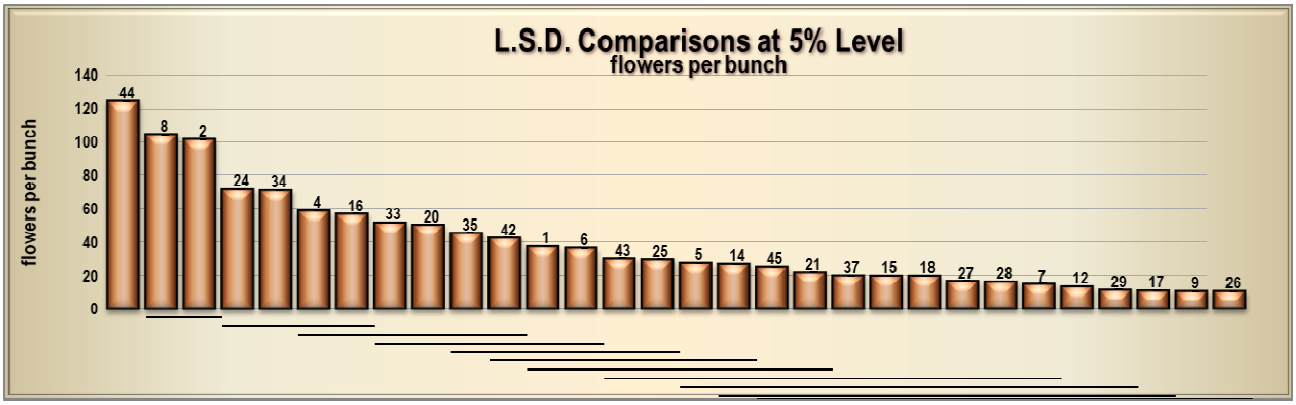

L.S.D. Comparisons at 5% Level
Bud Width
Bud Width
13
12
11
10
9
8
41 19 42 39 5 20 12 40 10 25 32 23 26 17 13 7 28 29 27 11 24 15 43 30 34 38 16 18 21 37

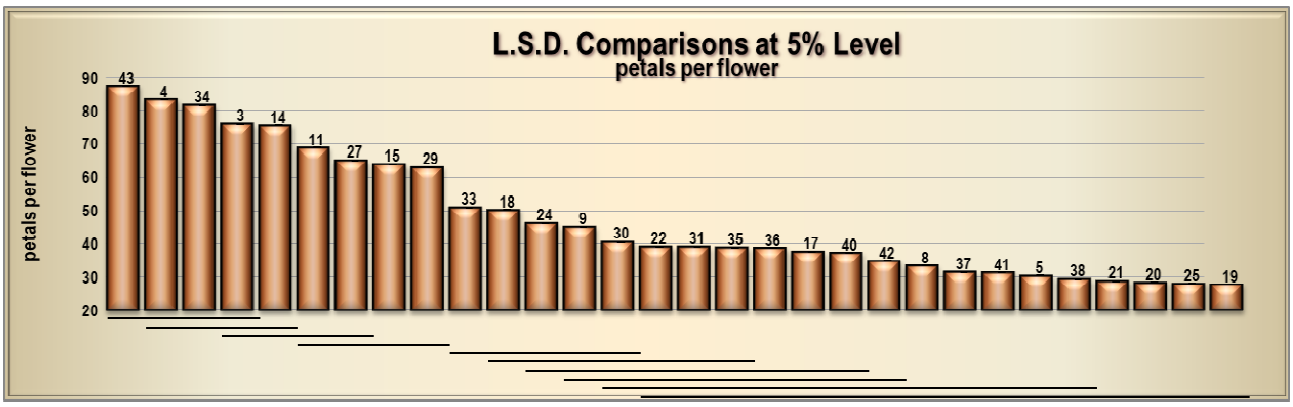

L.S.D. Comparisons at 5% Level
Flower Diameter
Flower Diameter
6.0
5.5
5.0
4.5
4.0
3.5
3.0
40 30 6 41 26 38 36 23 21 19 42 39 1 5 31 11 28 43 22 18 17 13 27 29 9 10 3 34 32 7


L.S.D. Comparisons at 5% Level
Petal length (mm)
Petal length (mm)
28
26
24
22
20
18
16
14
12
40 38 26 30 41 36 28 23 6 42 18 5 21 31 32 19 10 29 27 17 33 3 1 34 22 9 39 43 7 11


L.S.D. Comparisons at 5% Level
Petal Width (mm)
Petal Width (mm)
22
20
18
16
14
12
10
8
40 39 42 30 31 41 32 5 19 13 36 6 28 22 1 9 38 10 23 18 45 26 44 37 7 33 34 16 43 21


L.S.D. Comparisons at 5% Level
Pedicel Length (mm)
Pedicel Length (mm)
40
35
30
25
20
15
36 9 41 43 28 42 7 25 26 15 44 34 6 38 1 27 37 40 4 21 39 10 35 24 12 16 18 8 11 5


L.S.D. Comparisons at 5% Level
flowers per bunch
flowers per bunch
140
120
100
80
60
40
20
0
44 8 2 24 34 4 16 33 20 35 42 1 6 43 25 5 14 45 21 37 15 18 27 28 7 12 29 17 9 26


L.S.D. Comparisons at 5% Level
petals per flower
petals per flower
90
80
70
60
50
40
30
20
43 4 34 3 14 11 27 15 29 33 18 24 9 30 22 31 35 36 17 40 42 8 37 41 5 38 21 20 25 19

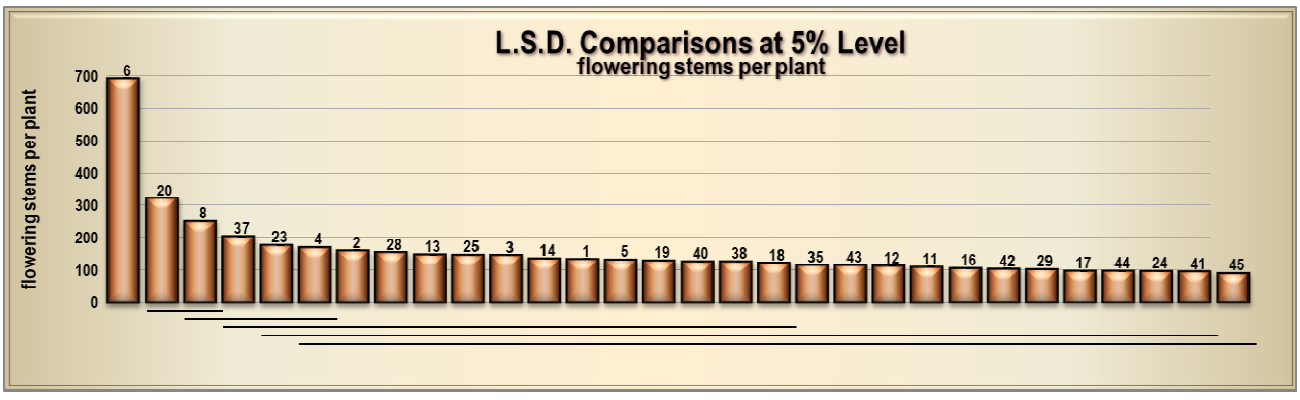

L.S.D. Comparisons at 5% Level
flowering stems per plant
flowering stems per plant
700
600
500
400
300
200
100
0
6 20 8 37 23 4 2 28 13 25 3 14 1 5 19 40 38 18 35 43 12 11 16 42 29 17 44 24 41 45

Plate 1a: Plants in full bloom in different miniature rose genotypes

Plate 1b: Plants in full bloom in different miniature rose genotypes

Plate 1c: Plants in full bloom in different miniature rose genotypes

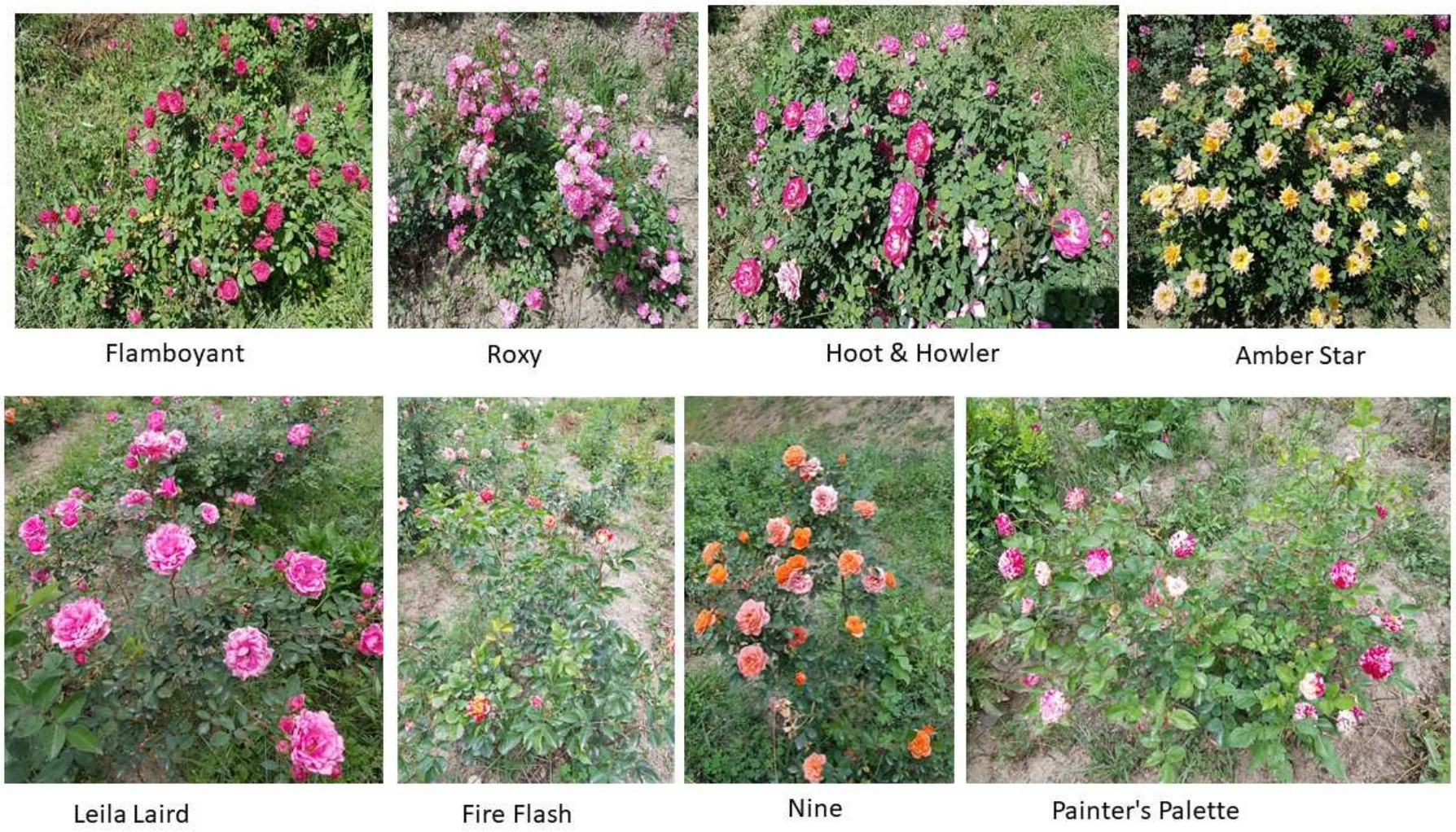


Plate 1d: Plants in full bloom in different miniature rose genotypes

4.1.2 Parameters of variability

The extent of variation with respect to twenty one characters of 45 genotypes of miniature Rose measured in terms of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), along with the amount of heritability (h^2) Broad sense and the genetic advance (5%) and genetic gain are presented in Table 4.2.1. Their respective ranges have been described in Table 3.2 (The range of genetic parameters for assessing variability).

The pooled analysis of variance presented in Table 4.2.1. revealed that the treatment mean squares were significant for all the characters indicating the varietal differences among the various characters studied.

4.1.2.1 Coefficients of variability

The observed variations in the characters among all the genotypes are due to effect of genotype and environment. Environmental variations are not fixable. The perusal of data present in Table 4.1.2 clearly showed that the phenotypic coefficients of variability (PCV) was higher than the genotypic coefficients of variability (GCV) for all the characters.

Pooled analysis over all the two years (2017-18) revealed highest values denoting high range of PCV (%) was observed for number of secondary branches (99.29), Plant height (36.53), primary branches (40.70), main stem girth (38.68), prickle density (77.05), internodal length (50.20), days to first flowering (31.00), days to peak flowering (38.91), leaf area (53.77), flowers per bunch (92.15), petals per flower (61.50), flowering stem per plant (94.91), plant spread (34.12), petal length (33.78), petal width (39.13) pedicel length (39.37), whereas, moderate values were observed in characters such as for most of the characters except flowering duration (15.02), Bud width (27.90), size of seed vessel (28.46), Bud length (28.54) and flower diameter (29.32). No character exhibited low PCV.

The genotypic coefficient of variability (GCV) was recorded maximum for secondary branches (61.13), primary branches (31.41), prickle density (75.65), internodal length (31.92), leaf area (50.63), flowers per bunch (90.97), petals per flower (55.50), flowering stem per plant (76.08), petal width (35.33) and pedicel length (36.56). However, GCV was found moderate in

plant height (28.72), main stem girth (28.93), days to first flowering (25.33), days to peak flowering (25.96), plant spread (28.75), petal length (27.91), Bud width (23.97), size of seed vessel (26.90), Bud length (21.75) and flower diameter (25.48). whereas, low values were observed in character flowering duration (7.93).

4.1.2 Estimates of genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic gain in genotypes of rose (pooled)

S. No.	Parameters	Coeffiecients of variability (%)		h^2 (Broad Sense) %	Genetic Advance 5%	Genetic Gain
		GCV	PCV			
1	Plant Height (cm)	28.72**	36.53***	62**	22.89*	46.51**
2	Primary Branches (No.)	31.41***	40.70***	60**	3.68*	49.93**
3	Secondary Branches (No.)	61.13***	99.29***	38*	21.81*	77.52***
4	Main Stem Girth (mm)	28.93**	38.68***	56**	3.67*	44.58**
5	Prickle density (Nos/ 15 cm stem)	75.65***	77.05***	96***	20.38*	53.01***
6	Internodal Length (cm)	31.92***	50.20***	40*	1.45*	41.80**
7	Days to First Flowering	25.33**	31.00***	67**	18.48*	42.63**
8	Days to Peak Flowering	25.96**	38.91***	45*	41.59**	35.69**
9	Leaf Area (cm^2)	50.63***	53.77***	89***	13.51*	98.22***
10	Flowering Duration	7.93*	15.02**	28*	12.81*	8.62*
11	Bud Length	21.75**	28.54***	58**	5.63*	34.15**
12	Bud Width	23.97**	27.90***	74**	3.97*	42.41**
13	Flower Diameter	25.48**	29.32***	76**	1.66*	45.63**
14	flowers per bunch	90.97***	92.15***	80***	52.08***	85.62***
15	petals per flower	55.50***	61.50***	81***	38.95**	93.18***
16	flowering stems per plant	76.08***	94.91***	64**	88.78***	75.62***
17	Size of seed vessel (mm)	26.90**	28.46***	89***	2.41*	52.37***
18	Plant Spread (cm^2)	28.75**	34.12***	71**	23.44*	49.92**
19	Petal length (mm)	27.91**	33.78***	68**	7.03*	47.50**
20	Petal Width (mm)	35.33***	39.13***	82***	7.20*	65.71***
21	Pedicel Length (mm)	36.56***	39.37***	86***	13.76*	69.94***

The estimates of phenotypic and genotypic coefficients of variability gave a clear picture of amount of variations present in the available germplasm. For all the characters studied, phenotypic coefficients of variability were higher in magnitude than genotypic coefficients of variability, though difference was less in majority the cases. Thus, showing that these traits are less influenced by environmental factors. Coefficients of variability varied in magnitude from character to character (either low or moderate or high).

Therefore, it indicated that there was a great diversity in the experimental material used. Similar results were reported by Misra and Gupta (2003) in carnation. Nazir *et al.,* (2004) and Pratap and Rao (2006) also reported higher PCV than GCV for most of the characters in gladiolus.

The GCV values were observed lowest for flowering duration suggesting low variability among the genotypes studied. These results are in conformity with the findings of Misra (2002); Namita *et al.* (2008) and Kadam *et al.* (2013) in gladiolus.

Narrow difference between PCV and GCV was noticed for pedicel length, leaf area, petal width, size of seed vessel, petals per flower, prickle density, flowers per bunch, flower diameter and days to first flowering which revealed greater stability of the character against environmental fluctuation which indicated that the phenotypic expression of all the genotypes is under genetic control and environment has less influence on their expression. Similar results were also reported by Misra (2002) in carnation and Balaram and Janakiram (2009) in gladiolus. Genetic improvement in the performance of these characters is very much desirable as the improved lines would not be affected by environment expressivity and thus productivity is predictable. De (1992) also reported narrow difference between PCV and GCV for characters like plant height, days for flowering, floret length etc. in gladiolus, thereby, suggesting major contribution of genetic variability towards the total variance. The marked differences between PCV and GCV were observed for secondary branches, internodal length, day to peak flowering, leaf area etc confirming the predominance of genotype x environment interaction for these traits.

4.1.2.2 Heritability

Heritability is the heritable portion of phenotypic variance. It is, therefore, good index of the transmission of characters from parents to offspring. The estimates of heritability help the plant breeder in selection of elite genotypes from diverse genetic populations. The genotypic coefficients of variation does not offer full scope to estimate the variations that are heritable and therefore, estimation of heritability becomes necessary. Burton and De-Vane

(1953) has suggested that genetic coefficients of variability along with heritability estimates would give a reliable indication of expected amount of improvement through selection. The estimates of heritability in broad sense give a measure of transmission of characters from one generation to another, thus giving an idea of heritable portion of variability and enabling the plant breeder in isolating the elite selection in the crop. In the present study, the estimates of heritability varied from 28 % to 96 % for different characters under study as shown in Table 4.1.2.

High heritability estimates were observed for prickle density (96 %), leaf area (89 %), flowers per bunch (80 %), petals per flower (81 %), petal width (82 %) and pedicel length (86 %). It was found moderate for Plant height (62 %), primary branches (60 %), main stem girth (56 %), days to first flowering (67 %), flowering stem per plant (64 %), plant spread (71 %), petal length (68 %), Bud width (74 %), size of seed vessel (89 %), Bud length (58 %) and flower diameter (76 %) whereas, low heritability was observed for secondary branches (38 %), internodal length (40 %), days to peak flowering (45 %), flowering duration (28 %),.

Low heritability values suggest the involvement of environmental component in the expression of character, thereby, direct selection of a particular character would be futile exercise and hence indirect selection needs to be adopted (Rao and Pratap, 2006).

4.1.2.3 Genetic advance and genetic gain

Genetic advance is the improvement in the mean genotypic value of selected plants over the parental population. High heritability estimates along with high genetic advance as per cent of mean will be more useful than heritability alone to know the ultimate effect of selection.

Perusal of data presented in the Table 4.1.2. revealed that the range of genetic advance was having range from 1.45 to 88.78. High genetic advance was found for flowers per bunch (52.08) and flowering stem per plant (88.78), whereas, the moderate genetic advance along with high heritability was recorded for days to peak flowering (41.59) and number of petals per flower (38.95). whereas, low genetic advance was observed in case of secondary branches (21.89), Plant height (22.89), primary branches (3.68), main stem girth (3.67), prickle density (20.38), internodal length (1.45), days to first flowering (18.48), leaf area (13.51), plant spread (23.44), petal length (7.03), petal width (7.20) pedicel length (13.76), flowering duration (12.81), Bud width (3.97), size of seed vessel (2.41), Bud length (5.63) and flower diameter (1.66).

A relative comparison of heritability estimates and genetic gain (genetic advance as per cent of mean) will give an idea of nature of gene action governing a particular character. Genetic gain (expressed as per cent of population mean) was High to moderate in nature and ranged from 34.15-93.18 per cent for different characters under study (Table 2).

High genetic gain was found in secondary branches (77.52), prickle density (53.01), leaf area (98.22), flowers per bunch (85.62), petals per flower (93.18), flowering stem per plant (75.62), petal width (65.71) pedicel length (69.94), size of seed vessel (52.37) while moderate genetic gain was observed in rest of the characters viz., Plant height (46.51), primary branches (49.93), main stem girth (44.58), internodal length (41.80), days to first flowering (42.63), days to peak flowering (35.69), plant spread (49.92), petal length (47.50), flowering duration (8.62), Bud width (42.41), Bud length (34.15) and flower diameter (45.63).

Characters viz., Prickle density (Nos/ 15 cm stem), Leaf Area (cm^2), flowers per bunch, petals per flower, Size of seed vessel (mm), Petal Width (mm) and Pedicel length showed high heritability along with high genetic gain indicated considerable additive gene effects. This character appeared to be controlled by additive gene action and selection for such characters will be very effective (Panse, 1957).

4.2 Genetic divergence

Genetic diversity plays an important role in plant breeding because hybrids between lines of diverse origin, generally, display a greater heterosis than those between closely related parents. On the basis of performance of various traits, during the present study, the clustering pattern of 45 diverse genotypes of miniature rose has been presented in the Table 4.2. All the genotypes were grouped into 19 distinct clusters. Maximum number of 14 genotypes was accommodated in cluster 2, followed by cluster 1 accommodating 8 genotypes, cluster 3 having 7 genotypes, whereas, rest of the clusters consisted of only one genotype each. The genotypes falling in the same cluster are more closely related than those belonging to another cluster.

Average inter and intra cluster divergence (D^2) values are presented in the Table 4.3.3. The diagonal figures in the table represent the intra cluster distances. The intra cluster distance was maximum in cluster-3 (17.60) followed by cluster-2 (15.55) and cluster 1 (11.61) whereas, minimum in rest of the clusters (0.00).

Whereas, highest inter cluster distance (154.87) was recorded between cluster-10 & cluster-19 followed by cluster-6 & cluster-19 (150-79) and cluster- 7 & cluster-19 and lowest

(8.27) was observed between cluster-9 & cluster-4 followed by cluster-10 & cluster-7 (10.07).

The cluster means for various important traits of rose is presented in Table 4.3.2. During this study, maximum cluster mean (96.7 cm) was recorded for plant height in cluster-17 followed by cluster-13 (85.90 cm), cluster-18 (79.7).

Cluster mean of Primary Branches (PB) was found highest in cluster- 17 (12.5) followed by cluster – 4 (10.8) and cluster- 9 (9.0).

In Secondary Branches highest cluster mean was found in cluster – 11 (74.2) followed by cluster- 17 (61.6) and cluster -12 (55.3).

In Main Stem Girth highest cluster mean was found in cluster – 14 (13.2) followed by cluster- 17 (13.1) and cluster -11 (12.6).

In Prickle density highest cluster mean was found in cluster – 19 (49.8) followed by cluster- 18 (34.3) and cluster - 3 (26.0).

In Internodal Length highest cluster mean was found in cluster – 18 (9.2) followed by cluster- 5 (5.6) and cluster -13 (4.3).

In Days to First Flowering highest cluster mean was found in cluster – 13 (60.0) followed by cluster- 2 (47.9) and cluster -19 (45.6).

In Days to Peak Flowering highest cluster mean was found in cluster – 6 (197.8) followed by cluster- 10 (171.1) and cluster -17 (144.2).

In Leaf Area highest cluster mean was found in cluster – 15 (35.1) followed by cluster- 16 (32.7) and cluster -6(28.3).

In Flowering Duration highest cluster mean was found in cluster – 17 (169.5) followed by cluster- 9 (165.3) and cluster -4 (159.9).

In Bud Length highest cluster mean was found in cluster – 14 (22.7) followed by cluster- 16 (22.4) and cluster -19 (19.9).

In Bud Width highest cluster mean was found in cluster – 14 (12.5) followed by cluster- 19 (12.2) and cluster -15 (11.9).

In Flower Diameter highest cluster mean was found in cluster – 17 (5.1) followed by cluster- 14 (5.0) and cluster -18 (4.6). In flowers per bunch highest cluster mean was found in cluster – 12 (124.1) followed by cluster- 11 (104.1) and cluster -9 (58.3).

In petals per flower highest cluster mean was found in cluster – 9 (83.3) followed by cluster- 10 (75.5) and cluster -4 (63.9).

In flowering stems per plant highest cluster mean was found in cluster – 17 (690.6) followed by cluster- 11 (248.2) and cluster -18 (174.8).

In Size of seed vessel highest cluster mean was found in cluster – 18 (7.0) followed by cluster- 16 (6.5) and cluster -6 (5.5).

In Plant Spread highest cluster mean was found in cluster – 18 (90.2) followed by cluster- 17 (83.4) and cluster -19 (63.5)

In Petal length highest cluster mean was found in cluster – 14 (21.2) followed by cluster- 18 (19.4) and cluster -17 (19.3).

In Petal Width highest cluster mean was found in cluster – 19 (18.2) followed by cluster- 6 (15.8) and cluster -14 (15.7).

In Pedicel Length highest cluster mean was found in cluster – 16 (37.8) followed by cluster- 14 (34.6) and cluster -19 (29.1).

Contribution % of different characters towards divergence:

Among 21 characters, different characters contributed differently towards divergence and is represented in Table 4.3.4. Range of contribution varied from 0.01 % to 35.35%. Highest contributing character was Prickle density (35.35 %) followed by Leaf Area (13.84 %) and Size of seed vessel (13.84 %). Lowest contribution was recorded from characters Main Stem Girth (0.01 %), Internodal Length (0.01 %) and Flowering Duration (0.01 %).

Table No. 4.2.1: Clustering pattern 45 miniature rose genotypes on the basis of genetic divergence (D^2).

Cluster	**Number of Genotypes**	**Name of Genotypes**
Cluster 1	8	The Fairy, Graine De Beaute, Roxy, Bharani, Red Figurine, Kayla, String of Pearls, Gourmet Popcorn
Cluster 2	14	Aishwarya, Lemon Sweet Dream, Amber Star, Simply Marvelous, Cup Cake, Don Don, Nine, Young Mistress, Ruby Star, Rise n Shine, Golden Century, Lavevender Midnette, Fire Flash, Mr. Blue Bird
Cluster 3	7	Sunday Brunch, Fairy Gold, Giggles, Zwekonig, Maigold Sweet Dream, Swinger, Hoot & Howler
Cluster 4	1	Scarlet Gem
Cluster 5	1	Mirabel
Cluster 6	1	Babe
Cluster 7	1	Flamboyant
Cluster 8	1	Priti
Cluster 9	1	Frothy
Cluster 10	1	Blue Blood
Cluster 11	1	Chandrika
Cluster 12	1	Dazzler
Cluster 13	1	China 65
Cluster 14	1	Leila Laird
Cluster 15	1	Vanessa
Cluster 16	1	Flash Dance
Cluster 17	1	Royal Midnette
Cluster 18	1	Wild Fire
Cluster 19	1	Painter's Pallete

Table No.4.2.2: Cluster means for different characters among 45 genotypes of miniature Rose

Cluster	1 Cluster	2 Cluster	3 Cluster	4 Cluster	5 Cluster	6 Cluster	7 Cluster	8 Cluster	9 Cluster	10 Cluster	11 Cluster	12 Cluster	13 Cluster	14 Cluster	15 Cluster	16 Cluster	17 Cluster	18 Cluster	19 Cluster
1 Cluster	**11.61**																		
2 Cluster	21.95	**15.55**																	
3 Cluster	39.75	27.70	**17.60**																
4 Cluster	14.81	21.35	31.22	0.00															
5 Cluster	16.82	23.14	50.35	30.73	0.00														
6 Cluster	33.81	25.53	49.14	47.71	23.74	0.00													
7 Cluster	18.88	19.97	40.89	23.16	20.25	**11.38**	0.00												
8 Cluster	14.35	32.04	51.10	19.14	17.80	36.42	23.01	0.00											
9 Cluster	20.53	28.33	32.18	**8.27**	47.78	48.18	24.84	25.90	0.00										
10 Cluster	20.30	29.16	58.31	24.51	23.73	20.38	**11.07**	16.44	23.99	0.00									
11 Cluster	17.08	31.59	50.59	25.69	30.54	33.48	19.33	18.55	18.03	17.95	0.00								
12 Cluster	17.12	39.16	54.45	27.30	30.20	47.24	26.90	16.84	25.59	30.75	11.72	0.00							
13 Cluster	21.21	39.19	53.95	32.92	31.64	42.08	24.41	20.57	26.25	25.71	11.93	13.49	0.00						
14 Cluster	32.29	22.52	36.58	36.43	31.63	31.19	34.47	48.18	46.16	49.63	49.42	49.31	62.92	0.00					
15 Cluster	34.02	29.53	36.87	35.63	43.01	24.18	21.72	43.33	34.18	39.86	35.97	43.36	42.11	24.05	0.00				
16 Cluster	51.87	30.57	42.28	46.60	61.57	33.90	35.66	69.47	46.78	57.54	57.22	65.01	73.31	18.88	19.03	0.00			
17 Cluster	36.91	28.03	43.44	50.15	35.89	26.58	33.19	50.56	50.43	44.35	42.70	54.36	47.86	25.28	35.88	39.70	0.00		
18 Cluster	80.63	52.01	25.97	68.43	88.64	76.29	71.39	101.80	65.02	103.08	90.94	98.38	91.13	58.68	57.62	51.99	64.54	0.00	
19 Cluster	102.89	96.51	50.31	84.26	137.28	**150.79**	**131.24**	116.12	77.47	**154.87**	119.85	105.47	119.38	94.39	96.28	103.68	**122.68**	56.18	0.00

Character Abbreviations: Plant Height (PH); Primary Branches (PB); Secondary Branches (SB); Main Stem Girth (MSG); Prickle density (PD); Internodal Length (IL); Days to First Flowering (DFF); Days to Peak Flowering (DPF); Leaf Area (LA); Flowering Duration (FD); Bud Length (BL); Bud Width (BW); Flower Diameter (FD); flowers per bunch (FB); petals per flower (PF); flowering stems per plant (FSP); Size of seed vessel (SSV); Plant Spread (PS); Petal length (PL); Petal Width (PW); Pedicel Length (PDL)

Table No.4.2.3: Average intra and inter cluster distance (D^2) between 19 clusters made by 45 miniature rose genotypes.

Cluster	PH	PB	SB	MSG	PD	IL	DFF	DPF	LA	FD	BL	BW	FD	FB	PF	FSP	SSV	PS	PL	PW	PDL
Cluster 1	42.7	8.0	40.0	6.6	8.2	3.3	43.2	98.6	8.7	154.5	13.7	9.7	2.9	46.2	36.1	133.9	3.4	46.2	12.4	9.3	20.0
Cluster 2	45.3	6.9	20.0	8.0	11.2	3.5	**47.9**	114.7	12.7	147.8	18.1	9.6	3.9	12.8	42.5	108.0	5.5	44.1	16.1	11.4	21.5
Cluster 3	53.6	7.9	25.8	10.0	**26.0**	2.7	42.1	135.8	14.1	154.6	17.9	10.7	4.5	12.0	37.1	109.8	5.0	53.6	17.5	12.8	16.1
Cluster 4	41.0	**10.8**	32.2	6.9	16.7	2.8	37.3	85.9	5.0	**159.9**	16.3	10.1	2.7	19.5	**63.9**	63.4	4.2	27.1	10.4	4.3	23.6
Cluster 5	30.7	8.4	30.4	6.2	0.0	**5.6**	40.3	117.9	8.5	106.7	14.2	11.1	3.3	3.7	7.4	36.1	4.2	32.7	16.1	15.5	15.1
Cluster 6	37.7	5.9	6.8	8.6	0.0	3.7	42.1	**197.8**	**28.3**	156.1	14.7	6.4	4.1	5.6	39.0	56.3	**5.5**	33.4	16.2	**15.8**	9.9
Cluster 7	48.1	8.9	31.3	5.0	5.3	2.5	32.3	85.6	20.0	140.9	15.1	7.8	2.5	51.3	50.8	57.6	5.4	38.6	13.6	10.6	9.9
Cluster 8	27.4	7.2	19.5	5.0	7.2	3.4	29.5	72.6	7.9	143.0	12.0	4.2	2.9	24.9	19.8	88.1	2.3	20.3	10.9	11.6	15.3
Cluster 9	61.5	**9.0**	26.3	8.8	19.7	3.4	43.3	126.8	11.4	**165.3**	12.4	6.7	2.8	**58.3**	**83.3**	168.1	3.8	48.4	11.2	2.5	21.2
Cluster 10	41.7	4.6	14.9	6.9	0.0	3.8	34.9	**171.1**	11.5	141.8	16.6	5.0	2.5	26.7	**75.5**	133.2	4.3	36.7	12.6	7.1	10.1
Cluster 11	51.7	4.1	**74.2**	**12.6**	6.9	3.2	59.1	88.3	14.6	142.3	8.7	6.0	2.8	**104.1**	33.3	**248.2**	3.6	42.3	10.7	6.3	16.1
Cluster 12	43.2	6.6	**55.3**	6.9	8.9	2.6	28.7	140.9	11.9	120.1	10.3	6.8	2.2	**124.1**	5.3	95.3	2.7	46.7	7.3	11.1	23.0
Cluster 13	**87.8**	8.5	14.3	5.0	7.6	**4.3**	**60.0**	116.7	10.8	136.2	12.2	5.2	2.1	101.2	5.0	158.1	2.6	53.5	6.9	6.0	10.1
Cluster 14	52.4	7.0	43.5	**13.2**	8.1	5.1	26.2	123.0	22.4	143.5	**22.7**	**12.5**	**5.0**	3.8	31.2	93.4	4.3	55.4	**21.2**	**15.7**	**34.6**
Cluster 15	59.3	5.1	19.9	7.8	11.8	3.6	45.8	78.6	**35.1**	149.0	18.4	**11.9**	2.9	13.0	24.7	111.4	3.5	32.7	11.9	8.6	18.9
Cluster 16	51.9	3.6	8.1	9.4	13.4	3.0	41.3	118.2	**32.7**	143.9	**22.4**	7.9	3.6	10.2	44.9	59.6	**6.5**	45.1	13.2	12.2	**37.8**
Cluster 17	**96.7**	**12.5**	**61.6**	10.3	5.2	2.4	41.1	**144.2**	19.9	**169.5**	18.9	7.8	**5.1**	36.2	17.3	**690.6**	4.8	**83.4**	**19.3**	12.5	22.4
Cluster 18	**79.7**	8.1	32.7	**13.1**	**34.3**	**9.2**	33.0	143.1	20.0	134.3	19.4	11.1	**4.6**	4.8	19.3	**174.8**	**7.0**	**90.2**	**19.4**	12.1	15.3
Cluster 19	52.7	5.5	13.8	9.8	**49.8**	3.2	**45.6**	88.7	13.2	149.2	**19.9**	**12.2**	4.3	42.3	34.7	101.7	2.2	**63.5**	17.4	**18.2**	**29.1**

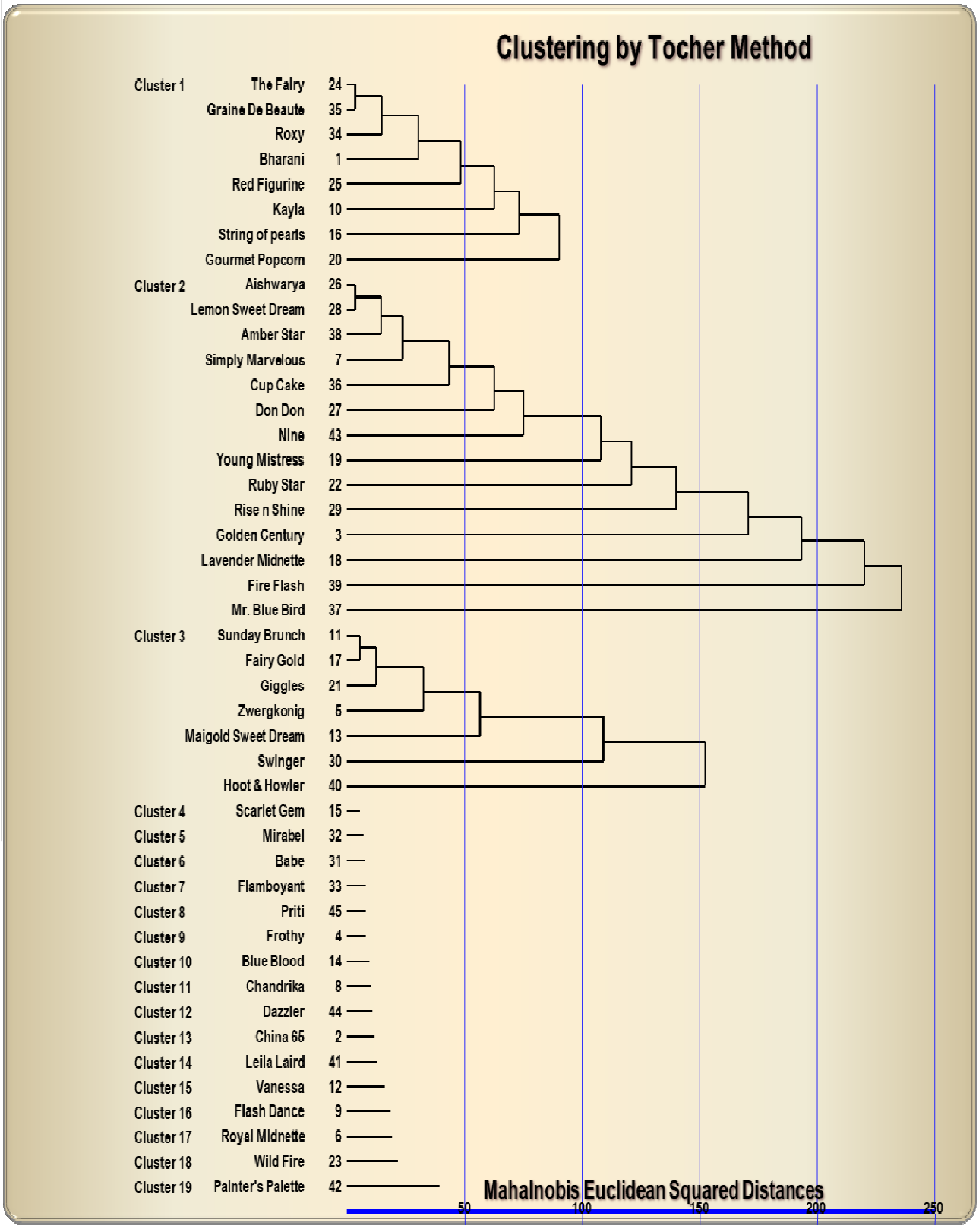
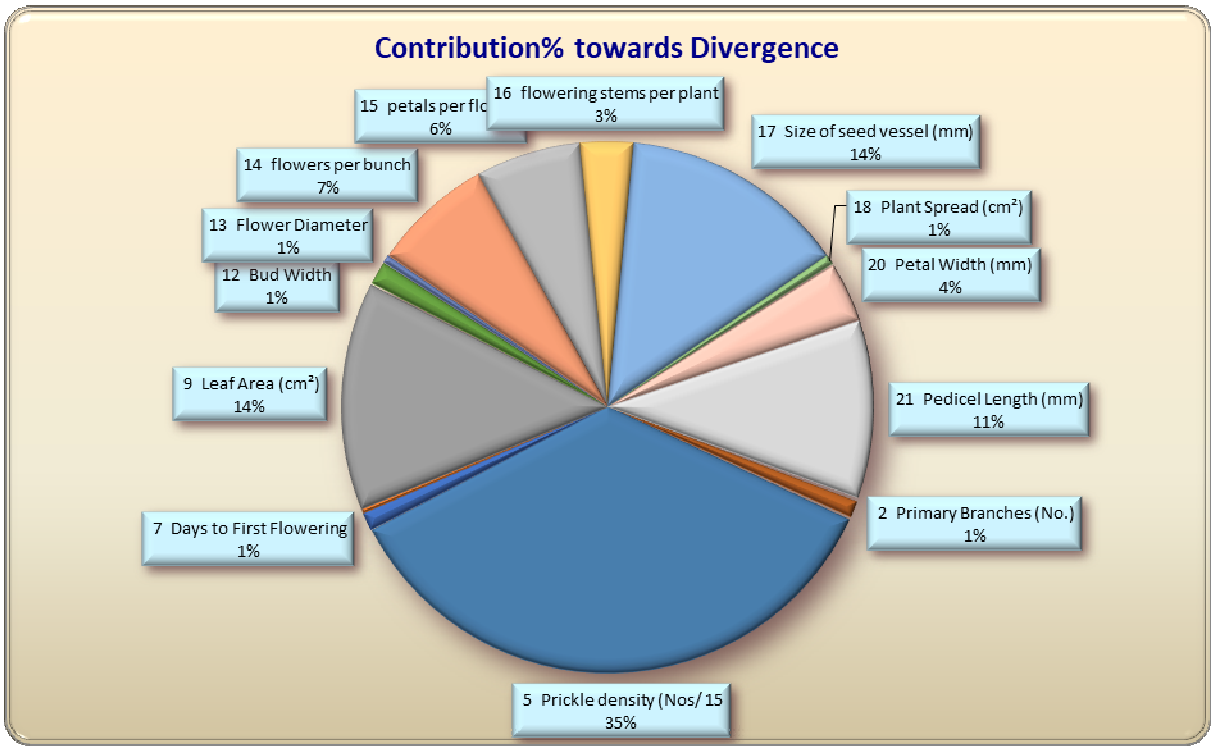


Figure 2. Genetic diveristy of 45 miniature rose genotypes using Mahanobilis D^2 Statistics.



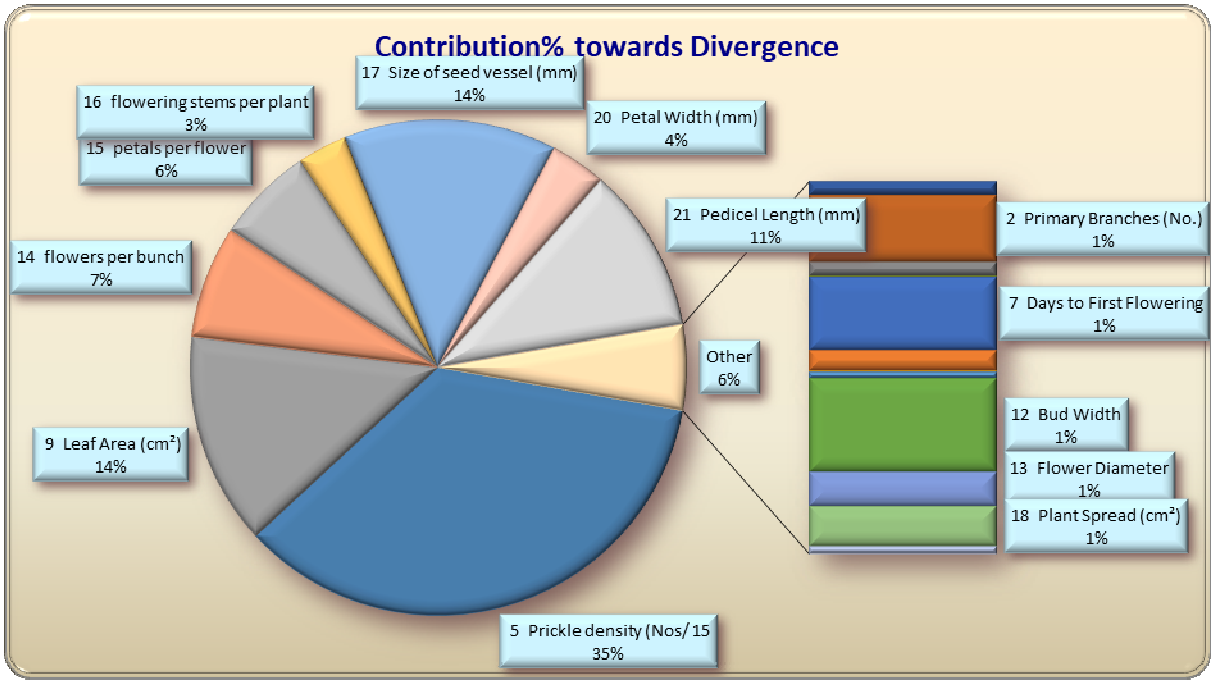


Figure 3. Contribution % of different characters towards divergence.

Table No.4.2.4: Contribution % of different characters towards divergence.

Character No.	Source	Contribution %	Times Ranked 1st
1	**Plant Height (cm)**	0.20	2.000
2	**Primary Branches (No.)**	1.01	10.000
3	**Secondary Branches (No.)**	0.20	2.000
4	**Main Stem Girth (mm)**	0.01	0.000
5	**Prickle density (Nos/ 15**	35.35	350.000
6	**Internodal Length (cm)**	0.01	0.000
7	**Days to First Flowering**	1.11	11.000
8	**Days to Peak Flowering**	0.30	3.000
9	**Leaf Area (cm^2)**	13.84	137.000
10	**Flowering Duration**	0.01	0.000
11	**Bud Length**	0.10	1.000
12	**Bud Width**	1.41	14.000
13	**Flower Diameter**	0.51	5.000
14	**flowers per bunch**	7.37	73.000
15	**petals per flower**	6.36	63.000
16	**flowering stems per plant**	3.23	32.000
17	**Size of seed vessel (mm)**	13.84	137.000
18	**Plant Spread (cm^2)**	0.61	6.000
19	**Petal length (mm)**	0.10	1.000
20	**Petal Width (mm)**	3.64	36.000
21	**Pedicel Length (mm)**	10.81	107.000

4.3 DUS Characterization and Grouping of varieties

4.3.1 Morphological characterization of genotypes

The present study was undertaken to characterize forty five miniature rose genotypes on the basis of 60 morphological characters. The evaluation for DUS testing was done as per the description prescribed by the PPVRA guidelines, GOI, New Delhi for DUS testing in Rose (Anonymous, 2009) and hence the genotypes were grouped accordingly as given in the Table 4.3.1a to Table No 4.3.7b. DUS descriptors for some of the parameters studied in the present study are shown in plate 2.

4.3.1.1 Plant Growth Type:

It is an essential pseudo qualitative characteristic which has to be observed for garden varieties, the characteristic was observed by visual assessment by a single observation of a group of plants at full bloom stage. The character was observed at first flush for both growing seasons.

The data from Table of characteristics (4.3.1a and 4.3.1b) clearly shows that genotype Golden Century was classified as a ground cover; genotypes Bharani, China 65, Golden Century, Frothy, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Sunday Brunch, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Babe, Mirabel, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler, Priti as miniature; Lemon Sweet Dream, Babe, Priti as dwarf; Royal Midnette, Maigold Sweet Dream, Wild Fire as climber. No genotype among the tested group was found to be bedding type or shrub type.

4.3.1.2 Plant growth habit (excluding climbing varieties):

It is an essential quantitative characteristic which has to be observed for garden varieties, the characteristic was observed by visual assessment by a single observation of a group of plants at full bloom stage. The character was observed at second flush for both growing seasons.

The data from Table of characteristics (4.3.1a and 4.3.1b) clearly shows that genotypes which showed upright growth habit are China 65, Frothy, Simply Marvelous, Kayla, Vanessa, Fairy Gold, Ruby Star, Red Figurine, Aishwarya, Rise n Shine, Babe, Mirabel, Hoot & Howler, Dazzler, Priti; Genotypes Bharani, Zwergkonig, Chandrika, Flash Dance, Sunday Brunch, Blue Blood, Scarlet Gem, Young Mistress, Gourmet Popcorn, Don Don, Lemon Sweet Dream, Flamboyant, Cup Cake, Mr. Blue Bird showed semi-upright growth habit while String Of Pearls, Giggles, Swinger were intermediate and genotypes Lavender Midnette, The Fairy, Roxy, Graine De Beaute were moderately spreading. Only Golden Century was found to be strongly spreading growth habit.

Plant growth ranges from upright to strongly spreading which can serve various purposes. The upright growing species can be used for upright growing purposes viz., Hedge,

while strongly spreading and moderately spreading species can be used for breeding climber types of cultivars or bedding purpose as described by Gaurav *et al* (2018). This character is influenced by genetics of genotypes as observed by Singh (2016).

4.3.1.3 Plant: Height (cm)

It is an essential quantitative characteristic which has to be observed for garden varieties, the characteristic was observed by measurement of a number of individuals at full bloom stage. The character was observed at second flush for both growing seasons.

The data from Table of characteristics (4.3.1a and 4.3.1b) clearly shows that genotypes which showed very short height (<30 cm) were Lemon Sweet Dream, Babe; Short Genotypes (31-60 cm) were Bharani, Golden Century, Simply Marvelous, Chandrika, Flash Dance, Kayla, Sunday Brunch, Vanessa, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Young Mistress, Giggles, Ruby Star, The Fairy, Red Figurine, Aishwarya, Swinger, Mirabel, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash; Medium height genotypes (61-100 cm) were China 65, Frothy, Zwergkonig, Maigold Sweet Dream, Lavender Midnette, Gourmet Popcorn, Wild Fire, Don Don, Rise n Shine, Hoot & Howler, Leila Laird, Painter's Palette while Royal Midnette was found Tall (100-150 cm). No genotype among the tested group were found to be very Tall (>150 cm) in height.

The result is in conformity with the earlier findings of Murusegan *et al* (1991) and Malhotra (1997) in roses and Dadlani (2016) in miniatures and Singh (2016) in floribunda.

4.3.1.4 Young shoot: Anthocyanin colouration (shoot about 20 cm long)

It is a qualitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* Young shoot of 20 cm length in first flush. This observation includes leaves along with stem for the purpose of observation.

As evident from the table (4.3.1a and 4.3.1b) the genotype Rise n Shine the character was absent while in rest of the genotypes *viz.*, Bharani, China 65, Golden Century, Frothy, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Sunday Brunch, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Swinger, Babe, Mirabel, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler, Priti.

Anthocyanin colouration of young shoots and its hue. As it is a well-known fact that anthocyanin acts as an antioxidant and protects plants from various abiotic stresses and delaying leaf senescence (Landi *et al.* 2015). Hence, species having strong hue of anthocyanin colouration can be an effective source of resistance against abiotic stress. The difference in this character among different genotypes was also reported by Gaurav *et al.* (2018) and might be attributed to genetic makeup of the respective genotypes.

4.3.1.5 Young shoot: Intensity of anthocyanin colouration (shoot about 20 cm long)

It is a qualitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* Young shoot of 20 cm length in first flush. This observation includes leaves along with stem for the purpose of observation.

As depicted in the table (4.3.1a and 4.3.1b) the young shoot intensity of anthocyanin colouration was found very weak in China 65, Golden Century, Frothy, Simply Marvelous, Chandrika, String of pearls, Fairy Gold, Gourmet Popcorn, The Fairy, Red Figurine, Swinger, Mirabel, Graine De Beaute, Amber Star, Nine, Dazzler; weak in genotypes Bharani, Zwergkonig, Flash Dance, Kayla, Vanessa, Lavender Midnette, Young Mistress, Lemon Sweet Dream, Roxy, Fire Flash; medium in Sunday Brunch, Maigold Sweet Dream, Blue Blood, Giggles, Aishwarya, Don Don, Babe, Flamboyant, Mr. Blue Bird while strong in genotypes Scarlet Gem, Ruby Star, Cup Cake and very strong in genotypes Royal Midnette and Wild Fire.

The difference in this character among different genotypes was also reported by Gaurav *et al.* (2018) and might be attributed to genetic makeup of the respective genotypes.

4.3.1.6 Stem: Number of prickles (excluding very small and hair like prickles)

It is a quantitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* Shoot of 15 cm length by counting the numbers of prickles form middle 3rd part of stem. Prickles are special structures associated with rose. They are different from the thorns and spines as vascular bundles are not present inside and are easily removable. They are present in various forms and densities among species and cultivars (Debener and Linde 2009). As prickles make commercial rose cultivation difficult mainly during cultural practices and harvesting, search for thornless cultivars have been a major breeding objective of almost all the breeding programs (Kanli and Kazaz 2009, Zlesak 2007).

The perusal of data from table (4.3.1a and 4.3.1b) the prickles in stem was found absent in Blue Blood, Babe, Mirabel while it was few in Lavender Midnette, The Fairy, Fire

Flash; Medium in Bharani, China 65, Royal Midnette, Chandrika, Kayla, Gourmet Popcorn, Wild Fire, Don Don, Rise n Shine, Flamboyant, Graine De Beaute, Mr. Blue Bird, Leila Laird, Dazzler, Priti while many prickles were observed in in Golden Century, Frothy, Zwergkonig, Simply Marvelous, Flash DanceSunday Brunch, Vanessa, Maigold Sweet Dream, Scarlet Gem, String of Pearls, Fairy Gold, Young Mistress, Giggles, Ruby Star, Red Figurine, Aishwarya, Lemon Sweet Dream, Swinger, Roxy, Cup Cake, Amber Star, Hoot & Howler, Painter's Palette, Nine. The variation in number of thorns might be attributed to genetic make up of the cultivar in conformity with findings of Murugesan *et al* (1991) Sundram *et al* (1996) Singh (2016) and Gaurav (2018).

4.3.1.7 Prickles: Predominant colour

It is a pseudo-qualitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* new shoot growth by taking the observation criteria from explanation of characteristics.

As per table (4.3.1a and 4.3.1b) Greenish coloured prickle was found in genotypes Bharani, China 65, Royal Midnette, Maigold Sweet Dream, Scarlet Gem, Gourmet Popcorn, Wild Fire, Aishwarya, Rise n Shine, Swinger, Flamboyant, Roxy, Amber Star, Painter's Palette, Nine, Priti; Reddish coloured prickles in Frothy, Zwergkonig, Chandrika, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Scarlet Gem, String of pearls, Fairy Gold, Young Mistress, Gourmet Popcorn, Giggles, Wild Fire, The Fairy, Red Figurine, Swinger Graine De Beaute, Mr. Blue Bird, Amber Star, Fire Flash, Hoot and Howler, Laila Laird; Brown coloured prickle was observed in genotype Lemon Sweet Dream while, China 65, Golden Century, Royal Midnette, Simply Marvelous, Sunday Brunch, Lavender Midnette, Ruby Star, Aishwarya, Don Don, Rise n Shine, Flamboyant, Roxy, Cup Cake, Painter's Palette, Dazzler, Priti showed purplish colour. Yellow colour prickle was found in one of the varieties studied.

The same character was studied by Singh (2016), Dadlani (2016) and Gaurav et al (2018) and they found variation in prickle shape and colour and the character might be attributed to genetic makeup of the genotype.

4.3.1.8 Prickle: Shape of lower side

It is a character observed by Visual assessment by observations of individual parts of plants *i.e.* prickles on new shoot growth by taking the observation criteria from explanation of characteristics.

As represented in table no. (4.3.1a and 4.3.1b) the genotypes which showed deep concave shape of the lower side of prickle were China 65, Frothy, Zwergkonig, Royal Midnette, Chandrika, Flash Dance, String of Pearls, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, The Fairy, Red Figurine, Lemon Sweet Dream, Swinger, Flamboyant, Graine De Beaute, Nine, Dazzler, Priti; the genotypes Bharani, Golden Century, Simply Marvelous, Kayla, Vanessa, Maigold Sweet Dream, Fairy Gold, Wild Fire, Aishwarya, Don Don, Rise n Shine, Mirabel, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler and Painter's Palette showed concave shape of the lower side of prickle while flat shape of the lower side of prickle was shown by genotypes Sunday Brunch, Scarlet Gem, Roxy, Leila Laird. The state of expression convex and highly convex was shown by none of the genotypes studied. The same character was studied by Singh (2016) and Gaurav *et al* (2018) and they found variation in prickle shape and colour and the character might be attributed to genetic makeup of the genotype.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Singh (2016), Dadlani (2016) and Gaurav *et al* (2018).

4.3.1.9 Leaf: Size

It is an essential quantitative character observed by Measurement of a number of individual parts of plants i.e. leaves with help of leaf area meter. Observations on the leaves and the leaflets shall be made on the middle third of the stem.

The representation data from table no (4.3.2a and 4.3.2b) the genotypes which showed small leaves were Simply Marvelous, Kayla, Sunday Brunch, Scarlet Gem, String of Pearls, Fairy Gold, Ruby Star, Red Figurine, Graine De Beaute, Cup Cake, Priti while the ones that showed medium size of leaves were Bharani, China 65, Golden Century, Frothy, Zwergkonig, Royal Midnette, Chandrika, Maigold Sweet Dream, Blue Blood, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Wild Fire, The Fairy, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Mirabel, Roxy, Amber Star, Fire Flash, Hoot & Howler, Painter's Palette, Nine, Dazzler and large leaf shape was shown by Flash Dance, Vanessa, Swinger, Babe, Flamboyant, Mr. Blue Bird, Leila Laird.

Singh (2016) and Dadlani (2016) also observed that leaf length and leaf breadth varied significantly among the varieties.

4.3.1.10 Leaf: Intensity of green colour on upper side (at the time of first flowering)

It is a quantitative character observed by Visual assessment by a single observation of a group of plant parts *i.e.* leaves. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the times of first flowering.

The perusal of data from table (4.3.2a and 4.3.2b) depicted that intensity of green colour was found very light in genotypes Chandrika, Gourmet Popcorn, Dazzler, Priti while the same characteristic showed light state of expression in Bharani, China 65, Blue Blood, Young Mistress, Mirabel, Flamboyant, Leila Laird, Nine; Medium intensity of green colour on upper side of leaf (at the time of first flowering) was observed in genotypes Golden Century, Frothy, Simply Marvelous, Flash Dance, Sunday Brunch, Wild Fire, The Fairy, Aishwarya, Swinger, Babe. Dark green state of expression for the same character was found in genotypes Royal Midnette, Kayla, Vanessa, Scarlet Gem, Giggles, Ruby Star, Don Don, Roxy, Amber Star, Fire Flash, Hoot & Howler, Painter's Palette while very dark green leaf expression was shown by Zwergkonig, Maigold Sweet Dream, String of pearls, Fairy Gold, Lavender Midnette, Red Figurine, Lemon Sweet Dream, Rise n Shine, Graine De Beaute, Cup Cake, Mr. Blue Bird.

The foliage colour at maturity varied significantly among the varieties. The observation on leaf colour at maturity showed that leaf colour in most of cultivars was dark green as supported by (Singh, 2016). The foliage beauty is one of the attractive features of the plant architecture for landscape use along with the flowers. The dark green leaves of the plant of a cultivar are desirable feature. Similar variation in leaf colour of cultivars had been reported earlier by many workers (Swarup *et al.,* 1971, Swarup *et al.,* 1978). The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al.* (2018).

4.3.1.11 Leaf: Anthocyanin colouration

It is a qualitative character observed by Visual assessment by a single observation of a group of plant parts *i.e.* leaves. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the times of first flowering. This observation was made on mature and fully expanded leaf.

Table No 4.3.1a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Plants**			**Young Shoot**		**Stem**	**Prickle**	
S. No.	**Variety**	**1. growth type**	**2.growth habit**	**3. Plant height (2nd flush)**	**4.Anthocyanin colouration**	**5. Intensity of anthocyanin colouration**	**6. Stem: No. of prickles**	**7. Prickle: Predominant colour**	**8. Prickle shape of lower side**
1	**Bharani**	Miniature	Semi-upright	Short (31-60 cm)	Present	Weak	Medium (6-10)	Greenish	Concave
2	**China 65**	Miniature	Upright	Medium (61-100 cm)	Present	Very Weak	Medium (6-10)	Purplish	Deep Concave
3	**Golden Century**	Ground Cover, Climber, Miniature	Strongly spreading	Short (31-60 cm)	Present	Very Weak	Many (>10)	Purplish	Concave
4	**Frothy**	Miniature	Upright	Medium (61-100 cm)	Present	Very Weak	Many (>10)	Reddish	Deep Concave
5	**Zwergkonig**	Miniature	Semi-upright	Medium (61-100 cm)	Present	Weak	Many (>10)	Reddish	Deep Concave
6	**Royal Midnette**	Miniature, Climber	Moderately Spreading	Tall (>100 cm)	Present	Very Strong	Medium (6-10)	Purplish	Deep Concave
7	**Simply Marvelous**	Miniature	Upright	Short (31-60 cm)	Present	Very Weak	Many (>10)	Purplish	Concave
8	**Chandrika**	Miniature	Semi-upright	Short (31-60 cm)	Present	Very Weak	Medium (6-10)	Reddish	Deep Concave
9	**Flash Dance**	Miniature	Semi-upright	Short (31-60 cm)	Present	Weak	Many (>10)	Reddish	Deep Concave
10	**Kayla**	Miniature	Upright	Short (31-60 cm)	Present	Weak	Medium (6-10)	Reddish	Concave
11	**Sunday Brunch**	Miniature	Semi-upright	Short (31-60 cm)	Present	Medium	Many (>10)	Purplish	Flat
12	**Vanessa**	Miniature	Upright	Short (31-60 cm)	Present	Weak	Many (>10)	Reddish	Concave
13	**Maigold Sweet Dream**	Miniature, Climber	Moderately Spreading	Medium (61-100 cm)	Present	Medium	Many (>10)	Reddish	Concave
14	**Blue Blood**	Miniature	Semi-upright	Short (31-60 cm)	Present	Medium	Absent (0)	-	-
15	**Scarlet Gem**	Miniature	Semi-upright	Short (31-60 cm)	Present	Strong	Many (>10)	Reddish	Flat
16	**String of pearls**	Miniature	Intermediate	Short (31-60 cm)	Present	Very Weak	Many (>10)	Reddish	Deep Concave
17	**Fairy Gold**	Miniature	Upright	Short (31-60 cm)	Present	Very Weak	Many (>10)	Reddish	Concave
18	**Lavender Midnette**	Miniature	Moderately Spreading	Medium (61-100 cm)	Present	Weak	Few (1-5)	Purplish	Deep Concave
19	**Young Mistress**	Miniature	Semi-upright	Short (31-60 cm)	Present	Weak	Many (>10)	Reddish	Deep Concave
20	**Gourmet Popcorn**	Miniature	Semi-upright	Medium (61-100 cm)	Present	Very Weak	Medium (6-10)	Greenish	Deep Concave
21	**Giggles**	Miniature	Intermediate	Short (31-60 cm)	Present	Medium	Many (>10)	Reddish	Deep Concave
22	**Ruby Star**	Miniature	Upright	Short (31-60 cm)	Present	Strong	Many (>10)	Reddish	Deep Concave
23	**Wild Fire**	Miniature,6	Intermediate	Medium (61-100 cm)	Present	Very Strong	Medium (6-10)	Reddish	Deep Concave

Table No 4.3.1b: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Plants**			**Young Shoot**		**Stem**	**Prickle**	
24	**The Fairy**	Miniature	Moderately Spreading	Short (31-60 cm)	Present	Very Weak	Few (1-5)	Reddish	Deep Concave
25	**Red Figurine**	Miniature	Upright	Short (31-60 cm)	Present	Very Weak	Many (>10)	Reddish	Deep Concave
26	**Aishwarya**	Miniature	Upright	Short (31-60 cm)	Present	Medium	Many (>10)	Purplish	Concave
27	**Don Don**	Miniature	Semi-upright	Medium (61-100 cm)	Present	Medium	Medium (6-10)	Purplish	Concave
28	**Lemon Sweet Dream**	Miniature	Semi-upright	Very Short (<30cm)	Present	Weak	Many (>10)	Brown	Deep Concave
29	**Rise n Shine**	Miniature	Upright	Medium (61-100 cm)	Absent	-	Medium (6-10)	Purplish	Concave
30	**Swinger**	Miniature	Intermediate	Short (31-60 cm)	Present	Very Weak	Many (>10)	Reddish	Deep Concave
31	**Babe**	Miniature	Upright	Very Short (<30cm)	Present	Medium	Absent (0)	-	-
32	**Mirabel**	Miniature	Upright	Short (31-60 cm)	Present	Very Weak	Absent (0)	-	-
33	**Flamboyant**	Miniature	Semi-upright	Short (31-60 cm)	Present	Medium	Medium (6-10)	Purplish	Deep Concave
34	**Roxy**	Miniature	Moderately Spreading	Short (31-60 cm)	Present	Weak	Many (>10)	Purplish	Flat
35	**Graine De Beaute**	Miniature	Moderately Spreading	Short (31-60 cm)	Present	Very Weak	Medium (6-10)	Reddish	Deep Concave
36	**Cup Cake**	Miniature	Semi-upright	Short (31-60 cm)	Present	Strong	Many (>10)	Purplish	Concave
37	**Mr. Blue Bird**	Miniature	Semi-upright	Short (31-60 cm)	Present	Medium	Medium (6-10)	Reddish	Concave
38	**Amber Star**	Miniature	Semi-upright	Short (31-60 cm)	Present	Very Weak	Many (>10)	Reddish	Concave
39	**Fire Flash**	Miniature	Semi-upright	Short (31-60 cm)	Present	Weak	Few (1-5)	Reddish	Concave
40	**Hoot & Howler**	Miniature	Upright	Medium (61-100 cm)	Present	Medium	Many (>10)	Reddish	Concave
41	**Leila Laird**	Miniature	Semi-upright	Medium (61-100 cm)	Present	Weak	Medium (6-10)	Reddish	Flat
42	**Painter's Palette**	Miniature	Semi-upright	Medium (61-100 cm)	Present	Medium	Many (>10)	Purplish	Concave
43	**Nine**	Miniature	Semi-upright	Short (31-60 cm)	Present	Very Weak	Many (>10)	Greenish	Deep Concave
44	**Dazzler**	Miniature	Upright	Short (31-60 cm)	Present	Very Weak	Medium (6-10)	Purplish	Deep Concave
45	**Priti**	Miniature	Upright	Very Short (<30cm)	Present	Weak	Medium (6-10)	Purplish	Deep Concave

The perusal of data from table (4.3.2a and 4.3.2b) clearly states that the leaf anthocyanin colouration was absent in Bharani, China 65, Golden Century, Frothy, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Sunday Brunch, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Babe, Mirabel, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler, Priti while it was present in genotype Kayla.

Mature leaves mostly lack anthocyanin colouration as observed by Singh (2016). The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al*. (2018).

4.3.1.12 Leaf: Glossiness of upper side

It is an essential qualitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* leaves. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the times of first flowering. This observation was made on mature and fully expanded leaf.

The perusal of data from table (4.3.2a and 4.3.2b) depicted that Glossiness of upper side was absent in genotypes Bharani, China 65, Chandrika, Flash Dance, Kayla, Sunday Brunch, Blue Blood, Gourmet Popcorn, Babe, Flamboyant, Fire Flash, Leila Laird, Painter's Palette, Nine, Dazzler, Priti; genotypes Frothy, Royal Midnette, Simply Marvelous, Vanessa, Maigold Sweet Dream, Scarlet Gem, Lavender Midnette, Young Mistress, Giggles, Wild Fire, Red Figurine, Aishwarya showed weak glossiness; Medium expression of leaf glossiness was seen in genotypes Golden Century, String of pearls, Ruby Star, Don Don, Cup Cake, Amber Star, Hoot & Howler whereas, strong expression was shown by genotypes Golden Century, String of pearls, Ruby Star, Don Don, Cup Cake, Amber Star, Hoot & Howler. Glossy surface is considered better than non-glossy leaf surface in roses (Singh, 2016). The study by Singh (2016) also found large variation among the genotypes in leaf upper surface glossiness.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al.* (2018).

4.3.1.13 Leaflet: Undulations of margin

It is an essential quantitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* leaflets. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the times of first flowering. This observation was made on mature and fully expanded leaflet excised from a compound leaf.

The perusal of data from table (4.3.2a and 4.3.2b) depicted that the character undulation of margin was absent in genotypes Bharani, China 65, Golden Century, Frothy, Simply Marvelous, Chandrika, Kayla, Sunday Brunch, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Gourmet Popcorn, Giggles, The Fairy, Red Figurine, Aishwarya, Don Don, Rise n Shine, Mirabel, Cup Cake, Amber Star, Hoot & Howler, Leila Laird, Nine, Dazzler, Priti; weak in Zwergkonig, Flash Dance, Vanessa, Young Mistress, Ruby Star, Lemon Sweet Dream, Swinger, Flamboyant, Roxy, Graine De Beaute, Mr. Blue Bird, Painter's Palette wheras the expression state medium in genotypes Royal Midnette, Maigold Sweet Dream, Wild Fire, Fire Flash. The genotype Babe showed strongest expression concerning undulation of margins in leaflets.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al.* (2018).

4.3.1.14 Leaflet: Serration of the margin

It is an essential quantitative character observed by visual assessment by a single observation of a group of plant parts *i.e.* leaflets. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the times of first flowering. This observation was made on mature and fully expanded leaflet excised from a compound leaf.

As clearly indicated in table (4.3.2a and 4.3.2b) it is evident that the genotypes China 65, Zwergkonig, Simply Marvelous, Kayla, String of pearls, Gourmet Popcorn, Giggles, The Fairy, Aishwarya, Lemon Sweet Dream, Rise n Shine, Mirabel, Flamboyant, Roxy, Dazzler showed fine serration; Bharani, Frothy, Royal Midnette, Chandrika, Flash Dance, Sunday Brunch, Vanessa, Maigold Sweet Dream, Fairy Gold, Young Mistress, Ruby Star, Wild Fire, Red Figurine, Don Don, Swinger, Amber Star, Fire Flash, Hoot & Howler, Priti showed medium serration while genotypes Golden Century, Blue Blood, Scarlet Gem, Lavender Midnette, Babe, Leila Laird, Painter's Palette, Nine exhibited dense serration. In none of the varieties the expression serration was absent.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al.* (2018).

4.3.1.15 Terminal leaflet: Shape of blade

It is an essential pseudo qualitative character observed by Measurement of a number of individual plants or parts of plants *i.e.* Terminal leaflets. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the time of first flowering. This observation was made on mature and fully expanded leaflet excised from a compound leaf.

The perusal of data from table (4.3.2a and 4.3.2b) depicted that the terminal leaflets of genotypes Golden Century, Blue Blood, Scarlet Gem, Graine De Beaute showed narrow elliptic shape; Medium elliptic shape was exhibited by China 65, Frothy, Chandrika, Sunday Brunch, String of pearls, Fairy Gold, Gourmet Popcorn, Wild Fire, The Fairy, Aishwarya, Lemon Sweet Dream, Rise n Shine, Cup Cake, Mr. Blue Bird, Amber Star, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler, Priti; genotypes Royal Midnette, Simply Marvelous, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Lavender Midnette, Young Mistress, Don Don, Roxy, Fire Flash showed ovate state of expression for shape of terminal leaflet while terminal leaflets of genotypes Zwergkonig, Giggles, Ruby Star, Swinger, Babe, Mirabel showed circular shape. The state of expression obovate was shown by Bharani, Red Figurine, Flamboyant.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al.* (2018).

4.3.1.16 Terminal leaflet: Shape of base of Blade

It is an essential pseudo qualitative character observed by Measurement of a number of individual plants or parts of plants *i.e.* base of terminal leaflets. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the time of first flowering. This observation was made on mature and fully expanded leaflet excised from a compound leaf.

According to the data from table (4.3.2a and 4.3.2b) it is evident that Acute shape of the base was shown by Bharani, Golden Century, Chandrika, Sunday Brunch, Blue Blood, Scarlet Gem, Gourmet Popcorn, The Fairy, Red Figurine, Rise n Shine, Amber Star, Painter's Palette, Nine, Dazzler; Obtuse base was exhibited by China 65, Frothy, Royal Midnette, Simply Marvelous, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, String of pearls, Fairy Gold, Aishwarya, Lemon Sweet Dream, Swinger, Flamboyant, Graine De Beaute, Cup

Cake, Mr. Blue Bird, Hoot & Howler, Leila Laird, Priti. Genotypes Zwergkonig, Lavender Midnette, Young Mistress, Giggles, Ruby Star, Don Don, Babe, Mirabel, Roxy showed round shape of base of leaflet blade whereas cordate was expressed by Fire Flash.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al* (2018).

4.3.1.17 Terminal leaflet: Shape of apex of Blade

It is a pseudo qualitative character observed by visual assessment by a single observation of a group of plants parts of *i.e.* apex of terminal leaflets. Observations on the leaves and the leaflets shall be made on the middle third of the stem at the time of first flowering. This observation was made on mature and fully expanded leaflet excised from a compound leaf.

The perusal of data from table (4.3.2a and 4.3.2b) depicted that the state of expression acuminate was exhibited in genotypes Bharani,China 65, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Sunday Brunch, Vanessa, Maigold Sweet Dream, String of pearls, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Wild Fire, Aishwarya, Don Don, Lemon Sweet Dream, Babe, Mirabel, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Priti while acute shape of apex of terminal leaflet blade was shown in genotypes Golden Century, Frothy, Blue Blood, Scarlet Gem, The Fairy, Flamboyant, Dazzler. Obtuse apex of blade was shown by genotype Red Figurine while rounded apex was exhibited by genotypes Zwergkonig, Giggles, Ruby Star, Rise n Shine, Swinger.

The differences among the cultivars of above character might be due to genetic make up of the cultivar and the study is in conformity with Gaurav *et al* (2018).

4.3.1.18 Flowering shoot: Flowering laterals

It is a qualitative character to be observed in garden varieties by Visual assessment by observations of individual plants or parts of plants at the time of peak flowering.

As evident from table of characteristics Table no. 4.3.3a & 4.3.3b, the character flowering lateral was present in genotypes Bharani, China 65, Frothy, Zwergkonig, Royal

Table No 4.3.2a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Leaf**				**Leaflets**		**Terminal Leaflet**		
S. No.	**Variety**	**9. Leaf size**	**10. Intensity of green colour on upper side**	**11. Anthocyanin colouration**	**12. Glossiness on upper side**	**13. Undulation of margin**	**14. serration of margin**	**15. shape of blade**	**16. Shape of base of blade**	**17. Shape of apex of blade**
1	**Bharani**	Medium (11-20 cm^2)	Light	Absent	Absent	Absent	Medium	Obovate	Acute	Acuminate
2	**China 65**	Medium (11-20 cm^2)	Light	Absent	Absent	Absent	Fine	Medium elliptic	Obtuse	Acuminate
3	**Golden Century**	Medium (11-20 cm^2)	Medium	Absent	Medium	Absent	Dense	Narrow elliptic	Acute	Acute
4	**Frothy**	Medium (11-20 cm^2)	Medium	Absent	Weak	Absent	Medium	Medium elliptic	Obtuse	Acute
5	**Zwergkonig**	Medium (11-20 cm^2)	Very Dark	Absent	Strong	Weak	Fine	Circular	Rounded	Rounded
6	**Royal Midnette**	Medium (11-20 cm^2)	Dark	Absent	Weak	Medium	Medium	Ovate	Obtuse	Acuminate
7	**Simply Marvelous**	Micro-mini (1-10 cm^2)	Medium	Absent	Weak	Absent	Fine	Ovate	Obtuse	Acuminate
8	**Chandrika**	Medium (11-20 cm^2)	Very light	Absent	Absent	Absent	Medium	Medium elliptic	Acute	Acuminate
9	**Flash Dance**	Large (>20 cm^2)	Medium	Absent	Absent	Weak	Medium	Ovate	Obtuse	Acuminate
10	**Kayla**	Micro-mini (1-10 cm^2)	Dark	Present	Absent	Absent	Fine	Ovate	Obtuse	Acuminate
11	**Sunday Brunch**	Micro-mini (1-10 cm^2)	Medium	Absent	Absent	Absent	Medium	Medium elliptic	Acute	Acuminate
12	**Vanessa**	Large (>20 cm^2)	Dark	Absent	Weak	Weak	Medium	Ovate	Obtuse	Acuminate
13	**Maigold Sweet Dream**	Medium (11-20 cm^2)	Very Dark	Absent	Weak	Medium	Medium	Ovate	Obtuse	Acuminate
14	**Blue Blood**	Medium (11-20 cm^2)	Light	Absent	Absent	Absent	Dense	Narrow elliptic	Acute	Acute
15	**Scarlet Gem**	Micro-mini (1-10 cm^2)	Dark	Absent	Weak	Absent	Dense	Narrow elliptic	Acute	Acute
16	**String of pearls**	Micro-mini (1-10 cm^2)	Very Dark	Absent	Medium	Absent	Fine	Medium elliptic	Obtuse	Acuminate
17	**Fairy Gold**	Micro-mini (1-10 cm^2)	Very Dark	Absent	Strong	Absent	Medium	Medium elliptic	Obtuse	Acuminate
18	**Lavender Midnette**	Medium (11-20 cm^2)	Very Dark	Absent	Weak	Absent	Dense	Ovate	Rounded	Acuminate
19	**Young Mistress**	Medium (11-20 cm^2)	Light	Absent	Weak	Weak	Medium	Ovate	Rounded	Acuminate
20	**Gourmet Popcorn**	Medium (11-20 cm^2)	Very light	Absent	Absent	Absent	Fine	Medium elliptic	Acute	Acuminate
21	**Giggles**	Medium (11-20 cm^2)	Dark	Absent	Weak	Absent	Fine	Circular	Rounded	Rounded
22	**Ruby Star**	Micro-mini (1-10 cm^2)	Dark	Absent	Medium	Weak	Medium	Circular	Rounded	Rounded
23	**Wild Fire**	Medium (11-20 cm^2)	Medium	Absent	Weak	Medium	Medium	Medium elliptic	Rounded	Acuminate

Table No 4.4.2b: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Leaf**				**Leaflets**		**Terminal Leaflet**		
S. No.	**Variety**	**9. Leaf size**	**10. Intensity of green colour on upper side**	**11. Anthocyanin colouration**	**12. Glossiness on upper side**	**13. Undulation of margin**	**14. serration of margin**	**15. shape of blade**	**16. Shape of base of blade**	**17. Shape of apex of blade**
24	**The Fairy**	Medium (11-20 cm^2)	Medium	Absent	Strong	Absent	Fine	Medium elliptic	Acute	Acute
25	**Red Figurine**	Micro-mini (1-10 cm^2)	Very Dark	Absent	Weak	Absent	Medium	Obovate	Acute	Obtuse
26	**Aishwarya**	Medium (11-20 cm^2)	Medium	Absent	Weak	Absent	Fine	Medium elliptic	Obtuse	Acuminate
27	**Don Don**	Medium (11-20 cm^2)	Dark	Absent	Medium	Absent	Medium	Ovate	Rounded	Acuminate
28	**Lemon Sweet Dream**	Medium (11-20 cm^2)	Very Dark	Absent	Strong	Weak	Fine	Medium elliptic	Obtuse	Acuminate
29	**Rise n Shine**	Medium (11-20 cm^2)	Very Dark	Absent	Strong	Absent	Fine	Medium elliptic	Acute	Rounded
30	**Swinger**	Large (>20 cm^2)	Medium	Absent	Strong	Weak	Medium	Circular	Obtuse	Rounded
31	**Babe**	Large (>20 cm^2)	Medium	Absent	Absent	Weak	Fine	Ovate	Rounded	Acuminate
32	**Mirabel**	Medium (11-20 cm^2)	Light	Absent	Strong	Absent	Fine	Circular	Rounded	Acuminate
33	**Flamboyant**	Large (>20 cm^2)	Light	Absent	Absent	Weak	Fine	Obovate	Obtuse	Acute
34	**Roxy**	Medium (11-20 cm^2)	Dark	Absent	Strong	Weak	Fine	Ovate	Rounded	Acuminate
35	**Graine De Beaute**	Micro-mini (1-10 cm^2)	Very Dark	Absent	Strong	Weak	Fine	Narrow elliptic	Obtuse	Acuminate
36	**Cup Cake**	Micro-mini (1-10 cm^2)	Very Dark	Absent	Medium	Absent	Fine	Medium elliptic	Obtuse	Acuminate
37	**Mr. Blue Bird**	Large (>20 cm^2)	Very Dark	Absent	Strong	Weak	Fine	Medium elliptic	Obtuse	Acuminate
38	**Amber Star**	Medium (11-20 cm^2)	Dark	Absent	Medium	Absent	Medium	Medium elliptic	Acute	Acuminate
39	**Fire Flash**	Medium (11-20 cm^2)	Dark	Absent	Absent	Medium	Medium	Ovate	Cordate	Acuminate
40	**Hoot & Howler**	Medium (11-20 cm^2)	Dark	Absent	Medium	Absent	Medium	Medium elliptic	Obtuse	Acuminate
41	**Leila Laird**	Large (>20 cm^2)	Light	Absent	Absent	Absent	Dense	Medium elliptic	Obtuse	Acuminate
42	**Painter's Palette**	Medium (11-20 cm^2)	Dark	Absent	Absent	Weak	Dense	Medium elliptic	Acute	Acuminate
43	**Nine**	Medium (11-20 cm^2)	Light	Absent	Absent	Absent	Dense	Medium elliptic	Acute	Acuminate
44	**Dazzler**	Medium (11-20 cm^2)	Very light	Absent	Absent	Absent	Fine	Medium elliptic	Acute	Acute
45	**Priti**	Micro-mini (1-10 cm^2)	Very light	Absent	Absent	Absent	Medium	Medium elliptic	Obtuse	Acuminate

Table No 4.3.3a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Flowering Shoot**				**Flower bud**	**Flower**		
S. No.	**Variety**	**18. Flowering laterals**	**19. Number of flowering laterals**	**20. Number of flowers (var. with no flowering lateral)**	**21. Number of flowers per lateral**	**22. Shape of LS**	**23. Flower type**	**24. Number of petals**	**25. Colour Group**
1	**Bharani**	Present	Medium	-	Medium	Ovate	Semi-double	Medium (21-30)	Red purple
2	**China 65**	Present	Few	-	Few	Ovate	Single	Few (<20)	Red purple
3	**Golden Century**	Absent	-	Many	-	Ovate	Double	Many (>30)	Yellow
4	**Frothy**	Present	Many	-	Many	Ovate	Double	Many (>30)	White or near white
5	**Zwergkonig**	Present	Medium	-	Medium	Ovate	Double	Medium (21-30)	Red
6	**Royal Midnette**	Present	Many	-	Few	Elliptic	Semi-double	Few (<20)	Red purple
7	**Simply Marvelous**	Present	Few	-	Few	Ovate	Double	Medium (21-30)	Red
8	**Chandrika**	Present	Few	-	Many	Ovate	Double	Many (>30)	White or near white
9	**Flash Dance**	Present	Few	-	Few	Ovate	Double	Many (>30)	Red purple
10	**Kayla**	Absent	-	Medium	-	Ovate	Semi-double	Few (<20)	Pink
11	**Sunday Brunch**	Absent	-	Many	-	Broad ovate	Double	Many (>30)	Yellow blend
12	**Vanessa**	Present	Few	-	Few	Ovate	Semi-double	Medium (21-30)	Orange blend
13	**Maigold Sweet Dream**	Absent	-	Few	-	Ovate	Semi-double	Few (<20)	Orange
14	**Blue Blood**	Present	Medium	-	Medium	Ovate	Double	Many (>30)	Red purple
15	**Scarlet Gem**	Present	Few	-	Few	Round	Double	Many (>30)	Red
16	**String of pearls**	Present	Many	-	Many	Elliptic	Double	Medium (21-30)	Pink
17	**Fairy Gold**	Present	Medium	-	Few	Ovate	Double	Many (>30)	Yellow blend
18	**Lavender Midnette**	Present	Many	-	Many	Ovate	Double	Many (>30)	Violet blend
19	**Young Mistress**	Present	Medium	-	Few	Ovate	Double	Medium (21-30)	Orange blend
20	**Gourmet Popcorn**	Present	Few	-	Few	Elliptic	Double	Medium (21-30)	White or near white
21	**Giggles**	Present	Medium	-	Many	Broad ovate	Semi-double	Few (<20)	Red
22	**Ruby Star**	Present	Few	-	Medium	Broad ovate	Double	Many (>30)	Red
23	**Wild Fire**	Absent	-	Medium	-	Ovate	Semi-double	Few (<20)	Orange blend

Table No 4.3.3b: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Flowering shoot**				**Flower bud**	**Flower**		
S. No.	**Variety**	**18. Flowering laterals**	**19. Number of flowering laterals**	**20. Flowering shoot: Number of flowers(var with no flowering lateral)**	**21. Number of flowers per lateral**	**22.Shape of LS**	**23. Flower type**	**24. Number of petals**	**25. Colour Group**
24	**The Fairy**	Present	Many	-	Many	Ovate	Double	Many (>30)	Pink
25	**Red Figurine**	Present	Many	-	Many	Round	Double	Many (>30)	Red
26	**Aishwarya**	Absent	-	Medium	-	Broad ovate	Double	Many (>30)	Orange
27	**Don Don**	Present	Medium	-	Medium	Broad ovate	Double	Many (>30)	Red
28	**Lemon Sweet Dream**	Absent	-	Few	-	Ovate	Semi-double	Medium (21-30)	Yellow
29	**Rise n Shine**	Absent	-	Few	-	Ovate	Double	Many (>30)	Yellow
30	**Swinger**	Present	Medium	-	Medium	Ovate	Double	Many (>30)	Yellow
31	**Babe**	Present	Many	Medium	-	Ovate	Double	Many (>30)	Yellow
32	**Mirabel**	Absent	-	Few	-	Elliptic	Semi-double	Few (<20)	Pink blend
33	**Flamboyant**	Present	Many	-	Many	Round	Double	Many (>30)	Red purple
34	**Roxy**	Present	Many	-	Many	Broad ovate	Double	Many (>30)	Pink
35	**Graine De Beaute**	Present	Many	-	Medium	Ovate	Double	Many (>30)	Pink
36	**Cup Cake**	Present	Medium	-	Few	Round	Double	Medium (21-30)	Pink
37	**Mr. Blue Bird**	Present	Medium	-	Medium	Ovate	Double	Many (>30)	Red purple
38	**Amber Star**	Absent	-	Many	-	Ovate	Double	Many (>30)	Yellow blend (Primary yellow with pink red)
39	**Fire Flash**	Present	Many	-	Many	Ovate	Semi-double	Few (<20)	Yellow blend (Primary yellow with pink red)
40	**Hoot & Howler**	Present	Many	-	Few	Ovate	Double	Medium (21-30)	Red purple
41	**Leila Laird**	Absent	-	Few	-	Ovate	Double	Medium (21-30)	Pink
42	**Painter's Palette**	Present	Many	-	Medium	Ovate	Double	Many (>30)	Red blend
43	**Nine**	Present	Medium	-	Medium	Ovate	Double	Many (>30)	Orange
44	**Dazzler**	Present	Many	-	Medium	Ovate	Single	Few (<20)	Red purple
45	**Priti**	Present	Medium	-	Few	Ovate	Semi-double	Few (<20)	White blend

4.3.1.27 Flower: Colour of the center

It is a pseudo qualitative characteristic to be observed by Visual assessment by a single observation of a group of plants or parts of plants *viz.,* flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics Table No.4.3.4a to 4.3.4b, the genotypes which showed green colour of the centre was Frothy, The Fairy, whereas yellow centre was observed by Bharani, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Vanessa, Scarlet Gem, Young Mistress, Gourmet Popcorn, Red Figurine, Don Don, Mirabel, Roxy, Graine De Beaute, Dazzler, Priti. Orange centre was shown by Sunday Brunch, Lavender Midnette. None of the varieties showed pink, red, purple coloured centres.

The differences in flower colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Murugesan *et al* (1991). Singh (2016), Dadlani (2016) and Gaurav *et al* (2018) also reported large variation in colour of flowers while studying Rose.

4.3.1.28 Flower: Density of petals

It is a quantitative characteristic to be observed by Measurement by a single observation of a group of plants or parts of plants *viz.*, flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics Table No.4.3.4a to 4.3.4b, the genotypes Bharani, China 65, Royal Midnette, Maigold Sweet Dream, Gourmet Popcorn, Wild Fire, Mirabel, Cup Cake, Dazzler showed very loose density whereas loose density was exhibited by Simply Marvelous, Chandrika, Flash Dance, Kayla, Vanessa, String of pearls, Fairy Gold, Young Mistress, Giggles, Red Figurine, Aishwarya, Lemon Sweet Dream, Flamboyant, Roxy, Graine De Beaute, Mr. Blue Bird, Fire Flash, Leila Laird, Painter's Palette, Priti. Medium density was shown by Zwergkonig, Lavender Midnette, Ruby Star, Swinger, Babe, Amber Star, Hoot & Howlers whereas dense petal was shown by Golden Century, Frothy, Sunday Brunch, Blue Blood, Scarlet Gem, Don Don, Rise n Shine, Nine.

The differences among the cultivars of above character might be due to genetic make up of the cultivar. The study is in conformity with findings of Dadlani (2016).

4.3.1.29 Flower shape: View from above

Bharani	China 65	Golden Century	Frothy	Zwergkonig	Royal Midnette	Simply Marvelous	Chandrika	Flash Dance

Kayla	Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem	String of Pearls	Fairy Gold	Lavender Midnette

Young Mistress	Gourmet Popcorn	Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine	Aishwarya	Don Don

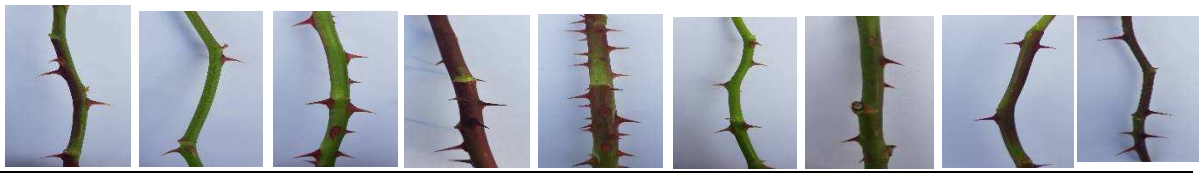
Lemon Sweet Dream	Rise n Shine	Swinger	Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute	Cup Cake

Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler	Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 2: Young shoot anthocyanin colouration in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig	Royal Midnette	Simply Marvelous	Chandrika	Flash Dance

Kayla	Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem	String of Pearls	Fairy Gold	Lavender Midnette



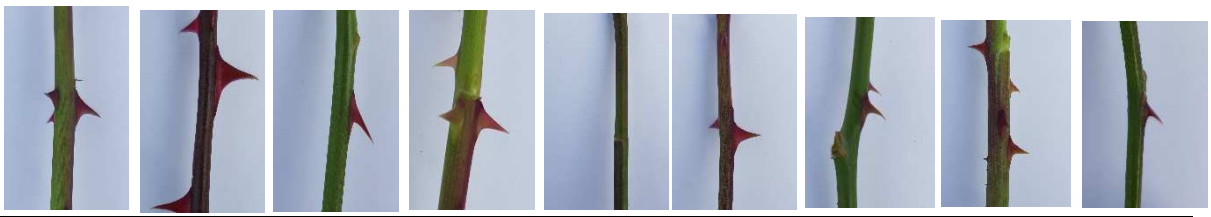
Young Mistress	Gourmet Popcorn	Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine	Aishwarya	Don Don

Lemon Sweet Dream	Rise n Shine	Swinger	Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute	Cup Cake

Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler	Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 3: Prickle density in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig	Royal Midnette	Simply Marvelous	Chandrika	Flash Dance



Kayla	Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem	String of Pearls	Fairy Gold	Lavender Midnette

Young Mistress	Gourmet Popcorn	Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine	Aishwarya	Don Don

Lemon Sweet Dream	Rise n Shine	Swinger	Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute	Cup Cake

Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler	Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 4: Shape of lower side of prickles and colour of prickles in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

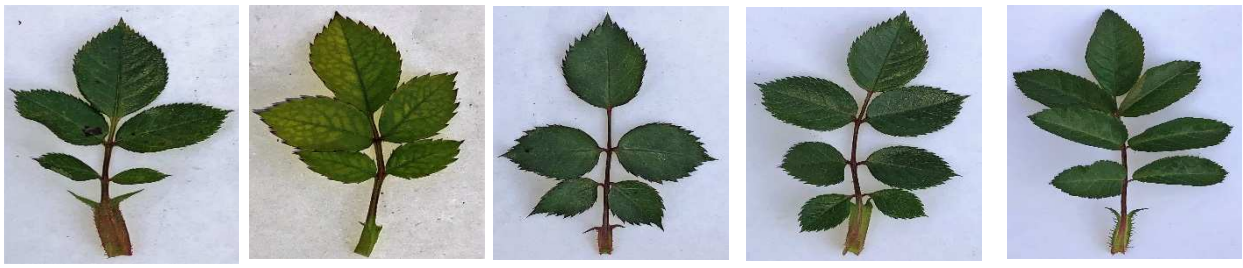
Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 5 a : Compound leaf of different miniature rose genotypes depicting green and anthocyanin colour intensity on upper leaf surface



Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

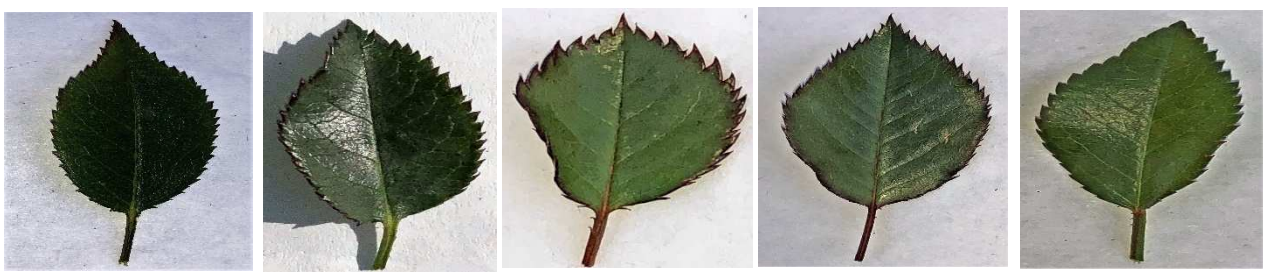
Plate 5 b: Compound leaf of different miniature rose genotypes depicting green and anthocyanin colour intensity on upper leaf surface

Bharani	China 65	Golden Century	Frothy	Zwergkonig

Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

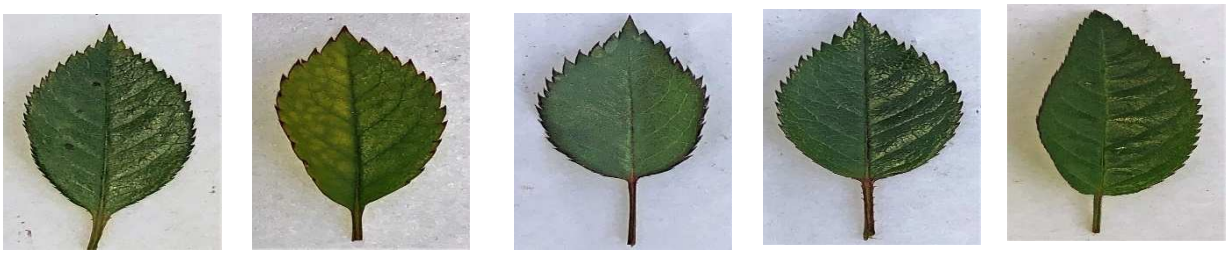
Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn



Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 6a: Glossiness and undulation of margin of foliage in different miniature rose genotypes



Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

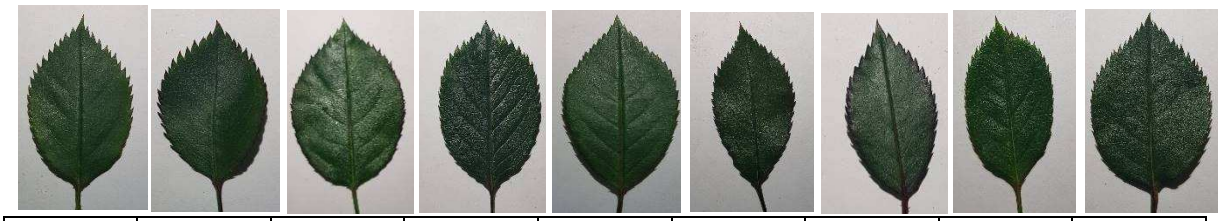
Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

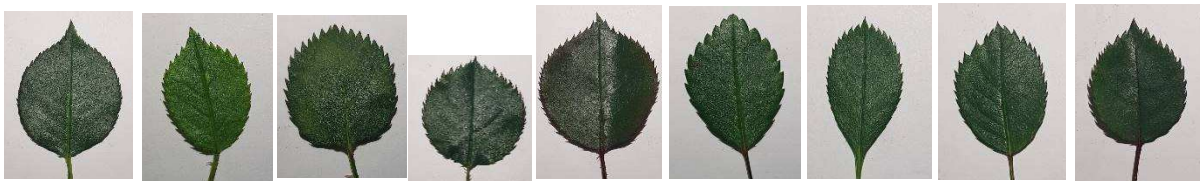
Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 6b: Glossiness and undulation of margin of foliage in different miniature rose genotypes

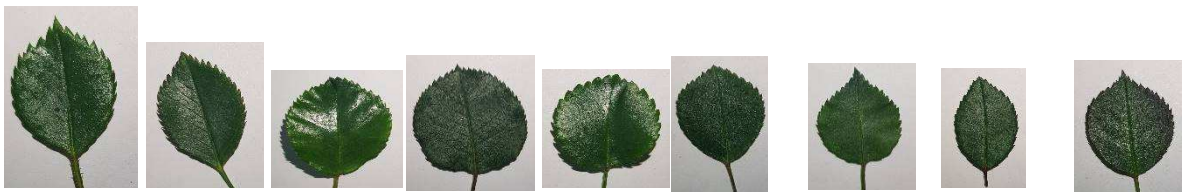
Bharani	China 65	Golden Century	Frothy	Zwergkonig	Royal Midnette	Simply Marvelous	Chandrika	Flash Dance



Kayla	Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem	String of Pearls	Fairy Gold	Lavender Midnette



Young Mistress	Gourmet Popcorn	Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine	Aishwarya	Don Don



Lemon Sweet Dream	Rise n Shine	Swinger	Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute	Cup Cake

Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler	Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 7: Shape of terminal leaflet in different miniature rose genotypes

Bharani	**China 65**	**Golden Century**	**Frothy**	**Zwergkonig**	**Royal Midnette**	**Simply Marvelous**	**Chandrika**	**Flash Dance**
Kayla	**Sunday Brunch**	**Vanessa**	**Maigold Sweet Dream**	**Blue Blood**	**Scarlet Gem**	**String of Pearls**	**Fairy Gold**	**Lavender Midnette**
Young Mistress	**Gourmet Popcorn**	**Giggles**	**Ruby Star**	**Wild Fire**	**The Fairy**	**Red Figurine**	**Aishwarya**	**Don Don**
Lemon Sweet Dream	**Rise n Shine**	**Swinger**	**Babe**	**Mirabel**	**Flamboyant**	**Roxy**	**Graine De Beaute**	**Cup Cake**
Mr. Blue Bird	**Amber Star**	**Fire Flash**	**Hoot & Howler**	**Leila Laird**	**Painter's Palette**	**Nine**	**Dazzler**	**Priti**

Plate 8: Shape of base of the leaf blade in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig	Royal Midnette	Simply Marvelous	Chandrika	Flash Dance

Kayla	Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem	String of Pearls	Fairy Gold	Lavender Midnette

Young Mistress	Gourmet Popcorn	Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine	Aishwarya	Don Don

Lemon Sweet Dream	Rise n Shine	Swinger	Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute	Cup Cake

Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler	Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 9: Shape of apex of leaf blade in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

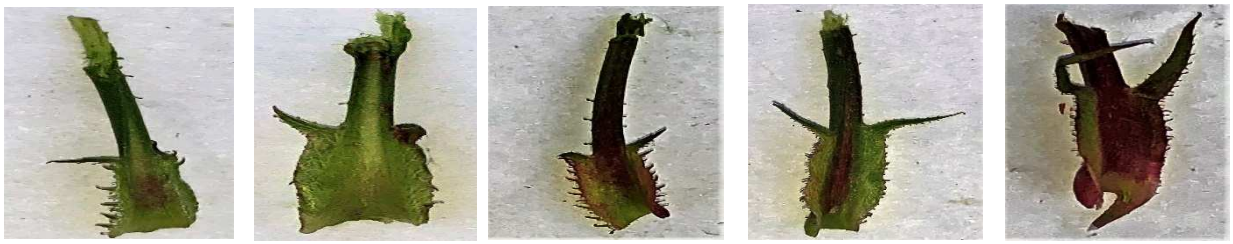
String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 10a: Shape of stipules in different miniature rose genotypes

Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute



Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 10b: Shape of stipules in different miniature rose genotypes

It is an essential pseudo qualitative characteristic to be observed by Visual assessment by a single observation of a group of plants or parts of plants *viz.,* flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics Table No.4.3.4a to 4.3.4b, Round shape from above was observed by genotypes Golden Century, Frothy, Zwergkonig, Simply Marvelous, Chandrika, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Lavender Midnette, Gourmet Popcorn, Giggles, Ruby Star, The Fairy, Aishwarya, Don Don, Lemon Sweet Dream, Flamboyant, Roxy, Graine De Beaute, Fire Flash, Priti while the shape irregularly round shape was exhibited in Bharani, China 65, Sunday Brunch, Fairy Gold, Young Mistress, Wild Fire, Red Figurine, Swinger, Babe, Mirabel, Cup Cake, Mr. Blue Bird, Hoot & Howler, Painter's Palette, Dazzler. The genotypes *viz.,* Royal Midnette, Rise n Shine, Amber Star, Leila Laird showed star shaped view from above.

The differences among the cultivars of above character might be due to genetic make up of the cultivar. The study is in conformity with findings of Gaurav *et al* (2018).

4.3.1.30 Flower: Side view of upper part (fully opened flower)

It is a pseudo qualitative characteristic to be observed in garden type plants by visual assessment by a single observation of a group of plants or parts of plants *viz.*, flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics, Table No.4.3.4a to 4.3.4b, flat state of expression was shown by genotypes Bharani, China 65, Zwergkonig, Royal Midnette, Kayla, Vanessa, Blue Blood, Scarlet Gem, Fairy Gold, Lavender Midnette, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Mirabel, Flamboyant, Roxy , Graine De Beaute, Cup Cake, Nine, Dazzler whereas genotypes which showed flattened convex shaped were Frothy, Simply Marvelous, Chandrika, Flash Dance, Maigold Sweet Dream, Young Mistress, Gourmet Popcorn, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Babe, Mr. Blue Bird, Fire Flash, Hoot & Howler, Leila Laird, Painter's Palette. The genotypes Golden Century, String of Pearls, Amber Star, Priti showed convex upper part.

The differences among the cultivars of above character might be due to genetic make up of the cultivar. The study is in conformity with findings of Gaurav *et al.* (2018).

4.3.1.31 Flower: Side view of lower part (fully opened flower)

It is a pseudo qualitative characteristic to be observed in garden type plants by Visual assessment by a single observation of a group of plants or parts of plants *viz.*, flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics Table No.4.3.4a to 4.3.4b, the genotypes which showed concave state of expression were Royal Midnette, Maigold Sweet Dream, String of pearls, Lavender Midnette, Wild Fire, Swinger, Cup Cake, Fire Flash while genotypes Frothy, Chandrika, Sunday Brunch, Fairy Gold, Young Mistress, Red Figurine, Rise n Shine, Babe, Roxy, Mr. Blue Bird, Amber Star, Hoot & Howler, Leila Laird, Painter's Palette showed flat state of expression. The genotypes which showed flattened state of expression were Zwergkonig, Kayla, Gourmet Popcorn, Ruby Star, Don Don, Nine. Convex state of expression was exhibited by genotypes Bharani, China 65, Simply Marvelous, Flash Dance, Vanessa, Blue Blood, Scarlet Gem, Giggles, The Fairy, Aishwarya, Lemon Sweet Dream, Mirabel, Flamboyant, Graine De Beaute, Dazzler, Priti.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.32 Flower: Fragrance (recorded during early morning)

It is a quantitative characteristic to be observed in garden type plants by assessment by a single observation of a group of plants or parts of plants *viz.*, flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics, Table No.4.3.4a to 4.3.4b, Genotypes such as China 65, Frothy, Flash Dance, Scarlet Gem, String of pearls, Fairy Gold, Gourmet Popcorn, Don Don, Swinger, Mirabel, Painter's Palette showed complete absence of fragrance whereas weak state of expression was found in Bharani, Golden Century, Royal Midnette, Simply Marvelous, Vanessa, Maigold Sweet Dream, Lavender Midnette, Ruby Star, Aishwarya, Flamboyant, Roxy, Graine De Beaute, Amber Star, Fire Flash, Hoot & Howler, Nine. Medium expression of fragrance was observed in Chandrika, Sunday Brunch, Young Mistress, Wild Fire, The Fairy, Lemon Sweet Dream, Rise n Shine, Babe, Mr. Blue Bird, Leila Laird, Dazzler whereas the genotypes Zwergkoni, Blue Blood, Giggles, Cup Cake recorded strong state of expression.

Singh (2016) also observed that fragrance of flowers varied significantly among the varieties. On the basis of flower fragrance cultivars had been considered as fragrant and non fragrant. The fragrance in rose is due to presence of various substances like phenylethyl alcohol, citronellol, geraniol, nerol, citral, menthol etc. The fragrant roses are preferred over non fragrant roses. Even among the genotypes the intensity of fragrance is varied. Fragrance also varied with age of flower as well as prevailing environmental conditions but in the study flowers were evaluated early in the morning at anthesis to evaluate true character of the genotype. The variation in flower fragrance among the cultivars might be due to genetic make up of the cultivar in conformity with the findings of Malik and Dadlani (1986) and Murugesan *et al* (1991).

4.3.1.33 Sepal: Extensions

It is an essential quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.,* flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

As evident from table of characteristics Table No.4.3.4a to 4.3.4b, the characteristic sepal extension was found absent in Zwergkonig, Royal Midnette, Kayla, Sunday Brunch, Gourmet Popcorn, Giggles, Babe, Mirabel, Roxy, Graine De Beaute, Mr. Blue Bird, Fire Flash, Hoot & Howler, Priti whereas few in genotypes Bharani, China 65, Golden Century, Flash Dance, Vanessa, Maigold Sweet Dream, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Ruby Star, Wild Fire, The Fairy, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Flamboyant, Cup Cake, Amber Star, Nine, Dazzler. The genotypes Frothy, Simply Marvelous, Chandrika, Young Mistress, Red Figurine, Leila Laird showed medium state of expression in sepal extension while genotypes Blue Blood, Painter's Palette showed many sepal extensions.

The differences among the cultivars of above character might be due to genetic make up of the cultivar. The study is in conformity with findings of Gaurav *et al* (2018).

4.3.1.34 Petal: Reflexing of petals one by one

It is a qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.,* flowers. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

Table No 4.3.4a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Flower**							**Sepal**
S. No.	**Variety**	**26.Diameter (cm)**	**27. Colour of the centre**	**28. Density of petal**	**29. Shape: View from above**	**30. Side view of upper part**	**31. Side view of lower part**	**32 Fragrance (recorded during early morning)**	**33. Sepal Extension**
1	**Bharani**	Small (4.1-6 cm)	Yellow	Very loose	Irregularly round	Flat	Convex	Weak	Few
2	**China 65**	Micro-mini (<4cm)	-	Very loose	Irregularly round	Flat	Convex	Absent	Few
3	**Golden Century**	Micro-mini (<4cm)	-	Dense	Round	Convex	Flat	Weak	Few
4	**Frothy**	Micro-mini (<4cm)	Green	Dense	Round	Flattened convex	Flat	Absent	Medium
5	**Zwergkonig**	Small (4.1-6 cm)	Yellow	Medium	Round	Flat	Flattened convex	Strong	Absent
6	**Royal Midnette**	Small (4.1-6 cm)	Yellow	Very loose	Star shaped	Flat	Concave	Weak	Absent
7	**Simply Marvelous**	Micro-mini (<4cm)	Yellow	Loose	Round	Flattened convex	Convex	Weak	Medium
8	**Chandrika**	Micro-mini (<4cm)	Yellow	Loose	Round	Flattened convex	Flat	Medium	Medium
9	**Flash Dance**	Micro-mini (<4cm)	Yellow	Loose	Round	Flattened convex	Convex	Absent	Few
10	**Kayla**	Micro-mini (<4cm)	Yellow	Loose	Round	Flat	Flattened convex	Strong	Absent
11	**Sunday Brunch**	Small (4.1-6 cm)	Orange	Dense	Irregularly round	Convex	Flat	Medium	Absent
12	**Vanessa**	Micro-mini (<4cm)	Yellow	Loose	Round	Flat	Convex	Weak	Few
13	**Maigold Sweet Dream**	Micro-mini (<4cm)	-	Very loose	Round	Flattened convex	Concave	Weak	Few
14	**Blue Blood**	Micro-mini (<4cm)	-	Dense	Round	Flat	Convex	Strong	Many
15	**Scarlet Gem**	Micro-mini (<4cm)	Yellow	Dense	Round	Flat	Convex	Absent	Few
16	**String of pearls**	Micro-mini (<4cm)	-	Loose	Round	Convex	Concave	Absent	Few
17	**Fairy Gold**	Micro-mini (<4cm)	-	Loose	Irregularly round	Flat	Flat	Absent	Few
18	**Lavender Midnette**	Micro-mini (<4cm)	Orange	Medium	Round	Flat	Concave	Weak	Few
19	**Young Mistress**	Small (4.1-6 cm)	Yellow	Loose	Irregularly round	Flattened convex	Flat	Medium	Medium
20	**Gourmet Popcorn**	Micro-mini (<4cm)	Yellow	Very loose	Round	Flattened convex	Flattened convex	Absent	Absent
21	**Giggles**	Small (4.1-6 cm)	-	Loose	Round	Flat	Convex	Strong	Absent
22	**Ruby Star**	Micro-mini (<4cm)	-	Medium	Round	Flat	Flattened convex	Weak	Few
23	**Wild Fire**	Small (4.1-6 cm)	-	Very loose	Irregularly round	Flat	Concave	Medium	Few

Table No 4.3.4b: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Flower**							**Sepal**
S. No.	**Variety**	**26.Diameter (cm)**	**27. Colour of the centre**	**28. Density of petal**	**29. Shape: View from above**	**30. Side view of upper part**	**31. Side view of lower part**	**32 Fragrance (recorded during early morning)**	**33. Sepal Extension**
24	**The Fairy**	Micro-mini (<4cm)	Green	Medium	Round	Flat	Convex	Medium	Few
25	**Red Figurine**	Micro-mini (<4cm)	Yellow	Loose	Irregularly round	Flat	Flat	Weak	Medium
26	**Aishwarya**	Small (4.1-6 cm)	-	Loose	Round	Flat	Convex	Weak	Few
27	**Don Don**	Micro-mini (<4cm)	Yellow	Dense	Round	Flattened convex	Flattened convex	Absent	Few
28	**Lemon Sweet Dream**	Small (4.1-6 cm)	-	Loose	Round	Flattened convex	Convex	Medium	Few
29	**Rise n Shine**	Micro-mini (<4cm)	-	Dense	Star shaped	Flattened convex	Flat	Medium	Few
30	**Swinger**	Small (4.1-6 cm)	-	Medium	Irregularly round	Flattened convex	Concave	Absent	Few
31	**Babe**	Small (4.1-6 cm)	-	Medium	Irregularly round	Flattened convex	Flat	Medium	Absent
32	**Mirabel**	Micro-mini (<4cm)	Yellow	Very loose	Irregularly round	Flat	Convex	Absent	Absent
33	**Flamboyant**	Micro-mini (<4cm)	-	Loose	Round	Flat	Convex	Weak	Few
34	**Roxy**	Micro-mini (<4cm)	Yellow	Loose	Round	Flat	Flat	Weak	Absent
35	**Graine De Beaute**	Micro-mini (<4cm)	Yellow	Loose	Round	Flat	Convex	Weak	Absent
36	**Cup Cake**	Small (4.1-6 cm)	-	Very loose	Irregularly round	Flat	Concave	Strong	Few
37	**Mr. Blue Bird**	Micro-mini (<4cm)	-	Loose	Irregularly round	Flattened convex	Flat	Medium	Absent
38	**Amber Star**	Small (4.1-6 cm)	-	Medium	Star shaped	Convex	Flat	Weak	Few
39	**Fire Flash**	Small (4.1-6 cm)	-	Loose	Round	Flattened convex	Concave	Weak	Absent
40	**Hoot & Howler**	Small (4.1-6 cm)	-	Medium	Irregularly round	Flattened convex	Flat	Weak	Absent
41	**Leila Laird**	Small (4.1-6 cm)	-	Loose	Star shaped	Flattened convex	Flat	Medium	Medium
42	**Painter's Palette**	Small (4.1-6 cm)	-	Loose	Irregularly round	Flattened convex	Flat	Absent	Many
43	**Nine**	Micro-mini (<4cm)	-	Dense	Star shaped	Flat	Flattened convex	Weak	Few
44	**Dazzler**	Micro-mini (<4cm)	Yellow	Very loose	Irregularly round	Flat	Convex	Medium	Few
45	**Priti**	Micro-mini (<4cm)	Yellow	Loose	Round	Convex	Convex	Weak	Absent

As evident from table of characteristics (4.3.5a and 4.3.5b) reflexing of petals one by one was observed absent in Bharani, China 65, Golden Century, Zwergkonig, Royal Midnette, Chandrika, Flash Dance, Kayla, Vanessa, Blue Blood, Scarlet Gem, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Lemon Sweet Dream, Rise n Shine, Flamboyant, Roxy, Graine De Beaute, Fire Flash, Leila Laird, Painter's Palette, Nine, Dazzler, Priti whereas the expression was present in following genotypes : Frothy, Simply Marvelous, Sunday Brunch, Maigold Sweet Dream, String of Pearls, Aishwarya, Don Don, Swinger, Babe, Mirabel, Cup Cake, Mr. Blue Bird, Amber Star, Hoot & Howler.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.35 Petal: Shape

It is a pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) the genotypes Golden Century, Frothy, Sunday Brunch, Scarlet Gem, Don Don, Rise n Shine, Nine showed elliptic shape while obovate shape was shown by Bharani, China 65, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Blue Blood, String of Pearls, Fairy Gold, Lavender Midnette, Gourmet Popcorn, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Lemon Sweet Dream, Swinger, Mirabel, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Amber Star, Hoot & Howler, Leila Laird, Painter's Palette, Dazzler. The genotypes Young Mistress, Giggles, Babe, Fire Flash, Priti exhibited round petal shape.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.36 Petal: incisions

It is a quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) the characteristic petal incision was found absent in genotypes China 65, Golden Century, Frothy, Simply Marvelous, Flash Dance, Kayla, Sunday Brunch, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of Pearls, Fairy Gold, Lavender Midnette, Young Mistress, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Mirabel, Flamboyant, Amber Star, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler, Priti while the incision was found weak in petals of genotypes Bharani, Zwergkonig, Royal Midnette, Gourmet Popcorn, Babe, Roxy, Mr. Blue Bird, Fire Flash. Genotypes Chandrika, Graine De Beaute, Cup Cake showed medium incision and strong expression was shown by none of the varieties.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.37 Petal: Reflexing of margin

It is a quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) the genotypes Simply Marvelous, Blue Blood, Scarlet Gem, The Fairy, Flamboyant, Nine showed no reflexing of margin whereas genotypes viz., Bharani, China 65, Golden Century, Frothy, Chandrika, Vanessa, Maigold Sweet Dream, String of pearls, Fairy Gold, Lavender Midnette, Gourmet Popcorn, Giggles, Wild Fire, Red Figurine, Aishwarya, Rise n Shine, Mirabel, Roxy, Graine De Beaute, Mr. Blue Bird, Dazzler showed weak expression for the same character. Medium expression was sown by Zwergkonig, Royal Midnette, Flash Dance, Kayla, Sunday Brunch, Young Mistress, Ruby Star, Don Don, Lemon Sweet Dream, Fire Flash, Leila Laird and strong expression was shown by Swinger, Babe, Cup Cake, Amber Star, Hoot & Howler, Painter's Palette, Priti.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.38 Petal: Undulation of margin

It is a quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) the undulation of petal margin was found absent in China 65, Golden Century, Frothy, Simply Marvelous, Chandrika, Flash Dance, Sunday Brunch, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Gourmet Popcorn, The Fairy, Red Figurine, Aishwarya, Lemon Sweet Dream, Rise n Shine, Mirabel, Flamboyant, Nine while genotypes Bharani, Zwergkonig, Kayla, Vanessa, Wild Fire, Don Don, Roxy, Graine De Beaute, Mr. Blue Bird, Fire Flash, Hoot & Howler, Leila Laird, Dazzler, Priti showed weak undulation of petal margin. Medium state of expression was shown by genotypes Royal Midnette, Young Mistress, Giggles, Swinger, Babe, Cup Cake, Painter's Palette and strong expression was exhibited by Ruby Star, Amber Star.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.39 Petal: Length

It is an essential quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) Petal length was found very short in genotypes China 65, Dazzler while short petal length was exhibited by Bharani, Golden Century, Frothy, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Flash Dance, Kayla, Sunday Brunch, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of pearls, Fairy Gold, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Babe, Mirabel, Flamboyant, Roxy, Graine De Beaute, Mr. Blue Bird, Fire Flash, Painter's Palette, Nine, Priti. Medium petal length was found in genotypes Aishwarya,

Swinger, Cup Cake, Amber Star, Hoot & Howler, Leila Laird and long and very long state of expression was found in none of the varieties.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.40 Petal: Width

It is an essential quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.,* petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) the genotypes which showed very narrow petal width were Frothy, Scarlet Gem whereas narrow petal width were shown by China 65, Golden Century, Chandrika, Sunday Brunch, Vanessa, Blue Blood, Fairy Gold, Gourmet Popcorn, Giggles, The Fairy, Red Figurine, Don Don, Rise n Shine, Graine De Beaute, Nine. Genotypes Bharani, Royal Midnette, Simply Marvelous, Flash Dance, Kayla, Maigold Sweet Dream, String of Pearls, Lavender Midnette, Young Mistress, Ruby Star, Wild Fire, Aishwarya, Lemon Sweet Dream, Flamboyant, Roxy, Cup Cake, Mr. Blue Bird, Amber Star, Leila Laird, Dazzler, Priti showed medium petal width and genotypes Zwergkonig, Swinger, Babe, Mirabel, Fire Flash, Painter's Palette showed broad petals. Hoot & Howler was the only genotype which showed very broad petals.

The differences among the cultivars of above character might be due to genetic make up of the cultivar.

4.3.1.41 Petal: Number of colours on inner side (basal spot excluded)

It is an essential qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.,* petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) Genotypes whose petals shown only one colour on inner side were Bharani, China 65, Golden Century, Frothy, Zwergkonig, Chandrika, Kayla, Vanessa, Blue Blood, Scarlet Gem, String of Pearls, Fairy

Gold, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Swinger, Babe, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Leila Laird, Nine, Dazzler while the ones which showed two colours on inner side are Royal Midnette, Simply Marvelous, Flash Dance, Sunday Brunch, Maigold Sweet Dream, Lavender Midnette, The Fairy, Mirabel, Amber Star, Hoot & Howler, Painter's Palette, Priti. The only genotype which showed multiple colours on inner side of petal was Fire Flash.

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Singh (2016), Dadlani (2016).

4.3.1.42 Varieties with one colour on inner side of petal: Intensity of colour excluding the basal spot

It is an essential quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.5a and 4.3.5b) The genotypes which showed one colour on the inner side of petal, showed lighter colour intensity towards base were, China 65, Zwergkonig, Kayla, Scarlet Gem, String of Pearls, Roxy, Graine De Beaute, Cup Cake, while the genotypes Bharani, Golden Century, Frothy, Chandrika, Vanessa, Fairy Gold, Young Mistress, Gourmet Popcorn, Giggles, Ruby Star, Wild Fire, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Babe, Flamboyant, Mr. Blue Bird, Leila Laird, Nine, Dazzler showed uniform intensity while Blue Blood, Swinger showed lighter intensity towards top.

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.43 Petal : Colour of the majority portion of the petal

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence).

Table No 4.3.5a:.Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**								
S. No.	**Variety**	**34. Reflexing of petals one by one**	**35. Petal Shape**	**36. Petal incision**	**37. Reflexing of margin**	**38. Undulation of margin**	**39. Petal length**	**40. Petal width**	**41. No. of colours on inner side (Excl.basal spot)**	**42. Variety with one colour on inner side of petal: Intensity of colour excluding the basal spot**
1	**Bharani**	Absent	Obovate	Weak	Weak	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
2	**China 65**	Absent	Obovate	Absent	Weak	Absent	Very short (<10 mm)	Narrow (5.01-10 mm)	Single	Lighter towards base
3	**Golden Century**	Absent	Elliptic	Absent	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
4	**Frothy**	Present	Elliptic	Absent	Weak	Absent	Short (10.01-20 mm)	Very narrow (<5 mm)	Single	Uniform
5	**Zwergkonig**	Absent	Obovate	Weak	Medium	Weak	Short (10.01-20 mm)	Broad (15.01-20 mm)	Single	Lighter towards base
6	**Royal Midnette**	Absent	Obovate	Weak	Medium	Medium	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-
7	**Simply Marvelous**	Present	Obovate	Absent	Absent	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-
8	**Chandrika**	Absent	Obovate	Medium	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
9	**Flash Dance**	Absent	Obovate	Absent	Medium	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-
10	**Kayla**	Absent	Obovate	Absent	Medium	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Lighter towards base
11	**Sunday Brunch**	Present	Elliptic	Absent	Medium	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Double	-
12	**Vanessa**	Absent	Obovate	Absent	Weak	Weak	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
13	**Maigold Sweet Dream**	Present	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-
14	**Blue Blood**	Absent	Obovate	Absent	Absent	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Lighter towards top
15	**Scarlet Gem**	Absent	Elliptic	Absent	Absent	Absent	Short (10.01-20 mm)	Very narrow (<5 mm)	Single	Lighter towards base
16	**String of pearls**	Present	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Lighter towards base
17	**Fairy Gold**	Absent	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
18	**Lavender Midnette**	Absent	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-
19	**Young Mistress**	Absent	Rounded	Absent	Medium	Medium	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
20	**Gourmet Popcorn**	Absent	Obovate	Weak	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
21	**Giggles**	Absent	Rounded	Absent	Weak	Medium	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
22	**Ruby Star**	Absent	Obovate	Absent	Medium	Strong	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
23	**Wild Fire**	Absent	Obovate	Absent	Weak	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform

Table No 4.3.5b: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**								
S. No.	**Variety**	**34. Reflexing of petals one by one**	**35. Petal Shape**	**36. Petal incision**	**37. Reflexing of margin**	**38.Undulation of margin**	**39. Petal length**	**40. Petal width**	**41. No. of colours on inner side (basal spot excluded)**	**42. Variety with one colour on inner side of petal: Intensity of colour excluding the basal spot**
24	**The Fairy**	Absent	Obovate	Absent	Absent	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Double	-
25	**Red Figurine**	Absent	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
26	**Aishwarya**	Present	Obovate	Absent	Weak	Absent	Medium (20.01-30 mm)	Medium (10.01-15 mm)	Single	Uniform
27	**Don Don**	Present	Elliptic	Absent	Medium	Weak	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
28	**Lemon Sweet Dream**	Absent	Obovate	Absent	Medium	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
29	**Rise n Shine**	Absent	Elliptic	Absent	Weak	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
30	**Swinger**	Present	Obovate	Absent	Strong	Medium	Medium (20.01-30 mm)	Broad (15.01-20 mm)	Single	Lighter towards top
31	**Babe**	Present	Rounded	Weak	Strong	Medium	Short (10.01-20 mm)	Broad (15.01-20 mm)	Single	Uniform
32	**Mirabel**	Present	Obovate	Absent	Weak	Absent	Short (10.01-20 mm)	Broad (15.01-20 mm)	Double	-
33	**Flamboyant**	Absent	Obovate	Absent	Absent	Absent	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
34	**Roxy**	Absent	Obovate	Weak	Weak	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Lighter towards base
35	**Graine De Beaute**	Absent	Obovate	Medium	Weak	Weak	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Lighter towards base
36	**Cup Cake**	Present	Obovate	Medium	Strong	Medium	Medium (20.01-30 mm)	Medium (10.01-15 mm)	Single	Lighter towards base
37	**Mr. Blue Bird**	Present	Obovate	Weak	Weak	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Single	Uniform
38	**Amber Star**	Present	Obovate	Absent	Strong	Medium	Medium (20.01-30 mm)	Medium (10.01-15 mm)	Double	-
39	**Fire Flash**	Absent	Rounded	Weak	Medium	Weak	Short (10.01-20 mm)	Broad (15.01-20 mm)	Multiple	-
40	**Hoot & Howler**	Present	Obovate	Absent	Strong	Weak	Medium (20.01-30 mm)	Very broad (>20 mm)	Double	-
41	**Leila Laird**	Absent	Obovate	Absent	Medium	Weak	Medium (20.01-30 mm)	Medium (10.01-15 mm)	Single	Uniform
42	**Painter's Palette**	Absent	Obovate	Absent	Strong	Medium	Short (10.01-20 mm)	Broad (15.01-20 mm)	Double	-
43	**Nine**	Absent	Elliptic	Absent	Absent	Absent	Short (10.01-20 mm)	Narrow (5.01-10 mm)	Single	Uniform
44	**Dazzler**	Absent	Obovate	Absent	Weak	Weak	Very short (<10 mm)	Medium (10.01-15 mm)	Single	Uniform
45	**Priti**	Absent	Rounded	Absent	Strong	Weak	Short (10.01-20 mm)	Medium (10.01-15 mm)	Double	-

Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As evident from table of characteristics (4.3.6a and 4.3.6b) The Royal Horticultural Society colour chart reference number for petal colour of different varieties were Bharani (Red Purple 61-A), China 65 (Red Purple 64-C), Golden Century (Greyed Yellow 160-C), Frothy (White 155-D), Zwergkonig (Red 44-A), Royal Midnette (Red Purple 60-A), Simply Marvelous (Red 44-B), Chandrika (White 155-D), Flash Dance (Red Purple 60-B), Kayla (Red-Purple 71-C), Sunday Brunch (Yellow 2-D), Vanessa (Orange Red 40 B), Maigold Sweet Dream (Orange 25-B), Blue Blood (Red Purple 58-B), String of Pearls (Red 52-D), Fairy Gold (Yellow Orange 18-A), Lavender Midnette (Purple-Violet 80-D), Young Mistress (Orange-Red 30-B), Gourmet Popcorn (White 154-A), Giggles (Red 44-B), Ruby Star (Red 46-A), Wild Fire (Orange Red 32-B), The Fairy (White 155-B), Red Figurine (Red 46-A), Aishwarya (Red 41-B), Don Don (Red 53-A), Lemon Sweet Dream (Yellow 10-A), Rise n Shine (Yellow 13-B), Swinger (Yellow Orange 18-C), Babe (Yellow Orange 15-B), Mirabel (White 155-D) , Flamboyant (Red Purple 66-B), Roxy (Red 55-A), Graine De Beaute (Red Purple 63-B), Cup Cake (Red Purple 68-C), Mr. Blue Bird (Red Purple 64-B), Amber Star (Yellow 13-C), Fire Flash (Red 46-C), Hoot & Howler (Red Purple 66-B), Leila Laird (Red 38-A), Painter's Palette (Red Purple 60-B), Nine (Orange Red 31-B), Dazzler (Red Purple 74-A), Priti (White 155-D).

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.44 Varieties with two or more colours on inner side of petal: Secondary colour of petal (basal spot excluded)

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.,* petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) the RHS colour chart reference number for petal colour of different varieties were Royal Midnette (Red Purple 59-A), Simply Marvelous (White 155-D), Flash Dance (White 155-B), Sunday Brunch (Red 36-A),

Maigold Sweet Dream (Yellow 9-A), Lavender Midnette (Purple 75-C), The Fairy (Red 56-A), Mirabel (Red Purple 74-A), Amber Star (Orange Red 35-B), Fire Flash (Yellow Orange 16-B), Hoot & Howler (White 155-D), Painter's Palette (White 155-D), Priti (Red Purple 62-B).

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.45 Varieties with two or more colours on inner side of petal: Tertiary colour of petal (basal spot excluded)

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) the RHS Chart reference number for petal colour in genotypes with tertiary colour is Fire Flash which showed Red Purple 63-A.

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.46 Varieties with two or more colours on inner side of petal: Petal distribution of secondary colour on inner side (basal spot excluded)

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) the genotypes which showed secondary colours on inner side of the petal showed following distribution. Genotypes Simply Marvelous, Maigold Sweet Dream showed distribution at base; Sunday Brunch at apex; Lavender Midnette, The Fairy, Amber Star, Hoot & Howler at marginal zone; Royal

Midnette as a flush; Flash Dance, Mirabel, Fire Flash, Painter's Palette as a segment or stripe; Amber Star, Hoot & Howler, Priti as speckle.

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.47 Varieties with two or more colours on inner side of petal: Petal distribution of tertiary colour on inner side (basal spot excluded)

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) in genotype showing tertiary colour which is Fire Flash showed distribution of colour as a flush.

The differences of colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.48 Petal: Spot at base of inner side

It is an essential qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) the spot at the base of inner side was absent in genotypes Frothy, Chandrika, Sunday Brunch, Blue Blood, Fairy Gold, The Fairy, Lemon Sweet Dream, Rise n Shine, Babe, Mirabel, Amber Star, Fire Flash, Priti whereas it was present in genotypes Bharani, China 65, Golden Century, Zwergkonig, Royal Midnette, Simply Marvelous, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Scarlet Gem, String of Pearls, Lavender Midnette, Young Mistress, Giggles, Ruby Star, Wild Fire, Red Figurine, Aishwarya, Don Don, Swinger, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Hoot & Howler, Leila Laird, Painter's Palette, Nine, Dazzler.

The differences in size of spot on petals in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) and Rai *et al* (2015).

4.3.1.49 Petal: Size of spot at base of inner side

It is an essential quantitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) for the above characteristics the size was observed small in genotypes Golden Century, Zwergkonig, Simply Marvelous, Flash Dance, Blue Blood, Lavender Midnette, Gourmet Popcorn, Giggles, Red Figurine, Cup Cake, Hoot & Howler; medium in Bharani, Vanessa, Maigold Sweet Dream, Scarlet Gem, String of pearls, Flamboyant, Mr. Blue Bird, Dazzler; large in China 65, Royal Midnette, Kayla, Young Mistress, Ruby Star, Wild Fire, Aishwarya, Swinger, Roxy, Graine De Beaute, Leila Laird, Painter's Palette, Nine.

The differences in size of spot on petals in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) and Rai *et al* (2015).

4.3.1.50 Petal: Colour of spot at base of inner side

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals. Observations on the flower which shall be made on a just fully opened flower (at the time of anther dehiscence). Observations on the petal shall be made from the 3rd outer whorl for double flowers and in case of semi- double flowers, these observations shall be made from the middle whorl.

As per data depicted in table (4.3.6a and 4.3.6b) the RHS colour chart reference number for petal colour of different varieties were Bharani (White 155-B), China 65 (White 155-B), Golden Century (Yellow 10-C), Zwergkonig (Yellow 3-D), Royal Midnette (Green Yellow 1-D), Simply Marvelous (Yellow 5-C), Flash Dance (Green Yellow 1-D), Kayla (White 155-B), Vanessa (White 155-B), Maigold Sweet Dream (Yellow 9-A), Blue Blood (White 155-D), Lavender Midnette (Red 56-A), Young Mistress (Yellow 11-A), Gourmet Popcorn (Yellow 4 -C), Giggles (White 155-B), Ruby Star (White 155-B), Wild Fire (Yellow 11-A), Red Figurine (White 155-D), Aishwarya (White 155-D), Don Don (Yellow 7-A), Swinger (Yellow 10-A), Flamboyant (White 155-D), Roxy (White 155-D), Graine De Beaute (White 155-D), Cup Cake

(White 155-D), Mr. Blue Bird (White 155-D), Hoot & Howler (Yellow 5-D), Leila Laird (Yellow 12-B), Painter's Palette (White 155-D), Nine (Yellow 10-A), Dazzler (White 155-D).

The differences of colour of spot at base of inner side in petals in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012), Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.51 Petal: Colour of spot at base of outer side

It is an essential characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals.

As per data depicted in table (4.3.6a and 4.3.6b) the RHS colour chart reference number for petal colour of different varieties were Bharani (White 155-B), China 65 (White 155-B), Zwergkonig (Yellow 3-D), Royal Midnette (Green Yellow 1-D), Simply Marvelous (Yellow 6-D), Flash Dance (Green Yellow 1-D), Kayla (White 155-D), Vanessa (White 155-B), Maigold Sweet Dream (Yellow 9-A), Blue Blood (White 155-D), String Of Pearls (White 155-B), Lavender Midnette (Red 56-A), Young Mistress (Yellow 11-A), Gourmet Popcorn (Yellow 4 -C), Wild Fire (Yellow 11-B), Red Figurine (White 155-D), Don Don (Yellow 7-A), Swinger (Yellow 10-B), Flamboyant (White 155-D), Roxy (White 155-D), Graine De Beaute (White 155-D), Cup Cake (White 155-D), Mr. Blue Bird (White 155-D), Hoot & Howler (Yellow 5-D), Leila Laird (Yellow 12-B), Dazzler (White 155-D).

The differences of colour of spot at base of outer side in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

Table No 4.3.6a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**								
S. No.	**Variety**	**43. Colour of majority portion of the petal**	**44. Variety with 2 or more colour on inner side of petal: Secondary colour (excluding basal spot)**	**45.Tertiary colour**	**46.Variety with 2 or more colour -Sec distribution**	**47.Distribution of tertiary colour**	**48. Spot at base of inner side**	**49. Size of spot at base of inner side**	**50. Colour of spot at base of inner side**	**51. Colour of spot at base of outer side**
1	**Bharani**	Red Purple 61-A	-	-	-	-	Present	Medium	White 155-B	White 155-B
2	**China 65**	Red Purple 64-C	-	-	-	-	Present	Large	White 155-B	White 155-B
3	**Golden Century**	Greyed Yellow 160-C	-	-	-	-	Present	Small	Yellow 10-C	-
4	**Frothy**	White 155-D	-	-	-	-	Absent	-	-	-
5	**Zwergkonig**	Red 44-A	-	-	-	-	Present	Small	Yellow 3-D	Yellow 3-D
6	**Royal Midnette**	Red Purple 60-A	Red Purple 59-A	-	As a flush	-	Present	Large	Green Yellow 1-D	Green Yellow 1-D
7	**Simply Marvelous**	Red 44-B	White 155-D	-	At base	-	Present	Small	Yellow 5-C	Yellow 6-D
8	**Chandrika**	White 155-D	-	-	-	-	Absent	-	White 155-D	-
9	**Flash Dance**	Red Purple 60-B	White 155-B	-	As a segment or stripe	-	Present	Small	Green Yellow 1-D	Green Yellow 1-D
10	**Kayla**	Red-Purple 71-C	-	-	-	-	Present	Large	White 155-B	White 155-D
11	**Sunday Brunch**	Yellow 2-D	Red 36-A	-	At apex	-	Absent	-	Yellow 2-D	-
12	**Vanessa**	Orange Red 40 B	-	-	-	-	Present	Medium	White 155-B	White 155-B
13	**Maigold Sweet Dream**	Orange 25-B	Yellow 9-A	-	At base	-	Present	Medium	Yellow 9-A	Yellow 9-A
14	**Blue Blood**	Red Purple 58-B	-	-	-	-	Absent	Small	White 155-D	White 155-D
15	**Scarlet Gem**	Red 45-C	-	-	-	-	Present	Medium	White 155-D	White 155-B
16	**String of pearls**	Red 52-D	-	-	-	-	Present	Medium	White 155-D	White 155-B
17	**Fairy Gold**	Yellow Orange 18-A	-	-	-	-	Absent	-	-	-
18	**Lavender Midnette**	Purple-Violet 80-D	Purple 75-C	-	At marginal zone	-	Present	Small	Red 56-A	Red 56-A
19	**Young Mistress**	Orange-Red 30-B	-	-	-	-	Present	Large	Yellow 11-A	Yellow 11-A
20	**Gourmet Popcorn**	White 154-A	-	-	-	-	-	Small	Yellow 4 -C	Yellow 4 -C
21	**Giggles**	Red 44-B	-	-	-	-	Present	Small	White 155-B	-
22	**Ruby Star**	Red 46-A	-	-	-	-	Present	Large	White 155-B	-
23	**Wild Fire**	Orange Red 32-B	-	-	-	-	Present	Large	Yellow 11-A	Yellow 11-B

Table No 4.3.6b:.Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**								
S. No.	**Variety**	**43. Colour of majority portion of the petal**	**44. Variety with 2 or more colour on inner side of petal: Secondary colour (excluding basal spot)**	**45.Tertiary colour**	**46.Variety with 2 or more colour - Sec distribution**	**47.Distribution of tertiary colour**	**48. Spot at base of inner side**	**49. Size of spot at base of inner side**	**50. Colour of spot at base of inner side**	**51. Colour of spot at base of outer side**
24	**The Fairy**	White 155-B	Red 56-A	-	At marginal zone	-	Absent	-	-	-
25	**Red Figurine**	Red 46-A	-		-	-	Present	Small	White 155-D	White 155-D
26	**Aishwarya**	Red 41-B	-	-	-	-	Present	Large	White 155-D	
27	**Don Don**	Red 53-A	-	-	-	-	Present	Medium	Yellow 7-A	Yellow 7-A
28	**Lemon Sweet Dream**	Yellow 10-A	-	-	-	-	Absent	-	-	-
29	**Rise n Shine**	Yellow 13-B	-	-	-	-	Absent	-	-	-
30	**Swinger**	Yellow Orange 18-C	-	-	-	-	Present	Large	Yellow 10-A	Yellow 10-B
31	**Babe**	Yellow Orange 15-B	-	-	-	-	Absent	-	-	-
32	**Mirabel**	White 155-D	Red Purple 74-A	-	As segment or stripe	-	Absent	-	-	-
33	**Flamboyant**	Red Purple 66-B	-	-	-	-	Present	Medium	White 155-D	White 155-D
34	**Roxy**	Red 55-A	-	-	-	-	Present	Large	White 155-D	White 155-D
35	**Graine De Beaute**	Red Purple 63-B	-	-	-	-	Present	Large	White 155-D	White 155-D
36	**Cup Cake**	Red Purple 68-C	-	-	-	-	Present	Small	White 155-D	White 155-D
37	**Mr. Blue Bird**	Red Purple 64-B	-	-	-	-	Present	Medium	White 155-D	White 155-D
38	**Amber Star**	Yellow 13-C	Orange Red 35-B	-	At marginal zone and as speckle	-	Absent	-	-	-
39	**Fire Flash**	Red 46-C	Yellow Orange 16-B	Red Purple 63-A	As a segment or stripe	As a flush	Absent	-	-	-
40	**Hoot & Howler**	Red Purple 66-B	White 155-D	-	As speckle and at marginal zone	-	Present	Small	Yellow 5-D	Yellow 5-D
41	**Leila Laird**	Red 38-A	-	-	-	-	Present	Large	Yellow 12-B	Yellow 12-B
42	**Painter's Palette**	Red Purple 60-B	White 155-D	-	As a segment or stripe	-	Present	Large	White 155-D	-
43	**Nine**	Orange Red 31-B	-	-	-	-	Present	Large	Yellow 10-A	-
44	**Dazzler**	Red Purple 74-A	-	-	-	-	Present	Medium	White 155-D	White 155-D
45	**Priti**	White 155-D	Red Purple 62-B	-	As a speckle	-	Absent	-	-	-

4.3.1.52 Petal : Main colour on the outer side (only if clearly different from inner side)

It is an essential pseudo qualitative characteristic to be observed by visual assessment by a single observation of a group of plants or parts of plants *viz.*, petals.

As per data depicted in table (4.3.7a and 4.3.7b) the RHS colour chart reference number for main colour of petal outer side of different varieties were Bharani (Red Purple 64-B), Golden Century (Yellow 9D), Zwergkonig (Red 54-A), Royal Midnette (Yellow White 158-C), Simply Marvelous (Red 38-C), Flash Dance (Red Purple 59-C), Maigold Sweet Dream (Yellow Orange 20-B), Scarlet Gem (Red 54-A), String of Pearls (Red Purple 73-C), Lavender Midnette (Red Purple 74-C), Young Mistress (Yellow Orange 22B), Giggles (White 155-D), Wild Fire (Orange 28-D), Aishwarya (Red 36-B), Flamboyant (Red Purple 68-A), Hoot & Howler (Red Purple 69-A), Painter's Palette (White 155-D), Nine (Orange 24-C).

The differences of petal; main colour on outer side in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.53 Petal: spot at base of the outer side

As per data depicted in table (4.3.7a and 4.3.7b) the spot at base of outer side was absent in genotypes Golden Century, Frothy, Chandrika, Sunday Brunch, Fairy Gold, Gourmet Popcorn, Ruby Star, The Fairy, Aishwarya, Lemon Sweet Dream, Rise n Shine, Babe, Mirabel, Amber Star, Fire Flash, Painter's Palette, Nine, Priti whereas it was present in genotypes Bharani, China 65, Zwergkonig, Royal Midnette, Simply Marvelous, Flash Dance, Kayla, Vanessa, Maigold Sweet Dream, Blue Blood, Scarlet Gem, String of Pearls, Lavender Midnette, Young Mistress, Giggles, Wild Fire, Red Figurine, Don Don, Swinger, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Hoot & Howler, Leila Laird, Dazzler.

The differences of size of spot in petals of cultivars might be due to genetic make up of the genotype.

4.3.1.54 Petal: Size of spot at base of outer side

The data represented in table no. (4.3.7a and 4.3.7b) depicted that The spot size was small in genotypes Zwergkonig, Flash Dance, Kayla, Maigold Sweet Dream, Blue Blood,

String of Pearls, Lavender Midnette, Young Mistress, Gourmet Popcorn, Giggles, Red Figurine, Swinger, Cup Cake, Mr. Blue Bird, Hoot & Howler, Dazzler; Medium sized spot was found in Bharani, China 65, Royal Midnette, Vanessa, Scarlet Gem, Wild Fire, Flamboyant; Genotypes Simply Marvelous, Don Don, Graine De Beaute, Leila Laird showed large spot.

The differences of size of spot in petals of cultivars might be due to genetic make up of the genotype.

4.3.1.55 Outer stamen: Predominant colour of the filament

This characteristic is pseudo qualitative and to be observed at full bloom at anther dehiscence.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that the genotypes Mirabel, Flamboyant, Mr. Blue Bird showed white filament colour; Flash Dance, Blue Blood, Scarlet Gem, String of Pearls, Ruby Star, The Fairy, Red Figurine, Don Don, Swinger, Nine showed green filaments; Zwergkonig, Chandrika, Sunday Brunch, Vanessa, Lemon Sweet Dream, Hoot & Howler, Painter's Palette, Priti showed light yellow filament colour; Golden Century, Royal Midnette, Simply Marvelous, Kayla, Fairy Gold, Young Mistress, Gourmet Popcorn, Giggles, Wild Fire, Babe, Amber Star, Fire Flash, Dazzler showed medium yellow filament, Maigold Sweet Dream, Leila Laird showed orange filament; Lavender Midnette, Cup Cake showed pink filament colour. Rest colours were not present in the population.

The differences of colour of outer stamen in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.56 Seed vessel: Size

This is a quantitative characteristic to be observed visually by observing a group of plant parts for garden varieties. This has to observed at petal fall.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that very small seed vessel size was shown by genotypes Bharani, China 65, Frothy, Royal Midnette, Chandrika, Kayla, Vanessa, Blue Blood, Scarlet Gem, String of Pearls, Gourmet Popcorn, Ruby Star, The Fairy, Red Figurine, Swinger, Mirabel, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Leila Laird, Painter's Palette, Dazzler, Priti while small state of expression in seed vessel size was exhibited by Golden Century, Zwergkonig, Simply Marvelous, Flash Dance,

Sunday Brunch, Maigold Sweet Dream, Fairy Gold, Lavender Midnette, Young Mistress, Giggles, Wild Fire, Aishwarya, Don Don, Lemon Sweet Dream, Rise n Shine, Babe, Flamboyant, Amber Star, Fire Flash, Hoot & Howler, Nine. The expressions medium large and very large was shown by none of the genotypes studied.

4.3.1.57 Hip: Shape

This is a pseudoqualitative characteristic to be observed visually by observing a group of plant parts for garden varieties. This has to observed on mature hips.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that the genotypes which showed funnel shaped hip is Scarlet Gem; genotypes Bharani, China 65, Golden Century, Zwergkonig, Kayla, Sunday Brunch, Lavender Midnette, Young Mistress, Ruby Star, Wild Fire, Aishwarya, Lemon Sweet Dream, Rise n Shine, Swinger, Hoot & Howler showed pitcher shaped hips. String of Pearls, Flamboyant, Mr. Blue Bird showed pear shaped hips. Genotypes Royal Midnette, Maigold Sweet Dream, The Fairy, Graine De Beaute, Dazzler, Priti showed round hips. Similar observation with respect to variation in hip shape was reported by Singh (1974) and Singh (1995) and Singh (2016).

4.3.1.58 Hip: Colour

This is a pseudoqualitative characteristic to be observed visually by observing a group of plant parts for garden varieties. This has to observed on mature hips especially for varieties grown for hip only.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that Genotypes Bharani, China 65, Kayla, Maigold Sweet Dream, Scarlet Gem, String of Pearls, Wild Fire, Priti showed orange hips; The Fairy, Flamboyant, Graine De Beaute, Mr. Blue Bird, Dazzler showed red hips; genotypes Golden Century, Zwergkonig, Sunday Brunch, Lavender Midnette, Young Mistress, Ruby Star, Aishwarya, Lemon Sweet Dream, Rise n Shine, Swinger, Hoot & Howler showed brown hips, while Royal Midnette showed purple hips.

The differences of hip colour in cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012), Singh (2016), Dadlani (2016) and Rai *et al* (2015).

4.3.1.59 Flower: Length of pedicle

This is an essential characteristic to be measured by observing a group of plant parts for garden varieties.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that short pedicels were recorded in genotypes China 65, Golden Century, Maigold Sweet Dream, Blue Blood, Fairy Gold, Young Mistress, Gourmet Popcorn, Ruby Star, Rise n Shine, Swinger, Babe, Flamboyant, Priti; medium length of pedicel was found in Bharani, Frothy, Zwergkonig, Royal Midnette, Simply Marvelous, Chandrika, Kayla, Sunday Brunch, Vanessa, Scarlet Gem, String of Pearls, Lavender Midnette, Giggles, Wild Fire, The Fairy, Red Figurine, Aishwarya, Don Don, Mirabel, Roxy, Graine De Beaute, Mr. Blue Bird, Amber Star, Fire Flash, Hoot & Howler, Painter's Palette, Dazzler. Genotypes Flash Dance, Lemon Sweet Dream, Cup Cake, Leila Laird, Nine exhibited long pedicels.

Singh (2016) also observed that the pedicle length varied significantly among the floribunda varieties. In miniature roses the shorter the pedicel length the fuller the flower bunch will look. Thus short pedicel length is proffered in miniatures. The differences in the pedicle length might be due to varietal characteristics of the cultivars as reported earlier by Murugesan *et al* (1991), Bhattacharjee *et al* (1993) and Sundram *et al* (1996). The variation in pedicle length might be due to retarded growth of the plants due to low temperature and low light intensity in winter in conformity with the findings of Gill and Atwal (1976) and Gill *et al* (1988).

4.3.1.60 Flower: Venation of petals

This is an essential characteristic to be noted by observing a group of plant parts for garden varieties.

The data represented in table no. (4.3.7a and 4.3.7b) depicted that the petal venation was absent in Flash Dance, Ruby Star, Red Figurine, Aishwarya, Don Don, Lemon Sweet Dream, Painter's Palette; weak state of expression was evident in Frothy, Zwergkonig, Simply Marvelous, Chandrika, Sunday Brunch, Vanessa, Maigold Sweet Dream, String of Pearls, Lavender Midnette, Young Mistress, Giggles, The Fairy, Rise n Shine, Mirabel, Amber Star, Fire Flash, Leila Laird, Nine, Dazzler; Medium venation was found in Bharani, China 65, Golden Century, Royal Midnette, Blue Blood, Scarlet Gem, Fairy Gold, Gourmet Popcorn, Wild Fire, Swinger, Flamboyant, Roxy, Graine De Beaute, Cup Cake, Mr. Blue Bird, Priti while strong venation of petal was shown by genotypes Kayla, Babe, Hoot & Howler.

The differences of venation in petals of cultivars might be due to genetic make up of the cultivar in conformity with the findings of Panwar *et al* (2012) and Rai *et al* (2015).

Table No 4.3.7a: Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**			**Stamen**	**Hip**			**Flower**	
S. No.	**Variety**	**52. Petal Main colour on outer side**	**53. Spot at base of outer side**	**54. Size of spot at base of outer side**	**55. Outer stamen:Predominant colour of filament**	**56. Seed vessel Size**	**57. Hip shape**	**58. Hip colour**	**59. Flower length of pedicel**	**60. Flower petal venation**
1	**Bharani**	Red Purple 64-B	Present	Medium	White	Very small	Pitcher shaped	Orange	Medium	Weak
2	**China 65**	-	Present	Medium	White	Very small	Pitcher shaped	Orange	Short	Weak
3	**Golden Century**	Yellow 9D	Absent	-	Medium Yellow	Small	Pitcher shaped	Brown	Short	Weak
4	**Frothy**	-	Absent	-	-	Very small	-	-	Medium	Weak
5	**Zwergkonig**	Red 54-A	Present	Small	Light yellow	Small	Pitcher shaped	Brown	Medium	Weak
6	**Royal Midnette**	Yellow White 158-C	Present	Medium	Medium Yellow	Very small	Pitcher shaped	Rougue	Medium	Weak
7	**Simply Marvelous**	Red 38-C	Present	Large	Medium Yellow	Small	-	-	Medium	Weak
8	**Chandrika**	-	Absent	-	Light yellow	Very small	-	-	Medium	Weak
9	**Flash Dance**	Red Purple 59-C	Present	Small	Green	Small	-	-	Long	Absent
10	**Kayla**	-	Present	Small	Medium Yellow	Very small	Pitcher shaped	Orange	Medium	Strong
11	**Sunday Brunch**	-	Absent	-	Light yellow	Small	Pitcher shaped	Brown	Medium	Weak
12	**Vanessa**	-	Present	Medium	Light yellow	Very small	-	-	Medium	Weak
13	**Maigold Sweet Dream**	Yellow Orange 20-B	Present	Small	Orange	Small	Round	Orange	Short	Weak
14	**Blue Blood**	-	Present	Small	Green	Very small	-	-	Short	Weak
15	**Scarlet Gem**	Red 54-A	Present	Medium	Green	Very small	Funnel shaped	Orange	Medium	Weak
16	**String of pearls**	Red Purple 73-C	Present	Small	Green	Very small	Pear shaped	Orange	Medium	Weak
17	**Fairy Gold**	-	Absent	-	Medium Yellow	Small	-	-	Short	Weak
18	**Lavender Midnette**	Red Purple 74-C	Present	Small	Pink	Small	Pitcher shaped	Brown	Medium	Weak
19	**Young Mistress**	Yellow Orange 22B	Present	Small	Medium Yellow	Small	Pitcher shaped	Brown	Short	Weak
20	**Gourmet Popcorn**	-	Absent	Small	Medium Yellow	Very small	-	-	Short	Weak
21	**Giggles**	White 155-D	Present	Small	Medium Yellow	Small	-	-	Medium	Weak
22	**Ruby Star**	-	Absent	-	Green	Very small	Pitcher shaped	Brown	Short	Absent
23	**Wild Fire**	Orange 28-D	Present	Medium	Medium Yellow	Small	Pitcher shaped	Orange	Medium	Weak

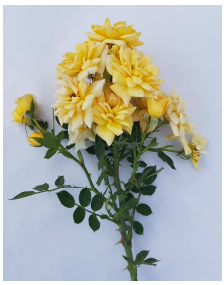
Table No 4.3.7b**:** Table of characteristics indicating qualitative, quantitative traits of 45 miniature rose genotypes for Distinctness, Uniformity and Stability testing.

	Observed on:-	**Petal**			**Stamen**	**Hip**			**Flower**	
S. No.	**Variety**	**52. Petal Main colour on outer side**	**53. Spot at base of outer side**	**54. Size of spot at base of outer side**	**55. Outer stamen:Predominant colour of filament**	**56. Seed vessel Size**	**57. Hip:Shape**	**58. Hip colour**	**59. Flower length of pedicel**	**60. Flower petal venation**
24	**The Fairy**	-	Absent	-	Green	Very small	Round	Red	Medium	Weak
25	**Red Figurine**	-	Present	Small	Green	Very small	-		Medium	Absent
26	**Aishwarya**	Red 36-B	Absent	-	White	Small	Pitcher shaped	Brown	Medium	Absent
27	**Don Don**	-	Present	Large	Green	Small	-		Medium	Absent
28	**Lemon Sweet Dream**	-	Absent	-	Light yellow	Small	Pitcher shaped	Brown	Long	Absent
29	**Rise n Shine**	-	Absent	-	White	Small	Pitcher shaped	Brown	Short	Weak
30	**Swinger**	-	Present	Small	Green	Very small	Pitcher shaped	Brown	Short	Weak
31	**Babe**	-	Absent	-	Medium Yellow	Small	-		Short	Strong
32	**Mirabel**	-	Absent	-	White	Very small	-		Medium	Weak
33	**Flamboyant**	Red Purple 68-A	Present	Medium	White	Small	Pear shaped	Red	Short	Weak
34	**Roxy**	-	Present	Small	-	Very small	-		Medium	Weak
35	**Graine De Beaute**	-	Present	Large	-	Very small	Round	Red	Medium	Weak
36	**Cup Cake**	-	Present	Small	Pink	Very small	-		Long	Weak
37	**Mr. Blue Bird**	-	Present	Small	White	Very small	Pear shaped	Red	Medium	Weak
38	**Amber Star**	-	Absent	-	Medium Yellow	Small	-		Medium	Weak
39	**Fire Flash**	-	Absent	-	Medium Yellow	Small	-		Medium	Weak
40	**Hoot & Howler**	Red Purple 69-A	Present	Small	Light yellow	Small	Pitcher shaped	Brown	Medium	Strong
41	**Leila Laird**	-	Present	Large	Orange	Very small	-		Long	Weak
42	**Painter's Palette**	White 155-D	Absent	-	Light Yellow	Very small	-		Medium	Absent
43	**Nine**	Orange 24-C	Absent	-	Green	Small	-		Long	Weak
44	**Dazzler**	-	Present	Small	Medium Yellow	Very small	Round	Red	Medium	Weak
45	**Priti**	-	Absent	-	Light yellow	Very small	Round	Orange	Short	Medium

Bharani	China 65	Golden Century	Frothy	Zwergkonig

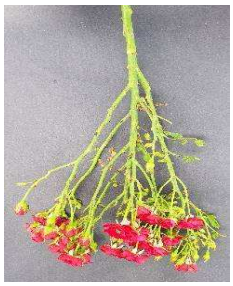
Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

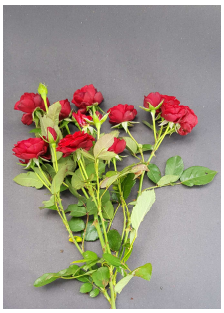


String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Plate 11a: Flower shoot of varieties with /without lateral in different miniature rose



Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine



Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Plate 11b: Flower shoot of varieties with /without lateral in different miniature rose

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 11c: Flower shoot of varieties with /without lateral in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

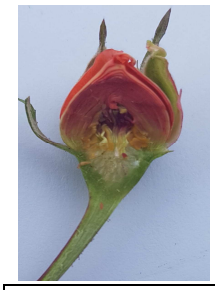
Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

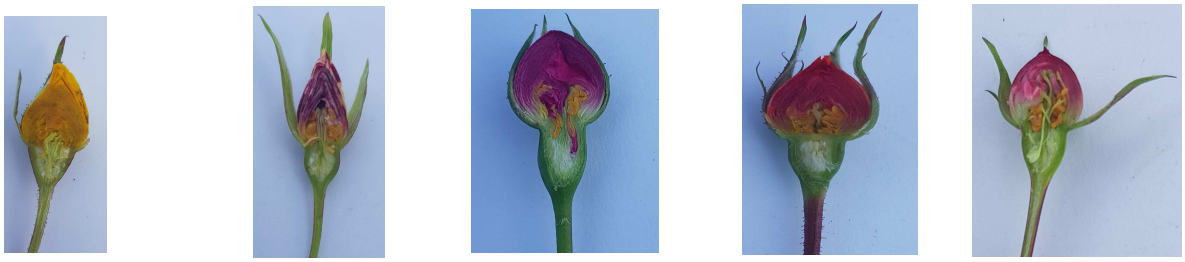
String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 12a: Shape of Longitudinal Section of flower bud in different miniature rose genotypes



Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger



Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 12b: Shape of Longitudinal Section of flower bud in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 13a: Flower (view from top) in different miniature rose genotypes

Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

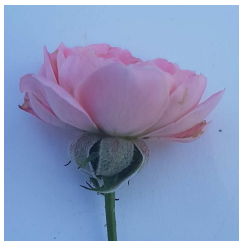
Leila Laird	Painter's Palette	Nine	Dazzler	Priti

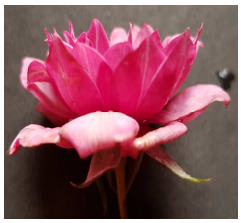
Plate 13b: Flower (view from top) in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

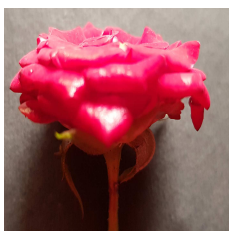
Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

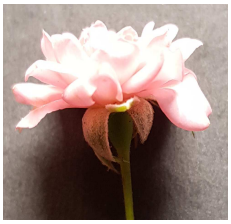
Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem





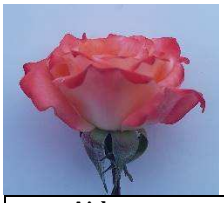
String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn



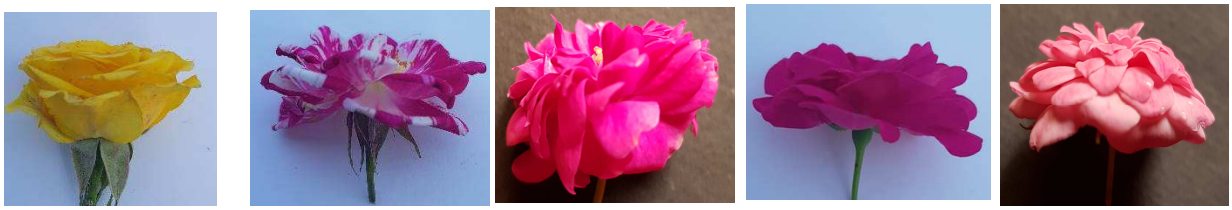


Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 14a: Flower (view from side) in different miniature rose genotypes

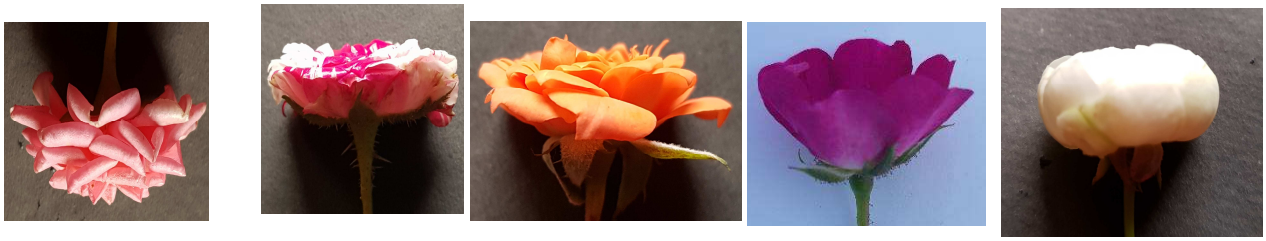


Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger



Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler



Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 14b: Flower (view from side) in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 15a: Sepal Extension in different miniature rose genotypes

Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 15b: Sepal Extension in different miniature rose genotypes

Bharani

China 65

Golden Century

Frothy

Zwergkonig

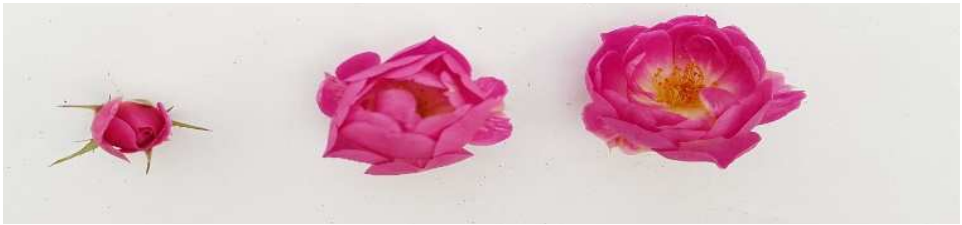
Plate 16a :Unfurling of petals in different miniature rose genotypes

Royal Midnette

Simply Marvelous

Chandrika

Flash Dance



Kayla

Plate 16b: Unfurling of petals in different miniature rose genotypes

Sunday Brunch

Vanessa

Maigold Sweet Dream

Blue Blood

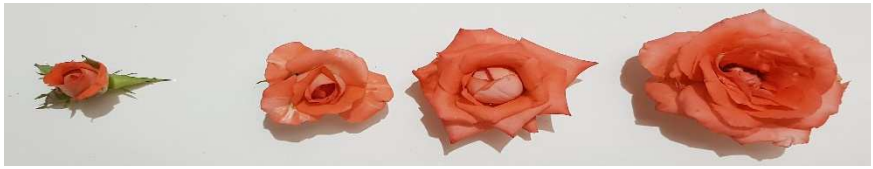
Scarlet Gem

Plate 16c: Unfurling of petals in different miniature rose genotypes

String of Pearls

Fairy Gold

The Fairy



Aishwarya

Don Don

Plate 16d: Unfurling of petals in different miniature rose genotypes

Rise n Shine

Swinger

Babe

Mirabel

Flamboyant

Plate 16e: Unfurling of petals in different miniature rose genotypes

Roxy

Graine de Beaute

Mr. Blue Bird

Amber Star

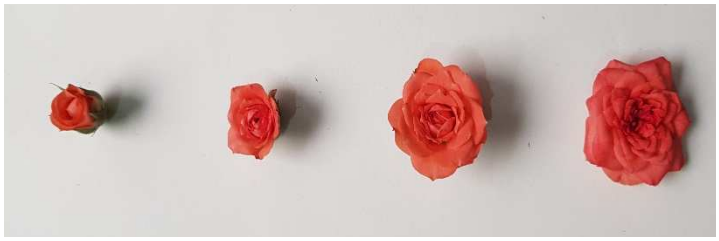
Fire Flash

Plate 16f: Unfurling of petals in different miniature rose genotypes

Hoot & Howler

Leila Laird

Painter's Palette



Nine

Priti

Plate 16g: Unfurling of petals in different miniature rose genotypes

Bharani	China 65	Golden Century	Frothy	Zwergkonig

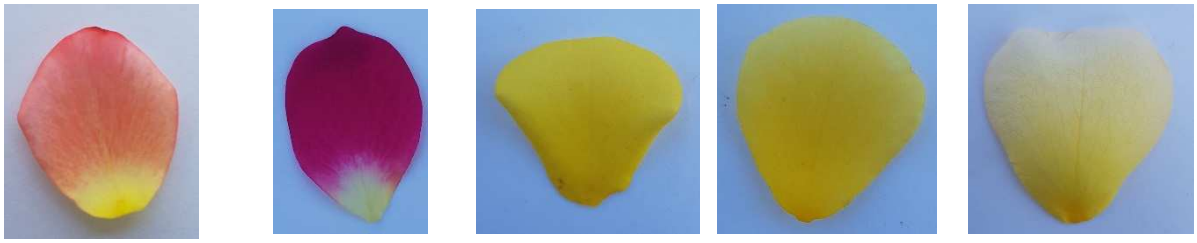
Royal Midnette	Simply Marvelous	Chandrika	Flash Dance	Kayla

Sunday Brunch	Vanessa	Maigold Sweet Dream	Blue Blood	Scarlet Gem

String of Pearls	Fairy Gold	Lavender Midnette	Young Mistress	Gourmet Popcorn

Giggles	Ruby Star	Wild Fire	The Fairy	Red Figurine

Plate 17a: Petals of different miniature rose genotypes



Aishwarya	Don Don	Lemon Sweet Dream	Rise n Shine	Swinger

Babe	Mirabel	Flamboyant	Roxy	Graine De Beaute

Cup Cake	Mr. Blue Bird	Amber Star	Fire Flash	Hoot & Howler

Leila Laird	Painter's Palette	Nine	Dazzler	Priti

Plate 17b: Petals of different miniature rose genotypes

Pitcher shaped Hips

Pear Shaped Hips

Round Hips

Plate 19a: View of the experimental plot (Year 2017)

Plate 19b: View of the experimental plot (Year 2018)

Chapter-5

SUMMARY AND CONCLUSION

The "DUS characterization and Genetic studies in Rose (*Rosa hybrida*)" were carried out in diverse group of 45 genotypes of miniature roses, to ascertain the variability, genetic divergence and characterize the genotypes morphologically. The experiment was laid out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan during 2017 – 2018.

The observations were recorded of three flowering flushes on plant height (cm), stem length (cm), number of days for bud formation, number of days for first flowering, number of flower stems per plant, flower size (cm), duration of flowering (days), vase life (days), stem length grade (%), stem strength grade (%), calyx splitting (%) and disease incidence (%) using the standard method. The results so obtained from present investigations are summarized below:

6.1 VARIABILITY STUDIES

6.1.1 Varietal evaluation

- **Plant height (cm):**The genotype 'Royal Midnette' recorded the maximum plant eight (96.67 cm) whereas, minimum plant height (27.36 cm) was recorded in genotype 'Priti'.
- **Primary Branches:**Maximum number of primary branches (15.50) in genotype 'String of Pearls' in contrast, minimum number of primary branches (3.61) observed in genotype 'Flash Dance'.
- **Secondary branches :**Maximum number of secondary branches was observed in genotype 'Gourmet Popcorn' (95). However, genotype 'Simply Marvelous' (6.50) had the minimum number of secondary branches.
- **Main stem girth (mm):**Maximum main stem girth was recorded in genotype 'Zwergkonig' (15.14 mm)however, genotype 'Mr. Blue Bird' recorded minimum main stem girth (4.33 mm).
- **Plant Spread (cm**): Maximum plant spread (90.21 cm) was obtained in genotype 'Wild Fire'whereas, minimum plant spread (20.33 cm) was obtained in genotype 'Priti'.

- **Internodal Length (cm):**Internodal length was observed highest (7.68) in genotype 'Fire Flash' In contrast, minimum internodal length was recorded in genotype 'Fairy Gold' (1.88 cm).
- **Prickle Density (No./15 cm stem):**Maximum prickle density (49.78) was recorded in genotype 'Painter's Palette', whereas, minimum prickle density recorded minimum (0.00) in genotypes 'Blue Blood', 'Babe' and 'Mirabel'.
- **Leaf area (cm^2):**Maximum leaf area (35.12 sq. cm) recorded in genotype 'Vanessa'In contrast, lowest leaf area (4.98 sq. cm) was observed in genotype 'Scarlet Gem'.
- **Days taken for first flowering :**It was observed maximum (62.56 days) in genotype 'Lemon Sweet Dream' and minimum number of days taken for first flowering was recorded in genotype 'Red Figurine' (23 days).
- **Days taken for peak flowering:**It was observed maximum (216.39 days) in genotype 'Maigold Sweet Dream'. In contrast, minimum number of days taken for peak flowering was recorded in genotype 'Aishwarya' (70.83 days).
- **Duration of flowering:**Maximum duration of flowering was found in 'Maigold Sweet Dream' (173.61 days) whereas,minimum duration of flowering was observed in 'Mirabel' (106.67 day).
- **Bud length (mm):**Maximum bud length was found in 'Maigold Sweet Dream' (24.39 mm),minimum bud length was observed in 'Chandrika' (8.69 mm).
- **Bud width (mm):** Maximum bud width was found in 'Mirabel' (12.97 mm), while , minimum bud width was observed in 'Priti' (4.21 mm).
- **Flower diameter (cm):**Highest (5.85 cm) in genotype 'Hoot & Howler' in contrast, minimum internodal length was recorded in genotype 'China 65' (2.03 cm).
- **Petal Length (mm):**Maximum petal length (27.75 mm) was found in 'Hoot & Howler', whereas minimum (6.94 mm) was found in 'China 65'.
- **Petal Width (mm):**Maximum petal width (21.58 mm) was found in 'Hoot & Howler', whereas minimum (2.48 mm) was found in 'Frothy'.
- **Length of Pedicel:**Maximum length of pedicel (38.63 mm) was recorded in genotype 'Cup Cake', minimum length of pedicel was found in 'Babe' (9.89 mm)
- **No. of flower per bunch:**Maximum number of flowers per bunch (124.11) was found in 'Dazzler', whereas, minimum number of flowers per bunch (3.72) was found in 'Mirabel'.

- **No. of petal per flower:**Maximum number of petals per flower (87.39) was recorded in genotype ‘Nine’, whereas, minimum number of petals per flower (5) was found in ‘China 65’ and ‘Dazzler’.
- **No. of flowering stem per plant:**Maximum number of flowering stems per plant (690.56) was found in ‘Royal Midnette’, whereas, minimum number of flowering stems per plant (36.11) was found in ‘Mirabel’,
- **Size of seed vessel (mm):**Largest seed vessel size (7 mm) was recorded in genotype ‘Wild Fire’, whereas, smallest seed vessel size was found in ‘Painter’s Palette’ (2.17 mm).

6.1.2 Parameters of variability

The phenotypic coefficient of variability (PCV) was recorded highest for Number of flowers per bunch, number of secondary branches, Plant height, primary branches, main stem girth, prickle density, internodal length, days to first flowering, days to peak flowering, leaf area, petals per flower, flowering stem per plant, plant spread, petal length, petal width and pedicel length. The genotypic coefficient of variability (GCV) was recorded maximum for secondary branches,primary branches,prickle density, internodal length,leaf area, flowers per bunch, petals per flower, flowering stem per plant,petal width and pedicel length.

High estimates of heritability in broad sense was observed for prickle density, leaf area, flowers per bunch, petals per flower, petal width and pedicel length.

High genetic advance was found for flowers per bunch and flowering stem per plant.High genetic gain was found in secondary branches, prickle density, leaf area, flowers per bunch, petals per flower, flowering stem per plant, petal width, pedicel length,size of seed vessel.

6.2 GENETIC DIVERGENCE

Genetic diversity among 45 genotypes was grouped into 19 clusters in which Maximum number of 14 genotypes was accommodated in cluster 2, followed by cluster 1 accommodating 8 genotypes, cluster 3 having 7 genotypes, whereas, rest of the clusters consisted of only one genotype each. The genotypes falling in the same cluster are more closely related than those belonging to another cluster. Role of different characters towards divergence varied in a wide range of contribution. It varied from 0.01 % to 35.35%. Highest contributing character was Prickle density (35.35 %) followed by Leaf Area (13.84 %) and

Size of seed vessel (13.84 %). Lowest contribution was recorded from characters Main Stem Girth (0.01 %), Internodal Length (0.01 %) and Flowering Duration (0.01 %)

6.3 MORPHOLOGICAL CHARACTERIZATION OF GENTOYPES

The magnitude and nature of variation among 45miniature genotypes with respect to various vegetative and floral characteristics were assessed. These genotypes were studied for 60 morphological characters and results were summarized in the form of table of characteristics in chapter IV.From the study it can be concluded that morphological DUS descriptor is highly efficient in identification of genotypes and also to group those genotypes into different categories for each character. The variation at the morphological level suggests very high diversity among the genotypes which can be utilized for trait specific breeding through systemic and scientific approaches.

CONCLUSION

From the present investigation, it can be concluded that the existence of wide variations for various vegetative and floral traits in 50 genotypes offered a good scope of selecting the suitable genotypes for all the economic traits.

- Genotype Royal Midnette had very high number of flowering stem per plant thus suitable for bedding purpose and providing an exquisite display of colour.
- Genotype Dazzler had maximum number of flower per bunch but the variety was classified as single variety, the genotypes which were double and were at par can well be used as spray rose.
- Maximum duration of flowering was found in Maigold sweet Dream thus is suitable for garden display.
- Maximum plant spread was in Wild Fire thus is suitable for bedding purpose.
- The study generated information regarding Distinctness Uniformity and stability as well as the relationship between 45 different genotypes of rose on the basis of DUS descriptor.
- On the basis of DUS descriptors 45 genotypes were grouped into 7 distinct clusters and the divergence contribution among the varieties by different characters were ranked.
- This study will aid in identification of genotypes studied. The Database of morphological data was prepared for further use as reference collection.

- The genetic information will help for making crosses or planning breeding programs for developing superior cultivars of miniature roses.
- Morphological evaluation of genotypes through DUS testing is not only suitable for varietalcharacterization but also reliable andreproducible for assessing the genetic purityof varieties and to establish their identity.Further, these identified diverse genotypes with peculiar characteristics may be used as parents in the crop improvement programme for evolving elite genotypes. Butmorphological traits alone may not suffice forthe DUS criteria, hence, collaboration throughbiochemical and molecular characters needto be explored for the delineation of varieties for varietal protection.

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APPENDIX-I

AGRO-METEOROLOGICAL DATA

Mean monthly meteorological data of Dr.Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the period of study (January, 2017 - December, 2017)

Months	Temperature (ºC)		Relative Humidity (%)	Rainfall (mm)
	Maximum	Minimum		
January, 2017	21.50	19.50	71.00	317.10
February, 201	18.90	18.80	84.00	269.80
March, 2017	24.20	16.20	111.80	111.80
April, 2017	26.70	8.20	3.50	3.50
May, 2017	32.50	4.20	3.90	3.90
June ,2017	34.20	2.10	18.40	184.00
July, 2017	28.90	1.10	56.00	113.60
August, 2017	26.90	4.50	64.00	184.60
September, 2017	27.70	8.30	53.00	85.60
October, 2017	25.90	11.50	39.00	5.40
November, 2017	22.30	16.30	43.20	48.20
December, 2017	20.30	17.30	54.40	168.80

Source: Meteorological Observatory, Department of Environmental Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) 173 230.

APPENDIX-II

AGRO-METEOROLOGICAL DATA

Mean monthly meteorological data of Dr.Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the period of study (January, 2018-December, 2018)

Months	Temperature (ºC)		Relative Humidity (%)	Rainfall (mm)
	Maximum	Minimum		
January, 2018	17.00	1.10	56.00	113.60
February, 2018	17.80	4.50	64.50	184.30
March, 2018	25.20	8.30	53.00	85.60
April, 2018	26.90	11.50	39.00	5.40
May, 2018	32.10	20.70	46.00	45.90
June ,2018	28.60	18.50	70.00	252.30
July, 2018	28.18	19.65	77.35	152.50
August, 2018	27.70	19.42	76.96	120.40
September, 2018	27.88	15.63	65.03	65.40
October, 2018	26.20	12.40	67.01	8.70
November, 2018	23.51	4.68	52.93	9.40
December, 2018	19.90	2.12	48.06	22.20

Source: Meteorological Observatory, Department of Environmental Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) 173 230.

APPENDIX – III

ANOVA for growth and flowering of Miniature Rose

Sources of variance	Df	Mean sum of square for 2017									
		Plant height (cm)	Primary branches	Secondary Branches	Main stem Girth (mm)	Plant Spread (cm)	Internodal length (cm)	Prickle density	Leaf area (cm^2)	Days taken for first flowering	Days taken for peak flowering
Genotypes	44	410.78	15.01	6.28	14.23	454.01	3.29	312.64	142.69	922.51	6204.6
Replications	2	73.07	0.082	15.18	3.66	12.98	0.112	4.99	13.46	2.512	246.0
Error	88	41.57	3.10	5.20	1.61	37.65	0.139	2.60	8.311	10.491	81.504

Sources of variance	df	Mean sum of square for 2017										
		Duration of flowering	Bud length (mm)	Bud width (mm)	Flower diameter (cm)	Petal length (mm)	Petal width (mm)	Length of pedicel (mm)	No. of flowers per bunch	No. of petals per flower	No. of flowering stems per plant	Size of seed vessel (mm)
Genotypes	44	1052.6	57.64	17.26	2.98	68.39	53.48	179.56	1787.07	1172.73	8255.9	4.80
Replications	2	252.22	3.87	3.29	0.48	18.19	0.93	4.08	50.93	52.89	4.02	0.27
Error	88	102.77	6.83	1.91	0.39	8.50	1.43	7.66	23.60	22.94	62.2	0.24

Sources of variance	Df	Mean sum of square for 2018									
		Plant height (cm)	Primary branches	Secondary Branches	Main stem Girth (mm)	Plant Spread (cm)	Internodal length (cm)	Prickle density	Leaf area (cm^2)	Days taken for first flowering	Days taken for peak flowering
Genotypes	44	1208.96	21.38	4598.47	35.33	938.21	4.49	303.90	157.98	119.60	5811.12
Replications	2	8.76	5.62	58.43	7.32	75.20	0.06	1.10	10.49	27.13	9.80
Error	88	118.86	4.96	32.74	3.99	35.90	4.15	4.94	3.45	10.31	78.19

Sources of variance	df	Mean sum of square for 2018										
		Duration of flowering	Bud length (mm)	Bud width (mm)	Flower diameter (cm)	Petal length (mm)	Petal width (mm)	Length of pedicel (mm)	No. of flowers per bunch	No. of petals per flower	No. of flowering stems per plant	Size of seed vessel (mm)
Genotypes	44	1114.59	39.12	16.21	2.69	58.432	47.09	144.63	4085.44	1223.99	75751.62	4.62
Replications	2	375.02	18.76	2.00	0.59	0.50	3.15	20.69	66.06	33.68	1322.68	0.29
Error	88	309.75	11.25	1.58	0.22	2.67	3.47	10.21	63.91	18.79	1104.67	0.17

Pooled ANOVA for growth and flowering of Miniature Rose

ANOVA for Plant Height (cm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	98.3128	49.1564	0.3982	0.6720	
Environments	1	13610.8418	13610.8418	416.6333	0.0000	***
Interactions	2	65.3373	32.6686	0.2646	0.7677	
Overall Sum	5	13774.4912	2754.8982	22.3167	0.0000	***
Treatments	44	58167.7734	1321.9949	10.7091	0.0000	***
Error	220	27158.0742	123.4458			
General Mean		49.2182	4.5359	95%	99%	
S.E.Diff.		6.4147	Critical Diff.	12.6421	16.6679	
S.E.Diff from Mean		4.4852	Critical Diff.	8.8394	11.6543	
Var Environmental		123.4458	ECV	22.5742		
Var Genotypical		199.7582	GCV	28.7162		
Var Phenotypical		323.204	PCV	36.5269		
h^2 (Broad Sense)		0.6181	S.E. of h^2	0.4882		
Genetic Advancement		22.8893	29.3339			
Gen.Adv as % of Mean		46.5059	59.5998	(selection intensity at 5% & 1%)		

ANOVA for Primary Branches (No.)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	8.1495	4.0748	1.1204	0.3280	
Environments	1	214.3835	214.3835	50.4467	0.0000	***
Interactions	2	8.4994	4.2497	1.1685	0.3128	
Overall Sum	5	231.0325	46.2065	12.7048	0.0000	***
Treatments	44	1573.8680	35.7697	9.8351	0.0000	***
Error	220	800.1251	3.6369			
General Mean		7.368	0.7786	95%	99%	
S.E.Diff.		1.101	Critical Diff.	2.1699	2.8609	
S.E.Diff from Mean		0.7699	Critical Diff.	1.5172	2.0004	
Var Environmental		3.6369	ECV	25.8831		
Var Genotypical		5.3555	GCV	31.4085		
Var Phenotypical		8.9924	PCV	40.6992		
h^2 (Broad Sense)		0.5956	S.E. of h^2	0.4834		
Genetic Advancement		3.679	4.7148			
Gen.Adv as % of Mean		49.9315	63.9899	(selection intensity at 5% & 1%)		

ANOVA for Secondary Branches (No.)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	44.6394	22.3197	0.0461	0.9550	
Environments	1	130422.7266	130422.7266	2542.4783	0.0000	***
Interactions	2	102.5950	51.2975	0.1059	0.8996	
Overall Sum	5	130569.9609	26113.9922	53.9015	0.0000	***
Treatments	44	99367.5703	2258.3538	4.6614	0.0000	***
Error	220	106584.7578	484.4762			
General Mean		28.1291	8.9859	95%	99%	
S.E.Diff.		12.708	Critical Diff.	25.0447	33.0201	
S.E.Diff from Mean		8.8855	Critical Diff.	17.5114	23.0879	
Var Environmental		484.4762	ECV	78.2491		
Var Genotypical		295.6463	GCV	61.1265		
Var Phenotypical		780.1224	PCV	99.2944		
h^2 (Broad Sense)		0.379	S.E. of h^2	0.4336		
Genetic Advancement		21.8051	27.9444			
Gen.Adv as % of Mean		77.5178	99.3433	(selection intensity at 5% & 1%)		

ANOVA for Main Stem Girth (mm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	19.6817	9.8409	2.2060	0.1126	
Environments	1	2563.2380	2563.2380	2227.9712	0.0000	***
Interactions	2	2.3010	1.1505	0.2579	0.7729	
Overall Sum	5	2585.2207	517.0441	115.9030	0.0000	***
Treatments	44	1692.2083	38.4593	8.6212	0.0000	***
Error	220	981.4219	4.4610			
General Mean		8.2277	0.8623	95%	99%	
S.E.Diff.		1.2194	Critical Diff.	2.4032	3.1685	
S.E.Diff from Mean		0.8526	Critical Diff.	1.6804	2.2155	
Var Environmental		4.461	ECV	25.6708		
Var Genotypical		5.6664	GCV	28.9318		
Var Phenotypical		10.1274	PCV	38.6787		
h^2 (Broad Sense)		0.5595	S.E. of h^2	0.4755		
Genetic Advancement		3.668	4.7007			
Gen.Adv as % of Mean		44.5808	57.1326	(selection intensity at 5% & 1%)		

ANOVA for Prickle density (Nos/ 15 cm stem)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	10.7958	5.3979	1.4255	0.2426	
Environments	1	0.3470	0.3470	0.4914	0.4840	
Interactions	2	1.4124	0.7062	0.1865	0.8300	
Overall Sum	5	12.5553	2.5111	0.6631	0.6518	
Treatments	44	26959.2500	612.7103	161.8025	0.0000	***
Error	220	833.0914	3.7868			
General Mean		13.3172	0.7944	95%	99%	
S.E.Diff.		1.1235	Critical Diff.	2.2142	2.9193	
S.E.Diff from Mean		0.7856	Critical Diff.	1.5482	2.0412	
Var Environmental		3.7868	ECV	14.6124		
Var Genotypical		101.4872	GCV	75.6473		
Var Phenotypical		105.274	PCV	77.0457		
h² (Broad Sense)		0.964	S.E. of h²	0.5579		
Genetic Advancement		20.376	26.1129			
Gen.Adv as % of Mean		153.005	196.0841	(selection intensity at 5% & 1%)		

ANOVA for Internodal Length (cm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	1.0324	0.5162	0.2851	0.7523	
Environments	1	2.7442	2.7442	37.6751	0.0000	***
Interactions	2	0.1457	0.0728	0.0402	0.9606	
Overall Sum	5	3.9222	0.7844	0.4332	0.8251	
Treatments	44	403.9433	9.1805	5.0698	0.0000	***
Error	220	398.3793	1.8108			
General Mean		3.4726	0.5494	95%	99%	
S.E.Diff.		0.7769	Critical Diff.	1.5311	2.0187	
S.E.Diff from Mean		0.5432	Critical Diff.	1.0706	1.4115	
Var Environmental		1.8108	ECV	38.751		
Var Genotypical		1.2283	GCV	31.9151		
Var Phenotypical		3.0391	PCV	50.2017		
h² (Broad Sense)		0.4042	S.E. of h²	0.4397		
Genetic Advancement		1.4514	1.8601			
Gen.Adv as % of Mean		41.7965	53.5645	(selection intensity at 5% & 1%)		

ANOVA for Days to First Flowering

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	29.8184	14.9092	0.2483	0.7803	
Environments	1	32951.3203	32951.3203	2236.4258	0.0000	***
Interactions	2	29.4678	14.7339	0.2454	0.7826	
Overall Sum	5	33010.6094	6602.1216	109.9522	0.0000	***
Treatments	44	34473.9141	783.4980	13.0484	0.0000	***
Error	220	13209.9785	60.0454			
General Mean		43.3556	3.1635	95%	99%	
S.E.Diff.		4.4738	Critical Diff.	8.817	11.6247	
S.E.Diff from Mean		3.1281	Critical Diff.	6.1649	8.1281	
Var Environmental		60.0454	ECV	17.8729		
Var Genotypical		120.5754	GCV	25.3271		
Var Phenotypical		180.6208	PCV	30.9984		
h² (Broad Sense)		0.6676	S.E. of h²	0.4988		
Genetic Advancement		18.4817	23.6853			
Gen.Adv as % of Mean		42.6282	54.6304	(selection intensity at 5% & 1%)		

ANOVA for Days to Peak Flowering

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	253.9510	126.9755	0.1113	0.8947	
Environments	1	45873.4219	45873.4219	356.0886	0.0000	***
Interactions	2	257.6518	128.8259	0.1130	0.8932	
Overall Sum	5	46385.0234	9277.0049	8.1339	0.0000	***
Treatments	44	291825.3125	6632.3931	5.8151	0.0000	***
Error	220	250918.2813	1140.5377			
General Mean		116.52	13.7873	95%	99%	
S.E.Diff.		19.4982	Critical Diff.	38.4268	50.6638	
S.E.Diff from Mean		13.6332	Critical Diff.	26.8683	35.4244	
Var Environmental		1140.5377	ECV	28.9837		
Var Genotypical		915.3092	GCV	25.9647		
Var Phenotypical		2055.8469	PCV	38.913		
h² (Broad Sense)		0.4452	S.E. of h²	0.4494		
Genetic Advancement		41.5853	53.2938			
Gen.Adv as % of Mean		35.6894	45.7379	(selection intensity at 5% & 1%)		

ANOVA for Leaf Area (cm²)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	10.1061	5.0530	0.8141	0.4443	
Environments	1	28.2270	28.2270	1.9632	0.1626	
Interactions	2	28.7555	14.3778	2.3165	0.1010	
Overall Sum	5	67.0886	13.4177	2.1619	0.0594	
Treatments	44	13088.3809	297.4632	47.9272	0.0000	***
Error	220	1365.4451	6.2066			
General Mean		13.7599	1.0171	95%	99%	
S.E.Diff.		1.4384	Critical Diff.	2.8347	3.7374	
S.E.Diff from Mean		1.0057	Critical Diff.	1.982	2.6132	
Var Environmental		6.2066	ECV	18.1056		
Var Genotypical		48.5428	GCV	50.6347		
Var Phenotypical		54.7493	PCV	53.7744		
h² (Broad Sense)		0.8866	S.E. of h²	0.5431		
Genetic Advancement		13.5146	17.3196			
Gen.Adv as % of Mean		98.2174	125.8709	(selection intensity at 5% & 1%)		

ANOVA for Flowering Duration

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	300.2354	150.1177	0.4172	0.6594	
Environments	1	166191.2813	166191.2813	348.3202	0.0000	***
Interactions	2	954.2442	477.1221	1.3259	0.2677	
Overall Sum	5	167445.7656	33489.1523	93.0636	0.0000	***
Treatments	44	52492.5859	1193.0133	3.3153	0.0000	***
Error	220	79167.4922	359.8522			
General Mean		148.6496	7.7444	95%	99%	
S.E.Diff.		10.9522	Critical Diff.	21.5845	28.458	
S.E.Diff from Mean		7.6578	Critical Diff.	15.092	19.898	
Var Environmental		359.8522	ECV	12.7614		
Var Genotypical		138.8602	GCV	7.9273		
Var Phenotypical		498.7124	PCV	15.0232		
h² (Broad Sense)		0.2784	S.E. of h²	0.4085		
Genetic Advancement		12.8091	16.4156			
Gen.Adv as % of Mean		8.617	11.0431	(selection intensity at 5% & 1%)		

ANOVA for Bud Length

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	37.7416	18.8708	2.0324	0.1335	
Environments	1	13.4804	13.4804	3.5825	0.0597	
Interactions	2	7.5257	3.7628	0.4053	0.6673	
Overall Sum	5	58.7477	11.7495	1.2654	0.2799	
Treatments	44	3806.2703	86.5061	9.3168	0.0000	***
Error	220	2042.7007	9.2850			
General Mean		16.4916	1.244	95%	99%	
S.E.Diff.		1.7593	Critical Diff.	3.4671	4.5712	
S.E.Diff from Mean		1.2301	Critical Diff.	2.4242	3.1962	
Var Environmental		9.285	ECV	18.4769		
Var Genotypical		12.8702	GCV	21.7535		
Var Phenotypical		22.1552	PCV	28.5414		
h^2 (Broad Sense)		0.5809	S.E. of h^2	0.4802		
Genetic Advancement		5.6327	7.2186			
Gen.Adv as % of Mean		34.1548	43.7712	(selection intensity at 5% & 1%)		

ANOVA for Bud Width

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	7.8275	3.9138	2.1941	0.1139	
Environments	1	5.1834	5.1834	14.8433	0.0002	***
Interactions	2	0.6984	0.3492	0.1958	0.8223	
Overall Sum	5	13.7093	2.7419	1.5371	0.1794	
Treatments	44	1404.1295	31.9120	17.8901	0.0000	***
Error	220	392.4326	1.7838			
General Mean		9.3491	0.5452	95%	99%	
S.E.Diff.		0.7711	Critical Diff.	1.5197	2.0036	
S.E.Diff from Mean		0.5392	Critical Diff.	1.0626	1.4009	
Var Environmental		1.7838	ECV	14.2857		
Var Genotypical		5.0214	GCV	23.9686		
Var Phenotypical		6.8052	PCV	27.903		
h^2 (Broad Sense)		0.7379	S.E. of h^2	0.5134		
Genetic Advancement		3.9653	5.0817			
Gen.Adv as % of Mean		42.4133	54.3549	(selection intensity at 5% & 1%)		

ANOVA for Flower Diameter

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	0.1825	0.0912	0.3297	0.7195	
Environments	1	13.0768	13.0768	96.3494	0.0000	***
Interactions	2	0.2714	0.1357	0.4905	0.6130	
Overall Sum	5	13.5307	2.7061	9.7794	0.0000	***
Treatments	44	237.9545	5.4081	19.5436	0.0000	***
Error	220	60.8780	0.2767			
General Mean		3.6291	0.2148	95%	99%	
S.E.Diff.		0.3037	Critical Diff.	0.5985	0.7892	
S.E.Diff from Mean		0.2124	Critical Diff.	0.4185	0.5518	
Var Environmental		0.2767	ECV	14.495		
Var Genotypical		0.8552	GCV	25.4823		
Var Phenotypical		1.1319	PCV	29.3165		
h^2 (Broad Sense)		0.7555	S.E. of h^2	0.5171		
Genetic Advancement		1.6559	2.1221			
Gen.Adv as % of Mean		45.6283	58.4751	(selection intensity at 5% & 1%)		

ANOVA for flowers per bunch

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	165.2683	82.6341	0.4025	0.6691	
Environments	1	12949.2656	12949.2656	376.8233	0.0000	***
Interactions	2	68.7286	34.3643	0.1674	0.8460	
Overall Sum	5	13183.2627	2636.6526	12.8426	0.0000	***
Treatments	44	220925.1406	5021.0259	24.4564	0.0000	***
Error	220	45167.1445	205.3052			
General Mean		28.057	5.8496	95%	99%	
S.E.Diff.		8.2725	Critical Diff.	16.3035	21.4953	
S.E.Diff from Mean		5.7842	Critical Diff.	11.3995	15.0296	
Var Environmental		205.3052	ECV	51.0691		
Var Genotypical		802.6201	GCV	100.9748		
Var Phenotypical		1007.9253	PCV	113.1546		
h^2 (Broad Sense)		0.7963	S.E. of h^2	0.5253		
Genetic Advancement		52.0791	66.7421			
Gen.Adv as % of Mean		185.6185	237.88	(selection intensity at 5% & 1%)		

ANOVA for petals per flower

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	161.3001	80.6500	0.8066	0.4477	
Environments	1	1520.1201	1520.1201	134.3264	0.0000	***
Interactions	2	22.6332	11.3166	0.1132	0.8930	
Overall Sum	5	1704.0533	340.8107	3.4086	0.0055	**
Treatments	44	120283.4609	2733.7151	27.3415	0.0000	***
Error	220	21996.5195	99.9842			
General Mean		37.7506	4.0822	95%	99%	
S.E.Diff.		5.773	Critical Diff.	11.3775	15.0006	
S.E.Diff from Mean		4.0365	Critical Diff.	7.9552	10.4885	
Var Environmental		99.9842	ECV	26.4875		
Var Genotypical		438.9551	GCV	55.4991		
Var Phenotypical		538.9393	PCV	61.4958		
h² (Broad Sense)		0.8145	S.E. of h²	0.5289		
Genetic Advancement		38.9509	49.9176			
Gen.Adv as % of Mean		103.1795	132.23	(selection intensity at 5% & 1%)		

ANOVA for flowering stems per plant

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	1188.3114	594.1557	0.1155	0.8910	
Environments	1	723852.3125	723852.3125	986.6802	0.0000	***
Interactions	2	1467.2480	733.6240	0.1426	0.8672	
Overall Sum	5	726507.8750	145301.5781	28.2468	0.0000	***
Treatments	44	2667283.7500	60620.0859	11.7846	0.0000	***
Error	220	1131681.0000	5144.0044			
General Mean		126.3926	29.2803	95%	99%	
S.E.Diff.		41.4086	Critical Diff.	81.6076	107.5953	
S.E.Diff from Mean		28.9531	Critical Diff.	57.0605	75.2313	
Var Environmental		5144.0044	ECV	56.7452		
Var Genotypical		9246.0136	GCV	76.0774		
Var Phenotypical		14390.018	PCV	94.9093		
h² (Broad Sense)		0.6425	S.E. of h²	0.4935		
Genetic Advancement		158.7783	203.4828			
Gen.Adv as % of Mean		125.623	160.9926	(selection intensity at 5% & 1%)		

ANOVA for Size of seed vessel (mm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	0.5063	0.2532	1.3901	0.2512	
Environments	1	0.5504	0.5504	1.8180	0.1789	
Interactions	2	0.6054	0.3027	1.6621	0.1921	
Overall Sum	5	1.6622	0.3324	1.8252	0.1090	
Treatments	44	410.8244	9.3369	51.2651	0.0000	***
Error	220	40.0687	0.1821			
General Mean		4.5923	0.1742	95%	99%	
S.E.Diff.		0.2464	Critical Diff.	0.4856	0.6402	
S.E.Diff from Mean		0.1723	Critical Diff.	0.3395	0.4477	
Var Environmental		0.1821	ECV	9.293		
Var Genotypical		1.5258	GCV	26.8977		
Var Phenotypical		1.7079	PCV	28.4578		
h^2 (Broad Sense)		0.8934	S.E. of h^2	0.5444		
Genetic Advancement		2.4051	3.0822			
Gen.Adv as % of Mean		52.3716	67.117	(selection intensity at 5% & 1%)		

ANOVA for Plant Spread (cm^2)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	48.4633	24.2316	0.3260	0.7221	
Environments	1	19088.8496	19088.8496	298.4131	0.0000	***
Interactions	2	127.9357	63.9679	0.8606	0.4243	
Overall Sum	5	19265.2480	3853.0496	51.8395	0.0000	***
Treatments	44	51379.4570	1167.7150	15.7106	0.0000	***
Error	220	16351.8252	74.3265			
General Mean		46.9512	3.5196	95%	99%	
S.E.Diff.		4.9775	Critical Diff.	9.8096	12.9334	
S.E.Diff from Mean		3.4803	Critical Diff.	6.8589	9.0431	
Var Environmental		74.3265	ECV	18.3622		
Var Genotypical		182.2314	GCV	28.7518		
Var Phenotypical		256.5579	PCV	34.1151		
h^2 (Broad Sense)		0.7103	S.E. of h^2	0.5078		
Genetic Advancement		23.4368	30.0355			
Gen.Adv as % of Mean		49.9173	63.9717	(selection intensity at 5% & 1%)		

ANOVA for Petal length (mm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	0.8365	0.4183	0.0527	0.9487	
Environments	1	2.5249	2.5249	85.5290	0.0000	***
Interactions	2	0.0590	0.0295	0.0037	0.9963	
Overall Sum	5	3.4205	0.6841	0.0862	0.9944	
Treatments	44	4854.1177	110.3209	13.9004	0.0000	***
Error	220	1746.0313	7.9365			
General Mean		14.7999	1.1501	95%	99%	
S.E.Diff.		1.6265	Critical Diff.	3.2055	4.2263	
S.E.Diff from Mean		1.1373	Critical Diff.	2.2413	2.955	
Var Environmental		7.9365	ECV	19.0351		
Var Genotypical		17.0641	GCV	27.9115		
Var Phenotypical		25.0006	PCV	33.7844		
h^2 (Broad Sense)		0.6825	S.E. of h^2	0.502		
Genetic Advancement		7.0303	9.0097			
Gen.Adv as % of Mean		47.5025	60.877	(selection intensity at 5% & 1%)		

ANOVA for Petal Width (mm)

Source of Variations	df	Sum of Squares	Mean Squares	F Ratio	Probability	
Replicate	2	0.8532	0.4266	0.1255	0.8821	
Environments	1	0.6202	0.6202	0.1699	0.6806	
Interactions	2	7.3009	3.6505	1.0738	0.3435	
Overall Sum	5	8.7743	1.7549	0.5162	0.7639	
Treatments	44	4110.1963	93.4136	27.4784	0.0000	***
Error	220	747.8962	3.3995			
General Mean		10.9632	0.7527	95%	99%	
S.E.Diff.		1.0645	Critical Diff.	2.0979	2.766	
S.E.Diff from Mean		0.7443	Critical Diff.	1.4669	1.934	
Var Environmental		3.3995	ECV	16.8179		
Var Genotypical		15.0023	GCV	35.3299		
Var Phenotypical		18.4019	PCV	39.1286		
h^2 (Broad Sense)		0.8153	S.E. of h^2	0.5291		
Genetic Advancement		7.2044	9.2328			
Gen.Adv as % of Mean		65.7141	84.2161	(selection intensity at 5% & 1%)		

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Department of Floriculture and Landscape Architecture

Title of Thesis	**:**	**"DUS Characterization and Genetic studies in Rose (*Rosa hybrida*)"**
Name of the student	**:**	Roshni Agnihotri
Admission number	**:**	H-15-04-D
Major advisor	**:**	Dr Y C Gupta
Major field	**:**	Floriculture and Landscape Architecture
Minor field	**:**	Genetics and Plant Breeding and Seed Science Technology
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ABSTRACT

The present investigation entitled "DUS Characterization and Genetic studies in Rose (*Rosa hybrida*)" was carried out at experimental farm of Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2017 to 2018. The experiment was laid out in a RBD with three replications and data was recorded for two years.Forty five diverse genotypes were evaluated for various growth and flowering parameters to assess the extent of variability, heritability, genetic divergence and the morphological characterization of these genotypes. Wide and significant variations for all the parameters were observed among the different miniature rose genotypes. Among the tested genotypes Royal Midnette had very high number of flowering stem per plant and genotype Dazzler had maximum number of flower per bunch. Maximum duration of flowering was found in MaigoldSweet Dream. Maximum plant spread was in Wild Fire thus is suitable for bedding purpose.Genetic diversity among 45 genotypes was grouped into 19 clusters in which Maximum number of 14 genotypes was accommodated in cluster 2, followed by cluster 1 accommodating 8 genotypes, cluster 3 having 7 genotypes, whereas, rest of the clusters consisted of only one genotype each.The study generated information regarding Distinctness Uniformity and stability as well as the relationship between 45 different genotypes of rose on the basis of DUS descriptor.On the basis of DUS descriptors 45 genotypes were grouped into 7 distinct clusters and the divergence contribution among the varieties by different characters were ranked.This study will aid in identification of genotypes studied. The Database of morphological data was prepared for further use as reference collection.The genetic information will help for making crosses or planning breeding programs for developing superior cultivars of miniature roses.

Signature of major advisor **Signature of the student**

Countersigned

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Educational Qualification **:**

Certificate/ degree	Month & Year	School/ College	Board/ University	Marks (%)	Division
10th	May, 2006	JNV, Begusarai	CBSE	81.89	First
12th	May, 2008	KV, IOC, Barauni	CBSE	79.80	First
B. Sc. (Hons) Agriculture	June, 2013	Allahabad School of Agriculture	SHIATS, Allahabad, UP	9.94	First
M.Sc. Horticulture (Floriculture and Landscape Architecture	May, 2015	ASPEE College of Horticulture and Forestry	NAU, Navsari, Guj.	8.89	First

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