# STANDARDIZATION OF GROWING MEDIUM AND GROWTH RETARDANTS FOR COMPACT GROWTH OF POTTED AFRICAN MARIGOLD


**By**

**NIRANJANA GOPAL**

**(2019-12-030)**

**DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE**

**COLLEGE OF AGRICULTURE**

**VELLANIKKARA, THRISSUR – 680656**

**KERALA, INDIA**


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**THESIS**

**MASTER OF SCIENCE IN HORTICULTURE**

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# DECLARATION

I hereby declare that this thesis entitled **"Standardization of growing medium and growth retardants for compact growth of potted African marigold "** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
30.11.2021

**Niranjana Gopal**
(2019-12-030)

# CERTIFICATE

Certified that this thesis entitled **"Standardization of growing medium and growth retardants for compact growth of potted African marigold"** is a record of research work done independently by **Niranjana Gopal (2019-12-030)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associate ship or fellowship to her.

Vellanikkara
30-11-2021

**Dr. Mini Sankar**
(Chairman, Advisory committee)
Assistant Professor
AICRP on Floriculture
Department of Floriculture and Landscape Architecture
College of Agriculture, Vellanikkara

# CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Niranjana Gopal (2019-12-030)** a candidate for the degree of **Masters of Science in Horticulture,** with major field in Floriculture and Landscape Architecture agree that the thesis **"Standardization of growing medium and growth retardants for compact growth of potted African marigold"** may be submitted by **Ms. Niranjana Gopal (2019-12-030),** in partial fulfillment of the requirement for the degree.

30/11/2021

**Dr. Mini Sankar**
(Chairman, Advisory committee)
Assistant Professor
AICRP on Floriculture
Department of Floriculture and Landscape Architecture
College of Agriculture, Vellanikkara

**Dr. U. Sreelatha**
(Member, Advisory committee)
Professor and Head
AICRP on Floriculture
Department of Floriculture and Landscape Architecture
College of Agriculture, Vellanikkara

30/11/2021

**Dr. P. Prameela**
(Member, Advisory committee)
Professor and Head
Department of Agronomy
College of Agriculture, Vellanikkara

Resmi Paul
30/11/2021

**Dr. Resmi Paul**
(Member, Advisory committee)
Assistant Professor
Department of Floriculture and Landscape Architecture
College of Agriculture, Vellanikkara

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## LIST OF ABBREVIATION AND SYMBOLS USED

| Symbols | Abbreviation |
|---|---|
| *et al.* | And others |
| CRD | Completely randomized block design |
| CD | Critical difference |
| Var. | variety |
| $^0$C | Degree Celsius |
| FYM | Farm Yard Manure |
| CCC | Cycocel |
| PBZ | Paclobutrazol |
| g | gram |
| cm | Centimeter |
| $cm^3$ | Cubic centimeter |
| L | Litre |
| ml | Milli litre |
| v/v | Volume by volume |
| Rs | Rupees |
| NS | Non significant |
| SE(m) | Standard error mean |
| dS/m | Deci Siemens per metre |
| % | Percent |
| @ | At |
| & | And |
| *Viz.* | Namely |
| ie, | That is |

# INTRODUCTION

# Chapter 1

# INTRODUCTION

Floriculture is the fastest growing segment of horticulture which include production and marketing of commercial flowers, cut foliage, potted flowering and foliage plants, seeds and other planting materials. Present trend in floriculture is the production and marketing of potted plants. The main advantages of potted plants are compactness, easy transportation and suitability for instant gardening.

African marigold (*Tagetes erecta* L.) is one of the most popular and commercial flowering annuals cultivated throughout the world. It belongs to the family Asteraceae. Because of ease in cultivation, flexibility to wide soil and climatic conditions, long span of blooming and appealing blooms, marigold is utilized for various landscaping purposes like bedding, edging and also as potted plants. It is one of the most popular and commercial flowering annuals cultivated in most of the states in India. It has great demand during various festivals for garlands, as cut and loose flowers, for decorative purposes *etc*. It is also being used for various industries like perfumery, cosmetics and pharmaceuticals. It is also a source of carotenoid pigment for poultry feed to intensify yellow colour of egg yolks and broiler skin. Apart from the poultry industry, marigold dye is also used in textile and food supplements and has advantage over synthetic dyes in terms of safety and eco-friendly nature. The principle pigment in the flower is xanthophyll particularly lutein which accounts for more than 80-90% and it is present in the form of esters of palmitic and myristic acid (Naik *et al*., 2004). In India, the extraction of carotenoids on commercial scale is being done in Kerala and Andhra Pradesh.

Potting media play an important role in growth, compactness and flowering of potted plants. They should have properties such as good drainage, water holding capacity, good aeration, light weight and free from disease causing organisms, insects and weed seeds. Even though soil is the most commonly used potting media component, it is heavier and there is a risk of soil borne pathogens. Light weight media are desirable for easy handling of potted plants.

Profuse flowering and compact growth determine the attractiveness of potted ornamental flowering plants. Height control is very essential for compact growth. Nowadays growth regulator application has become an essential practice in floriculture industry. Plant growth retardants are being used by the growers to restrict the stem inter-nodal length to desired level and to hasten the flowering. Plant growth retardants are synthetic compounds used to retard the shoot length of the plants in a desired way without changing developmental patterns (Rajiv *et al*.,2018).

In Kerala, the utilization of potted flowering plants has become a recent trend in exhibitions and flower displays. One of these is the potted African marigold, which is commonly used for exhibitions, flower shows, and decorations. Hence it is imperative to standardize an alternate light weight medium and appropriate plant growth retardant and its rate of application for compact growth.

So the present study was conducted with the objective of standardization of growing medium and growth retardants for regulating growth of potted African marigold for display purpose.

# REVIEW OF LITERATURE

# Chapter - 2

# REVIEW OF LITERATURE

African marigold (*Tagetes erecta*) is one of the most popular and commercial flowering annuals cultivated throughout the world. It is grown for loose flower purpose as well as potted bedding plant. Among various factors affecting growth and yield of ornamental flowering plants, growing media play a vital role. Compact growth is very important with respect to potted plants and nowadays various chemicals are used to induce compact growth in potted ornamentals. Literature pertaining to the effect of growing media and growth retardants on compact growth of potted ornamental flowering plants are reviewed here.

## 2.1 GROWING MEDIA

Growing media is the material which is organic or inorganic material that provides anchorage to the plants by holding the root system. It gives the plants the vital nutrients needed for metabolism, growth, and development.

### 2.1.1 Effect of soil based media on potted ornamental flowering plants

Soil is one of the major ingredients of growing media. It is inexpensive and simple to use. On an average most soils consist of 50 percent air and water, 46-49 percent mineral particles and 1-6 percent organic matter. Sand (0.05-2 mm), silt (0.002-0.05 mm) and clay (less than 0.002 mm) are the mineral particles found in soil.

Sekar and Sujata (2001) investigated the effects of five different growing substrates on the growth and flowering of *Gerbera jamesonii* Cv. Mammut grown in pots and observed significant positive results with respect to number of flowers, flower stalk length, flower diameter and vase life in medium containing coir pith, garden soil and FYM (1:1:1 v/v).

Zinnia cv. Blue Point, cultivated in medium containing soil, leaf manure, coconut pith compost (1:1:1 v/v) produced flowers with superior characters *viz*. more flower diameter, stalk length and number of flowers per plant (Riaz *et al*.,2008).

Kulkarni (2016) analyzed different growing media in gerbera and found that a mix of cocopeat (40%), red soil (30%), farm yard manure (20%), and sand (10%) was superior in terms of plant height, number of functional leaves, leaf area, leaf area index, number of days to first bud emergence, number of days to flower development, number of days to first harvest, number of flowers per plant, flower diameter, flower stalk length, diameter of flower stalk and vase life.

Kumar *et al.* (2016) reported that soil and vermicompost in 1:1 proportion is ideal for better rooting of marigold shoot cuttings.

### 2.1.2 Effect of cocopeat on potted ornamental flowering plants

Cocopeat is the non-fibrous, spongy, light weight, corky material that holds together the coir fibre in coconut husk. Cocopeat being sustainable and eco-friendly, is used as an ingredient in potting media to improve the moisture retention capacity and buffering capacity of the potting media. Because of its lightness, durability and aeration, it is gaining popularity among growers as a top component in growing medium. Cocopeat is a light weight material with high total porosity, high moisture retention capacity (600-800%), slightly acidic pH, CEC ranging between 32-95 mEq /100g and C/N ratio of 117. It contain low amount of N, Ca and Mg but having high P and K levels (Noguera *et al*., 2000). With the growth of commercial horticulture, decrease in the supply of good quality soil, has recently become a problem. Cocopeat has been recognized as an integral part of container-grown horticultural plants.

Yahya *et al*. (1997) reported that cocopeat and sand in 2:1 ratio recorded the maximum plant height, plant fresh weight, days to flower bud appearance and number of flowers in marigold.

Gupta *et al*. (2004) experimented with growing media under protected environmental condition for gerbera. Cocopeat, sawdust and sand (1: 1: 1) was found to be the best for enhancing flower size, stalk length, number of blooms per plant, number of blooms per $m^2$ and vase life.

Kashyap *et al*. (2005) studied the effect of different combinations of cocopeat, leaf mould, municipal solid waste, organic manure and soil on *in vitro* multiplied gloxinia (*Sinningia speciosa)* and African violet (*Saintpaulia ionantha*). Based on their findings, cocopeat, leaf mould and municipal solid waste in 1:1:1 ratio was recommended as a growing medium for maximum growth and flowering of gloxinia and African violet plants.

Srinivasa (2006) evaluated different growing media for *Anthurium andreanum* cv. Hondura and an improvement in plant height, canopy width, leaf length and leaf width were observed in medium containing cocopeat alone, than other growing media.

The use of growing media containing 40% cocopeat and 60% kenaf core fibre resulted in a faster rate of development of stem, canopy, leaves and flowers in *Celosia cristata* (Awang *et al*., 2010).

Ankita *et al.* (2010) reported that Dutch rose cv. Naranga planted in cocopeat and leaf mould (1:1) medium produced taller plants, longer shoots, more leaves and more leaf area than the other treatments.

Anwar *et al*. (2012) undertook a study to evaluate the influence of different soilless and soil-based media on growth, yield, and bloom quality of *Tagetes erecta* under controlled environmental conditions and observed that cocopeat had the highest plant height, number of side branches, number of flowers, stem thickness before bloom, flower diameter and total yield among the treatments.

According to Basheer and Thekkayam (2012) a study on cultivation of anthurium on coir pith and sand based medium resulted in improvement in growth parameters *viz.* plant height, leaf area, petiole length, fresh and dried leaf weight, bloom quantity per plant, spathe size, flower stem length, flower thickness and vase life.

Panj *et al*. (2012) studied the effect of different growing media with soil, sand, FYM, vermicompost, cocopeat and rice husk on the vegetative growth, yield and quality of gerbera ( *Gerbera jamesonii*). The findings indicated that a blend of cocopeat, rice husk and FYM (1:2:1) is ideal for producing good quality gerbera plants for various landscape purposes and cut flower production.

Thakur *et al.* (2013) conducted an experiment to evaluate different organic growing media on growth and flowering of *Calendula officinalis*. The results revealed that growing medium containing cocopeat and vermicompost (1:1) was the best in which maximum plant height, plant spread, flower size and early bud appearance were observed.

According to Muraleedharan and Karuppaiah (2015), potting media containing cocopeat and coconut husk enhanced plant height, plant spread, number of flowers per plant, flower stalk length, spathe length and width of spathe in anthurium grown under 75 percent shade.

A potting medium made up of equal parts of cocopeat, FYM and sand produced the greatest plant height, spread, inflorescence per plant, flowering time and pot presentability in *Primula malacoides* (Gupta and Dilta, 2015).

Giree and Shrestha (2018) conducted a comparative study of marigold (*Tagetes erecta*) in soil and soilless media. Out of the six different treatments, growing medium with 60% cocopeat, 25% compost, 10% perlite, 5% rice husk and 168 g hydrogel recorded the highest mean plant height, leaf number, number of buds and number of flowers and suggested that soilless media consisting of cocopeat, compost, perlite, rice husk in a ratio with hydrogel can be considered the most suitable media to grow marigold in pots.

Singh (2018) found that the medium containing cocopeat and vermicompost (1:1) was the best for gerbera in which minimum days for first flower bud appearance, maximum plant height, plant spread, number of leaves, length and girth of flower stalk, flower diameter, number of flowers, number of ray florets and length of ray florets were observed.

Thakur *et al.* (2018) observed that a growing medium comprising of cocopeat and farm yard manure in 2:1 ratio improved vegetative characters such as plant height, number of leaves, number of roots and number of suckers in *Chrysanthemum morifolium* cv. Snowball.

Lalmuanpuii *et al.* (2021) studied the effect of different growing media in the growth, flowering and yield of gerbera (*Gerbera jamesonii*) and treatment containing cocopeat alone was shown to be the most promising in terms of plant height, plant spread, number of leaves, flower diameter, flower stalk length, flower stalk girth, vase life and flower yield.

### 2.1.3 Effect of vermicompost on potted ornamental flowering plants

Vermicompost is the end product of the breakdown of organic matter by the earthworm. This is an odorless, clean, organic material containing adequate quantities of N, P, K and several micro nutrients essential for plant growth. Vermicompost is rich in beneficial micro flora such as N-fixers, P- solubilizers, cellulose decomposing micro-flora and it also contain plant growth regulators such as auxins and gibberellins. It improves structure, texture, aeration, and water holding capacity of growing medium.

Chamani *et al.* (2008) examined the effects of conventional base medium consisting of a mixture of 70% farm soil and 30% sand combined with cocopeat at 30 and 60% as well as vermicompost 20, 40 and 60% on the development and blooming of *Petunia hybrida* 'Dream Neon Rose' under glasshouse conditions. They found that when petunias were grown on vermicompost containing media, they exhibited an improvement in number of blooms, leaf growth, fresh weight of shoots and dry weight of shoots, compared to both control and peat containing media.

Shadanpour *et al*. (2011) observed that vermicompost, sand and soil (60: 30: 10) improved the stem diameter, flower size, shoot fresh and dry weight in marigold cv. Tishan.

According to a research conducted by Moghadam *et al.* (2012), adding 30% vermicompost into growing medium resulted in the production of bigger flowers in *Lilium asiaticum* hybrid Var Navona.

Sardoei *et al.* (2014) investigated the effect of vermicompost on the growth and flowering of African marigold (*Tagetes erecta*) grown on a traditional base medium containing farm soil and sand in 7:3 proportion with treatments consisting of 10, 20, 30, 40, 50 and 60% vermicompost incorporated into the base medium. Plant performance was observed to be optimum at 60% and had a substantial favourable effect on flower quality, leaf growth, number of flowers, fresh and dry weight of shoots.

Gupta *et al.* (2014) found that increasing the concentration of vermicompost in potting media increased growth and yield parameters in marigold (*Tagetes erecta*), such as plant biomass, plant height, number of buds and flowers.

Rajvanshi and Dwivedi (2014) observed that a medium consisting of vermicompost, coarse sand and soil in 3:2:2 ratio was the most effective for enhancing vegetative and floral characteristics in zinnia.

Nair and Bharathi (2015) conducted an experiment on the effect of growing medium on potted chrysanthemum production cv. Sadhbhavana and found that cocopeat, sand and vermicompost in 2:1:1 ratio was the best growing media resulting in the greatest number of flowers per plant and the longest flowering duration.

Alvarez *et al.* (2017) conducted a comparative study to determine the suitability of vermicompost and biochar as partial substitutes for cocopeat-based growing medium for geranium (*Pelargonium peltatum*) and petunia (*Petunia hybrida*) production. The results showed that medium containing 30% vermicompost and 12% biochar promoted growth and blossom production in both flower crops.

Lokhande *et al.* (2019) conducted a field investigation on the performance of marigold rooted cutting raised on different combination growing media *viz.* soil and sand (1:1), soil and vermicompost (1:1), soil and FYM (1:1), sand and vermicompost (1:1), sand and FYM (1:1), soil, sand and vermicompost (1:1:1) and soil, sand and FYM (1:1:1). The results revealed that the performance of transplanted marigold plants with respect to the yield parameters such as weight of the flower/plant, number of flowers/plant, flower yield/plant were maximum in the plants obtained from the vermicompost media.

### 2.1.4 Effect of farm yard manure on potted ornamental flowering plants

The most common of organic manure applied to plants is farmyard manure, which is a variable mixture of animal dung, urine, bedding material, feed leftovers and other components. Farmyard manure has a high proportion of organic material which nurtures soil organisms and is essential for maintaining an active soil life. The high organic matter content and the active soil life improve or maintain friable soil structures, increase the cation exchange capacity, water holding capacity, infiltration rate and reducing the risk of soil pests building up.

Wazir *et al*. (2009) studied the efficacy of five growing media with soil, sand, cocopeat, vermicompost and FYM (1:1:1:1:1), soil, sand, Municipal solid waste (MSW), leaf mould and FYM (1:1:1:1:1), cocopeat, sand, vermicompost and FYM (1:1:1:1), cocopeat, sand, MSW and FYM (1:1:1:1) and soil, sand and FYM (1:1:1) as control for potted plant production of three alstroemeria cultivars. The best results for vegetative, flowering and pot presentability attributes such as days of flower bud formation, plant height and duration of flowering of all three cultivars were reported in the growing medium comprising of soil, cocopeat, vermicompost, sand and FYM (1:1:1:1).

Best growth, flowering and pot presentability of geranium was reported in growing medium containing forest soil, FYM and Vermicompost in 2:1:1 ratio (Singh *et al.,* 2010).

Ikram *et al.* (2012) observed that tuberose grown in medium containing sand and FYM (1:1) improved the characteristics such as plant spread and number of leaves, whereas plant height, leaf area and length of spike recorded were maximum in the medium containing coirpith and FYM (1:1).

Riaz *et al.* (2014) reported more number of flowers per branch, leaf area, number of roots, fresh weight of plant and dry weight of plants cultivated in FYM incorporated silt - topsoil combination under protected cultivation in G*erbera jamesonii* cv. Hybrid.

Rajasekhar and Suresh (2015) found that miniature roses grown in soil and farm yard manure (FYM) combination had the highest plant height and spread. They also found that in potting media made up of soil, farm yard manure and leaf manure, the number of branches per plant was higher.

Nair and Bharathi (2019) conducted an experiment to standardize substrate composition for pot plant production of tuberose Var. Arka Sugandhi. The substrate combination of Arka fermented cocopeat, soil, sand and FYM in 1:1:1:1 ratio was found to be the most ideal medium for tuberose pot plant production with highest number of spikes per plant and spike longevity.

**2.1.5 Effect of vermiculite on potted ornamental flowering plants**

Vermiculite is a naturally occurring micaceous mineral that expands when heated. It is made up of hydrated magnesium, aluminum-iron silicate and water. Vermiculite is a good soil conditioner and an excellent growing medium for hydroponics when used as a blend with perlite. Vermiculite is sterile and has high water holding capacity and it is one of the popular substrate used for propagation and greenhouse cultivation. Vermiculite has excellent exchange and buffering capacities as well as the ability to supply potassium and magnesium.

Manish *et al* (2000) studied the effects of different growing media on the proliferation of bulb scales in lilium cv. Chianti. Bulb scales were grown in media containing sawdust, soil and sawdust (1:1), moss grass, perlite, vermiculite, sawdust and moss grass (1:1) and sand. Vermiculite considerably increased the width, number of leaves, root length, number of bulblets/scale and weight of the bulblets compared to the other treatments.

Sindhu *et al.* (2010) found that a soilless substrate of cocopeat, vermiculite and perlite in 4:1:1 ratio supplemented with a soil conditioner (Samridhi) was excellent for gerbera cut flower production under protected conditions.

Thakur *et al.* (2018) investigated the effect of media composition on the blooming of *Chrysanthemum morifolium* cv. Snowball and they reported that maximum flower diameter and long duration of flowering was observed in vermiculite-based medium containing farm yard manure in 2:1 ratio.

Al Mazroui *et al.* (2020) evaluated the effects of capillary barrier structured potting media on the growth and physiology of marigold under salinity stress. The substrates employed in these configurations were vermiculite (V), perlite (P), sand (S) and peat moss (PM) piled in three layers from top to bottom in a pot ie, V-P-V, V-S-V, and V-P-PM. Four salinity levels of irrigation water were applied to each of the three configurations. The results showed that salinity adversely affected the vegetative, reproductive and physiological parameters of marigold. However, the best growth of marigold was for those grown in the layered V-S-V media.

**2.1.6 Effect of rice husk on potted ornamental flowering plants**

Rice husk is a valuable by product of the paddy rice milling process. Rice hulls, despite their small weight are highly effective in improving drainage and provide optimum pore space and reduced bulk density. Rice husk has a large amount of amorphous silica and it is a natural and sustainable biomass source for extracting silica.

An improvement in stalk length, stalk thickness, stalk diameter and number of flowers/$m^2$ were observed in gerbera cultivars when grown in medium containing red soil, FYM, sand and rice husk in 3:3:3:1 proportion ( Kadam *et al*., 2005).

Meng *et al.* (2012) conducted an experiment to investigate the effect of different growing media on the growth of *Gerbera jamesonii* growing under high-tunnel. The results revealed that rice husk, peat and sand (3:1:1) was the best growing media in terms of leaf number, leaf length, leaf width, crown width, plant height, peduncle length, peduncle diameter, flower diameter and vase life.

A blend of cocopeat, rice husk and FYM (1:2:1) was found to be the best for producing good quality gerbera plants for various ornamental uses in landscaping and cut flower production (Panj *et al*., 2012).

Chauhan *et al.* (2014) conducted an experiment to study the effect of different growing media on growth, flowering and cut flower yield in gerbera (*Gerbera jamesonii*) cv. Alcochete under protected conditions. The results revealed that the growing medium amended with normal soil, rice husk, coco peat, castor cake and vermicompost (1:1:1:1:1) was ideal for improvement of vegetative characters such as plant height, plant spread, number of leaves and number of suckers. Similar trend was also noted for flowering characters such as diameter of flower, length of flower stalk, thickness of flower stalk, number of ray florets, longevity and vase life.

According to Hohn *et al.* 2018, in *Gypsophylla paniculata,* 100 percent carbonated rice husk medium or 85 percent raw rice husk medium with organic amendment offered superior growth characteristics, but 100 percent raw rice husk medium resulted in inferior growth, reduced stem formation and quality.

**2.1.7 Effect of sand on potted ornamental flowering plants**

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. Most common constituent of sand is silica (silicon dioxide, $SiO_2$), usually in the form of quartz. Sand is a valuable amendment for both potting and propagation media. However, fine sand (0.05mm - 0.25mm) do little to improve the physical properties of a growing media and may result in reduced drainage and aeration (Kaushal and Kumari, 2020).

According to Yasmeen *et al.* (2012), leaf compost with sand (1:1) was an appropriate substrate for *Dianthus caryophyllus* as it supplied nutrients such as nitrogen, potassium, an optimal pH range and soil structure for the great establishment and blooming.

Naik *et al.* (2018) reported that a sand-based medium increased rooting percentage in ornamental stem cuttings such as ixora, hibiscus, crape jasmine, croton, java fig tree, acalypha, bougainvillaea, golden shower, and clerodendron. They also found that when hibiscus was planted on pure sand, it had the highest percentage of rooting (88.89%) compared to other rooting media.

## 2.2 GROWTH RETARDANTS

Plant growth retardants are synthetic compounds which are used to reduce the shoot length of plants in a desired way without changing developmental patterns or being phytotoxic. This is achieved primarily by reducing cell elongation and the rate of cell division. In their effect on the morphological structure of plants, growth retardants are antagonistic to gibberellins (GA's) and auxins, the plant hormones that are primarily responsible for shoot elongation. The quality of ornamental and bedding plants is generally improved by keeping them compact, which also reduces the space in a greenhouse required for production.

### 2.2.1 Effect of cycocel on potted ornamental flowering plants

Cycocel is a plant growth regulator for ornamentals, including bedding plants and herbaceous crops. Cycocel enhances the crop's aesthetic appeal and improves durability during post production shipping and handling. Treated crops are more compact with shorter internodes, stronger stems and greener leaves. Cycocel contains 11.8% chlormequat (2-chlorethyl) trimethyl ammonium chloride. The optimum Cycocel rate, timing of application and frequency vary for different crops.

The impact of growth retardants on growth and yield of the African marigold (*Tagetes erecta*) was studied by Khandelwal *et al.* (2003), and the application of CCC @ 3000 ppm as foliar spray resulted in reduced plant height, more number of flowers per plant and highest flower yield.

Naik *et al.* (2004) conducted a study to determine the effects of growth regulators and nutrient sprays on growth, flowering, and xanthophyll production of African marigold. The experiment consisted of two levels of two growth regulators (CCC and mepiquat chloride at 500 and 1000 ppm) and nutrients (DAP and MOP at 1 and 2%). The foliar spray of CCC at 1000 ppm exhibited maximum growth, flowering, and xanthophyll production.

Balachandra *et al.* (2004) reported that spray of CCC @ 1000 ppm in ageratum resulted in reduction of plant height, maximum number of branches, higher seed yield, maximum germination percentage and seedling vigour index compared to control.

Cycocel (CCC) at 750 ppm caused a significant reduction in plant height and resulted in the highest number of branches per plant, maximum plant spread, early flowering, minimum days to 50% flowering, maximum flower diameter, highest flower weight, flower longevity, vase life, maximum number of flowers per plant, and yield per plant, in African marigold cv. Double orange (Dani *et al.*, 2010).

Imran *et al.* (2012) studied the effect of different levels of Cycocel and Maleic hydrazide on growth and flowering of African marigold (*Tagetes erecta* ) cv. Pusa Narangi Gainda and reported that application of CCC @ 2000 ppm resulted in reduction in plant height, more number of branches per plant, more plant spread, maximum flower size, more number of flowers per plant, more weight of flowers and highest yield as compared to control.

A reduction in plant height, increased number of flowers, diameter of flowers and total yield of flowers were observed by application of CCC (400 ppm) in African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda (Pal *et al*., 2014).

Sasikumar *et al.* (2015) investigated the effects of pinching and growth retardants on African marigold. Growth retardants such as Chloremequat chloride (CCC) at 1000 ppm, 1500 ppm and 2000 ppm, Malic hydrazide (MH) at 500 ppm, 1000 ppm and 1500 ppm, and Alar (B-nine) at 500 ppm, 750 ppm and 1000 ppm were used for the study. Minimum plant height, maximum plant spread, maximum number of branches, long blooming period, more number of flowers per plant, more flower diameter and maximum shelf life were recorded with CCC @ 2000 ppm.

Moon *et al*. (2017) examined at the effects of pinching and cycocel on yield and quality of gaillardia and observed that cycocel (CCC) sprayed at 1000 ppm resulted in the highest number of blooms, flower weight, flower length, flower life span, yield per plant and shelf life.

Sunayana *et al*. (2018) reported that application of CCC at 1000 ppm for May sown crop and 2000 ppm for January sown crop substantially increased the number of flowers per plant, total flower production and carotenoid content of flower petals in African marigold cultivars Pusa Narangi Gaida and Maxima yellow.

Sikarwar and Vikram (2017) investigated the effect of plant growth retardants, namely CCC, Ethephon, and MH, on the growth and flower output of African marigold (*Tagetes erecta*) during rabi season and observed that application of CCC @ 1100 ppm resulted in minimum plant height and improved the number of branches per plant, number of leaves per plant, stalk length of flower, flower diameter as well as flower yield per hectare.

### 2.2.2 Effect of paclobutrazol on potted ornamental flowering plants

Paclobutrazol belongs to the triazole family. This compound regulates plant growth by influencing the isoprenoid pathway, inhibiting GA synthesis and decreasing ethylene production. It protects plants against several types of abiotic stresses, including chilling, water deficit, flooding and salinity. It helps to maintain water content, membrane stability, photosynthetic activity, and photosynthetic pigments. The ornamental value of pot grown plants depends upon a strong straight trunk, dense crown and prolific flowering. Hence, the use of paclobutrazol become important in achieving the desired shape and form of the pot plants. Application technique has a huge impact on effectiveness of a growth retardant on the crop. Generally, it is necessary that not only the effective concentration but also the most efficient method of application of the growth retardant is required to obtain the desired effect.

Auda *et al.* (2002) studied the effect of chlormequat (1000, 2000, 3000 ppm), paclobutrazol (100, 150, 200 ppm) and mepiquat chloride (2, 4, 6 ppm) on the growth, flowering and chemical composition of *Barleria cristata.* They reported that the application of 150 ppm paclobutrazol was optimum for improving vegetative growth and flowering of *Barleria cristata.*

Chen-Li Yun *et al*. (2004) treated *Ixora duffii* cv. ‘King Ixora’ plants with different concentrations of paclobutrazol and uniconazole. They found that the optimum concentration of paclobutrazol (100 ppm) and uniconazole (150 ppm) reduced the plant height and inflorescence diameter, thereby improving the ornamental quality of potted plants. Also, plants recorded early flowering due to the application of these chemicals.

Abou-Dahab and Habib (2005) observed in *Barleria cristata* that pinching combined with paclobutrazol at 400 ppm treatment reduced the plant height and increased the number of side shoots as well as stem diameter. They also reported that pinching and application of paclobutrazol at 200 ppm enhanced the number of flowers and duration of flowering.

Application of paclobutrazol (PBZ) at 100 ppm coupled with 20 mEq $NO_3$-N and 0.5% $ZnSo_4$ checked the vegetative growth and increased the number of flowers per plant in *Rosa damascena* (Misra *et al*., 2005).

Jeong and Ryong (2007) experimented on the effect of paclobutrazol at different concentrations (0.5, 1.0, 1.5 or 2.0 mg/L) supplied to a recirculated nutrient solution in an ebb and flow system on potted peace lily cultivars Top-Pin and Mini and concluded that paclobutrazol was most effective in inhibiting the plant height, plant width and petiole length. The effect increased with increasing paclobutrazol concentration and also accompanied by an increase in chlorophyll content, leaf length and leaf area. Phytotoxicity was observed at 2.0 mg paclobutrazol/litre.

Paclobutrazol (PBZ) at 50, 100, and 150 ppm as well as cycocel (CCC) at 1000, 1500, and 2000 ppm, were tested on the growth, blooming, and chemical compositions of potted *Tabernaemontana coronaria.* The results indicated that in plants sprayed with paclobutrazol (PBZ) at 150 ppm had an improvement in plant height, number of branches per plant, number of leaves per plant, flower diameter, leaf area, fresh and dried weight of plants (Youssef and Abd El-Aal, 2013).

Bhardwaj *et al*. (2020) examined the effect of benzyl adenine and paclobutrazol on the growth and flowering of *Barleria cristata* and reported that paclobutrazol at 200 ppm resulted in maximum side shoots per plant, leaves per plant, flower clusters per plant, flowers per cluster and flowering duration. However, paclobutrazol at 100 ppm was used to achieve optimal pot presentability, plant height and plant spread.

Chauhan *et al.* (2020) investigated the vegetative characteristics of the chrysanthemum cv. Dolly white in response to various concentrations of paclobutrazol (30, 60, 90 and 120 ppm) and daminozide (250, 500, 750 and 1000 ppm) and shortest plants were observed under 120 ppm paclobutrazol applied as media drench.

Sahu *et al.* (2021) investigated the impact of plant growth regulators and the time of their application on the floral quality characteristics of African marigold (*Tagetes erecta*). The treatment consisted of a three dose combination of two plant growth retardants, paclobutrazol (PBZ) at 50, 100, and 150 ppm and cycocel (CCC) at 500, 750 and 1000 ppm, as well as two application times of 30 and 45 days after transplanting (DAT). The application of paclobutrazol at 150 ppm on 30 DAT resulted in the maximum vase life, shelf life, flower diameter, and fresh weight of flowers.

# MATERIALS AND METHODS

# Chapter -3

# MATERIALS AND METHODS

The present study entitled "Standardization of growing medium and growth retardants for compact growth of potted African marigold" was carried out in the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara, Thrissur from October 2021 to May 2021. The materials used and methodology adopted for the study are mentioned in this chapter.

## 3.1 LOCATION OF THE EXPERIMENT

Geographically the experiment site is situated at 22.25 m above MSL at a latitude of 103°1'N and longitude of 76°13'E.

## 3.2 CLIMATE

The region is having a warm humid tropical climate with maximum temperature of 36.8°C and minimum temperature of 21.3°C during the period of study. The mean relative humidity varied from 71- 88 percent. The maximum rainfall recorded during the period of work was 607.7 mm (Appendix I).

## 3.3 MATERIALS

### 3.3.1. Planting material

The experiment was carried out with African marigold Var. Double Orange, a popular ornamental marigold from Namdhari seeds company.

### 3.3.2. Container

Seedlings of African marigold were grown in plastic pots measuring eight inches in diameter.

### 3.3.3 Growing media

Pots were filled with various combinations of growing media components *viz.* cocopeat, vermiculite, vermicompost, FYM, rice husk, soil and M-sand on volume by volume (v/v) basis.

$M_1$ - cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)

$M_2$ - cocopeat (60%) + FYM (20%) + vermiculite (10%) +rice husk (10%)

$M_3$ - cocopeat (40%) + Soil (20%) +vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_4$ - cocopeat (40%) + Soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_5$ - soil: FYM: sand (1:1:1)

### 3.3.3 Growth retardants

Growth retardants *viz*. cycocel (CCC) and paclobutrazol (PBZ) at three different concentrations were used in the experiment. Paclobutrazol was used at 30 ppm, 60 ppm and 90 ppm, whereas cycocel was used at 750 ppm, 1000 ppm and 1500 ppm. In addition, a control group was retained without the use of growth retardants.

3.4 EXPERIMENTAL DESIGN AND TREATMENTS

| | |
|---|---|
| Design of experiment | : CRD |
| Number of treatments | : 35(5x2x3+5) |
| Number of replications | : 2 |
| Number of pots per replication | : 5 |

### 3.4.1 Treatment details

| Sl. No. | Treatments | Sl. No. | Treatments |
|---|---|---|---|
| 1 | $T_1$ - $M_1$ + CCC 750 ppm | 19 | $T_{19}$ - $M_4$ + CCC 750 ppm |
| 2 | $T_2$ - $M_1$ + CCC 1000 ppm | 20 | $T_{20}$ - $M_4$ + CCC 1000 ppm |
| 3 | $T_3$ - $M_1$ + CCC 1500 ppm | 21 | $T_{21}$ - $M_4$ + CCC 1500 ppm |
| 4 | $T_4$ - $M_1$ + PBZ 30 ppm | 22 | $T_{22}$ - $M_4$ + PBZ 30 ppm |
| 5 | $T_5$ - $M_1$ + PBZ 60 ppm | 23 | $T_{23}$ - $M_4$ + PBZ 60 ppm |
| 6 | $T_6$ - $M_1$ + PBZ 90 ppm | 24 | $T_{24}$ - $M_4$ + PBZ 90 ppm |
| 7 | $T_7$ - $M_2$ + CCC 750 ppm | 25 | $T_{25}$ - $M_5$ + CCC 750 ppm |
| 8 | $T_8$ - $M_2$ + CCC 1000 ppm | 26 | $T_{26}$ - $M_5$ + CCC 1000 ppm |
| 9 | $T_9$ - $M_2$ + CCC 1500 ppm | 27 | $T_{27}$ - $M_5$ + CCC 1500 ppm |
| 10 | $T_{10}$ - $M_2$ + PBZ 30 ppm | 28 | $T_{28}$ - $M_5$ + PBZ 30 ppm |
| 11 | $T_{11}$ - $M_2$ + PBZ 60 ppm | 29 | $T_{29}$ - $M_5$ + PBZ 60 ppm |
| 12 | $T_{12}$ - $M_2$ + PBZ 90 ppm | 30 | $T_{30}$ - $M_5$ + PBZ 90 ppm |
| 13 | $T_{13}$ - $M_3$ + CCC 750 ppm | 31 | $T_{31}$ - $M_1$ (control) |
| 14 | $T_{14}$ - $M_3$ + CCC 1000 ppm | 32 | $T_{32}$ - $M_2$ (control) |
| 15 | $T_{15}$ - $M_3$ + CCC 1500 ppm | 33 | $T_{33}$ - $M_3$ (control) |
| 16 | $T_{16}$ - $M_3$ + PBZ 30 ppm | 34 | $T_{34}$ - $M_4$ (control) |
| 17 | $T_{17}$ - $M_3$ + PBZ 60 ppm | 35 | $T_{35}$ - $M_5$ (control) |
| 18 | $T_{18}$ - $M_3$ + PBZ 90 ppm | | |

## 3.5 MANAGEMENT PRACTICES

Throughout the research, uniform management practices were adopted for all of the treatments. Fertilizer application was done as per the package of practice recommended for marigold (KAU PoP, 2016). Half dose of N (112.5 kg/ha), the full dose of $P_2O_5$ (60kg/ha) and half $K_20$ (30kg/ha) was applied after 2 weeks of transplanting. The balance half dose of N and $K_2O$ was given at the time of flowering. Urea, Factomphos and Muriate of potash (MOP) were used for supplying nutrients. Foliar applications of NPK (19:19:19) at a dosage of 2 g per litre was done at biweekly intervals. Irrigation was supplied on alternate days at 1.5 litre per pot for all the treatments under $M_5$ medium and 1 litre per pot for the rest of the treatments. Whenever necessary, suitable plant protection measures were taken.

## 3.6 OBSERVATIONS

Observations were recorded from five plants in each replication, and the average was calculated and expressed in corresponding units.

### 3.6.1. Vegetative characters

Observations on vegetative characters were recorded at the stage of flower bud initiation.

***a. Plant height(cm)***

Plant height was measured from base to the tip of the main stem at the stage of flower bud initiation.

***b. Plant spread (EW-NS)***

The plant spread was recorded by measuring the growth of plant in North-South and East-West directions at the stage of flower bud initiation. Average was taken and expressed in cm.

***c. Number of branches per plant***

The total number of branches originated from the main shoot were counted at the stage of flower bud initiation and the average was calculated and expressed as number of branches per plant.

***d. Number of leaves per branch***

The total number of leaves present on each branch at the stage of flower bud initiation was observed and expressed as number of leaves per branch.

**3.6.2. Floral characters**

**a. *Days taken for first flower bud emergence***

The number of days taken for first flower bud emergence was recorded by counting the days from the date of planting to the emergence of first flower bud.

**b. *Days taken from flower bud initiation to flower opening***

The number of days taken to flower opening from the day of flower bud initiation was observed.

**c. *Number of flowers per plant***

Number of fully opened flowers from each plants was counted and noted.

**d. *Flower diameter***

Diameter of fully opened flowers was measured and expressed in cm.

***e. Flowering duration***

Flowering duration is the period during which a plant produces flowers. This was calculated by counting the total number of days from flower initiation to wilting of the last flower.

***f. Field life of individual flowers***

Field life of individual flowers was calculated by counting the number of days taken from flower opening to wilting of outer petals of the fully opened flowers

**3.6.3. Media characters**

Before and after the experiment, samples of growing medium were collected and the physio-chemical characteristics of the media were assessed. The physical properties of growing medium, such as water holding capacity, porosity and bulk density of soil were determined prior to the experiment, whereas the chemical properties, such as pH, EC and available nutrient levels of N, P and K of growing medium were calculated before and after the completion of the experiment. Methods adopted for growing medium analysis are furnished in Table 1.

**Table 1. Methods followed for analysis of growing medium**

| Sl. No. | Parameter | Method adopted | Reference |
|---|---|---|---|
| **Physical properties of growing medium** | | | |
| 1 | Bulk density ($g/cm^3$) | Keen Raczkowski brass cup method | Piper (1942) |
| 2 | Porosity (%) | | |
| 3 | Water holding capacity (%) | | |
| **Chemical properties of growing medium** | | | |
| 1 | pH | pH meter (1:2.5) | Jackson (1958) |
| 2 | EC (dS/m) | Electrical conductivity meter (1:2.5) | |
| 3 | Available N (kg/ha) | Alkaline permanganate method | Subbiah and Asija (1956) |
| 4 | Available P (kg/ha) | Bray No.1 Ascorbic acid reduction method | Bray and Kurtz (1945) |
| 5 | Available K (kg/ha) | Neutral normal ammonium acetate extract using flame photometer | Jackson (1958) |

3.6.4. OTHER OBSERVATIONS

**a. Plant nutrient content**

***a.1. Nitrogen content***

Microkjeldhal digestion and distillation method was used (Jackson, 1958) to estimate the content of nitrogen. Plant sample (0.5 g) was digested using concentrated sulphuric acid in presence of catalysts. The digested material was made alkaline and then distilled to release ammonia, which was quantified.

***a.2. Phosphorus content***

The plant sample of 0.5 g was taken and digested using diacid mixture of nitric acid ($HNO_3$) and per chloric acid ($HClO_4$) taken in the ratio of 9:4 and phosphorus was estimated using Vanadomolybdo phosphoric yellow colour method (Jackson,1958). The intensity of yellow colour was read at 470 nm.

***a.3. Potassium content***

The plant sample of 0.5 g was taken and digested using diacid mixture of nitric acid ($HNO_3$) and per chloric acid ($HClO_4$) taken in the ratio of 9:4 and potassium in the sample was estimated using normal ammonium acetate solution. Contents of respective element were determined by flame photometry (Jackson, 1958)

**b. Nutrient uptake by the plants**

$$\text{Nutrient uptake (g/plant)} = \frac{\text{Plant nutrient content (\%) x Dry matter production (g)}}{100}$$

Nutrient uptake by plants in each treatment were measured using the mentioned formula and expressed in gram per plant.

**c. Total chlorophyll content of leaves**

The chlorophyll content in the leaves were estimated using 80 percent acetone (Porra, 2002). Recently developed fully matured leaves were taken and cut into small pieces of 100 mg and then ground well using mortar and pistle along with 10 ml of 80 percent acetone. Then the ground material was centrifuged at 5000 rpm for 10 minutes. The supernatant solution thus obtained was poured into small vials and the absorbance was read at 646.5 nm and 663.6 nm using distilled water as blank with spectrophotometer. From the values obtained from the spectrophotometer, total chlorophyll contents were estimated using the formula and expressed in mg/g fresh weight.

Total chlorophyll = 17.76 ($A_{646.6}$) +7.34 ($A_{663.6}$) x 10 ml / 100 mg leaf

**d. Pest and disease incidence**

Incidence of pest and diseases during the study was noted.

**e. Physiological abnormalities**

The plants were observed for changes in physical appearance such as chimeras, deficiencies and malformations.

**f. Cost of growing media**

The cost of growing medium was estimated by multiplying unit cost by the quantity of each component per pot. The cost per pot was calculated in rupees.

3.7 STATISTICAL ANALYSIS

Statistical analysis were carried out with the help of OPSTAT.

Plate 1. Materials used for the experiment

**Cocopeat**

**Vermicompost**

**Vermiculite**

**Rice husk**

**FYM**

**Soil**

**Sand**

**Media components used for the study**

**Plate 2. Materials used for the experiment**


**African marigold variety used for the study - Double Orange**



**Paclobutrazol (PBZ)**

**Cycocel (CCC)**

**Growth retardants used for the study**

**Plate3. Materials used for the experiment**

Sowing of seeds

Seedling ready for transplanting

**General view of the experimental field**

# RESULTS

# Chapter 4

# RESULTS

The results of the study “Standardization of growing medium and growth retardants for compact growth of potted African marigold” conducted at the Department of Floriculture and Landscape Architecture during 2020-21 are presented in this chapter.

## 4.1 VEGETATIVE CHARACTERS

Influence of growing medium and growth retardants on vegetative characters of African marigold are furnished in Table 2.

### 4.1.1. Plant height (cm)

There was significant variation in plant height among different treatments at the time of bud initiation. The growing medium M5 [soil: FYM: sand (1:1:1)] recorded the greatest plant height (27.74 cm), followed by $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)]. Lowest plant height (25.43 cm) was observed $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)].

During the study period, there were significant differences with respect to the effect of growth retardants on plant height. Paclobutrazol at 90ppm recorded the least plant height (21.42 cm), followed by Cycocel at 1500 ppm (22.85 cm). Taller plants were observed under control (40.29 cm).

M x GR interaction had significant influence on plant height. Shortest plants (20.53 cm) was observed under treatment combination of $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm]. Plant height was more under treatment combination $M_5$ x Control with growing medium containing soil: FYM: sand (1:1:1) without the application of growth retardants (45.77cm) (Table 3 & 4).

### 4.1.2 Plant spread (EW and NS) (cm)

Significant variation due to growing media on plant spread was observed. Greatest plant spread of 21.77 cm was recorded in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] followed by $M_5$ [soil : FYM : sand (1:1:1)] (20.69cm) and $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] with 18.06 cm. The lowest plant spread was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] with 15.04 cm.

Throughout the study period, the administration of growth retardants resulted in a considerable variation in plant spread. Application of Paclobutrazol at 90 ppm resulted in greatest plant spread (21.77cm). The lowest plant spread (15.28 cm) was observed in Cycocel at 750 ppm.

M x GR interaction had significant effect on plant spread. Maximum plant spread was recorded in treatment combinations of $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] and $M_5$ [soil: FYM: sand (1: 1: 1)] x $GR_6$ [paclobutrazol 90 ppm] (25.02 cm and 24.75 cm respectively). Plant spread was lowest under the treatment combination $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk ( 10%)] x $GR_4$ [paclobutrazol 30 ppm] (13.22cm).

### 4.1.3 Number of branches per plant

A significant difference in the number of branches per plant was observed with respect to the growing media. Greatest number of branches (6.47) was observed under $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] (6.47) and $M_5$ [soil: FYM: sand (1: 1: 1)] (6.23). Among the growing media, the lowest number of branches (4.92) was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)].

Growth retardants had a significant influence on the number of branches per plant. Paclobutrazol at 90 ppm was found to produce greatest number of branches

(7.13) whereas the lowest number of branches (4.70) was observed in Cycocel at 750 ppm (Table 2)

M x GR interaction was found to have significant influence on the number of branches per plant. Highest number of branches per plant (9.00) was observed in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] and $M_5$ [soil : FYM : sand ( 1: 1: 1)] x $GR_6$ [paclobutrazol 90 ppm] (8.50). The lowest number of branches (4.17) was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm] (Table 3 & 4)

**Table 2. Effect of growing medium and growth retardants on vegetative characters of African marigold var 'Double Orange'**

| Treatments | | Plant height(cm) | Plant spread (EW-NS) (cm) | Number of branches per plant | Number of leaves per branch |
|---|---|---|---|---|---|
| GROWING MEDIUM | $M_1$ | 25.43 | 15.04 | 4.92 | 6.52 |
| | $M_2$ | 26.23 | 16.92 | 5.71 | 7.90 |
| | $M_3$ | 26.54 | 18.06 | 5.57 | 7.91 |
| | $M_4$ | 26.62 | 21.77 | 6.47 | 9.52 |
| | $M_5$ | 27.74 | 20.69 | 6.23 | 8.52 |
| **CD(0.05)** | | **0.28** | **0.24** | **0.31** | **0.37** |
| **SE(m)** | | **0.10** | **0.08** | **0.11** | **0.13** |
| GROWTH RETARDANTS | $GR_1$ | 26.61 | 15.28 | 4.70 | 6.90 |
| | $GR_2$ | 25.52 | 16.69 | 5.33 | 7.47 |
| | $GR_3$ | 22.85 | 19.32 | 6.63 | 8.27 |
| | $GR_4$ | 25.35 | 16.34 | 5.00 | 7.80 |
| | $GR_5$ | 23.55 | 18.74 | 6.20 | 8.40 |
| | $GR_6$ | 21.42 | 21.77 | 7.13 | 10.06 |
| | CONTROL | 40.29 | 21.37 | 5.50 | 7.63 |
| **CD(0.05)** | | **0.33** | **0.28** | **0.37** | **0.43** |
| **SE (m)** | | **0.11** | **0.10** | **0.13** | **0.15** |

$M_1$ – cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)
$M_2$ – cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)
$M_3$ – cocopeat (40%) + Soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)
$M_4$ – cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)
$M_5$ - soil: FYM: sand (1: 1: 1)

$GR_1$ - cycocel 750 ppm
$GR_2$ - cycocel 1000 ppm
$GR_3$ - cycocel 1500 ppm
$GR_4$ - paclobutrazol 30 ppm
$GR_5$ - paclobutrazol 60 ppm
$GR_6$ - paclobutrazol 90 ppm
Control - without Growth Retardants

**Table 3. Effect of M x GR interaction vegetative characters of African marigold var 'Double Orange'**

| Treatments | Plant height (cm) | Plant spread (EW-NS) (cm) | Number of branches per plant | Number of leaves per branch |
|---|---|---|---|---|
| **$M_1$ x $GR_1$** | 25.43 | 13.25 | 4.17 | 5.83 |
| **$M_1$ x $GR_2$** | 24.95 | 13.50 | 5.17 | 5.67 |
| **$M_1$ x $GR_3$** | 20.90 | 14.94 | 5.67 | 6.34 |
| **$M_1$ x $GR_4$** | 25.53 | 13.22 | 4.33 | 6.67 |
| **$M_1$ x $GR_5$** | 24.60 | 14.83 | 5.00 | 6.67 |
| **$M_1$ x $GR_6$** | 20.53 | 15.90 | 5.67 | 8.33 |
| **$M_1$ x CONTROL** | 36.12 | 19.68 | 4.50 | 6.17 |
| **$M_2$ x $GR_1$** | 26.97 | 14.27 | 5.00 | 7.33 |
| **$M_2$x $GR_2$** | 25.95 | 15.30 | 5.17 | 7.33 |
| **$M_2$ x $GR_3$** | 23.85 | 16.85 | 6.50 | 8.34 |
| **$M_2$ x $GR_4$** | 25.78 | 14.86 | 5.00 | 7.33 |
| **$M_2$ x $GR_5$** | 23.88 | 16.68 | 6.83 | 9.00 |
| **$M_2$ x $GR_6$** | 22.47 | 20.82 | 5.84 | 8.67 |
| **$M_2$ x CONTROL** | 34.71 | 19.70 | 5.67 | 7.33 |
| **$M_3$ x $GR_1$** | 25.62 | 13.90 | 4.33 | 7.00 |
| **$M_3$ x $GR_2$** | 24.82 | 15.74 | 5.34 | 7.01 |
| **$M_3$ x $GR_3$** | 23.33 | 19.37 | 6.50 | 8.34 |
| **$M_3$ x $GR_4$** | 25.14 | 14.11 | 4.67 | 7.33 |
| **$M_3$ x $GR_5$** | 23.98 | 19.83 | 6.00 | 8.67 |
| **$M_3$ x $GR_6$** | 21.42 | 22.37 | 6.67 | 9.33 |
| **$M_3$ x CONTROL** | 41.54 | 21.16 | 5.50 | 7.67 |
| **CD(0.05)** | **0.74** | **0.63** | **0.83** | **0.98** |
| **SE(m)** | **0.26** | **0.22** | **0.29** | **0.34** |

**Table.4. Effect of M x GR interaction vegetative characters of African marigold var 'Double Orange'**

| Treatments | Plant height (cm) | Plant spread (EW-NS) (cm) | Number of branches per plant | Number of leaves per branch |
|---|---|---|---|---|
| **$M_4$ x $GR_1$** | 28.19 | 17.85 | 5.17 | 7.33 |
| **$M_4$ x $GR_2$** | 26.15 | 20.08 | 5.50 | 9.67 |
| **$M_4$ x $GR_3$** | 22.47 | 24.01 | 7.50 | 9.67 |
| **$M_4$ x $GR_4$** | 24.68 | 20.12 | 5.67 | 9.67 |
| **$M_4$ x $GR_5$** | 20.90 | 21.70 | 7.00 | 9.67 |
| **$M_4$ x $GR_6$** | 20.65 | 25.02 | 9.00 | 12.34 |
| **$M_4$ x CONTROL** | 43.34 | 23.72 | 5.50 | 8.34 |
| **$M_5$ x $GR_1$** | 26.88 | 17.16 | 4.84 | 7.00 |
| **$M_5$ x$GR_2$** | 25.77 | 18.92 | 5.50 | 7.67 |
| **$M_5$ x $GR_3$** | 23.72 | 21.44 | 7.00 | 8.67 |
| **$M_5$ x $GR_4$** | 25.65 | 19.40 | 5.34 | 8.00 |
| **$M_5$ x $GR_5$** | 24.40 | 20.64 | 6.17 | 8.00 |
| **$M_5$ x $GR_6$** | 22.05 | 24.75 | 8.50 | 11.67 |
| **$M_5$ x CONTROL** | 45.77 | 22.61 | 6.34 | 8.67 |
| **CD(0.05)** | **0.74** | **0.63** | **0.83** | **0.98** |
| **SE(m)** | **0.26** | **0.22** | **0.29** | **0.34** |

**Plate 4. Effect of growing medium and growth retardants on plant height (cm)**



$M_1$ x $GR_6$ - [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%) + PBZ 90 ppm]



$M_4$ x $GR_6$ - [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) + PBZ 90 ppm]

**Effect of growing medium and growth retardants on plant height (cm)**

**Plate 5. Effect of growing medium and growth retardants on plant spread (cm), number of branches & leaves**



$M_4$ x $GR_6$ - [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) + PBZ 90 ppm]



$M_5$ x $GR_6$ - [soil: FYM: sand (1:1:1) + PBZ 90 ppm]

**Effect of growing medium and growth retardants on plant spread (cm), number of branches & leaves**

#### 4.1.4 Number of leaves per branch

There was considerable difference among the growing medium in terms of the number of leaves per branch $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] recorded the highest number of leaves per branch (9.52), followed by $M_5$ [soil : FYM : sand ( 1: 1: 1)] (8.52) whereas the lowest number of leaves per branch (6.52) was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)].

Regarding the influence of growth retardant application on number of leaves per branch, the greatest number of leaves per branch (10.06) was observed with application of paclobutrazol at 90 ppm and the lowest number of leaves per branch (6.90) was observed with the application of cycocel at 750 ppm (Table 2).

M x GR interaction was found to have significant influence on the number of leaves per branch. Highest number of leaves per branch (12.34) was observed in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] and $M_5$ [soil: FYM: sand (1: 1: 1)] x $GR_6$ [paclobutrazol 90 ppm] (11.67). The lowest number of leaves per branch (5.67) was recorded in $M_1$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_2$ [Cycocel 1000 ppm] (Table 3 & 4)

### 4.2 FLORAL CHARACTERS

Influence of growing medium and growth retardants on floral characters are depicted in Table 5

#### 4.2.1. Days taken for first flower bud emergence

Regarding days taken for first flower bud emergence, $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] took lowest number of days for first flower bud emergence (27.48days) while $M_5$ [soil : FYM : sand (1:1:1)] took more number of days for first flower bud emergence of flower bud (34.26 days).

Significant influence on number of days taken for first flower bud emergence was noted with the application of growth retardants. The lowest number of days for first flower bud emergence (26.00 days) was observed with the application of cycocel at 750 ppm, while paclobutrazol at 90 ppm application resulted in more number of days for first flower bud emergence (33.86 days).

M x GR interaction exhibited significant influence on flower bud initiation. Early emergence of flower bud was observed in treatment combination of $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm] (23.83 days) while $M_5$ [soil : FYM : sand] x $GR_5$ [paclobutrazol 60 ppm], $M_5$ [soil : FYM : sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm], $M_5$ [soil : FYM : sand (1:1:1)] x $GR_3$ [cycocel 1500 ppm], $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x $GR_2$ [cycocel 1000 ppm] were on par which took more number of days for first flower bud emergence (36.83, 36.50, 35.50, 35.50 and 35.00 days respectively) (Table 6 & 8).

### 4.2.2 Days taken from flower bud initiation to flower opening

Growing media showed significant variation with respect to days taken from flower bud initiation to flower opening. Lowest number of days taken for flower bud initiation to flower opening (19.48 days) was observed in $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and the highest number of days for flower bud initiation to flower opening (26.26 days) was observed in $M_5$ [soil : FYM : sand](Table 7.)

Regarding the influence of growth retardants, lowest number of days taken for flower bud initiation to flower opening was observed 18.00 days under cycocel at 750 ppm, whereas greatest number of days taken for flower bud initiation to flower opening (25.86 days) was observed under paclobutrazol at 90 ppm.

M x GR interaction had significant effect on the days taken for flower bud initiation to flower opening. Earliest flower opening was observed in $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%) x $GR_1$ [cycocel 750 ppm], $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%) x $GR_1$ [cycocel 750 ppm], $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm], $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%) x $GR_4$ [paclobutrazol 30 ppm] and $M_1$[cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm] (15.83, 16.66, 16.83, 17.50 and 18.00 days respectively). $M_5$ [soil: FYM: sand (1:1:1)] x $GR_5$ [paclobutrazol 60 ppm] (28.83 days) took more number of days from flower bud initiation to flower opening (Table 6 & 8).

### 4.2.3. Number of flowers per plant

There was significant influence of growing media on number of flowers per plant. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] was found to have highest number of flowers per plant (10.14) and lowest number of flowers per plant (4.02) was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)].

Growth retardants had significant effect on the number of flowers per plant. Application of paclobutrazol at 90 ppm had the highest number of flowers per plant (9.50) whereas the lowest number of flowers per plant (6.50) was observed under paclobutrazol at 30 ppm (Table 5).

M x GR interaction exhibited significant influence on the number of flowers per plant. Treatment combinations of $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm], $M_5$ [soil : FYM : sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_5$ [paclobutrazol 60 ppm] were on par and produced more number of flowers per plant (12.00, 11.66 and 11.00 respectively) while less number of flowers per plant (2.33) was obtained for treatment combination of $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm].

### 4.2.4. Flower diameter

Significant influence could be observed for flower diameter among the growing media evaluated $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] had the highest flower diameter of 4.61 cm which was statistically superior to other media. The lowest flower diameter of 3.25 cm was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)].

Flower diameter was greatly influenced by growth retardants. Application of paclobutrazol at 90 ppm had the greatest flower diameter of 4.22 cm which was statistically superior to other growth retardants. The lowest flower diameter of 3.26 cm was observed under control [without the application of growth retardants] (Table 5).

M x GR interaction exhibited significant influence on flower diameter. Highest flower diameters of 5.41cm and 5.18 cm were observed in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) x $GR_4$ [paclobutrazol at 30 ppm] respectively, whereas the treatment combination of $M_5$ [soil : FYM : sand (1:1:1)] x $GR_1$ [cycocel 750 ppm] recorded lowest flower diameter ( 3.03) (Table 8).

### 4.2.5 Flowering duration

From the results it could be concluded that growing media had no significant effect on flowering duration throughout the study period (Table 5).

The results revealed that there was significant influence on flowering duration with application of growth retardants. Application of paclobutrazol at 90 ppm recorded maximum flowering duration of 96 days whereas the minimum flowering duration of 79.56 days were recorded for the control [without application of growth retardants].

It was evident that M x GR interaction had no significant effect on flowering duration (Table 6, 7 & 8)

### 4.2.6. Field life of individual flower

The data revealed that growing media had significant effect on field life of individual flowers. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] had maximum field life of individual flowers (9.21 days) compared to other growing medium and the minimum field life of individual flowers

(7.66 days) was observed in $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)].

It could be seen that growth retardants had significant effect with respect to field life of individual flowers. Maximum field life of individual flower (9.93 days) was recorded with application of paclobutrazol at 90 ppm whereas minimum field life of individual flowers (6.80 days) was recorded for control [without the application of growth retardants] (Table 5).

M x GR interaction was found to have significant influence on field life of individual flowers. The maximum field life for individual flowers was recorded in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) x $GR_6$ [paclobutrazol 90 ppm] (11.34 days), $M_5$ [soil : FYM : sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] (11.17 days) and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_5$ [paclobutrazol 60 ppm] (10.33 days) while the minimum field life for individual flowers was recorded in $M_1$ x Control [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%) without the application of growth retardants] (6.00days).

**Table 5. Effect of growing medium and growth retardants on floral characters of African marigold var 'Double Orange'**

| Treatments | | Days taken for first flower bud emergence | Days taken from flower bud initiation to flower opening | Number of flowers per plant | Flower diameter (cm) | Flowering duration | Field life of individual flowers |
|---|---|---|---|---|---|---|---|
| GROWING MEDIUM | $M_1$ | 29.67 | 21.64 | 4.02 | 3.25 | 83.67 | 7.88 |
| | $M_2$ | 27.48 | 19.48 | 7.43 | 3.39 | 84.36 | 7.66 |
| | $M_3$ | 29.43 | 21.43 | 7.67 | 3.44 | 85.38 | 8.11 |
| | $M_4$ | 30.11 | 22.31 | 10.14 | 4.61 | 86.53 | 9.21 |
| | $M_5$ | 34.26 | 26.26 | 8.77 | 3.64 | 81.79 | 9.07 |
| **CD(0.05)** | | **0.88** | **0.84** | **0.52** | **0.09** | **NS** | **0.39** |
| **SE(m)** | | **0.30** | **0.29** | **0.18** | **0.03** | **1.93** | **0.13** |
| GROWTH RETARDANTS | $GR_1$ | 26.00 | 18.00 | 6.83 | 3.39 | 79.56 | 7.90 |
| | $GR_2$ | 29.56 | 21.56 | 7.40 | 3.49 | 85.03 | 7.87 |
| | $GR_3$ | 32.76 | 24.80 | 8.10 | 3.63 | 95.03 | 8.50 |
| | $GR_4$ | 29.16 | 21.16 | 6.50 | 3.66 | 81.13 | 8.53 |
| | $GR_5$ | 31.13 | 23.06 | 7.56 | 3.98 | 80.03 | 9.20 |
| | $GR_6$ | 33.86 | 25.86 | 9.50 | 4.22 | 96.00 | 9.93 |
| | CONTROL | 29.10 | 21.10 | 7.36 | 3.26 | 73.60 | 6.80 |
| **CD(0.05)** | | **1.04** | **0.99** | **0.61** | **0.11** | **6.59** | **0.46** |
| **SE(m)** | | **0.36** | **0.34** | **0.21** | **0.04** | **2.29** | **0.16** |

**Table 6. Effect of M x GR interaction on floral characters of African marigold var 'Double Orange'**

| Treatments | Days taken for first flower bud emergence | Days taken from flower bud initiation to flower opening | Number of flowers per plant | Flower diameter (cm) | Flowering duration | Field life of individual flowers |
|---|---|---|---|---|---|---|
| **$M_1$ x $GR_1$** | 26.00 | 18.00 | 2.33 | 3.38 | 79.00 | 7.50 |
| **$M_1$ x $GR_2$** | 29.66 | 21.66 | 2.83 | 3.20 | 83.50 | 7.50 |
| **$M_1$ x $GR_3$** | 32.00 | 24.16 | 5.16 | 3.26 | 93.50 | 7.84 |
| **$M_1$ x $GR_4$** | 28.16 | 20.16 | 3.16 | 3.10 | 80.16 | 8.50 |
| **$M_1$ x $GR_5$** | 29.66 | 21.33 | 4.50 | 3.28 | 84.16 | 8.84 |
| **$M_1$ x $GR_6$** | 32.66 | 24.66 | 5.50 | 3.43 | 94.16 | 9.00 |
| **$M_1$ x Control** | 29.50 | 21.50 | 4.66 | 3.08 | 71.16 | 6.00 |
| **$M_2$ x $GR_1$** | 23.83 | 15.83 | 6.66 | 3.11 | 79.33 | 7.67 |
| **$M_2$ x $GR_2$** | 26.66 | 18.66 | 7.00 | 3.40 | 84.33 | 7.50 |
| **$M_2$ x $GR_3$** | 30.50 | 22.50 | 8.66 | 3.56 | 94.33 | 7.50 |
| **$M_2$ x $GR_4$** | 25.50 | 17.50 | 5.83 | 3.33 | 81.16 | 8.00 |
| **$M_2$ x $GR_5$** | 27.50 | 19.50 | 6.33 | 3.60 | 84.83 | 8.00 |
| **$M_2$ x $GR_6$** | 31.33 | 23.33 | 9.33 | 3.66 | 94.83 | 8.67 |
| **$M_2$ x Control** | 27.00 | 19.00 | 8.16 | 3.05 | 71.66 | 6.34 |
| **CD (0.05)** | **2.32** | **2.22** | **1.37** | **0.24** | **NS** | **1.02** |
| **SE(m)** | 0.80 | 0.77 | 0.47 | 0.08 | 5.11 | 0.35 |

**Table 7. Effect of M x GR interaction on floral characters of African marigold var 'Double Orange'**

| Treatments | Days taken for first flower bud emergence | Days taken from flower bud initiation to flower opening | Number of flowers per plant | Flower diameter (cm) | Flowering duration | Field life of individual flowers |
|---|---|---|---|---|---|---|
| **$M_3$ x $GR_1$** | 24.66 | 16.66 | 7.50 | 3.33 | 79.33 | 7.33 |
| **$M_3$ x $GR_2$** | 28.50 | 20.50 | 8.16 | 3.28 | 85.16 | 7.84 |
| **$M_3$ x $GR_3$** | 32.83 | 24.83 | 8.33 | 3.20 | 95.16 | 8.17 |
| **$M_3$ x $GR_4$** | 28.00 | 20.00 | 6.00 | 3.50 | 80.16 | 8.17 |
| **$M_3$ x $GR_5$** | 30.00 | 22.00 | 7.33 | 3.65 | 86.66 | 8.67 |
| **$M_3$ x $GR_6$** | 33.33 | 25.33 | 9.00 | 4.03 | 96.16 | 9.50 |
| **$M_3$ x Control** | 28.66 | 20.66 | 7.33 | 3.05 | 75.00 | 7.17 |
| **$M_4$ x $GR_1$** | 24.83 | 16.83 | 9.66 | 4.08 | 80.16 | 8.50 |
| **$M_4$ x $GR_2$** | 28.00 | 20.00 | 10.33 | 4.36 | 85.83 | 8.00 |
| **$M_4$ x $GR_3$** | 33.00 | 25.00 | 10.00 | 4.46 | 95.83 | 9.17 |
| **$M_4$ x $GR_4$** | 30.33 | 22.33 | 10.00 | 5.18 | 81.50 | 9.84 |
| **$M_4$ x $GR_5$** | 31.66 | 23.66 | 11.00 | 5.05 | 88.00 | 10.33 |
| **$M_4$ x $GR_6$** | 35.50 | 27.50 | 12.00 | 5.41 | 98.00 | 11.34 |
| **$M_4$ x Control** | 28.83 | 20.83 | 8.00 | 3.66 | 76.33 | 7.34 |
| **CD (0.05)** | **2.32** | **2.22** | **1.37** | **0.24** | **NS** | **1.02** |
| **SE(m)** | **0.80** | **0.77** | **0.47** | **0.08** | **5.11** | **0.35** |

**Table 8. Effect of M x GR interaction on floral characters of African marigold var 'Double Orange'**

| Treatments | Days taken for first flower bud emergence | Days taken from flower bud initiation to flower opening | Number of flowers per plant | Flower diameter (cm) | Flowering duration | Field life of individual flowers |
|---|---|---|---|---|---|---|
| **$M_5$ x $GR_1$** | 30.66 | 22.66 | 8.00 | 3.03 | 80.00 | 8.50 |
| **$M_5$ x $GR_2$** | 35.00 | 27.00 | 8.66 | 3.21 | 86.33 | 8.50 |
| **$M_5$ x $GR_3$** | 35.50 | 27.50 | 8.33 | 3.66 | 96.33 | 9.83 |
| **$M_5$ x $GR_4$** | 33.83 | 25.83 | 7.50 | 3.20 | 82.66 | 8.17 |
| **$M_5$ x $GR_5$** | 36.83 | 28.83 | 8.66 | 4.35 | 86.50 | 10.17 |
| **$M_5$ x $GR_6$** | 36.50 | 28.50 | 11.66 | 4.56 | 96.83 | 11.17 |
| **$M_5$ x Control** | 31.50 | 23.50 | 8.66 | 3.46 | 73.83 | 7.17 |
| **CD (0.05)** | **2.32** | **2.22** | **1.37** | **0.24** | **NS** | **1.02** |
| **SE(m)** | **0.80** | **0.77** | **0.47** | **0.08** | **5.11** | **0.35** |

4.3 MEDIA CHARACTERS

### 4.3.1 Physical properties of media

Data pertaining to pre-planting analysis of potting media is furnished in Table 9.

***a. Bulk density (g/cm$^3$)***

Lower bulk density values indicates higher water holding capacity of growing media. In the study, the lowest bulk density of 0.13 g/cm$^3$ was recorded media $M_1$ comprising of cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%) [0.13g/cm$^3$], whereas the $M_5$ media comprising of soil: FYM: sand (1: 1: 1) was found to have the highest bulk density of 0.67g/cm$^3$.

***b. Porosity (%)***

Lowest porosity of 72.19% was noted in $M_5$ media comprising of soil : FYM : sand ( 1: 1: 1) and the highest porosity of 92.74 % was noted in $M_1$ media comprising of cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk ( 10%) followed by $M_2$ media comprising of cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%) with porosity of 90.61%.

***c. Water holding capacity (%)***

The highest water holding capacity (333.96%) was recorded in $M_1$ media comprising of cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%) and minimum water holding capacity (40.71%) was noted for $M_5$ media comprising of soil : FYM : sand ( 1: 1: 1).

### 4.3.2. Chemical properties of media

Chemical properties of media evaluated before and after the conduct of experiment are furnished in the Table 10 and 11.

***a. pH***

pH of growing media was observed before and after the experiment. Highest pH (6.52) was observed in growing media $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] which was closely followed by $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)], $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] and

$M_5$[soil : FYM : sand (1:1:1)] (6.38, 6.34 and 6.33 respectively). The lowest pH was observed in growing media $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] before the experiment. Whereas after the experiment highest pH (6.80) was observed for $M_1$ and $M_5$. Lowest pH after the experiment was observed for $M_3$ and $M_2$ (6.6 and 6.6 respectively). However the different potting media were having almost similar pH.

***b. EC(dS m$^{-1}$)***

Media differed with respect to EC and the highest EC was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] (0.71 and 0.35dS/m) before and after the experiment whereas the lowest EC (0.45 and 0.20 dS/m) was observed in $M_5$ [soil: FYM: sand (1:1:1)]. Generally a reduction in EC was observed in all treatments, after the experiment.

***c. Available Nitrogen (%)***

Growing media combination of $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_5$ [soil: FYM: sand (1:1:1)] were found to have highest available nitrogen before (0.35 and 0.34 respectively) and after (0.42 and 0.41 respectively) the experiment. Lowest available nitrogen before and after the experiment (0.09% and 0.21% respectively) was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)].

***d. Available Phosphorus (%)***

Among different growing media, $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_5$ [soil: FYM: sand] were found to be superior with respect to maximum available phosphorus before (0.009 and 0.008 respectively) and after (0.049 and 0.048 respectively) the experiment. The minimum available phosphorus before and after the experiment was recorded for $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] (0.002% and 0.042% respectively)

***e. Available Potassium (%)***

From the results it could be concluded that $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] had the highest available potassium (0.091%) and $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] had the lowest available potassium (0.0.24%) before the experiment, whereas the highest available potassium (0.56%) after the experiment was recorded for $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] and lowest (0.38%) was recorded for $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)].

**Plate 6. Effect of growing medium and growth retardants on number of flowers per plant**



$M_4$ x $GR_6$ - [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10 %) + rice husk (10%) + PBZ 90 ppm]



$M_5$ x $GR_6$ - [soil: FYM: sand (1:1:1) + PBZ 90 ppm]

**Effect of growing medium and growth retardants on number of flowers**

**Table 9. Physical properties of different growing media**

| Media | Bulk density (g/cc) | Porosity (%) | Water holding capacity (%) |
|---|---|---|---|
| **$M_1$** | 0.13 | 92.74 | 333.96 |
| **$M_2$** | 0.17 | 90.61 | 247.88 |
| **$M_3$** | 0.28 | 86.79 | 148.24 |
| **$M_4$** | 0.31 | 86.92 | 122.38 |
| **$M_5$** | 0.67 | 72.19 | 40.71 |

$M_1$ – cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_2$ – cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_3$ – cocopeat 40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_4$ – cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_5$ - soil: FYM: sand (1: 1: 1)

**Table 10. Chemical properties of growing media before the experiment**

| Media | pH | EC(dS/m) | Available N (%) | Available P (%) | Available K (%) |
|---|---|---|---|---|---|
| **$M_1$** | 6.34 | 0.71 | 0.09 | 0.002 | 0.024 |
| **$M_2$** | 6.38 | 0.47 | 0.27 | 0.007 | 0.053 |
| **$M_3$** | 6.25 | 0.52 | 0.28 | 0.004 | 0.057 |
| **$M_4$** | 6.52 | 0.62 | 0.35 | 0.009 | 0.091 |
| **$M_5$** | 6.33 | 0.45 | 0.34 | 0.008 | 0.087 |

$M_1$ – cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_2$ – cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_3$ – cocopeat 40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_4$ – cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_5$ - soil: FYM: sand (1: 1: 1)

**Table 11. Chemical properties of growing media after the experiment**

| Media | pH | EC(dS/m) | Available N (%) | Available P (%) | Available K (%) |
|---|---|---|---|---|---|
| **$M_1$** | 6.8 | 0.35 | 0.21 | 0.042 | 0.41 |
| **$M_2$** | 6.6 | 0.27 | 0.34 | 0.046 | 0.38 |
| **$M_3$** | 6.6 | 0.22 | 0.36 | 0.043 | 0.56 |
| **$M_4$** | 6.7 | 0.24 | 0.42 | 0.049 | 0.45 |
| **$M_5$** | 6.8 | 0.20 | 0.41 | 0.048 | 0.54 |

$M_1$ – cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_2$ – cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_3$ – cocopeat 40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)

$M_4$ – cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)

$M_5$ - soil: FYM: sand (1: 1: 1)

4.4. OTHER OBSERVATIONS

### 4.4.1 Plant nutrient content

***a. Nitrogen content***

Treatment combination of $M_5$ [soil : FYM : sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] recorded the highest plant nitrogen content (4.84%) whereas the lowest plant nitrogen content (3.52%) was observed in treatment combination $M_2$ x Control [without the application of growth retardants].

***b. Phosphorus content***

Highest phosphorus content was recorded under the treatment combination $M_5$ [soil : FYM : sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm], $M_5$ [soil: FYM: sand (1:1:1)] x Control [without application of growth retardants], $M_5$ [soil: FYM: sand (1:1:1)] x $GR_3$ [cycocel 1500 ppm], $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_3$ [cycocel 1500ppm], $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_2$ [cycocel 1000 ppm], $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) +rice husk (10%)] x $GR_3$ [cycocel 1000 ppm], $M_5$ [soil : FYM : sand (1:1:1)] x $GR_5$ paclobutrazol 60 ppm], $M_5$ [soil : FYM : sand (1:1:1)] x $GR_2$ [cycocel 1000 ppm], $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ paclobutrazol 90 ppm] and $M_4$ [cocopeat (40%) + Soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] which were on par (0.98, 0.97, 0.96, 0.96, 0.93, 0.93, 0.92, 0.91, 0.91 and 0.90% respectively). The lowest phosphorus content (0.70%) was recorded in $M_3$ [cocopeat (40%) + soil (20%) +vermicompost (20%) + vermiculite (10%) +rice husk (10%)] x $GR_1$ [cycocel 750 ppm] (Table 15).

***d. Potassium content***

The data revealed that growing media has significant effect on potassium content. $M_5$ [soil: FYM: sand (1:1:1)] had highest potassium content (4.90%) compared to other growing medium and lowest potassium content was observed in $M_1$

[cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] (Table 12).

It could be seen that growth retardants had significant effect with respect to phosphorus content. Application of paclobutrazol at 90 ppm had highest potassium content (4.68%) whereas lowest potassium content (4.09%) was recorded for cycocel at 750 ppm.

Among the treatments potassium was recorded highest in treatment combination of $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] (5.24%) and the lowest potassium content (3.37%) was observed in treatment combination of $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm].

### 4.4.2 Nutrient uptake by plants

Maximum uptake of nitrogen was recorded under $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol 90 ppm] (0.60 and 0.58%) whereas no significant variation was noted for uptake of phosphorus. Nutrient uptake of potassium was maximum in $M_4$ x $GR_6$ (0.68%) and $M_5$ x $GR_6$ (0.66%). The minimum nutrient uptake for nitrogen (0.14%) was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x Control [without the application of growth retardants] while the minimum nutrient uptake for potassium (0.15%) was recorded in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm](Table 13, 14 & 15)

### 4.4.3 Total chlorophyll content of leaves

Among the different growing media $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_5$ [soil : FYM : sand (1:1:1)] were on par and found to have highest total chlorophyll content (0.63 and 0.60 mg/g respectively) The lowest total chlorophyll content of the leaves (0.55 mg/g) was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] and $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)].

It could be seen that the growth retardants had significant effect in the total chlorophyll content of the leaves. The highest chlorophyll content (0.74 mg/g) was recorded for paclobutrazol at 90 ppm while the lowest chlorophyll content (0.46 mg/g) was recorded for cycocel at 750 ppm.

It was found that M x GR interaction was significant with respect to total chlorophyll content of the leaves. The treatment combination of $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ and [paclobutrazol 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol 90 ppm] recorded highest total chlorophyll content (0.80 and 0.78 mg/g). The minimum total chlorophyll content of the leaves (0.39mg/g) was observed in $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] x $GR_1$ [cycocel 750 ppm].

### 4.4.4 Pest and disease incidence

***a. Major pest incidence***

**a1. Leaf miner**

Leaf miners are small insect larvae which burrow in between the leaf layers of soft succulent leaved crops. Adult insects lay eggs in leaves and larvae hatch out and feed tissues in between leaf surfaces, creating a hollow track or "mine" without any proper straight way.

Symptoms: Initial symptoms on leaf miners infestations appeared as twisted marks in white colour on leaves. The mines were noticed after 3 to 4 days after oviposition by the adults and size of the mine goes on increasing with the maturity of the larvae. Severely damaged leaves appeared like stipples, leaf mining by the larvae and stippling of leaves reduced the photosynthetic ability of the leaves. Extensive mining caused the pre mature leaf drop.

Management: Application of *Verticillium lecanii* at 10g/l twice at weekly intervals or Fipronil 5 SC (5% w/w) at 2 ml/L at fortnightly interval and installation of yellow sticky traps controlled the incidence.

**a2. Mealy bug**

Mealy bugs are a type of soft scale coated with a woolly, waxy secretion that provides protection and decreases the effectiveness of contact insecticides. Like many other soft-bodied insects, mealy bugs damage plants by feeding on sap and other cell contents.

Symptoms: white cottony mealy bugs were gathered on the tender parts of the stem and leaves. Distorted stem and reduced plant vigor were observed after the infestation.

Management: Application of *Verticillium lecanii* at 10g/l twice at weekly intervals

**a3. Leaf feeders**

Leaf feeders damaged vegetative parts, which were controlled by the application of quinalphos (Ekalux 2ml/l).

***b. Major disease incidence***

**b1. Bacterial wilt**

Symptoms: Leaves first appeared as dull green, wilted during the day and leaves eventually turned yellow and brown at the margins, completely withered and died. This was confirmed with ooze test. Apart from bacterial wilt, no major diseases were identified during the research period. This might be due to the fungicide being sprayed prophylactically at the time of pinching.

Management: soil drenching with Copper hydroxide (Kocide) at 2g/l and drenching with *Pseudomonas fluorescens* at 2g/l

***c. Physiological abnormalities***

No physiological abnormalities were noticed during the period of study.

***d. cost of growing media***

The unit cost of growing media is given in Appendix II and the cost incurred for the growing media is given in Table 16. The cost of growing media per pot was found to be highest (Rs. 21/- per pot) for M1 [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%] and the cost incurred for the growing media was found lowest (Rs. 12.08/- per pot) in M5 [soil: FYM: sand (1:1:1)].

**Plate 7. Incidence of pest and diseases**

Leaf feeders/ Defoliators

Leaf Miner

Mealy Bug

Bacterial wilt

**Table 12. Effect of growing medium and growth retardants on plant nutrient content, nutrient uptake and total chlorophyll content of African marigold var 'Double Orange'**

| Treatments | | Plant nutrient content | | | Nutrient uptake by plants | | | Total chlorophyll content |
|---|---|---|---|---|---|---|---|---|
| | | N | P | K | N | P | K | |
| GROWING MEDIUM | $M_1$ | 3.73 | 0.82 | 3.68 | 0.20 | 0.079 | 0.20 | 0.55 |
| | $M_2$ | 3.83 | 0.83 | 4.17 | 0.30 | 0.064 | 0.32 | 0.55 |
| | $M_3$ | 4.00 | 0.76 | 4.50 | 0.36 | 0.067 | 0.40 | 0.58 |
| | $M_4$ | 4.19 | 0.86 | 4.79 | 0.44 | 0.087 | 0.50 | 0.63 |
| | $M_5$ | 4.46 | 0.92 | 4.90 | 0.49 | 0.100 | 0.54 | 0.60 |
| **CD(0.05)** | | **0.02** | **0.03** | **0.04** | **0.01** | **NS** | **0.01** | **0.02** |
| **SE(m)** | | **0.01** | **0.01** | **0.02** | **0.003** | **0.02** | **0.003** | **0.01** |
| GROWTH RETARDANTS | $GR_1$ | 4.00 | 0.78 | 4.09 | 0.31 | 0.06 | 0.33 | 0.46 |
| | $GR_2$ | 4.05 | 0.86 | 4.26 | 0.34 | 0.07 | 0.37 | 0.50 |
| | $GR_3$ | 4.14 | 0.91 | 4.43 | 0.38 | 0.13 | 0.41 | 0.59 |
| | $GR_4$ | 4.12 | 0.76 | 4.34 | 0.37 | 0.06 | 0.40 | 0.60 |
| | $GR_5$ | 4.19 | 0.81 | 4.46 | 0.42 | 0.08 | 0.45 | 0.67 |
| | $GR_6$ | 4.24 | 0.88 | 4.68 | 0.45 | 0.09 | 0.50 | 0.74 |
| | CONTROL | 3.57 | 0.84 | 4.63 | 0.20 | 0.05 | 0.27 | 0.53 |
| **CD(0.05)** | | **0.02** | **0.04** | **0.05** | **0.01** | **NS** | **0.01** | **0.023** |
| **SE(m)** | | **0.01** | **0.01** | **0.02** | **0.003** | **0.018** | **0.003** | **0.008** |

**Table 13. Effect of M x GR interaction on plant nutrient content, nutrient uptake and total chlorophyll content of African marigold var 'Double Orange'**

| Treatments | Plant nutrient content | | | Nutrient uptake by plants | | | Total chlorophyll content |
|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | |
| **$M_1$ x $GR_1$** | 3.64 | 0.84 | 3.37 | 0.17 | 0.039 | 0.15 | 0.49 |
| **$M_1$ x $GR_2$** | 3.73 | 0.86 | 3.51 | 0.19 | 0.045 | 0.18 | 0.50 |
| **$M_1$ x $GR_3$** | 3.81 | 0.88 | 3.48 | 0.23 | 0.053 | 0.21 | 0.54 |
| **$M_1$ x $GR_4$** | 3.81 | 0.79 | 3.44 | 0.20 | 0.041 | 0.18 | 0.56 |
| **$M_1$ x $GR_5$** | 3.82 | 0.80 | 3.65 | 0.23 | 0.047 | 0.21 | 0.64 |
| **$M_1$ x $GR_6$** | 3.84 | 0.85 | 3.77 | 0.26 | 0.057 | 0.25 | 0.72 |
| **$M_1$ x Control** | 3.87 | 0.75 | 4.55 | 0.14 | 0.030 | 0.18 | 0.44 |
| **$M_2$ x $GR_1$** | 3.86 | 0.66 | 3.85 | 0.28 | 0.048 | 0.28 | 0.46 |
| **$M_2$ x $GR_2$** | 3.88 | 0.84 | 4.09 | 0.31 | 0.068 | 0.33 | 0.49 |
| **$M_2$ x $GR_3$** | 3.88 | 0.93 | 4.12 | 0.33 | 0.079 | 0.35 | 0.59 |
| **$M_2$ x $GR_4$** | 3.90 | 0.82 | 4.13 | 0.28 | 0.059 | 0.29 | 0.55 |
| **$M_2$ x $GR_5$** | 3.90 | 0.87 | 4.24 | 0.34 | 0.076 | 0.37 | 0.60 |
| **$M_2$ x $GR_6$** | 3.92 | 0.91 | 4.28 | 0.37 | 0.086 | 0.40 | 0.70 |
| **$M_2$ x Control** | 3.52 | 0.77 | 4.51 | 0.17 | 0.037 | 0.22 | 0.50 |
| **CD (0.05)** | **0.05** | **0.08** | **0.12** | **0.02** | **NS** | **0.02** | **0.05** |
| **SE(m)** | **0.01** | **0.02** | **0.04** | **0.007** | **0.041** | **0.008** | **0.01** |

**Table 14. Effect of M x GR interaction on plant nutrient content, nutrient uptake and total chlorophyll content of African marigold var 'Double Orange'**

| Treatments | Plant nutrient content | | | Nutrient uptake by plants | | | Total chlorophyll content |
|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | |
| **$M_3$ x $GR_1$** | 3.91 | 0.70 | 4.27 | 0.32 | 0.057 | 0.35 | 0.39 |
| **$M_3$ x $GR_2$** | 3.97 | 0.76 | 4.35 | 0.36 | 0.069 | 0.39 | 0.46 |
| **$M_3$ x $GR_3$** | 4.08 | 0.83 | 4.36 | 0.38 | 0.079 | 0.41 | 0.65 |
| **$M_3$ x $GR_4$** | 4.15 | 0.65 | 4.45 | 0.39 | 0.063 | 0.42 | 0.69 |
| **$M_3$ x $GR_5$** | 4.17 | 0.70 | 4.52 | 0.42 | 0.071 | 0.45 | 0.68 |
| **$M_3$ x $GR_6$** | 4.19 | 0.76 | 4.96 | 0.44 | 0.081 | 0.52 | 0.70 |
| **$M_3$ x Control** | 3.56 | 0.86 | 4.62 | 0.21 | 0.052 | 0.27 | 0.55 |
| **$M_4$ x $GR_1$** | 4.14 | 0.85 | 4.42 | 0.34 | 0.072 | 0.37 | 0.48 |
| **$M_4$ x $GR_2$** | 4.26 | 0.93 | 4.50 | 0.37 | 0.083 | 0.39 | 0.53 |
| **$M_4$ x $GR_3$** | 4.24 | 0.96 | 5.08 | 0.39 | 0.091 | 0.47 | 0.63 |
| **$M_4$ x $GR_4$** | 4.33 | 0.72 | 4.83 | 0.51 | 0.085 | 0.56 | 0.67 |
| **$M_4$ x $GR_5$** | 4.36 | 0.77 | 4.93 | 0.55 | 0.098 | 0.62 | 0.69 |
| **$M_4$ x $GR_6$** | 4.39 | 0.90 | 5.10 | 0.58 | 0.121 | 0.68 | 0.80 |
| **$M_4$ x Control** | 3.64 | 0.88 | 4.65 | 0.27 | 0.067 | 0.48 | 0.61 |
| **CD (0.05)** | **0.05** | **0.08** | **0.12** | **0.02** | **NS** | **0.02** | **0.05** |
| **SE(m)** | **0.01** | **0.02** | **0.04** | **0.007** | **0.041** | **0.008** | **0.01** |

**Table 15. Effect of M x GR interaction on plant nutrient content, nutrient uptake and total chlorophyll content of African marigold var 'Double Orange'**

| Treatments | Plant nutrient content | | | Nutrient uptake by plants | | | Total chlorophyll content |
|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | |
| **$M_5$ x $GR_1$** | 4.44 | 0.86 | 4.56 | 0.47 | 0.092 | 0.48 | 0.50 |
| **$M_5$ x $GR_2$** | 4.41 | 0.91 | 4.86 | 0.50 | 0.104 | 0.55 | 0.53 |
| **$M_5$ x $GR_3$** | 4.70 | 0.96 | 5.09 | 0.55 | 0.113 | 0.59 | 0.54 |
| **$M_5$ x $GR_4$** | 4.42 | 0.83 | 4.83 | 0.50 | 0.095 | 0.55 | 0.58 |
| **$M_5$ x $GR_5$** | 4.72 | 0.92 | 4.94 | 0.57 | 0.113 | 0.60 | 0.74 |
| **$M_5$ x $GR_6$** | 4.84 | 0.98 | 5.24 | 0.60 | 0.123 | 0.66 | 0.78 |
| **$M_5$ x Control** | 3.67 | 0.97 | 4.79 | 0.24 | 0.064 | 0.31 | 0.55 |
| **CD (0.05)** | **0.05** | **0.08** | **0.12** | **0.02** | **NS** | **0.02** | **0.05** |
| **SE(m)** | **0.01** | **0.02** | **0.04** | **0.007** | **0.041** | **0.008** | **0.01** |

**Table 16. Cost of growing media**

| Media | components | Quantity of each components | Total weight of growing media per pot(kg) | Cost of growing media per pot(Rs.) |
|---|---|---|---|---|
| **$M_1$** | cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%) | cocopeat (0.96 kg), vermicompost (0.6 kg), vermiculite (0.16 kg) and rice husk (0.04 kg) | 1.76 | 21.40 |
| **$M_2$** | Cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%) | cocopeat (0.96 kg), FYM (0.48 kg),vermiculite (0.16 kg) and rice husk (0.04 kg) | 1.64 | 16.12 |
| **$M_3$** | cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) +rice husk (10%) | cocopeat (0.64 kg), soil (1 kg),vermicompost (0.6 kg), vermiculite (0.16 kg) and rice husk (0.04 kg) | 2.44 | 20.20 |
| **$M_4$** | cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) | cocopeat (0.64 kg), Soil (1 kg), FYM (0.48 kg), vermiculite (0.16 kg) and rice husk (0.04 kg) | 2.32 | 14.92 |
| **$M_5$** | soil: FYM: sand (1:1:1) | soil(1.7 kg), FYM(0.825 kg) and sand (2.48 kg) | 5.00 | 12.08 |

# DISCUSSION

# Chapter - 5

# DISCUSSION

African marigold (*Tagetes erecta* L. family: Asteraceae) is native to South and Central America. It is one of the most popular and commercial flowering annuals cultivated in most of the states in India. It has great demand during various festivals for garland, cut flower and decorative purposes. It is suitable for potted plant, bedding, edging, garland making, religious offerings and also for making value added products.

Growing media play an important role in growth, compactness and flowering of potted plants. Height control is very essential for compact growth and external application of growth retardants was found to be very effective for compact growth in African marigold. The study entitled “Standardization of growing medium and growth retardants for compact growth of potted African marigold was carried out at the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara. The results of the study are discussed here.

## 5.1 EFFECT OF GROWING MEDIA

### 5.1.1. Vegetative characters

Vegetative parameters like plant height, plant spread, number of branches per plant and number of leaves per branch are the parameters that decide the compact growth of potted African marigold. Short plant stature enhances the presentability of potted plants. In the present study, $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] was found to produce shortest plants throughout the growing period.

Regarding plant spread, $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_5$ [soil: FYM: sand (1:1:1] were found to exhibit greatest plant spread. Number of branches is an important parameter which decides the attractiveness of potted ornamentals. In the present study, $M_4$

[cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) and $M_5$ [soil: FYM: sand (1:1:1)] were observed to be on par and recorded more number of branches.

Number of leaves per branch determines the leaf area and fullness of the pot. There was a significant influence of growing media with respect to number of leaves per branch. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] and $M_5$ [soil: FYM: sand (1:1:1)] was superior with regard to this parameter.

In the present study the desirable characters with respect to vegetative parameters for potted African marigold was observed in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)]. This might be due to the influence of components of the medium. Forty per cent of this medium consisted of cocopeat. Addition of cocopeat enhances the texture and avoid compaction of the media. Cocopeat increases water holding capacity of the medium due to its high porosity. High cation exchange capacity (CEC) of cocopeat allows easy absorption of nutrients and slow release as per plant requirement. Apart from this, cocopeat contain substantial amount of nutrients such as N, P, K, Ca and Mg required for plant growth. Beneficial effect of cocopeat on growth and yield of flowering ornamentals had been reported in various ornamental crops *viz*; Yahya *et al*. (1997) in celosia and marigold; Riaz *et al*. (2008) in zinnia; Thakur *et al*. (2013) in calendula; Kameswari *et al*. (2014); Singh *et al*. (2010) in geranium; Bhandari *et al*. (2016) and Bhat *et al.* (2019) in lilium; Katebi *et al*. (2020) in poinsettia and Lalmuanpuii *et al*. (2021).

FYM is rich in organic matter. The beneficial effect of FYM on vegetative parameters may be attributed due to balanced supply of nutrients in accessible form after decomposition, which leads to greater root development and easier nutrient absorption, resulting in improved vegetative growth. When amended with other components of the growing medium, FYM provides conducive environment for root growth, absorption and translocation of nutrients. The findings in the study are in accordance with the reports of Wazir *et al.* (2009); Bala and Singh (2013); Kameswari *et al*. (2014); Nair and Bharathi (2015) and Ganesh *et al*. (2015) in chrysanthemum (Fig. 1 & 2).

Rice husk is a byproduct of rice milling industry. Rice husk is rich in $SiO_2$. When it is added to growing medium it will improve the porosity of the medium (Evans and Gachukia, 2004). Rice husk is reported to absorb heavy metals from growing medium and irrigation water (Alzrog *et al*., 2013) and alter the pH of the medium into favourable range for plant growth ( El Sharkawi *et al*., 2014). The beneficial effects of rice husk in various ornamentals were reported by Meng *et al.* (2012); Chauhan *et al.* (2014) in gerbera and Giree and Shrestha (2018)

Vermiculite was also used as one of the components of $M_4$ in the present study. Vermiculite is hydrated phyllosilicate mineral having good aeration and water retention capacity as well as low bulk density. When added to growing media it was found to alter the physical and chemical properties into favourable conditions for plant growth. Using vermiculite in the growing medium was reported to enable the plants for easy absorption of ammonium, potassium, calcium and magnesium. Beneficial influence of vermiculite on plant growth was reported in several ornamental crops *viz;* Manish *et al*. (2000) in lilium; Sindhu *et al*. (2010) in Gerbera; Thakur and Grewal (2019); Al- mazroui *et al*. (2020) in marigold and Sharif *et al*. (2020) in gerbera (Fig. 1 & 2).

In the present study twenty percent of the medium composition of $M_4$ was soil. Soil is rich in organic matter and it supplies all nutrients for plant growth as well it provide habitat to many beneficial microorganisms. In combination with other components, soil provides an excellent growing media composition for plant growth. Positive effects of soil as a growing media component was reported by Sekhar and Sujatha (2001) in gerbera; Khelikuzzaman (2007) in tradescantia; Riaz *et al*. (2008) in zinnia; Wazir *et al*. (2009) in alstromeria; Bala and Singh (2013) in chrysanthemum; Kameswari *et al*. (2014); Kulkarni (2016) in gerbera and Kumar *et al*. (2016) in marigold.

From the analysis of chemical properties of growing medium, available NPK (%) was found maximum for $M_4$ compared to other growing media. The optimum pH values and electrical conductivity (EC) might have further helped in better uptake of nutrients from the medium. These results are in accordance with the findings of Sharma *et al.* (2017) and Kumar *et al*. (2019) in marigold. Similar findings were also reported in other flower crops *viz;* Kulkarni *et al.* (2016) in gerbera; Mongal *et al.* (2006) in china aster; Dhiman *et al.* (2010); Khanna *et al.* (2016) in chrysanthemum and Diwivedi *et al.* (2018) in jasmine. Complementary effect of all these media components might have altered the physical and chemical properties and nutrient status of the growing medium.

**5.1.2 Floral characters**

Earliness in flowering and shortest time for flower opening are desirable characters for potted flowering ornamentals. In the present study, days taken for first flower bud emergence and days taken from flower bud initiation to flower opening was noticed lowest in $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%). Early emergence of flower bud in $M_2$ might be due to the easy availability of nutrients from FYM and cocopeat which advances the translocation of phytohormones to the shoot apex resulting in early emergence and media components *viz*; cocopeat, vermiculite and rice husk might have increased the porosity of the medium resulting in better uptake of nutrients by the plant. The results were in accordance with findings of Wazir *et al.* (2009) in alstroemeria; Singh (2010) in geranium; Ikram *et al*. (2012) in tuberose; Bhatia *et al.* (2004) and Ganesh *et al*. (2015) in chrysanthemum (Fig. 7 & 8).

The number of flowers and size of the flowers determine the beauty of flowering pot plants. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] was found to have more number of flowers per plant as well as flower diameter compared to other growing media. The enhanced floral growth in terms of more number of flowers and flower diameter might be due to the change in physical properties of the medium with the addition of cocopeat, vermiculite and rice husk which have resulted in more nutrient uptake and vegetative growth leading to more flower production. Presence of soil and FYM also might have increased the availability of nutrients to the plants. Similar findings were reported by Singh (2004); Rathore and Mishra (2014); Pushkar and Singh (2012) in marigold; Misra *et al*. (2005) in rose and Bhardwaj *et al*. (2020) in barleria.

Growing media had no significant effect on flowering duration. Field life of individual flowers is an important parameter which decides the period up to which the potted flowering ornamentals remains in presentable form. More number of days with respect to field life of individual flowers was found in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)]. Analysis of growing media for available plant nutrients revealed that $M_4$ had highest nitrogen, phosphorus and potassium contents. pH, EC and physical properties of the medium were in favourable range which facilitate the uptake of nutrients. Better uptake of nitrogen and phosphorus might have caused an improvement of plant growth resulting the synthesis and translocation of photosynthates for production of flowers. Potassium determines the quality of the produce and availability of more potassium might have improved the quality of flowers and there by more field life. Similar findings were reported by Singh *et a*l. (2010) in geranium; Youssef and Abd El- Aal (2013) in *Tabernaemontana coronaria* and Sahu *et al*. (2021) in marigold.

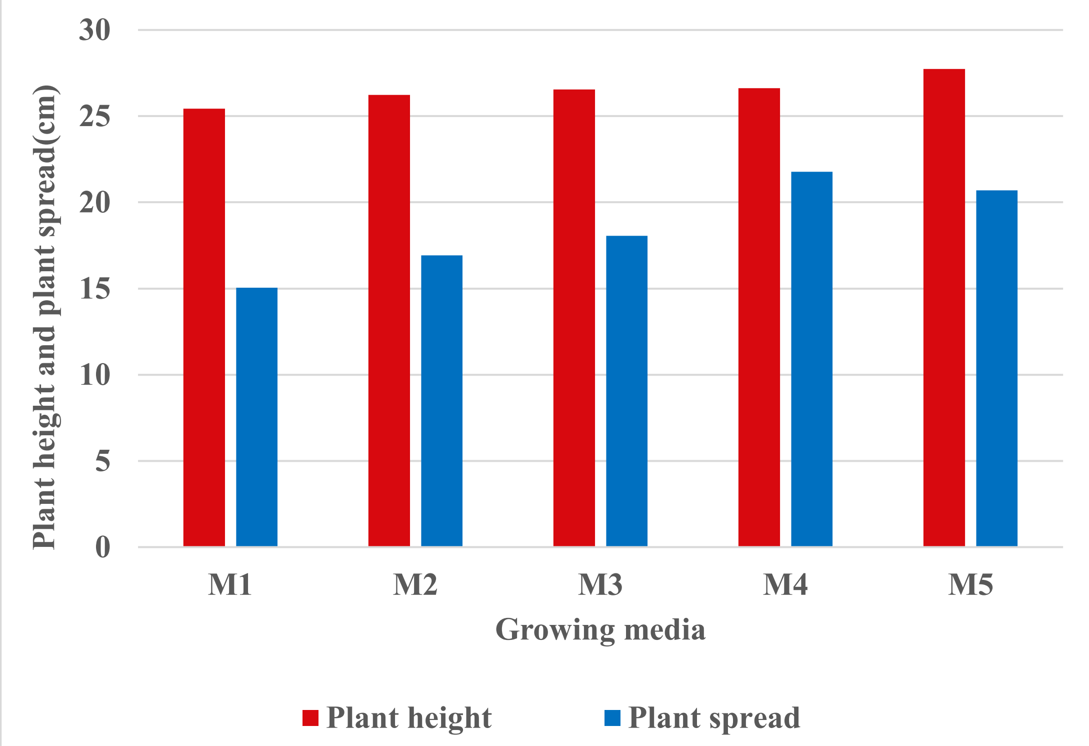


**Fig 1. Effect of growing media on plant height and plant spread (cm)**

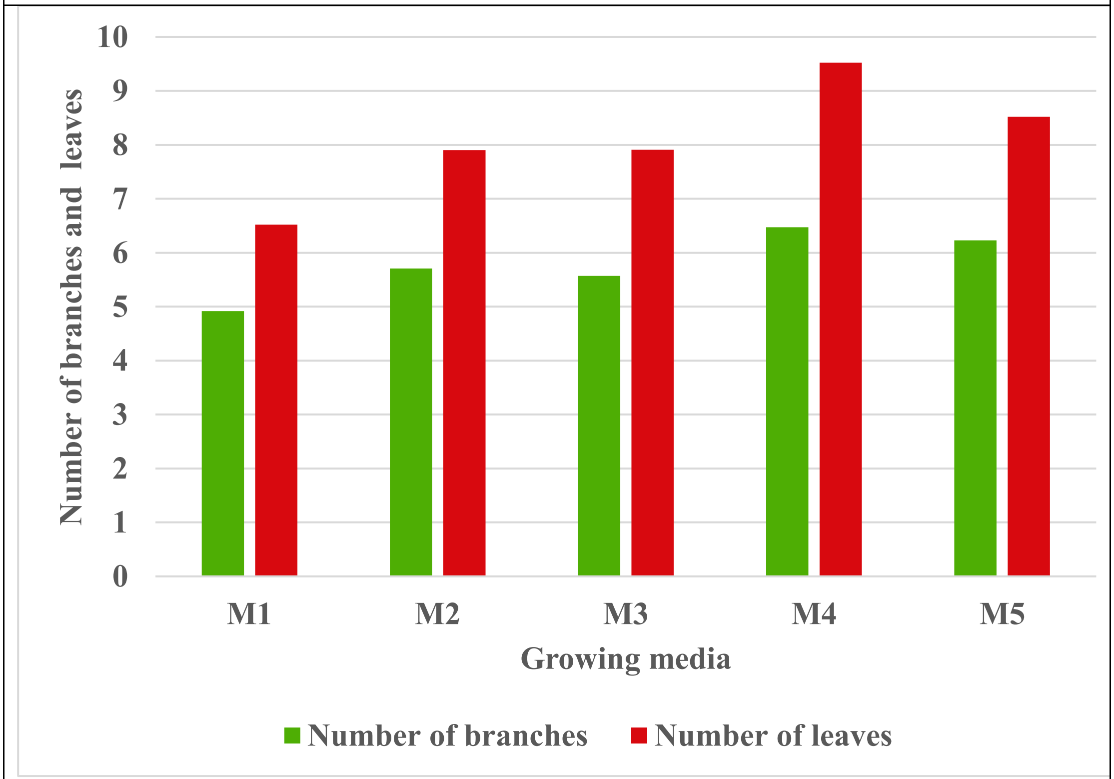


**Fig 2. Effect of growing media on number of branches and leaves**

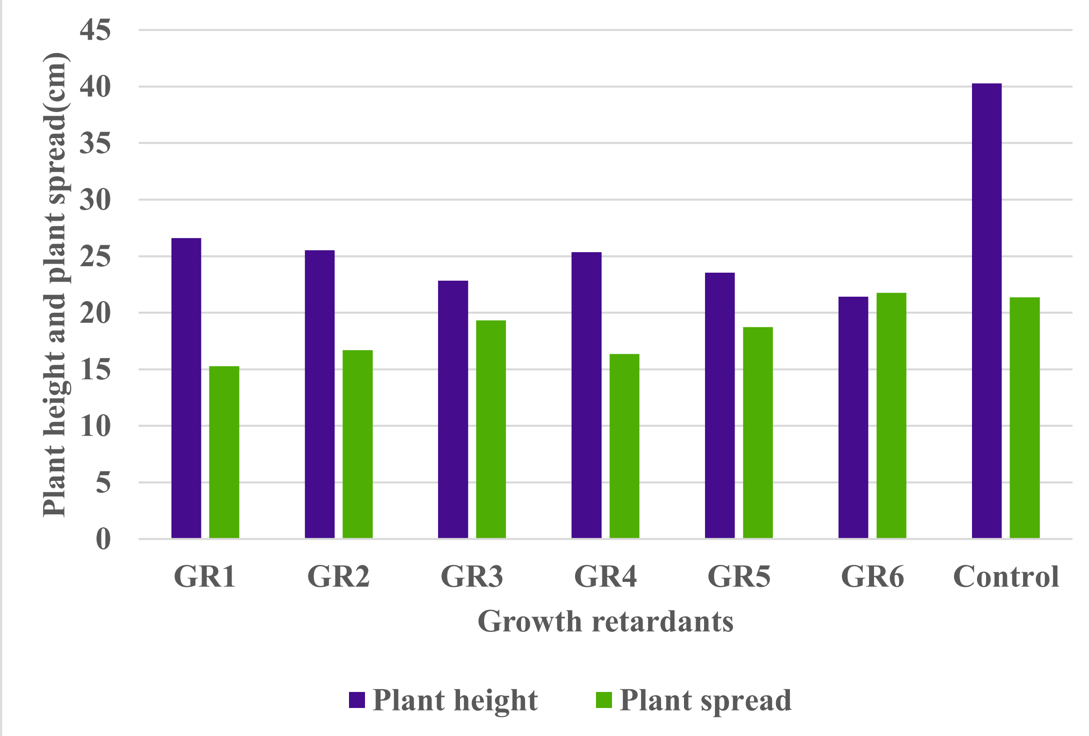


**Fig 3. Effect of growth retardants on plant height and plant spread (cm)**

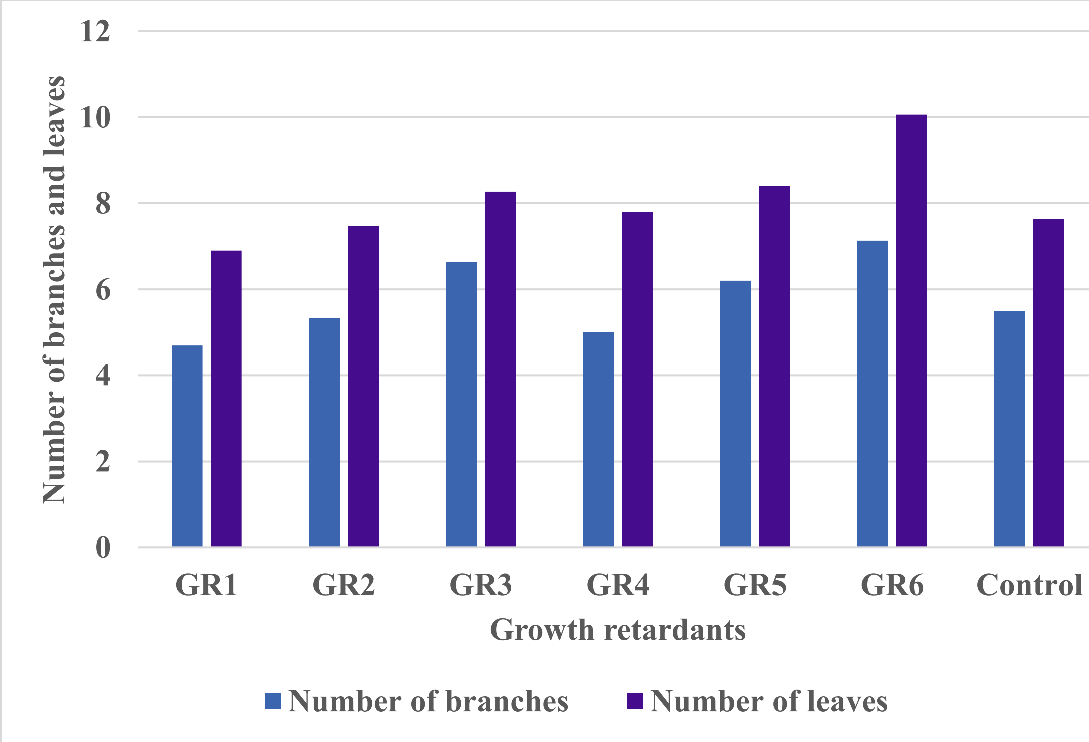


**Fig 4. Effect of growth retardants on number of branches and leaves**

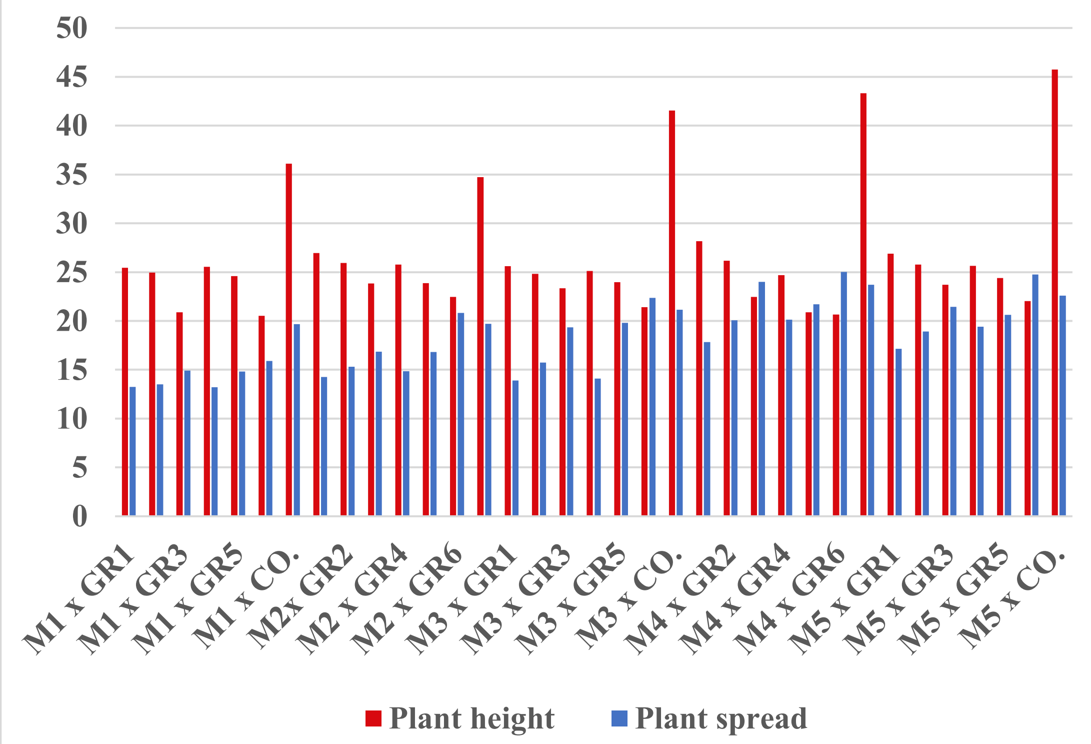


**Fig 5. M x GR interaction on plant height and plant spread (cm)**

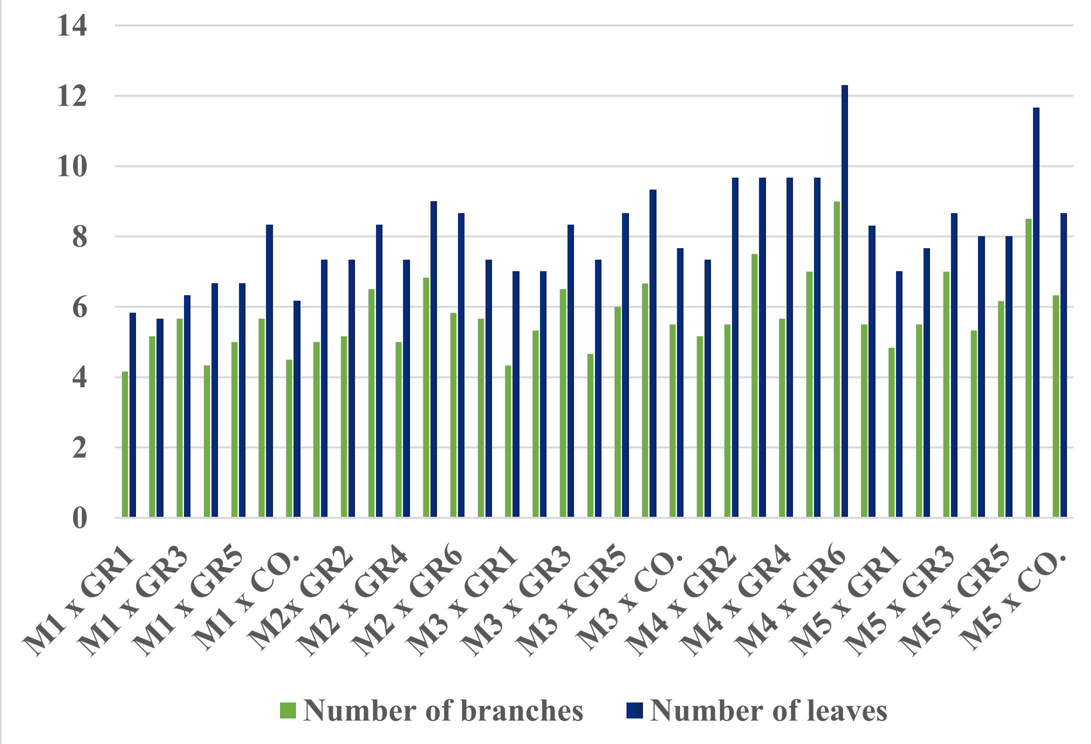


**Fig 6. M x GR interaction on number of branches and leaves**

5.2 EFFECT OF GROWTH RETARDANTS

**5.2.1 Vegetative characters**

Regarding the plant height, significant variation could be observed due to the application of plant growth retardants. Shortest plants were observed by the application of paclobutrazol at 90 ppm.

Decrease in plant height due to exogenous application of paclobutrazol might be because of their inhibitory role on cell division and cell elongation of apical meristematic cells. According to Rademacher (2000) paclobutrazol affects the isoprenoid pathway and alter the level of plant hormones by inhibitory effect on gibberellin biosynthesis. Blocking the biosynthesis of active gibberellin results in reduction of internodal length and plant height (Mahgoub *et al*., 2006). Similar findings had been reported by Dani *et al.* (2010) in marigold; Karlovic *et al.* (2004), Dorajeerao *et al*. (2012) and Jagdale *et al.* (2017) in chrysanthemum. Significant effect of growth retardants on plant spread was noticed with the application of paclobutrazol at 90 ppm ($GR_6$) which was found to produce greatest plant spread.

Growth retardants had significant influence on the number of branches per plant and the number of leaves per branch. Application of paclobutrazol at 90 ppm ($GR_6$) was found to produce more number of branches per plant and number of leaves per branch. The increase in plant spread, number of branches per plant and number of leaves per branch with application of paclobutrazol at 90 ppm might be due to the suppression of auxin by paclobutrazol which lead to increase in plant spread, number of branches and number of leaves. An enhancement in number of branches per plant and number of leaves per branch by application of paclobutrazol was reported by Sahu *et al*. (2021) in marigold. Similar finding were also reported by Kholiya *et al*. (2020), Pushkar and Singh (2012), Rathore and Mishra (2014) and Kumar *et al.* (2016) in marigold; Auda *et al.* (2002) and Abou-Dahab and Habib (2005) in barleria; Suradinata *et al*. (2013) in begonia.

**5.2.2 Floral characters**

Growth retardants had significant effect on the floral characters *viz.* days taken for first flower emergence, days taken from flower bud initiation to flower opening, number of flowers per plant, flower diameter, flowering duration and field life of individual flowers. Minimum number of days for first flower bud emergence and days taken from flower bud initiation to flower opening was observed in cycocel 750 ppm ($GR_1$) whereas maximum number of days for first flower bud emergence and days taken from flower bud initiation to flower opening was observed in paclobutrazol 90 ppm ($GR_6$).

More number of flowers per plant, maximum flowering duration and field life of individual flower was observed with the application of paclobutrazol at 90 ppm. Application of paclobutrazol resulted in production of more lateral branches. Flowers per plant is related to number of branches. Production of more number of branches due to application of paclobutrazol might have caused an increase in number of flowers. Continuous production of flower buds in this treatment might have increased the flowering duration also. One of the most important effects of paclobutrazol is the repression of senescence in the plant tissue by decreasing ethylene production which increase the individual field life of flowers. The results were in accordance with the studies of Mansuroglu *et al*. (2009) in *Consolida orientalis*; Kumar *et al.* (2015) in china aster; Suradinata *et al*. (2013) in begonia; El-Sadek (2016) in hibiscus; Kholiya *et al*. (2020); Sahu *et al*. (2021) in marigold; Banon *et al.* (2009) in geranium and Mounika *et al*. (2019) in chrysanthemum.

5.3 EFFECT OF M X GR INTERACTION

**5.3.1 Vegetative and floral characters**

In general $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] in combination with $GR_6$ [paclobutrazol 90 ppm] was found to possess all the desirable characters for potted African marigold in terms of vegetative as well as floral characters. This might be due to complementary effects of growing medium and growth retardants on plant growth. $M_4$ consisted of 40% cocopeat, which in combination with vermiculite and rice husk might have altered the physical properties of the medium *viz*; bulk density, porosity and moisture holding capacity as well as pH and EC of the medium into a favourable range. Apart from this cocopeat also release nutrients slowly to the medium. Soil and FYM in the growing medium might have contributed to the nutrient. Application of paclobutrazol along with this resulted in inhibiting apical dominance and diverting plant metabolites from vertical growth to horizontal growth, resulting in more plant spread, more branches and more leaves per plant (Fig. 5&6).

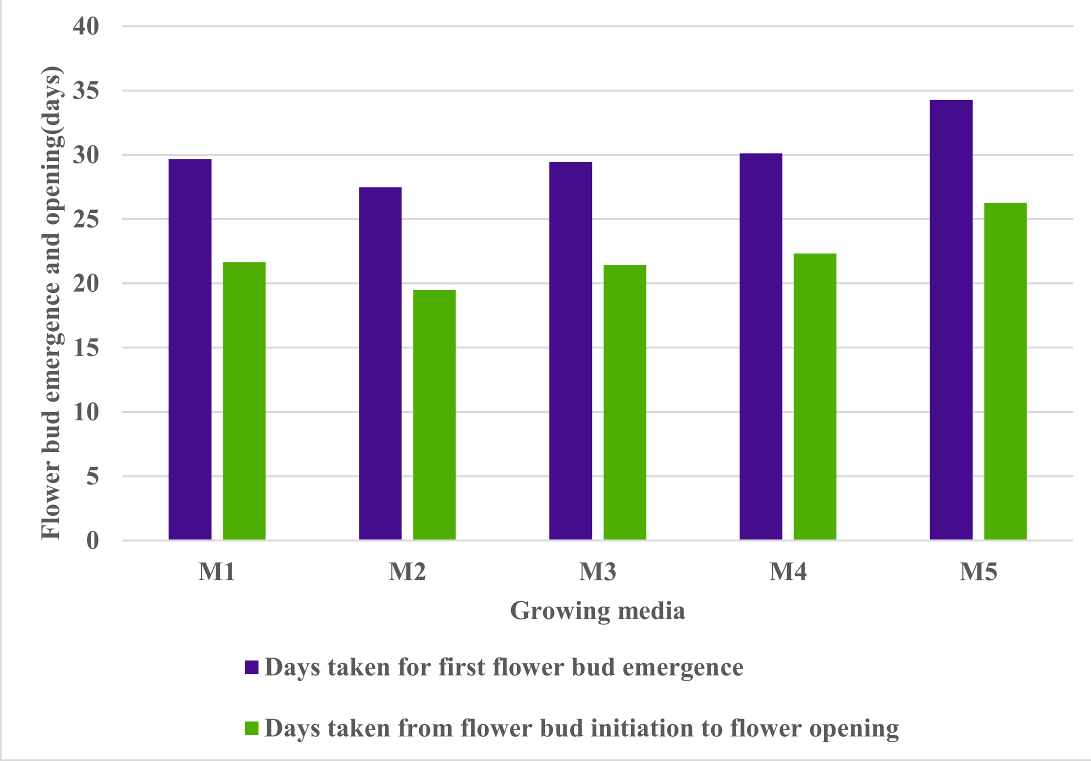


**Fig 7. Effect of growing media on days to flower bud emergence and opening**

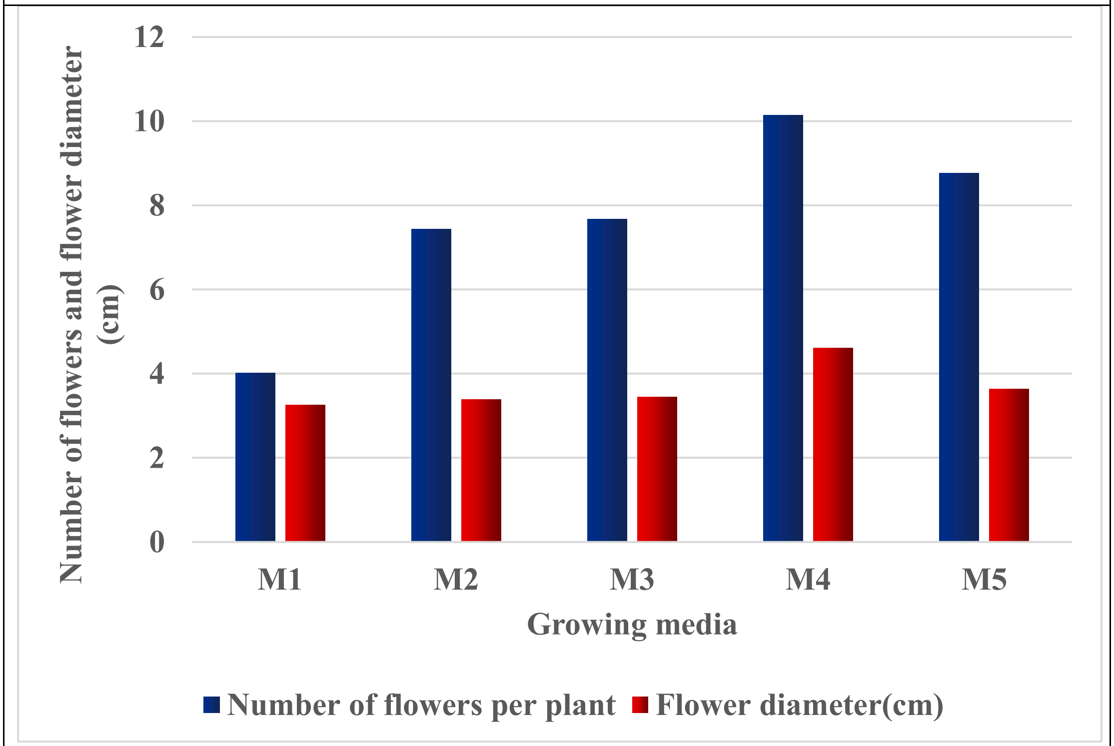


**Fig 8. Effect of growing media on number of flowers and flower diameter(cm)**

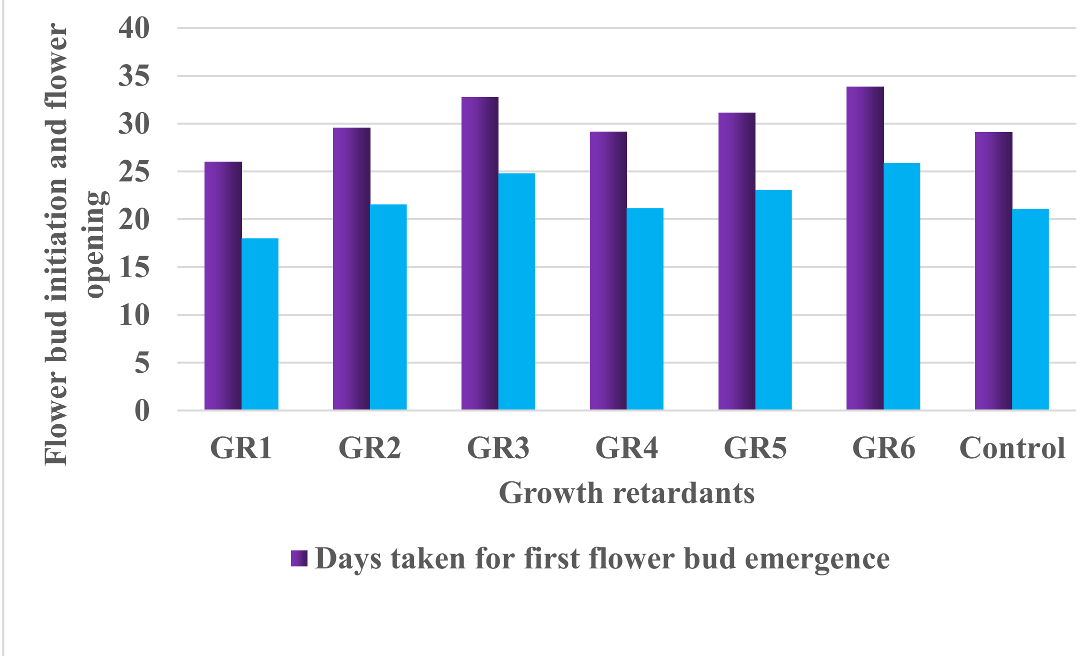


**Fig.9. Effect of growth retardants on days to flower bud emergence and opening**

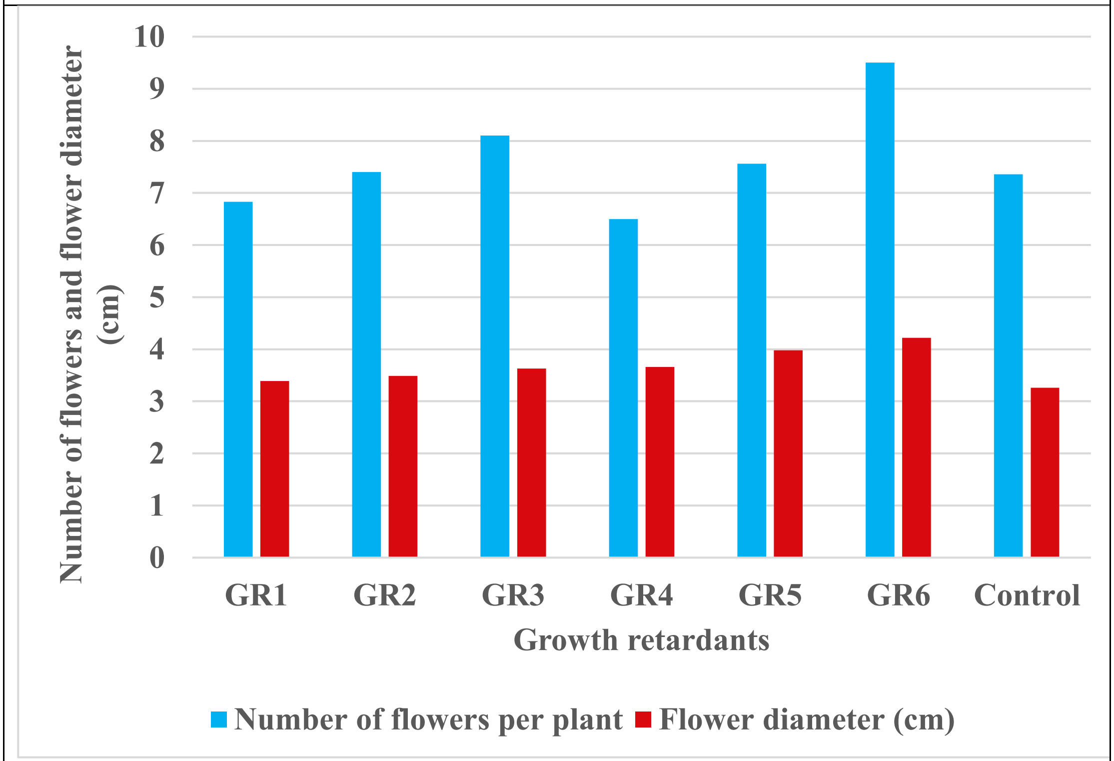


**Fig 10. Effect of growth retardants on number of flowers and flower diameter(cm)**

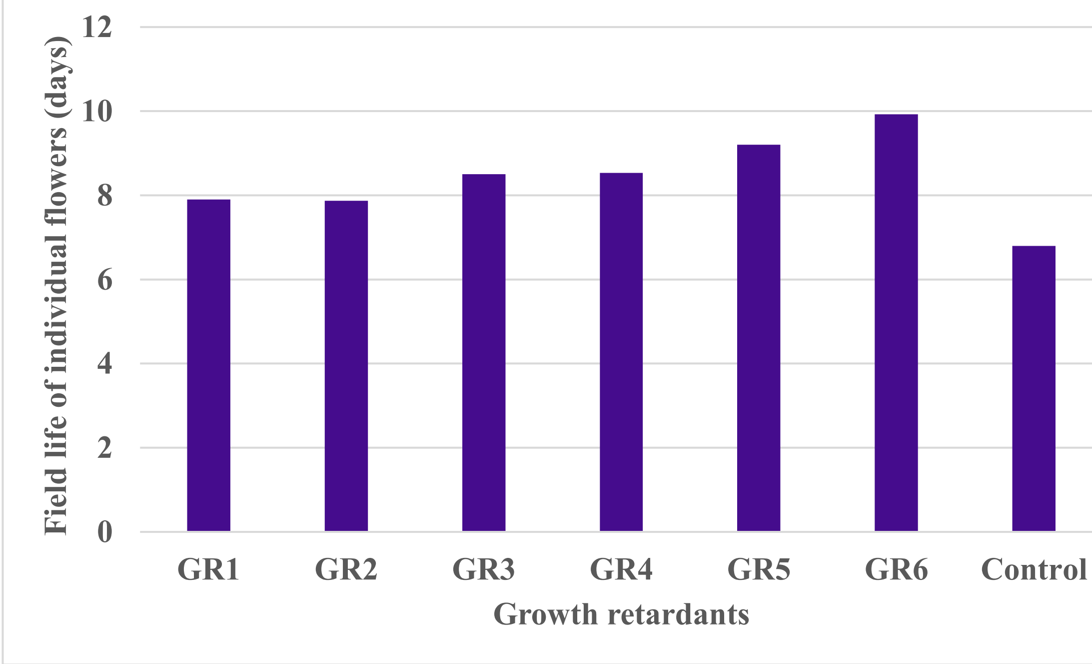


**Fig 11. Effect of growth retardants on field life of individual flowers (days)**

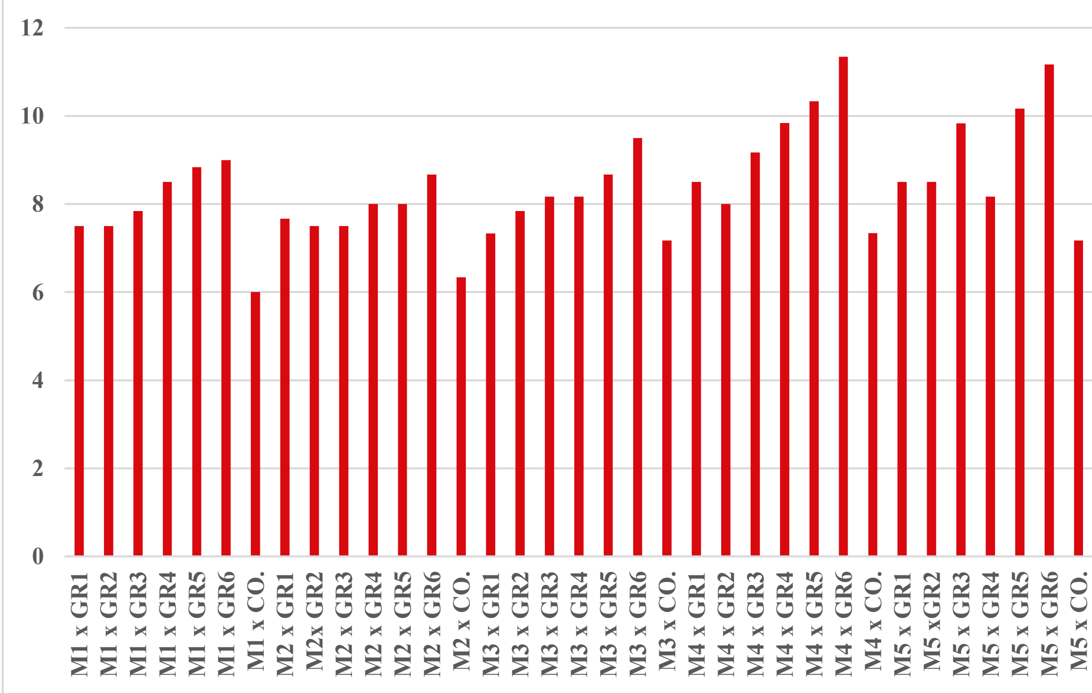


**Fig 12. Effect of M x GR interaction on field life of individual flowers(days)**

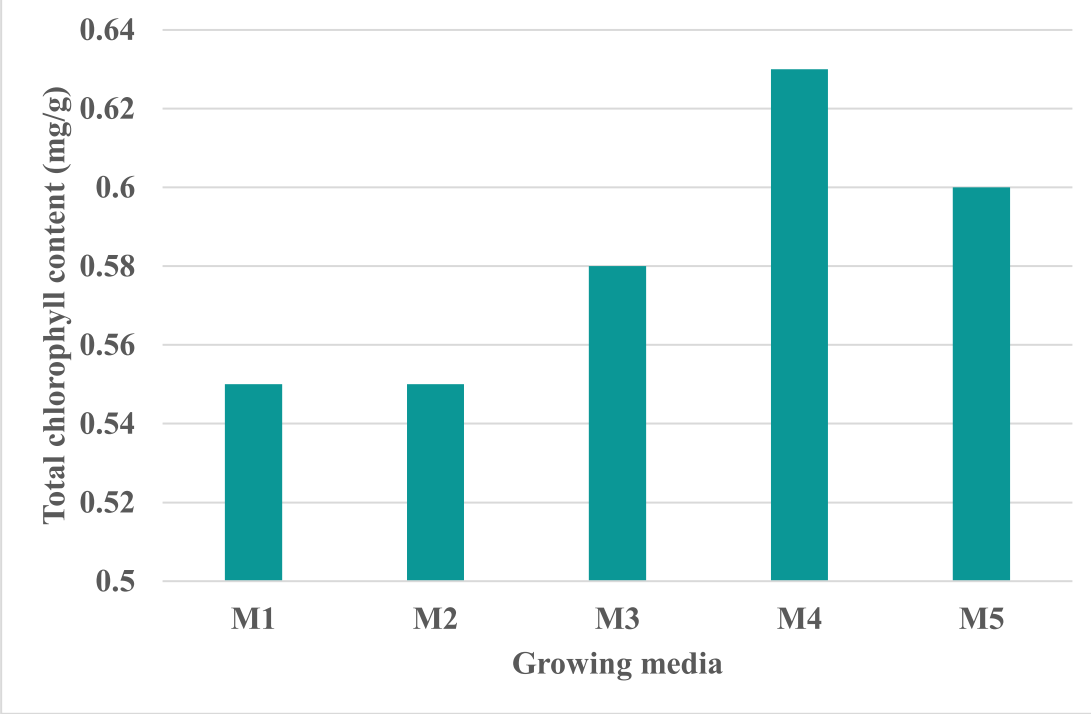


**Fig 13 Effect of growing media on total chlorophyll content of leaves (mg/g)**

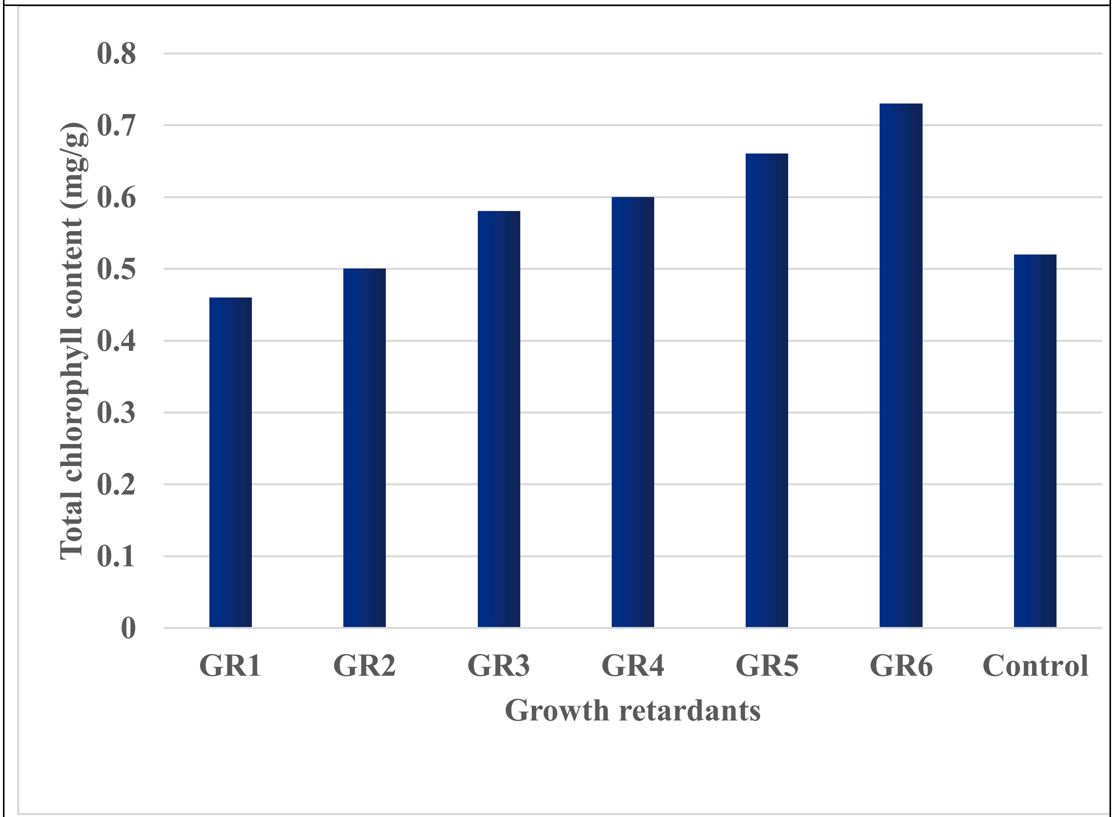


**Fig 14. Effect of growth retardants on total chlorophyll content of leaves(mg/g)**

### 5.4 MEDIA CHARACTERS

#### 5.4.1 Physical properties of the growing media

Bulk density (g/cm3), porosity (%) and water holding capacity (%) are the physical properties of the media. Lower the bulk density higher will be the porosity. Low bulk density was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] which favoured higher porosity. Water holding capacity of the media was found more in $M_1$ and was found less in $M_5$

In the present study, lower bulk density of medium $M_1$ may be due to presence of cocopeat which constitute 60% of the growing media composition. In addition to this, presence of vermiculite and rice husk might have also contributed to lowering the bulk density.

#### 5.4.2 Chemical properties of the growing media

pH is an indication of acidity - alkalinity scale. It affects the availability of nutrients and the capacity of the plants to absorb the nutrients. Marigold prefer optimum pH in range of 5.8 - 6.2 for better growth. Among different growing media, the pH levels of all were in favourable range before and after the completion of experiment. Electrical conductivity (EC) is a measure of soluble salts in the medium. EC directly influence the nutrient absorption. Optimum electrical conductivity for media should be less than 1.5 dS/m and all the growing media were in the favourable range of EC before and after the completion of experiment. This might be due to the changes in pH level due to complementary effects of media components.

Available N, P and K (%) are essential for the growth and flowering of the marigold. Highest available nitrogen (%) and phosphorus (%) was present in $M_4$ [cocopeat (40%) + soil (20%) +FYM (20%) + vermiculite (10%) + rice husk (10%)] before and after the experiment whereas available K (%) was found highest in M4 before the experiment and $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)] after the experiment. Available nitrogen and phosphorus was found to have influence on shoot and root growth as well as plant spread. Increased availability of potassium improves the translocation of carbohydrates to root system of plants resulting in better absorption of nutrients and plant growth.

## 5.5 TOTAL CHLOROPHYLL CONTENT

**a. Effect of growing media**

Growing media had significant influence on total chlorophyll content of the plant. $M_4$ and $M_5$ were on par with respect to total chlorophyll production and this might be due to the increased supply of nitrogen by FYM that might have helped for easy absorption of plant nutrients essential for greening of the leaves. Similar findings were reported by Mukesh *et al*. (2007) in marigold (Fig.13).

**b. Effect of growth retardants**

Growth retardants had significant influence on total chlorophyll content. Application of paclobutrazol at 90 ppm have resulted in highest total chlorophyll content. Paclobutrazol influence the isoprenoid pathway inhibiting gibberellic acid synthesis, decreasing ethylene production and enhancing the content of both cytokinin and abscisic acid. Biosynthesis of chloroplast pigment is affected by paclobutrazol application. Xia *et al*. (2018) reported the plants treated with paclobutrazol enhances the levels of cytokinin which in turn enhance the chlorophyll differentiation and chlorophyll biosynthesis and prevent them from further degradation. Similar findings were reported by Youssef and Abd El- Aal (2013) in *Tabernaemontana coronaria* and Sahu *et al.* (2021) in marigold and Xia *et al*. (2018) in peony (Fig. 14).

## 5.6 COST OF GROWING MEDIA

In the present study $M_5$ [soil: FYM: sand (1:1:1)] was found to be cheapest (Rs. 21/-) compared to other growing media but the cost of components are less and the local availability. Cost of $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%) was found highest.

# SUMMARY

# Chapter 6

## SUMMARY

The study entitled "Standardization of growing medium and growth retardants for compact growth of potted African marigold" was carried out at Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara, Thrissur. The experiment was laid out in completely randomized block (factorial) design and consisted of thirty five treatment combinations using five different growing media containing cocopeat, vermicompost, FYM, vermiculite, rice husk, soil and sand along with growth retardants include cycocel (CCC) at 750, 1000 and 1500 ppm and paclobutrazol (PBZ) at 30 ppm, 60ppm and 90ppm. A control group of media was maintained without the application of growth retardants. Popular flowering annual marigold variety double orange 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 growing media on plant height throughout the study. $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] recorded the lowest plant height and the highest plant height was observed in $M_5$ [soil: FYM: sand (1:1:1)].

Growth retardants had significant influence on plant height throughout the study. Application of paclobutrazol at 90 ppm was found to have minimum plant height during the study. In case of M x GR interaction, there was significant variation among treatments during the period of study. $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] along with application of paclobutrazol at 90 ppm ($GR_6$) recorded the minimum plant height.

The highest plant spread was observed in $M_4$ [cocopeat (40%) + soil (20%) +FYM (20%) + vermiculite (10%) + rice husk (10%)] and the lowest plant spread was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10%) + rice husk (10%)]. Results revealed that there was significant influence of growth retardants on plant spread, paclobutrazol at 90 ppm was observed with greatest plant spread. Growing medium and growth retardant interaction had significant influence on plant spread, plant spread were on par in treatment combination $M_4$ [cocopeat (40%) + soil

(20%) +FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x

$GR_6$ [paclobutrazol at 90 ppm].The number of branches per plant varied significantly among the growing media. The highest number of branches per plant was observed in $M_4$ [cocopeat (40%) + soil (20%) +FYM (20%) + vermiculite (10%) + rice husk (10%)] which was on par with $M_5$ [soil: FYM: sand (1:1:1)]. The lowest number of branches could be observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)]. Significant variation in number of branches per plant was noticed due to growth retardants. Paclobutrazol at 90 ppm was found to have greatest number of branches and application of cycocel at 750 ppm was found to have the lowest number of branches. There was a significant influence of M x GR interaction on number of branches per plant and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol at 90 ppm], were on par and statistically superior with respect to this parameter.

There was significant influence of growing media with respect to number of leaves per branch. Maximum number of leaves was observed in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)]. With regard to the influence of growth retardants prominent variation could be observed in number of leaves per branch. Application of paclobutrazol at 90 ppm was found to have the highest number of leaves per branch. There was a significant influence of M x GR interaction on number of leaves per branch. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol at 90 ppm] were on par and recorded maximum number of leaves per branch.

Growing medium $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] produced superior results with respect to number of flowers, flower diameter and field life of individual flowers. Early flower bud emergence and days to flower opening was observed in growing medium $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)].

Number of flowers, flower diameter, flowering duration and field life of individual flowers were found superior with the application of paclobutrazol at 90 ppm whereas the least number of days taken for first flower bud emergence and days taken from flower bud initiation to flower opening was found with the application of cycocel at 750 ppm. M x GR interaction had significant influence on the floral characters. Days taken for flower bud emergence and days taken from flower bud initiation to flower opening was shortest in $M_2$ [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_1$ [cycocel at 750ppm] while $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm], $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_5$ [paclobutrazol at 60 ppm] were on par in terms of number of flowers per plant while $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_4$ [paclobutrazol at 30 ppm] were on par with respect to flower diameter.

Flowering duration was found superior in treatment combination of $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm], which recorded maximum number of days. Field life of individual flower had significant influence with M x GR interaction, $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm], $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_5$ [paclobutrazol at 60 ppm] were on par in terms of field life of individual flower.

pH, EC, available N, P and K of growing media were analysed before and after the completion of experiment. Almost all the growing media were in the favourable pH and EC before and after the experiment. Highest available N and P was found in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] before and after the experiment while available K was found highest in $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)]

before the experiment and $M_3$ [cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk ] after the experiment.

Growing media had significant influence on total chlorophyll content of leaves. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] had maximum total chlorophyll content of the leaves and minimum chlorophyll content was observed in $M_1$ [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)]. With respect to the application of growth retardants significant influence was noticed in this parameter. Application of paclobutrazol at 90 ppm recorded the highest total chlorophyll content in leaves.

M x GR interaction had significant influence on total chlorophyll content of the leaves. $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x $GR_6$ [paclobutrazol at 90 ppm] and $M_5$ [soil: FYM: sand (1:1:1)] x $GR_6$ [paclobutrazol at 90 ppm] were on par in terms of total chlorophyll content of the leaves.

**Salient findings of the experiment**

In general the specification of potted ornamental flowering plants is that it should have good uniform growth, each plant should have more number of flowering branches, evident growth giving full pot coverage and plants should be at least 150mm (15 cm) high with no etiolation. In the present study, growing medium $M_4$ in combination with application of paclobutrazol at 90 ppm was found to satisfy the characters mentioned. In addition to this, the growing medium is a great alternative to the declining availability of sand and soil for pot plant production making it sustainable and eco-friendly. The lightness of media favours easy transportation and help in reducing the incidence of soil borne pathogens. Hence the treatment combination of $M_4$ x $GR_6$ can be recommended as an alternate potting medium and growth retardant for compact growth of potted African marigold.

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# Chapter 7
# REFERENCE

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# APPENDIX

## APPENDIX - I

### Meteorological data during the period of observation from April 2020 to April 2021

| Monthly data (2020-2021) | | | | | | |
|---|---|---|---|---|---|---|
| | **Temperature (°C)** | | **RH (%)** | | | **Rainfall (mm)** |
| Month | Max. | Min. | I | II | Mean | |
| April-20 | 36.4 | 24.7 | 86 | 55 | 71 | 44.7 |
| May | 35.0 | 25.2 | 90 | 63 | 77 | 59.6 |
| June | 31.1 | 23.7 | 94 | 75 | 85 | 427.2 |
| July | 30.5 | 23.2 | 96 | 78 | 87 | 563.0 |
| August | 30.2 | 23.1 | 96 | 77 | 87 | 607.7 |
| September | 30.0 | 22.4 | 96 | 80 | 88 | 587.6 |
| October | 31.0 | 21.5 | 95 | 69 | 82 | 310.3 |
| November | 33.0 | 22.0 | 84 | 57 | 71 | 56.1 |
| December | 32.0 | 21.9 | 75 | 55 | 65 | 7.7 |
| January | 32.3 | 21.3 | 78 | 50 | 64 | 45.7 |
| February | 34.6 | 21.6 | 70 | 38 | 54 | 0.0 |
| March | 36.8 | 23.0 | 84 | 34 | 59 | 31.8 |
| April-21 | 34.9 | 23.6 | 89 | 58 | 74 | 72.4 |

## APPENDIX II

**Cost of growing media components used for the study**

| Component | Unit cost (kg) |
|---|---|
| Soil | 2.00 |
| Sand | 3.00 |
| FYM | 1.50 |
| Vermicompost | 10.00 |
| Cocopeat | 10.00 |
| vermiculite | 35.00 |
| Rice husk | 5.00 |

# STANDARDIZATION OF GROWING MEDIUM AND GROWTH RETARDANTS FOR COMPACTGROWTH OF POTTED AFRICAN MARIGOLD


By

**NIRANJANA GOPAL**

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## ABSTRACT OF THE THESIS

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**Kerala Agricultural University**


**DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE**

**COLLEGE OF AGRICULTURE**

**VELLANIKKARA, THRISSUR – 680656**

**KERALA, INDIA**


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# ABSTRACT

The study entitled " Standardization of growing medium and growth retardants for compact growth of potted African marigold" was carried out in the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara during 2020-2021. The objective of the study was standardization of growing medium and growth retardants for regulating growth of potted African marigold for display purpose.

The experiment consisted of five different media *viz*; cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%) [M1], cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%) [M2], cocopeat (40%) + soil (20%) + vermicompost (20%) + vermiculite (10%) + rice husk(10%) [M3], cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%) [M4] and soil: FYM: sand (1:1:1) [M5] and two growth retardants in three different levels *viz*; cycocel [750 ppm (GR1), 1000 ppm (GR2) and 1500 ppm (GR3)] and paclobutrazol [30 ppm (GR4), 60 ppm (GR5) and 90 ppm (GR6)] along with a control group of each media without application of growth retardants. Four week old seedling of marigold variety 'Double Orange' was used for the study. Observations on vegetative characters, Floral characters as well as the nutrient status of growing media were recorded.

With regard to vegetative characters, growing media, growth retardants and interaction between growing media and growth retardants had significant influence. Shortest plants were observed in M1 [cocopeat (60%) + vermicompost (20%) + vermiculite (10 %) + rice husk (10%)] and among the growth retardants, paclobutrazol at 90 ppm [GR6] was found to produce short plants. The same treatment were also found superior with respect to plant spread, number of branches and number of leaves. Regarding interaction effect an improvement in all vegetative parameters was observed in M4 [cocopeat (40%) + soil (20%) +FYM (20%) + vermiculite (10%) + rice husk (10%)] x GR6 [paclobutrazol 90 ppm]. Significant effects of growing media could be observed in floral characters and M4 was found superior with respect to floral characters *Viz*; number of flowers per plant (10.14), flower diameter (4.61 cm)and field life of individual flowers (9.21 days). M2 was found superior in terms of other floral

characters *viz*; days taken for first flower bud emergence and days taken from flower bud initiation to flower opening.

With respect to the influence of growth retardants on floral characters, a greater number of flowers per plant (9.50), flower diameter (4.22), flowering duration (96 days) and field life of individual flowers were observed by the application of paclobutrazol at 90 ppm. Growing medium and growth retardant interaction had significant influence on floral characters. Lowest days for first flower bud emergence and from flower bud initiation to flower opening were observed in M2 [cocopeat (60%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] x GR1 [cycocel 750 ppm]. Number of flowers per plant was highest in M4 x GR6, M5 x GR6 and M4 x GR5 [paclobutrazol 60 ppm]. Treatment combination M4 x GR6, M5 x GR6 and M4 x GR4 [paclobutrazol 30 ppm] were superior with respect to flower diameter and field life of individual flowers.

Analysis of growing media before and after the experiment for different physio- chemical properties revealed that M1 had the lowest bulk density ($g/cm^3$) highest porosity (%) and water holding capacity (%).The chemical properties pH and EC of all the media were found in the favourable range [pH - 5.8-6.2; EC<1.5dS/m] both before and after the experiment. Available N, P, K before and after the experiment was found highest in M4 .Plant nutrient content (NPK), Total chlorophyll content and uptake of nitrogen and potassium by plants were also found higher in M4.

From the overall performance, it could be noted that the vegetative parameters viz; plant spread, number of branches and number of leaves as well as floral parameters such as number of flowers, size of flowers and field life of individual flowers were in desirable range in treatment combination $M_4$ x $GR_6$. Hence the medium $M_4$ [cocopeat (40%) + soil (20%) + FYM (20%) + vermiculite (10%) + rice husk (10%)] along with application of paclobutrazol 90 ppm [GR6] 20 and 35 days after pinching can be recommended for compact growth of potted Africanmarigold.