VEGETATIVE PROPAGATION IN AFRICAN MARIGOLD (*Tagetes erecta* L.) HYBRID.

By

AMRUTA SANKANNAVAR

(2016-12-022)

THESIS

Submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARGOD 671 314

KERALA, INDIA

2019

DECLARATION

I, hereby declare that this thesis entitled **"Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Padannakkad

Date: 27/03/2019

Amruta Sankannavar

(2016 -12- 022)

CERTIFICATE

Certified that this thesis entitled **"Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid"** is a record of research work done independently by Ms. Amruta Sankannavar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to her.

Place: Padannakkad

Date: 27-03-2019

Dr Satheeshan K. N.

(Major Advisor, Advisory Committee)

Associate Director of Research

Professor (Horticulture)

RARS, Pilicode

CERTIFICATE

We, the undersigned members of the advisory committee of Amruta Sankannavar, a candidate for the degree of **Master of Science in Horticulture** with major in floriculture, agree that the thesis entitled **"Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid"** may be submitted by Amruta Sankannavar, in partial fulfilment of the requirement for the degree.

Dr Satheeshan K. N.
(Chairman, Advisory Committee)
Associate Director of Research
Professor (Horticulture)
RARS, Pilicode.

Dr. A. Rajagopalan
(Member, Advisory Committee)
Professor and Head
Dept. of Pomology & floriculture

27/3/19

Dr. G. V. Sudarsana Rao
(Member, Advisory Committee)
Professor and Head
Department of Plant Physiology

27/3/19

Dr. Meera Manjusha. A. V.
(Member, Advisory Committee)
Assistant Professor (Horticulture)
RARS, Pilicode

27/3/19

27.03.19

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

I take this opportunity to look back on the path traversed during the course of this endeavour and to remember the guiding faces behind the task with a sense of gratitude.

*It is with great respect I express my deep sense of gratitude and indebtedness to **Dr. Satheeshan K. N.** Chairman of my Advisory Committee, Associate Directorate of Research, Regional Agriculture Research Station, Pilicode, for his expert advice, valuable suggestions, inspiring guidance, enthusiastic approach, constructive criticisms, unreserved help and kind concern during the conduct of this research work and preparation of thesis. I value his knowledge and wisdom which nurtured this research in right direction without which fulfillment of this endeavor would not have been possible, he has been a support to me during each step of this venture and my obligation to him lasts forever, I really consider it my greatest fortune in having his guidance for my research work.*

*I take this opportunity to express sincere thanks to my advisory committee consisting **Dr. A. Rajagopalan** former Associate Dean, College of Agriculture, Padannakka and Head of Pomology and Floriculture Department , **Dr. Meera Manjusha A. V.** Assistant Professor, Department of horticulture, RARS Pilicode, and **Dr. G. V. Sudarsana Rao**, Professor and Head, Department of Plant Physiology, College of Agriculture, Padannakkad, for their constant help, valuable suggestions during the investigation, sensible criticism in animating and ameliorating the manuscript and valuable counsel during the period of study. I pay my heartful thanks to **Dr. Suresh, P. R.** Associate Dean, College of Agriculture, padannakkad for providing me all facilities from the University during the whole course of study.*

*I express my sincere thanks to my teachers, **Dr. P.K. Mini, Dr. M. Sreekumar, Dr. Bridgit T. K., Dr. Sujatha N., Dr. Binitha., Dr. Ramesha B., Mrs. Sangeetha K. G., Dr. N. Rajivasudevan, Mrs. Rejitha, Dr. Rajesh Kumar, Mr.***

Shivamurthy and Dr Shruthi for their expert teaching, moral support and valuable guidance during the course of study.

My diction doesn't seem too rich enough to provide suitable words to articulate my sincere and heartfelt gratitude to my batchmates **Ajeesh, Shiva, Eurekha, Mubarack, Shana, Ashwini, Manju, Hassain, Anto, , Laya, and Sreelaja, and** my seniors, **Ashok, Sunu, Vineetha, Sherin, Shanti, Ashiba, Dr. Rinchan** and my juniors **Fathima, Vinayak, Chethan, Akhil, Ashok, Glady, Giffy, Roshni, Jessira, Anu, Shwetha, Sujatha, Padmapriya, Veena, Nimya, Hasna, Jeevitha, and Adarsh,** who has given sound and fruitful advice, timely help and also a constant encouragement throughout my venture of this study. I express gratitude to my friends **Priya, Dhanyashree, Amal, Ashwini L, Meghalaxmi, Bhagyashree, Susmitha, Ramya, Sukesh, Virupakshi** and other friends for their support.

I am thankful to **Kerala Agricultural University** for financial support in the form of fellowship during the tenure of the M.Sc. (Agriculture) programme.

This research work would be incomplete if I do reckon the sacrifices, love, affection and support of my family members, it is immense pleasure to express my sincere gratitude and heartfelt respect to my grandparents **Late. Sri. Hampayya Sankannavar** and **Late. Smt. Annapoorna,** Father **Late. Dr. Shivakumar Sankannavar**, mother **Late. Smt. Dakshayani,** my uncle's **Sri. Vijaykumar and Vidyadhar,** Aunt **Smt. Mangalagouri, all sisters and brothers.**

God Almighty for all the bountiful blessings showered on me at each and every moment without which this study would never have seen light. Any omission in this acknowledgement does not mean lack of gratitude.

Amruta Sankannavar.

CONTENTS

7

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

%	**-**	**Per cent**
^{0}C	**-**	**Degree Celsius**
@	**-**	**At the rate of**
B:C	**-**	**Benefit cost ratio**
BSS	**-**	**Bright Sunshine**
COC	**-**	**Copper oxy chloride**
CD	**-**	**Critical difference**
cm	**-**	**Centimeter**
cm^2	**-**	**Centimeter square**
DAT	**-**	**Days after transplanting**
et al	**-**	**And others**
FYM	**-**	**Farm yard manure**
Fig.	**-**	**Figure**

G - Gram

ha^{-1} - Per hectare

i.e. - That is

KAU - Kerala Agriculture University

Kg - Kilogram

Kg/ha - Kilogram per hectare

K_2O - Potash

MAP - Months after planting

mg – Milli gram

ml - milli litre

m^2 - Square meter

NS - Non significant

ppm - Parts per million

P_2O_5 - Phosphate

pH	-	**Negative Logarithm of the H+ activity**
RARS	–	**Regional Agricultural Research Station**
Rs.	-	**Rupees**
SEm	-	**Standard Error of mean**
t	-	**tons**
Viz.	-	**namely**

INTRODUCTION

1. Introduction

Marigold (*Tagetes erecta* L.) holds prominent place among the annual flower crops in India. It is extensively used as loose flower for making garlands in religious and social functions, as cut flowers and for garden decoration in landscaping. Marigold has gained popularity among gardeners throughout the world on account of its easy cultivation, wide adaptability and year round flower production. Its free flowering habit, short duration to produce marketable flowers, wide spectrum of attractive colours, shapes, size and good keeping quality has attracted the attention of many amateur and commercial flower growers who utilise them for bedding, edging, herbaceous borders and for pot planting.

Marigold plants are also economically important due to presence of oil in their leaves and carotenoid pigments in flowers (Stojanova *et al.*, 2000). Oil derived from marigold leaf has insect repellent properties and pigments such as carotenoids extracted from petals are used in poultry feed for increasing yellow colour of egg yolk. Lutein extracted from flower is used for blood purification, cancer treatment and curing skin diseases (Shruthi, 2015). Leaf extract is good remedy for treating earache. Leaf paste is applied against boils and carbuncles. Root exudates from marigold have anti-nematicidal properties (Sunayana, 2017).

Marigold belongs to the family Asteraceae and the centre of origin is Mexico (Choudhary *et al*., 2014). There are 33 species under the genus *Tagetes* out of which *Tagetes erecta* L. *(African marigold)*, *Tagetes patula* L. (French marigold), *Tagetes tenuifolia* L. (Signet marigold), *Tagetes minuta* L. (Perfume marigold), *Tagetes lucida* (Sweet scented marigold) are commercially exploited for various uses.

Marigold production during 2016 – 2017 was 608.97 million tonnes as loose flower and 7.90 million tonnes as cut flower with area of 64.65 million ha. At present Karnataka, Tamil Nadu, Gujarat, Madhya Pradesh and Andhra Pradesh are the major states growing marigold. Tamil Nadu is the leading state in flower production with 19 per cent share in Indian flower production followed by Karnataka (NHB, 2018).

Even though there is a huge demand for marigold flowers in Kerala during festive seasons like Onam and social functions like marriages and as temple offerings, most of the demand is met from neighbouring states. So there is great scope for expanding its cultivation in Kerala.

The commercial method of cultivating marigold crop is through seed propagation. Plants raised from seeds show great variability with respect to vigour, precocity and quality. True to type plants cannot be obtained through seed propagation as it is an often cross pollinated crop (Bhatt and Chauhan, 2012). Vegetative propagation through cuttings is the most convenient and cheapest method of obtaining a fully developed stronger plants in considerably less time. Propagation through cutting is commonly used in commercial propagation of ornamental plants (Blythe *et al.*, 2004a). Cuttings require comparatively less time to root and mature for field transplantation, than the plants propagated through seeds. Moreover vegetative propagation method is presumed to result in true to type plants for preservation of all characters of a particular variety (Dawane *et al.*, 2015), which can be exploited for planting material production in marigold.

Hybrid marigolds with high yield are available today and are preferred by farmers. The main constraint that limits area expansion for marigold in Kerala is the lack of availability of seeds of suitable varieties in bulk as well as the prohibitive cost of hybrid seeds. Marigold plants raised from hybrid seeds do not produce viable seeds (Kumar *et al.*, 2015) and hence farmers have to purchase hybrid seeds for raising subsequent crops. This adds to the cost of cultivation and reduces profit margin. If vegetative propagation is standardized, the cost of planting material can be reduced.

Propagation through cutting is an easy and quick method and results in early flowering compared to plants which are propagated through seeds. The presence of adventitious roots along the stem helps in the rooting of cuttings in marigold. About 10 cm long cuttings taken from shoot tips which are not flowered when planted in media could strike roots (Kumar *et al*., 2015). This method is promising for maintaining the hybrids and varietal purity, and reducing juvenile period. Rooted cuttings raised from hybrid plants can be maintained as mother plants for continuous production of planting material so that purchase of hybrid seeds can be avoided during every season.

Plant growth regulators have been exploited in floriculture to control plant growth in ideal direction (Sharma *et al*., 2001). They can stimulate plant quantitative factors like plant height, number of branches, number of roots, rooting percentage, yield and also qualitative aspects by exogenous application. The success of IBA in rooting of various annuals and ornamentals was described by Bose *et al*. (1982) in marigold, Montero *et al*. (1985) in carnation, Wodecki and Holcomb (1989) in chrysanthemum.

Cuttings treated with alpha-napthalene acetic acid (NAA) and indole-3-butyric acid (IBA) as rooting hormone helps in early and better rooting with easy establishment of plants in the field. The rooting percentage was increased due to ability of terminal cuttings in a number of ornamental plants as reported by Nikolova–kmristeva (1973) as cited by Bose *et al*. (1986) and Jeevajothi *et al*., (1987) in chrysanthemum. The functional and biological status of cuttings are of some significance (Bose *et al*.,1975). The age of cuttings and their uniformity is relevant in the success percentage in rooting. Hence it will be worthwhile to study the proper age of cuttings for better rooting percentage.

Appropriate growing media are also critical in rooting due to their unique properties for holding moisture, ventilation, discharge or capillary action, and recycle potentiality (Vendrame *et al.,* 2005). Among the several media, coir-pith, vermi-compost and FYM are most commonly used in tropical areas. The presence of adequate nutrients, moisture holding ability, permeability and lump forming capacity of media increases root and shoot growth, which eventually, results in high crop yield (Chong, 2008). It is also necessary to assess the comparative benefits from seed propagated and vegetative propagated marigold in terms of yield, quality and cost.

Experiments on the above aspects will provide information on the feasibility of vegetative propagation in marigold hybrids, the outcome of which has practical implications in the crop management and economics leading to improved productivity, and income.

In this context, present study was undertaken with the following objectives:

1) To standardise the age of cuttings for better rooting percentage in hybrid marigold
2) To assess the response of media and plant bio regulator for rooting and establishment of hybrid marigold
3) To compare the performance of vegetatively propagated hybrid marigold with that of seed propagated plants.

19

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Marigold is an important annual ornamental flower crop grown throughout India on a commercial scale. However, availability of seeds of premium commercial varieties at an affordable price is the main constraint in expansion of cultivable area and boosting the production of flowers. Hence, it is worthwhile to probe the potential of vegetative propagation in marigold with an intention of generating true to type plants and reducing seed cost. Empirical evidences are scanty regarding the vegetative propagation of marigold under varying agro - climatic conditions. Hence, a research programme entitled "Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid" was undertaken during the period from 2016 to 2018 at College of Agriculture, Padannakkad, and Regional Agricultural Research Station, Pilicode, Kasaragod (Dt.) for standardisation of the age, media and IBA levels for rooting of cuttings and a comparison of vegetatively propagated plants and seedling plants in African marigold (*Tagetes erecta*) hybrid.

An attempt is made in this chapter to review the relevant literature on propagation methods in marigold and other seasonal flower crops, and the influence of such methods on yield and quality parameters.

2.1 EFFECT OF STOCK PLANTS ON ROOTING OF CUTTINGS

Rooting of cutting is one of the oldest techniques to propagate several crops vegetatively which results in true to type plants. Propagation through cuttings has been adopted in various flower crops, as it is the cheapest method of vegetative propagation and helps to obtain the stronger plants within a short period. Many ornamental plants are commercially propagated through cuttings (Blythe *et al.*, 2004a). Cuttings take short time to root and get ready for field transplantation compared to plants that are propagated through seeds. Plants propagated through cuttings also flower early and develop faster than plants propagated through seeds.

Singh (1999) propagated the hybrid tomato (*Lycopersicon esculentum* M.) through stem cutting and found good for survival percentage, length of roots and number of roots. Blythe *et al.* (2004a) worked on the propagation of different foliage plants using terminal cutting of branches and they observed that effective rooting was found in *Aglaonema modestum*, *Gardenia augusta* L. and *Hedera helix* L. Lal *et al.* (2008) studied the rooting behaviour of stem cuttings of *Lawsonia inermis* and found that cuttings sprouted within 14 days of planting. In African marigold (*Tegetes erecta* L.) propagated through stem cuttings, Bhatt and Chouhan (2012) found that cuttings produced good rooting percentage, root length and number of roots.

The rooting and survival of cuttings usually depend upon the favourable factors like environmental conditions, physiological condition of the parent plant, type of cutting, maturity of the cuttings, rooting medium and hormone situations (Bose *et al.*, 1986). The rooting potential of the cutting diminishes with progression in age of stock plant. So also, frequent extraction of cuttings from same mother plant results in premature bud formation, which diminishes the size of flower and productivity of the crop from rooted cuttings. So also, cuttings extracted from shoots, which were already flowered, also influence rooting.

Nikolova-Kmristeva (1973) as cited by Bose *et al.* (1986) observed that shoots from young stock plants responded better to rooting in chrysanthemaum and cuttings from young mother plants produced advanced multiplication rate and quick rooting as well as superior roots. Jing and You-Gang (2007) studied the propagation of *Euphorbia pulcherrima* through cutting and found that the young cuttings showed good rooting percentage.

Cuttings from older mother plants displayed diminished fresh weight and slender stems (Anderson and Carpenter, 1974) but exhibited early flower development during longer day conditions in chrysanthemum as reported by Runger (1976) as cited by Jyoti (2017). Rober (1978) as cited by Jyoti (2017) stated that increase in age of stock plants lead to the more fibrous nature of cuttings. In *Hibiscus rosa- sinensis*, success percentage in rooting of cuttings diminished even with IBA treatment when cuttings from older mother plants were used (Wang and Anderson, 1989).

Polyanitsa (1972) cited by Bose *et al.* (1986) stated that rooting of cuttings is also influenced by factors such as physiological age of mother plants who observed that rooting capability of cuttings acquired from mother plants which was not allowed to flower rooted better compared to those from plants destabilized by flowering in carnation. Similar reports were also available in chrysanthemum where cuttings, extracted from mother plants with established flowers recorded diminished root formation, as there was straight competition between flowers and root for reserves (Devier and Geneve, 1997).

The practice of pinching above the 4 or 8 nodes also resulted in apical axillary outgrowth which produced greater number of cuttings in chrysanthemum (Heins and Wilkins, 1979). The pinching of mother plant of 4 weeks after planting improved time from pinching to cuttings harvested. This early pinching caused more number of cuttings, value and accelerated speed of rooting in *Kalanchoe blossfeldiana* (Kim *et al.*, 2006).

Nikolova-Kmristeva (1973) as cited by Bose *et al.* (1986) studied effect of growth regulator on rooting of cuttings of chrysanthemum and they showed that the percentage of rooting, number and length of root were also highest in terminal cuttings than basal cuttings.

Padsumbiya and Dave (1991) studied the rooting of cuttings in African marigold (*Tagetes erecta* L.) and observed that the terminal cuttings were superior in all the characters compared to middle and basal stem cuttings, but was on par with middle stem cuttings in rooting percentage, length of root, and number and length of shoots.

23

2.2 THE IMPACT OF PLANT BIO REGULATOR AND MEDIA ON ROOTING AND ESTABLISHMENT OF CUTTINGS

2.2.1 EFFECT OF AUXINS ON ROOTING OF CUTTINGS

Plant growth regulators are commonly used for enhancing success percentage in rooting of cuttings. Tiberia *et al.* (2011) reviewed the physiological aspects of auxin in adventitious root formation. The formation of adventitious roots is a quantitative genetic trait regulated by both environmental and endogenous factors. Among phytohormones, auxin plays an essential role in regulating root development and are involved in the process of adventitious rooting.

Auxins, such as NAA (alpha-naphthalene acetic acid) and IBA (Indole 3 butyric acid), are used for treating cuttings for good rooting and excellent establishment of plants in field. Some species will root without the hormone treatment but exogenous application of plant bio regulators may enhance rooting. The impact of rooting hormones on rooting of cuttings in plants is influenced by several factors such as species, type of cutting (softwood, semi-hard wood or hardwood), time of taking cuttings *etc.* (Griffith, 1998; Hartmann *et al.*, 2002)

2.2.1.1 EFFECT OF IBA IN ROOTING OF MARIGOLD CUTTINGS

Bhatt and Chauhan (2012) experimented different combinations of auxins at different levels for rooting of African marigold (*Tagetes erecta* L.). They observed more number of roots in cuttings treated with a combination of IBA+NAA 150 ppm. The number of roots observed after 20 and 30 days was 40.53 and 58.79, respectively. The average length of roots was highest (4.6 cm) in NAA 200 ppm observed after 20 days and in IBA+NAA 150 ppm after 30 days (5.51 cm). Cuttings treated with IBA+NAA 150 ppm had also showed maximum stem length (6.1 cm and 15.33 cm) after 20 days and 30 days. Ullah *et al.* (2013) reported the maximum root size (6.5 cm) at 100 ppm IBA, while increasing the concentration of IBA to 400 ppm decreased the root size in marigold (*Tagetes erecta* L.). Dipping of cuttings in 400 ppm, showed maximum number of roots (82.4) and 300 ppm showed the minimum value (37). Sharma (2014) reported that in marigold, the root length (9.14 cm) as well as root spread (4.53 cm) was the maximum when the cuttings were treated with 200 ppm of IBA. Whereas, the number of roots (44.43), fresh weight of roots (0.71 gm) and dry weight of roots (0.079 gm) were the maximum in 400 ppm of IBA and the rooting percentage was maximum (92.80 %) under IBA+ NAA 200 ppm.

Watane (2018) conducted an experiment to study the response of IBA on rooting of cutting in African marigold cv. African Double Orange at the College of Agriculture, Nagpur. Results of the investigation revealed that among different concentrations, IBA 100 ppm recorded significantly early sprouting of cuttings and maximum values for number of leaves, fresh and dry weight of shoot, final success percentage of rooted cuttings, length of roots and number of roots.

2.2.1.2 Effect of IBA in rooting of other ornamental crops

Lingaraj and Chandrasekhariah (1961) observed prolific rooting in *Antirrhinum majus* when IAA and IBA were used at 3000 ppm.

Shah *et al.* (1996) reported in rosemary (*Rosmarinus officinalis* Linn.) that stem cuttings treated with1000 ppm IBA resulted in highest rooting percentage (93.33 %). A study by Singh (1999) in tomato (*Lycopersicon esculentum*) revealed that plant growth regulator treatments, in general, enhanced the length of roots, number of roots and survival percentage and was the highest (8.10 cm) in cuttings treated with 500 ppm IBA.

Sidhu and Singh (2002) studied the effect of auxins on propagation in *Chrysanthemum morifolium* cv. Flirt and reported that IBA at 250 ppm gave maximum number of roots. Similarly, when cuttings from Chrysanthemum cv. Sonali Tara, were treated with IBA 2000 ppm through quick dip method in combination with 2 sprays of 10 ppm IBA after 30 and 60 days of planting, it significantly advanced the number of primary roots (20.85) and survival percentage (96.57%) (Ranpise *et al.*, 2004). Grewal *et al.* (2005) studied the effect of IBA and NAA and their combinations on the rooting of stem cuttings of *Dendranthema grandiflora* cv. Snowball and reported that the maximum rooting (88.7%) and root

25

number (8.67) was observed in cuttings treated with IBA at 400 ppm. Bharmal *et al.* (2005) observed that the IBA 2000 ppm as a quick dip method along with 2 sprays of 10 ppm IBA after 30 and 60 days of planting of cuttings recorded the highest number of primary roots (20.85) and survival percentage (96.57%) after 30 days of planting of cuttings in Chrysanthemum cv. Sonali Tara.

In Indian lavender (*Bursera delpechiana),* Swetha (2005) found that IBA 2000 ppm increased the rooting in cuttings (66.66%) compared to control (15.33%). In *Thunbergia grandiflora,* stem cuttings treated with IBA+NAA 2000 ppm promoted rooting percentage (63.73%) which was followed by IBA+NAA 1500 ppm (Vinaykumar *et al.*, 2008).

Ingle (2008) used different concentrations and combinations of IBA on rooting of stevia cuttings (*Stevia rebaudiana* B.) and observed that the maximum number of roots (49.69), length of root (14.05 cm), fresh weight (0.50 gm) and dry weight (0.29 gm) of roots and rooting percentage (92%) were found with IBA 500 ppm. In an experiment by Abdullateef and Osman (2011) apical cuttings of *Stevia rebaudiana* B were treated with different concentrations of IBA. They observed that IBA 2.3 mM was optimal for rooting of apical cuttings, which rooted on the 5th day with root number ranging from 2.8 to 13.8.

Nanda and Mishra (2010) used IBA and NAA for rooting in stem cuttings of *Hibiscus rosa-sinensis*. The results revealed that IBA treatment was superior for sprouting, rooting, root length, number of roots and leaves per cutting, higher leaf area and percentage of survival in the field.

In Damask rose, Shenoy (1992) found that longevity of rooted basal woody cuttings increased by treating with IBA at 3000 ppm (48.97%). Susaj *et al.* (2012) reported maximum survival percentage by using IBA 500 ppm in two different cultivars of *Rosa sp.* (91% and 89%, respectively), whereas, maximum number of roots (50 and 47 roots) and the longest roots (31 and 28 cm) were recorded in cuttings treated with IBA 1000 ppm. The shoot length was reduced when IBA concentration increased from 500 to 1000 ppm. They concluded that IBA at 500 ppm was best for rooting of cuttings in rose for vegetative propagation. However, Haixia *et al.* (2013) reported the maximum survival percentage of rose cuttings treated with IBA 250 ppm (93.33%). Abbas *et al.* (2015) reported that the maximum number of roots (30.25) was noted in IBA 2000 ppm, whereas, the control produced the least number of roots (16.0) in stem cuttings of Rose cv. Bajazzo. Yeshiwas *et al.* (2015) reported that the number of roots (54.2), root length (11.29 cm), shoot length (14.4 cm), fresh weight of shoot (2.05 g), dry weight of shoot (0.61 g) and dry weight of root (0.21 g) were recorded maximum under IBA 1000 ppm whereas fresh weight of root (0.90 g) was highest in IBA 1500 ppm in stem cuttings of Rose. Akhtar *et al.* (2015) found that IBA 450 ppm concentration produced maximum shoot length (10.67 cm), shoot dry weight (3.02 g), number of roots (14.00), root length (11.90 cm) and root dry weight (0.50 g) in stem cuttings of *Rosa centfolia.* Nasri *et al.* (2015) reported that application of different levels of 0, 500 and 1,000 ppm (quick dip method for 20 s) of IBA in 12 wild genotypes of *R. damascena* (including: Kurdistan-1 to Kurdistan-12) highest rooting (79.56%) and callus production (69.08%), number of roots (8.33), fresh weight of root (361.80 mg) and dry weight of root (244.74 mg) were recorded in Kurdistan- 5 genotype with 1,000 ppm IBA. The maximum root length (5.84 cm) was observed in Kurdistan-5 genotype with 500 ppm IBA that showed a significant difference compared to the control treatment (0.96 cm). The highest number of leaves (7.33 at 500 ppm IBA) and number of buds (5.00 at 1,000 ppm IBA) were recorded in Kurdistan-1 genotype.

In *Bougainvillea glabra*, Singh *et al.* (2011) reported that in stem cuttings treated with IBA, the length of sprout (18.77 cm) and number of roots (21.22) recorded were the maximum in 3000 ppm of IBA and length of root was maximum (15.32 cm) in 5000 ppm IBA. Sahariya *et al.* (2013) also conducted an experiment to know the effect of IBA on rooting of cutting in bougainvillea. They used four levels of IBA (0, 1000, 1500, 2000 ppm) for treating hard wood stem cuttings. Increased IBA level was observed to be the best in poly house conditions compared to open conditions. The highest number of rooted cuttings (6.33), percentage of rooted cuttings (63.33%), and number of roots per cutting (30.00), length of roots

(12.85 cm) and dry weight of the roots (0.43 g) were obtained at IBA 2000 ppm concentrations. Mehraj *et al.* (2013) conducted an experiment to know the impact of IBA on rooting of *Bougainvillea spectabilis* cuttings and observed that IBA 1000 ppm was the best because of highest number of leaves (35.2), longest root (33.2 cm), more number of roots per cutting (64.2) and increased number of branches (4.7) and 100 per cent survival. Sayedi *et al.* (2014) reported that the rooting percentage (72.3 %), length of roots (36 mm) and number of roots (9.0) were maximum with IBA 4000 ppm in hard wood cuttings of *Bougainvillea glabra* L.

Experiment conducted by Singh *et al.* (2013a), in *Thuja compecta,* soft wood cuttings from 4 years old plant are treated with IBA at 1000, 2000, 3000, 4000 and 5000 mg/L revealed that the number of roots (19.67) and rooting percentage (82.70%) recorded were maximum under treatment 5000 mg/L. The IBA level at 2000 mg/L gave maximum root length (9.33 cm). The study concluded that IBA at 5000 mg/L was the best for easy and faster multiplication of *Thuja compecta* cuttings.

Singh *et al.* (2013b) studied the effect of IBA concentrations on rooting of stem cuttings in night queen (*Cestrum nocturnum* L) and reported that while the rooting per cent (76.53), length of the roots/cutting (23.76 cm), fresh weight (6.06 g) and dry weight (1.33 g) of roots were higher in cuttings treated with IBA 100 ppm, maximum length of sprout per cutting (190.00 cm) was recorded in IBA 300 ppm.

Kumar *et al.* (2014) investigated the effect of various auxins on rooting of carnation (*Dianthus caryophyllus*) cuttings. Both tip and basal cuttings were used for this experiment. The treatments were IBA, IAA and NAA of 100, 200 and 500 mg/L. The treatment NAA 500 ppm gave best results in terms of rooting percentage (73.02%), number of roots (12.25), longest roots (10.04 cm) and fresh weight and dry weight of roots (4.27 g and 43.19 mg).

Gowda *et al.* (2017) conducted an experiment to know the impact of Indole-3-butyric acid (IBA) at 200 ppm on twelve genotypes of Carnation (*Dianthus* *caryophyllous*). They observed that IBA had significantly influenced the rooting percentage, number of roots and root length among different genotypes.

In Jasmine (*Jasminum sambac*), Singh (2001) studied the effects of plant growth substances on the rooting and establishment of cuttings and observed that IBA at 2000 ppm recorded highest rooting percentage, root length, root number and root fresh weight. Similarly, Netam *et al.* (2018) studied the influence of different IBA concentrations (500, 1000, 1500 and 2000 ppm) in inducing rooting of jasmine stem cuttings. Observations recorded at 45 and 60 days after planting indicated that there was increase in fresh weight of shoots, number of leaves, number of roots and root length among treated cuttings. Survival rate of cuttings was highest in IBA at 1500 ppm (88.33%) and this treatment was considered as best for easy and quicker growth of *Jasminum sambac* cuttings.

2.2.1.3 Effect of auxins on plant growth and yield in marigold

Swaroop *et al.* (2007) reported that the plant height (79.05 cm), number of flowers per plant (41.66), single flower weight (6.23 g) and flower yield per plant (357.50 g) were the highest in plants of African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda when treated with NAA at 300 ppm. Pandey and Chandra (2008) reported that the NAA 200 ppm was found to be optimum in increasing the plant height, number of branches and earliness in flowering of French marigold (*Tagetes patula* L.). While NAA at 100 ppm showed increase in flower size, number of flower and weight of flower per plant was increased with the application of 50 ppm NAA. Kanwar and Khandelwal (2013) studied the effect of plant growth regulator on growth and yield of African marigold (*Tagetes erecta*) and found that the application of NAA 150 ppm significantly increased plant height (72.22 cm), duration of flowering (69.14 days), yield of flowers per plant (360.09 g) as well as per hectare (13.04 tonnes). Uliah *et al.* (2013) observed maximum plant height and flower size with the use of 100 ppm IBA, followed by 300 ppm NAA when marigold (*Tagetes erecta* L.) was propagated vegetatively with the use of auxin. Yadav *et al.* (2013) reported that the maximum weight of flower was recorded with application of NAA 300 ppm in African marigold (*Tagetes erecta* L.).

2.2.1.4 Effect of auxins on plant growth and yield in other ornamentals

Bharmal *et al.* (2005) reported maximum number of primary branches (8.12) and secondary branches (9.18), flower size (3.76 cm) and flower yield (768.49 q/ha) with treatment of IBA 2000 ppm in chrysanthemum (*Dendranthema morifolium*) cv. Sonali Tara.

Lal *et al.* (2008) reported maximum shoot length (84.4 cm) and branches per cutting (40.2) when IBA 1000 ppm was used for vegetative propagation in henna (*Lawsonia inermis*).

Girisha *et al.* (2012) observed 150 ppm concentration of IBA and NAA as optimum to increase the plant height, number of spikes, flower yield, vase life of flowers and dry weight, whereas 100 ppm IBA and 150 ppm NAA optimum to increase the plant spread and size of flower in daisy (*Aster amellus* L.).

2.2.2 SELECTION OF MEDIA FOR ROOTING OF CUTTINGS

Rooting medium plays a crucial role in promoting the rooting of cuttings and their establishment. Growing media is also important, because it not only supports the plant but also provides moisture, essential nutrients and proper drainage facilities for rooting. Ultimately, both physical and chemical properties of planting medium are known to influence rooting percentage and growth of cutting (Hartmann *et al.*, 1997). A number of rooting media either alone or in combination are exploited for rooting of cuttings in various ornamental plants.

Soil is the key component of media, forms main part of diverse media mixture. Majority of soils are typically constituted of 50% air and water, mineral particles 46-49% and organic matter 1-6% (Gohil *et al.*, 2018).

Addition of FYM to the soil results in amplification of microflora like Azotobacter (Gupta *et al.*, 1983) and was able to function as an effective rooting medium to give 100 per cent success in rooting of vanilla cuttings (Bhat ,1994).

Vermicompost is another media useful in propagation. It is also known as worm manure which can be prepared from different organic wastes such as cattle manure, food and plant debris, crop residue *etc*., It is having good aeration, moisture holding capacity and drainage properties (Edwards and Borrows, 1988). It is a plentiful source of micro and macro nutrients, vitamins, development hormones and micro flora. It contains nutrients in readily available form to plants, such as nitrates, phosphates, calcium and potassium (Orozco *et al*.,1996). It is also a rich source of helpful bacteria and actinomycetes (Rashmita, 2015). It aids in easy rooting and development since it contains growth hormones like auxins and gibberlins (Gohil *et al*., 2018).

Cocopeat, a by-product of coconut husk, has suitable physical and chemical properties and can be used as a medium for propagation of several ornamental plants (Savithri and Hameed, 1994). Hence, Evan and Stamps (1996) considered cocopeat as a substitute for peatmoss used as a component in the media for rooting of cuttings. Nichols and Savidov (2009) opined that soil alone is not considered as noble media for rooting.

2.2.2.1 Effect of different of media for rooting of cuttings in marigold

Kumar *et al*. (2015) investigated the rooting of marigold cutting in nine different growing media including soil (control, sand, vermicompost, soil + vermicompost (1 : 1), sand + vermicompost (1 : 1), sand + vermicompost + soil (1 : 1 : 1), FYM + sand (1 : 1) and FYM + Soil + Sand (1 : 1 : 1) in 20 cm deep earthen trays. Among all rooting media, pure vermicompost showed better performance with respect to days to callusing, days to rooting, number of roots/plant and root length while highest rooting success was recorded in soil + vermicompost mixture i.e. 88.33 per cent in equal ratios. This experiment showed that vermicompost alone or soil + vermicompost (1 : 1) media mixture can be opted for better rooting success in marigold shoot cuttings. Highest number of roots per cutting (83.00) and root length (13.93 cm) was observed in treatment where vermicompost was only used.

The least number of days for rooting (39.00) was found with sand+ vermicompost. FYM produced the tallest plants with greatest height (27.33 cm).

Watane (2018) conducted an experiment to study the response of IBA and rooting media on rooting of cutting in African marigold cv. African Double. Media such as Sand 100 per cent, Cocopeat + Perlite (3:1), Sand + FYM (1:1), Soil + FYM (2:1) were used for the study. Results revealed that Soil: FYM (2:1) was superior for shoot and root parameters in rooted cuttings. However, minimum days to rooting of cuttings was observed in the treatment combination IBA 50 ppm with rooting media cocopeat: perlite (3:1)

2.2.2.2 Effect of different of media for rooting of cuttings in other ornamentals

Shirol *et al.* (2001) investigated the effect of diverse rooting media *viz.*, red soil, sand, potting mixture, vermicompost and compost on rooting ability of Dwarf Poinsettia cuttings. The treatment sand + vermicompost (1:1) recorded the maximum rooting (67.0%) followed by vermicompost alone (63.0%). Rooting was poor when compost alone was used as the media.

Singh and Nair (2003) conducted an experiment to know the impact of media on rooting of ornamental plants. They reported 100 per cent rooting in Dieffenbachia cuttings planted in red soil + sand +compost.

In a research study conducted by Sameei *et al.* (2005) in pothos (*Epipremnum aureum*), different organic media such as peat moss, coco peat, palm peat and bagasse were used along with two level of perlite (0 and 50 %) for rooting of cuttings. It was observed that the highest values of leaf area, leaf number, shoot and root fresh and dry weights and shoot length were observed in coco peat and the lowest values of measured growth indices were obtained in bagasse.

Karmegan and Daniel (2009) reported that media containing vermicompost when used for rooting of cuttings in *Codiaeum variegatum* had shown highest root length, number of roots, root fresh weight and dry weight followed by vermicompost and peat.

Izadi *et al.* (2012) reported that 10 cm cuttings of dog rose shown better rooting in cocopeat and perlite media. Avdic *et al.* (2013) studied the impact of various media such as sand, peat, vermicompost and their mixtures on rooting of cuttings of alpine rose (*Rosa pendula)* and found that sand+vermicompost increased the fresh weight of roots. Khatik and Mishra (2017) reported that soil+sand+vermicompost influenced the cuttings of Damask rose positively. The number of leaves, root length, number of roots and survival rate was the highest in media mixture soil+sand+vermicompost.

Renuka and Chandrasekhar (2017) conducted a work to know the influence of media such as red earth, vermicompost, press mud, cocopeat on cuttings of in carnation cv. Keiro. They stated that vermicompost recorded the greatest number of roots followed by cocopeat. A combination of red earth + coirpith recorded the maximum rooting percentage and survival rate, and highest root fresh weight.

2.2.2.3 Effect of media on growth and flowering in marigold

The growth of marigold seedlings was boosted with application of 10 per cent or 20 per cent vermicompost prepared from food wastes in green house (Atiyen *et al*., 2000). Syamal *et al.* (2006) found that total leaves per plant and leaf area increased in Marigold by the application of vermicompost while an increase in the number of flowers per plant was observed by Arancon *et al.* (2008). Sangwan *et al.* (2010) reported that soil along with proper amount of vermicompost accelerated the plant growth. They used diverse quantity of vermicompost 10, 20, 30 and 40 per cent and they inferred that supplementing soil with vermicompost promoted plant growth in terms height, shoot and root biomass.

Shandour *et al.* (2011) evaluated the influence of different doses of vermicompost *viz*., 20, 40 and 60 per cent. In African marigold variety Tiashan, the fresh weight and dry weight of shoots were found be greater than before with 60 per cent vermicompost. Bigger flower size was observed in treatment containing 60 per cent vermicompost compared to treatments without vermicompost. The level of nutrients such as nitrogen, phosphorous, potassium, calcium, magnesium and other micro nutrients was more in 60 per cent vermicompost. Gupta *et al.* (2014) reported pronounced rise in marigold biomass, plant height and flowering due to the effect of vermicompost as media. The plant height was 2-3 times extra compared to control as vermicompost contains greater quantity of NPK.

2.2.2.4 Effect of media on growth and flowering in other ornamentals

In crossandra, Gajalakshmi and Abbasi (2002) performed experiment using compost and vermicompost. They found increased growth and flowering in treated plants compared to untreated plants. Vermicompost showed better influence on growth and flowering compared to compost.

In marigold, Haripriya and Sriramachandrashekaran (2002) investigated the effect of FYM, mine soil, leaf mould and press mud and reported that FYM + mine soil in 1:2 ratio promoted the growth and flowering.

The use of FYM (5 t/ha) in rose caused increase in leaf area, length of laterals branches and highest flowers per meter square (Singh, 2005). In rose cv. Naranga, Ankita (2010) reported that cocopeat + leafmould in 1:1ratio resulted in highest plant height (67.40 cm), maximum shoot length (35.46 cm) increased number of leaves and leaf area (35.46 cm^2)

Khelikuzzaman (2007) discovered that a media containing cocopeat + soil+ sand in 1:1:1 ratio was promising in *Tradescantia sp.* in increasing the number of leaves, fresh weight, and secondary branches.

Chamani *et al.* (2008) investigated the impact of vermicompost on growth and flowering of *Petunia hybrida* variety 'Dream Neon Rose'. The vermicompost was used at different concentrations of 20, 40 and 60 per cent. Overall growth of petunia was promoted in terms of total number of leaves, flowers, shoot fresh weight and dry weight due to influence of vermicompost compared to control. The vermicompost at 20 per cent level was most efficient in terms of plant performance.

The nutrient (N, P, K, Ca, Mg, Zn and Fe) content was found be greater than before with 60 per cent vermicompost.

In alstromeria, Wazir (2011) reported that mixture of soil + vermicompost + FYM + cocopeat influenced the plant height and spread.

Tariq *et al.* (2012) reported an increase in plant height and total branches in *Dahlia hortensis* when coconut coirpith was used as a medium.

Thakur *et al.* (2013) assessed the influence of various combinations of media on growth of *calendula officinalis*. The cocopeat + vermicompost treatment had shown highest plant height (30.40 cm).

Bala and Singh (2013) studied the impact of media mixture in chrysanthemum and stated that combination of soil+sand+FYM+vermicompost (2:1:0.5:0.5) resulted in maximum height (20.46) and number of branches followed by soil+sand+vermicompost (2:1:1).

2.2.3 EFFECT OF COMBINATION OF IBA AND GROWTH MEDIUM

Blythe and Sibley (2003) assessed the impact of auxin when applied through rooting media for English ivy and miniature rose 'Red Cascade' cuttings. In this experiment different level of auxin was used. They found cuttings supplied with the low concentration of auxin at 45 mg/litre was beneficial as this recorded increased number of roots and root length. Phytotoxic symptoms were observed under higher concentrations.

Khewale *et al.* (2005), in carnation, documented that quick rooting, highest rooting percentage, number of roots, and root length and root volume were observed in cuttings planted in cocopeat media + IBA 125 ppm.

Dhakar *et al.* (2011) reported highest number of shoots and shoot length in pomegranate cuttings planted in cocopeat media after treating with IBA.

Renuka and Chandrasehkhar (2015) studied the effect of different combinations of growth regulator and media on growth and rooting of carnation (*Dianthus caryophyllus*) cuttings. Among the media used, combination of red earth and cocopeat was found promising in terms of root initiation, rooting percentage, highest number of roots followed by vermicompost + cocopeat. Terminal cuttings treated with 200 ppm IBA showed better results in terms of rooting of cuttings, highest number of cuttings and rooting percentage.

Singh *et al.* (2015) conducted a research to know the impact of combinations of various levels of IBA and growing media in phalsa. He reported FYM and soil in 1: 2 ratio affected the survival rate of cuttings.

Chaudhari (2016) studied the interaction effect of different combinations of IBA (2000 ppm, 3000 ppm, 4000 ppm, 5000 ppm) and growing substrates (sand, soil, cocopeat) on poinsettia cuttings. The growth parameters like survival percentage, rooting percentage, number of roots and shoot growth were enhanced with treatment containing IBA 4000 mg /l along with coco peat + red soil.

Patel (2016) observed the interaction effect of different combinations of IBA (2000 ppm, 3000 ppm, 4000 ppm, 5000 ppm) and growth media (sand, soil, cocopeat) in *Hibiscus rosa sinensis*. They reported that a combination of red soil + cocopeat recorded the highest number of roots, survival percent, root length, fresh weight of root and shoot, dry weight of root and shoot and number of leaves.

2.3 COMPARISION OF VEGETATIVELY PROPAGATED PLANTS AND SEEDLING PLANTS IN AFRICAN MARIGOLD.

Dawane *et al.* (2015) conducted a study comparing propagation methods in marigold and their impact on growth, development, yield and quality parameters. The propagation by seeds significantly increased height and number of primary branches per plant where as the spread of plants was significantly increased by propagation through cuttings. The seedlings recorded a height of 29.36 cm at 30 days and 76.33 cm at 60 days whereas cuttings documented 24.61cm at 30 days and 67.5 cm at 60 days. Plants raised from seeds recorded the highest number of primary branches both at 30 (6.1) and 60 (9.87) days observed, while cuttings documented 4.13 at 30 days and 7.6 at 60 days.

The period of initiation of flower bud was significantly early in plants propagated through cuttings. Similar trend was noticed for period of first flowering (34.52 days), days to 50 per cent flowering and days to first harvest. The size of flowers was also more in plants propagated through cuttings compared to those propagated by seed. However, the duration of flowering and crop duration were significantly more in plants propagated through seeds as compared to that of plants propagated by cuttings (42.22 days). The shelf life of flowers obtained from plants through cutting was significantly more than that of seed propagated plants. The outcome of the study revealed that the propagation methods ensured a substantial effect on period of flowering

Naveen (2016) conducted the study to know the response of planting material and nutrition in marigold cv. Calcutta orange. The propagation methods varied significantly for both growth characters and flower qualities. He reported that highest plant height was observed in plants propagated by seedlings in contrast to cuttings. The seedlings documented the greatest height at 30 DAT and 60 DAT about 33.53 and 42.91 cm, respectively while cuttings recorded least height of 22.91 cm at 30 DAT and 32.35 at 60 DAT. The plants raised from seeds showed higher number of primary branches both at 30 DAT and 60 DAT. The seedlings documented 9.99 and 12.23 number of primary branches at 30 DAT and 60 DAT whereas cuttings recorded 7.40 and 10.05 number of primary branches at 30 DAT and 60 DAT respectively. He correspondingly described that the number of days taken (41.29 days) for flower bud initiation was least in plants raised from seeds while cuttings took more days (44.58 days). Flower initiation was faster in seedlings (47.86 days) compared to cuttings (53.80 days) and 50 per cent flowering was completed early in seedlings (57.66 days) compared to cuttings (64.19 days). Duration of flowering was less in seedlings (67.59 days) while cuttings displayed greater period of flowering (70.67 days). The seedlings documented more number of flowers (67.53) and yield (431.56 g) per plant and while plants from cuttings recorded less number of flowers (46.46) and yield (316.41g). However, average flower weight (8.73 g) and size (7.12 cm dia). Similarly, shelf life was also more (5.95 days) for flowers from in cuttings whereas plants raised from seedlings displayed less shelf life (5.70 days).

Dejong (1981) reported that in chrysanthemum cuttings flowered earlier compared to seedlings at two levels of irradiance. In chrysanthemum, variety Golden yellow (21.55) recorded highest number of primary branches and lowest in Sharad shoba (4.5) when propagated by tip cuttings (Chezhiyan *et al.*, 1985). Khadar *et al.* (1990) reported tip cuttings of chrysanthemum variety CO-1(15.8) resulted in increased number of branches contrasted to local cultivars (10.40). Isac and Cheziyan (2002) assessed various varieties of chrysanthemum by tip cutting. The maximum number branches were observed in variety ACC-4 (20.8) and minimum branches were recorded in ACC-115 (6.30). Laxmi (2006) tested yellow flowering varieties of chrysanthemum by cuttings. Among the varieties Co-1 took least number of days for 50 per cent flowering (102.33 Days) which was excellent significantly over other varieties.

In Carnation, Dwivedi and Kareem (2004) conducted varietal assessment through tip cutting. They reported that varieties like Copalmor, Alora and Shocking pink had highest flower diameter (5.9 cm) while variety White Candy had minimum flower diameter.

Laxmi (2006) tested yellow flowering varieties (CO-1, Raichur, Punjab Anuradha, Yellow Gold, Punjab Gold, Basanti, Silper) of chrysanthemum by cuttings. Raichur (114.01) noted highest number of flowers per plant which was on par with Basanti (112.12).

Kathiravan *et al.* (2007) investigated proper size of cuttings, compared the cuttings and seedlings for various growth and yield characters in *Jatropha curcas*. Linn. They reported that plants propagated through seedlings produced better quality flowers whereas plants raised from cuttings flowered early with more number of female flowers.

Plant height also was as influenced by the method of propagation. The maximum height was found in seedlings (1.65 m) compared to cuttings (1.52 m). The cuttings documented the least number of branches (2.4) compared to seedlings (3.2). The plants propagated by seeds flowered later than that of cuttings. The plants propagated by cuttings took 114 days for first flowering but seedlings took 118 days. The plants grown by seeds noted the maximum dry matter (3.04 g) while cuttings recorded less dry matter (2.90 g) correspondingly the yield was also more in plants propagated by seeds.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The research entitled "Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid" was conducted at the Department of Pomology and Floriculture, College of Agriculture, Padannakkad, Kasargod and Regional Agricultural Research Station, Pilicode during the period of 2016 to 2018.The present chapter deals with the investigational particulars regarding the materials used and methods adopted for the conduct of above experiment.

3.1 EXPERIMENTAL SITE:

Experiment 1 and 2 were conducted at the instructional farm of College of Agriculture, Padannakkad. The plot is located in the northern part of Kerala at 12° 20' 30'' N latitude, 75° 04' 15'' E longitude and altitude of 20 m above mean sea level. Experiment 3 was conducted at RARS Pilicode, located at $12^0$12'N latitude and $75^0$10'E longitude and at an altitude of 15m above mean sea level.

3.2 AGROCLIMATIC CONDITION:

College of Agriculture, Padannakkad and Regional Agricultural Research Station, Pilicode, where the experiments were laid out, comes under tropical humid region. It comes under the NARP northern zone of the state of Kerala and under AZ109^{th} climatic zone of the country. Monthly average meteorological data relating to mean values of light, temperature, relative humidity and rainfall during the period of experiments, as recorded at Meteorological Observatory, RARS Pilicode are presented in Fig 1 and Appendix I (a and b).

The annual average rainfall is 3533 mm in 2017 and 3073 mm in 2018 out of which about 75.35 per cent in 2017 and 68.89 per cent in 2018 is received from First of June to mid-September and low rainfall from October to December. The total rainfall received during this period was 2662.60 mm in 2017 and 2092.29 mm in 2018 and the number of rainy days was 269. The pattern of rainfall, particularly during June to December months has great variation, with heavy rains during June to July and occasional heavy to light showers from August to December.

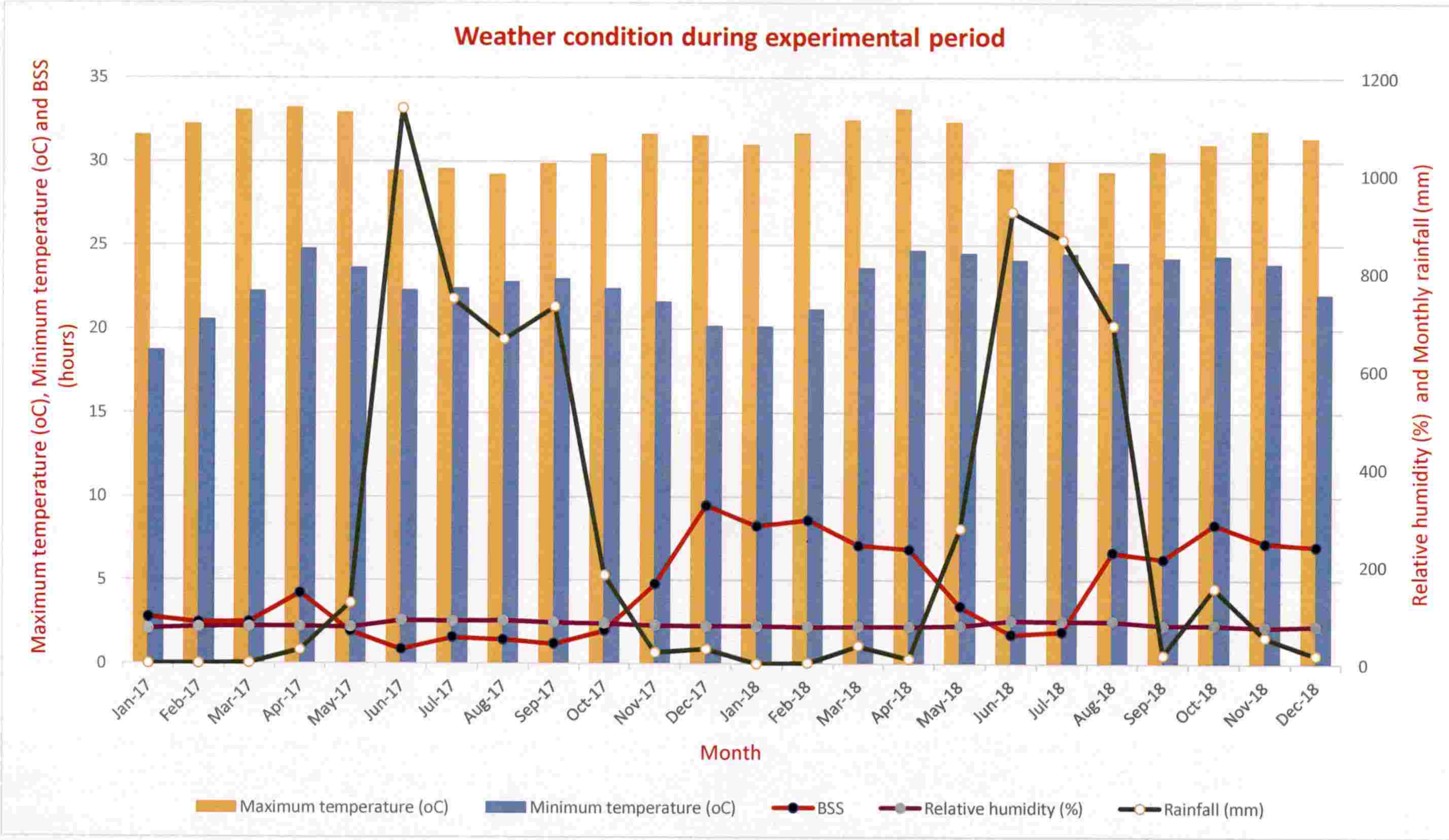


Fig 1: Weather Condition during experimental period

42

April was the hottest month (33.19 °C in 2017 and 33.13 °C in 2018) and January is the coolest month (18.70 °C in 2017 and 20.13 °C in 2018) of the year. The BSS was maximum during the month of December in 2017 (9.44 hours) and February in 2018 (8.58 hours) while it was the least during the month of June (0.84 hours in 2017 and 1.76 hours in 2018). Similarly, Relative humidity recorded during the period fluctuated between May to November and was highest during the month of June (88.62 % in 2017 and 88.94 % in 2018) and lowest during the month of January in 2017 (72.15 %) and February (75.84 %).

3.3 SOIL CHARACTERISTICS:

The soil of the site for the third experiment was lateritic loam. It was acidic in reaction with a pH of 5.98, organic carbon content 0.48 per cent, available N 225.79 Kg/ha, available P_2O_5 126.47 Kg/ha and available K_2O 431.64 Kg/ha.

3.4 THE EXPERIMENTAL MATERIAL:

The African marigold variety, Maxima Yellow F_1 was used for the experiment. The seeds were procured from Bioscience Seed Company, Coimbatore, Tamil nadu.

3.5 LAYOUT OF EXPERIMENT:

The study included total 3 experiments. The first and second experiments were conducted at College of Agriculture, Padannakkad and third experiment at Regional Agriculture Research Station, Pilicode under open polyhouse.

3.5.1 Experiment 1:

Standardisation of age of cuttings for rooting in African marigold (*Tagetes erecta* L.) hybrid

Design of experiment: CRD

Replications: 4

Number of plants per replication: 20

Treatments: Age of cuttings (4)

T_1: cuttings taken after 30 days transplanting (DAT)

T_2: cuttings taken 50 DAT

T_3: cuttings taken 70 DAT

T_4: cuttings taken 90 DAT

3.5.2 Experiment 2:

Standardisation of media and IBA levels for rooting of cuttings in African marigold (*Tagetes erecta* L.) hybrid.

Design of experiment: factorial CRD

Replications: 3

No. of plants per replication: 10

Treatments: 9

Rooting media: 3

IBA: 3 levels (0 mg/l, 200mg/l, 400 mg/l)

Treatments:

T_1- media (Soil + FYM 1:1) + IBA 0 mg/l

T_2- media (Soil + Coir pith compost 1:1) + IBA 0 mg/l

T_3- media (Soil + Vermicompost 1:1) + IBA 0 mg/l

T_4- media (Soil + FYM 1:1) + IBA 200 mg/l

T_5-media ((Soil + Coir pith compost 1:1) + IBA200 mg/l

T_6- media (Soil + Vermicompost 1:1) + IBA 200 mg/l

T_7- media (Soil + FYM 1:1) + IBA 400 mg/l

T_8- media (Soil + Coir pith compost 1:1) + IBA 400 mg/l

T_9- media (Soil + Vermicompost 1:1) + IBA 400 mg/l

3.5.3 Experiment 3:

Comparison of vegetatively propagated plants and seedling plants in African marigold (*Tagetes erecta* L.) hybrid

Design: t – test analysis

Treatments: 2

T_1: Vegetatively propagated plants (rooted cuttings)

T_2: Seedlings

Replication: 20

No. of plants per replication: 20

The layout of the third experiment is given in fig 2.

3.5.4 Nursery techniques

The Maxima Yellow F_1 Seeds were sown in pot trays filled with coir pith compost. For experiment one, seeds were sown in the month of January (2017), for second experiment seeds were sown in the month of September 2017and for third experiment in month of June 2018. The seed trays were irrigated daily using a Rose can. The germination percentage was found to be 95 per cent for first experiment during January 17, 98 per cent for the second experiment during September 17 and 96 per cent for third experiment during June 18. No serious pest or diseases were observed in general in the nursery. However, damping off was observed in seedlings during second experiment which was controlled by drenching and spraying COC.

3.5.5 Transplanting

One month old seedlings were used for transplanting. For the first experiment, eighty seedlings were transplanted to grow bags containing standard potting mixture consisting of soil and FYM (1:1) and maintained as mother plants

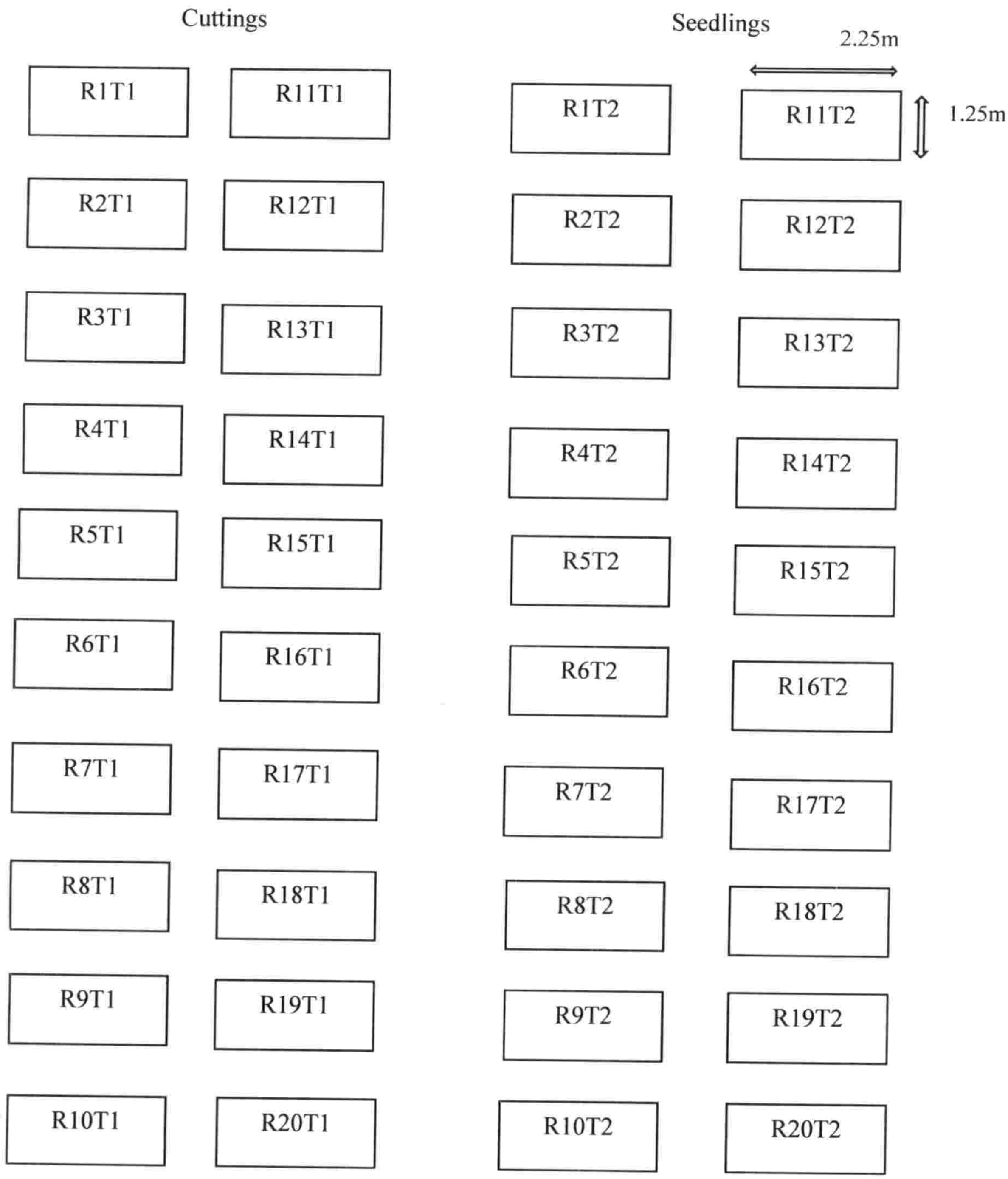


Fig.2 Layout of third experiment

Plate 1 : Mother plants for first experiment

for removal of shoots at intervals proposed and Mother plants used are shown in Plate1.

For second experiment three hundred and sixty seedlings were transplanted to polybags and maintained as mother plants. These plants were utilised for taking cuttings and planting in different media and IBA combinations.

For third experiment, seeds were sown initially to produce seedlings. Rooted cuttings were prepared from seedlings. Seedlings of same age and rooted cuttings were transplanted to prepared beds and picture of rooted cuttings and seedlings is shown in Plate 2.

3.5.6 Crop management

For first and second experiment, the mother plants were grouped according to treatments and isolated at a distance between each other. Timely weeding and irrigation was done. For third experiment beds of size $2.25 \times 1.2\ m^2$ were prepared by removing stones and weeds. Lime and farm yard manure were applied to beds as basal dose along with fertilisers adopting package of practices recommended by Kerala Agricultural University (KAU, 2016). The rooted cuttings and seedlings were planted at spacing of $30 \times 45\ cm^2$ on beds and distance of 50 cm was maintained between beds. The bed preparation and transplanting is shown in Plate3.

3.5.7 Pest and Diseases

During first experiment, incidence of leaf minor attack was observed which was controlled by application of neem oil @ 2ml per litre to the mother plants. There was also incidence of bacterial wilt disease in plants during second and third experiments against which COC- 3mg/l was drenched per plant. The bacterial wilt was too severe during third experiment. The control measures like drenching beds with bleaching powder about 10 g/l and COC-3mg/l was practiced to overcome this. Bacterimycin @ 0.5 g/l was also tried for controlling bacterial wilt. Pests such as mealy bug also attacked the crop which could be controlled by spraying dimethoate @ 2ml/l. Pest and diseases occurred are presented in Plate 4.

Plate 2:Planting materials for third experiment

Plate 2 a: Seedlings

Plate 2 b : Rooted cuttings

Plate 3: Field preparation and transplanting

Plate 3 a: Layout of beds & Field preparation

Plate 3 b : Transplanting of rooted cuttings and seedlings

Plate 4 : Pest and diseases

Plate 4 a : Mealybug attack

Plate 4 b: Bacterial wilt

3.5.8 Imposing of treatments

For first experiment, cuttings were taken at 30, 50, 70 and 90 days after transplanting and planted in polybags containing potting mixture and periodically observed.

The cuttings during second experiment were taken 30 days after transplanting. Cuttings were planted in polybags containing 3 different media combinations as mentioned in the treatments for experiment second after dipping in three doses., one without IBA, with IBA 200 mg/l and 400 mg/l. The three media combinations were 1) Red soil + Vermicompost, 2) Red soil + Vermicompost and 3) Red soil + FYM. Polybags were kept under open poly house condition for better rooting.

The IBA stock solution of 400 mg/l was prepared by dissolving IBA in crystal form (NICE chemicals) with distilled water and 90 per cent ethanol agreeing to the principle that 1 mg of IBA in 1L of distilled water will make 1ppm solution (Hartmann and Kester,1972). It was further diluted with distilled water to prepare the required strength of solution as per treatments. This solution was used for dipping the cuttings according to the treatments. Soft wood cutting of uniform length and diameter of marigold were dipped for two minutes as per treatments. The cuttings under control were dipped in distilled water instead of IBA solution.

During third experiment, cuttings were taken 30 days after transplanting and planted for rooting. The rooted plants and seedlings of same age were transplanted to field.

3.5.9 Harvesting

Fully opened flowers were harvested during morning hours. The number of flowers, yield and fresh weight were documented.

3.6 Collection of experimental data

3.6.1 Sampling procedure:

The observations were recorded after 45 days of planting for experiment one and two. The plants from each replication were selected and observations were recorded.

3.7 OBSERVATIONS

3.7.1 FOR FIRST AND SECOND EXPERIMENT

3.7.1.1 Growth characters

3.7.1.1.1 Survival per cent:

Survival percentage was calculated after 45 days after planting in polybags by following formula

Survival % of cuttings = T-MP/T×100

Where,

T = Total number of rooted cuttings

Mp = Mortal plants

3.7.1.1.2 Plant height (cm):

The height of individual plant was computed with the help of quantifying scale from the ground level up to the growing tip of plant. The height of 4 selected and 5 selected plants was recorded during first and second experiment respectively.

3.7.1.1.3 Number of leaves per plant:

The number of leaves from four selected plants from each replication during first experiment and five plants from second experiment was recorded and average expressed in numbers per plant.

3.7.1.1.4 Leaf area (cm^2):

The leaf area from all leaves of selected plants was calculated using portable leaf area meter, LI-COR Model LI-3000A model and stated in square centimetre per plant.

3.7.1.1.5 Shoot fresh weight and dry weight (g)

The shoots from selected plants originated from rooted cuttings were separated and weighed with electronic balance for fresh weights and mean was calculated and stated in gram per plant. The shoots after recording fresh weight were kept in hot air oven at 60 °C for drying. The dry weight of each shoot was calculated and the mean was stated in gram per plant.

3.7.1.1.6 Root fresh and dry weight (g)

The roots are separated from selected plants raised form rooted cuttings and weighed with electronic balance and mean was calculated and stated in gram per plant as fresh weight. After recording fresh weight of roots, root length and root number the samples were kept in hot air oven for recording dry weight. The dry weight of roots was calculated and the mean was expressed in gram per plant.

3.7.1.1.7 Mean root number:

The number of roots per cutting was calculated from four and five randomly selected plants from each treatment from first and second experiment after 45 days and mean was calculated and expressed in numbers per plant.

3.7.1.1.8 Mean root length (cm):

The length of each root was measured with measuring scale in centimetres after 45 days after planting of cuttings and average of root length per rooted cutting was calculated and presented in cm.

3.7.1.1.8 Rooting Percentage (%):

The rooting percentage was calculated by arriving at the ratio of rooted cuttings to total number of cuttings planted and multiplied by 100.

$$\text{Rooting percentage} = \frac{\text{Number of cuttings rooted}}{\text{Total number of cuttings planted}} \times 100$$

3.7.1.1.9 Root to shoot ratio:

The root to shoot ratio was obtained by dividing the root fresh weight by shoot fresh weight.

3.7.2 Experiment 3

3.7.2.1 Morphological observations

3.7.2.1.1 Plant height (cm):

The height of individual plant was computed with the help of quantifying scale from the ground level up to the growing tip of plant. The height of 4 selected plants was tabulated at 1, 2 and 3 months after planting in third experiment. The mean of the height was expressed in centimetres.

3.7.2.1.2 Number of primary branches per plant:

The number of primary of branches arising from the main stem was recorded at first, second and third months after planting. The mean number of primary branches was calculated and stated in figures per plant.

3.7.2.1.3 Number of secondary branches per plant:

The number of secondary branches arising from the primary branches was recorded at first, second and third months after planting and calculated and mean was expressed in figures per plant.

3.7.2.1.4 Total fresh and dry weight of plants (3MAP):

Completely flowered observational plants from all replications were dried in oven and dry weight was recorded and stated in grams per plant.

3.7.2.2 Flower observations

3.7.2.2.1 Days to first flowering:

The number of days taken for first flowering was documented by totalling the days from transplanting to first flower opening.

3.7.2.2.2 Days to 50% flowering:

The number of days taken for 50% flowering in each treatment was calculated by totalling the days from transplanting to flowering in 50% of plants in a bed and represented in days.

3.7.2.2.3 Days to first harvest:

The number of days for first harvest was calculated from the day of germination to first harvest and expressed in number of days.

3.7.2.2.4 Number of flowers per plant:

Whole quantity of flowers harvested from labelled individual plant picked at different intervals was recorded and the whole quantity arrived at. Finally, mean total number of flowers per plant was calculated and stated in numbers.

3.7.2.2.5 Mean flower weight (g):

Weight of ten individual flowers from each replication was computed and mean was calculated and expressed in grams.

3.7.2.2.6 Flower yield per plant (g):

Fresh weight of flowers picked from time to time from labelled plants of each replication was documented and mean were calculated and reported in grams.

3.7.2.2.7 Total flower yield / ha (Kg):

Flower yield per plant (g) was converted to total flower yield per ha by multiplying it with total number of plants per ha.

3.7.2.2.8 Flower diameter:

Longest width of ten randomly designated flowers from all replications were computed by using a measuring scale and mean was calculated and expressed in centimetres.

3.7.2.2.9 Duration of flowering:

The sum of days taken from first flower opening to last flower opening of labelled plants from all the replications was observed and mean was calculated and represented in number of days.

3.7.2.2.10 Vase life:

Ten flowers from labelled plants were harvested at precise harvest index of fully opened stage and kept at room temperature after dipping the peduncle in water for observing vase life. The number of days was counted till the colour of petals faded and withered and recorded.

3.7.2.2.11 BC ratio:

It is the ratio of gross return to the cost of cultivation.

$$BCR = \frac{\text{Gross return ha}^{-1} \text{ (Rs.)}}{\text{Cost of cultivation ha}^{-1}\text{(Rs.)}}$$

Benefit – cost ratio worked out using the cost of cultivation for seedling plants and rooted cuttings, marketable flower yield and the average price of flowers in the local market and comparing the benefits.

3.7.2.2.12 Statistical analysis

Observations on different characters were tabulated and statistically analysed using the OPSTAT online Agriculture Data Analysis. The analysis of variance was carried out for each character separately as per method of Panse and Sukhatme (1985).

RESULTS

4. RESULTS

An experiment entitled "Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid" was conducted at College of Agriculture, Padannakkad and RARS, Pilicode during 2016-2018. The objective was to standardise the age of cuttings, media and IBA levels for rooting of cuttings and to compare the performance of vegetatively propagated plants and seedling plants in African marigold (*Tagetes erecta* L.) hybrid based on various vegetative and floral parameters. The observations for each experiment were recorded and the data are subjected to statistical analysis. The results are presented in this chapter.

4.1 STANDARDISATION OF AGE OF CUTTINGS FOR ROOTING IN AFRICAN MARIGOLD HYBRID.

The observations on different parameters mentioned below has been recorded at 45 days after planting of cuttings for rooting.

4.1.1 Number of cuttings available from mother plant

Cuttings were extracted from the mother plants after 30 days, 50 days, 70 days and 90 days after transplanting. There was significant difference in the number of cuttings that is available from a single mother plant of different age (Table 1). 90 days old mother plants (T_4) were significantly superior in providing maximum number of cuttings (9.125) while the number was lesser (3.31) in 30 days old mother plant (T_1).

4.1.2 Survival percentage

The results has shown that the age of mother plants have no influence on rooting since the cuttings extracted from all the age groups rooted perfectly with 100 percent rooting and survival percentage. The data regarding survival percentage is given in table (Table 1).

Table 1: Effect of age of cuttings on survival percentage and total number of cuttings

Treatments	Survival percentage (%)	Total number of cuttings
T_1 (30 DAT)	100	3.31
T_2 (50 DAT)	100	4.87
T_3 (70 DAT)	100	4.93
T_4 (90 DAT)	100	9.12
SEm(±)		**0.48**
CD(0.05)		**1.48**

Table2: Effect of age of cuttings on plant height(cm), number of leaves and leaf area(cm^2)

Treatments	Plant height (cm)	Number of leaves	Leaf area(cm^2)
T_1 (30 DAT)	51.12	52.75	69.325
T_2 (50 DAT)	53.31	45	66.205
T_3 (70 DAT)	55.18	42.06	61.305
T_4 (90 DAT)	55.87	39.43	60.065
SEm(±)	**0.80**	**1.87**	**2.08**
CD(0.05)	**2.46**	**8.63**	**6.416**

Note: T_1: cuttings taken 30 Days after transplanting

T_2: cuttings taken 50 Days after transplanting

T_3: cuttings taken 70 Days after transplanting

T_4: cuttings taken 90 Days after transplanting

4.1.3 Plant height (cm)

There was significant difference in plant height with respect to the age of cuttings (Table 2 and Fig 3). Rooted cuttings from 90 days old mother plants (T_4) has recorded maximum plant height (55.87 cm) which was on par (55.18 cm) with 70-day old mother plant (T_3). Cuttings from 30-day old mother plants (T_1) have shown minimum plant height (51.12 cm) which was significantly lower than the other three treatments.

4.1.4 Number of leaves

There was significant difference in number of leaves with respect to the age of cuttings (Table 2 and Fig 3). Cuttings from 30-day old mother plants (T_1) has recorded the highest number of leaves (52.75) but was on par with rooted cuttings from 50-day old mother plants (T_2). The leaves present in rooted cuttings from 70-day and 90-day old mother plants are significantly lesser but was on par with T_2.

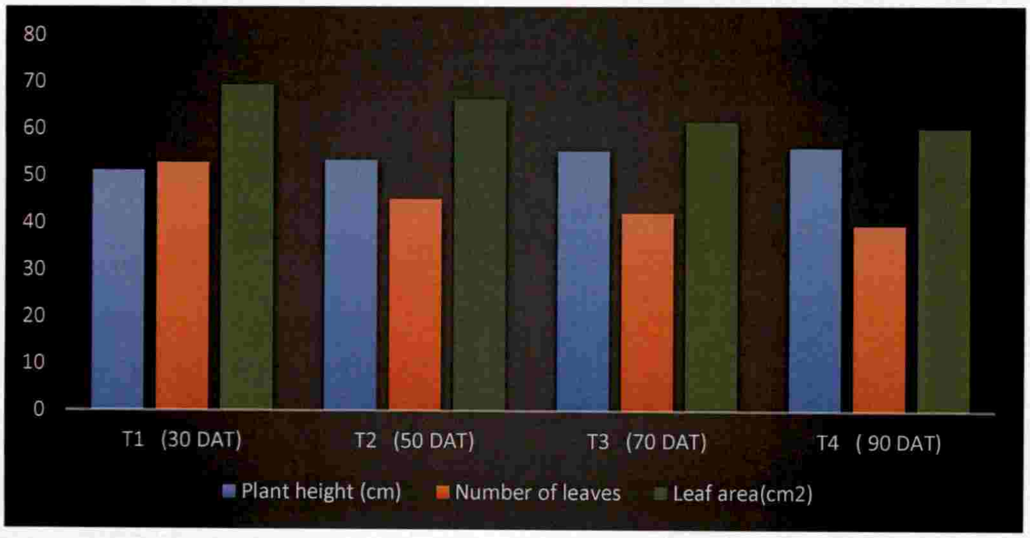
4.1.5 Leaf area (cm^2)

There was significant difference in leaf area with respect to the age of cuttings (Table 2 and Fig 3). Cuttings from 30-day old mother plants (T_1) has recorded the maximum leaf area (69.32 cm^2) which was on par with the leaf area (66.20 cm^2) recorded by rooted cuttings of 50-day old mother plants (T_2). The other two treatments recorded significantly lower leaf area compared to T_1.

4.1.6 Shoot fresh weight and dry weight

There was no significant difference in shoot fresh weight of rooted cuttings with respect to the age of cuttings (Table 3). The results revealed that fresh weight of shoots from different age groups of rooted cuttings recorded were on par. This indicates that the age of mother plants had no impact on fresh weight of cuttings. However, cuttings from 30-day old mother plants (T_1) has recorded the highest shoot fresh weight (37.86 g) compared to that of rooted cuttings of other ages groups whereas it least (33.96 g) in rooted cuttings from 50 days old mother plants (T_2). There was significant difference in shoot dry weight of rooted cuttings with

Fig 3. Effect of age of mother plants on plant height (cm), number of leaves and leaf area(cm^2)



respect to the age of cuttings (Table 3). Cuttings from 30-day old mother plants (T_1) has recorded the highest shoot dry weight (5.365 g) which was significantly on par with shoot dry weight of (5.125 g) rooted cuttings from 50-day old mother plants (T_2). This was followed by treatments T_3 and T_4.

4.1.7 Root fresh weight and dry weight

There was significant difference in root fresh weight and dry weight of plants with respect to the age of cuttings (Table 3). The results have revealed that the age of mother plants have impact on root fresh weight and dry weight as the cuttings extracted from age groups are significantly different. Cuttings from 30-day old mother plants (T_1) has recorded the maximum root fresh weight (13.98 g) which was on par with the root fresh weight of rooted cuttings from 50-day (T_2) and 70-day old mother plants (T_3). Root fresh weight was significantly lower in T_4.

Cuttings from 30-day old mother plants (T_1) has recorded the highest root dry weight (2.74g) which was on par (2.06g) with rooted cuttings from 50-day old mother plants (T_2). This was followed by T_3 and T_4 which were significantly lower. This parameter follows the trend similar to that of root fresh weight.

4.1.8 Root to shoot ratio

The data pertaining to root to shoot ratio of plants from rooted cuttings of different age groups are presented in Table 3. The root to shoot ratio was recorded maximum (0.39) by rooted cuttings from 30 days old mother plants (T_1) while it was significantly similar to rooted cuttings from 50 days and 70 days old plants

4.1.9 Number of roots

The number of roots was recorded at 45 days after planting. There was significant difference in number of roots in plants with respect to the age of cuttings (Table 4). The results indicate that the age of mother plants have influence on number of roots as the cuttings extracted from all the age groups. Cuttings from 30-day old mother plants (T_1) has recorded the maximum number of roots (85.37) which however was on par with the number of roots of in from 70-day old mother

Table 3: Effect of age cuttings on shoot fresh and dry weight, root fresh and dry weight, root to shoot ratio

Treatments	Shoot		Root		Root to shoot ratio
	Fresh weight	Dry weight	Fresh weight	Dry weight	
T_1 (30 DAT)	37.86	5.36	13.98	2.74	0.39
T_2 (50 DAT)	33.96	5.12	12.43	2.06	0.37
T_3 (70 DAT)	35.36	4.38	12.12	1.96	0.31
T_4 (90 DAT)	35.41	3.85	9.24	1.16	0.26
SEm(±)	**1.95**	**0.36**	**0.82**	**0.25**	0.02
CD(0.05)	**N/A**	**1.13**	**2.55**	**0.77**	0.08

Table 4: Effect of age of cuttings on number of roots, root length(cm) and rooting percentage

Treatments	Number of roots	Root length (cm)	Rooting percentage (%)
T_1 (30 DAT)	85.37	10.75	100
T_2 (50 DAT)	78.62	9.69	100
T_3 (70 DAT)	82.75	8.86	100
T_4 (90 DAT)	70.56	7.61	100
SEm(±)	**2.30**	**0.48**	
CD (0.05)	**7.10**	**1.38**	

Note: T_1: cuttings taken 30 Days after transplanting

T_2: cuttings taken 50 Days after transplanting

T_3: cuttings taken 70 Days after transplanting

T_4: cuttings taken 90 Days after transplanting plants (T_3), 50-day old mother plants (T_2). Number of roots was significantly lower in 90-day old mother plants. The root growth of cuttings taken from 30 days old mother plants is shown in Plate 5.

4.1.10 Root length

The results indicated that the age of mother plants had influence on root length (Table 4). Cuttings from 30-day old mother plants (T_1) has documented the greatest root length (10.75cm) which was significantly on par with the root length of rooted cuttings from 50-day old mother plants (T_2). The length of roots was significantly less in T_4.

4.1.11 Rooting percentage

The data regarding rooting percentage is given in Table 4. The results revealed that the age of mother plants had no impact on success of rooting since the cuttings extracted from all the age groups rooted perfectly with 100 per cent rooting.

4.2 STANDARDISATION OF MEDIA AND IBA LEVELS FOR ROOTING OF CUTTINGS IN AFRICAN MARIGOLD HYBRID.

The observations on different parameters mentioned below has been recorded at 45 days after planting of cuttings for rooting.

4.2.1. Rooting of cuttings

Irrespective of the treatments whether the different levels media, IBA or their interactions, 100 per cent rooting was recorded by all of them (Table 5). This indicated that there is no significant effect of media, IBA or their interactions in rooting success percentage.

4.2.2 Mean root number

The figures regarding number of roots are presented in Table 5. IBA @ 400 mg/l (I_3) recorded maximum number of roots (54.34) significantly on par with number of roots recorded by IBA @ 200 mg/l. Media also have significant effect on the number of roots. The media comprising Soil + Vermicompost (M_3) is best with respect to the number of roots (53.91) produced per cutting and it was

Plate 5 : Root growth in rooted cuttings taken from 30-day old mother plants.

significantly on par with Soil + Coirpith. The interaction effect also proved that a combination of Soil + Vermicompost and IBA @ 400 mg/l (I_3M_3) had recorded highest number of roots (70.66) and this effect is shown in Plate 5 and significantly similar to interaction effect between IBA @ 200 mg/l and Soil + Vermicompost.

4.2.3 Mean root length

The figures regarding mean root length are presented in Table 5. Mean root length was also found highest (20.83 cm) in IBA @ 400 mg/l and it was on par with IBA @ 200 mg/l (18.36 cm). Among media Soil + Vermicompost recorded maximum root length (22.39 cm). Among interaction effects, interaction between IBA @ 400 mg/l and Soil + Vermicompost recorded maximum root length (25.38 cm) which was on par with IBA @ 200 mg/l and Soil + FYM.

4.2.4 Influence on plant height

The figures related to plant height are presented in Table 6. The plant height was significantly influenced by IBA levels. Cuttings treated with IBA recorded significantly lower height compared to untreated ones which were the tallest (22.11cm)

Similarly, plant height also varied significantly with different media. Among three media maximum plant height (18.48 cm) was observed in Soil + Vermicompost (1:1) (M_3). However, plant height was not significantly influenced by interaction effect of IBA and media.

Plate 6: root growth in cuttings treated with IBA 400 ppm and planted in Soil + Vermicompost

Table 5. Effect of different levels of IBA and different types of media on root number, root length and rooting percentage.

Treatment	Mean root number	Mean root length	Rooting percentage (%)
Levels of IBA			
I_1	44.33	17.77	100
I_2	47.88	18.36	100
I_3	54.34	20.83	100
SEm (±)	**2.37**	**0.80**	
CD (0.05)	**7.12**	**2.42**	
Types of media			
M_1	45.11	19.69	100
M_2	47.55	14.87	100
M_3	53.91	22.39	100
SEm (±)	**2.37**	**0.80**	
CD (0.05)	**7.12**	**2.42**	
Interactions			
I_1M_1	40.50	16.22	100
I_1M_2	31.18	16.37	100
I_1M_3	41.33	20.71	100
I_2M_1	53.50	22.64	100
I_2M_2	42.73	11.34	100
I_2M_3	59.60	21.10	100
I_3M_1	48.33	20.20	100
I_3M_2	51.86	16.91	100
I_3M_3	70.66	25.38	100
SEm (±)	**4.12**	**1.40**	
CD (0.05)	**12.33**	**4.19**	

I_1= 0mg/l,

I_2= 200mg/l

I_3= 400 mg/l

M_1= Soil +FYM (1:1),

M_2= Soil + Coir pith compost (1:1),

M_3=Soil + Vermicompost

70

4.2.5 Number of leaves

The data related to number of leaves is presented in Table 6. Number of leaves per plant significantly influenced by IBA levels. IBA level @ 400 mg/l (I_3) recorded the highest number of leaves (38.48) followed by I_2. Untreated plants recorded the least number of leaves. Similarly, different media also have significant effect on the number of leaves produced per plant. Among different media Soil + Vermicompost (1:1) recorded the highest number of leaves (36.15) which was significantly superior to other media.

Among the various interaction effect between IBA and media, IBA @ 200 mg/l, Soil + Vermicompost (1:1)) (I_2M_3) recorded maximum number of leaves (56.73) which was significantly superior to all other treatments, followed by I_3M_2 (48.33).

4.2.6 Leaf area (cm^2)

The figures pertaining to leaf area are recorded in Table 6. Leaf area followed a similar trend to that of number of leaves. IBA levels significantly influenced the leaf area and IBA level @ 400 mg/l recorded the highest leaf area (48.63 cm^2) compared to other levels of IBA. Since the leaf area was also significant at IBA 200 ppm, it indicates that IBA application enhances leaf area.

Leaf area was significantly influenced by different media. Among different media Soil + Vermicompost (1:1) recorded the highest leaf area (44.81 cm^2) and was significantly superior to other media.

Interaction effect of IBA and media also has significant effect on leaf area. Among various interactions, IBA @ 200mg/l, Soil + Vermicompost (1:1)) (I_2M_3) recorded maximum leaf area (61.28 cm^2).

Table.6: Effect of different levels of IBA and different types of media on plant height, number of leaves and leaf area.

Treatment	Plant height (cm)	Number of leaves plant^{-1}	Leaf area plant^{-1} (cm^2)	Survival percentage(%)
Levels of IBA				
I_1	22.11	17.20	28.03	72.05
I_2	14.51	29.95	38.87	86.11
I_3	14.64	38.48	48.63	86.11
SEm (±)	**0.52**	**1.25**	**0.79**	**3.33**
CD (0.05)	**1.55**	**3.74**	**2.36**	**9.98**
Types of media				
M_1	16.47	25.28	36.98	80.15
M_2	16.30	24.20	33.74	74.44
M_3	18.48	36.15	44.81	89.67
SEm (±)	**0.52**	**1.25**	**0.79**	**3.33**
CD (0.05)	**1.55**	**3.74**	**2.36**	**9.98**
Interactions				
I_1M_1	22.66	19.53	30.05	90.46
I_1M_2	20.40	12.80	23.87	76.66
I_1M_3	23.26	19.26	30.18	85.70
I_2M_1	13.43	21.66	32.80	75.00
I_2M_2	13.50	11.46	22.52	91.66
I_2M_3	16.60	56.73	61.28	91.66
I_3M_1	13.33	34.66	48.10	75.00
I_3M_2	15.00	48.33	54.83	91.66
I_3M_3	15.60	32.46	42.96	91.66
SEm (±)	**0.90**	**2.16**	**1.36**	**5.77**
CD (0.05)	**NS**	**6.48**	**4.09**	**17.30**

I_1= 0mg/l,

I_2= 200mg/l

I_3=400 mg/l

M_1= Soil + FYM (1:1),

M_2= Soil + Coir pith compost (1:1),

M_3=Soil + Vermicompost

4.2.7 Survival percentage

The figures pertaining to survival percentage are recorded in Table 6 and Fig 4. The Survival percentage was significantly influenced by different IBA levels. It was recorded maximum (86.11%) in treatment IBA @ 400mg/l and 200mg/l.

Survival percentage was significantly influenced by different media. Among different media Soil + Vermicompost (1:1) recorded the highest survival percentage (89.67%) which was on par with Soil + FYM (1:1). Similarly, interaction effect had no significant effect influence on survival percentage.

4.2.8 Shoot fresh and dry weight

The data pertaining to both fresh weight and dry weight is presented in Table 7 and Fig 5. Both fresh and dry weight of shoot was significantly influenced by IBA levels. Plants treated with IBA @ 400 mg/l recorded maximum Shoot fresh weight (15.18 g) and it was on par with untreated plants and dry weight (6.24 g) was significantly highest in IBA 400 ppm.

Similarly, media also had significant influence on both Shoot fresh and dry weight. Shoot fresh weight was found to be highest (16.36 g) in Soil + Vermicompost (1:1). Shoot dry weight was recorded maximum (5.17 g) in Soil + Vermicompost (1:1) and significantly similar to Soil + FYM

With respect to different combinations I_2M_3 (IBA @ 200mg/l and Soil + Vermicompost) recorded maximum shoot fresh weight (20.93 g) and dry weight (9.49 g).

4.2.9 Root fresh and dry weight

The data related to both fresh weight and dry weight are presented in Table 7 and Fig 6. Both fresh weight and dry weight of roots were significantly influenced by IBA levels. Maximum fresh weight of roots (6.38 g) and dry weight (1.82 g) were recorded in plants treated with IBA @ 400 mg/l which were significantly superior to other levels of IBA.

Fig 4: Effect of IBA levels, media and their interaction effect on survival percent.

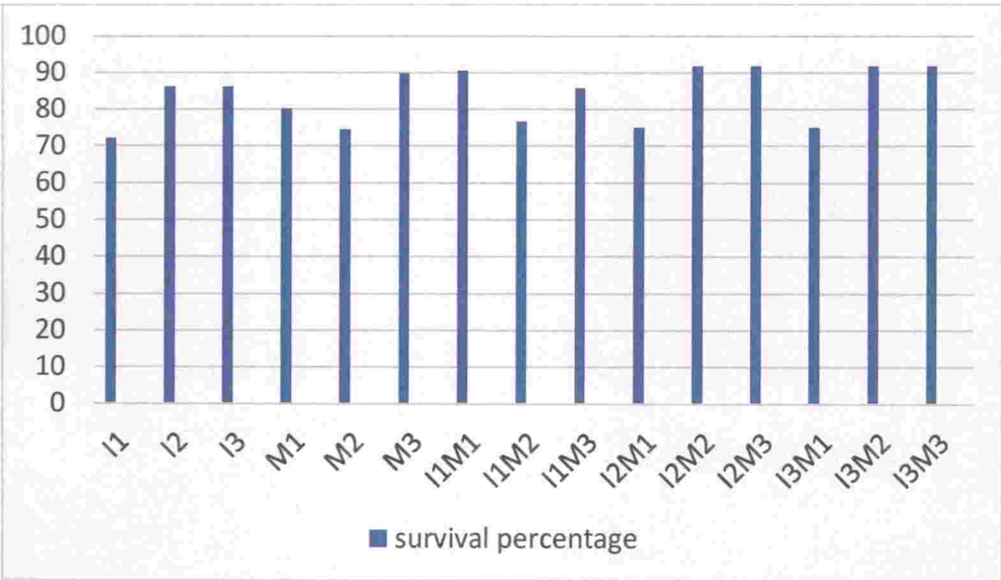


Fig 5: Interaction effect of IBA levels and media on shoot fresh weight and dry weight

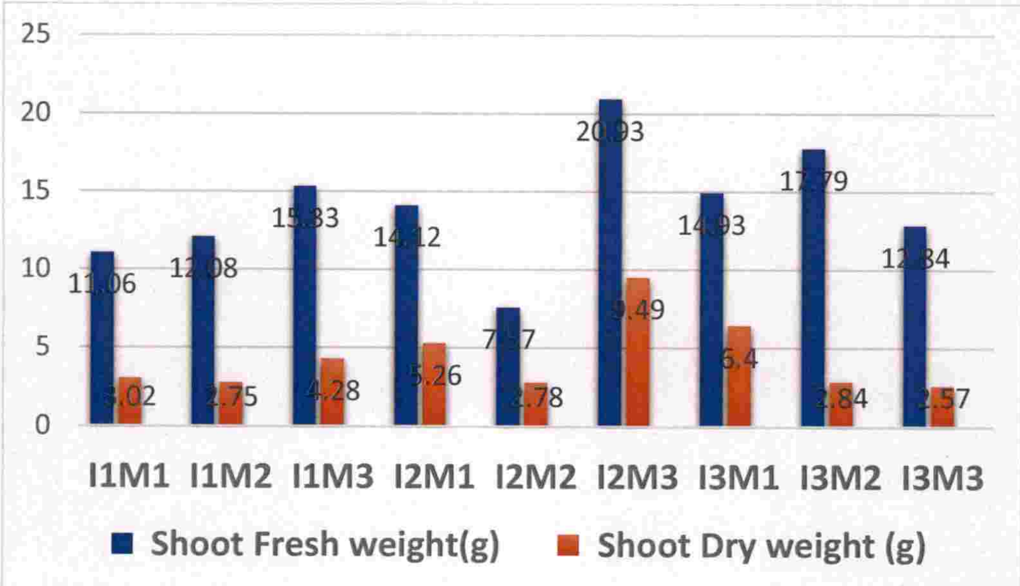
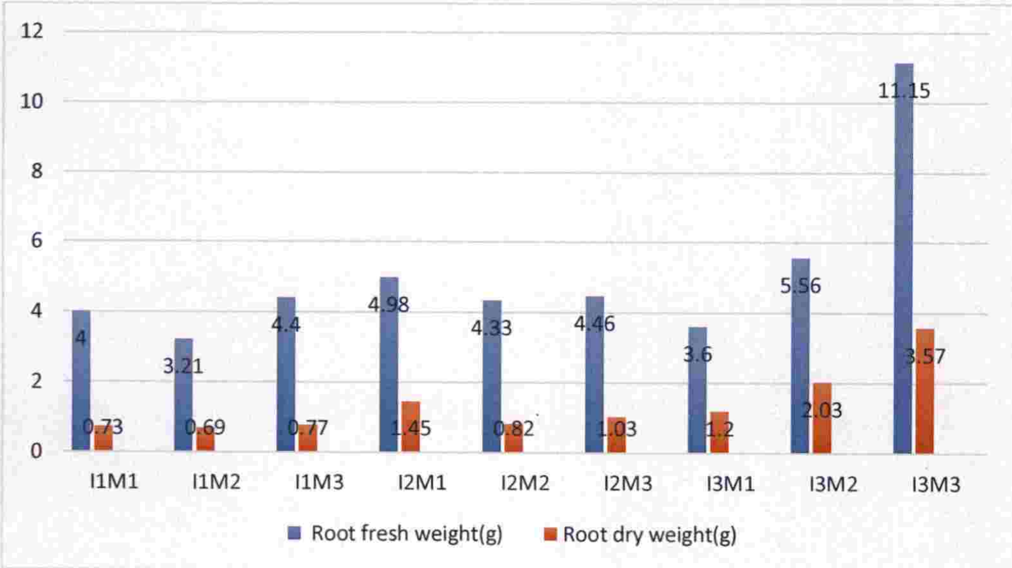


Fig 6: Interaction effect of IBA levels and media on root fresh weight and dry weight



Different media also significantly influenced the root fresh weight and dry weight. Media containing Soil + Vermicompost (1:1) recorded maximum root fresh weight (6.65 g) and dry weight (1.77 g) whereas root dry weight was on par with Soil + Coirpith.

Among various combinations, the interaction of media and growth regulator I_3M_3 (IBA @ 400mg/l and Soil + Vermicompost) recorded maximum root fresh weight (11.15 g) and dry weight (3.57 g) which was significantly superior to all other treatments.

4.2.10 Root to shoot ratio

The root to shoot ratio was significantly influenced either by IBA levels and media. Root to shoot ratio was calculated by recording the shoot fresh weight and root fresh weight. Among IBA levels, IBA @ 400 mg/l recorded the maximum root to shoot. Media composition Soil + Vermicompost recorded the maximum root to shoot ratio. The data related to the root to shoot ratio is presented in Table 7. However, the root to shoot ratio was significantly influenced by interaction effect of IBA levels and different media. Among different combinations,I_3M_3 (IBA @ 400mg/l and Soil + Vermicompost) recorded maximum root to shoot ratio (0.86).

Table 7: Effect of different levels of IBA and different types of media on shoot fresh and dry weight, root fresh and dry weight, root to shoot ratio

Treatment	Shoot		Root		Root to shoot ratio
	Fresh weight	Dry weight	Fresh weight	Dry weight	
Levels of IBA					
I_1	14.69	3.35	4.22	1.18	0.32
I_2	12.34	3.54	4.63	1.10	0.36
I_3	15.18	6.24	6.38	1.82	0.44
SEm (±)	**0.59**	**0.65**	**0.31**	**0.14**	**0.01**
CD (0.05)	**1.77**	**1.97**	**0.93**	**0.42**	**0.05**
Types of media					
M_1	13.37	5.17	4.12	0.97	0.32
M_2	12.48	2.79	4.46	1.35	0.36
M_3	16.36	5.17	6.65	1.77	0.45
SEm (±)	**0.59**	**0.65**	**0.31**	**0.14**	**0.01**
CD (0.05)	**1.77**	**1.97**	**0.93**	**0.42**	**0.05**
Interactions					
I_1M_1	11.06	3.02	4.00	0.73	0.35
I_1M_2	12.08	2.75	3.21	0.69	0.46
I_1M_3	15.33	4.28	4.4	0.77	0.27
I_2M_1	14.12	5.26	4.98	1.45	0.34
I_2M_2	7.57	2.78	4.33	0.82	0.42
I_2M_3	20.93	9.49	4.46	1.03	0.20
I_3M_1	14.93	6.40	3.60	1.20	0.28
I_3M_2	17.79	2.84	5.56	2.03	0.32
I_3M_3	12.84	2.57	11.15	3.57	0.86
SEm (±)	**1.02**	**1.14**	**0.53**	**0.24**	**0.03**
CD (0.05)	**3.07**	**3.42**	**1.61**	**0.74**	**0.09**

I_1= 0mg/l,

I_2= 200mg/l

I_3=400 mg/l

M_1= Soil + FYM (1:1)

M_2= Soil + Coir pith compost (1:1)

M_3=Soil + Vermicompost

4.3 COMPARISON OF VEGETATIVELY PROPAGATED PLANTS AND SEEDLING PLANTS IN AFRICAN MARIGOLD HYBRID

4.3.1 Morphological characters

The data regarding morphological characters such as plant height, number of primary and secondary branches recorded by vegetative propagated plants and seedlings are analysed and presented in Table 8 and illustrated graphically in Fig 7.

4.3.1.1 Plant height

Plant height was recorded at 30 days, 60 days and 90 days after planting from both seedlings originated plants and those from cuttings. During all the stages, plant height recorded was correspondingly more in seedlings (T_2) compared to rooted cuttings (T_1). Maximum plant height was recorded by seedling originated plants at 90 DAP (90.40 cm) while the height recorded by rooted cuttings was significantly lesser (67.8 cm).

4.3.1.2 Primary branches

Similarly, number of primary branches was also recorded at 30 days, 60 days and 90 days after planting from both seedlings originated plants and those from cuttings. A similar trend followed here also where seedling originated plants (T_2) recorded significantly more number of primary branches at all the stages observed compared to cuttings (T_1). Maximum number of primary branches was recorded in seedling originated plants at 90 DAP (10.50) while this was 36 per cent lesser in rooted cuttings at the same stage (6.35). However, the increase in the number of primary branches between 60 and 90 days was minimal and most of the development of primary branches occurred within 60 days after planting in both seedlings originated plants and rooted cuttings.

Table 8: Effect of propagation methods (Seedlings and cuttings) on plant morphological characters.

Variable	Seedlings	SEm.	Cuttings	SEm.	CD value at 0.05%	t value
Plant Height at 30 Days	51.72	0.443	39.31	0.709	1.75	14.839
Plant Height at 60 Days	87.91	0.296	66.89	0.519	1.25	35.139
Plant Height at 90 days	90.40	0.215	67.800	0.281	0.59	83.87
Primary Branches at 30 Days	4.65	0.076	2.77	0.087	0.24	16.196
Primary Branches at 60 Days	9.62	0.230	6.15	0.107	0.53	13.681
Primary branches at 90 days	10.50	0.118	6.35	0.125	0.36	24.01
Secondary Branches at 30 Days	10.15	0.155	6.77	0.126	0.41	16.919
Secondary Branches at 60 Days	19.57	0.271	12.12	0.187	0.69	22.591
Secondary Branches at 90 days	21.975	0.095	14.150	0.100	0.28	56.831

78a

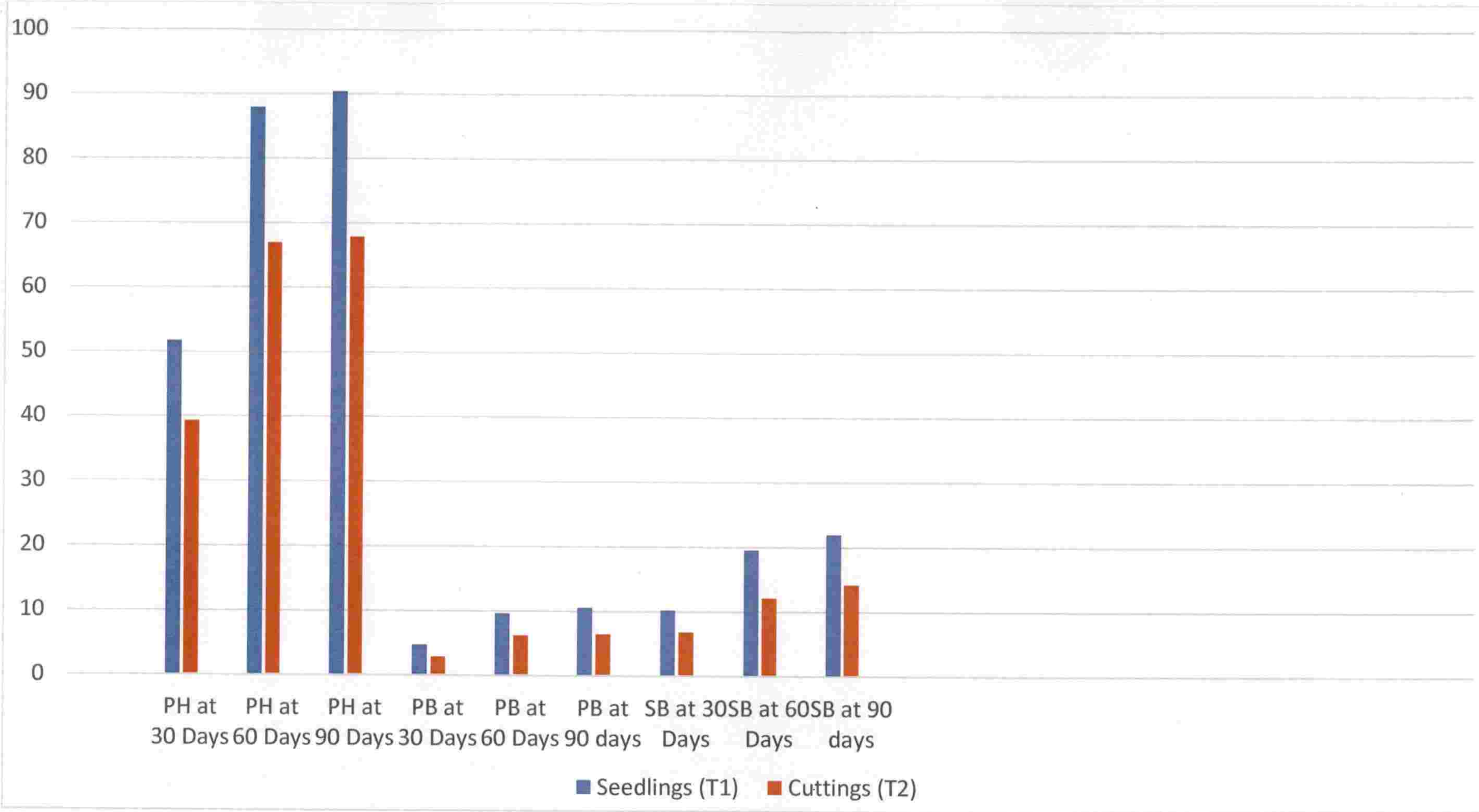


Fig 7: Effect of propagation methods on morphological characters

4.3.1.3 Secondary Branches

Production of secondary branches also followed a similar trend to that of primary branches irrespective of the stages observed whether at 30, 60 or 90 days after planting. Seedling originated plants (T_2) documented significantly higher number of secondary branches in all the stages observed compared to plants from rooted cuttings. Here also, the maximum number of secondary branches was recorded in seedling originated plants at 90 days after planting (21.97) compared to rooted cuttings (14.15). The production of secondary branches was also minimal between 60 days and 90 days as there was no significant increase in the number of secondary branches after 60 days both in seedling plants and rooted cuttings.

4.3.2 Total fresh Weight and dry weight of plant

The data on total fresh and dry weight of plants recorded after the crop are analysed and presented in Table 10. The treatments, seedlings and cuttings had shown impact on total plant fresh and dry weight. Seedling plants (T_2) recorded higher total fresh weight (211.51g) and dry weight (47.97g) compared to rooted cuttings.

4.3.3 Yield parameters

The data on yield parameters days to first flowering, 50 per cent flowering, first harvest, number of flowers per plant, mean flower weight, flower diameter, flowering duration, flower yield per plant, flower yield per hectare and vase life are analysed and presented in Table 9.

4.3.3.1 Days to first flowering

Flower initiation seems to be earlier in rooted cuttings as the number of days required for first flowering was lesser in rooted cuttings. The number of days required for initial flowering in rooted cuttings (T_1) was 8.65 days while this required 13.125 days in seedlings. So this indicated that plants originated cuttings have earliness in flowering and its number are presented in Table 9.

4.3.3.2 Days to 50% flowering

The observation on days to 50% flowering also followed a similar trend to that of days to first flowering and its values are presented in Table 9, as the cuttings (T_1) recorded least number of days to complete 50 per cent flowering compared to seedling plants (T_2). The number of days required for cuttings (T_1) was17.9 days for 50 per cent flowering while it was significantly longer (22.6 days) in seedling plants (T_2).

4.3.3.3 Days to first harvest

For this parameter also, plants from cuttings (T_1) recorded significantly lesser number of days (21.10) to first harvest indicating earliness in this character also. Seedling originated plants required longer days (29.72) for first harvest. The values are presented in Table 9.

4.3.3.4 Number of flowers/ plant

A reversal of trend was observed with this parameter as the number of flowers recorded was maximum (42.05) in seedling plants (T_2) compared to cuttings (T_1) where the flower production was 21.75 per cent lesser (37.45) (Table 9).

4.3.4.5 Mean flower weight

The maximum mean flower weight (8.32 g) was recorded from cuttings (T_1) which was significantly similar (8.16) to treatment seedling (T_2). The figures regarding mean flower weight are presented in Table 9.

4.3.3.6 Flower diameter

The seedlings and cuttings made no significant impact on flower diameter and the maximum flower diameter (6.13 cm) was found in treatment cuttings (T_1)

Table:9 Effect of propagation methods (Seedlings and Cuttings) on flower yield parameters.

Variable	Seedlings	SEm.	Cuttings	SEm.	CD value at 0.05%	t value
Days to 1st Flowering	13.12	0.150	8.65	0.242	0.59	15.70
Days to 50% Flowering	22.60	0.371	17.90	0.180	0.86	11.39
Days to 1st Harvest	29.72	0.142	21.10	0.163	0.45	39.89
Number of Flowers/ Plant	42.05	0.44	32.95	0.57	1.52	12.56
Mean Flower Weight	8.16	0.078	8.32	0.097	0.261	2.02
Flower Diameter	5.96	0.093	6.13	0.172	0.41	0.87
Flowering Duration	62.87	0.239	52.00	0.467	1.10	20.72
Flower Yield/ Plant(g)	489.85	2.35	389.07	1.48	5.84	36.22
Flower yield per plot (g)	9804.8	46.04	7781.5	29.68	115.09	36.93
Total flower yield/ha (Kg)	29027.84	139.39	23056.18	87.95	346.28	36.23

4.3.3.7 Duration of flowering

The treatments significantly influenced the flowering duration as evidenced by the data presented. Seedling originated plants (T_2) recorded longer flowering duration (62.87 days) which was significantly superior to cuttings (T_1) in which the duration was 17.28 per cent lesser (52 days). This indicates the superiority of seedling plants over rooted cuttings for this parameter.

4.3.3.8 Flower Yield/ Plant (g)

Flower yield per plant was significantly affected by the treatments. The treatment seedlings (T_2) recorded maximum flower yield per plant (489.85 g) which was significantly greater than treatment cuttings (T_1). Individual plants originated from seedling recorded 20.57 per cent higher flower yield compared to rooted cuttings (389.07 g).

4.3.3.9 Flower Yield/ plot (g)

Flower yield per plot was significantly affected by treatments. The treatment seedlings (T_2) recorded maximum flower yield per plot (9804.8g) which was significantly greater than cuttings(T_1).

4.3.3.10 Flower Yield/ hectare (Kg)

Flower yield per hectare was significantly affected by the treatments. The treatment seedlings (T_2) recorded maximum flower yield per hectare (29027.84 Kg) which was significantly greater than treatment cuttings (T_1).

Table 10: Effect of propagation methods (Seedlings and cuttings) on physiological, qualitative characters and BC ratio of flowers.

Variable	Seedlings	SEm.	Cuttings	SEm.	CD value at 0.05%	t value
Total fresh Weight	211.51	3.504	149.48	1.665	8.15	15.98
Dry Weight	47.976	2.301	33.723	0.941	5.22	5.73
Vase Life	5.450	0.153	7.05	0.170	0.48	7.00
BC ratio	5.34		3.91			

4.3.3.10 Vase life

The seedlings and cuttings made significant impact on vase life of flowers and its numbers are presented in Table 10. The maximum vase life (7.05 days) was recorded in cuttings (T_1) which was significantly higher than seedlings (T_2).

6. B:C ratio

The seedlings and cuttings made significant impact on B:C ratio and its numbers are presented in Table 10. The maximum (5.34) cost to benefit ratio was seen in treatment cuttings (T_1) compared to seedlings (T_2). The calculated B:C ratio is presented in Appendix II.

DISCUSSION

5. DISCUSSION

Marigold is an annual flower crop that could be grown on a commercial scale in Kerala. The main constraint that hampers the area expansion of marigold in Kerala is the lack of availability of seeds of suitable varieties in bulk as well as the prohibitive cost of hybrid seeds. Marigold plants raised from hybrid seeds do not produce viable seeds and hence farmers have to purchase hybrid seeds for raising each crop which adds to the cost of cultivation. In order to overcome this problem, standardization of vegetative propagation in African marigold hybrid was undertaken. The outcome of the study is discussed below.

5.1 STANDARDISATION OF AGE OF CUTTINGS FOR ROOTING IN AFRICAN MARIGOLD HYBRID.

5.1.1 Total number of cuttings

The total number of cuttings was found to be highest (9.12) in cuttings removed from mother plants after 90 days (T_4) of transplanting which was significantly superior over the other treatments and least total number (3.31) of cuttings was observed in cuttings taken after 30 (T_1) days after transplanting. Similar results were obtained by Naveen (2016) in African marigold in which 90 day old plants are best for extracting more number of cuttings. This might be due to the production of more number of primary and secondary branches in mother plants after 90 days which could be utilised as planting material reported by Kumar *et al.* (2016).

5.1.2 Survival percentage

The survival percentage of plants was 100 per cent for all the four treatments which indicates that age of cuttings had no influence on rooting and survival percentage. This finding was in contrary to the results obtained by Padsumbiya and Dave (1991) in marigold cuttings. The survival percentage might be influenced by several factors such as biological condition of plant which may decide the number of roots and rooting percentage and more importantly climatic conditions and biotic and abiotic stresses (Bose *et al.*, 1986). In the present study all these factors might have been favourable, which lead to 100 per cent rooting and survival in all four treatments.

5.1.3 Morphological characters

Morphological characters such as plant height, number of leaves and leaf area differed significantly in plants with respect to the age of cuttings selected for rooting.

In the current investigation, the plant height was significantly affected by age of cuttings. The plants were tallest in cuttings removed from mother plants after 90 days while it was the lowest in cuttings removed after 30 days. The results are in conformity with Dawane *et al.* (2015). The rate of growth in height was considerable between 70 and 90 days in plants developed through rooting of cuttings.

The impact of age on number of leaves varied significantly. The cuttings taken after 30 days recorded the maximum number of leaves (52.75) which was similar to the number of leaves produced in cuttings taken from 50 days old mother plant. The results are in conformity with the results of Padsumbiya and Dave (1991). It might be due to the use of terminal cuttings as planting material. As the mother plants become older with established leaves, the cuttings taken from such stock plants produce the terminal flower buds prematurely. Due to this reason, vegetative growth may be less with increased age of mother plants (Furuta and Kiplinger, 1955).

The leaf area was significantly affected by age of cuttings. The cuttings taken after 30 days recorded the maximum leaf area (69.32 cm^2) which was on par with cuttings taken after 50 days (66.20 cm^2). The results were in conformity with the report in marigold by Padsumbiya and Dave (1991). This might be due to the presence of large number leaves observed in cuttings from plants taken after 30 days and 50 days of planting that resulted in increased leaf area in these treatments.

The shoot fresh weight and dry weight were significantly influenced by age of cuttings. Even though treatments were non-significant for shoot fresh weight, the highest shoot fresh weight (37.86g) was observed in cuttings taken after 30 days (T_1). The dry weight (5.365g) was also recorded maximum in T_1. The results are in agreement with Padsumbiya and Dave (1991). According to Anderson and Carpenter (1974) cuttings displayed reduction in fresh weight and thinner stem. The increase in number of leaves and assimilates also could be the reason for increased shoot fresh weight. More number of leaves were observed in cuttings taken after 30 days.

5.1.4 Root parameters

The root fresh weight and dry weight were significantly influenced by age of cuttings. The maximum root fresh weight was recorded in cuttings taken after 30 days (T_1) which was critically on par with cuttings taken after 50 days(T_2) and 70 days (T_3) whereas dry weight the greatest in cuttings taken after 30 days (T_1) which was significantly similar to cuttings taken after 50 days (T_2). These results are in line with the findings of Padsumbiya and Dave (1991). The reason might be due to more number of roots produced per cutting. Wott and Tukey (1969) acknowledged that the increase in the weight of cutting enhanced the number and dry weight of roots formed per plant.

The number of roots and root length were significantly varied with the age of cuttings. The highest number of roots (85.37) recorded in T_1 significantly on par with the number of roots in cuttings taken from 50 days and 70 days old plants and root length (10.75cm) were recorded in cuttings taken after 30 days (T_1) after transplanting and significantly on par with root length recorded by 50-days old mother plant. These results are in conformity with Padsumbiya and Dave (1991). As age increases sclerenchyma tissue grow which diminishes the rejuvenating capacity of roots (Bose *et al.*,1986). Cuttings taken after 30 days also recorded maximum number of leaves which resulted in maximum photosynthates required for better rooting and may be also due to auxin that transported from leaves. More presence of the auxin, sugar and starch contents in leaves and stems caused an efficient rooting (Stoltz, 1968). Riehl (1957) cited by Bose *et al.* (1986) found that diminished leaf area of carnation cuttings resulted in reduced rooting. Mukhopadyay and Bose (1979) examined the part of leaves in hibiscus and ixora cuttings evidently stimulated rooting and rooting percentage equally the number of roots per cutting intensified with raised in number of leaves. Leafless and budless cuttings were unsuccessful to give roots even with treatment of IBA.

All the treatments shown 100% rooting in contrary to Padsumbiya and Dave (1991) and Shalini (2017) in marigold. Marigold is easy to root type; it produces adventitious roots along its stem. It might be because of good health condition of mother plant and also because of favourable climatic conditions for growth and development of cuttings. Mukhopadyay and Bose (1981) reported that retaining of leaves in cuttings of *Ixora singaporensis* upto 30 days exhibited 100% rootingwith large number of roots while retaining of leaves up to 10 days' lessened the rooting percentage to 75.

5.2 STANDARDISATION OF MEDIA AND IBA LEVELS FOR ROOTING OF CUTTINGS IN AFRICAN MARIGOLD HYBRID.

5.2.2 Root parameters

5.2.2.1. Rooting of cuttings

Irrespective of the treatments whether the different levels media, IBA or their interactions, 100 per cent rooting was recorded by all of them. This indicated that there is no significant effect of media, IBA or their interactions in rooting success percentage. This may be because marigold is an easy to root plant as it produces adventitious roots along its stem. Favourable climatic conditions as well as good health condition of mother plant also might have contributed to rooting success. However, Nikolova-Krmristeva (1973) as cited by Bose *et al.* (1986) observed better rooting percentage in cuttings taken from younger mother plants. Padsumbiya and Dave (1991) and Shalini (2017) reported better rooting success from younger mother plants in marigold.

5.2.2.2. Number of roots and root length

Root parameters such as number of roots as well as mean root length were influenced by IBA and media treatments. Individually, IBA 400 ppm (I_3) recorded maximum number of roots which was significantly on par with IBA 200 ppm (I_2) and the media comprising Soil + Vermicompost (M_3) was best with respect to the number of roots produced per cutting and also significantly similar with number of roots produced per plant in Soil + Coirpith. So also, a combination of Soil + Vermicompost and IBA at 400ppm (I_3M_3) was the best with respect to the number of roots and it was similar to IBA at 200 ppm in combination with Soil + Vermicompost.

The root length was found to be highest by cuttings treated with IBA at 400 ppm which was par IBA at 200 ppm and among media Soil + Vermicompost recorded maximum root length. Interaction effect between IBA at 400 ppm and Soil + Vermicompost recorded maximum root length which was on par with IBA 200 ppm along with Soil + FYM.

The influence of vermicompost is in conformity with the work of Kumar *et al.* (2015) in marigold, Renuka and Chandrasekhar (2017) in carnation, Khatik and Mishra in rose, Karmegan and Daniel (2009) in *Codiaeum variegatum*, and Shirol *et al.* (2001) in poinsettia. The impact of vermicompost is due to development of soil properties such as soil structure, texture, which aided the proper aeration and water holding capacity (WHC) and accessibility of plant nutrients that enabled the transportation of solutes (Tomati and Galli ,1995). Vermicompost aids in easy rooting and development also because it contains hormones like auxins and Gibberelins (Gohil *et al.*, 2018). Neilson (1965) found the presence of growth hormone (indole substances) in tissues of earthworm like *Eisenia foetida* and *Lumbricus rubellus*. Vermicomposts are ultimate supplier of plant growth hormones formed by associations between microorganisms and earthworms which meaningfully supports the plant growth.

The impact of IBA in production of more number of roots and root length is in agreement with the study of Nanda and Mishra (2010) in Hibiscus, Grewal *et al.* (2005) in chrysanthemum, Susaj *et al.* (2012) and Abbas (2015) in rose. The reason for influence of IBA on maximum number of roots was because of production of greater number of rooting primordia due to the enhanced conversion and movement of carbohydrates to the base of cuttings which resulted in rooting. The IBA treatment increases the endogenous auxin levels which leads to structural and functional variations in the cells at the base of cuttings to develop root primordia resulting enhanced rooting in treated cuttings (Davies,1995).

The increase in root length recorded as a result of IBA application in the present investigation is in line with the work of Singh *et al.* (2013b) in *Cestrum nocturnum*, Gowda *et al.* (2017) in carnation and Yeshiwas *et al.* (2015) in rose. This might be due to quick differentiation and greater elongation of cells increasing the root length.

5.2.2.3 Root fresh weight and dry weight

Both fresh weight and dry weight of roots were significantly influenced by IBA levels, media and their interactions. Maximum fresh weight of roots (6.38g) and dry weight (1.82g) were recorded in plants treated with IBA @ 400mg/l which were significantly superior to other levels of IBA. Media containing Soil + Vermicompost (1:1) recorded maximum root fresh weight (6.65g) and dry weight (1.77g). Among various combinations, the interaction between media I_3M_3 recorded maximum root fresh weight (11.15g) and dry weight (3.57g) which was significantly superior to all other treatments.

The impact of IBA is in conformity with the work of Yeshiwas *et al.* (2015), Akhtar *et al.* (2015) and Nasri *et al.* (2015) in rose. The reason for this might be increased number of roots and root length which increased surface area for nutrients uptake. Rolston *et al.* (1996) also stated amplified number of root primordia in IBA treated cuttings compared to non-treated cuttings. The effect of vermicompost on root weight is in line with the work conducted by Karmegan and Daniel (2009) in *Codiaeum variegatum*, and Avdic *et al.* (2013) in rose. Tomati and Galli (1995) said that worm's casts were valuable supplier of polysaccharides which improves soil structure. Well aerated soil results in good root development and nutrient availability.

5.2.2.4 Root to shoot ratio

The root to shoot ratio was significantly influenced by IBA levels and media. The root to shoot ratio was significantly influenced by interaction effect of IBA levels and different media. The maximum root to shoot ratio was recorded by IBA 400 ppm and among media vermicompost recorded maximum root to shoot ratio. Among different combinations, interaction between IBA 400 ppm and Soil + Vermicompost recorded maximum root to shoot ratio. The highest root to shoot ratio is good for growth of plants. It helps in better uptake of nutrients and translocation resulting in better performance of plants.

5.2.3 Shoot characters

5.2.3.1 Influence on plant height

Cuttings treated with IBA recorded significantly lower height compared to untreated ones. Similarly, plant height also varied significantly with different media. The finding that untreated cuttings were taller compared to IBA treated plants is line with work of Khan *et al.* (2011) in tomato cuttings where height was maximum in control without IBA treatment. The results are also in conformity with reports from Ullah *et al.* (2013) in which marigold cuttings recorded the minimum plant height at 400 mg/l concentration of IBA. The reason for the reduction in plant height with increased concentration of IBA may be basipetal movement of IBA which helped in root development compared to shoot development.

The cuttings planted in Soil + Vermicompost (1:1) recorded maximum plant height among the different media combinations. However, plant height was not significantly influenced by interaction effect of IBA and media. The results are in conformity with the findings of Sangawan *et al.* (2010) and Gupta *et al.* (2014) in marigold. This influence of vermicompost might be because it contains both macro and micronutrients in available form to plants and it also contains growth promoting substances.

5.2.3.2 Number of leaves

Number of leaves per plant was significantly influenced by IBA levels as well as different media combinations. IBA level @ 400 mg/l recorded the highest number of leaves followed by IBA 200 mg/l. Untreated plants recorded the least number of leaves. Among different media, Soil + Vermicompost (1:1) recorded the highest number of leaves (36.15) which was significantly superior to other media. Among the various interaction effect between IBA and media, IBA@ 200mg/l and Soil + Vermicompost (1:1)) (I_2M_3) recorded maximum number of leaves (56.73) which was significantly superior to all other treatments.

The impact of IBA on leaf production is in conformity with the study by Mehraj *et al.* (2013) in *Bougainvillea spectabilis* and Nasri *et al.* (2015) in Rose. The increase in number of leaves due to IBA might be because of the quick commencement of roots leading to more absorption of nutrients resulting in rapid growth by better utilization of stored food as stated by Stancato *et al.* (2003). Roots are also source of cytokinins production which helps in cell division and cell differentiation increasing leaf production.

The effect of vermicompost on leaf production is line with study of Khatik and Mishra (2017) in rose, Chamani *et al.* (2008) in Petunia hybrid and Syamal *et al.* (2006) in marigold where the number of leaves increased when planted in vermicompost media. Vermicompost provides sufficient quantities of nutrients and increases the soil physical characters and water holding capability of soil as reported by Soegiman, (1982) as cited by Idriyani *et al.* (2011).

5.2.3.3 Leaf area

Leaf area followed a similar trend to that of number of leaves. IBA levels, media as well as their interaction significantly influenced the leaf area. IBA level @400 mg/l recorded the highest leaf area (48.63 cm^2) compared to other levels of

IBA. Since the leaf area was significant at IBA 200 ppm as well, this indicate that IBA application enhances leaf area. Among different media, Soil + Vermicompost (1:1) recorded the significantly higher leaf area (44.81 cm^2) and compared to other media. Among various interactions, IBA@ 200mg/l, Soil + Vermicompost (1:1) (I_2M_3) recorded maximum leaf area (61.28 cm2).

The response of IBA to leaf area was in line with the study by Nanda and Mishra (2010). The reason for increased leaf area as a result of application of IBA may be due to the vigorous root growth that helps in efficient utilization of nutrients for growth and development as reported by Prati *et al.* (1999) as cited by Stancato *et al.* (2003). Similarly, the favourable response by the rooted cuttings when planted in vermicompost is similar to the findings of Syamal *et al.* (2006) in marigold because of the positive effect on plant growth due to the presence of nutrients like nitrogen, potassium and phosphorous and also since it contains growth promoting hormones.

5.2.3.4 Survival percentage

The Survival percentage was also significantly influenced by different media and IBA levels. Survival percentage was significantly higher in IBA treated plants. IBA 400 ppm 200 ppm recorded maximum and similar survival percent and The media (M_3) Soil + Vermicompost (1:1) recorded the maximum survival percentage. However, interaction effect between media and IBA was not significant.

The influence of IBA on survival percentage is in line with the findings by Susaj*et al.* (2012) in rose. The reason may be because, IBA is a good root promoter and induces meristem initiation resulting in meristem zone extension and intake of food required for plant growth. The impact of vermicompost on survival percentage is in line with Khatik and Mishra (2017) which might be due to presence of macro and micronutrients and proper aeration required for growth and development.

5.2.3.5 Shoot fresh weight and dry weight

Both fresh and dry weight of shoot were significantly influenced by IBA levels, different media and their interactions (Fig 6). Plants treated with IBA @ 400mg/l recorded maximum shoot fresh weight (15.18g) and dry weight (6.24g). Shoot fresh weight was found to be highest (16.36g) in Soil + Vermicompost (1:1). Shoot dry weight was recorded maximum (5.17g) in Soil + Vermicompost (1:1) and significantly similar to Soil + FYM. With respect to different combinations I_2M_3 (IBA@ 200mg/l and Soil + Vermicompost) recorded maximum shoot fresh weight (20.93g) and dry weight (9.49g).

The effect of IBA in increasing shoot fresh and dry weight was in conformity with study of Yeshiwas *et al.* (2015) in which they confirmed that increase in concentration of IBA level promoted shoot fresh weight and dry weight of rose cuttings. The growth hormones promote growth rate by translocation of photosynthates from source to sink which consequently results in greater shoot fresh and dry weight (Singh, 2004)

Simialrly, the effect of vermicompost on shoot weight is in line with the work of Chamani *et al.*, (2008) in *Petunia hybrida* and Shandour *et al.* (2011) in marigold. According to them it was due to nutrients (N, P, K, Ca, Mg, Zn and Fe) present in vermicompost which might have boosted the growth and increased both shoot fresh weight and dry weight.

5.3 COMPARISON OF VEGETATIVELY PROPAGATED PLANTS AND SEEDLING PLANTS IN AFRICAN MARIGOLD HYBRID

This experiment was laid out with the objective of assessing the comparative advantage of the methods of propagation tried with respect to the morphological, physiological, yield and quality parameters which ultimately decide the yield and the economic benefits based on which suggestions could be made for adopting the practice. The results are discussed below.

5.3.1 MORPHOLOGICAL CHARACTERS

Data regarding morphological characters such as plant height, number of primary branches and secondary branches recorded by vegetative propagated plants and seedlings differed significantly during the periods observed.

During all the stages, plant height, number of primary and secondary branches recorded was correspondingly more in seedlings (T_2) compared to rooted cuttings (T_1). Maximum plant height, number of primary branches and number of secondary branches was recorded by seedling originated plants at 90 DAP. This indicates that plants originated from cuttings tend to be dwarf and the production of primary and secondary branches were significantly lesser in them irrespective of the stages of growth compared to seedling originated plants. In both cases however, the increase in the number of primary branches between 60 and 90 days was minimal and most of the development of primary branches occurs within 60 days after planting.

The results are in agreement with the reports by Dawane *et al.* (2015) and Naveen (2016) in marigold in which the plant height and number of primary and secondary branches were more in seedling plants than rooted cuttings. The reason might be due their vigorous nature of growth and the taproot system present in seedlings which helps in more absorption of nutrients and water making plants stronger, taller, well branched and well established. Vegetatively propagated plants are less vigorous and usually short in stature and less branching due to the fibrous root system is present in them and low absorption of nutrients from soil.

The propagation methods significantly influenced the total plant fresh weight and dry weight. Seedling plants recorded higher total fresh weight and dry weight compared to rooted cuttings. The results are in line with the findings by Kathiravan *et al.* (2007). The dominance of seedling plants for these parameters could be because of more number of primary and secondary branches in them compared to that of cuttings

5.3.2 FLOWERING AND YIELD ATTRIBUTES

Flower initiation seems to be earlier in rooted cuttings as the number of days required for first flowering was lesser in them. The number of days required for initial flowering in rooted cuttings was 32 per cent lesser than seedlings. Similarly, the number of days to complete 50% flowering also was significantly lesser in rooted cuttings compared to seedling plants (T_2). 50% flowering in plants from rooted cuttings was completed five days earlier than seedling plants.

Earlier flower initiation and days to 50 per cent flowering in rooted cuttings may be due to the reduced juvenile phase in vegetatively propagated plants as reported by Bose *et al.* (2005) and early maturity of cuttings to flower (Hartman *et al.*, 2004) The present results are also in agreement with reports by Dawane *et al.* (2015) in marigold.

Plants from cuttings also recorded significantly lesser number of days to first harvest indicating earliness in this character also. Seedling originated plants required longer days for first harvest. Earliness in harvest might have resulted from the associated factors presented above such as earlier flower bud imitation and days to complete fifty percent flowering as observed in plants originated from rooted cutting.

A reversal of trend was observed in flower production as the number of flowers recorded was maximum in seedling plants compared to cuttings where the flower production was 21.75 per cent lesser. The results are in conformity with the findings of Dawane *et al.* (2015) and Naveen (2016) in marigold. The production of more number of branches might have resulted in more number of flowers in seedlings.

Weight of individual flowers and diameter of flowers was not influenced by the propagation methods. Similar individual flower weight and diameter of flowers recorded by both seedling plants and rooted cuttings substantiates this. These findings are contrary to the findings by Dawane *et al.* (2015) and Naveen (2016) in marigold where they reported significantly higher flower weight and flower diameter from seedling plants

Seedling originated plants recorded longer flowering duration where asF the duration was 10 days longer than cuttings. This indicates the superiority of seedling plants over rooted cuttings for this parameter. The reason behind the increased duration of flowering in seedlings might be due to their vigorous and robust nature (more number of lateral shoots). The outcome is in conformity with the work of Dawane *et al.* (2015) in marigold.

The flower yield per plant, flower yield per plot and flower yield per hectare were significantly affected by propagation methods. Seedling plants recorded maximum flower yield per plant as well as per hectare which was significantly superior to cuttings. Individual plants originated from seedling recorded 20.73 per cent higher flower yield compared to rooted cuttings. The cause for improved flower yield per plant in seedlings might be due to more number of branches, leaves and increased assimilates for development of flowers as well as higher duration of flowering, more number of flowers per plant. The results are in conformity with the findings of Dawane *et al.* (2015) in marigold. The flowering in seedlings and cuttings can be seen in Plate 7.

The propagation methods had significant influence on vase life. The maximum vase life was recorded by cuttings which was significantly superior to seedlings. The results are in conformity with the findings of Dawane *et al.* (2015) in marigold. The increased vase life might be because of reduced transpiration and respiration and also increased quantity of antioxidants, antibiotics, phenols hormones.

The B:C ratio was significantly influenced by propagating methods. The maximum B:C was found in cuttings (T_1) which was higher than seedlings (T_2). This was contrary to the findings of Naveen (2016). The reason for increased B:C ratio in cuttings might be production of more number of plant from single mother plant and high cost of hybrid seeds.

Plate 7: Seedling and cuttings plot

Plate 7 a : Seedling plot

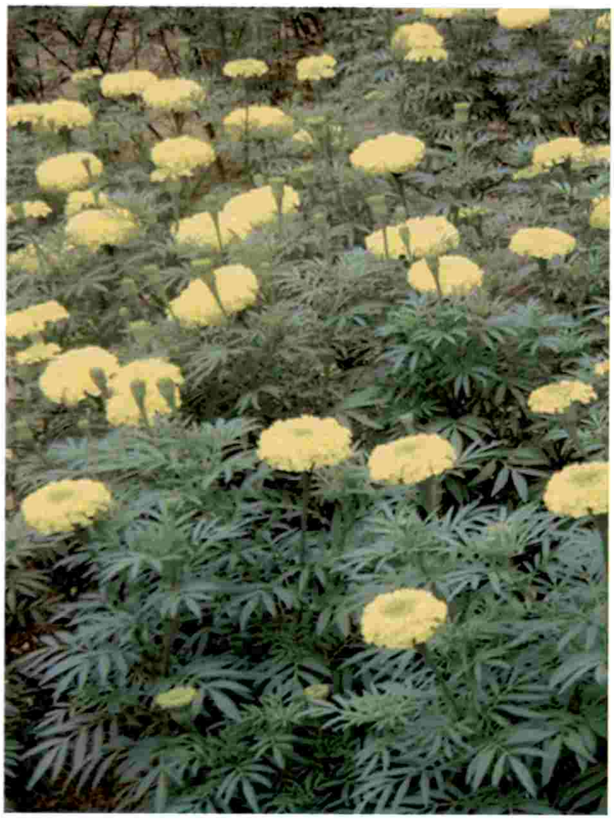


Plate 7 b: Rooted cuttings plot

SUMMARY

6. SUMMARY

The present study entitled "Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid" was conducted at the department of Pomology and Floriculture, College of Agriculture, Padannakkad and RARS, Pilicode during the period from 2016 to 2018. The study was conducted in three experiments. The first experiment was for the standardization of age of mother plants for rooting of cuttings with four treatments, in which cuttings are removed at 30, 50, 70 and 90 days after transplanting respectively.

The second experiment was to find out the effect of growth regulator IBA at 3 levels of 0, 200, and 400 ppm, 3 different media (Soil + FYM 1:1), (Soil + Coir pith compost 1:1), (Soil + Vermicompost 1:1) and their interaction. The third experiment was to compare the performance of seedlings and rooted cuttings for their vegetative and yield parameters. For first and second experiment observations were made on shoot and root characters whereas for third experiment, observations were made on morphological and yield characters.

The outcome of the current study is summarized below:

- Shoot and root parameters of rooted cuttings are influenced by the age of the mother plants. The maximum number of cuttings were extracted from mother plants after 90 days of transplanting, which was significantly superior to other age stages.
- Age of mother plants had no significant difference on survival and rooting per cent. There was 100 per cent survival and rooting was observed in cuttings obtained from different ages of mother plants.
- The minimum plant height (51.12 cm) was observed in rooted cuttings extracted from 30-day old mother plant whereas it was higher in rooted cuttings from 90-day old mother plant. The number of leaves (52.75) and leaf area (69.32 cm^2) were found be maximum in rooted cuttings extracted from 30 days old mother plant which was on par with rooted cuttings from 50 days.

- Even though the age of mother plants has no significant influence on shoot fresh weight, it was found maximum in rooted cuttings taken from 30-day old mother plant (37.86 g). The rooted cuttings taken from 30-day old mother plant recorded maximum shoot dry weight (5.36 g) and it was on par with plants from 50-day old mother plant. Rooted cuttings extracted from 30-day old mother plants recorded significantly more root fresh weight (13.98 g) and dry weight (2.74 g) but were on par with rooted cuttings extracted from 50- day old mother plants.
- The root to shoot ratio also was significantly higher in rooted cuttings taken from 30- day old mother plant but was on par with 50 and 70 day- old mother plant. Similarly, the maximum number of roots (85.37) and root length (10.75cm) were recorded in rooted cuttings extracted from 30-day old mother plants which were on par with rooted cuttings extracted from 50-day old mother plant. Cuttings from younger mother plant performed better with respect to growth parameters.
- Coming to second experiment, results revealed that both shoot and root characters were influenced by IBA and media levels. The rooting was 100 per cent irrespective of treatments. Among IBA levels, IBA @ 400 mg/l recorded maximum number of roots as well as maximum root length which was on par with IBA @ 200 mg/l. Among media, Soil + Vermicompost (1:1) recorded maximum number of roots and maximum root length. The combination of IBA @ 400 mg/l and Soil + Vermicompost (1:1) recorded maximum number of roots and maximum root length and it was on par with IBA @ 200 mg/l in combination with Soil + Vermicompost. The survival percentage was maximum in IBA @ 400 mg/l which was on par with IBA 200 mg/l. Among media Soil + Vermicompost (1:1) recorded maximum survival percentage which was on par with Soil + FYM (1:1). The interaction effects had no influence on survival percentage.
- The plants were taller in IBA untreated rooted cuttings and in rooted cuttings planted in Soil + Vermicompost (1:1) and plants were shorter in

103

IBA treated plants. The interaction between IBA levels and media had no significant influence on plant height. Among various individual media and IBA levels, Soil + Vermicompost and IBA @ 400 mg/l recorded the maximum number of leaves respectively whereas in treatment combination, IBA @ 200mg/l and Soil + Vermicompost recorded the maximum number of leaves. The leaf area followed same trend as that of number of leaves. Maximum leaf area was recorded by IBA @ 400mg/l and among media by Soil + Vermicompost whereas interaction effect between IBA@ 200mg/l and Soil + Vermicompost (I_2M_3) recorded the maximum leaf area.

- The shoot fresh and dry weight were significantly influenced by IBA levels and media. IBA @400mg/l recorded maximum shoot fresh weight and dry weight. Shoot fresh weight and dry weight were found to be highest in Soil + Vermicompost (1:1). Combination IBA@ 200mg/l and Soil + Vermicompost (1:1) recorded maximum shoot fresh weight and dry weight.
- The maximum fresh weight and dry weight of roots were recorded in plants treated with IBA @ 400mg/l which were significantly superior to other levels of IBA. Media containing Soil + Vermicompost (1:1) recorded maximum root fresh weight and dry weight. Among interactions, IBA @ 400 mg/l and Soil + Vermicompost recorded maximum root fresh and dry weight.
- Root to shoot ratio was significantly influenced by IBA levels and media. IBA @ 400 mg/l and among media Soil + Vermicompost recorded maximum root to shoot ratio. Interaction effect between IBA @ 400 mg/l and Soil + Vermicompost recorded the highest root to shoot ratio. Finally, we can conclude that application of IBA @ 400 mg/l and medium as Soil + Vermicompost (1:1) is the best method for vegetative propagation through rooting of cuttings because these treatments resulted in better root length rooting intensity and survival per cent.
- In the third experiment designed to compare the performance of seedling originated plants and those developed through rooted cuttings, results

104

revealed that there was significant difference on various morphological and yield attributes. Seedlings produced significantly taller plants at 30, 60 and 90 days after transplanting than rooted cuttings. The maximum number of primary branches was recorded in seedling originated plants at 30, 60 and 90 days compared to that of cuttings. The same trend was visible in the case of secondary branches also, in which maximum number of secondary branches was recorded in seedlings at 30, 60, 90 days compared to that of cuttings.

- Flowering was significantly early in cuttings compared to seedlings. Similarly, cuttings required significantly lesser number of days for completing 50% flowering and days to first harvest. Seedlings required comparatively more number of days for 50% flowering and first harvest.
- The seedlings recorded maximum number of flowers per plant, flower yield per plant, flower yield per plot, flower yield per hectare and extended duration of flowering compared to cuttings. There was no significant difference between seedling originated plants and rooted cuttings for flower diameter and mean flower weight. However, vase life was significantly longer for flowers from rooted cuttings.
- The total plant fresh weight and dry weight were significantly influenced by the method of propagation. Seedling originated plants recorded maximum plant fresh weight and dry weight compared to cuttings.
- Maximum B:C ratio of 5.34 was obtained when rooted cuttings were used as the planting material while BC ratio was 3.91 when seedlings were used. Propagation and planting through rooted cuttings can be promoted in hybrid marigold as this helps to maintain purity of varieties as well as reduce the cost of seeds. A single mother plant can provide up to 15 to 20 shoots amenable for rooting which can be retained as source for planting materials. This practice not only reduce the cost of cultivation but also ease the burden of procuring seeds each season which are not available locally.

REFERENCES

7. REFERENCES

Abbas, M. M., Baksh, M. A., Ahmad, S., Javaid, M. A., and Rehman, A. 2015. Effect of individual and combined concentrations of IBA and NAA for root development of Rose cultivar, Bajazzo. *J. Agric. Res.* 53 (2): 225-231.

Abdullateef, A. R. and Osman, M. 2011. Studies on effects of pruning on vegetative traits in *Stevia rebaudiana Bertoni* (Compositae). *Int. J. Biol.* 4 (1): 146.

Akhtar, G., Akram, A., Sajjad, Y., Balal, R. M., Shahid, M. A., Sardar, H., and Shah, S. M. 2015. Potential of plant growth regulators on modulating rooting of *Rosa centifolia. Am. J. Plant Sci.* 6 (5): 659.

Anderson, G. A. and Carpenter, W. J. 1974. High intensity supplementary lighting of chrysanthemum stock plants. *Hort. Sci.* 9: 58-60.

Ankita, H. D. and Yadav, B. K. 2010. Vegetative growth and flowering of greenhouse Dutch rose cv. Naranga influenced by different potting media. *Hortic. J.* 23 (2): 85-87.

Arancon, N. Q., Edwards, C. A., Babenko, A., Cannon, J., Galvis, P., and Metzger, J. D. 2008. Influences of vermicomposts, produced by earthworms and microorganisms from cattle manure, food waste and paper waste, on the germination, growth and flowering of petunias in the greenhouse. *Appl. Soil Economy* 39: 9-99.

Atiyeh, R. M., Subler, S., Edwards, C. A., Bachman, G., Metzger, J. D., and Shuster, W. 2000. Effect of vermicompost and composts on plant growth in horticultural container media and soil. *Pedobiologia* 44: 579–590.

Avdic, J., Becic, B., Sarajlic, N., Turalija, A., and Murtic, S. 2013. The effect of substrates on rooting of semi-ripe cuttings of alpine rose (*Rosa pendulina* L.). In: *Proceedings of the 24th International Scientific-Expert-Conference of Agriculture and Food Industry, Sarajevo, Bosnia and Herzegovina, 25-*

28 September 2013. Faculty of Agriculture and Food Sciences, University of Sarajevo pp.462-466.

Bala, M. and Singh, K. 2013. Effect of different potting media for pot mum production in chrysanthemum grown under open and polyhouse conditions. *Indian Soc. Ornam. Hortic*. 16 (1,2): 35-39.

Bharmal, V. S., Ranpise, S. A., and Darwade, R. T. 2005. Effect of different levels of indole butyric acid (IBA) on rooting, growth and flower yield of Chrysanthemum cv. Sonali Tara. *Orissa J. Hortic*. 33 (2): 36- 41.

Bhat, N. 1994. Studies on propagation of Vanilla (*Vanilla planifolia*). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Bhatt, S. T. and Chouhan, N. M. 2012. Effect of auxin on rooting of African Marigold (*Tegetes erecta* L.). *Adv. Res. J.* 11 (3): 69-70.

Blythe, G. and Sibley, J. L. 2003a. Novel methods of applying rooting hormone in cutting propagation. Combined Proceedings International Plant Propagators Society. 53: 406-410.

Blythe, E. K., Sibley, J. L., Ruter, J. M., and Tilt, K. M. 2004b. Cutting propagation of foliage crops using a foliar application of auxin. *Sci. Hortic*. 103: 31-37.

Blythe, E. K., Sibley, J. L., Tilt, K. M., and Ruter, J. M. 2004. Rooting of rose cuttings in response to foliar applications of auxin and surfactant. *Hortic. Technol.* 14: 479–483.

Bose, T. K., Mitra, S. K., and Sadhu, M. K. 1986. *Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash*, Calcutta, 27p.

Bose, T. K., Mukherjee, T. P., and Roy, T. 1975. Standardisation of propagation from cuttings under mist, I - effect of type of wood and size of cutting on root formation. *Punjab Hortic. J.* 15 (3-4): 139-142.

108

Bose, T. K., Mukhopadhya, T. P., and Basu, T. X. 1982. A note on the effect of ascorbic acid and IBA on rooting in cutting. *Indian Plant Physiol.* 25 (3): 310-312.

Bose, T. K., Yadav, L. P., Pal, P., Das, P., and Parthasarathy, V. A. 2003. *Commercial Flowers*, 2 (2): 164-165.

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

Chaudhari, B. B. 2016. Effect of different concentration of IBA and rooting media on root induction of Poinsettia (*Euphorbia pulcherrima* (Willd.). M.Sc.(Hort) thesis, Navsari Agricultural University, Navsari, 56p.

Chezhiyan, N., Pannuswamy. V., and Thamburaj, S. 1985. Evaluation of chrysanthemum cultivars. *S. Indian Hortic.* 33 (4): 279-282.

Chong, C. 2008. Media and containers for seed and cutting propagation and transplanting. In: Beyl, C. A. and Trigiano, R. N. (eds.) *Plant propagation Concepts and Laboratory Exercises*. 43-56.

Choudhary, M., Beniwal, B. S. and Kumari, A., 2014. Evaluation of marigold genotypes under semi-arid conditions of Haryana. *Annals Hortic.* 7 (1): 30-35.

Davies, P.J. 1995. Plant hormones and their role in plant growth development, 2nd ed. Kluwer Academic Publishers, Dordrecht, Netherlands, p13-38.

Dawane, P. T., Desmukh, M. R., Katwate, S. M., Ambad, S. N., and Chavan, S. R. 2015. Influence of propagation methods of marigold (*Tagetes erecta* L.) on growth, yield and quality of flowers. *Indian J. Agric. Res. Technol.* 40 (1): 20-24.

DeJong, J. 1981. Flower initiation of chrysanthemum seedlings grown continuously in short days at four levels of irradiance. *Sci. Hortic.* 14 (3): 277-284.

109

Devier, C. L. and Geneve, R. L. 1997. Flowering influences adventitious root formation in chrysanthemum cuttings. *Scientia Horticulturae.* 70 (4): 309-318.

Dhakar, M. K., Sarolia, D. K., Kaushik., and Bana, M. L. 2011. Rooting response of Pomegranate (*Punica granatum* L.) cv. Bhagwa to different media and growth regulator. National Seminar on Tropical and Subtropical Fruits. Book of Abstracts. pp. 35-36.

Dwivedi, S. K. and Kareem, A. 2004. Introduction and evaluation of carnation (*Dianthus caryophyllus* L.) varieties under cold and arid region of India. *J. Ornam. Hortic.* 7 (2): 207-209.

Edwards, C.A. and Burrows, I. 1988. The potential of earthworm composts as plant growth media. In: Edwards, C.A. and Neuhauser, E. (Eds.). Earthworms in Waste and Environmental Management. SPB Academic Press. The Hague, The Netherlands, pp. 21-32.

Evans, M. R. and Stamps, R. H. 1996. Growth of bedding plants in sphagnum peat and coir dust-based substrates. *J. Environ. Hortic.* 14: 187-190.

Furuta, T. and Kiplinger, D.C. 1955. Chronological age of cuttings, a factor influencing the spray formation of pompon chrysanthemums. In: *Proc. Amer. Soc. Hort. Sci.* 66: 383-385.

Gajalakshmi, S. and Abbasi, S. A. 2002. Effect of the application of water hyacinth compost/vermicompost on the growth and flowering of *Crossandra undulaefolia* and on several vegetables. *Bioresour. Technol.* 85: 197-199.

Girisha, R., Shirol, A. M., Kulkarni, B. S., Reddy, B. S., and Anupa, T. 2012. Studies on effect of plant growth regulators on growth, flowering and quality of daisy (*Aster amellus L.*) cv. Dwarf pink. *Int. J. Agric. Environ. Biotech.* 5 (2): 127-131.

Gohil, P., Gohil, M., Rajatiya, J., Halepotara, F., Solanki, M., Malam, V. R., and Barad, R. 2018. Role of Growing Media for Ornamental Pot Plants. *Int. J. Pure Appl. Biosci*. 6 (1): 1219-1224.

Gowda, P., Dhananjaya, M. V., and Kumar, R. 2017. Effect of indole butyric acid on rooting of different carnation (*Dianthus caryophyllus* L.) genotypes. *Int. J. Pure Appl. Biosci.* 5 (2): 1075-1080.

Grewal, H. S., Ramesh, K., and Rupinder, C. 2005. Effect of IBA and NAA on rooting of chrysanthemum (*Dendranthema grandiflora)* terminal cuttings. *J. Ornam. Hortic*. 8 (3): 230-232.

Griffith Jr., L. P. 1998. Tropical Foliage Plants: A Grower's Guide. Ball Publishing.

Gupta. R., Yadav, A., and Garg, V. K. 2014. Influence of vermicompost application in potting media on growth and flowering of marigold crop. *Int. J. Recycling Org. Waste Agric.* 3 (1): 47.

Gupta, R. D., Jha, K. K., and Dev, S. P. 1983. Effect of fertilizers and organic manures on the microflora and microbiological processes in soils. *Indian J. Agric. Sci.* 53: 266–269.

Haixia, Y., JiaShi, L., ChangYan, H., JingZhou, H., XiaoGuo, W., Jie, G., TingTing, Q., and ZhaoYang, B. 2013. Effects of NAA and IBA on survival of rose hardwood cutting. *J. South Agric.* 44 (11): 1870-1873.

Haripriya, K. and Sriramachandrasekharan, M. V. 2002. Effect of organic amendments on the growth and yield of marigold in lignite mine soil. *Adv. Plant Sci.* 15 (1): 177-179.

Hartman, H. T. and Kester, D. E. 1972. *Plant propagation: Priciples and Practices*. 2nd ed. Prentice Hall of India Private Limited, New Delhi, pp 211-257 and 222-284.

Hartmann, H. T., Kester, D. E., Davies, F.T., and Geneve, R. L. 1997. *Plant Propagation: Principles and Practices*. Prentice-Hall, Englewood Cliffs, NJ, 90.

Hartmann, H. T., Kester, D. E., Davies, J. R., and Geneve, R. L. 2002. *Plant Propagation: Principles and Practices*, 7th ed. Prentice hall, Upper Saddle. NJ.

Heins, R. D., and Wilkins, H. F. 1979. The influence of node number, light source and time of irradiation during darkness on lateral branching and cutting production in 'Bright Golden Anne chrysanthemum. *J. Am. Soc. Hortic. Sci.* 104: 265-270.

Ingle, M. R. 2008. Effect of growth regulators and environments on rooting of stevia cuttings (*Stevia rebaudiana Bertoni*). M. Sc. (Ag.) Thesis, Department of Agriculture, College of Agriculture, Dharwad.

Isac, D. and Chezhiyan, N. 2002. Evaluation of chrysanthemum cultivars for yield and related traits. *S. Indian Hortic.* 50 (4-5): 444-450

Izadi, Z., Zarei, H., and Alizadeh, M. 2012. Studies on vegetative propagation of *Rosa canina*. *Indian J. Hortic.* 69(4): 598-601.

Indriyani, N. L. P., Hadiati, S. and Soemargono, A., 2011. The effect of planting medium on the growth of pineapple seedling. *J. Agric. Biological Sci.* 6 (2) : 1-6.

Jyoti, C. 2017. Studies on the effect of types of propagule on cut flower production of chrysanthemum (*Dendranthema grandiflora*). M. Sc. (Hort.) Thesis, Department of Horticulture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, 50p.

Jeevajothi, 'L., Nanjan, K., Chezhiyan, N., and Abdul, K. 1987. Influence of propagules, medium and season on rooting of chrysanthemum cuttings. *South Indian Hortic.* 35 (3): 220-225.

112

Jing, H. U. and You-Gang, W. E. I. 2007. Study on the cutting propagation of *Euphorbia pulcherrima*. *J. Sci. Technol.* 3: 005.

Kanwar, J. and Khandelwal, S. K. 2013. Effect of plant growth regulators on growth and yield of african marigold *(Tagetes erecta* L.). *Madras Agric. J.* 100 (1,3): 45-47.

Karmegam, N. and Daniel, T. 2009. Effect of application of vermicasts as layering media for an ornamental plant *Codiaeum variegatum* L. *Bl. Dyn. Soil Dyn. Plant.* 3: 100-104.

Kathiravan, M., Ponnuswamy, A. S., and Vanitha, C. 2007. Influence of soil types on elite seedings production in Jatropha (*Jatropha curcas* L.). *Plant Arch.* 8 (1): 111-113.

KAU (Kerala Agricultural university). 2016. *Package of practices recommendations*: *Crops*. (14th Ed.). Kerala Agriculture University, Thrissur, 360p.

Khader, M.A., Thamburaj, S., Chezhiyan, N., and Ponnuswami, V. 1990. Early blooming of chrysanthemum Co-1 gives longer lasting flowers. *Indian Hortic.* 35 (3): 26.

Khan, T.N., Jeelani, G., Tariq, S., Mahmood, T., and Hussain, S.I. 2011. Effect of different concentrations of rooting hormones on growth of tomato cuttings (*Solanum esculentus* L.). *J. Agric. Res.* 49 (2): 241-247.

Khatik, V. K. and Mishra, A. 2017. Influence of growing media and indole butyric acid on damask rose cuttings (*Rosa damascena. Mill*) var. Ranisahiba. *Vegetos-An Int. J. Plant Res.* 30: 262-266.

Khelikuzzman, M. H. 2007. Effect of different potting media on growth of a hanging ornamental plant. *J. Trop. Agric. Sci*. 35 (1): 41-48.

Khewale, A. P., Golliwar, V. J., Poinkar, M. S., Jibhakate, S. B., and Athavale, M. P. 2005. Influence of different concentrations of IBA and media on root

113

parameters in the propagation of *Carnation cv. Gaudina. J. Soils Crops.* 15 (2): 406-410.

Kim, S. H., Oh, W., Shim, M. S., Son, J. E., and Kim, K. S. 2006. Effects of pinching time on stock plant growth, cutting yield, and quality in *Kalanchoe blossfeldiana. Hortic. Environ. Biotechnol.*47 (6): 359-365.

Kumar, P., Kumar, V., and Kumar, D. 2016. Response of INM to Plant growth, Flower yield and Shelf life of African marigold (*Tagetes erecta* L.) cv. PusaBasantiGainda. *Int. J. of Agric. Invention.* 1 (1):108-112.

Kumar, R., Ahmed, N., Sharma, O. C., and Lal, S. 2014. Influence of auxins on rooting efficacy in carnation (*Dianthus caryophyllus* L.) cuttings. *J. Hortic. Sci.* 9 (2): 157-160.

Kumar, V., Pal, M., and Singh R. S. 2015. Effect of rooting media on propagation of marigold (*Tagetes erecta* L.) through shoot cutting. *Environ. Ecol.* 34 (3): 930-932.

Lal, G., Roy, P. K., and Singh, Y. V. 2008. Effect of auxins on rooting and sprouting behaviour of stem cutting of henna (*Lawsonia inermis*). *Indian J. Agric. Sci.* 78 (12): 1013-1017.

Laxmi, P. 2006. Studies on evaluation of yellow cultivars and influence of staggered planting on growth, flowering and yield of three cultivars of chrysanthemum *(Dendranthema grandiflora)*. Doctoral dissertation, Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad, 132p.

Lingaraj, D. S. and Chandrasekhariah, S. R. 1961. Growth regulators and rooting of cuttings in *Antirrhinum majus. Curr. Sci.* 30: 392-393.

Mahale, V. 1999. Influence of growth regulators, media and biofertilizers on rooting of carnation (*Dianthus caryophyllus* L.) stem cuttings. M.Sc.(Ag) thesis, University of Agricultural Sciences, Bangalore, 70p.

Mehraj. H., Shahrin, T., and Uddin, A. F. 2013. Influence of Indole-3-Butyric acid (IBA) on sprouting and rooting potential of *Bougainvillea spectabilis* cuttings. *Bangladesh Res. Pub. J.* 9 (1): 44-49.

Montero, F.P., Aguera, E., and Jimenez, F. 1985. Comparative effect of different growth regulators and boron on rooting of carnation cuttings. *Agrochimica.* 29 (5-6): 356-363.

Mukhopadhyay, T.P. and Bose, T.K. 1979. Standardization of propagation from cuttings under mist III. Effect of leaf number on root formation in cuttings of different species of ornamental plants. *Punjab Hortic. J.* 19: 98-101.

Mukhopadhyay, T.P. and Bose, T.K. 1981. A note on the role of leaf retention on cuttings during root formation. *Punjab Hortic. J.* 21: 105-108.

Nadeem, M., Riaz, A., Younis, A., Akond, M., Farooq, A., & Tariq, U. 2013. Improved technique for treating seed dormancy to enhance germination in Rosa× hybrida. *Turkish J. Bot. 37*(3): 521-529.

NHB [National Horticulture Board]. 2018. *Horticulture Statistics at a glance-*2017.National Horticulture Board, Gurgaon,173p.

Nanda, I. P. and Mishra, M. 2010. Effect of IBA and NAA on rooting in stem cutting of *Hibiscus rosa-sinensis L. Adv. Plant Sci.* 23 (2): 513-514.

Nasri, F., Fadakar, A., Saba, M. K., and Yousefi, B. 2015. Study of indole butyric acid (IBA) effects on cutting rooting improving some of wild genotypes of damask roses (*Rosa damascena Mill.*). *J. Agric. Sci. Belgrade.* 60 (3): 263-275.

Naveen, K. 2016. Response of marigold (*Tagetes erecta* L.) var. Calcutta Orange to type of planting material and nutrition. M.Sc.(Hort) thesis, University of Horticultural Sciences, Bagalkot, 97p.

115

Netam, N., Shukla, N., Sharma, G., and Shahu, J, K. 2018. Effect of Different IBA concentration on survivability and rooting of Jasmine (*Jasminum sambac)* stem cuttings. *J. Pharmacognosy. Phytochem.* 614:617.

Nichols, M. A. and Savidov, N. A. 2009. Recent advances in coir as a growing medium. *Acta Hortic.* 843: 333-336.

Nielson, R. L. 1965. Presence of plant growth substances in earthworms demonstrated by paper chromatography and the Went pea. *Nature Lond.* 208: 1113-1114.

Orozco, F. H., Cegarra, J., Trujillo, L. M., and Roig, A. 1996. Vermicomposting of coffee pulp using the earthworm Eisenia foetida: effects on C and N contents and the availability of nutrients. *Biol. Fertil. Soils* 22: 162–166.

Padsumbiya, H. D., and Dave, S. K. 1991. A note on effect of plant growth regulators on rooting of cuttings in African marigold (*Tagetes erecta* L.). *Haryana J. Hortic. Sci.* 23 (3): 218-220.

Pandey, A. K. and Chandra, H. 2008. Studies on the effect of GA_3 and NAA on growth and flowering of French marigold (*Tagetes patula* L.). *Prog. Hortic.* 40 (1): 96-99.

Panse, V. G. and Sukhatme, P. V. 1985. Statical methods for Agriculture workers. 4^{th} ede. *ICAR, New Delhi*, 347p.

Patel, K. J. 2016. Effect of different IBA concentration and rooting media on cutting of *Hibiscus rosa-sinensis.* M.Sc.(Hort) thesis, Agricultural University Navsari, Navasari, 110p.

Ranpise, S. A., Bharmal, V. S., and Darwade, R. T. 2004. Effect of different levels of indole butyric acid (IBA) on rooting, growth and flower yield of chrysanthemum cv. Sonali Tara. *J. of Ornam. Hortic.* 7 (3,4)331-337.

116

Rashmita. 2015. Effect of different media on rooting and survival of pear (*Pyrus pyrifolia* L.) cuttings cv. Patharnak. M.Sc.(Hort) thesis, Birsa Agricultural University Ranchi, Jharkhand, 37p.

Renuka, K. and Chandrasekhar, R. C. 2015. Effect of different media treatments on rooting of carnation (*Dianathus cryophyllus* L.) cuttings of cv. Baltico under poly house conditions. *Asian J. Hortic.* 10 (1): 118-121.

Renuka, K. and Chandrasekhar, R. C. 2017. Studies on the effect of different media and their combinations on rooting of carnation (*Dianthus caryophyllus* L.) Cuttings of cv. Keiro under polyhouse conditions. *Plant Arch.* 17 (1): 509-512.

Rolston S. H., Carlos A. F. B and Carlos A. P. M. (1996) Adventitious root formation and development in cuttings of *Mussaenda erythrophylla* L. *Hortic. Sci.* 31: 1023-1025.

Sahariya, K., Singh, J. N., Singh, A. 2012. Studies on the effect of IBA on rooting of bougainvillea (var. Thimma) cuttings in open field and polyhouse condition. *Asian J. Hortic.* 8 (1): 140-142.

Sameei, L., Khalighi, A., Kafi, M., and Samavat, S. 2005. Peat moss substituting with some organic wastes in pothos (*Epipremnum aureum*) growing media. *Iran. J. Hortic. Sci. Technol.* 6 (2): 79-88.

Sangwan, P., Kaushik, C. P., and Garg, V. K. 2010. Growth and yield response of marigold to potting media containing vermicompost produced from different wastes. *Environ.* 30 (2): 123–130.

Savithri, P. and Hameed Khan, H. 1994. Characteristics of coconut coir pith and its utilization in agriculture. *J. Plant Crops*. 22: 1-18.

Sayedi, A., Esmaeili, A., Zadeh, K. N. A., and Porsiabidi, M. M. 2014. Comparative evaluation of the rooting in cuttings in (*Bougainvillea glabra L.*). *Int. J. Farm Allied Sci.* 3 (8): 872-875.

Shadanpour, F., Mohammadi, T.A., and Hashemi, M. K., 2011. The effect of cow manure vermicompost as the planting medium on the growth of Marigold. *Ann. Biol. Res.* 2 (6): 109-115.

Shah, S. C., Gupta, L. K., Bhujwan, H. S., and Bhujwan, S. H. 1996. Effect of auxins on rooting of stem cuttings of rosemary (*Rosmarinus officinalis* L.). *Recent. Hortic.* 3 (1): 126–128.

Shalini, K. 2017. Effect of IBA and NAA and their combination on rooting in stem cuttings of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. M.Sc. thesis, College of Agriculture Indira Gandhi Krishi Vishwavidyalaya, Raipur,46p.

Sharma, C. P., Maurya, A. N., Srivastava, O. P., and Mishra, A. 2001. Role of GA_3, MH and ethrel in modifying vegetative and floral characters of *Chrysanthemum morifolium* Ram. *The Orissa J. Hortic*. 29 (2):35-38.

Sharma, R. 2014. Study on the effect of Auxins on Rooting, Growth and Flowering of African Marigold (*Tagetes erecta* L.) propagated through stem cuttings. M. Sc. (Hort.) Thesis. I.G.K.V., Raipur, 73p.

Shenoy, R. 1992. Influence of planting material and growth regulators on the rooting of stem cuttings in *Rosa damascena Mill.* M. Sc. (Hort.) Thesis. University of Agricultural Sciences, Bangalore.

Sheoran, O. P., Tonk, D. S., Kaushik, L. S., Hasija, R. C. and Pannu, R.S. 1998. *Statistical Software Package for Agricultural Research workers. Recent Adanvces in information theory, Statistics & Computer Applications.* Haryana Agricultural university, Hisar, 139-143p.

Shirol, A. M., Kulkarni, B. S., Reddy, B. S., Kanamadi, V. C., and Thammaiah, N. 2001. Influence of different rooting media on rootability of tip cuttings of dwarf poinsettia. *Karnataka J. Agric. Sci.* 14 (4): 1145-1146.

118

Shruthi, P. 2015. Impacts of seasons and pinching on growth and flowering in African marigold (*Tagetes erecta* L.). M.Sc.(Hort) thesis, Kerala Agriculture University, Kerala, 84p.

Sidhu, G. S., and Singh, P. 2002. Effect of auxins on propagation in *Chrysanthemum morifolium*. *Floriculture research trend in India*. Proceedings of the national symposium on Indian floriculture in the new millennium, Lal Bagh, Bangalore, February 25. Vol. 27.

Singh, A. K. 2001. Effect of auxins on rooting and survival of jasmine (*Jasminum sambac*) stem cutting. *Prog. Hortic*. 33 (2): 174-177.

Singh, A. K. 2005. Response of rose plant growth and flowering to nitrogen, Azotobacter and farm-yard manure. *J. Ornam. Hortic.* 8 (4): 296-298.

Singh, D. K. 1999. Response of hybrid tomato (*Lycopersicon esculentum*) growth regulators. *Indian J. Agric. Sci*. 69 (7): 523-525.

Singh, D. R. and Nair, S. A. 2003. Standardization of rooting media for cuttings of certain house plants. *J. Ornam. Hortic*. 6 (1): 78-79.

Singh, K. K., Rawat, J. M. S., and Tomar, Y. K. 2011. Influence of IBA on rooting potential of Torch Glory *Bougainvillea glabra* during winter season. *J. Hortic. Sci. Ornam. Plants*. 3 (2): 162-165.

Singh, K. K.; Rawat, J. M. S.; Tomar, Y. K. and Kumar, P. 2013a. Effect of IBA Concentration on inducing rooting in stem cuttings of *Thuja compacta* under mist house condition. *Hort. Flora Res. Spectrum.*2 (1): 3034.

Singh, K. K., Rawat, V., Rawat, J. M. S., Tomar, Y. K., and Kumar, P. A. 2013b. Effect of IBA and NAA concentrations on rooting in stem cuttings of Night Queen (*Cestrum nocturnum L*) under sub-tropical valley conditions. *Hortic. Flora. Res. Spectrum*. 2 (1): 81-83.

Singh, K. K., Chauhan, J. S., Rawat, J. M. S., and Rana, D. K. 2015. Effect of different growing condition and various concentration of IBA on the rooting

119

and shooting of hardwood cutting of phalsa (*Grewia subinequalis* L.) under valley condition of Garhwal Himalayas. *Plant Arch.* 15 (1): 131-136.

Stancato, G. C., Aguiar, F. F. A., Kanashiro, S., Tavares, A. R., Catharino, E. L. M. and Silveira, R. B. D. A. 2003. *Rhipsalis grandiflora* propagation by stem cuttings. *Sci. Agric.* 60 (4): 651-656.

Stojanova, A., Primova, T., and Anastassov, C. H. 2000. Effect of mineral fertilization on the essential oil composition of *Tagetes patula* L. from Bulgaria. *J. Essent. Oil Res.* 12:609-612.

Stoltz, L.P. 1968. Factors influencing root initiation in an easy-and a difficult-to-root Chrysanthemum. In: *Proceedings of the American Society for Horticultural Science*. North saint asaph street, Alexandria, Amer. Soc. Horticultural Science. p. 622.

Sunayana, N. 2017. Effect of growth retardants on growth and yield of African marigold (*Tagetes erecta*). M.Sc.(Hort) thesis, Kerala Agricultural University. Kerala,1p.

Susaj, E., Susaj, L., and Kallco, I. 2012. Effect of different NAA and IBA concentrations on rooting of vegetative cuttings of two rose cultivars. *Res. J. Agric. Sci.* 44 (3): 121-127.

Swaroop, Kishan, Kanwar, P., Singh, and Raju, D. V. S. 2007. Vegetative growth, flowering and seed characters of African marigold (*Tagetes erecta L.*) as influenced by different growth substances during mild off seasons. *J. Ornam. Hortic.* 10 (4): 268-270.

Swetha, H. 2005. Propagation of Indian Lavender (*Bursera delvpechiana*) through cuttings under mist. Ph. D. Thesis. University of Agriculture Sciences, Dharwad, Karnataka.

Syamal, M. M., Dixit, S. K., and Kumar, S. 2006. Effect of biofertilizers on growth and yield of marigold. *J. Ornam. Hortic.* 9 (4): 304-305.

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

Thakur, R., Dubey, R. K., Kukal, S. S., and Singh, S., 2013. Evaluation of different organic potting media on growth and flowering of calendula (*Calendula officinalis* L.). *Indian Soc. Ornam. Hortic.* 16 (1,2): 57-63.

Tiberia, I., Doru, P., and Catherine, B. 2011. Auxin control in the formation of adventitious roots. *Not. Bot. Hortic. Agrobot. Cluj.* 39 (1): 307-316.

Tomati, U. and Galli, E. 1995. Earthworms, soil fertility and plant productivity. *Acta Zoologica Fennica.* 196:11-14.

Ullah, Z., Abbas, S. J., Naeem, N., Lutfullah, G., Malik, T., Khan, U., Mallik, A., and Khan, I. 2013. Effect of indole butyric acid (IBA) and naphthalene acetic acid (NAA) plant growth regulators on Marigold (*Tagetes erecta* L.). *African J. Agric. Res.* 8 (29): 4015-4019.

Vendrame, A. W., Maguire, I., and Moore, K. K. 2005. Growth of selected bedding plants as affected by different compost percentages. *Proc. Fla. State Hortic. Soc.* 118: 368-371.

Vinaykumar, J., Kulkarni, B. S., Krishnamurthy, G. H., and Reddy, B. S. 2008. Effect of Growth Regulators on Rooting of *Thunbergia grandiflora. Karnataka J. Agric. Sci.* 21 (2): 322-323.

Wang, Q. and Andersen, A. S. 1989. Propagation of *Hibiscus rosa-sinensis*: Relationships between stock plant cultivar, age, environment, and growth regulator treatments. *Acta hortic.* 251:289-309.

Watane, A. A. 2018. Comparative studies on vegetative propagation of African marigold and its field performance. M.Sc.(Hort) thesis, Dr. Panjabrao Deshmukh krishi Vidyapeeth, Krishnagar PO, Akola, 74p.

Wazir, J. S. 2011. Response of potted Alstroemeria to different growth retardants under protected conditions. *J. Farm Sci.* 1 (1): 27-36.

Wodecki, M. J. and Holcomb, J. 1989. Varying concentrations of IBA affects rooting of chrysanthemum cuttings cv. Bright Golden Anne. *Bulletin-Pennsylvania flower growers (USA)*. 391(1-3): 5.

Wott, J.A. and Tukey, H.B. 1969. Cutting size and nutrient mist affect rooting of Chrysanthemums. *New York State Flower Growers Bulletin*. 284: 1-4.

Yadav, H. K., Singh, A. K., Singh, H. K. and Bhupinder, K. 2013. Response of African marigold (*Tagetas erecta* L.) to various plant growth regulators. *Agric. Biological Res*. 29 (2): 139-141.

Yeshiwas., Tadele., Alemayehu, M., and Alemayehu, G. 2015. Effects of indole butyric acid (iba) and stem cuttings on growth of stenting-propagated Rose in Bahir Dar, Ethiopia. *World J. Agric. Sci.* 11(4): 191-197.

ABSTRACT

VEGETATIVE PROPAGATION IN AFRICAN MARIGOLD (*Tagetes erecta* L.) HYBRID.

By

AMRUTA SANKANNAVAR

(2016-12-022)

Abstract of the Thesis

Submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARGOD 671 314

KERALA, INDIA

2019

ABSTRACT

Hybrid marigold varieties with high yield potential and attractive income are available today in India and are preferred by farmers. However, the availability of seeds in bulk and the prohibitive cost of hybrid seeds in the market are the main constraints for the expansion of marigold cultivation in Kerala. Propagating through cuttings is cheap and convenient method. This method gives strong plants within short time and helps in preservation of all the characters and maintains purity of a particular variety. In order to overcome the constraints of seed cost and availability of hybrid seeds, propagation of marigold by cuttings is a viable option. So it is essential to standardize this propagation technique for producing quality planting material.

Hence, the study entitled "Vegetative propagation in African marigold (*Tagetes erecta* L.) hybrid" was conducted in the Department of Pomology and Floriculture, College of Agriculture, Padannakkad and RARS, Pilicode during the period from 2016 to 2018 with three prime objectives.

The first experiment was intended to standardize the best age of the cuttings with respect to the rooting and survival of cuttings with four treatments *i.e.* cutting removed from mother plants at 30 DAT, 50 DAT, 70 DAT and 90 DAT. The second experiment was to find out the effect of growth regulator IBA at 3 levels of 0, 200, and 400 ppm, 3 different media (Soil + FYM 1:1), (Soil + Coir pith compost 1:1) and (Soil + Vermicompost 1:1) and their interaction with nine treatment combinations. The third experiment was to compare the performance of seedlings and rooted cuttings for their vegetative and yield parameters.

In the first experiment, results revealed that shoot and root parameters of rooted cuttings are influenced by age of mother plants. Number of leaves, leaf area, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, root length and root shoot ratio were found to be higher in rooted cuttings from 30-day old mother plants. The terminal cuttings from younger mother plants performed better with respect to growth parameters.

In the second experiment, both shoot and root parameters were found to be significantly influenced by IBA and rooting media. The root fresh weight, dryweight and root to shoot ratio recorded were significantly higher in rooted cuttings treated with IBA at 400 mg/l whereas cuttings treated with IBA 200 mg/l had made significant effect by recording maximum number of leaves, leaf area, shoot fresh weight and dry weight. The application of IBA 400 mg/l and planting in a medium of Soil + Vermicompost (1:1) was the best practice for vegetative propagation through rooting of cuttings because it resulted in better root length, rooting intensity and survival percentage.

The third experiment was designed to compare the performance of seedlings to those developed through rooted cuttings on morphological parameters and yield attributes. Seedlings were significantly taller, produced maximum number of primary branches and secondary branches at 30, 60 and 90 days after transplanting. Yield parameters such as number of flowers per plant (42.05), flower yield per plant (489.85g), flower yield per plot (9.8 Kg), flower yield per hectare (29.02 t/ha) and duration of flowering were significantly more in seedling originated plants. Seedlings also recorded maximum plant fresh weight and dry weight. Plants from rooted cuttings flowered early, took significantly lesser number of days for 50% flowering and first harvest. Shelf life of marigold flowers were also more (7.05 days) in vegetatively propagated plants compared to that from seedlings (5.45 days). Plants raised from rooted cuttings recorded the maximum B:C (5.34 :1) ratio compared to seedlings (3.91:1).

Marigold can be propagated commercially through cuttings since we can obtain more number of plants from single mother plant which reduces the cost of cultivation, increases benefit to growers as well as helps to maintain the purity of varieties.

സംക്ഷിപ്തം

അത്യുല്പാദനശേഷിയും ആകർഷകവുമായ സങ്കരയിനം ചെണ്ടുമല്ലി വിത്തിന്റെ ദൗർലഭ്യവും വിലക്കൂടുതലും കണക്കിലെടുത്ത് ചെണ്ടുമല്ലിയിൽ കായിക പ്രജനന രീതിയുടെ അടിസ്ഥാന മാതൃക ക്രമീകരിക്കുന്നതിനായി പടന്നക്കാട് കാർഷിക കോളേജിലെ പഴവർഗ്ഗ-പുഷ്പ വർഗ്ഗ ശാസ്ത്ര വിഭാഗത്തിൽ 2016-2018 കാലയളവിൽ പഠനം നടത്തുകയുണ്ടായി. വിത്തിനു പകരം മാതൃസസ്യത്തിൽ നിന്നെടുക്കുന്ന തണ്ട് നടീൽ വസ്തുവായെടുക്കുകയും അവ ശേഖരിക്കുന്ന ചെടിയുടെ പ്രായം, വേര് പിടിക്കാൻ ഉപയോഗിക്കേണ്ട വളർച്ചാത്വരിത ഹോർമോണിന്റെ അളവ്, വളർത്തേണ്ട മാധ്യമം എന്നിവ ക്രമീകരിക്കലും വിത്തുവഴിയും കായിക പ്രജനനം വഴിയും വളർത്തുന്ന ചെടികളിൽ നിന്നുള്ള വരവ്-ചെലവ് അനുപാതം കണ്ടെത്തുകയുമായിരുന്നു പരീക്ഷണ ലക്ഷ്യങ്ങൾ.

നട്ടതിനു ശേഷം 30 ദിവസം പ്രായമായ ചെണ്ടുമല്ലിതൈകളിൽ നിന്നെടുക്കുന്ന തൈകളുടെ വളർച്ച 50, 70, 90 ദിവസം പ്രായമായ തൈകളിൽ നിന്നെടുക്കുന്ന നടീൽ വസ്തുക്കളേക്കാൾ കൂടുതലായി കണ്ടെത്തി. ഇൻഡോൾ ബ്യൂട്ടിറിക് ആസിഡ് എന്ന വേര് പിടിക്കാൻ സഹായിക്കുന്ന ഹോർമോൺ 400 മില്ലിഗ്രാം ഒരു ലിറ്ററിൽ എന്ന തോതിൽ എടുത്ത് നടീൽ വസ്തുവിന്റെ ചുവടു ഭാഗം മുക്കിവച്ചതിനു ശേഷം മണ്ണും മണ്ണിരകമ്പോസ്റ്റും 1:1 എന്ന അനുപാതത്തിലുള്ള മാധ്യമത്തിൽ വളർത്തിയപ്പോൾ കൂടുതൽ തൈകൾ അതിജീവിക്കുന്നതായി കണ്ടെത്തി. വിത്ത് വഴി ഉത്പാദിപ്പിക്കുന്ന ചെടികളിൽ ഒരു ഹെക്ടറിൽ നിന്നുള്ള വിളവ് കൂടുതലായി കണ്ടെത്തിയെങ്കിലും കായിക പ്രജനനം വഴിയായി ഉത്പാദിപ്പിച്ച തൈകളിൽ കാലത്തിനു മുൻപേ പൂവുണ്ടാവുന്നതായും വിളവെടുപ്പിനു ശേഷം വാടാതെ പുതുമയോടെ അധിക സമയം നിലനിൽക്കുന്നതായും കണ്ടെത്തി. വിത്ത് വഴിയുള്ള കൃഷിയേക്കാൾ (വരവ്-ചെലവ് അനുപാതം 3.91:1) ലാഭകരമായി കൃഷി ചെയ്യാൻ സാധിച്ചത് കായിക പ്രജനനത്തിലൂടെയുള്ള നടീൽ വസ്തു ഉപയോഗിച്ചപ്പോഴാണ് (വരവ്-ചെലവ് അനുപാതം 5.34:1).

APPENDICES

APPENDIX I (a)

Weather data during the experimental period (2017)

Date	Temperature (°C)		Relative humidity (%)			Monthly rainfall (mm)	BSS (Hours)
	Maximum	Minimum	I	II	Average		
Jan	31.57	18.70	89.16	55.13	72.15	0	2.78
Feb	32.20	20.53	89.39	60.93	75.16	0	2.46
Mar	33.06	22.24	89.26	63.36	76.31	1.20	2.48
Apr	33.19	24.78	85.83	66.10	75.97	28.20	4.20
May	32.89	23.62	85.29	64.35	74.82	124.00	1.93
Jun	29.41	22.29	95.27	81.97	88.62	1137.30	0.84
Jul	29.52	22.42	94.23	80.19	87.21	746.48	1.57
Aug	29.18	22.79	95.13	81.1	88.12	663.71	1.43
Sep	29.85	22.96	92.03	77.70	84.87	731.10	1.18
Oct	30.41	22.37	92.42	72.65	82.54	181.35	1.98
Nov	31.63	21.58	92.13	65.30	78.72	23.10	4.74
Dec	31.54	20.17	92.64	61.67	77.16	30.38	9.44

APPENDIX I (b)

Weather data during the experimental period (2018)

Date	Temperature (^oC)		Relative humidity (%)			Monthly rainfall (mm)	BSS (Hours)
	Maximum	Minimum	I	II	Average		
Jan	30.98	20.13	93.29	61.61	77.45	0	8.21
Feb	31.68	21.14	92.07	59.61	75.84	1.60	8.58
Mar	32.47	23.63	90.38	62.84	76.61	36.89	7.07
Apr	33.13	24.68	87.47	64.53	76.00	10.20	6.83
May	32.36	24.51	88.48	67.74	78.11	277.14	3.43
Jun	29.55	24.11	94.07	83.80	88.94	925.20	1.76
Jul	29.99	24.48	94.45	81.06	87.76	868.00	1.93
Aug	29.34	23.95	94.87	80.94	87.91	692.54	6.64
Sep	30.57	24.21	89.20	69.03	79.12	18.00	6.24
Oct	31.01	24.37	90.81	68.10	79.46	155.31	8.32
Nov	31.83	23.85	90.1	61.63	75.87	54.90	7.21
Dec	31.39	22.05	91.61	64.35	77.98	17.98	7.01

Appendix II

Comparison of BC ratio of cultivating cuttings and seedlings for one hectare

Particulars	**Cuttings (T_1)**	**Seedlings (T_2)**
Cost of seeds/cuttings	25185	131750
Nursery	23500	5000
Land preparation	25000	25000
Transplanting	4800	4800
FYM and Fertilizers	55800	55800
Plant protection	10000	10000
Staking	-	6000
Weeding	2700	2700
Harvesting	9000	14000
Transportation	5000	8000
Irrigation	2500	2500
Cost of cultivation	163485	265550
Marketable yield (25% of total flower yield)	17292.14	21770.88
Gross income (@ 60/- kg)	1037528.10	1306252.80
Net income	874043.10	1040402.80
BC ratio	**5.34**	**3.91**