STANDARDIZATION OF GROWING MEDIA AND GROWTH REGULATORS FOR ROSE (*Rosa* spp.) UNDER TOP VENTILATED RAIN SHELTER

By

SIJO JOHN

(2017 - 12 - 018)

DEPARTMENT OF FLORICULTURE AND LANDSCAPING

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2019

STANDARDIZATION OF GROWING MEDIA AND GROWTH REGULATORS FOR ROSE (*Rosa* spp.) UNDER TOP VENTILATED RAIN SHELTER

By

SIJO JOHN

(2017 - 12 - 018)

THESIS

Submitted in partial fulfilment of the
requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF FLORICULTURE AND LANDSCAPING
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680 656
KERALA, INDIA

2019

DECLARATION

I, hereby declare that this thesis entitled **"Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara **Sijo John**
30-10-2019 (2017-12-018)

CERTIFICATE

Certified that this thesis entitled **"Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter"** is a record of research work done independently by **Sijo John (2017-12-018)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

Vellanikkara
30-10-2019

Dr. Mini Sankar
(Chairman, Advisory committee)
Assistant Professor
AICRP on Floriculture
Department of Floriculture and Landscaping
College of Horticulture, Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Sijo John (2017-12-018)** a candidate for the degree of **Master of Science in Horticulture**, with major field in **Floriculture and Landscaping**, agree that the thesis **"Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter"** may be submitted by **Mr. Sijo John (2017-12-018)**, in partial fulfilment of the requirement for the degree.

Dr. Mini Sankar
(Chairman, Advisory Committee)
Assistant Professor
AICRP on Floriculture
Department of Floriculture and Landscaping
College of Horticulture, Vellanikkara

Dr. U. Sreelatha
(Member, Advisory Committee)
Professor and Head
Department of Floriculture and Landscaping
College of Horticulture, Vellanikkara

Dr. K. Ajith Kumar
(Member, Advisory Committee)
Professor
Associate Director of Research and Special Officer
RARS, Ambalavayal
Wayanad

Dr. Deepthy K. B
(Member, Advisory Committee)
Assistant Professor
Department of Agricultural Entomology
College of Horticulture, Vellanikkara

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS USED

Symbols	Abbreviations
et al.	And others
RBD	Randomized Block Design
CD	Critical difference
CV	Coefficient of Variation
cv.	Cultivar
^{0}C	Degree Celsius
FYM	Farmyard manure
GA	Gibberellic acid
BA	Benzyl adenine
ppm	Parts per million
g	Gram
cm	Centimeter
ml	Millilitre
NS	Non-significant
sp. or spp.	Species (Singular and Plural)
v/v	Volume by volume
TNAU	Tamil Nadu Agricultural University

ACKNOWLEDGEMENT

*First and foremost, I bow my head before **ALMIGHTY GOD** for showering grace on me to complete the work with good health, strength, enthusiasm, confidence and interest.*

*My words cannot express my deep sense of gratitude and indebtedness to my beloved chairperson **Dr. Mini Sankar**, Assistant Professor, AICRP on Floriculture, Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara for the esteemed advice, inspiring guidance, untiring interest, valuable suggestions, motherly approach, whole hearted cooperation and immense help rendered throughout the course of this investigation and preparation of the thesis.*

*I am ever grateful to **Dr. Sreelatha U.**, Professor and Head, Department of Floriculture and Landscaping, College of Horticulture, and member of my advisory committee for her unfailing support, valuable suggestions and guidance rendered to me for the completion of the research programme and preparation of the thesis. I am genuinely indebted to her for the constant encouragement and affectionate advice rendered throughout the academic programme.*

*I am deeply obliged to **Dr. Ajith Kumar**., Professor, ADR, RARS, Ambalavayal, Wayanad member of my advisory committee for his support and enthusiasm, relevant suggestions and constructive professional criticism and guidance rendered throughout the period of investigation and preparation of thesis.*

*I am extremely thankful to **Dr. Deepthy K. B**, Assistant Professor, Deparment of agricultural entomology, member of my advisory committee for her whole hearted cooperation, relevant suggestions lingering help and critical comments which enabled me to complete the work successfully.*

*I sincerely thank **Dr. Anupama T. V.,** Assistant Professor, AICRP on Floriculture, Department of Floriculture and Landscaping for her support, scholarly suggestions and cooperation throughout my study period.*

*I am highly thankful to **Dr. Reshmi Paul,** Assistant Professor, Department of Floriculture and Landscaping for her support, relevant suggestions and guidance rendered throughout the study period.*

I consider it as my privilege to express my deep felt gratitude to ***Dr. Ayoob K.C****, Assistant Professor, Department of Agricultural Statistics,* ***Dr. Berin Pathrose****, Assistant professor, Department of Agricultural Entomology and* ***Dr. Reshmi Vijayaraghavan****, Assistant professor, Department of Plant Pathology for their support, critical comments and valuable advice during the period of experiment and preparation of thesis.*

I am highly indebted to ***Dr. C. K. Geetha*** *(Retd.) Professor and Head, Department of Floriculture and Landscaping,* ***Dr. P. K. Sudhadevi*** *(Retd.) Professor, Department of Floriculture and Landscaping and* ***Dr. S.Krishnan*** *(Retd) Professor and Head, Department of Agricultural Statistics for offering all possible help and support during the period of pursuance of my post-graduation.*

I take this opportunity to extend my profound gratitude to ***Librarian****, College of Horticulture and all other staff from* ***library*** *and* ***computer club*** *for the facilities offered.*

I am grateful to all the non-teaching staff of the Department of Floriculture and Landscaping especially ***Rajani chechi, Dincy chechi, Shilpa, Sachin, Sudha, and Anju*** *for the help rendered by them during the course of my study and also to all labourers especially* ***Usha chechi, Rema chichi, Bindhu chechi and Pankajakshan chettan*** *for their whole hearted help during the research work.*

I wish to express my sincere gratitude to my seniors especially ***Dr. Alex, Shilpa chechi, Aswathi chechi, Justo chettan,*** *and my juniors* ***Rashidha, Shuhda, Reshma*** *and my batchmates* ***Alfin, Jesabel*** *and my dear friends especially* ***Vysakh, Ahal, John, Anil, Alan, Anirudh, Vidhu, Priya, Alfi, Arya, Athulya, Athira, Fazee, Aruna, Jeen****,and* ***Athmaja*** *for their support.*

I am greatly thankful to ***Vishnu, Adarsh, Ajil, Sadiq, Ajin, Pavithran, vivekettan, Tijochettayi, Tiji chechi*** *and* ***Rosamma*** *for their love, whole hearted approach and moral support given to me during my study period.*

I am forever beholden to my beloved ***Pappa, amma, aniyan*** *for their profound love, personal sacrifice, incessant inspiration and constant prayers, which supported me to stay on track.*

My word of apology to those I have not mentioned in person for the successful completion of this endeavour.

Sijo John

Introduction

1. INTRODUCTION

Floriculture is one of the most emerging, vibrant, income generating and export oriented industries in India. Green house technology introduced in past few years has changed the Indian floriculture scenario (Ramalingam, 2008). Among the cut flowers grown under protected conditions for export purpose, rose occupies a prime position.

Rose is acclaimed as 'queen of flowers' because of its colour, fragrance and mesmerising quality. It represents love, affection and purity. Rose belongs to the family Rosaceae. Rose is a perennial flowering plant with diverse classification which include hybrid teas, floribundas, grandifloras, miniatures, climbers and ramblers.

Versatility of rose is the main reason of its prime position among cut flowers. Cut roses are used for flower arrangements, bouquets, interior decorations and other social and religious purposes whereas loose flower roses are used for preparation of rose water, otto of rose, garlands as well as value added products like gulkhand. Because of these diversified uses, Indian roses are having great demand in international market. To produce superior quality flowers, stakeholders require high yielding plants with enhanced and improved cultural practices and technologies. Hence, priority of research should be focussed on the quality improvement, productivity enhancement, pest and disease resistance, standardisation of new practices and refinement of existing technologies.

Roses can be successfully cultivated under top ventilated rain shelters in Kerala. Growing medium plays a crucial role in the growth and yield of crops. A good growing medium maximizes the root and shoot growth through supply of adequate water and nutrients and thereby enhancing the yield.

An ideal growing medium should possess properties such as proper drainage, water holding capacity, proper ratio of air to water space and it should facilitate uptake of water and nutrients by the roots. Growing media consisting of soil, sand and farmyard manure (FYM) are commonly used by farmers.

Soilless media consisting of vermiculite, perlite and rock wool are now popularly used for the commercial production of roses under protected condition.

But these materials are costly and are not easily available to farmers. Hence, there is a need to develop a cost effective growing media composition with locally available materials for the commercial production of roses under protected conditions in Kerala.

Among the commercial growers of cut roses, the use of synthetic plant growth regulators for maximizing yield have gained wide acceptance. Exogenous application of plant growth regulators improves the yield and quality of cut flowers by manipulating the hormonal regulations in the plant system. Even though commercial formulations of different growth regulators are available in the market, the type and precise concentration of growth regulators for maximising growth and yield are yet to be standardised. Hence the current experiment was carried out with the following objective;

To standardise growing media and growth regulators for commercial production of cut roses in agroclimatic conditions of Kerala.

Review of literature

2. REVIEW OF LITERATURE

Rose is one of the beautiful creations of nature and it is the most traded cut flowers in the world due to its preferable choice for various ceremonies and social occasions. Growing medium influences, the growth and yield parameters of rose and external application of growth regulators was found to be very effective for enhancing the yield and quality. For commercial purpose, cultivation of rose can be undertaken under protected conditions and type of structures for protected cultivation varies with the regions. Literature pertaining to the influence of growing media, growth regulators and protected cultivation on vegetative and floral characters of rose and other flower crops are reviewed here.

2.1. Growing media

2.1.1. Effect of FYM

2.1.1.1. Rose

Pooja *et al*. (2017) evaluated three different soil based substrates for rose and observed that plants grown under the growing media containing soil, FYM and saw dust in 2:1:1 v/v and fertilized with water soluble fertilizers were superior in terms of plant height, leaf area, days taken for flowering and flower yield.

Rajasekhar *et al*., (2017) reported that a media composition of Soil, FYM, leaf mould 1:1:1 v/v was very effective for improving the number of flowers per season, number of flowers per m^2 and duration of flowering.

Rajasekar and Suresh (2015) recorded highest plant height and plant spread in E-W and N-S directions, when plants were grown in a media containing Soil + FYM (1:1 v/v).

Bisht *et al.* (2013) studied five different composition of growing substrates for *Rosa hybrida* cv. 'Grand Gala'. Among different combinations of media, soil + FYM (2:1 v/v) along with various combinations of water soluble NPK produced highest number of flowers and number of days from bud emergence to harvest was also found to be minimum.

2.1.1.2. Other flower crops

Eight different substrate combinations were evaluated for pot plants of tuberose and a substrate combination of Arka fermented cocopeat, soil, sand and FYM in 1:1:1:1 v/v was found to be the most suitable medium for pot plant productions of tuberose variety Arka Sugandhi (Nair and Bharathi, 2019).

An experiment to evaluate light weight growing media composition for growth and flowering of potted chrysanthemum revealed that media combination of cocopeat, vermiculite and FYM in 1:1:1 proportion was the best for growth and flower production (Thakur *et al*., 2018).

Effect of different growing media on vegetative and floral characters of China aster cv. Kamini was investigated by Khanna *et al*. (2016). They found that plants grown in media containing FYM + forest litter (1.5 kg/m^2) and phosphate solubilizing bacteria (50 ml/15L) showed positive effects in plant height, plant spread, number of primary branches, days taken for flower bud initiation, number of flowers per plant, stalk length, flower diameter and vase life.

Nair and Bharathi (2015) reported that, among the potting media evaluated, a media combination of soil, sand, FYM, cocopeat and vermicompost in 2:1:0.5:0.5 v/v was the best resulting in the production of highest number of flowers per plant with prolonged duration of flowering in pot chrysanthemum cv. Sadbhavana.

Sisodia and Singh (2015) found that gladiolus cv. Nova lux exhibited significant enhancement in length of spike, number of florets per spike and duration of flowering when plants grown in a media consisting of FYM (5kg/m^2).

Ikram *et al*. (2012) observed an improvement in vegetative characters like plant height, plant spread and number of leaves when tuberose plants were grown under a medium consisting of FYM and sand or coir pith in 1:1 proportion.

2.1.2. Effect of vermicompost

Vermicompost is a product derived from the accelerated biological degradations of organic wastes by earthworms and microorganisms. It is having high porosity, aeration, drainage, water holding capacity as well as the ability for strong adsorption and retention of nutrients which make it an excellent media constituent for crop growth.

2.1.2.1. Rose

An experiment was conducted by Bisht *et al.* (2013) in *Rosa hybrida* cv. 'Grand Gala' using different growing substrate and observed that growing media combination of soil + vermicompost was most effective for enhancing number of flowers, length of flower bud and number of petals per flower.

Nilawonk *et al*. (2015) reported increased vegetative and floral characters *viz*; diameter of flower, length of stem and fresh weight of flowers when plants were grown in a growing media containing vermicompost along with worm tea and NPK fertilizer application.

2.1.2.2. Other flower crops

An investigation to find out suitable media combination for gerbera revealed that combination of red soil, cocopeat and vermicompost in 1:1:1 was ideal for improving yield as well as quality of flowers in terms of flower diameter, stalk length, number of ray florets per flower and fresh weight of flower (Swarupa *et al*., 2019).

Padhiyar *et al*. (2017) reported that a growing medium consisting of cocopeat + vermicompst and biocompost (2:1:1 v/v) was best suited for enhancing vegetative growth, flower yield and duration of flowering in chrysanthemum var. Ajina purple.

A medium containing (sand + soil + FYM) + vermicompost + cocopeat (2:1:1 v/v) was most suitable for quality flower production in LA hybrid lily (Rajera *et al*., 2017).

A media combination of soil + vermicompost + rice husk + coco peat + castor cake was found to enhance the growth, flower diameter, flower stalk length, flower stalk thickness and duration of flowering in gerbera cv. Alcochete (Chauhan *et al*., 2014).

Performance of gerbera varieties was evaluated in different growing media in naturally ventilated polyhouse and it was observed that growth and flower quality were superior in plants grown under soil with vermicompost medium (Thangam *et al*., 2009).

2.1.3. Effect of poultry manure

Tirkey *et al*. (2017) reported that improvement in plant height, number of leaves per plant, number of spike per plant, number of spike per hectare and number of corms per plant in gladiolus (*Gladiolus grandiflorus*) cv. Jester by the application of poultry manure (25%) along with 75 % of RDF.

A study to evaluate influence of different media composition on growth and yield of *Duranta erecta* var. variegata revealed that a media composition of sand and poultry manure in 2:1 v/v was very effective for improving plant height, number of branches, number of leaves and leaf area (Said, 2016).

Ahmad and Saravanan (2014) observed highest plant height, number of leaves, leaf area, number of shoots per plant, shoot girth, root length, number of roots per plant, number of spikes per plant, spike length, number of flowers per spike and longevity of spike on orchids when grown under a medium containing brick pieces, gravel and poultry manure.

Ikram *et al*. (2012) reported an enhancement in characters such as spike length, spike weight, spike diameter and vase life in tuberose grown in medium combination of poultry manure and coir pith (1:1).

Impatiens plants grown in a substrate containing peat, municipal waste compost and poultry manure in 1:2:1 v/v had larger abundant flowering period compared to other treatments (Dede *et al*., 2006).

Among different media combinations evaluated, a medium comprising of soil, poultry manure and sand in 2:1:1 produced longest scapes in tulip (Jhon *et al*., 2007).

2.1.4. Effect of coir pith compost

2.1.4.1. Rose

Among the six combinations of growing media analyzed, a combination of cocopeat along with leaf mould and soil (1:1:1) showed superior results in terms of vegetative and floral characters such as plant height, leaf area, leaves per stalk, stalk length, length of petal, number of petals per flower and flower diameter in *Rosa hybrid* cv. Top secret (Chavada *et al*., 2017).

A study conducted by Ketter *et al*. (2015) revealed that cocopeat based growing system with reuse of drain water resulted in water saving, higher yield and improvement in quality of flowers in rose.

Chandore *et al*. (2010) observed highest plant height, number of shoots per plant, number of leaf pairs per flowering shoot, shoot length and number of flowers per plant in rose cv. First Red grown in a medium containing red soil, black soil, coco peat in 1:1:1 proportion.

Growing media comprised of cocopeat and perlite in 1:1 proportion was found to improve the flower yield as well as flower stalk length in four rose varieties *viz*; Anastasia, Fenice, New fashion and Gold strike (Fascella and Zizzo, 2005).

Eleni *et al*. (2001) reported highest flower yield with more number of extra class flowers and high stalk length in two rose varieties ‘Bianca’ and ‘First Red’ when grown in a medium containing cocopeat and perlite in 3:1 proportion.

2.1.4.2. Other flower crops

Muraleedharan and Karuppaiah (2015) observed highest plant height, plant spread, number of flowers per plant, flower stalk length, spathe length and spathe breadth in anthurium when grown in a medium comprised of coirpith compost and coconut husk.

Greatest plant height, petiole length, leaf area as well as fresh and dry weights of leaves in anthurium was observed when young plants were grown in a media containing sand and coirpith compost (Basheer and Thekkayam, 2012).

A media consisting of cocopeat, saw dust and sand in 1:1:1(v/v) was found to be the best with respect to number of days to bud initiation, flower diameter, flower stalk length, number of flowers per plant and vase life in gerbera (Gupta *et al*., 2004).

Barreto and Jagtap (2002) reported that application of coirpith compost as a constituent along with compost or vermicompost medium influence the vase life and yield in gerbera.

2.2. Growth regulators

2.2.1. Effect of Benzyl Adenine (BA)

2.2.1.1. Rose

Mondal and Sarkar (2017) reported that application of BA at 200 ppm enhanced number of primary branches, number of secondary shoots, leaf area, stalk diameter, days to flower bud appearance, flowering duration and vase life whereas maximum plant spread in E-W and N-S directions, highest number of flowers per plant and flower diameter at cup shape were observed in the plants treated with BA at 100 ppm.

Vasudevan and Kannan (2015) reported that application of BA at 200 ppm along with bending at shoot junction improved the plant height, plant spread, shoot length, length of flower bud, neck/pedicel length, number of cut stems/m^2 and vase life in rose.

Application of BA at 100 ppm in rose (*Rosa hybrida*) cv. Poison resulted in production of more number of leaves per plant, flower longevity and bud length Baghele *et al*. (2014).

2 .2.1.2. Other flower crops

Maximum vase life and early colour appearance of 1st and 3rd buds of lily flowers were observed under the treatment of single dose of BA at 100 ppm. (Kapri *et al*., 2018).

A study conducted to examine the influence of 6-BAP in flower quality of *Dendrobium* spp. orchid by Bogahawatta and Kumara (2017) revealed that 200 mg/L of 6-BAP had the greatest potential to improve the flower quality in terms of total area of flower as well as width of petal, sepal and labellum.

Foliar application of BA at 350 ppm resulted in highest number of buds per node after harvest and highest number of buds sprouted per harvested stalk in carnation cv. Domingo. (Kasturi and Sekhar, 2017).

Foliar application of BA (100 µM/L) had resulted an enhancement in length of basal bud, diameter of basal bud, length of upper bud, diameter of upper bud, diameter of basal flower, and diameter of upper flower in *lilium* cv. Arcachon (Kumari *et al*., 2017).

Ramtin *et al*. (2015) reported that foliar application of Benzyl Adenine (50 µM and 100 µM) improved the plant height, length of floret, and floret diameter in carnation.

Nambiar *et al*. (2012) reported highest percentage of inflorescence production, early emergence of first inflorescence, long inflorescence, and highest number of flowers per inflorescence in *Dendrobium* hybrid (Angel white) due to the application of BAP 200 mg/L. Maximum number of leaves were observed in dendrobium orchid because of BA 15mg/L application (Bhatt and Chauhan, 2012).

2.2.2. Effect of Gibberellic Acid (GA)

2.2.2.1. Rose

Mondal and Sarkar (2017) observed earliness in flowering and maximum internodal length due to the application of GA 100 ppm and 200 ppm respectively in hybrid rose cv. Bugatti.

Parmar *et al*. (2015) reported highest number of flowers per plant, number of flowers/m^2 and longest vase life in rose cv. Passion, due to foliar application of at 200ppm GA.

Effect of three different growth regulators and cow's urine was studied in rose (*Rosa hybrida*) cv. Poison and it was observed that application of GA at 100 ppm improved plant height, plant spread, initiation of flower bud, vase life, stalk length, bud length, bud as well as flower diameter, and number of flowers per plant per year (Baghele *et al*., 2014).

Among different growth regulators evaluated, GA at 100 ppm was proved to improve plant height, stalk length, girth of stem, flower diameter, vase life, and days for emergence of flower bud in rose cv. First Red (Kumar *et al*., 2012).

Hashemabadi and Zarchini (2010) reported that different concentrations of GA_3 resulted a significant improvement in internodal length, stem length of flower, and number of flowers per unit area of rose cv. Poison.

Arun *et al*. (2000) studied the effects of various levels of GA on growth and flowering of rose cv. First Red and found that plant height, shoot length, neck length and stem length were highest with GA at 300 ppm and also reported that application of 200 ppm GA could influence the number of days for flower bud emergence, bud length, bud circumference, number of flowers/m^2 and flower diameter.

2.2.2.2. Other flower crops

Kapri *et al*. (2018) observed that flowering and post harvest characters of lily were influenced by the application of growth regulator and observed that GA at 200 ppm influenced the number of flower buds per plant and early flowering whereas single dose of GA at 100 ppm produced highest flower diameter.

Highest flower bud size as well as flower size, duration of flowering, highest fresh weight of flower and vase life were observed in chrysanthemum plants when treated with GA at 100mg/L (Sajid *et al*., 2018).

Kasturi and Sekhar (2017) observed minimum number of days for sprouting of buds after harvest, highest length of laterals at 20 days and 80 days after harvest of flower stalk in carnation cv. Domingo treated with 250 ppm of GA.

Among different levels of GA evaluated, 150 ppm was found to be the most effective in terms of plant height, number of leaves per plant, plant spread, days to first flower bud emergence, flower diameter, stalk length as well as girth and number of flowers per plant in gerbera (Sangma *et al*., 2017).

Patil *et al*. (2014) reported an improvement in plant height, sprouting of corms, diameter of spike, number of florets per spike, vase life, and number of spikes per hectare in gladiolus under the treatment of GA at 200 ppm. Improvement in vase life and increased water uptake were observed in *Asiatic lilium* cv. Arcachon by the application of 250 ppm/L GA (Kumari *et al*., 2017).

Gladiolus cv. H.B.Pitt recorded an increased plant height, number of leaves, number of florets /spike, length of floret and length of spike when GA was applied as foliar spray at 200 ppm (Sable *et al*., 2015).

Highest number of pseudobulbs, longer shoots and more number of flowers were observed in *Dendrobium* spp. due to the application of GA 15 mg/L (Bhatt and Chauhan, 2012).

Dalal *et al*. (2009) observed that gerbera (*Gerbera jamesonii*) cv. Sangria exhibited superior qualities in terms of plant height, leaves per plant, flowers per plant, flowers/m^2, length of flower stalk and diameter of flower by the application of GA at 150 ppm.

According to Padaganur *et al*. (2005), foliar application of GA at 150 ppm resulted in greatest plant height, number of leaves, number of shoots, spike length, spike weight, number of florets per spike and floret diameter in tuberose (*Polianthes tuberosa*) cv. Single.

2.3. Protected cultivation

2.3.1. Rose

Mohanty *et al*. (2011) studied the effect of open field and protected environment on the growth and yield of four rose varieties and the varieties ‘Montezuma’ and ‘Gladiator’ were found to be superior in vegetative and floral characters respectively. More yield and quality flowers were observed under protected condition when compared to open field.

Ranpise *et al*. (2008) reported that rose varieties grown under poly house conditions exhibited superior results in yield parameters, when compared to other growing structures.

An experiment was conducted to determine suitable growing structure for rose by Teital *et al*. (2007) and observed that plants grown under fan and pad system had vigorous growth and produced flower stems with highest stalk length.

Mandhar and Carolin (2004) observed that naturally ventilated poly houses (32 x 6 x 3.5m) had the ability to support the rose plants to produce 160 flowers/ m^2 per year.

A study conducted to evaluate the efficiency of two different growing environment *viz*. open field and fan and pad system for rose variety Gladiator, revealed that plants grown under fan and pad cooled greenhouse produced highest number of flowers with more stalk length and fresh weight (Patil *et al*., 2003).

Rose cv. Raktagandha produced greatest plant height, plant spread and highest number of A grade flowers, when grown under polythene covering with 25 per cent summer shading. However, maximum number of flowers per plant was observed under 50 per cent summer shading and polythene covering (Ramesh and Kumar, 2000).

Fonseca and Hanan (1987) reported that greenhouse cover and shading influenced yield attributes of rose. They also noted that roses grown under double layered polyvinyl chloride produced 76.7 flowers per plant during the period of 15.5 month.

2.3.2. Other flower crops

Sangma *et al*. (2016) evaluated three types of covering material *viz*; tarpaulin, high density polyethylene (HDPE) and black sateen cloth for chrysanthemum in naturally ventilated polyhouse and observed that HDPE had the ability to enhance plant height, plant spread, number of cut stems, duration of flowering and early emergence of flower bud.

An experiment was conducted to study the performance of gerbera under two protected conditions *viz*; naturally ventilated polyhouse and low cost green house and found that vegetative growth, flowering attributes and vase life were significantly higher under naturally ventilated polyhouse than the low cost green house. There was an improvement in flower diameter, stalk length, stalk diameter and vase life of gerbera grown under low cost green house (Kumar *et al*., 2014).

Materials and methods

3. MATERIALS AND METHODS

The investigations entitled "Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter" was conducted at the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara during 2018 - 2019. The materials used, and the methodology adopted for the study are presented in this chapter.

3.1. Location of experiment

The site of experiment is located at a latitude of 10^0 31 N and Longitude of 76^0 13 E

3.2. Climate and weather conditions

Climate is humid tropical. Meteorological data recorded during the period of observations are presented in Appendix I.

3.3. Experimental details

3.3.1. Planting material

The experiment was carried out using red coloured rose variety 'Tajmahal'. Six months old grafts were used for planting.

3.3.2. Growing structures

The study was conducted in a top ventilated rain shelter of size 60 x 10 m

3.3.3. Growing media

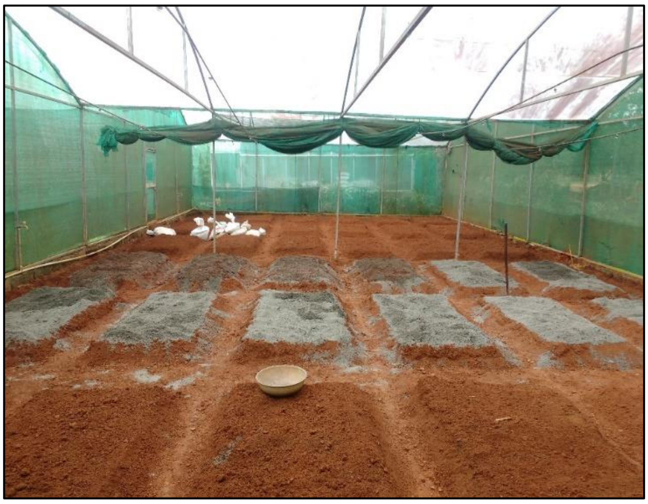
Three different combinations of growing media *viz*. soil + M-sand + coco peat + FYM (M_1), soil + M-sand + coco peat + vermicompost (M_2), soil + M-sand + coco peat + poultry manure (M_3) in 2:1:1:1 ratio were used for the study.

Six months old grafts of rose variety Tajmahal

Growing media containing vermicompost

Growing media containing poultry manure

Growing media containing FYM



Raised beds

Plate 1. Materials used for experiment

3.3.4. Growth regulators

Two growth regulators *viz.* Gibberellic acid and Benzyl adenine at two different levels *viz.* 200 ppm and 250 ppm were applied as foliar spray. First spraying was done at two months after planting and subsequent sprays at monthly intervals.

3.3.5. Planting and general management

Beds of dimension 2.1 x 1.2 m were made using different growing media and planting was done at a spacing of 40 x 30 cm. Flower buds are not allowed up to two months of planting. Sprouts arising from root stock were removed as and when observed. Manuring was done as per TNAU recommendation for rose. Half of the dose was applied as basal and remaining half as equal splits at monthly intervals. Need based application of plant protection chemicals were also done

3.3.6. Design, layout and treatments

Design : RBD

No. of treatments : 12

No. of replications : 3

No. of plants per treatment : 15

3.3.6.1. Treatment

Treatments	**Treatments**
T_1 - M_1 + BA 200 ppm	T_2 - M_1 + BA 250 ppm
T_3 - M_1 + GA 200 ppm	T_4 - M_1 + GA 250 ppm
T_5 - M_2 + BA 200 ppm	T_6 - M_2 + BA 250 ppm
T_7 - M_2 + GA 200 ppm	T_8 - M_2 + GA 250 ppm
T_9 - M_3 + BA 200 ppm	T_{10} - M_3 + BA 250 ppm
T_{11} - M_3 + GA 200 ppm	T_{12} - M_3 + GA 250 ppm

One month after planting

At peak flowering period

Plate 2. General view of the field

3.3.6.2. Lay out of the experiment

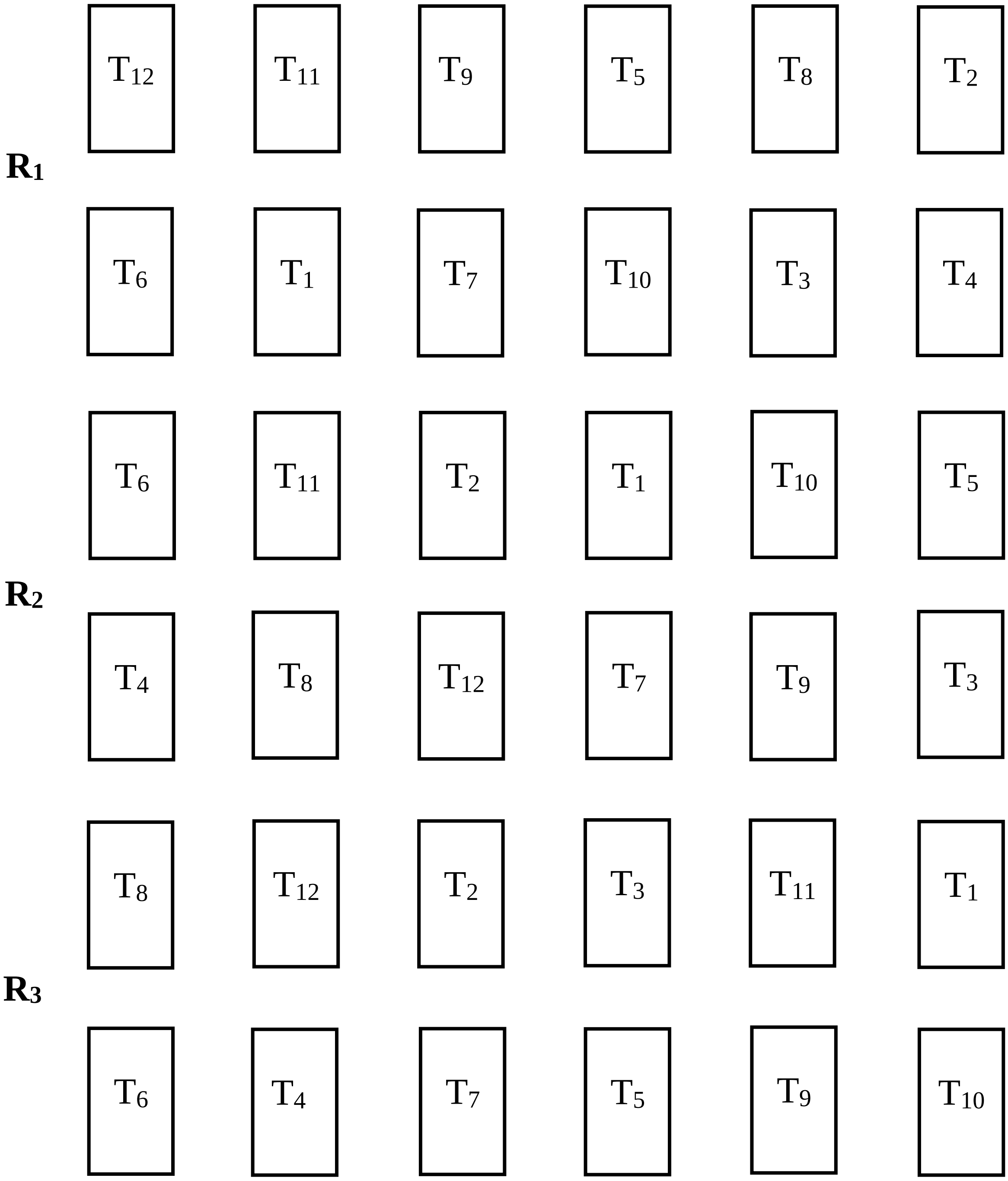


Figure 1. Lay out of the experiment

No. of treatments: 12	No. of plants per treatment: 15	Plot size: 2.1 x 1.2 m
No. of replications: 3	Spacing between plants : 40x30 cm	Design : RBD

3.4. Observations

In each treatment eight plants were selected for recording observations and observations are as follows.

3.4.1. Vegetative characters

Observations on vegetative characters were records at monthly intervals.

3.4.1.1. Plant height

Plant height was recorded by measuring from bottom to the tip of the main shoot and expressed in cm.

3.4.1.2. Plant spread (EW and NS)

The growth of the plant in East -West and North -South were taken and the average was expressed in cm.

3.4.1.3. Number of branches/plant

The total number of branches originated from the main shoot was observed and recorded.

3.4.1.4. Number of leaves/branch

The total number of leaves present on each branch at the time of observation were counted and recorded.

3.4.2. Floral characters

3.4.2.1. Days taken for flower bud initiation

Number of days taken from the day of planting to the emergence of first flower bud was counted and recorded.

3.4.2.2. Days taken from flower bud initiation to commercial stage of harvest

Number of days taken from emergence of the flower bud to the unfurling of one or two rows of outer petals was counted and recorded.

3.4.2.3. Days taken from flower bud initiation to complete opening

Number of days taken from flower bud initiation to the complete opening of the flower was recorded.

3.4.2.4. Length of flower bud

Length from base to tip of the flower bud was measured and expressed in cm.

3.4.2.5. Diameter of flower bud

The diameter of flower bud was measured using vernier callipers at tight bud stage and expressed in cm.

3.4.2.6. Number of flowers/plant

Total number of flowers produced by the plant during the period of experiment was counted and recorded.

3.4.2.7. Number of petals/flower

Total number of petals of fully opened flower was counted and recorded.

3.4.2.8. Length of flower shoot

Length was measured from the base to the terminal node of the shoot and expressed in cm.

3.4.2.9. Neck length

Length from the end of first terminal node to the base of flower bud was taken and expressed in cm.

3.4.2.10. Neck girth

Diameter of the neck was taken using vernier callipers and expressed in cm.

3.4.2.11. Stalk length of the flower

The length of flower stalk from the base of the flower shoot to the base of flower bud was taken and expressed in cm.

3.4.2.12. Stalk girth of the flower

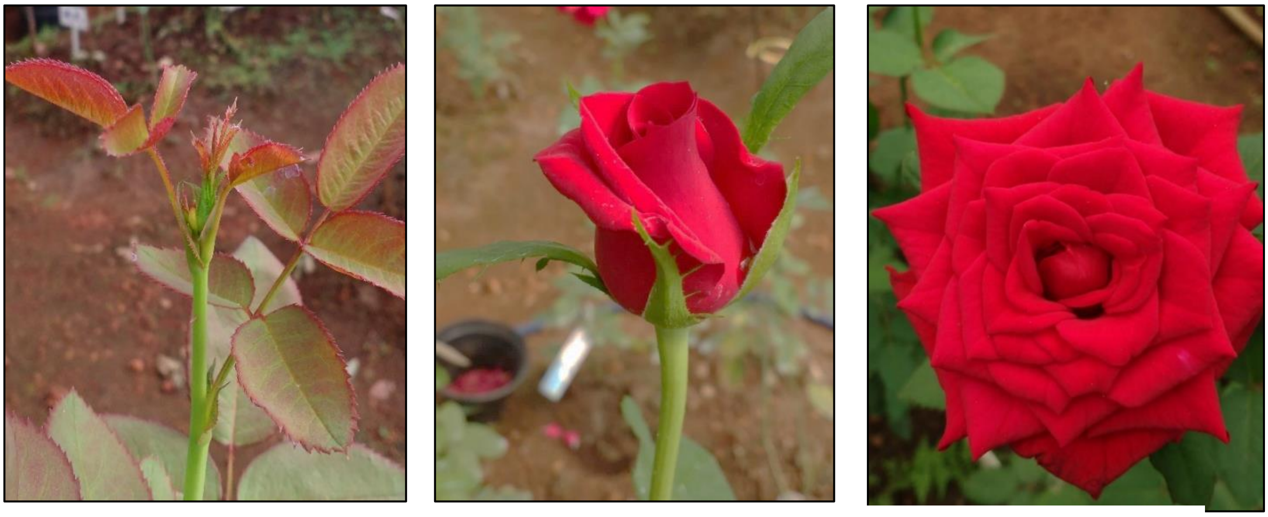
Diameter of flower stalk was taken and expressed in cm.

3.4.2.13. Flower diameter at fully opened stage

Diameter of flower was taken at fully opened stage and expressed in cm.

3.4.2.14. Flower persistence

Number days taken from commercial stage of harvest to wilting of the outer petals of the fully opened flower was observed and recorded.



(a) (b) (c)

(a). Flower at visible bud emergence stage, (b). Commercial stage of harvest, (c). Complete opening stage

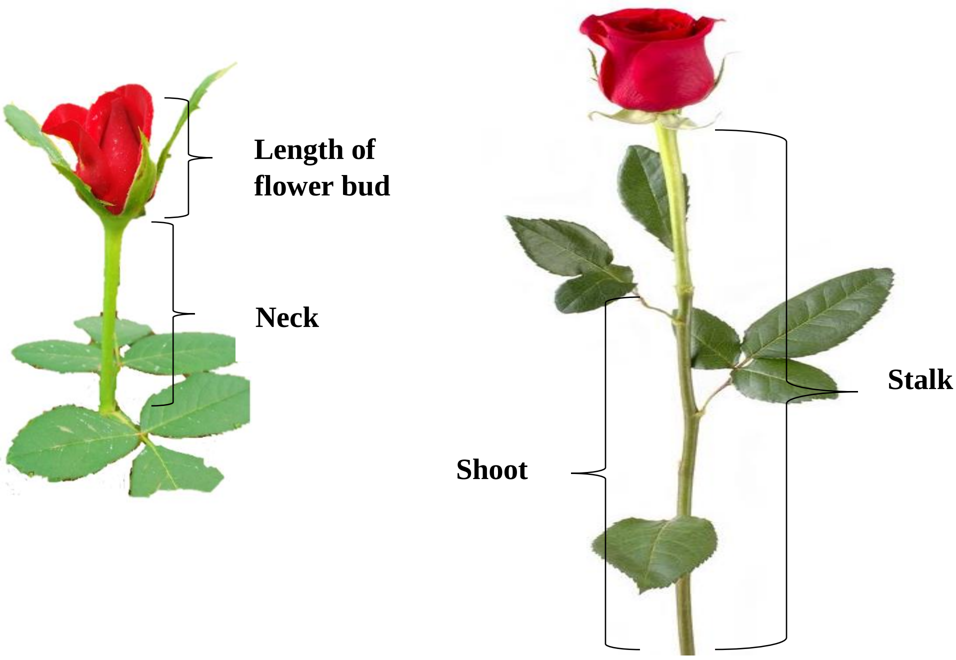


Plate 3. Stages of flower development and parts of flower

3.4.3. Incidence of pests and diseases

Pest and disease incidence were noted.

3.4.4. Post-harvest studies

3.4.4.1. Fresh weight of the flower

Weight of flower with flower stalk was taken and expressed in g.

3.4.4.2. Physiological loss in weight

Difference between the fresh weight of the flower and weight of the flower at the end of vase life was calculated and expressed in g.

3.4.4.3. Total water uptake

Difference between the initial volume of the water and the volume of the water at the end of vase life was measured and expressed in ml.

3.4.4.4. Vase life

Flowers harvested at commercial stage of harvest was kept in tap water for observing vase life. The number of days taken for wilting of outer row of petals was counted and recorded as vase life.

3.5. Analysis of growing media

Samples of growing media were collected before and after the conduct of experiment. The samples were analysed to estimate the status of organic carbon, available N, P and K as well as chemical properties using the following methods (Table 1).

Table. 1. Analysis of growing media

Sl. No.	Parameter	Method followed	Reference
1	Organic Carbon (%)	Walkley and Black's rapid titration method	Jackson (1958)
2	Available N (Kg ha^{-1})	Alkaline permanganate method	Subbiah and Asija (1956)
3	Available P (Kg ha^{-1})	Bray-1 extractant Ascorbic acid reductant method	Jackson (1958)
4	Available K (Kg ha^{-1})	Neutral normal ammonium acetate extract using flame photometer	Jackson (1958)
5	pH	Digital pH meter	-
6	E.C	Electrical conductivity meter	-

3.6. Meteorological parameters

Meteorological parameters such as temperature, relative humidity and light intensity inside the rainshelter was observed daily thrice *viz*; 8.15 am, 12 noon and 3 pm. Thermohygrometer was used for observing temperature and humidity. Temperature was expressed in ˚C and relative humidity as percentage. Light intensity was measured using lux meter and expressed as lux.

3.7. Statistical analysis

The data pertaining to vegetative, floral, post harvest and nutrient analysis were statistically analyzed using WASP statistical software.

Results

4. RESULTS

The results of the investigation on "Standardization of growing media and growth regulators for rose under top ventilated rain shelter" carried out at Department of Floriculture and Landscaping are presented in this chapter.

4.1. Vegetative characters

Influence of growing media and growth regulators on vegetative characters are furnished in Table 2 (a) to 5 (b).

4.1.1. Plant height

Plant height was significantly influenced by growing media composition and significant variation in plant height among different treatments could be observed during the period of observation. M_1 (growing media containing FYM) was found to have greatest plant height throughout the period of observation except during the month of March at which M_2 (growing media containing vermicompost) and M_1 (growing media containing FYM) were on par in terms of this parameter (69.07 cm and 67.58 cm respectively). Similar trend was observed during September, November, January and April. Lowest plant height was observed in M_3 (media containing poultry manure) during the entire period of observation. Among different growing media combinations, maximum plant height was observed during May in M_1 (growing media containing FYM) with 77.96 cm which was on par with M_2 (growing media containing vermicompost) (73.91 cm) and lowest plant height was in M_3 (64.08 cm) during the month of May (Table 2).

Regarding influence of different levels of growth regulators on plant height, considerable difference could be observed during the experimental period. Application of GR_4 (GA at 250 ppm) produced greatest plant height during major part of growth period which was significantly superior over other growth regulators. During September maximum plant height (20.81 cm) was observed under the treatment containing GR_3 (GA at 200 ppm) which was on par with GR_2 (BA at 250 ppm) with 20.22 cm. Highest plant height (41.33 cm) could be observed by the application of GR_2 (BA at 250 ppm) in January which was closely followed by GR_4 (GA at 250 ppm) with 41.29 cm and GR_3 (GA at 200 ppm) with 38.75 cm. Tallest plants (79.56 cm) were observed in the treatment containing GR_4 (GA at 250 ppm) during the month of May. Among different levels of growth regulators, GR_1 (Benzyl Adenine at 200 ppm) was found to produce the shortest plants during the period of observation.

Effect of M x GR interaction produced significant influence on plant height during the period of experiment. Greatest plant height was observed under the treatment combination of M_1 x GR_4 (growing media containing FYM along with GA at 250 ppm) in October which was statistically superior than all other treatment combination (38.67 cm). Same trend was Observed during the months of November (50.20 cm), December (70.46 cm), April (85.32 cm), and May (91.60 cm). During September treatment combination of M_2 x GR_2 (growing media containing vermicompost + BA at 250) produced highest plant height (24.88 cm) same trend was noticed in March (80.90 cm). M_2 x GR_2 (growing media containing vermicompost + BA at 250ppm), M_1 x GR_1 (growing media containing FYM + BA at 200 ppm), M_2 x GR_4 (vermicompost + GA at 250 ppm), M_1 x GR_4 (growing media containing FYM + GA at 250 ppm) and M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) (46.38, 46.09, 43.78, 43.70, 40.69 respectively) were on par with respect to this parameter during January. Maximum height during February could be observed in the treatment combination of growing media containing FYM with BA at 200 ppm (62.12 cm) which was on par with growing media containing vermicompost + BA at 250 ppm (61.43 cm), growing media containing FYM + BA at 250 ppm, growing media containing FYM + GA at 200 ppm and growing media containing FYM + GA at 250 ppm (59.08 cm, 59.66 cm and 57.01 cm respectively). Application of BA at 250 and 200 ppm on plants which grown in growing media containing poultry manure recorded lowest plant height in most of the months during the experimental period (Table 3).

4.1.2. Plant spread

Regarding the influence of growing media on plant spread, significant variation among treatments could be observed during the period of observation. Highest plant spread was recorded in M_1 (growing media containing FYM) during the major part of growing period, which was maximum during May (30.05 cm). M_2 (growing media containing vermicompost) had maximum plant spread during the months of September and January which was on par with M_1 (growing media containing FYM). M_3 (growing media containing poultry manure) was found to have lowest plant spread, during the period of observation.

There was a significant variation in plant spread due to the application of growth regulators throughout the experimental period. Application of GR_2 (BA at 250 ppm) produced highest plant spread during the months of September, January, March, April and May (15.93, 23.60, 30.66, 29.72 and 33.49 cm respectively). Highest plant spread was recorded by the application of GR_4 (GA at 250 ppm) in October (19.09 cm) whereas in November, GR_4 (GA at 250 ppm) was on par with GR_3 (GA 200 ppm) with 21.34 cm, GR_2 (BA at 250 ppm) with 21.15 cm and GR_1 (BA at 200 ppm) with 21.12 cm regarding to this parameter. During December (27.00 cm) and in February (26.85 cm) maximum plant spread was recorded by the application of GR_1 (BA at 200 ppm) (Table 4).

M x GR interaction had significant effect on plant spread. Maximum plant spread (17.60 cm) during September was recorded in the treatment combination of M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) which was on par with M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) (17.06 cm). Treatment combination of M_1 x GR_4 (growing media containing FYM with GA at 250 ppm) had more plant spread during October (21.99 cm) and November (25.73 cm). During December highest plant spread was recorded in the treatment combination of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) (32.09 cm) which was superior than all other treatments combinations. In January M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm), M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) and M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) (26.49, 26.49, 25.40 and 25.28 cm respectively) were on par with each other in terms of plant spread. Treatment combination of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) had the highest plant spread (28.96 cm) during February which was on par with M_1 x

GR_2 (growing media containing FYM + BA at 250 ppm), M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) and), M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm) (28.65, 28.87 and 28.21 cm respectively) Highest plant spread was observed under treatment combination of M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) (33.43 cm) which was on par with M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) in March (31.94 cm). The treatment combination of M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_3 x GR_1 (Growing media containing poultry manure + BA at 200 ppm), M_1 x GR_1 (growing media containing FYM + BA at 200 ppm), M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm), M_3 x GR_1 (Growing media containing poultry manure + BA at 200 ppm) and M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) ((30.54, 30.21, 30.19, 28.99, 28.77, 28.42 cm respectively) were on par with respect to plant spread during April. Treatment combinations of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) and M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) were on par with each other during May (37.08 and 35.71 cm) (Table 5).

4.1.3. Number of branches per plant

With regard to number of branches per plant, significant variation could be observed among different growing media during the period of observation except in April. Highest number of branches were observed under M_1 (growing media containing FYM) during October, November, February and March (1.85, 1.86, 2.88 and 3.00 respectively) which was on par with M_2 (growing media containing vermicompost) in the months of October and November. Treatments of M_2 (growing media containing vermicompost) and M_1 (growing media containing FYM) were on par with each other in terms of this parameter during September, December, January and May (1.92, 2.18, 2.42 and 3.76 respectively). There was no significant variation among treatments in April. Among all treatments, more number of branches of 3.76 were observed in M_2 (growing media containing vermicompost) during May. Growing media M_3 (growing media containing.

Table 2. Effect of growing media and growth regulators on plant height of rose variety ‘Tajmahal’

Treatments		Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
GROWING MEDIA	M_1	20.85	30.09	36.83	57.58	41.95	59.46	67.58	68.92	77.96
	M_2	20.85	26.12	35.25	48.54	41.61	51.37	69.07	66.84	73.91
	M_3	17.44	23.59	26.89	39.24	35.25	44.98	49.93	53.97	64.08
CD (0.05)		**0.80**	**1.10**	**3.20**	**3.71**	**2.87**	**3.29**	**3.90**	**3.24**	**3.13**
GROWTH REGULATORS	GR_1	18.45	26.22	28.99	43.36	37.06	52.49	59.46	61.04	69.72
	GR_2	20.22	24.69	32.01	47.65	41.33	53.88	63.99	59.77	72.97
	GR_3	20.81	26.06	32.89	47.62	38.75	52.14	64.57	63.78	65.69
	GR_4	19.38	29.44	38.08	55.18	41.29	49.24	60.75	68.39	79.56
CD (0.05)		**0.92**	**1.27**	**3.69**	**4.28**	**3.32**	**NS**	**NS**	**3.74**	**3.61**
CV		**4.81**	**4.90**	**11.45**	**9.04**	**8.57**	**7.48**	**7.41**	**6.05**	**5.14**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 - GA 250 ppm**

Table 3. Effect of M x GR interaction on plant height of Rose variety 'Tajmahal'

Treatments	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
M_1 x GR_1	18.98	32.30	32.12	51.68	46.09	62.12	71.98	64.74	75.48
M_1 x GR_2	20.08	23.13	33.61	52.69	40.07	59.08	71.40	63.55	73.84
M_1 x GR_3	22.15	26.27	31.39	55.49	37.94	59.66	70.10	62.08	70.94
M_1 x GR_4	22.18	38.67	50.20	70.46	43.70	57.01	56.84	85.32	91.60
M_2 x GR_1	19.28	23.82	32.84	42.02	35.61	50.28	57.96	64.77	72.52
M_2 x GR_2	24.88	29.15	36.28	51.14	46.38	61.43	80.95	70.92	77.04
M_2 x GR_3	20.86	24.27	33.90	45.85	40.69	45.33	67.52	72.13	67.96
M_2 x GR_4	18.41	27.26	38.00	55.15	43.78	48.44	69.84	59.54	78.12
M_3 x GR_1	17.08	22.55	22.01	36.38	29.47	45.09	48.45	53.61	61.16
M_3 x GR_2	15.72	21.80	26.16	39.14	37.55	41.12	39.62	44.84	68.04
M_3 x GR_3	19.42	27.65	33.38	41.51	37.62	51.44	56.09	57.13	58.17
M_3 x GR_4	17.55	22.39	26.04	39.93	36.39	42.29	55.58	60.33	68.97
CD (0.05)	**1.60**	**2.20**	**6.40**	**7.42**	**5.75**	**6.58**	**7.81**	**6.48**	**6.26**
CV	**4.81**	**4.90**	**11.45**	**9.04**	**8.57**	**7.48**	**7.41**	**6.05**	**5.14**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 - GA 250 ppm**

Table 4. Effect of growing media and growth regulators on plant spread of rose variety ‘Tajmahal’

Treatments		Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
GROWING MEDIA	M_1	16.10	19.44	23.52	29.25	24.26	27.31	29.65	27.94	30.05
	M_2	16.33	18.23	21.75	26.34	25.05	26.05	26.27	25.78	26.28
	M_3	14.28	16.01	18.64	20.46	19.86	21.75	24.12	25.48	26.51
CD (0.05)		**0.46**	**0.78**	**0.73**	**0.92**	**0.87**	**0.79**	**1.10**	**1.14**	**1.10**
GROWTH REGULATORS	GR_1	15.67	17.41	21.12	27.00	23.39	26.85	27.94	29.32	30.22
	GR_2	15.93	17.77	21.15	25.80	23.60	26.43	30.66	29.72	33.49
	GR_3	15.39	17.31	21.34	25.28	23.56	24.11	24.06	23.71	22.71
	GR_4	15.30	19.09	21.60	23.33	21.67	22.75	24.06	22.85	24.03
CD (0.05)		**0.53**	**0.90**	**0.85**	**1.07**	**1.01**	**0.91**	**1.28**	**1.31**	**1.26**
CV		**3.50**	**5.13**	**4.05**	**4.30**	**4.47**	**3.70**	**4.88**	**5.09**	**4.68**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

Table 5. Effect of M x GR interaction on plant spread of rose variety 'Tajmahal'

Treatments	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
M_1 x GR_1	17.06	19.92	24.17	32.09	24.30	28.96	31.94	30.19	37.08
M_1 x GR_2	15.19	17.69	22.96	29.71	26.49	28.65	33.43	30.54	35.71
M_1 x GR_3	15.75	18.15	21.20	27.68	24.05	26.58	26.79	26.23	23.81
M_1 x GR_4	16.39	21.99	25.73	27.52	22.17	25.02	26.45	24.79	23.57
M_2 x GR_1	16.47	17.93	21.86	27.71	26.49	28.21	29.39	28.99	27.25
M_2 x GR_2	17.60	19.50	21.78	27.27	25.28	28.87	28.54	28.42	30.96
M_2 x GR_3	15.59	17.76	21.91	26.25	25.40	23.34	23.68	23.51	22.41
M_2 x GR_4	15.65	17.73	21.42	24.11	23.02	23.78	23.44	22.19	24.50
M_3 x GR_1	13.46	14.39	17.31	21.19	19.36	23.38	22.48	28.77	26.32
M_3 x GR_2	14.98	16.12	18.71	20.39	19.02	21.77	29.99	30.21	33.78
M_3 x GR_3	14.81	15.99	20.89	21.89	21.22	22.40	21.69	21.39	21.91
M_3 x GR_4	13.84	17.55	17.64	18.35	19.82	19.44	22.28	21.56	24.02
CD (0.05)	**0.92**	**2.11**	**1.46**	**1.84**	**1.74**	**1.57**	**2.20**	**2.27**	**2.19**
CV	**3.50**	**5.13**	**4.05**	**4.30**	**4.47**	**3.70**	**4.88**	**5.09**	**4.68**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

poultry manure) was observed to have lowest number of branches throughout the period of observation.

Growth regulators had significant influence on number of branches per plant throughout the experimental period, except in October and November. GR_1 (BA at 200 ppm) was found to produce highest number of branches in the months of September, December, January, March, April and May (1.92, 2.17, 2.59, 3.16, 3.52 and 4.15 respectively) which was on par with GR_2 (BA at 250 ppm) during January and March. In February, GR_2 (BA at 250 ppm) recorded maximum number of branches (2.93) which was statistically superior than other growth regulators. Number of branches per plant was maximum (4.15) during May in all treatment and highest being under GR_1 (BA at 200 ppm) and lowest number (2.74) of branches were observed in GR_4 (GA at 250 ppm) (Table 6).

M x GR interaction was found to have significant influence on number of branches per plant except in October. Highest number of branches per plant (2.25) was observed under M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) in September which was on par with M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm), M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) (2.12, 2.04, 1.91 respectively). Same trend was observed in the month November. Treatment combination of M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm) produced highest number of branches (2.55) during December which was on par with M_1 x GR_1 (growing media containing FYM + BA at 200 ppm), M_1 x GR_4 (growing media containing FYM + GA at 250 ppm), M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) and M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) (2.41, 2.18, 2.25 and 2.20 respectively). During January, M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) was on par with M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm), M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) and M_3 x GR_2 (Growing media containing poultry manure + BA at 250 ppm) (2.75, 2.45 and 2.68 respectively) in terms of plant spread. From the data it was evident that combination of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) had highest number of branches in the period of January to May (2.82, 3.41, 3.64, 3.83 and 4.53 respectively). Lowest number of branches per plant were observed under the treatment combination of M_3 x GR_2 (Growing media containing poultry manure + BA at 250 ppm) (1.37, 1.34 and 1.27) during initial three months of observation, whereas in January, lowest number of branches per plant was observed under treatment of M_3 x GR_3. In December, February, March, and April number of branches per plant was recorded lowest under the treatment of M_3 x GR_4 (1.38, 1.53, 1.70 and 1.68 respectively), and in May M_1 x GR_3 produced lowest number of branches per plant (Table 7).

4.1.4. Number of leaves per branch

Regarding number of leaves per branch, significant difference among growing media could be observed and more number of leaves per branch was recorded in M_1 (growing media containing FYM) during December, January and February (4.92, 5.28 and 6.25 respectively), which was on par with M_2 (growing media containing vermicompost) during February and January (5.71 and 5.08 respectively).

From the results, it was evident that application of growth regulators had significant influence on number of leaves per branch. Growth regulator GR_2 (BA at 250 ppm) produced highest number of leaves per branch in January, February and May (5.58, 6.21 and 6.34 respectively) which was on par with GR_3 (GA at 200 ppm) (5.17) during January, and with GR_1 during February. Lowest number of leaves per branch was observed in GR_4 (GA at 250 ppm) during January and February (4.54 and 5.17) (Table 8).

There was no significant influence of M x GR interaction on number of leaves per branch during initial three months. In December, highest number of leaves could be observed in the treatment combination of M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) which was on par with M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) (5.85 and 5.12 respectively). During January, highest number of leaves per branch were recorded in M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm), M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_3 x GR_3 (Growing media containing

FYM

Vermicompost

Poultry manure

Effect of growing media on plant height

FYM

Vermicompost

Poultry manure

Effect of growing media on number of flowers per plant

Plate 4. Effect of growing media on plant height and number of flowers per plant

poultry manure + GA at 200 ppm) and M_1 x GR_3 (growing media containing FYM+ GA at 200 ppm) (6.18, 6.12, 5.89 and 5.33 respectively) which were statistically on par with each other. Treatment combination of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) had the more number of leaves per branch in February (6.94) which was on par with M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm), M_1 x GR_3 (growing media containing FYM + GA at 200 ppm) and M_1 x GR_2 (growing media containing FYM+ BA at 250 ppm) (6.75, 6.54, 6.08 respectively). In May M_3 x GR_2 (growing media containing poultry manure + BA at 250 ppm) had highest number of leaves per branch (7.05), which was on par with M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) (6.49) (Table 9).

4.2. Floral characters

Influence of growing media and growth regulators on floral characters are depicted in table 10 and 11.

4.2.1. Days taken for flower bud initiation

Regarding days taken for flower bud initiation, M_1 (growing media containing FYM) took lowest number of days for initiation of flower buds (129.41 days) while M_3 (Growing media containing poultry manure) took more number of days for initiation of flower bud (140.45 days) which was on par with M_2 (growing media containing vermicompost) (136.19 days).

No significant influence of growth regulators on days taken for flower bud initiation could be observed during the period of observation.

M x GR interaction exhibited significant influence on this parameter during the period of observation. Early initiation of flower bud was observed in the treatment combination of M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) (119.22 days) while M_3 x GR_1 (Growing media containing poultry manure + BA at 200 ppm) took maximum days for flower bud initiation which was on par with M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm), M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm), M_3 x GR_2 (growing media containing poultry manure + BA at 250 ppm), and M_3 x GR_4

(growing media containing poultry manure + GA at 250 ppm) (143.42, 141.70, 141.20 and 137.78 days respectively).

4.2.2. Days taken from flower bud initiation to commercial stage of harvest

There was no significant effect of growing media as well as growth regulators on days taken from flower bud initiation to commercial stage of harvest.

The results revealed that interaction between growing media and growth regulators had significant effect on days taken from flower bud initiation to commercial stage of harvest. The minimum days required for days taken from flower bud initiation to commercial stage of harvest (13.83 days) was observed under the treatment of M_3 x GR_2 (Growing media containing poultry manure + BA at 250 ppm) whereas highest number of days was recorded under M_2 x GR_4 (15.60 days) which was on par with M_2 x GR_2, M_3 x GR_3, M_1 x GR_3, M_2 x GR_1, M_1 x GR_2 and M_1 x GR_1 (15.36, 15.17, 15.03, 14.99, 14.77 and 14.55 respectively).

4.2.3. Days taken from flower bud initiation to complete opening

Growing media was found to have no influence on the parameter, days taken from flower bud initiation to complete opening.

Regarding influence of growth regulators, lowest number of days from flower bud initiation to complete opening was observed with 19.91 days under GR_4 (GA at 250 ppm), whereas highest number of days from flower bud initiation to complete opening (21.00 days) was observed under GR_1 (BA at 200 ppm) which was on par with GR_2 (BA at 250 ppm) and GR_3 (GA at 200 ppm) (20.75 and 20.45 days).

M x GR interaction had significant effects on the parameter days taken from flower bud initiation to complete opening. Shortest duration of 19.41 days for flower bud initiation to complete opening was observed under the treatment combination of M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) whereas the treatment combination of M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm) took more number of days (21.61 days) for this parameter which was on par with M_3 x GR_3, M_2 x GR_2, M_1 x GR_2, M_3 x GR_1, M_1 x GR_3, M_1 x GR_1 (21.51, 21.23, 21.09, 21.03, 20.43 and 20.37 days respectively).

Table 6. Effect of growing media and growth regulators on number of branches per plant of rose variety 'Tajmahal'

Treatments		Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
GROWING MEDIA	**M_1**	1.82	1.85	1.86	2.00	2.37	2.88	3.00	3.01	3.22
	M_2	1.92	1.73	1.83	2.18	2.42	2.41	2.42	3.05	3.76
	M_3	1.48	1.44	1.35	1.56	1.96	2.14	2.53	2.87	3.25
CD (0.05)		**0.21**	**0.26**	**0.18**	**0.22**	**0.18**	**0.11**	**0.16**	**NS**	**0.21**
GROWTH REGULATORS	**GR_1**	1.92	1.69	1.74	2.17	2.59	2.78	3.16	3.52	4.15
	GR_2	1.66	1.64	1.54	1.89	2.51	2.93	3.07	3.21	3.58
	GR_3	1.80	1.79	1.76	1.83	1.99	2.16	2.31	2.99	3.17
	GR_4	1.58	1.56	1.68	1.77	1.92	2.03	2.05	2.18	2.74
CD (0.05)		**0.24**	**NS**	**NS**	**0.26**	**0.21**	**0.13**	**0.19**	**0.17**	**0.24**
CV		**14.51**	**18.74**	**13.06**	**13.86**	**9.83**	**5.37**	**7.39**	**6.08**	**7.28**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

Table 7. Effect of M x GR interaction on number of branches per plant of rose variety ‘Tajmahal’

Treatments	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
M_1 x GR_1	1.91	1.87	2.00	2.41	2.82	3.41	3.64	3.83	4.53
M_1 x GR_2	2.04	2.08	1.91	1.74	2.39	3.25	3.55	2.87	3.77
M_1 x GR_3	1.79	1.62	1.62	1.68	2.16	2.48	2.43	2.80	2.26
M_1 x GR_4	1.56	1.83	1.91	2.18	2.12	2.39	2.39	2.54	2.32
M_2 x GR_1	2.12	1.83	1.83	2.55	2.75	2.67	2.81	3.26	4.32
M_2 x GR_2	1.58	1.49	1.43	2.25	2.45	2.43	2.41	3.37	3.55
M_2 x GR_3	2.25	2.16	2.31	2.20	2.37	2.38	2.39	3.24	3.91
M_2 x GR_4	1.74	1.43	1.75	1.75	2.12	2.16	2.08	2.34	3.29
M_3 x GR_1	1.75	1.38	1.39	1.55	2.20	2.27	3.04	3.49	3.61
M_3 x GR_2	1.37	1.34	1.27	1.68	2.68	3.13	3.25	3.39	3.44
M_3 x GR_3	1.37	1.61	1.35	1.62	1.46	1.62	2.12	2.93	3.36
M_3 x GR_4	1.45	1.44	1.39	1.38	1.52	1.53	1.70	1.68	2.62
CD (0.05)	**0.42**	**NS**	**0.37**	**0.45**	**0.37**	**0.22**	**0.33**	**0.30**	**0.42**
CV	**14.51**	**18.74**	**13.06**	**13.86**	**9.83**	**5.37**	**7.39**	**6.08**	**7.28**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

Table 8. Effect of growing media and growth regulators on number of leaves per branch of rose variety 'Tajmahal'

Treatments		Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
GROWING MEDIA	M_1	3.20	3.95	4.26	4.92	5.28	6.25	5.99	6.16	5.65
	M_2	3.38	3.46	3.99	4.37	5.08	5.71	5.85	6.36	5.34
	M_3	3.37	3.70	3.73	4.03	4.51	5.25	5.53	5.61	5.24
CD (0.05)		**NS**	**NS**	**NS**	**0.45**	**0.43**	**0.43**	**NS**	**NS**	**NS**
GROWTH REGULATORS	GR_1	3.22	3.57	3.98	4.39	4.51	5.85	5.69	6.04	5.78
	GR_2	3.71	3.72	4.00	4.78	5.58	6.21	6.11	6.33	6.34
	GR_3	3.09	3.87	4.26	4.45	5.17	5.71	5.86	5.73	4.61
	GR_4	3.24	3.66	3.74	4.15	4.54	5.17	5.50	6.09	4.93
CD (0.05)		**NS**	**NS**	**NS**	**NS**	**0.50**	**0.49**	**NS**	**NS**	**0.48**
CV		**19.60**	**14.60**	**12.46**	**11.88**	**10.36**	**8.87**	**11.51**	**12.07**	**9.13**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

Table 9. Effect of M x GR interaction on number of leaves per branch of rose variety 'Tajmahal'

Treatments	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19
M_1 x GR_1	3.45	3.99	4.37	4.91	4.84	6.94	6.14	6.30	6.14
M_1 x GR_2	2.95	3.80	3.83	5.85	6.12	6.08	6.04	6.24	6.49
M_1 x GR_3	3.04	4.45	4.62	4.23	5.33	6.54	6.20	5.61	4.73
M_1 x GR_4	3.37	3.56	4.24	4.70	4.83	5.43	5.57	6.49	5.25
M_2 x GR_1	3.08	3.62	3.70	4.23	5.08	5.76	5.66	6.03	5.83
M_2 x GR_2	4.70	3.56	4.37	4.24	6.18	6.75	6.31	6.50	5.48
M_2 x GR_3	2.99	3.37	4.12	5.12	4.31	5.47	5.64	6.53	5.08
M_2 x GR_4	2.74	3.31	3.77	3.91	4.74	4.87	5.81	6.39	4.99
M_3 x GR_1	3.12	3.11	3.89	4.03	3.63	4.85	5.27	5.79	5.38
M_3 x GR_2	3.49	3.80	3.81	4.24	4.45	5.81	5.99	6.24	7.05
M_3 x GR_3	3.24	3.80	4.04	3.99	5.89	5.12	5.74	5.04	4.01
M_3 x GR_4	3.62	4.11	3.20	3.84	4.06	5.21	5.12	5.39	4.55
CD (0.05)	**NS**	**NS**	**NS**	**0.89**	**0.87**	**0.86**	**NS**	**NS**	**0.84**
CV	**19.60**	**14.60**	**12.46**	**11.88**	**10.36**	**8.87**	**11.51**	**12.07**	**9.13**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

4.2.4. Length of flower bud

There was significant influence of growing media on length of flower bud. Longest flower bud (3.37 cm) was observed under M_1 (growing media containing FYM) whereas M_3 (Growing media containing poultry manure) was found to have shortest length of flower bud (3.12 cm).

Growth regulators as well as M x GR interaction had no significant influence on this parameter during the period of observation.

4.2.5. Diameter of flower bud

Significant influence of growing media on diameter of flower bud could be observed during the period of observation. M_1 (growing media containing FYM) had the highest diameter of 2.16 cm which was statistically superior than other media. Lowest diameter (1.98 cm) could be observed in M_3 (Growing media containing poultry manure).

Growth regulators and M x GR interaction had no significant influence on flower diameter during the growth period.

4.2.6. Number of flowers per plant

There was significant influence of growing media on number of flowers per plant. M_1 (growing media containing FYM) was found to have highest number of flowers (5.04) and lowest number of flowers per plant (3.76) was recorded in M_3 (growing media containing poultry manure).

Growth regulators had significant effect on number of flowers per plant. Treatment containing GR_1 (BA at 200 ppm) had the highest number of flowers (5.38) which was statistically on par with GR_2 (BA at 250 ppm) (5.10). Lowest number of flowers (3.28) was observed in GR_4 (GA at 250 ppm).

No significant variation due to M x GR interaction could be observed on this parameter during the period of experiment.

4.2.7. Number of petals per flower

From the results it could be concluded that growing media had significant effect on number of petals per flower. Growing media M_1 (growing media containing FYM) had highest number of petals per flower which was superior

Table 10. Effect of growing media and growth regulators on floral characters of rose variety 'Tajmahal'

Treatments		Days taken for flower bud initiation	Days taken from flower bud initiation to commercial stage of harvest	Days taken from flower bud initiation to complete opening	Length of flower bud (cm)	Diameter of flower bud (cm)	Number of flowers per plant	Number of petals per flower	Length of flower shoot (cm)	Neck length (cm)	Neck girth (cm)	Stalk length of flower (cm)	Stalk girth of flower (cm)	Flower diameter at fully opened stage (cm)	Flower persistence (days)
GROWING MEDIA	**M_1**	129.41	14.63	20.45	3.37	2.16	5.04	51.92	40.11	7.24	0.29	47.94	0.46	8.44	15.99
	M_2	136.19	15.04	20.55	3.24	2.06	4.40	46.24	38.54	6.92	0.29	45.53	0.44	7.95	16.44
	M_3	140.45	14.45	20.59	3.12	1.98	3.76	47.50	32.74	6.56	0.26	39.97	0.41	7.46	15.52
CD (0.05)		**4.65**	**NS**	**NS**	**0.11**	**0.08**	**0.63**	**2.77**	**1.77**	**0.23**	**0.01**	**1.44**	**0.02**	**0.35**	**NS**
GROWTH REGULATORS	**GR_1**	133.35	14.66	21.00	3.27	2.08	5.38	50.87	35.16	6.23	0.29	41.75	0.43	8.33	16.95
	GR_2	132.21	14.65	20.75	3.25	2.11	5.10	47.08	36.93	5.90	0.28	43.01	0.45	7.75	15.99
	GR_3	137.50	14.81	20.45	3.24	2.10	3.84	46.91	38.79	7.68	0.28	47.92	0.45	7.73	15.76
	GR_4	138.34	14.71	19.91	3.21	1.99	3.28	49.36	37.64	7.81	0.27	45.25	0.42	7.99	15.24
CD (0.05)		**NS**	**NS**	**0.66**	**NS**	**NS**	**0.72**	**NS**	**2.04**	**0.27**	**NS**	**1.66**	**0.02**	**0.41**	**NS**
CV		**4.03**	**4.29**	**3.32**	**4.21**	**5.06**	**16.89**	**6.75**	**5.64**	**4.02**	**5.15**	**3.83**	**5.83**	**5.27**	**8.10**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

Table 11. Effect of M x GR interaction on floral characters of rose variety 'Tajmahal'

Treatments	Days taken for flower bud initiation	Days taken from flower bud initiation to commercial stage of harvest	Days taken from flower bud initiation to complete opening	Length of flower bud (cm)	Diameter of flower bud (cm)	Number of flowers per plant	Number of petals per flower	Length of flower shoot (cm)	Neck length (cm)	Neck girth (cm)	Stalk length of flower (cm)	Stalk girth of flower (cm)	Flower diameter at fully opened stage (cm)	Flower persistence (days)
M_1 x GR_1	130.24	14.55	20.37	3.39	2.19	6.77	52.97	37.123	6.62	0.31	44.99	0.46	9.25	15.95
M_1 x GR_2	119.22	14.77	21.09	3.36	2.15	5.67	52.43	39.40	6.21	0.29	44.22	0.50	8.04	15.96
M_1 x GR_3	132.65	15.17	20.43	3.43	2.30	4.16	51.18	42.43	8.40	0.29	52.48	0.47	8.24	16.72
M_1 x GR_4	135.54	14.03	19.91	3.28	1.98	3.56	51.12	41.49	7.75	0.28	50.09	0.42	8.23	15.34
M_2 x GR_1	123.44	14.99	21.61	3.33	2.11	5.16	49.77	37.18	6.29	0.29	43.07	0.45	8.14	17.51
M_2 x GR_2	136.21	15.36	21.23	3.31	2.10	4.90	43.30	39.22	5.86	0.29	46.40	0.44	8.03	16.80
M_2 x GR_3	143.42	14.24	19.41	3.12	1.98	3.87	40.78	38.63	7.18	0.29	46.68	0.45	7.63	15.52
M_2 x GR_4	141.70	15.60	19.96	3.22	2.06	3.66	51.13	39.13	8.35	0.28	45.99	0.44	8.02	15.95
M_3 x GR_1	146.39	14.44	21.03	3.10	1.94	4.21	49.86	31.20	5.78	0.26	37.19	0.39	7.60	17.39
M_3 x GR_2	141.20	13.83	19.94	3.08	2.07	4.74	45.50	32.19	5.65	0.27	38.41	0.41	7.19	15.20
M_3 x GR_3	136.44	15.03	21.51	3.17	2.01	3.49	48.79	35.30	7.46	0.27	44.60	0.44	7.32	15.04
M_3 x GR_4	137.78	14.51	19.87	3.15	1.92	2.61	45.85	32.30	7.35	0.26	39.69	0.39	7.72	14.45
CD (0.05)	**9.25**	**1.06**	**1.15**	**NS**	**NS**	**NS**	**5.55**	**NS**	**0.23**	**NS**	**2.88**	**NS**	**NS**	**NS**
CV	**4.03**	**4.29**	**3.32**	**4.21**	**5.06**	**16.89**	**6.75**	**5.64**	**4.02**	**5.15**	**3.83**	**5.83**	**5.27**	**8.10**

M_1 - FYM **M_2 - Vermicompost** **M_3 - Poultry manure**

GR_1 - BA 200 ppm **GR_2 - BA 250 ppm** **GR_3 - GA 200 ppm** **GR_4 – GA 250 ppm**

than all other growing media combinations.

Number of petals per flower did not vary significantly among different growth regulator treatments.

Growing media and growth regulator interaction had significant influence on number of petals per flower. Highest number of petals per flower was observed in the treatment of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) with 52.97 petals which was on par with M_1 x GR_2, M_1 x GR_3, M_2 x GR_4, M_1 x GR_4, M_3 x GR_1, M_3 x GR_3, M_2 x GR_1 (52.43, 51.18, 51.13, 51.12, 49.86, 48.79, and 49.77 respectively).

4.2.8. Length of flower shoot

From the results it is evident that growing media had significant effect on the length of flower shoot. M_1 (growing media containing FYM) had the longest flower shoot (40.11 cm) which was on par with M_2 (growing media containing vermicompost) (38.54 cm). Lowest shoot length was noticed in M_3 (growing media containing poultry manure) with 32.74 cm.

Growth regulators was found to have significant influence on length of flower shoot. Longest flower shoot was observed in the treatment of GR_3 (GA at 200 ppm) (38.79 cm) which was on par with GR_4 (GA at 250 ppm) and GR_2 (BA at 250 ppm) (37.64 and 36.93 cm). Shortest flower shoot (35.16 cm) was observed under GR_1 (BA at 200 ppm).

M x GR interactions had no significant effect on length of flower shoot.

4.2.9. Neck length

Significant difference among growing media with regard to neck length could be observed during the period of observation. Longest neck (7.24 cm) was observed in M_1 (growing media containing FYM) which was superior to all other treatments. Shortest neck length was observed in growing media M_3 (growing media containing poultry manure) with 6.56 cm of length.

Significant influence of growth regulators on neck length was observed during the period of observation. Longest neck (7.81 cm) was observed under GR_4 (GA at 250 ppm) which was on par with GR_3 (GA at 200 ppm) (7.68 cm) and shortest neck (5.90 cm) was observed under GR_2 (BA at 250 ppm).

Interaction effect was found to have significant influence on neck length. Highest neck length was observed in the treatment combination of M_1 x GR_3 (8.40 cm) which was on par with M_2 x GR_4 (8.35 cm) (growing media containing vermicompost + GA at 250 ppm). Lowest neck length of 5.65 cm was noticed in the treatment combination of M_3 x GR_2 (growing media containing poultry manure + BA at 250 ppm).

4.2.10. Neck girth

It was observed that neck girth was significantly influenced by growing media and M_1 (growing media containing FYM) was found to have highest neck girth (0.29 cm) which was on par with M_2 (growing media containing vermicompost) (0.29 cm). Lowest neck girth was observed in M_3 (growing media containing poultry manure) with 0.26 cm.

Growth regulators and M x GR interaction had no significant influence on neck girth.

4.2.11. Stalk length of the flower

From the results it could be observed that growing media had significant influence on stalk length of flower. Flowers with longest stalk (47.94 cm) were observed under M_1 (growing media containing FYM) which was statistically superior to all other growing media combinations. M_3 (growing media containing poultry manure) had the shortest stalk length of flower (39.97 cm).

There was significant variation in stalk length of flowers due to growth regulators during the period of investigation. Foliar application of GR_3 (GA at 200 ppm) produced highest stalk length (47.92 cm). Shortest stalk of 41.75 cm was observed under GR_1 (BA at 200 ppm).

It was evident that M x GR interaction had significant effect on stalk length of flower. Longest stalk was observed under M_1 x GR_3 (growing media containing FYM + GA at 200 ppm) and M_1 x GR_4 (growing media containing FYM + GA at 250 ppm) (52.48 and 50.09 cm respectively) which were statistically on par with

Effect of treatments on stalk length of flower

Effect of growing media on flower diameter at fully opened stage

Plate 5. Treatment comparison

each other. Treatment combination of M_3 x GR_1 (growing media containing poultry manure + BA at 200 ppm) was found to have shortest stalk length (37.19 cm).

4.2.12. Stalk girth of the flower

The data revealed that growing media had significant effect on stalk girth of flower throughout the period of observation. M_1 (growing media containing FYM) had highest stalk girth of flower (0.46 cm) which was on par with M_2 (0.44 cm). M_3 (growing media containing poultry manure) had the lowest stalk girth of flower.

Stalk girth of flowers vary significantly among different growth regulators. Highest stalk girth was recorded in the growth regulators GR_3 (GA at 200 ppm), GR_2 (BA at 250 ppm) and GR_1 (BA at 200 ppm) (0.45, 0.45 and 0.43 cm respectively).

Interaction had no significant influence on stalk girth of flower.

4.2.13. Flower diameter at fully opened stage

There was significant difference among growing media with regard to this parameter throughout the period of observation. M_1 (growing media containing FYM) produced flowers with highest diameter (8.44 cm) and M_3 (Growing media containing poultry manure) had the lowest flower diameter (7.46 cm).

It was found that growth regulators had significant influence on flower diameter. Growth regulators GR_1 (BA at 200 ppm) and GR_4 (GA at 250 ppm) produced flowers with highest flower diameter (8.33 and 7.99 cm respectively) which were statistically on par with each other.

M x GR interactions did not have significant influence on flower diameter during the period of observation.

4.2.14. Flower persistence

No significant influence of growing media, growth regulators and M x GR interaction could be observed with respect to this parameter during the period of observation.

4.3. POST HARVEST CHARACTERS

Data pertaining to post harvest characters are furnished in the table 12 and 13.

4.3.1. Fresh weight of the flower

Fresh weight of flower was significantly influenced by the growing media. Flowers produced from growing media M_1 (growing media containing FYM) had the maximum fresh weight (16.36 g), followed by M_2 (growing media containing vermicompost) (14.87 g). Lowest fresh weight of flowers (10.54 g) was observed in M_3 (growing media containing poultry manure).

It could be seen that growth regulators had significant effect with respect to the fresh weight of flower during the period of observation. Flower with highest weight of 15.17g was obtained from GR_1 (BA at 200 ppm) and lowest fresh weight of flower was observed under the treatment of GR_4 (GA at 250 ppm) with 12.81 g.

M x GR interaction was found to have significant influence on fresh weight of the flowers. Highest flower weight (18.71g) was observed under the treatment combination of M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) which was on par with and M_2 x GR_4, M_1 x GR_3, M_1 x GR_2 (18.22, 17.35 and 16.95 g respectively). Treatment M_3 x GR_4 was recorded with lowest fresh weight of flowers (7.77 g).

4.3.2. Physiological loss in weight

Growing media was found to have significant influence on physiological loss in weight and lowest physiological loss in weight (4.09 g) was observed under M_3 (growing media containing poultry manure) and physiological loss in weight was highest under M_1 (growing media containing FYM) with 5.89 g.

Growth regulators had significant influence on physiological loss in weight. Application of GR_4 (GA at 250 ppm) recorded with lowest physiological loss in weight (4.97g) and maximum loss in physiological weight (5.82g) was observed under GR_2 (BA at 250 ppm).

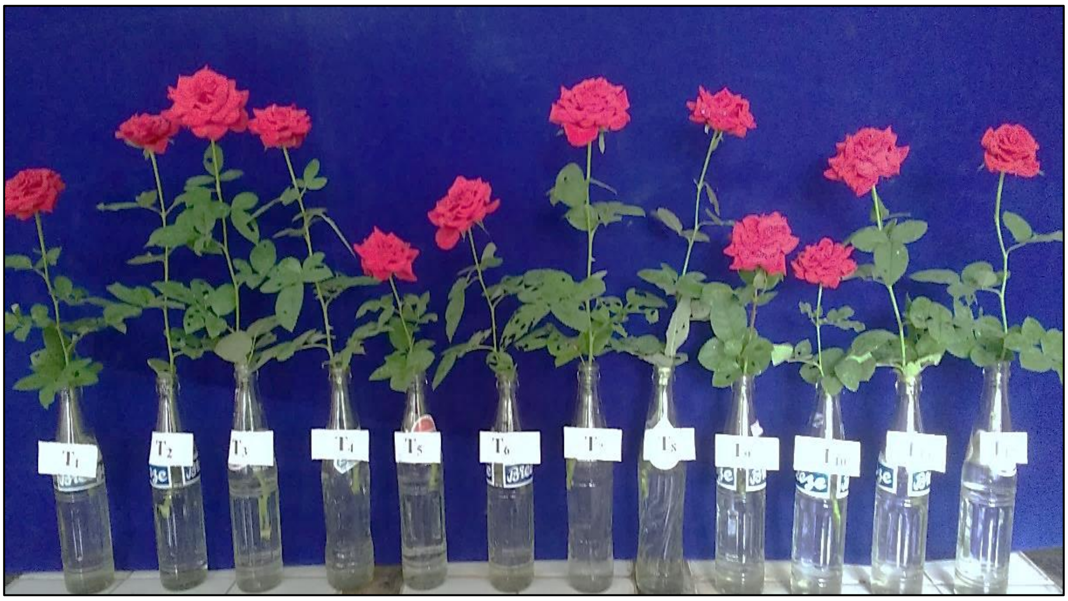


Plate 6. Vase life study

Regarding interaction effect, the lowest physiological loss in weight was in the treatment of M_3 x GR_1, (growing media containing poultry manure + BA at 200 ppm) while it was maximum under the treatments of M_2 x GR_4, M_1 x GR_2, M_1 x GR_1 (7.32, 6.74 and 6.71g accordingly).

4.3.3. Total water uptake

Among growing media, M_1 (growing media containing FYM) had the highest water uptake (49.48 ml) and lowest (29.56 ml) uptake of water was observed in M_3 (growing media containing poultry manure).

In the case of growth regulators highest water uptake was recorded in GR_3 (GA at 200 ppm) (48.89 ml) and lowest (33.30 ml) uptake of water was observed under GR_4 (GA at 250 ppm).

With respect to M x GR interaction, total water uptake was significantly varied among different treatment combinations. Highest water uptake (54.91 ml) was under the treatment of M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) which was on par with M_1 x GR_3, M_1 x GR_1, M_1 x GR_2, (54.66, 51.84 and 49.58 ml respectively).

4.3.4. Vase life

There was significant variation in vase life due to growing media during the period of observation. Maximum vase life was observed under the growing media M_1 (growing media containing FYM) with 8.46 days which was on par with M_2 (growing media containing vermicompost) (7.98 days).

With regard to growth regulators, GR_1 (BA at 200 ppm) was recorded with highest vase life of 8.62 days which was on par with GR_3 (GA at 200 ppm) (8.37 days). Lowest vase life (7.39 days) was observed under the treatment of GR_4 (GA at 250 ppm).

M x GR interaction had significant influence on vase life of flowers. Longest vase life was observed under M_1 x GR_1 (9.38 days) which was on par with M_1 x GR_3, M_1 x GR_2, M_2 x GR_1 (8.84, 8.74 and 8.50 days respectively). M_3 x GR_2 interaction was found to have shortest vase life.

Table 12. Effect of growing media and growth regulators on post harvest characters of rose variety 'Tajmahal'

Treatment		Fresh weight of flower (g)	Physiological loss in weight (g)	Total water uptake (ml)	Vase life (days)
GROWING MEDIA	**M_1**	16.36	5.89	49.48	8.46
	M_2	14.87	5.77	39.29	7.98
	M_3	10.54	4.09	29.56	7.57
CD (0.05)		**0.94**	**0.45**	**5.24**	**0.55**
GROWTH REGULATORS	**GR_1**	15.17	5.04	41.85	8.62
	GR_2	13.85	5.82	33.72	7.64
	GR_3	13.86	5.17	48.89	8.37
	GR_4	12.81	4.97	33.30	7.39
CD (0.05)		**1.09**	**0.52**	**6.05**	**0.64**
CV		**8.03**	**10.24**	**15.69**	**7.63**

M_1 - FYM M_2 - Vermicompost M_3 - Poultry manure

GR_1 - BA 200 ppm GR_2 - BA 250 ppm GR_3 - GA 200 ppm

GR_4 – GA 250 ppm

Table 13. Effect of M x GR interactions on post harvest characters of rose variety 'Tajmahal'

Treatment	Fresh weight of flower (g)	Physiological loss in weight (g)	Total water uptake (ml)	Vase life (days)
M_1 x GR_1	18.71	6.71	51.84	9.38
M_1 x GR_2	16.95	6.74	49.58	8.74
M_1 x GR_3	17.35	5.91	54.66	8.84
M_1 x GR_4	12.46	4.21	41.83	6.88
M_2 x GR_1	14.79	5.70	40.56	8.50
M_2 x GR_2	12.23	5.12	27.16	7.83
M_2 x GR_3	14.25	4.97	54.91	8.06
M_2 x GR_4	18.22	7.32	34.54	7.53
M_3 x GR_1	12.02	2.73	33.16	7.99
M_3 x GR_2	12.38	5.62	24.42	6.35
M_3 x GR_3	9.99	4.63	37.11	8.22
M_3 x GR_4	7.77	3.39	23.55	7.75
CD (0.05)	**1.89**	**0.91**	**10.48**	**1.11**
CV	**8.03**	**10.24**	**15.69**	**7.63**

M_1 - FYM M_2 - Vermicompost M_3 - Poultry manure
GR_1 - BA 200 ppm GR_2 - BA 250 ppm GR_3 - GA 200 ppm
GR_4 – GA 250 ppm

4.4. INCIDENCE OF PESTS, DISEASES, AND MALFORMATIONS

4.4.1. Incidence of pests

4.4.1.1. Thrips

Severe incidence of thrips was noticed during November to June. Nymph colonized under the tender leaves as well as inside the petals of unopened flower buds and suck the sap which leads to loss of lustre of leaves and flowers and become un marketable.

Management practices *viz*; use of blue sticky traps, continues removal and disposal of affected parts and application of Spinosad 45 SC (Taffin), Flonicamid (Ulala), Imidacloprid 70 WG (Admire) were practiced to control further spread.

4.4.1.2. Peach green aphids

Incidence of peach green aphids was noticed in July. Aphids gathered near the tender parts of the plant and suck sap from it. Need based application of Imidacloprid 17.8 SL (Tropical Magic) was found to reduce the population.

4.4.1.3. Bud borers, leaf feeders and leaf webbers

Bud borers make holes on the flower bud and consumes succulent parts of flower bud. Leaf feeders and leaf webbers damage vegetative parts, which were controlled by the application of quinalphos (Ekalux 2ml/l).

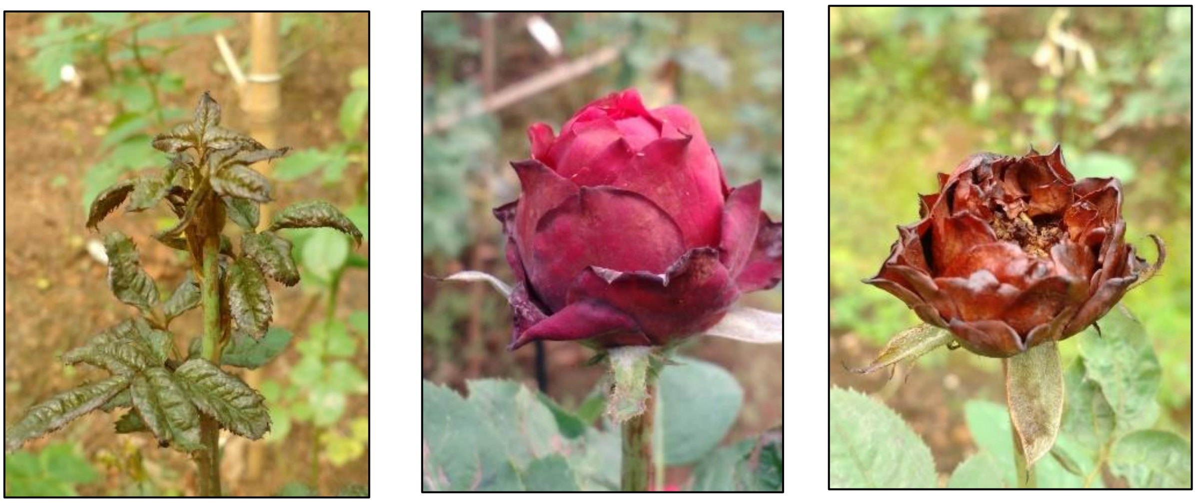
4.4.1.4. Mealy bugs

Mealy bugs were noticed during December to February. Withering and drying up of leaves were observed as the result of mealy bug attack. Application of Flonicamid (Ulala) or Imidacloprid (Tatamida) prevented the further damage.

4.4.2. Diseases

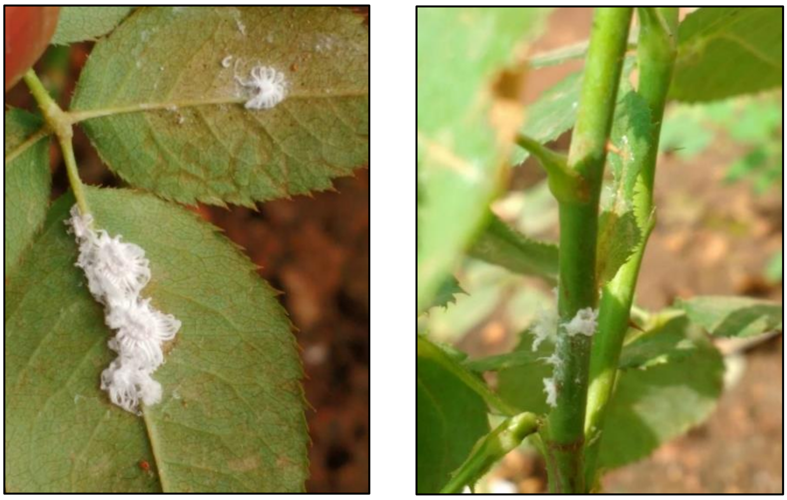
4.4.2.1. Die back

Die back caused by *Diplodia*, *Colletotrichum* sp. was observed during the months of July and August. Plants started to dry up from the cut ends of scion and progressed downwards, resulting withering and drying of plants.



Thrips infestation

Foliage feeders and bud borers



Mealy bug infestation

Green peach aphid

Plate 7. Incidence of pest

This could be controlled by removal of affected parts and application of Carbendazim 50WP (Bavistin).

4.4.2.2. Black spot

Black spot disease caused by *Diplocarpon rosea*, was noticed during the months of July, August and November to January. The typical symptom of the disease was black spot surrounded by a yellow halo on leaves, causing defoliation of leaves.

Tebuconazole 25.9 EC (Folicur) and carbendazim 50 WP (Bavistin) were effective to control the disease

4.4.2.3. Leaf spots

Leaf spot diseases caused by *Pestalotia* sp. and *Alternaria* sp. were observed during the period of December to February. Application of Carbendazim 1g/L controlled further infection.

4.4.3. Flower disorders

4.4.3.1. Vegetative malformations

Reproductive parts of flowers were transformed into greenish structures protruding out of the petals. This disorder was observed when the temperature was relatively high within the rain shelter.

4.5. PHYSIO – CHEMICAL ATTRIBUTES OF MEDIA

Data with respect of physio chemical attributes of the media before and after the experiment is furnished in the Table 14.

4.5.1. pH

Significant variation in pH of growing media was observed before and after experiment. Highest pH was observed in M_3 (growing media containing poultry manure), before and after experiment (6.72 and 6.36 respectively) which was closely followed by M_2 (growing media containing vermicompost). Lowest was pH

Dieback

Black spot

Plate 8. Incidence of diseases

was observed in Media M_1 (growing media containing FYM) (6.45 and 6.08) before and after experiment.

4.5.2. EC

Media differed significantly with respect to E.C and highest E.C was observed in M_3 (growing media containing poultry manure) before and after experiment (2.8 and 0.315 dSm^{-1} respectively).

4.5.3. Organic Carbon

Growing media combination M_2 (growing media containing vermicompost) had the highest organic carbon (2.23 and 2.37 %) before and after experiment. Lowest organic carbon was observed in M_3 (Growing media containing poultry manure) before the experiment (1.51 %) whereas M_1 (growing media containing FYM) was found to have lowest organic carbon after experiment (1.96 %).

4.5.4. Available Nitrogen

Growing media combination of M_2 (growing media containing vermicompost) was found to have highest available nitrogen before and after the experiment (539.74 and 413.24 kg ha^{-1}). M_1 (growing media containing FYM) had the lowest available nitrogen before and after the experiment (287.33 and 159.99 kg ha^{-1}).

4.5.4. Available Phosphorus

Among different growing media, M_3 (growing media containing poultry manure) was statistically superior with maximum available P (150.07 and 167.56 kg ha^{-1}) before and after the experiment. Lowest available P was observed in M_2 (growing media containing vermicompost) (51.98 kg ha^{-1}) before the experiment whereas after the experiment M_1 (growing media containing FYM) recorded lowest available P (53.67 kg ha^{-1}).

4.5.5. Available Potassium

From the results it could be concluded that M_3 (growing media containing poultry manure) had the highest available potassium both before and after the experiment (976.60 and 744.32 kg ha^{-1}).

Growing media, M_2 (growing media containing vermicompost) recorded lowest available potassium before and after experiment (610.80 and 495.80 kg ha^{-1}).

4.6. CORRELATION STUDIES

The correlation between different vegetative, floral, and meteorological parameters was analyzed and presented in Table 15.

4.6.1. Correlation between vegetative characters

Plant height was positively correlated with plant spread (0.746) and a negative correlation of plant height was observed with number of branches per plant and number of leaves per branch (-0.799 and -0.886 respectively). Plant spread was negatively correlated with number of branches per plant (-0.426) and number of leaves per branch (-0.761). Number branches per plant had a significant positive correlation with number of leaves per branch (0.901).

4.6.2. correlation between floral characters

Among different floral characters, number of flowers were significantly and positively correlated with diameter of flower bud (0.892), flower diameter (0.890) and neck length (0.934) and it was negatively correlated with the parameters *viz*; number of petals (-0.881) and stalk length (-0.794). Length of flower bud had a significant positive correlation with stalk girth of the flower (0.925) and it was negatively correlated with diameter of flower bud (-0.273), flower diameter (-0.413) and stalk length of flower (0.342). Diameter of flower bud was positively and significantly correlated with flower diameter (0.840) and neck length (0.829) and it had a negative correlation with number of petals per flower (-0.824), stalk length of flower (-0.664) and stalk girth of flower (-0.201).

There was a significant positive correlation between number of petals and stalk length (0.772) whereas a negative correlation of number of petals was observed with flower diameter (-0.818) and neck length (-0.862). A negative correlation of flower diameter was observed with stalk length of flower (-0.582) and stalk girth of flower (-0.341). There was a significant positive correlation between flower diameter and neck length (0.877).

Table 14. Physio - chemical attributes of growing media

Treatment		pH		E C		**O**rganic **C**arbon		Available **N**		Available **P**		Available **K**	
		Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
GROWING MEDIA	**M_1**	6.45	6.08	0.88	0.22	1.80	1.96	287.33	159.99	73.24	53.67	854.41	639.79
	M_2	6.62	6.22	0.92	0.26	2.23	2.37	539.74	413.24	51.98	59.63	610.80	495.80
	M_3	6.72	6.36	2.80	0.31	1.51	2.10	534.32	327.48	150.07	167.56	976.60	744.32
CD (0.05)		**0.15**	**0.11**	**0.04**	**0.02**	**0.06**	**0.07**	**10.04**	**8.56**	**2.76**	**2.49**	**15.86**	**8.22**

4.6.3. Correlation between vegetative and floral characters

Plant height had a significant and positive correlation with number of petals per flower (0.342), stalk length (0.737), whereas a negative correlation was observed with number of flowers (-0.384), length of flower bud (-0.704), diameter of flower bud (-0.225), stalk girth of flower (-0.768) and neck length (-0.371). A significant positive correlation of plant spread was observed with number of petals per flower and stalk length of flower (0.789 and 0.946 respectively) and it was negatively correlated with number of flowers (-0.844), length of flower bud (-0.280), diameter of flower bud (-0.724), flower diameter (-0.656), stalk girth of flower (-0.368) and neck length of flower (-0.840).

Number of branches per plant had positive and significant correlation with length of flower bud (0.941) and stalk girth of flower (0.977) whereas there was negative correlation with diameter of flower bud (-0.151), flower diameter at fully opened stage (-0.301) and stalk length (-0.484). Number of leaves per branch was positively and significantly correlated with number of flowers (0.431), length of flower bud (0.788), diameter of flower bud (0.258), stalk girth of flower (0.857) and neck length (0.451). A negative correlation of number of leaves could be observed with number of petals per flower and stalk length of flower (-0.414 and -0.787 respectively).

4.6.4. Correlation of meteorological parameters with vegetative and floral characters

Temperature was significantly and positively correlated with stalk girth of flower (0.978), length of flower bud (0.943), number of branches per plant (0.997) and number of leaves per branch (0.895), whereas negative correlation of temperature could be observed with diameter of flower bud, flower diameter at fully opened stage, stalk length of flower, plant height and plant spread (-0.160, -0.321, -0.475, -0.800 and -0.416 respectively). Number of flower per plant, number of petals per flower had no significant correlation with temperature.

Table 15. Correlation between vegetative and floral characters with meteorological parameters

	NF	LFB	DFB	NP	FD	SL	SG	NL	PH	PS	NB	NLB	TEM	R.H	L.I
NF	1.000														
LFB	-0.131^{NS}	1.000													
DFB	0.892**	-0.273**	1.000												
NP	-0.881**	0.119^{NS}	-0.824**	1.000											
FD	0.890**	-0.413**	0.840**	-0.818**	1.000										
SL	-0.794**	-0.342**	-0.664**	0.772**	-0.582**	1.000									
SG	-0.032^{NS}	0.925**	-0.201**	0.038^{NS}	-0.341**	-0.425**	1.000								
NL	0.934**	-0.091^{NS}	0.829**	-0.862**	0.877**	-0.791**	-0.004^{NS}	1.000							
PH	-0.384**	-0.704**	-0.225**	0.342**	-0.088^{NS}	0.737**	-0.768**	-0.371**	1.000						
PS	-0.844**	-0.280**	-0.724**	0.789**	-0.656**	0.946**	-0.368**	-0.840**	0.746**	1.000					
NB	0.020^{NS}	0.941**	-0.151*	-0.022^{NS}	-0.301**	-0.484**	0.977**	0.058^{NS}	-0.799**	-0.426**	1.000				
NLB	0.431**	0.788**	0.258**	-0.414**	0.115^{NS}	-0.787**	0.857**	0.451**	-0.886**	-0.761**	0.901**	1.000			
TEM	0.002^{NS}	0.943**	-0.160*	-0.008^{NS}	-0.321**	-0.475**	0.978**	0.030^{NS}	-0.800**	-0.416**	0.997**	0.895**	1.000		
R.H	0.480**	-0.773**	0.619**	-0.459**	0.685**	-0.060^{NS}	-0.760**	0.498**	0.438**	-0.120^{NS}	-0.737**	-0.443**	-0.747**	1.000	
L.I	-0.833**	-0.361**	-0.700**	0.785**	-0.619**	0.942**	-0.453**	-0.835**	0.753**	0.972**	-0.513**	-0.832**	-0.500**	-0.057^{NS}	1.000

*significant at 1% level, **significant at 5% level

NF-Number of flowers per plant, LFB-Length of flower bud, DFB-Diameter of flower bud, NP-Number of petals per flower, FD-Flower diameter at fully opened stage, SL-Stalk length of the flower, SG-Stalk girth of flower, NL-Neck length, PH- Plant height, PS-Plant spread, NB-Number of branches per plant, NLB-Number of leaves per branch, TEM-Temperature, R.H-Relative humidity, L.I-Light intensity

Number of flowers (0.480), diameter of flower bud (0.619), flower diameter (0.685), neck length (0.498) and plant height (0.438) were positively correlated with relative humidity and a negative correlation of relative humidity was observed with length of flower bud (-0.773), number of petals (-0.459), stalk girth of flower (-0.760), number of branches per plant (-0.737) and number of leaves per branch (-0.443).

There was a significant negative correlation of light intensity with number of flowers per plant (-0.833), length of flower bud (-0.361), diameter of flower bud (-0.700), flower diameter at fully opened stage (-0.619), stalk girth of the flower (-0.453), neck length (-0.835), number of branches per plant (-0.513) and number of leaves per branch (-0.832), however light intensity was positively correlated with number of petals per flower (0.785), stalk length of flower (0.942), plant height (0.753) and plant spread (0.972).

Discussion

5. DISCUSSION

Rose ranks first among the top ten cut flowers in international market due to its elegant colours, attractive shape and fragrance. Since rose is regarded as the symbol of love, adoration, and innocence, it is largely used in religious and social functions throughout the world.

Growing medium plays a vital role in growth and yield of rose. External application of growth regulators was also found to be very effective for growth and yield improvement in rose. An investigation entitled "Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter" was carried out at the Department of floriculture and Landscaping, college of Horticulture, Vellanikkara. The results of the study are discussed here under.

5.1. VEGETATIVE CHARACTERS

5.1.1. Effect of growing media

Vegetative parameters like plant height, plant spread, number of branches and number of leaves per branch are influencing the flower yield and quality of rose. From the results, it could be concluded that growing media had significant influence on plant height. There was a progressive increase in plant height in all treatments upto December. A decline in plant height observed in January was due to first pruning and there after a steady increase in plant height was noticed. Treatment containing M_1 (growing media containing FYM) was superior in terms of plant height throughout the growth period and in all treatments highest plant height was noticed in May. M_3 (growing media containing poultry manure) was found to have lowest plant height throughout the growing period.

Regarding plant spread, growing media M_1 (growing media containing FYM) was found to have highest plant spread during major part of growth period. Among all treatments, highest plant spread was recorded in May. During September and January M_2 (growing media containing vermicompost) and M_1 (growing media containing FYM) were on par in terms of this parameter. Lowest plant spread was observed in M_3 (growing media containing poultry manure) throughout the period of observation.

Treatment containing M_1 (growing media containing FYM) and M_2 (growing media containing vermicompost) were observed to be on par regarding the number of branches per plant during the period of observation, except in the months of February, March and May.

There was a significant influence of growing media with respect to number of leaves per branch during December, January and February. During December, M_1 (growing media containing FYM) was superior, whereas in January and February M_1 (growing media containing FYM) and M_2 (growing media containing vermicompost) were found to be on par with regard to this parameter.

The positive influence of FYM on vegetative parameters may be due to the balanced supply of nutrients in available form after decomposition, which leads to better root growth and easy absorption of nutrients resulted in an improvement in vegetative growth. These results are in accordance with the findings of Pooja *et al*. (2017); Rajasekhar and Suresh, (2015); and Singh, (2006) in rose. Similar findings are also reported in other flower crops *viz*; Diwivedi *et al*. (2018) in jasmine; Khanna *et al*. (2016); Dhiman *et al*. (2010) in chrysanthemum and Mongal *et al*. (2006) in China aster.

From the present study it could be observed that vermicompost was as effective as FYM for improvement of vegetative parameters *viz;* plant height, plant spread and number of branches per plant and number of leaves per branch. Vermicompost is a sustainable source of macro nutrients in the form of nitrates, phosphates, exchangeable calcium, and soluble potassium as well as micro nutrients. Presence of plant growth regulators like gibberellins and cytokinin are also reported in vermicompost. it is also an excellent soil conditioning agent and incorporation of vermicompost in growing media improves soil texture, structure, permeability, and water holding capacity which might have led to an improvement in root growth and absorption of nutrients and ultimately resulted in an

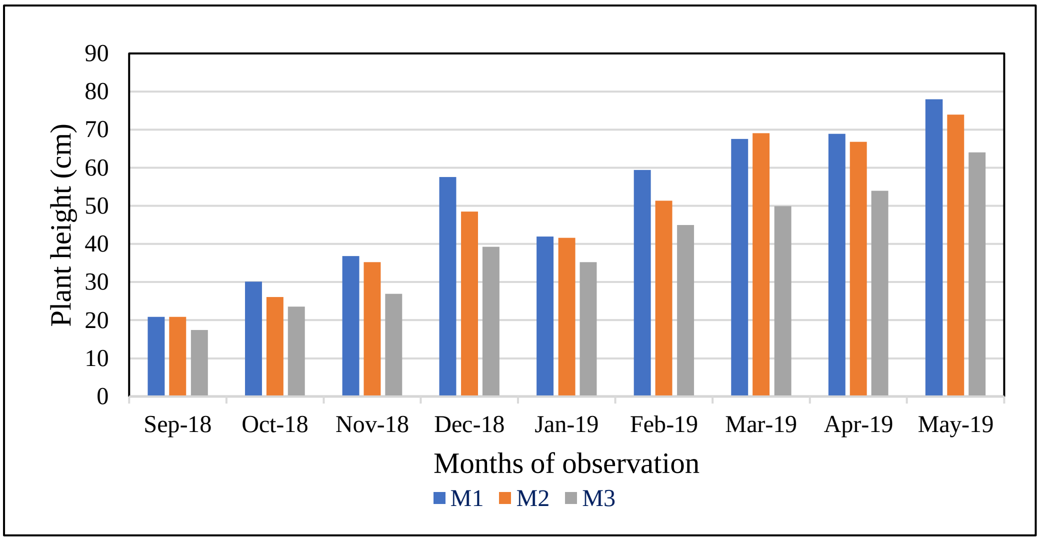


Figure 2. Effect of growing media on plant height

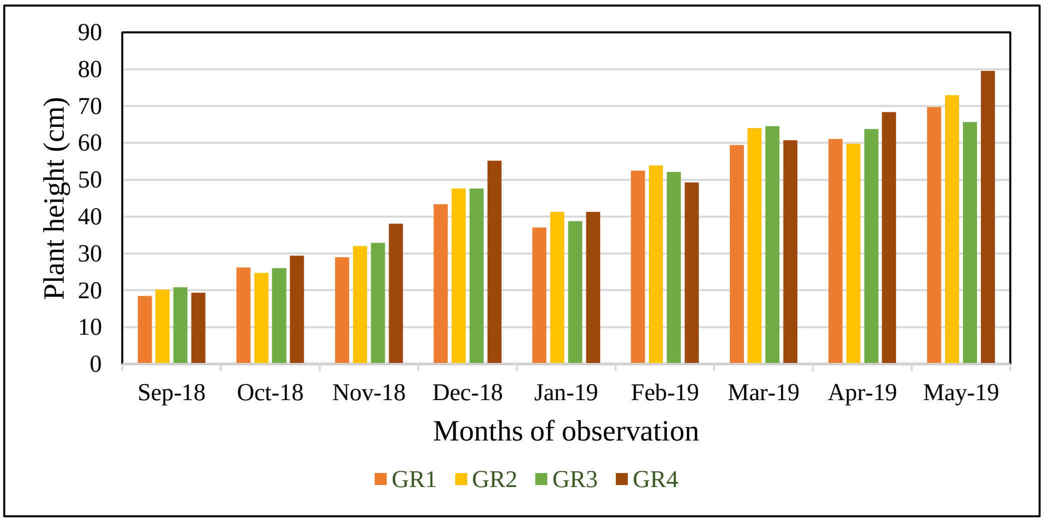


Figure 3. Effect of growth regulators on plant height

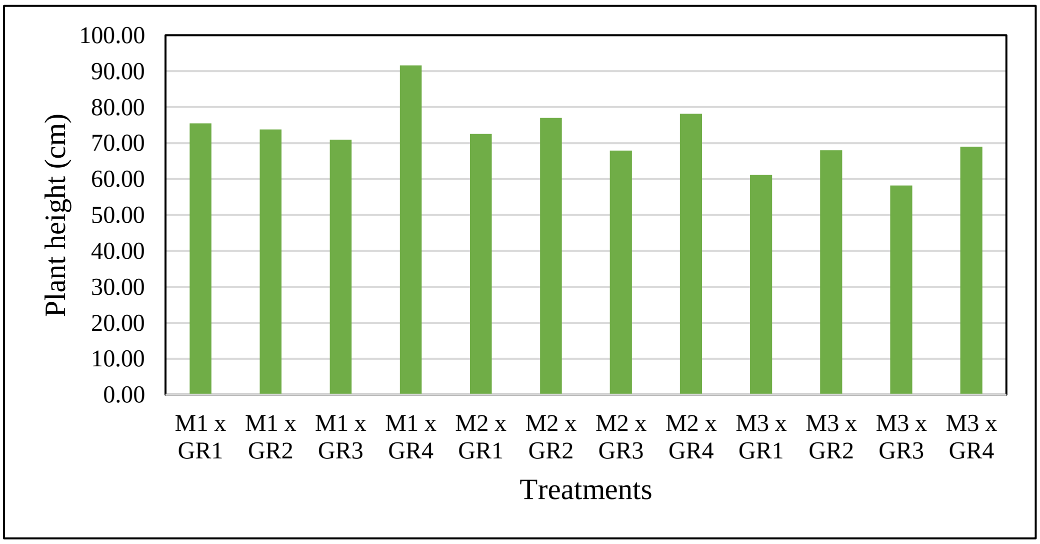


Figure 4. Effect of M x GR interaction on plant height

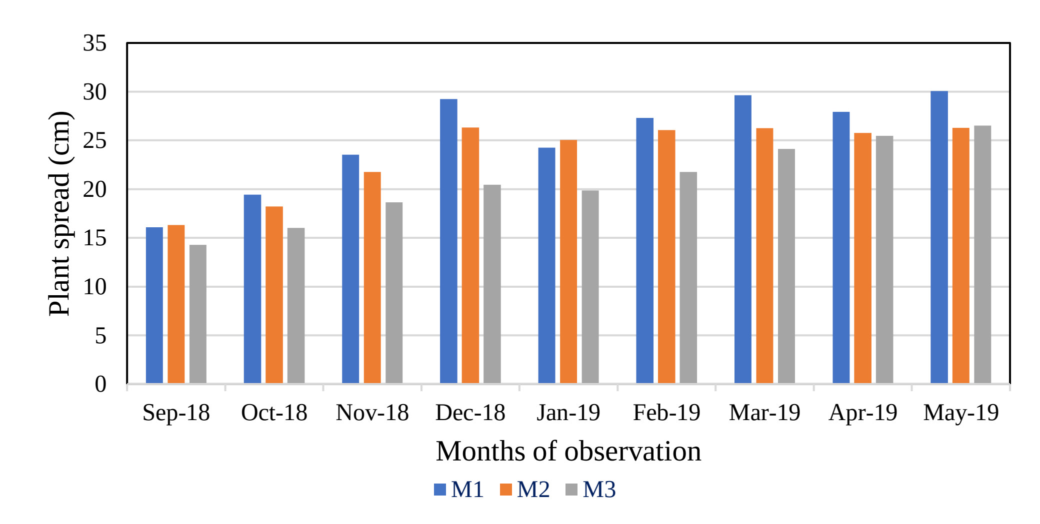


Figure 5. Effect of growing media on plant spread

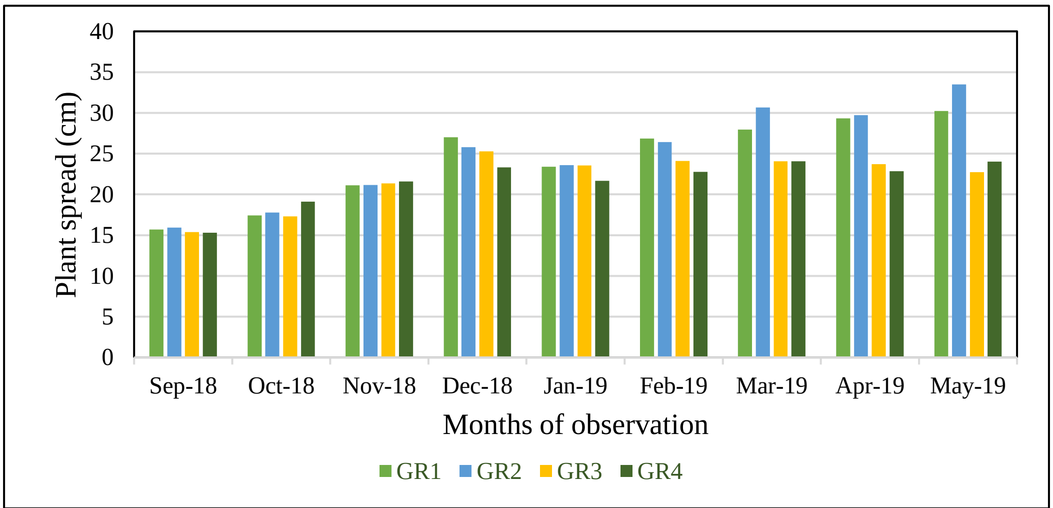


Figure 6. Effect of growth regulators on plant spread

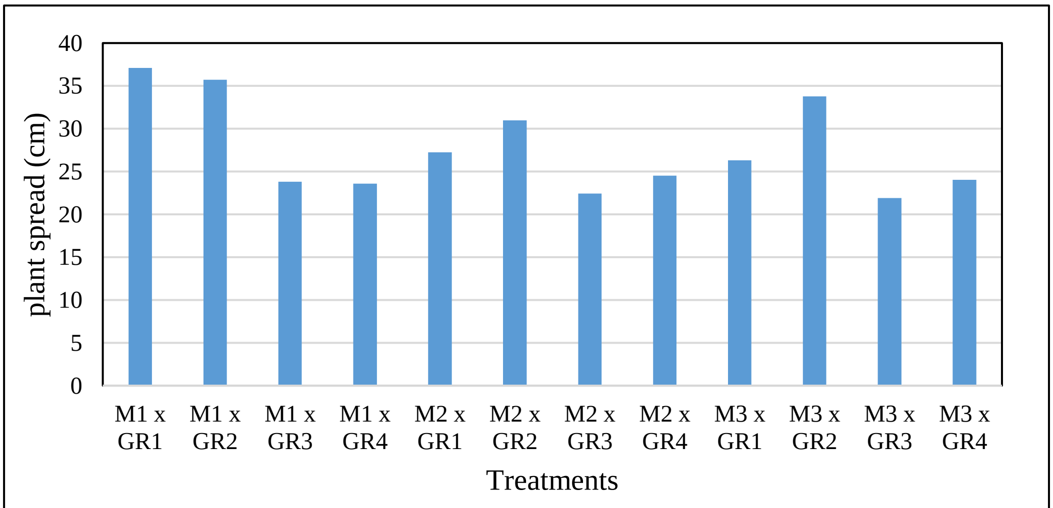


Figure 7. Effect of M x GR interaction on plant spread

improvement of vegetative growth. An improvement in vegetative growth by the incorporation of vermicompost in growing media was reported in various ornamental crops *viz*; Akter *et al*. (2017) in gladiolus; Pandey *et al*. (2017) in Dahlia; Tirkey *et al.* (2017) in gladiolus; and Bhalla *et al*. (2007) in carnation.

5.1.2. Effect of growth regulators

Regarding the plant height, significant variation could be observed due to plant growth regulators during the period of observation. Foliar application of GR_4 (GA at 250 ppm) was recorded with greatest plant height in major part of growth period.

Significant effect of growth regulators on plant spread was noticed throughout the period of observation. Application of GR_2 (BA at 250 ppm) was found to produce highest plant spread in major part of growth period and during the months of September, January, February and April this treatment was observed to be on par with GR_1 (BA at 200 ppm).

Growth regulators had significant influence on number of branches per plant during the period of observation except in October and November. Application of BA 200 ppm as well as 250 ppm was found to produce highest number of branches throughout the experimental period. In all treatments, highest number of branches was observed in May.

From the results, it could be observed that there was significant variation in number of leaves per branch due to growth regulators during January, February and May. GR_2 (BA at 250 ppm) was superior in terms of number of leaves per branch which was on par with GR_3 (GA at 200 ppm) in January. In February GR_1 and GR_2 were on par with each other. Number of leaves per branch was found to have direct correlation with flower production. An improvement in number of leaves by the foliar application of BA was reported by Baghele *et al*. (2014); Dekhaney *et al*. (2000) in rose. Similar results were found in the investigations of Nambiar *et al*. (2012) in *Dendrobium* spp.

Increase in plant height due to the application of GA might be due to the stimulation of cell production beneath the apical region resulting the generation of new cells in this region and GA also increases the size of the meristematic region. Similar findings were observed in the results of Kumar *et al*. (2012); Baghele *et al*. (2014); and Arun *et al*. (2000) in rose; Gul *et al*. (2006) in *Araucaria heterophylla*.

Cytokinins are having the ability to enhance the production of lateral buds by the way of suppressing apical dominance. This might have caused production of more number of branches. Exogenous application of cytokinin enhances the auxin-cytokinin ratio and promotes axillary bud production and growth in ornamental plants. Growth enhancement due to the external application of growth regulators have been reported in rose and other ornamental crops *viz*; Mondal and Sarkar, (2018); Mondal and Sarkar, (2017); Vasudevan and Kannan, (2015); Baghele *et al*. (2014) in rose, Bhaskaran *et al*. (2014); Suresh *et al*. (2008) in gladiolus; Carey *et al*. (2007) in petunia; Svenson, (1990) in verbena

5.1.3. Effect of M x GR interaction

Growing media and growth regulator interaction had significant effect on plant height during the period of observation. Tallest plants were observed under the treatment combination of M_1 x GR_4 (growing media containing FYM + GA at 250 ppm) during majority of months (October, November, December, April, and May). In September and March plant height was highest under the treatment of M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm). In January, M_2 x GR_2, M_1 x GR_1, M_1 x GR_4, M_2 x GR_3, M_2 x GR_4 were on par with each other with regard to plant height. The maximum plant height of 91.60 cm was observed in the treatment combination of M_1 x GR_4 (growing media containing FYM + GA at 250 ppm) during the month of May. More absorption and translocation of nutrients due to enhanced root growth in the medium enriched with FYM coupled with growth accelerating effect of GA might have caused an improvement in plant height in treatments consisting of FYM and Gibberellic acid. These results are in conformity with the findings of Pooja *et al*. (2017) in rose.

Regarding plant spread there was significant effect of M x GR interaction among different treatments. M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) and M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) were

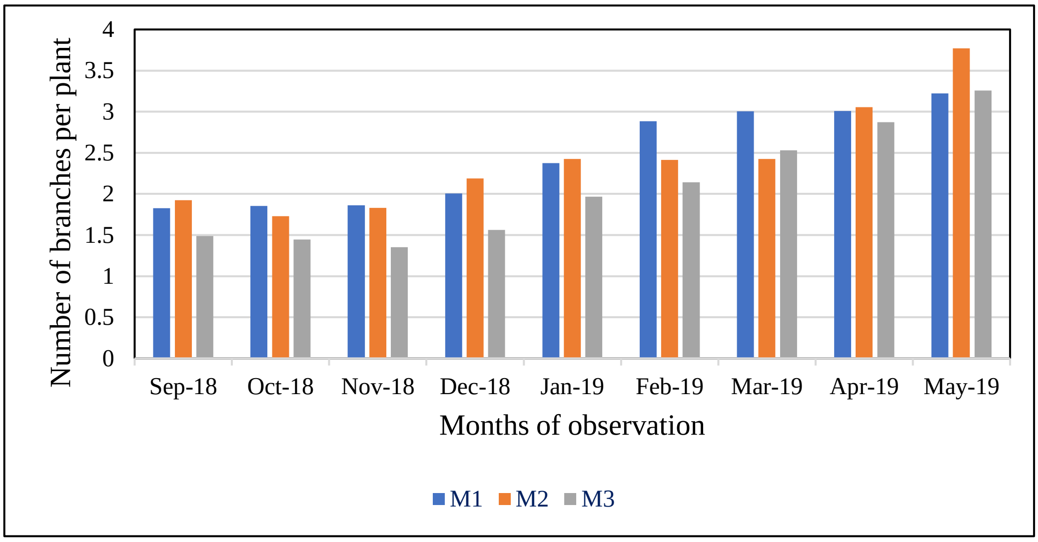


Figure 8. Effect of growing media on number of branches per plant

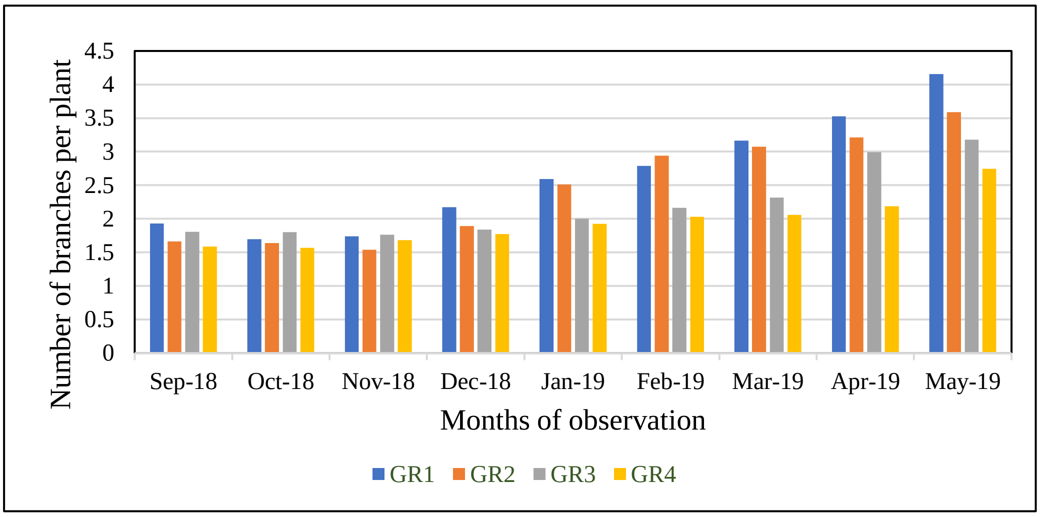


Figure 9. Effect of growth regulators on number of branches per plant

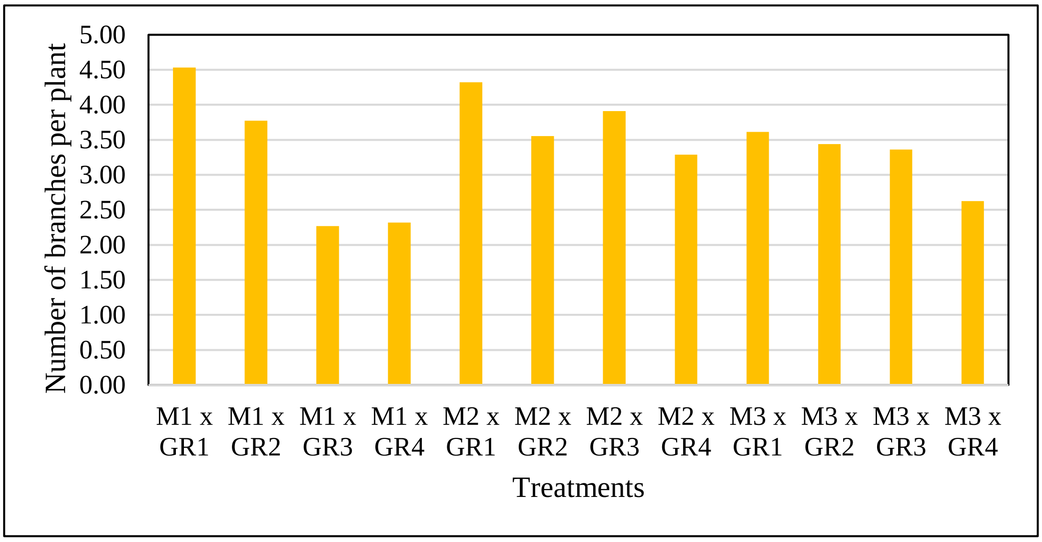


Figure 10. Effect of M x GR interaction on number of branches per

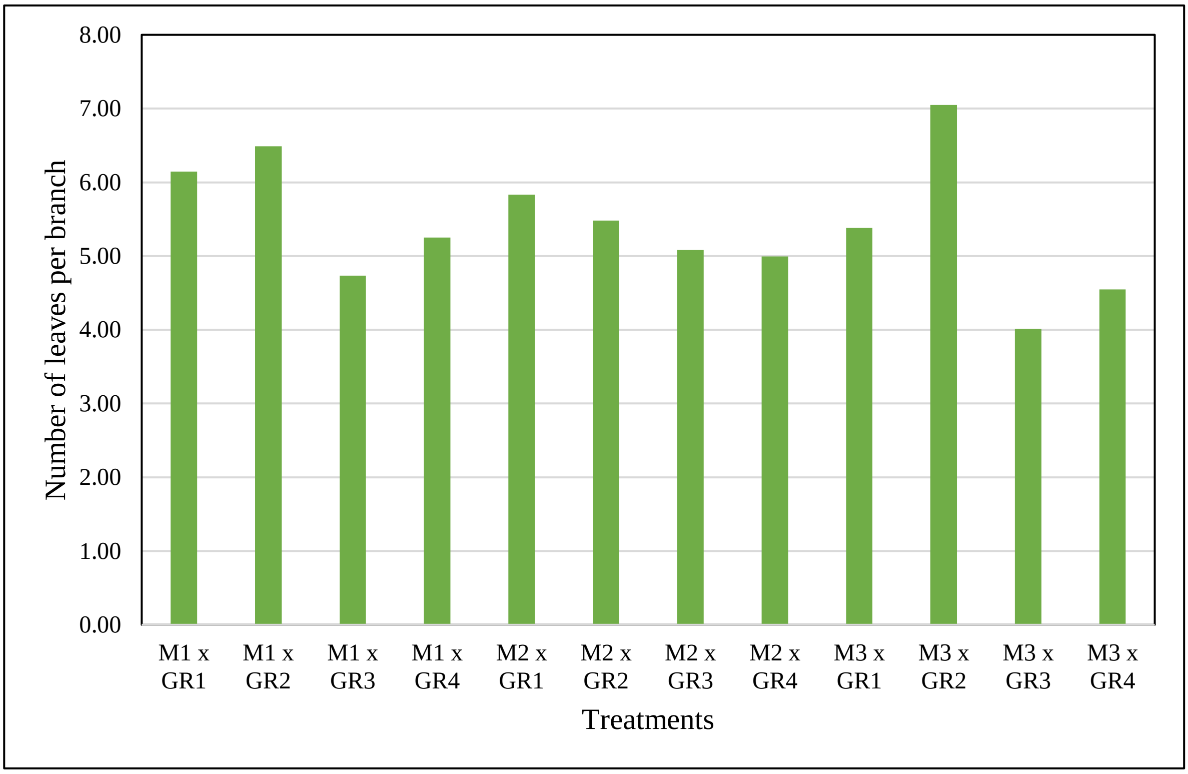


Figure 11. Effect of M x GR interaction on number of leaves per branch

superior during December, January, February, March, April and May. In October and November highest plant spread was under the treatment combination of M_1 x GR_4 (growing media containing FYM + GA at 250 ppm) whereas during September it was under M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm).

Significant variation in number of branches due to M x GR interaction could be noticed all over the period of experiment except in October. M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) was observed to have highest number of branches from January to May. In September and November, more number of branches were noticed under the treatment of M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) and in December it was in M_2 x GR_1 (growing media containing vermicompost + BA at 250 ppm). The maximum number of branches (4.53) were produced under M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) in May.

There was no significant variation in number of leaves per branch due to M x GR interaction except in December, January, February, and May. Growth regulators BA in two concentrations *viz*; 200 and 250 ppm along with growing medium enriched with FYM was found to have positive influence on this parameter during December and February. In January, treatment M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm) was found to have highest number of leaves per branch.

Addition of organic amendments *viz*; FYM and vermicompost might have improved the physio-chemical properties of the soil which in turn increased the nutrient absorption of the plant. Application of BA or GA along with this resulted in increased cell division, elongation, and production of maximum lateral branches. Similar findings were reported by Mondal and Sarkar, (2017); Rajasekhar and Suresh, (2015); Baghele *et al*. (2014); and Kirad *et al.* (2001) in rose; Thakur *et al*. (2018); Kameswari *et al*. (2014) and Dhiman *et al*. (2010) in chrysanthemum; Priya *et al*. (2015) in flowering annuals; El-Naggar and El-Nashary, (2009) in *Hippeastrum vittatum*; Turhan *et al*. (2007) in saffron; Maurya and Nagada, (2002) in gladiolus.

5.2. FLORAL CHARACTERS

5.2.1. Effect of growing media

Significant variation in floral characters due to different growing media could be observed during the period of observation. Early flower bud initiation was observed under M_1 (growing media containing FYM) and more number of days for flower bud initiation was noticed in M_3 (growing media containing poultry manure). Early initiation of flower bud in the growing media containing FYM might be due to easy availability of nutrients from FYM which advances translocation of phytohormones to the shoot apex resulting early flower bud initiation of flower bud. These results were in concordance with the conclusions of Pooja *et al*. (2017); and Bisht *et al*. (2013) in rose; Diwivedi *et al*. (2018) in Jasmine; and Khanna *et al*. (2016) in china aster.

M_1 (growing media containing FYM) was found to have highest length as well as diameter of flower bud compared to other two growing media. Highest number of flowers per plant was observed under M_1 (growing media containing FYM) and which was superior than other two growing media. The enhanced vegetative growth in terms of plant height, plant spread and number of branches due to the application of FYM might have resulted in synthesis, accumulation, and translocation of more photosynthates thus results in the production of more flowers. From the correlation analysis also, a positive correlation of plant height could observe with length of flower bud, number of petals per flower and stalk length. Number of branches had positive and significant correlation with number of flowers, diameter of flower bud and girth of stalk. Similar findings were reported by Rajasekar *et al*. (2017) in rose; and Khanna *et al*. (2016) in china aster; Tariq *et al*. (2012) in Dahlia; Yasmeen *et al*. (2012) in *Dianthus caryophyllus*; Riaz *et al*. (2008) in Zinnia; Bhatia *et al*. (2004) and Bhatia, (2004) in carnation; and Sekar and Sujata, (2001) in gerbera.

More number of petals per flower were observed under the M_1 (growing media containing FYM). Other flower parameters *viz*; Neck length, stalk length and flower diameter at fully opened stage were highest in the growing media M_1 (growing media containing FYM). This might be due to enhanced availability of N and K from growing media containing FYM which improves the quality of flower was reported by Pooja *et al*. (2017); Prasad *et al*. (2017); Rajasekhar and Suresh, (2015) in rose; Khanna *et al*. (2016) in China aster; Ahmed *et al*. (2004) in dahlia; Bhatia *et al*. (2004) in carnation; and Sekar and Sujata, (2001) in gerbera.

Growing media M_1 and M_2 (growing media containing FYM and vermicompost) were found to be on par with regard to other floral characters *viz*; length of flower shoot, stalk girth of flower and neck girth.

From the results it could be observed that addition of FYM had positive influence on yield and flower quality. Vermicompost also had significant positive effect on floral characters.

Soil properties such as bulk density, porosity, soil pH as well as microbial activity are found to be improved by the application of vermicompost in growing medium. Improvement in soil properties might have increased nutrient uptake by plant resulting faster mobilization of photosynthates and early transformation from vegetative to reproductive phase, resulting production of more number of flowers. These results are in accordance with the findings of Akter *et al*. (2017) in gladiolus; Pandey *et al*. (2017) in dahlia; and Chamani *et al*. (2008) in Petunia.

5.2.2. Effect of growth regulators

Growth regulators were found to have significant effect on floral characters such as days taken from flower initiation to complete opening, number of flowers per plant, length of flower shoot, neck length, length of flower stalk, girth of flower stalk and flower diameter at fully opened stage. Maximum number of days (21.00 days) from flower bud initiation to complete opening was observed under GR_1 (BA 200 ppm) which was on par with GR_2 (BA 250 ppm) and GR_3 (GA at 200 ppm). GR_4 (GA at 250 ppm) took lowest number of days (19.91) from flower bud initiation to complete opening.

Highest number of flowers per plant was observed under GR_1 (BA 200 ppm) which was on par with GR_2 (BA at 250 ppm) (5.38 and 5.10 respectively). GR_3 (GA

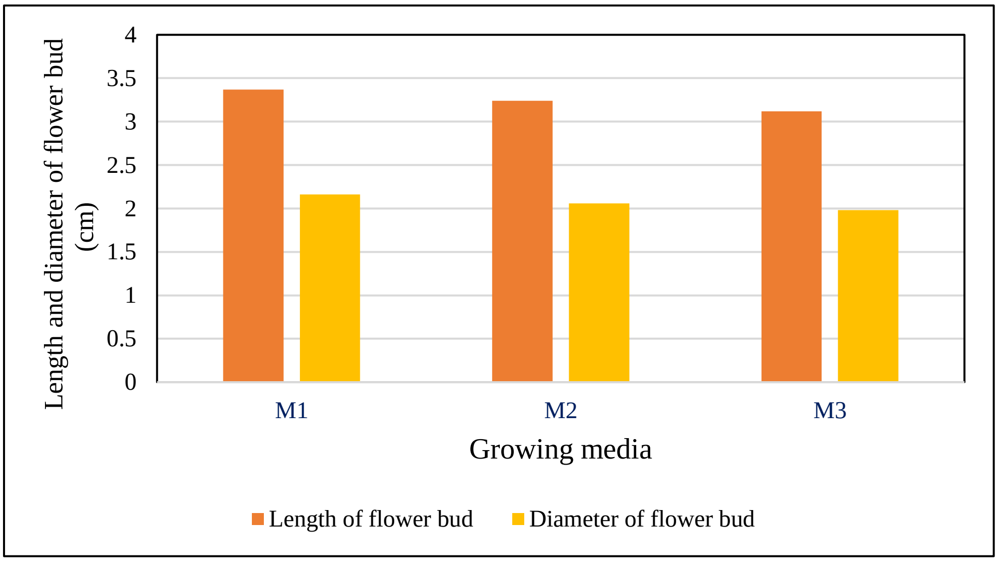


Figure 12. Effect of growing media on floral characters

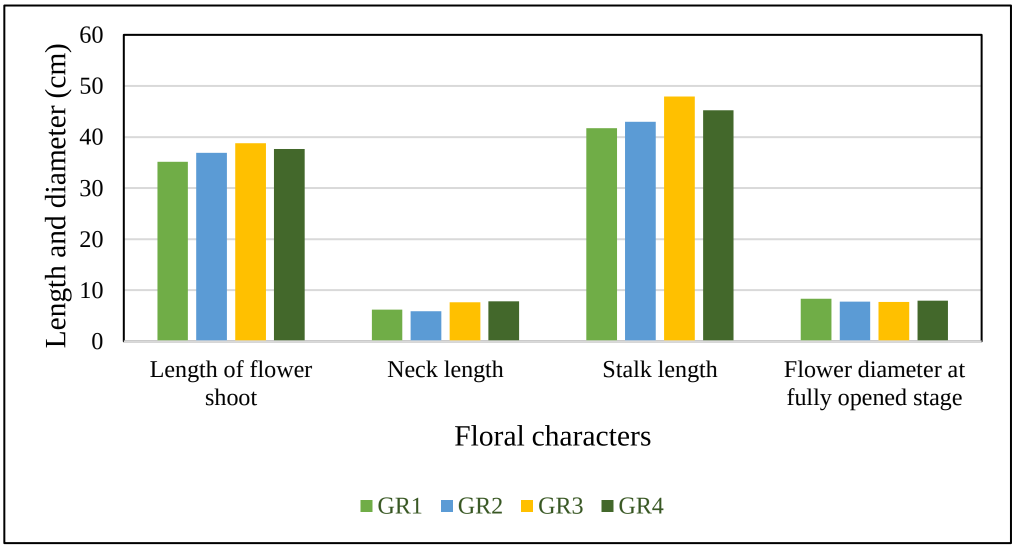


Figure 13. Effect of growth regulator on floral characters

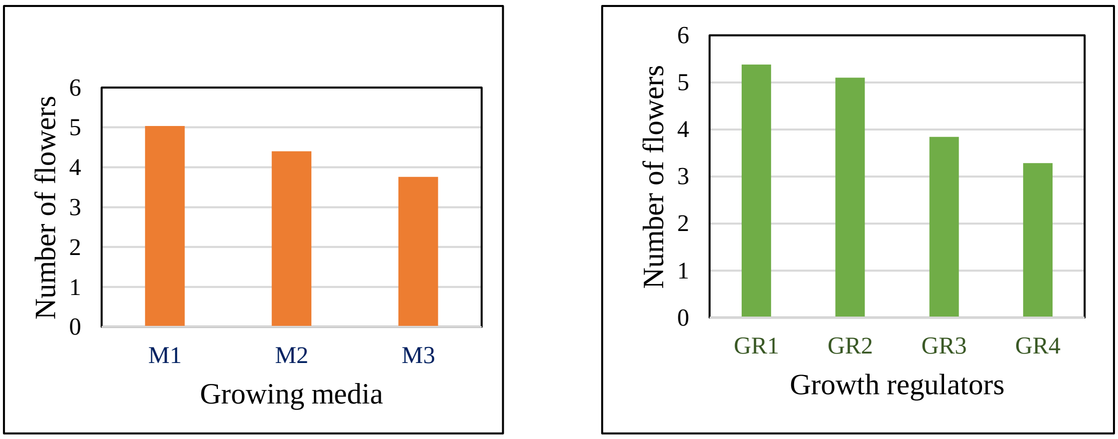


Figure 14. Effect of Growing media and growth regulator on number of flowers

at 200 ppm) had the longest flower shoot which was on par with GR_4 (GA at 250 ppm) and GR_2. With respect to neck length, GR_4 (GA at 250 ppm) and GR_3 (GA at 200 ppm) were on par with respect to neck length (7.81 and 7.68 cm respectively) and lowest neck length was observed under GR_2 (BA at 250 ppm). Longest flower stalks were produced by the foliar application of GR_3 (GA at 200 ppm) similarly girth of flower stalk was also higher under GR_3 which was on par with GR_1 and GR_2. GR_1 (BA at 200 ppm) was found to produce largest flowers at fully opened stage which was statistically on par with GR_4.

Application of BA might have caused enhanced cell division and plant growth resulting more number of flowers. Foliar application of cytokinin stimulates the production of endogenous cytokinin in the plant resulting enhanced flower production (Shilpa, (2017) in *Dendrobium* orchids; Blanchard and Runkle, (2008) in *Doritaenopsis* and *Phalaenopsis* orchid).

Production of more lateral branches, more number of leaves and high chlorophyll content in leaves as the result of the foliar application of BA, might have enhanced the photosynthetic area as well as assimilation and translocation of carbohydrates to the growing point, resulting production of more number of flowers. Similar results could be found in the results of Vasudevan and Kanan, (2015) in rose variety Tajmahal; Janowska, (2014) in calla lily; and Nambiar *et al*. (2012) in *Dendrobium* orchids.

Pre-harvest foliar application of GA produced longer flower shoots and flower stalk. This might be due to the effect of GA which could accelerate cell division and improves the longitudinal growth of cells and leading to vertical growth of plants as reported by Kumar *et al*. (2012); Hashemabadi and Zarchini (2010); Saffari *et al.* (2004); Arun *et al*. (2000); and Robert *et al*. (1999); in rose; Dalal *et al*. (2009); and Sainath, (2009) in chrysanthemum; Gnyandev, (2006) in China aster; Verma, (2003) in Carnation; and Patil, (2001) in gerbera.

Increased neck length observed under GA treatment might be due to influence of GA in cell elongation. Similar findings were reported by Mondal and Sarkar, (2018); and Parmer *et al*. (2015) in rose. Application of GA produced thickest flower stalk during period of observation. Similar results could be found in the findings of Kumar *et al*. (2012); Ramalingam, (2008) in rose; and Mayoli *et al*. (2009) in ranunculus.

Growth regulators BA and GA produced larger flowers at fully opened stage. Significant positive effect of Benzyl adenine on flower size was described by Kumari *et al*. (2017) in *Asiatic lilium* cv. Arcachon; Nambiar *et al*. (2012) in *Dendrobium* orchids; and Kim and Miller, 2008 in Tulip. Increased flower diameter by the application of GA was reported by Kumar *et al*. (2012) in rose; Delvadia, (2009) in gaillardia; Bhaskaran and Misra, (2007) in gladiolus.

5.2.3. Effect of M x GR interaction

Results revealed that M x GR interaction had considerable influence on floral characters during the growth period. Early flower bud initiation was occurred in the treatment combination of M_1 x GR_2 (growing media containing FYM + BA at 250 ppm) whereas maximum days required for flower bud emergence could be observed in M_3 x GR_1 (growing media containing poultry manure + BA at 200 ppm) which was on par with M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm), M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm), M_3 x GR_2 (Growing media containing poultry manure + BA at 250 ppm), and M_3 x GR_4 (Growing media containing poultry manure + GA at 250 ppm). Days from flower bud initiation to commercial stage of harvest, was minimum under the treatment combination of M_3 x GR_2 (growing media containing poultry manure + BA at 250 ppm), while maximum days required for initiation to commercial stage of harvest was observed in M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm). Maximum days from flower bud initiation to complete opening was recorded under M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm) which was on par with M_1 x GR_2 (media containing FYM + BA at 250 ppm), M_1 x GR_3 (growing media containing FYM + GA at 200 ppm), M_2 x GR_2 (growing media containing vermicompost + BA at 250 ppm), M_3 x GR_1 (growing media containing poultry manure + BA at 200 ppm), M_3 x GR_3 (growing media containing poultry manure + GA at 200 ppm). Lowest number of days was observed under M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm).

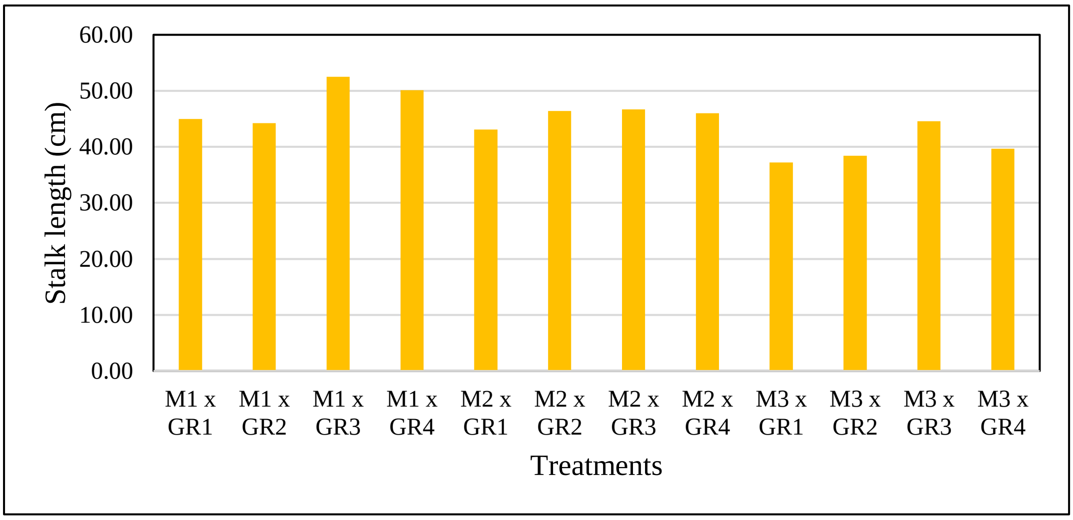


Figure 15. Effect of M x GR interaction on stalk length

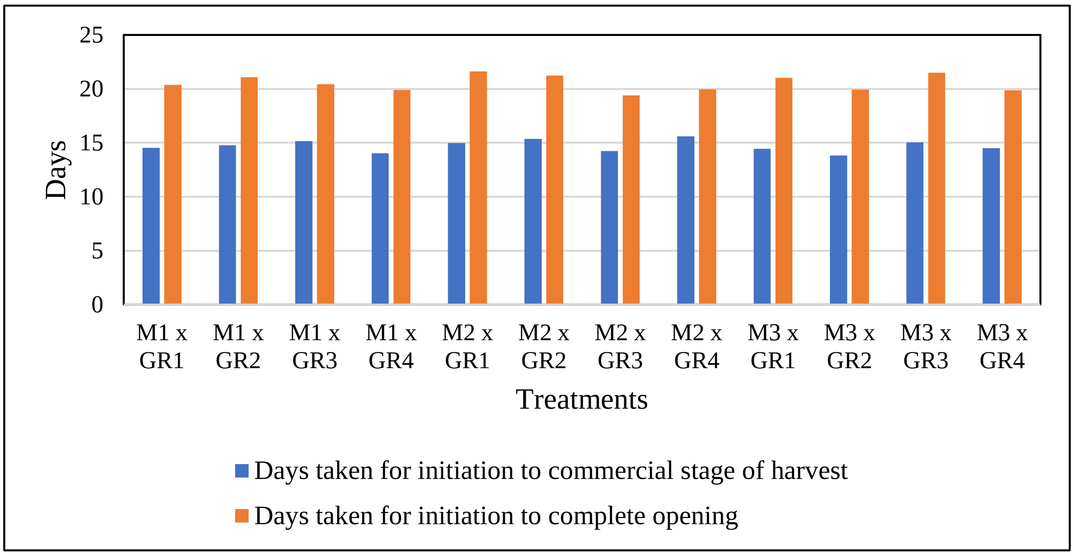


Figure 16. Effect of M x GR interaction on floral characters

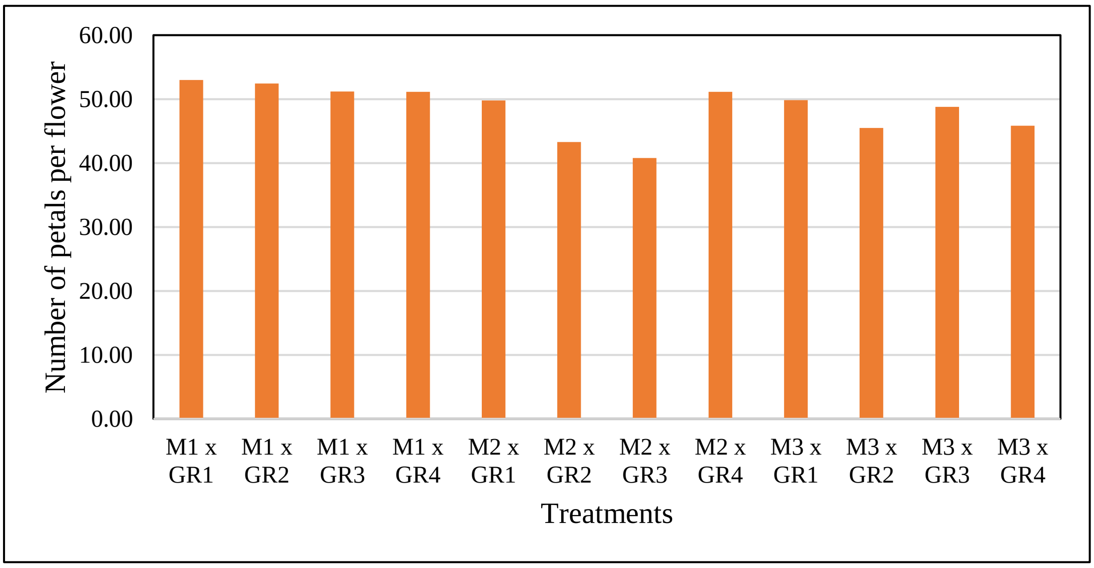


Figure 17. Effect of M x GR interaction on number of petals per flower

Growing media and growth regulator interaction had produced significant improvement in number of petals per flower, neck length and stalk length. Most number of petals were recorded in the treatment combination of M_1 x GR_1 (growing media containing FYM + BA at 250 ppm) which was on par with M_1 x GR_2, M_1 x GR_3, M_1 x GR_4, M_2 x GR_1, M_2 x GR_4, M_3 x GR_1, M_3 x GR_3. Longest flower stalk was recorded under the treatment combination of M_1 x GR_3 (growing media containing FYM + GA at 200 ppm).

Availability of nutrients from growing media depends on the properties such as pH and EC which will vary according to different crops. In the present study the growing media containing FYM possess the pH and EC required for rose which might have enhanced the nutrient availability of crop.

Easy availability of nutrients from growing media enriched with FYM along with beneficial effects of growth regulators BA and GA might have caused an improvement in yield and quality of flower. Similar results were found in the findings of Rajasekar *et al*., 2017; Vasudevan and Kannan, 2015; Ramalingam, (2008); Saffari *et al*. (2004); Arun *et al*. (2000) in rose; Ikram *et al*. (2012) in tuberose; Nambiar *et al*. (2012) in dendrobium; Bhaskaran and Misra (2007) in gladiolus; Sainath, (2009) in chrysanthemum; Bhatia, (2004); and Bhatia *et al*. (2004) in carnation cv. Sunrise; Sekar and Sujata, (2001) in gerbera.

5.3 POST HARVEST CHARACTERS

5.3.1. Effect of growing media

Post harvest parameters *viz*; fresh weight of flower and total water uptake were found to be significantly higher under M_1 (growing media containing FYM) and M_3 (Growing media containing poultry manure) was found to have lowest value with respect to this parameter. Longest vase life was observed under M_1 (growing media containing FYM) which was on par with M_2 (growing media containing vermicompost) and it was lowest under M_3 (growing media containing poultry manure). Physiological loss in weight was found to be highest in growing media containing FYM (M_1). The positive influence of growing media containing FYM on post harvest parameters *viz*; fresh weight and total water uptake might be due to better translocation of nutrients to floral parts leading to an improvement of fresh weight as well as well-developed vascular system in flower stalk resulting more uptake of water. Highest physiological loss in weight of flower under M_1 (growing media containing FYM) may be due to increased physiological activity within the flower petals after harvest. These results are in concordance with the findings of Colombo *et al*. (2016) in rose; Ghisewad *et al*. (2016) in gladiolus; Khanna *et al*. (2016) in China aster; Kameswari *et al*. (2014) in Chrysanthemum; Gayathri and Anuburani, (2008) in jasmine; and Sekar and Sujata, (2001) in gerbera.

5.3.2. Effect of growth regulators

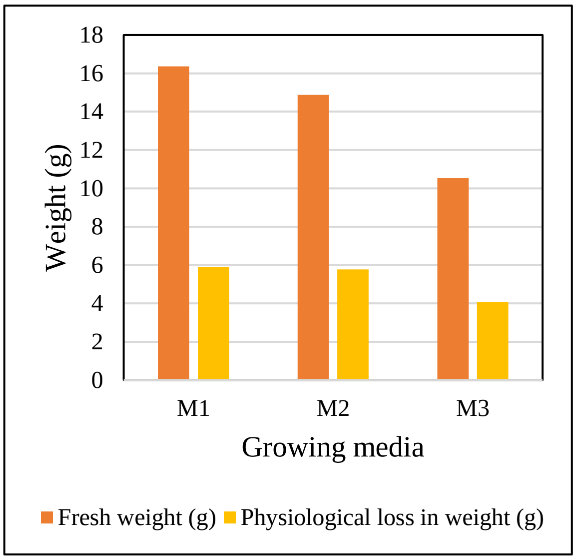
Regarding post harvest characters, maximum fresh weight was observed in GR_1 (BA at 200 ppm). Regarding vase life, GR_1 (BA at 200 ppm) and GR_2 (BA at 250 ppm) were on par with each other. With respect to physiological loss in weight of flowers, it was higher under the application of GR_2 (BA at 250 ppm) and lowest could be observed in GR_4 (GA at 250 ppm). Total water uptake was highest under GR_3 (GA at 200 ppm) and lowest uptake of water was noticed under GR_4 (GA at 250 ppm).

Highest water uptake might be due to well developed flower stalk under GA at 200 ppm resulting more uptake of water. This is in accordance with the findings of Kumar *et al*. (2012) in rose; and Kumari *et al*. (2017) in *Asiatic lilium*.

Application of BA marks improvement in chlorophyll content on leaves resulting delayed senescence and slowdown of aging process were reported by Leopold, (1964); Vasudevan and Kannan, (2015); and Baghele *et al*. (2014) in rose.

5.3.3. Effect of M x GR interaction

Among post harvest characters, fresh weight was highest under the treatments M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) which was on par with M_1 x GR_2 (growing media containing FYM + BA at 200 ppm), M_1 x GR_3 (growing media containing FYM + GA at 200 ppm), and M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm).



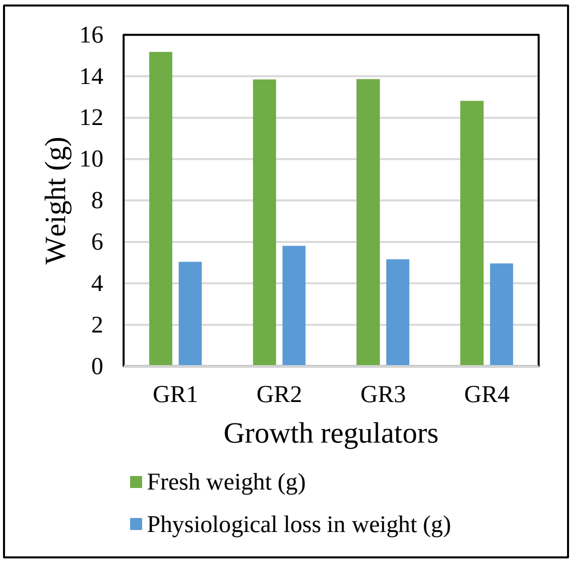


Figure 18. Effect of growing media and growth regulators on fresh weight of flower and physiological loss in weight

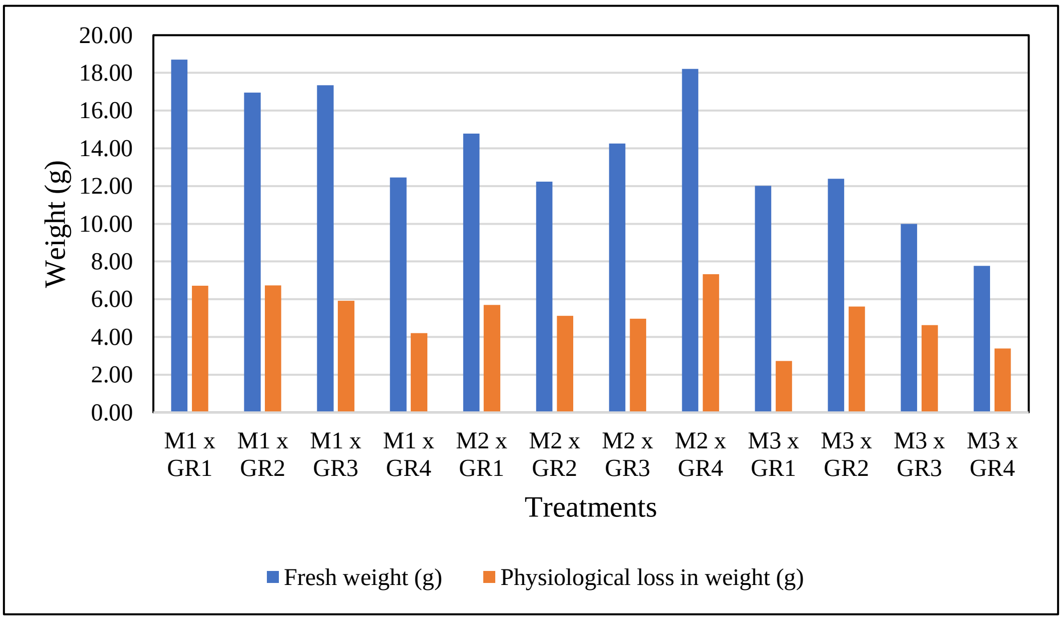


Figure 19. Effect of M x GR interaction on fresh weight of flowers and physiological loss in weight

Regarding the physiological loss in weight, lowest was recorded under M_3 x GR_1 (growing media containing poultry manure + BA at 200 ppm) whereas M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm) was recorded with highest physiological loss in weight which was on par with M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) and M_1 x GR_2 (growing media containing FYM + BA at 250 ppm).

Treatment combination of M_2 x GR_3 (growing media containing vermicompost + GA at 200 ppm) had the maximum water uptake which was followed by M_1 x GR_1 (growing media containing FYM + BA at 200 ppm), M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_1 x GR_3 (growing media containing FYM + BA at 200 ppm).

Vase life was found to be significantly influenced by M x GR interaction. M_1 x GR_1 (growing media containing FYM + BA at 200 ppm) was observed to have longest vase life which was on par with M_1 x GR_2 (growing media containing FYM + BA at 250 ppm), M_1 x GR_3 (growing media containing FYM + GA at 200 ppm), M_2 x GR_1 (growing media containing vermicompost + BA at 200 ppm), M_2 x GR_4 (growing media containing vermicompost + GA at 250 ppm) and M_3 x GR_3 (growing media containing poultry manure + GA at 200 ppm).

The positive effect of BA on vase life might be due to the ability of cytokinin to retard senescence. Longer vase life due to the application of BA, was reported by Mondal and Sarkar, 2018 in rose.

Improvement in vase life under GA treatments may be due to anti senescence activity of GA. Higher stalk length and less water loss under the treatments consisting of GA also might have contributed to improvement in vase life. Similar findings were reported by Kumar *et al.* (2012) in rose; Rao, (2010) in chrysanthemum; Kazaz and Karagazed, (2010) in golden rod; Delvadia *et al*. (2009) in gaillardia; and Goszczynska and Rudnicki, (1988).

Longest vase life observed under growing media containing FYM as well as vermicompost might be due to well developed vascular system in plant grown under these media which might have increased the uptake of water and nutrients

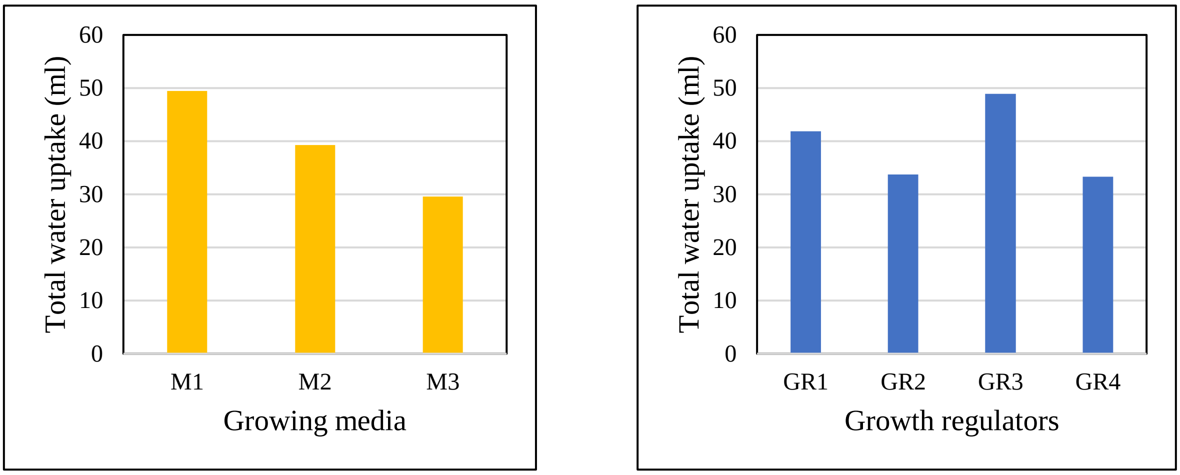


Figure 20. Effect of growing media and growth regulators on total water uptake

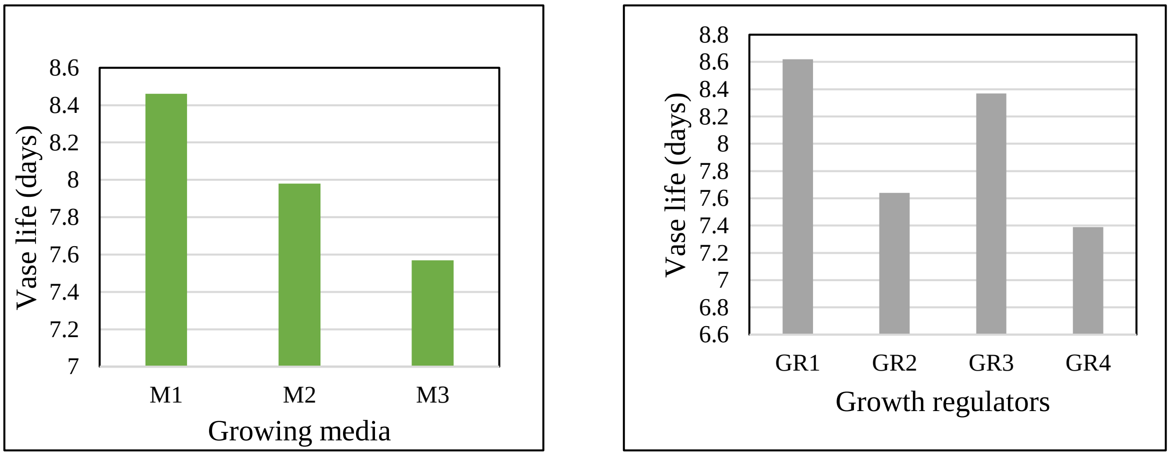


Figure 21. Effect of growing media and growth regulator on vase life

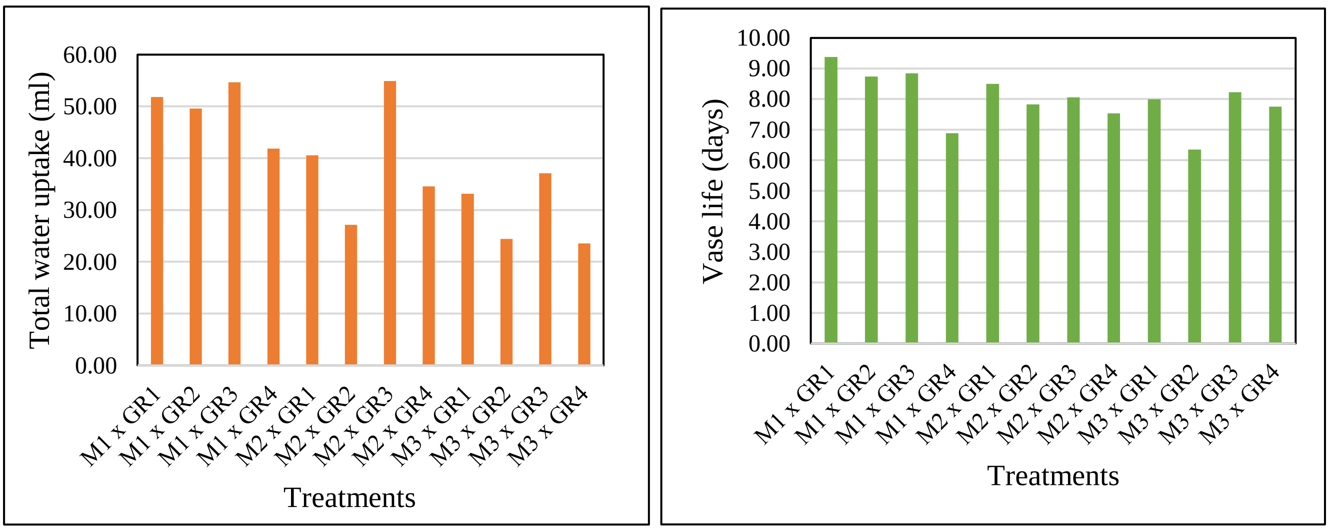


Figure 22. Effect of M x GR interaction on total water uptake and vase life

resulting better vegetative growth and production of quality flowers with longer vase life. (Chavada *et al*. (2017) in rose; and Bhalla *et al*. (2007) in carnation).

5.4. PEST AND DISEASES

The major pest observed was thrips during the late winter and summer months which became severe during summer. Affected flower buds failed to open and there was a loss of luster of flower. Under severe infestation petals of flower turned to dark. All treatments were susceptible to the thrips attack. Infestation of thrips in rose was reported by Bukero *et al*. (2015); Vashisth *et al*. (2013); Duraimurugan and Jagadish, (2011). Application of spinosad showed appreciable results in controlling and regulating thrips population in roses. Similar results were reported by Gupta, (2013) in rose. Smitha *et al*. (2017) identified various pest complex that deteriorating the flower quality of rose in Wayanad district In Kerala.

The major diseases found to be fatal in rose were black spot and die back. Die back is one of the severe diseases occurring during the period of July – August caused by *Diplodia rosarum*. Young plants were severely affected by the disease. Among different media, media containing poultry manure was more susceptible to die back compared to others. Black spot was also noticed during July to January in the rain shelter. Damaging effect of black spot disease was report by Faheem *et al*. (2016).

5.5. PHYSIO - CHEMICAL ATTRIBUTES OF MEDIA

pH is an indication of acidity – alkalinity scale. It affects the availability of nutrients and the capacity of plants to absorb the nutrients. Among different media highest pH was observed in growing media containing poultry manure (6.7 and 6.3). Rose prefer slightly acidic soils of pH range 5.5-6. Among different growing media, FYM had range of pH required for rose which might have caused an improvement in growth under this medium. Similar result was reported by Brady, (1974).

Electrical conductivity (EC) is a measure of soluble salts in the medium. E.C directly influence the nutrient absorption. Growing media containing poultry manure (2.80 and 0.31) had the highest E.C before and after the experiment. Lowest E.C was recorded in growing media containing FYM before and after the experiment (0.88 and 0.22) which was closely followed by vermicompost (0.92 and 0.26). For rose optimum range of E.C is below one. Similar findings were reported by Bhattacharjee and De, (2003); and Raja, (2000); Dadlani, (1999).

The optimum pH and E.C required for rose prevailed in media consisting of FYM as well as vermicompost might have facilitated easy availability of essential nutrients resulting better growth and yield in this media. The poor vegetative growth observed in medium containing poultry manure may be due to highest E.C. resulting the reduced availability of nutrients to plants grown in this medium.
Organic carbon is essential for the population of soil microbes and to support and supply essential nutrients. Vermicompost was recorded with the highest content of organic carbon.

Available N, P and K are essential for the growth and flowering of the rose. Highest available nitrogen was present in vermicompost, before the experiment whereas highest N was recorded in growing media containing poultry manure, after the experiment. In the case of available P and K, growing media containing poultry manure had the highest content. Available phosphorus was found to have influence on shoot and root growth as well as plant spread. Increased concentration of available K improves the translocation of carbohydrates to root system of plants, resulting better nutrient absorption and plant growth. In the present study even though growing media containing poultry manure was having highest content of available P and K, the higher EC prevailed in the medium enriched with poultry manure might have reduced the availability of these nutrients to the plants.

5.6. CORRELATION STUDIES

Number of flowers per plant is the prime factor which determines the yield potential of rose. Correlation of number of flowers per plant with growth parameters, quality attributes and meteorological parameters revealed a significant positive correlation of number of flowers with number of leaves per branch. There was a negative correlation of number of flowers with other vegetative parameters such as plant height and plant spread. Quality attributes of flowers like diameter of flower bud, flower diameter and neck length were positively correlated with number of flowers. A negative correlation of number of flowers could be observed with length of flower bud, number of petals and stalk length. Regarding meteorological parameters, relative humidity was positively correlated with number of flowers whereas there was negative correlation of light intensity with this parameter. There was no significant correlation between temperature and number of flowers per plant. In the present study also, more number of flowers was observed under treatments which are superior in terms of number of leaves per branch. These results are in accordance with the findings of Mondal and Sarkar, (2017) in rose.

Summary

6. SUMMARY

A study entitled "Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter" was carried out at the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara. The experiment consists of twelve treatment combinations using three growing media *viz*; FYM, vermicompost and poultry manure and growth regulators BA and GA at two levels *viz*; 200 and 250 ppm. Rose variety Tajmahal was used for the study. The salient findings of the study are summarized below.

With regard to vegetative characters, there was a significant influence of media on plant height throughout the period of observation. The growing media containing FYM was superior with respect to plant height throughout the period of observation and lowest plant height was observed under the growing media containing poultry manure during the experimental period.

Growth regulators had significant influence on this parameter throughout the period of observation. Foliar application of GA at 250 ppm was found to have maximum plant height during the period of observation. In the case of M x GR interaction, there was significant variation among treatments in the period of investigation. Media containing FYM along with the application of GA at 250 ppm was superior in terms of plant height during the major part of the experimental period, whereas in September, January and March it was highest under the treatment combination of vermicompost and BA at 250 ppm.

The highest plant spread was observed under growing media containing FYM which was on par with the plant spread under treatments containing vermicompost. Lowest plant spread was observed under growing media containing poultry manure, throughout the period of observation. Results revealed that there was significant influence of growth regulators on plant spread, BA 200 ppm as well as 250 ppm were on par during the period of observation, however, in October and November, this parameter was higher under GA at 250 ppm. Growing media and growth regulator interaction had significant influence on plant spread. During most of the months, plant spread was highest under growing media containing FYM along with BA at 200 ppm and BA at 250 ppm.

The number of branches per plant varied significantly among the treatments, during the period of observation. The highest number of branches per plant was observed under growing media containing FYM which was on par with growing media containing vermicompost throughout the period of observation. The lowest number of branches could be observed under treatments containing poultry manure. Significant variation in the number of branches per plant due to growth regulators could be observed during the experimental period except in October and November. Growth regulators BA 200 and 250 ppm were on par with respect to this parameter and application of GA 250 ppm was found to have lowest number of branches per plant. There was a significant influence of M x GR interaction on number of branches per plant except in October. During September and November, it was higher under the treatment combination of growing media containing vermicompost + GA at 200 ppm whereas in December this parameter was highest under growing media containing vermicompost + BA at 200 ppm. Treatment combination of FYM + BA at 200 ppm had the highest number of branches from January to May.

No significant influence of growing media could be observed with respect to the number of leaves per branch during the period of observation except in December, January, and February. During these months it was higher under the growing media containing FYM which was on par with number of leaves in growing media containing vermicompost. With regard to the influence of growth regulators, prominent variation could be observed during the growth period in December, January, and February. Treatment containing growth regulator BA at 250 ppm was found to have the highest number of leaves per branch. There was a significant influence of M x GR interaction on a number of leaves during December, January, February, and May. In December and February, the treatment combination of FYM along with BA at 200 and 250 ppm were superior with regard to this parameter, while in January highest number of leaves per branch was under growing media containing vermicompost along with BA at 250 ppm. In May this parameter was higher under vermicompost together with GA at 250 ppm.

Growing media containing FYM produced superior results with respect to floral characters *viz*; length of flower bud, diameter of flower bud, number of flowers per plant, number of petals per flower, length of the flower stalk, and flower diameter. Early flower bud initiation was observed under treatment containing FYM. Growing media containing FYM as well as vermicompost were on par with each other with respect to floral characters *viz*; length of flower shoot, neck girth and girth of flower stalk. Treatment containing BA 200 ppm was superior with respect to number of flowers per plant and flower diameter at fully opened stage, whereas GA 200 and 250 ppm were found to have superior effects on the floral characters *viz*; days taken from flower bud initiation to complete opening, length of flower shoot, neck length, length of flower stalk and girth of flower stalk. M x GR interaction had no significant influence on floral characters during the period of observation except in days taken for flower bud initiation, days taken from flower bud initiation to commercial stage of harvest, days taken from flower bud initiation to complete opening, number of petals per flower, neck length and stalk length of flower. Among the floral characters, early flower bud initiation was recorded in the treatment of FYM + BA at 250 ppm. Early commercial stage of harvest and minimum days for complete opening from flower bud initiation could be observed in the treatment of growing media containing poultry manure + BA at 250 ppm and vermicompost + GA at 200 ppm respectively. More number of petals per flower was observed in the treatment combination of growing media containing FYM and BA at 200 ppm, whereas, the treatment FYM + GA at 200 ppm was superior in terms of stalk length of flower.

Among post-harvest characters, growing media containing FYM had exhibited the highest fresh weight of flowers and total water uptake. Growing media containing FYM and vermicompost were on par with respect to vase life. Physiological loss in weight was lowest under growing medium containing poultry manure. Growth regulators were found to have significant effect on post-harvest characters. Fresh weight of flower and vase life were longer under the treatment containing BA at 200 ppm. Application of GA at 250 ppm showed the lowest physiological loss in weight. Highest water uptake was recorded by the foliar application of GA at 200 ppm.

Significant influence of M x GR interaction could be observed on post-harvest parameters during the period of experiment. Among post-harvest characters, fresh weight of flower and vase life were highest under the treatment growing media containing FYM + BA at 200 ppm. Treatment combination of growing media containing poultry manure together with BA at 200 ppm had lowest physiological loss in weight. Maximum water uptake was observed under the treatment vermicompost + GA at 200 ppm.

pH, EC, organic carbon and available N, P and K of growing media were analysed before and after the experiment. The highest pH and Electrical conductivity were observed in growing media with poultry manure. Growing media containing FYM had the lowest pH and EC both before and after the experiment. Vermicompost was recorded with the highest organic carbon content as well as available nitrogen both before and after the experiment. Growing media containing poultry manure was found to have the highest available phosphorus and potassium before and after the experiment.

Correlation between vegetative parameters, floral characters as well as meteorological parameters were observed. Yield in terms of the number of flowers per plant was significantly and positively correlated with number of leaves per branch, whereas a negative correlation of this parameter could be observed with plant height and plant spread. Among yield attributing factors diameter of flower bud, flower diameter, and neck length were positively correlated with a number of flowers. A negative correlation of number of flowers was observed with number of petals as well as stalk length of flower. About meteorological parameters, relative humidity was positively correlated with a number of flowers whereas a negative correlation was observed between light intensity and number of flowers.

References

REFERENCES

Ahmad, G. and Saravanan, S. 2014. Effect of NPK and potting media on plant growth and spike yield of *Dendrobium* orchid cv. Sonia Hiskula. *Hortflora Res. Spectrum*. 3(4): 383-385.

Ahmad, M., Khan, M.F., Hamid, A., and Hussain, A. 2004. Effect of urea, DAP and FYM on growth and flowering of Dahlia (*Dahlia variabilis*). *Int. J. Agric. Biol.* 6(2): 393-395.

Akter, N., Ara, K.A., Akand, M.H., and Alam, M.K. 2017. Vermicompost and Trichocompost in combination with inorganic fertilizers increased growth, flowering and yield of Gladiolus cultivar (GL-031) (*Gladiolus grandiflorus* L.). *Adv. Res*. 12(3): 1-11.

Arun, D.S., Ashok, A.D., and Rengasamy, P. 2000. Effect of some growth regulating chemicals on growth and flowering of rose 'First Red' under greenhouse conditions. *J. Ornam. Hortic.* 3(1): 51-53.

Baghele, R.D., Dhaduk, B.K., Chawla, S.L., and Jadeja, R. 2014. Effect of growth regulators and cow urine on rose (*Rosa hybrida*) cv. Poison. *Bioinfolet*. 11(2c): 673-676.

Barreto, M.S. and Jagtap, K.B. 2002. Studies on polyhouse gerbera substrate. In: Misra, R.L. and Misra, S. (eds.), *Recent floriculture research trends in India*. ISOH, New Delhi, pp. 173-176.

Basheer, S.N. and Thekkayam, S.G. 2012. Effect of growing media and organic nutrition on vegetative growth in anthurium plants (*Anthurium andreanum* cv. Tropical). *Asian J. Hortic*. 7(2): 354-358.

Baskaran, V. and Misra, R.L. 2007. Effect of plant growth regulators on growth and flowering of gladiolus. *Indian J. Hortic*. 64(4): 479-482.

Baskaran, V., Abirami, K., and Roy, S. 2014. Effect of plant growth regulators on yield and quality in gladiolus under Bay Island conditions. *J. Hortic. Sci*. 9: 213-216.

Bhalla, R., Shivakumar, M.H., and Jain, R. 2007. Effect of organic manures and biofertilizers on growth and flowering in standard carnation (*Dianthus caryophyllus* L.). *J. Ornam. Hortic*. 10(4): 229-234.

Bhatia, S. 2004. Effect of growing media and fertilization on growth and flowering of carnation (*Dianthus caryophyllus* L.). MSc(Hort) thesis, DR. Y. S. Parmar. University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh.

Bhatia, S., Gupta, Y.C., and Dhiman, S.R. 2004. Effects of growing media and fertilization on carnation production under protected conditions [abstract]. In: *Abstracts of International Seminar on Recent Trends in Hi-Tech Horticulture and Post-Harvest Technology*; 4-6 Feb. 2004, Kanpur. p.53.

Bhatt, S.T. and Chauhan, N.M. 2012. Effect of GA_3 and BA on growth and flowering of *Dendrobium* cv. Sonia – 17. *The Asian J. Hortic*. 7(1): 197-199.

Bhattacharjee, S.K. and De L.C. 2003. *Rose: Advanced Commercial Floriculture*. Diamond Printing Press, Jaipur, pp. 207-228.

Bisht, D., Singh, C.P., Kumar, S., and Singh, N. 2013. Interactive effect of growing substrates and fertigation in flowering attributes of rose cv. 'Grand Gala'. *Prog. Hortic*. 45(2): 306-311.

Blanchard, M.G. and Runkle, E.S. 2008. Benzyl adenine promotes flowering in *Doritaenopsis* and *Phalaenopsis* orchids. *J. Plant Grow. Reg*. 27: 141-150.

Bogahawatta, A. and Kumara, K. 2017. Application of cytokinin and gibberellic acid to regulate flower quality in *Dendrobium* orchid. In: Proceedings of the 4th International Conference on Agriculture and Forestry, 24-25 Aug. 2017, Colombo. 3: 1-5.

Brady, N. C. 1974. *The Nature and Properties of Soils*. MacMillian, New York, 639p.

Bukero, A., Talpur, M.A., Rais, M.U.N., Lanjar, A.G., Arain, I., and Nahiyoon, S.A. 2015. Activity of thrips and their natural enemies on rose. *Sci. Int*. 27(4): 3293-3296.

Carey, D., Whipker, B., McCall, I., and Buhler, W. 2007. Cytokinin based PGR affects growth of vegetative petunia. In: Carver, S. (ed.), *Proceedings of SNA Research Conference*. 2007, McMinnville. 52: 102-109.

Chamani, E., Joyce, D.C., and Reihanytabar, A. 2008. Vermicompost effects on the growth and flowering of *Petunia hybrida* 'Dream Neon Rose'. *Am.-Eur. J. Agric. Environ. Sci*. 3(3): 506-512.

Chandore, H.D., Viradia, R.R., Bhor, P.B., Kadlag, R.R., and Jadhav, Y.B. 2010. Effect of various substrates and their mixtures on growth parameters, yield components and economy in rose (*Rosa hybrida* Linn.) cv. First Red under fan and pad greenhouse system. *Haryana J. hortic. Sci*. 39(3&4): 280-282.

Chauhan, R.V., Varu, D.K., Kava, K.P., and Savaliya, V.M. 2014. Effect of different media on growth, flowering and cut flower yield of gerbera under protected condition. *Asian J. Hortic*. 9(1): 228-231.

Chavada, J.R., Thumar, B.V., Vihol, A.N., Patel, V.S., and Padhiyar, B.M. 2017. Effect of media on growth, flower yield and quality of rose (*Rosa hybrida* L.) cv. Top Secret under protected condition. *Int. J. Pure Appl. Biosci*. 5(5): 821-827.

Colombo, R.C., Vanessa, F., Thadeu, R.M., Ricardo, T.F., and Marcelo, A.A. 2016. Potting media, growth and build-up of nutrients in container-grown desert rose. *Aust. J. Crop Sci*. 10(2): 258-263.

Dadlani, N.K. 1999. Development of new production technologies for rose in India. *J. Ornam. Hortic*. 2(1): 25-31.

Dalal, S.R., Somavanshi, A.V., and Karale, G.D. 2009. Effect of gibberellic acid on growth, flowering, yield and quality of gerbera under polyhouse conditions. *Int. J. Agric. Sci*. 5(2): 355-356.

Dede, O.H., Koseoglu, G., Ozdemir, S., and Celebi, A. 2006. Effects of organic waste substrates on the growth of *impatiens*. *Turkish J. Agric*. 30: 375-381.

Delvadia, D.V., Ahlawat, T.R., and Meena, B.J. 2009. Effect of different GA_3 concentration and frequency on growth, flowering and yield in gaillardia (*Gaillardia pulchella* Foug.) cv. Lorenziana. *J. Hortic. Sci*. 4(1): 81-84.

Dhekney, S.A., Ashok, A.D., and Rengasamy, P. 2000. Action of various growth regulators and flora preservatives on vase life of cut rose cv. First Red grown under controlled conditions. *S. Indian Hortic*. 48(1-6): 69-71.

Dhiman, S.R., Thakur, P., Gupta, Y.C., and Bhalla, R. 2010. Standardization of potting medium for growing chrysanthemum as pot mum. *In: Proc. National Symposium on Lifestyle Floriculture: Challenges and Opportunities*, March 2010, Solan. Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, (H.P.), p 76.

Diwivedi, R., Saravanan, S., Shabi, M., and Kasera, S. 2018. Effect of organic and inorganic fertilizers on growth and flower yield of jasmine (*Jasminum grandiflorum* L.). *Pharma. Innovation J*. 7(6): 683-686.

Duraimurugan, P. and Jagadish, A. 2011. Preliminary studies on the biology of *Scirtothrips dorsalis* Hood. (Thysanoptera: Thripidae) as a pest of rose in India. *Arch. Phytopathol. Plant Prot*. 44(1): 37-45.

Eleni, M., Sabri, K., and Dimitra, Z. 2001. Effect of growing media on the production and quality of two rose varieties. *Acta Hortic*. 548: 79-83.

El-Naggar, A.H. and El-Nasharty, A.B. 2009. Effect of growing media and mineral fertilization on growth, flowering, bulbs productivity and chemical constituents of *Hippeastrum vittatum*, Herb. *Am-Eur. J. Agric. Environ. Sci.* 6: 360-371.

Faheem, A., Ahmed, Q.N., Hussain, D.S., Gani, M.Y., and Talib, S. 2016. Evaluation of genus Rosa germplasm for resistance to black spot and powdery mildew. *Int. J. Agric. Sci*. 8(42): 1859-1862.

Fascella, G. and Zizzo, G.V. 2005. Effect of growing media on yield and quality of soilless cultivated rose. *Acta Hortic*. 697: 133-138.

Fonseca, C.E. and Hanan, J.J. 1987. The effect of greenhouse cover and shading on royalty rose yield. *Colarado greenhouse growers association*. Inc. in cooperation with Colorado state university.

Gayathiri, M. and Anuburani. 2008. Influence of integrated nutrient management on major nutrients in mullai (*Jasminum auricultatum*). *Asian J. Hortic*. 3(2): 142-143.

Ghisewad, S.K., Sable, P.B., and Rohidas, S.B. 2016. Effect of organic and inorganic fertilizers on growth and flower quality of gladiolus cv. H.B. PITT. *Asian J. Hortic*. 11(2): 275-279.

Gnyandev, B. 2006. Effect of pinching, plant nutrition and growth retardants on seed yield, quality and storage studies in China aster (*Callistephus chinensis* (L.) Nees.). M.Sc(Ag) thesis, University of Agricultural Sciences, Dharwad.

Goszczynska, D. and Rudnicki, R.M. 1988. Storage of cut flowers. *Hortic. Rev*. 10: 35-62.

Gul, H., Khattak, A.M., and Amin, N. 2006. Accelerating the growth of *Araucaria heterophylla* seedling through different GA_3 concentrations and nitrogen levels. *J. Agric. Biol. Sci*. 1(2): 25-29.

Gupta, G. 2013. Managing thrips on roses with combination of neonicotinoid and biological insecticides. *J. Agric. Urban Entomol*. 29(1): 16-24.

Gupta, Y.C., Dein, L.Q., Dhiman, S.R., and Jain, R. 2004. Standardization of growing media under protected environment in gerbera in mid-hills of Himachal Pradesh. *J. Ornam. Hortic*. 7(1): 99-102.

Hashemabadi, D. and Zarchini, M. 2010. Yield and quality management of rose (*Rosa hybrida* cv. Poison) with plant growth regulators. *Plant Omics J*. 3(6): 167-171.

Ikram, S., Habib, U., and Khalid, N. 2012. Effect of different potting media combinations on growth and vase life of tuberose (*Polianthes tuberosa* LINN.). *Pakist. J. Agric. Sci*. 49(2): 121-125.

Jackson, M.L. 1958. *Soil Chemical Analysis* (Indian Reprint, 1967). Prentice Hall of India Private Ltd., New Delhi, p. 498.

Janowska, B. 2014. Effect of benzyl adenine on flower and leaf yield of calla lily (*Zantedeschia spreng*.). *Bulgarian J. Agric. Sci.* 20: 633-637.

Jhon, A.Q., Mir, M.M., Neelofar., and Khan, F.U. 2007. Response of organic manure and inorganic fertilizer on growth and bulb production in tulip (*Tulipa gesneriana* Linn.). *J. Ornam. Hortic*. 10(3): 157-160.

Kameswari, L.P., Girwani, A., and Padmavathamma, A.S. 2014. Effect of different potting media mixtures on growth and flowering of chrysanthemum (*Dendranthema grandiflora* T.). *Prog. Hortic*. 46(2): 314-318.

Kapri, M., Singh, A.K., Sisodia, A., and Padhi, M. 2018. Influence of GA_3 and BA (Benzyl adenine) on flowering and post-harvest parameters in lily. *J. Pharmacognosy Phytochem*. 7(3): 1916-1918.

Kasturi, A. and Sekhar, C. 2017. Effect of plant growth regulators on vegetative growth of carnation (*Dianthus caryophyllus* L.) cv. Domingo in second season crop. *Plant Arch.* 17(2): 1113-1116.

Kazaz, S. and Karaguzel, O. 2010. Influence of growth regulators on the growth and flowering characteristics of goldenrod (*Solidago x hybrida*). *Eur. J. Sci. Res*. 45(3): 498-507.

Ketter, N.C., Wesonga, J.M., Wariara, K., Elings, A., and Hoogerwerf, F. 2015. Evaluation of a cocopeat-based substrate system for rose production in Naivasha, Kenya. *Acta Hortic*. 1077: 111-120.

Khanna, P.R., Bohra, M., Punetha, P., and Nautiyal, B.P. 2016. Studies on the effect of organic manures and PSB on vegetative and floral parameters of China aster (*Callistephus chinensis* (L.) Ness) cv. Kamini under mid hills region of Himalaya. *Bioscan*. 11(4): 2707-2710.

Kim, H.J. and Miller, W.B. 2008. Effects of GA and benzyl adenine application on post-production quality of 'Seadov' pot tulip flowers. *Post harvest Biol. Technol.* 47(3): 416-421.

Kirad, K.S., Banafar, R.N.S., Barche, S., Billore, M., and Dalal, M. 2001. Effect of growth regulators on gladiolus. *Ann. Agric. Res*. 22(2): 278-281.

Kumar, S., Roy, R.K., Goel, A.K., and Tewari, S.K. 2014. Comparative studies on growth and cut flowers production of gerbera under naturally ventilated polyhouse and low cost greenhouse in north eastern plains of Uttar Pradesh. *Indian J. Hortic.* 71(4): 531-535.

Kumar, S.M., Ponnuswami, V., Jawaharlal, M., and Kumar, A.R. 2012. Effect of plant growth regulators on growth, yield and exportable quality of cut roses. *Bioscan*. 7(4): 733-738.

Kumari, S., Kumar, S., Singh, C.P., and Dhami, V. 2017. Effect of pre harvest treatment on flower quality and vase life of *Asiatic lilium* cv. Arcachon. *Int. J. Curr. Microbiol. Appl. Sci.* 6(9): 2969-2974.

Leopold, A.C. and Kawase, M.K. 1964. Benzyl adenine effects on Bean leaf growth and senescence. *Am. J. Bot*. 51(3): 294-298.

Mandhar, S.C. and Carolin, R.A. 2004. Performance evaluation of microclimate inside naturally ventilated greenhouses for cultivation of flower crops. *J. Ornam. Hortic*. 7(3): 191-201.

Maurya, R.P. and Nagda, C.L. 2002. Effect of growth substances on growth and flowering of gladiolus (*Gladiolus grandiflorus* L.) cv. Friendship. *Haryana J. Hortic. Sci*. 31(3-4): 203-204.

Mayoli, R.N., Isutsa, D.K., and Tunya, G.O. 2009. Growth of ranunculus cut flower under tropical high altitude conditions: Effects of GA_3 and shade. *Afr. J. Hortic. Sci*. 2: 13-28.

Mohanty, C.R., Mohanty, A., Das, A.B., and Kar, D.S. 2011. Comparative performance of some varieties under open and protected environment. *Asian J. Hortic*. 6(2): 288-293.

Mondal, S. and Sarkar, M.M. 2017. Influence of plant growth regulators on growth, flowering and yield characteristics of hybrid tea rose cv. Bugatti during spring-summer months. *Adv. Res*. 12(6): 1-7.

Mondal, S. and Sarkar, M.M. 2018. Performance of hybrid tea rose cv. Bugatti in response to growth regulators. *Int. J. Curr. Microbiol. Appl. Sci*. 7(1): 196-205.

Mongal, S.A., Khiratkar, S.D., Chopde, N.K., and Dalvi, A.M. 2006. Effect of organic manures and biofertilizers with reduced doses of nitrogen on growth, yield and quality of China aster. *J. Soils Crops.* 16(1): 180-185.

Muraleedharan, A. and Karuppaiah, P. 2015. Studies on the effect of shade and growing media on the growth and yield of anthurium (*Anthurium andreanum*) cv. Tropical. *Int. J. Adv. Res. Eng. Sci. Technol*. 2(10): 28-31.

Nair, S.A. and Bharathi, T.U. 2015 Influence of potting media composition on pot mum production. *Bioscan*. 10(1): 73-76.

Nair, S.A. and Bharathi, T.U. 2019. Standardization of substrate composition for pot plant production of tuberose var. Arka Sugandhi. *Int. J. Curr. Microbiol. Appl. Sci*. 8(1): 2197-2203.

Nambiar, N., Siang, T.C., and Mahmood, M. 2012. Effect of 6-Benzylaminopurine on flowering of a *Dendrobium* orchid. *Aust. J. Crop Sci*. 6(2): 225-231.

Nilawonk, W. and Tancho, A. 2015. Influence of vermicompost and compost application to the growth and yield of jasmine and rose in Chiang Mai, Thailand. In*: 2nd International Conference on Agriculture, Environment and Biological Sciences,* 16-17 Aug.2015, Bali, Indonesia. pp. 6-10.

Padaganur, V.G., Mokashi, A.N., and Patil, V.S. 2005. Effect of growth regulators on growth and yield of tuberose cv. Single. *Karnataka J. Agric. Sci*. 18(2): 469-473.

Padhiyar, B.M., Bhatt, D.S., Desai, K.D., Patel, V.H., and Chavda, J.R. 2017. Influence of different potting media on growth and flowering of pot chrysanthemum var. Ajina Purple. *Int. J. Chem. Stud*. 5(4): 1667-1669.

Pandey, S.K., Kumari, S., Singh, D., Singh, V.K., and Prasad, V.M. 2017. effect of biofertilizers and organic manures on plant growth, flowering and tuber production of dahlia (*Dahlia variabilis* L.) Cv. S.P. Kamala. *Int. J. Pure Appl. Biosci*. 5(2): 549-555.

Parmar, A.R., Chovatia, R.S., and Karetha, K.M. 2015. Effect of plant growth regulators on flower yield, vase life and economics of dutch rose (*Rosa hybrida* Linn) cv. Passion under polyhouse condition. *The Asian J. Hortic*. 10(2): 286-291.

Patil, A., Chopde, N., Jadhav, J.G., and Gore, K.S. 2014. Effect of growth regulators and methods of application on growth, yield and quality of gladiolus. *J. Soils Crops*. 24(1): 99-103.

Patil, B. R., Gohil, K. B., and Vaghasiya, P.M. 2003. Response of Gladiator rose to fan and pad cooled greenhouse under humid climate of Navsari. *All India Seminar on Potential and Prospects for Protective Cultivation*. pp. 113-116.

Patil, S.J. 2001. Effect of different growth regulators on growth and flowering of gerbera (*Gerbera jamesonii* Bolus) cv. Sangria. MSc(Hort) thesis, N.A.U, Navasari.

Pooja, D., Gupta, N.K., Bhadouria, R.S., and Ajay, H. 2017. Effect of growing media on growth and flowering of cut roses under the protected environmental conditions. *Int. J. Microbiol. Res*. 9(2): 861-863.

Prasad, L., Saravanan, S., Lall, D., and Singh, V.K. 2017. Effect of organic manure and inorganic fertilizers on plant growth and flower yield of Asiatic Lily (*Lilium longiflorum*) Sp. Zephyranthes. *Environ. Ecol.* 35(2A): 929-932.

Priya, K., Kannan, M., and Kumar, S.R. 2015. Studies on the influence of growing media consortia for the production of quality flowering annuals in pots. *Int. J. Trop. Agric*. 33(2): 956-958.

Raja, E.M. 2000. Fertigation for flower crops. In: *Compendium of lectures on protected cultivation of ornamental crop*. 12-22 Sept. 2000, Bangalore. IIHR, Bangalore.

Rajasekar, P. and Suresh, J. 2015. Effect of different growing media on growth of pot grown rose (*Rosa chinensis* Jacq.). *Res. Environ. Life Sci*. 8(3): 477-478.

Rajasekar, P., Suresh, J., and Rajadurai, K.R. 2017. Effect of potting media composition for flowering in pot grown rose (*Rosa chinensis* Jacq.). *Environ. Ecol*. 35(2A): 873-876.

Rajera, S. and Sharama, P. 2017. Effect of different growing media on bulb production of LA hybrid lily. *Chem. Sci. Rev. Lett*. 6(23): 1382-1387.

Ramalingam, K. 2008. Effect of growth regulating substances on growth, yield and post harvest quality of cut Rose cv. Happy Hour, MSc(Hort) thesis, Tamil Nadu Agricultural University, Coimbatore.

Ramesh, M. and Kumar, R. 2000. Effect of pruning height, shading and polythene covering on growth and flower production of rose cv. Raktagandha. *J. Ornam. Hortic*. 3(2): 94-99.

Ramtin, A., Kalatejari, S., Naderi, R., and Matinizadeh, M. 2015. Effect of pre-harvest foliar application of benzyl adenine and salicylic acid on carnation cv. spray and standard. *Biol. Forum Int. J*. 7(2): 955-958.

Ranpise, S. A., Patil, S. B., Chougule, A.A., Shinde, S. B., and Gaikwad, A.G. 2008. Performance of Dutch roses under polyhouse condition. In: *National symposium on recent advances in floriculture*, Navasari Agricultural University, Navasari.

Rao, A.V.D.D. 2010. Standardisation of production technology in garland chrysanthemum (*Chrysanthemum coronarium* L.), Ph.D(Hort) thesis, University of Agricultural Sciences, Dharwad.

Riaz, A., Arshad, M., Younis, A., Raza, A., and Hameed, M. 2008. Effect of different growing media on growth and flowering of *Zinnia elegans* cv. Blue Point. *Pakist. J. Bot*. 40(4): 1579-1585.

Roberts, A.V., Black, P.S., Taylor, J.M., and Dunstan, D.I. 1999. The effect of gibberellins on flowering in roses. *J. Plant Grow. Reg*. 18: 113-119.

Sable, P.B., Ransingh, U.R., and Waskar, D.P. 2015. Effect of foliar application of plant growth regulators on growth and flower quality of Gladiolus cv. ‘H.B.Pitt’. *J. Hortic*. 2(3): 141-143.

Saffari, V.R., Khalighi, A., Lesani, H., Babalar, M., and Obermaier, J.F. 2004. Effect of different plant growth regulators and time of pruning on yield components of *Rosa damascena* Mill. *Int. J. Agric. Biol*. 6(6): 1040-1042.

Said, R.M. 2016. Response of sky flower (*Duranta erecta* L. var. *Variegata*) transplants as pot-plant to growing media and water amounts. *Middle E. J. Agric. Res*. 5(2): 201-207.

Sainath. 2009. Influence of spacing, fertilizer and growth regulators on growth, seed yield and quality in annual chrysanthemum (*Chrysanthemum coronarium* L.). MSc(Ag) thesis, University of Agricultural Sciences, Dharwad.

Sajid, M., Rab, A., Khan, I.A., Jan, I., Amin, N.U., Mateen, A., Usman, H., Alam, M., and Shah, S.T. 2018. The pre-harvest foliar application influenced the flower quality and vase life of chrysanthemum cultivars. *Hortic. Int. J*. 2(4): 145–152.

Sangma, P.M., Dhiman, S.R., Thakur, P., and Gupta, Y.C. ,2016. Effect of covering materials on off-season cut flower production in chrysanthemum (*Dendrathema Grandiflora*). *Indian J. Agric. Sci.* 86(4): 522-526.

Sangma, Z.C.K., Singh, D., and Fatmi, U. 2017. Effect of plant growth regulators on growth, yield and flower quality of Gerbera (*Gerbera jamesonii* L.) cv. Pink Elegance under naturally ventilated polyhouse. *Int. J. Curr. Microbiol. Appl. Sci*. 6(10): 468-476.

Sekar, K. and Sujata, A. 2001. Effect of growing media and GA_3 on growth and flowering of gerbera (*Gerbera jamesonii* H. Bolus.) under naturally ventilated greenhouse. *S. Indian Hortic*. 49(Spec.): 338-341.

Shilpa, P. 2017. Refinement of nutrient management practices in *Dendrobium* orchids. MSc(Hort) thesis, Kerala Agricultural University, Thrissur, 62p.

Singh, A.K. 2006. Effect of farmyard manure, *Azotobacter* and nitrogen on leaf nutrient composition, growth, flowering and yield in rose. *Indian J. Hortic*. 63(1): 62-65.

Sisodia, A. and Singh, A.K. 2015. Effects of farmyard manure, vermicompost and *Trichoderma* on flowering and corm attributes in gladiolus. *Bangladesh J. Bot*. 44(2): 309-314.

Smitha, R., Rajendran, P., Sandhya, P.T., Aparna, V. S., and Rajees, P.C. 2017. Insect pest complex of rose at Regional Agricultural Research Station, Ambalavayal, Wayanad. *Acta Hortic*. 1165(6): 39-44.

Subbiah, B.V. and Asija, C.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci*. 25: 259–260.

Suresh, K.P., Bhagawat, R., Rajiv, K., and Ronya, T. 2008. Effect of plant growth regulators on vegetative growth, flowering and corm production of gladiolus in Arunachal Pradesh. *J. Ornam. Hortic*. 11(4): 265-270.

Svenson S.E. 1990. Branching of *Verbena liners* is influenced by cytokinin application during cutting propagation. *Proc. Fla. State Hortic. Soc*. 103: 201-203.

Swarupa, N., Lakshminarayana, D., Prasanth, P., and Naik, D.S. 2019. Influence of different combinations of media and biofertilizers on flowering and quality of gerbera cv. Natasha under protected conditions. *Int. J. Curr. Microbiol. Appl. Sci*. 8(4): 2805-2812.

Tariq, U., Rehman, S., Khan., M.A., Younis, A., Yaseen, M., and Ahsan, M. 2012. Agricultural and municipal waste as potting media components for the growth and flowering of *Dahlia hortensis* cv. ‘Figaro’. *Turk. J. Bot*. 36: 378-385.

Teitel, M., Barvak, M, Ben Yaakou, E., Gatken, J., Tanny, J., and Cohen, S. 2007. Comparing greenhouse natural ventilation to fan and pad cooling. *Acta Hortic*. 761(2): 33-39.

Thakur, T., Grewal, H.S., and Kukal, S.S. 2018. Impact of growing medium composition on morphological development of chrysanthemum (*Chrysanthemum morifolium* Ramat cv. Snowball). *Curr. Sci*. 115(6): 1198-1203.

Thangam, M., Ladaniya, M.S., and Korikanthimath, V.S. 2009. Performance of gerbera varieties in different growing media under coastal humid conditions of Goa. *Indian J. Hortic*. 66(1): 79-82.

Tirkey, P., Kullur, L.R., and Prasad, V.M. 2017. Effect of organic and inorganic source of N,P,K on growth and yield parameters of gladiolus (*Gladiolus grandiflorus*) cv. Jester. *J. Pharmacognosy Phytochem*. 6(5): 1004-1006.

Turhan, H., Kahriman, F., Egesel, C.O., and Gul. M.K. 2007. The effect of different rooting media on the flowering and corm formation of saffron (*Crocus sativus* L.). *Afr. J. Biotechnol.* 6: 2328-2332.

Vaishisth, S., Chandel, Y.S., and Kumar, S. 2013. Observations on insect-pest problems of polyhouse crops in Himachal Pradesh. *J. Ent. Res*. 37(3): 253-258.

Vasudevan, V. and Kannnan, M. 2015. Effect of bending and plant growth regulators on maximising the yield and quality of rose (*Rosa hybrid* var. Tajmahal) under greenhouse conditions. *Prog. Hortic*. 47(2): 275-279.

Verma, V.K. 2003. Response of foliar application of nitrogen and gibberellic acid on growth and flowering of carnation (*Dianthus caryophyllus* L.). *Himachal J. Agric. Res*. 29(1&2): 59-64.

Yasmeen, S., Younis, A., Rayit, A., Riaz, A., and Shabeer, S. 2012. Effect of different substrates on growth and flowering of *Dianthus caryophyllus* cv. ‘Chauband Mixed’. *Am.-Eur. J. Agric. Environ. Sci*. 12(2): 249-258.

Appendix

APPENDIX I

Meteorological data during the period of observation from July 2018 to June 2019 inside the rain shelter

Months of observation	Temperature(^{0}C)	Relative Humidity (%)	Light Intensity* (lux)
July	30.03	95.00	56.18
August	28.12	85.60	59.23
September	32.68	59.96	109.66
October	31.42	69.91	89.11
November	30.88	63.01	82.38
December	31.27	57.81	91.16
January	30.13	46.58	105.12
February	26.33	43.83	88.69
March	34.60	42.77	143.77
April	34.61	48.60	215.92
May	33.54	63.44	257.83
June	31.76	69.08	256.00

STANDARDIZATION OF GROWING MEDIA AND GROWTH REGULATORS FOR ROSE (*Rosa* spp.) UNDER TOP VENTILATED RAIN SHELTER

By

SIJO JOHN
(2017 - 12 - 018)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture
(FLORICULTURE AND LANDSCAPING)

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF FLORICULTURE AND LANDSCAPING
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2019

ABSTRACT

Rose is acclaimed as 'Queen of flowers' because of its colour, fragrance and elegance. Cut roses are having very high demand in domestic as well as international market due to versatile uses. Roses can be successfully cultivated under top ventilated rain shelters in Kerala. Soilless media consist of vermiculite, perlite, and rockwool are popularly used for commercial production of rose under protected condition. These are costly and not easily available to farmers. Thus, there is a need to develop a cost effective growing media with locally available materials. Exogenous application of plant growth regulators improves the yield and quality of cut flowers by manipulating hormonal regulations in the plant system. Even though commercial formulations of different growth regulators are available in the market, the type and precise concentration of growth regulators are to be standardised. Hence the present study entitled "Standardization of growing media and growth regulators for rose (*Rosa* spp.) under top ventilated rain shelter" was carried out in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara during 2018-2019. Objective of the study was to standardize growing media and growth regulators for commercial production of cut roses in agroclimatic conditions of Kerala.

The experiment consisted of twelve treatments, which included different combinations of three growing media *viz*; soil + M-sand + cocopeat + FYM (M_1), soil + M-sand + cocopeat + vermicompost (M_2) and soil + M-sand + cocopeat + poultry manure (M_3) in 2:1:1:1 ratio and two levels each of two growth regulators *viz*; Benzyl adenine (BA) and Gibberellic acid (GA) at 200 and 250 ppm. Six months old grafts of rose variety 'Tajmahal' was used for the study. Observations on growth characters, yield, post harvest aspects as well as nutrient status of the growing media were recorded.

With regard to vegetative characters, growing media, growth regulators and interaction between growing media and growth regulators had significant influence during the period of observation. Growing media containing FYM (M_1) recorded the greatest plant height and was on par with growing media containing

vermicompost (M_2). Among growth regulators, GA 250 ppm was found to be superior in terms of plant height. With respect to interaction effect, greatest plant height was observed under the media containing FYM (M_1) and GA at 250 ppm. Plant spread was highest under medium containing FYM (M_1). Growth regulators had significant influence on plant spread and BA at 200 and 250 ppm were superior and on par in terms of this parameter. Regarding interaction, growing media containing FYM (M_1) along with 200 ppm BA was observed to have the highest plant spread during the growth period.

Media containing FYM (M_1) as well as vermicompost (M_2) were found to produce more number of branches and among growth regulators, BA at 200 and 250 ppm were on par and superior with respect to this parameter. Regarding interaction effect, highest number of branches was observed under growing media containing FYM (M_1) and BA at 200 ppm.

Significant effects of growing media could be observed on floral characters and media containing FYM (M_1) was found to be superior with respect to floral characters *viz*; length of flower bud (3.37 cm), diameter of flower bud (2.16 cm), number of flowers /plant (5.04), number of petals/ flower (51.92), stalk length (47.94 cm) and flower diameter at fully opened stage (8.44 cm). Growing media containing FYM (M_1) and growing media containing vermicompost (M_2) were on par in terms of other floral characters *viz*; length of flower shoot, neck girth and stalk girth of flower.

With respect to the influence of growth regulators on floral characters, a greater number of flowers/plant (5.38 and 5.10) as well as largest flowers at fully opened stage (8.33 and 7.99 cm) were observed under BA at 200 and 250 ppm. Stalk length of the flower was found to be maximum under GA at 200 ppm (47.92 cm). Highest length of flower shoot was observed in GA at 200 ppm and BA at 200 ppm which were on par with each other (38.79 and 36.94 cm respectively). Growing media and growth regulator interaction had significant influence on floral parameters *viz*; stalk length and number of petals per flower. Media containing FYM (M_1) with GA 200 as well as 250 ppm were found to have maximum stalk length (52.48 and 50.09 cm respectively). Highest number of petals were observed under media containing FYM (M_1) along with BA 200 and 250 ppm, media containing FYM (M_1) along with GA 200 and 250 ppm, media containing vermicompost (M_2) along with BA 200 ppm and GA 200 ppm as well as media containing poultry manure (M_3) along with BA 200 ppm. Early initiation of flower bud was observed under media containing FYM (M_1) along with BA 250 ppm (119.22 days).

Regarding post harvest characters, media containing FYM (M_1) was superior in terms of fresh weight of flower (16.36 g), total water uptake (49.48 ml) and vase life (8.46 days). Among growth regulators BA 200 ppm had longest vase life which was on par with GA at 200 ppm. Maximum fresh weight was observed under BA 200 ppm (15.17g). With regard to interaction effect, treatment combination of FYM + BA at 200 was found to have maximum vase life and fresh weight of flower (9.38 days and 18.71g respectively).

Considering overall performance, growing media combination of soil + M-sand + cocopeat + FYM (2:1:1:1) along with monthly application of BA at 200 ppm can be recommended for commercial cultivation of rose under protected condition in Kerala.