“INFLUENCE OF MEDIA AND SEED TREATMENT CHEMICALS ON THE ENHANCEMENT OF GERMINATION AND SEEDLING GROWTH OF PAPAYA (*Carica papaya* L.) CV. MADHU BINDU”

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GUJARAT STATE

October - 2015

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A

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OF

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(HORTICULTURE)
IN
FRUIT SCIENCE

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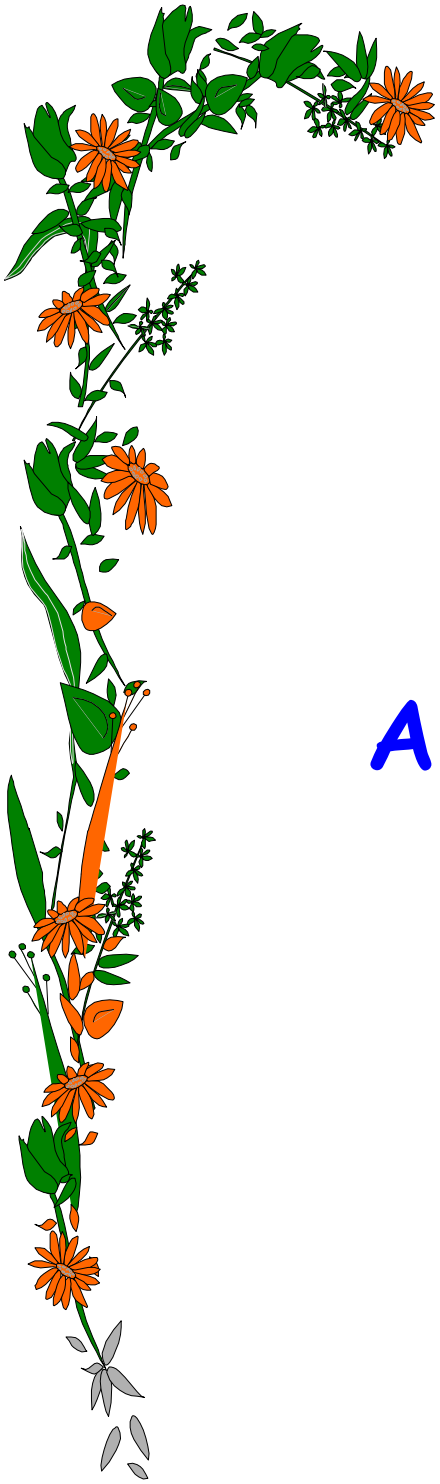

ABSTRACT

"INFLUENCE OF MEDIA AND SEED TREATMENT CHEMICALS ON THE ENHANCEMENT OF GERMINATION AND SEEDLING GROWTH OF PAPAYA (*Carica papaya* L.) CV. MADHU BINDU"

Name of Student	Major Guide
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A B S T R A C T

The present investigation entitled "Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu" was carried out during 2014-15 at Regional Horticultual Research Station, Navsari Agricultural University, Navsari. The experiment was laid out in Completely Randomized Design with two factors repeated three times. The treatments comprised of four different media viz. red laterite soil + vermicompost (M_1), red laterite soil + cocopeat (M_2), red laterite soil + vermicompost + cocopeat (M_3) and red laterite soil + vermicompost + sand (M_4) and seven different seed treatment chemicals viz. GA_3 100 mg/l (C_1), GA_3 200 mg/l (C_2), NAA 100 mg/l (C_3), NAA 200 mg/l (C_4), thiourea 1000 mg/l (C_5), thiourea 2000 mg/l (C_6) and without chemical-control (C_7).

The papaya seeds sown in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) recorded minimum days

required for initiation of germination and maximum germination percentage which was followed by treatment M_4 (red laterite soil + vermicompost + sand) (1:1:1). The media M_3 (red laterite soil + vermicompost + cocopeat (1:1:1) (M_3)) maintained its superiority in producing maximum seedling height, number of leaves per seedling, stem diameter, leaf area, fresh weight of seedling and dry weight of seedling. Significantly the maximum length of longest tap root, tap root diameter, root/shoot ratio and chlorophyll content was also noted in media M_3 (red lateritesoil + vermicompost + cocopeat (1:1:1)).

Among the different seed treatment chemicals, papaya seeds treated with GA_3 200 mg/l for 12 h (C_2) was found better for germination parameters, growth parameters, root parameters and biochemical parameter as compared to other seed treatment chemicals.

Considering the interaction effect between media and seed treatment chemicals, treatment combination M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l for 12 h) was found better for germination percentage, seedling height, number of leaves per seedling, stem diameter, leaf area, fresh and dry weight of seedling, length of longest tap root, tap root diameter and root/shoot ratio. Whereas minimum germination percentage, growth parameters and root parameters were noted in media red laterite soil + vermicompost (1:1) and without chemical treatment i.e. control (M_1C_7).

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*At this gratifying moment of completion of my research problem, I feel obliged to record my gratitude to those who have helped me. First of all, I wish to express my deepest gratitude and soulful respect to '**Shree Krishna**', who helped me on every path of life and made every step a great success.*

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I wish to end this note by expressing thanks to all those whom, I was able to recall here and also to those I might have left unknowingly.

Now, as I carry this in my hand, I carry with me memories that will enrich my nostalgia.

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C E R T I F I C A T E

This is to certify that the thesis entitled **"INFLUENCE OF MEDIA AND SEED TREATMENT CHEMICALS ON THE ENHANCEMENT OF GERMINATION AND SEEDLING GROWTH OF PAPAYA (*Carica papaya* L.) CV. MADHU BINDU"** submitted by PATEL ROSHANKUMAR RAMESHBHAI (Reg. No: 2020213036) in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in the subject of **FRUIT SCIENCE** to Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: **Navsari** **(R. V. TANK)**
Date: / /2015 **Major Guide**

DECLARATION

This is to declare that the whole of the research work now submitted in this thesis for the partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** is the result of investigation done by me under direct guidance and supervision of **Dr. R. V. TANK,** Associate Professor of fruit science, ASPEE College of Horticulture and Forestry, N.A.U., Navsari and that no part of the work has been submitted for any other degree so far.

Place: Navsari

Date : / /2015 **(Patel Roshan R.)**

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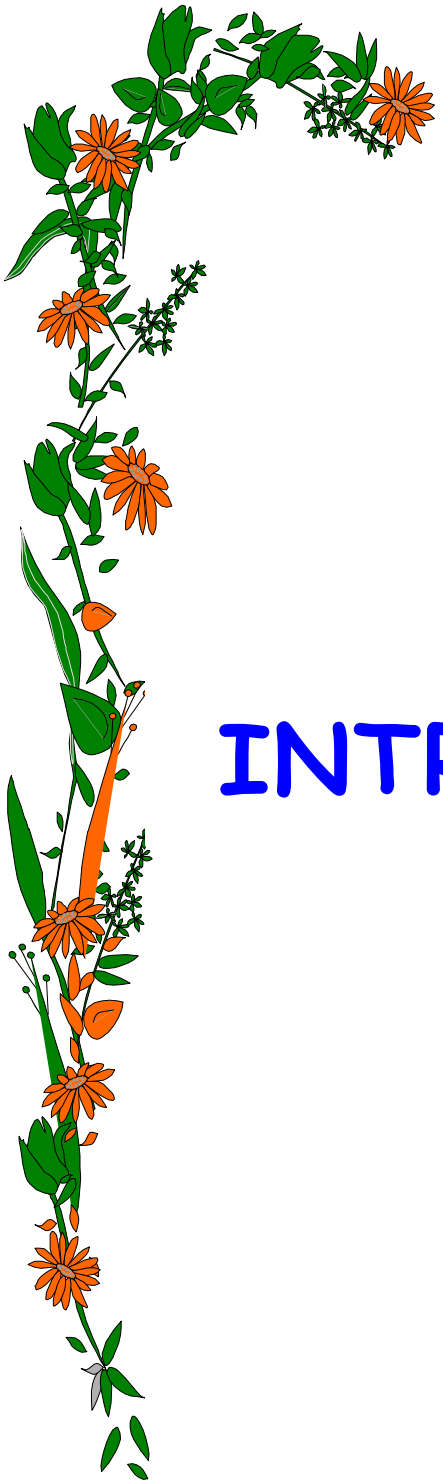
ABBREVIATION'S

SR. NO.	ABBREVIATION	MEANING
1.	X	Multiply
2.	:-	Colon and dash
3.	( )	Bracket
4.	;	Semi colon
5.	:	Hyphen
6.	@	At the rate of
7.	%	Per cent
8.	^{o}C	Degree Celsius
9.	Max.	Maximum
10.	Min.	Minimum
11.	C.D.	Critical difference
12.	C.V.	Co-efficient of variance
13.	S.Em. $\pm$	Standard error of mean
14.	NS	Non-significant
15.	Cm	Centimeter
16.	cv.	Cultivar
17.	Ha	Hectare
18.	*et al*.	and his co-workers
19.	Anon.	Anonymous
20.	G	Grams
21.	/	Per
22.	*i.e.*	That is
23.	FYM	Farm Yard Manures
24.	N	Nitrogen
25.	P	Phosphorus
26.	T	Tonnes
27.	a. m.	ante meridian
28.	Ml	Milliliter
29.	m^2	Square meter
30.	CO	Coimbatore
31.	DAS	Days After Sowing
32.	pH	Puissance de hydrogen
33.	RHRS	Regional Horticultural Research Station



INTRODUCTION

I. INTRODUCTION

Papaya *(Carica papaya* L.) is an important fruit crop of tropical world and has long been known as wonder fruit of the tropics. It belongs to the family Caricaceae and originated in Tropical America. It gives higher production of fruit per hectare and income next to banana (Singh, 1990). It was taken by the Spanish to Manila in the mid 16th century and reached Malacca shortly afterwards. From there it was brought to India (Kumar and Abraham, 1943).

Presently, the papaya is one of the most important fruit crops of the Australia, Hawaii, India, Sri Lanka, Myanmar, Taiwan, Brazil, Peru, Puerto Rico, Florida, Texas, California, South Africa and Kenya. In India, it is successfully grown all over the country and is available round the year. Papaya occupies 1.8 per cent of the total fruit crop area and 6.3 per cent of total fruit production in India. It occupies 133.36 thousand hectare cultivated area with 5639.30 thousand MT production with average productivity of 42.3 t/ha (Anon., 2014). The important papaya growing states in India are Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, Bihar, West Bengal, Tamil Nadu, Kerala, Assam and Rajasthan and have ideal climate conditions for its growth and production.

In Gujarat state area under papaya cultivation is about 19.59 thousand hectare with 1185.47 thousand MT annual production and productivity of fruit 60.5 t/ha (Anon., 2014). Gujarat holds 2nd position with 21.0 per cent shares in papaya production of the country next to Andhra Pradesh which has

27.4 per cent share (Anon., 2014). The major papaya growing districts of Gujarat are Anand, Vadodara, Bhavnagar, Kutch, Surat, Bharuch, Kheda, Sabarkanta, Mehsana, Jamnagar, Tapi, Gandhinagar, Junagadh and Narmada.

Papaya is a short-lived, fast growing, large herb 10 or 12 feet in height. The hollow green or deep purple colour trunk is straight and cylindrical with prominent leaf scars. Its diameter may be from 2 to 3 inches to over a foot at the base. The leaves emerge directly from the upper part of the stem in a spiral on nearly horizontal petioles 30-105 cm long, hollow, succulent, green or more or less dark purple. The blade deeply divided into 5 to 9 main segments, each irregularly subdivided, varies from 30-60 cm in width and has prominent yellowish ribs and veins. The 5 petalled flowers are fleshy, waxy and slightly fragrant. Some plants bear only short-stalked pistillate flowers, waxy and ivory-white or hermaphrodite flowers, ivory-white with bright yellow anthers and borne on short stalks; while other may bear only or staminate flowers, clustered on panicle to 2-3 ft long. The fruit is melon-like, oval to nearly round, somewhat pyriform or elongated club-shaped, 15-50 cm long and 10-20 cm thick; weighing up to 9 kg.

Papaya can be eaten as such as a dessert fruit, when fully ripe or with salt, pepper, sugar or lime juice. Its seeds are also eaten by some people for their slightly flavor and reputed medicinal value. The unripe fruit can be used as vegetable. Papaya fruits can also be made into pickles and preserves of various kinds. The fruits are beneficial in piles, dyspepsia of

liver, spleen and digestive disorders. Ripe fruits are used in preparation of jam, jelly, nectar, soft drinks, ice cream, flavouring crystallized fruits and are canned as syrup. Young leaves are also used as vegetable in Java. Immature fruits of papaya are the rich source of papain and proteolytic enzyme which is helpful in digestion of protein, meat tenderizer and for medicinal and industrial purpose. The fruit is an excellent source of vitamin C and also contain vitamin A and minerals. A single 100 g serving of papaya would be sufficient to cover the daily nutritional requirements for one person. Thus, it holds a great economic potential.

The papaya has tremendous yielding potential due to precious bearing and indeterminate growth habit with simultaneous vegetative growth, flowering and fruiting. The yield of fruits is about 70-80 tonnes per hectare under proper management.

Madhu Bindu is dioecious cultivar of papaya. It is also known as Honey Dew and grown all over India as well as in Gujarat. The plant is of medium height and bears fruits quite heavily on the trunk. The proportion of the male plant is low. The fruit is large, elongated and contains a few seeds. The flesh is extra fine and sweet with pleasant flavor. The keeping quality of fruit is medium.

Propagation of papaya is done only through seeds as a viable option. Seed germination is affected by many factors, which include type of substrate used, environmental factors such as oxygen, water, temperature and light (Hartmann *et al.*, 2001). The germination of papaya seed is frequently reported

to be slow, erratic and is incomplete (Lange, 1961). The seed is enclosed within a gelatinous sarcotesta (aril or outer seed coat which is formed from the outer integument). This sarcotesta can prevent germination and dormancy is also observed in seeds from which the sarcotesta has been removed. However freshly extracted seeds show low germination due to presence of dormancy. But dried freshly extracted seeds results in increased germination. Pre-soaking the seeds in plant growth regulators and chemicals reported to promote germination (Riely, 1981). The significant role of chemical treatment through gibberellic acid, KNO_3, sodium thiosulphate and thiourea (Kadam, 1992) in relation to breaking dormancy, seed germination, growth and development of plant has been observed. Germination of papaya is improved by soaking the seeds in gibberellic acid (Nagao and Furtani, 1986).

Growing medium directly affects the development and later maintenance of the extensive functional rooting system. The most important physical properties of a medium for suitability are good aeration and drainage, optimum water conductivity and low bulk density (Carbrera, 2003). The quality of such media becomes very important because it determines the performance of the potted plant (William, 1975). Better performance can only be achieved using mixture of potting media. Mixed potting media improves internal porosity, for the roots to receive air, moisture and nutrients for good growth. The properties of different materials used as

growing substrates exhibit direct and indirect effect on plant physiology and production (Verdonck *et al*., 1981).

The soil is usually used a basic medium because it is cheapest and easy to procure. Supplementing of the sand is aimed to make media more porous. While the organic matter (vermicompost) is added so as to enrich adequate nutrients for the seedling. There is better relationship between the manure and rooting rather than conventional soil mix and less susceptibility of the seedling to soil borne pests and diseases (Akanbi *et al*. 2002). Vermicompost applied in the medium increased plant height, leaf area and dry weight of peppers, tomatoes and marigold (Arancon *et al*, 2004). Cocopeat is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes (Abad et al. 2002). Cocopeat has good physical properties, high water content, low shrinkage, low bulk density and slow biodegradation. The results of many experiments revealed that cocopeat used alone or as a component of soil medium is suitable for roses, gerbera, many potted plants and also for vegetables. (De Kreij and Leeuven, 2001; Pickering, 1997).

The delay in germination and poor seedling growth is often a handicap to the nurserymen and seed growers. Considering the above facts, the present investigation entitled “Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu” was carried out with following objectives.

1. To study the effect of different media on seed germination and seedling growth of papaya cv. Madhu Bindu.
2. To know the effect of seed treatment chemicals on seed germination and seedling growth of papaya cv. Madhu Bindu.
3. To determine the interaction effect of media and seed treatment chemicals on seed germination and seedling growth of papaya cv. Madhu Bindu.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The literature pertaining to the "Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu" has been reviewed in this chapter. The available literature has shown that very little research work has been conducted on this aspect in papaya. Therefore, literature pertaining to other relevant horticultural crop has been incorporated in this chapter.

2.1 Effect of seed treatment chemicals on seed germination and seedling growth:

Papaya

The experiment was conducted at Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.), during the year 2013-14 to study the seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Coorg Honey Dew as influenced by media and chemicals by Kumawat *et al.* (2014). They noted that the application of GA @ 150 ppm with the media soil + compost + cocopeat (1:1:1) was found superior for early as well as higher germination percentage, better shoot growth, better growth of tap root, secondary root production and chlorophyll content in seedling of papaya under drier tracts of subtropical area of Lucknow.

Anjanawe *et al.* (2013) studied the effect of plant growth regulators and growing media on seed germination and growth vigour of papaya seedling cv. Barwani Red at college of Horticulture, Mandasaur (M.P.). They noticed the maximum

seed germination (65.4%) under the application of 100 ppm GA_3 along with FYM: soil: sand (1:1:1). However, days for completion of germination (23.75), plant height (17.41 cm), stem diameter (0.441 cm), number of leaves per plant (10.42), average leaf area (41.28 cm^2), fresh weight of stem and leaves (13.45g), dry weight of stem and leaves (1.036 g) and number of lateral roots per primary roots (76.32) and length of the longest root (25.36 cm), were found superior with application of 200 ppm GA_3.

Padma Lay *et al.* (2013) conducted experiment at Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bangalore to investigate the effect of seed treatments on seed quality of papaya (*Carica papaya* L.) cv. Surya. They employed different treatments like, GA_3 (200, 300, and 400 ppm), KNO_3 (0.5%, 1%, 1.5% and 2%) for 12 hrs, 24 hrs, 36 hrs and 48 hrs and *Azotobacter chrococcum* treatments for 5, 10, 15 and 20 days. They recorded the highest germination (93%) when seeds were treated with GA_3 @ 300 ppm for 12 hrs. The maximum seedling dry weight (4.22 mg) was observed in the treatment comprising GA_3 @ 100 ppm for 36 hrs.

A field investigation was carried out by Deb *et al.* (2010) to identify a suitable treatment for getting better seed germination and seedling growth of papaya and observed that the maximum seed germination (72.2 %), seedling growth (52.30 cm seedling height and 5.18 cm seedling girth) with GA_3 200 ppm.

Anburani and Shakila (2010) conducted an experiment at Annamalai Nagar, Tamil Nadu to find out the influence of seed treatment on the enhancement of germination and seedling vigour of papaya cv. Local and the treatments included soaking the seeds in GA_3 (50,100 and 200 ppm), NAA (100 and 200 ppm) and thiourea (1000 and 2000 ppm) for 6 and 12 hours duration. The results revealed that seeds soaked in GA_3 @ 200 ppm for 12 h reduced the time taken for 50% germination, increased root and shoot length and vigour index followed by seed treatment with thiourea @ 2000 ppm for 12 h.

Barche *et al.* (2010) studied the response of seed treatment on germination of different cultivars of papaya and found that the maximum germination (78.50 %), seedling height (12.21 cm), stem diameter (0.27 cm), number of leaves (7.23), leaf area (24.84 cm^2), survival percentage (84.02 %) and minimum days (15) required for completion of germination were recorded under gibberellic acid at 500 ppm.

An experiment was carried out at Barapani, Meghalaya during 2001-02 to study the seed germination, seedling growth and vigour of papaya by Babu *et al.* (2010). The result revealed that GA_3 @ 100 ppm recorded the minimum period for germination (29.73 days). They also found that seeds soaking with GA_3 treatment had a significant effect in enhancing the seedling length and it was maximum with GA_3 @ 100 ppm (17.38 cm) as against control recording only 10.98 cm.

Sehrawat *et al.* (2010) carried out seed invigouration studies in papaya (*Carica papaya* L.) at Haryana Agricultural University, Hissar, Harya na to identify suitable priming treatments for freshly extracted and aged seeds. The fresh and 24 hrs accelerated aged seeds treated with 1000 ppm GA_3 showed significantly the highest germination percentage and exhibited maximum seedling length followed by 500 ppm GA_3. Similar trends were observed in case of accelerated aged seeds at 24 and 48 hrs. The fresh seeds and accelerated aged seeds at 24 and 48 hrs exhibited higher dry weight for seedlings.

Yogeesha *et al.* (2007) studied the effect of temperature and chemical pre-treatment on seed germination on papaya and revealed that GA_3 @ 200 ppm was found effective at 25º C in all cultivars with 85.0, 69.3 and 75.0 per cent germination in Surya, CO 2 and CO 7 respectively.

Sasikala and Srimathi (2006) investigated the influence of storage period and GA_3 on germination and vigour of papaya seeds cv. CO 2 at TNAU, Coimbatore, Tamil Nadu. The duration of storage was 5 months and the concentration of GA_3 used for breaking dormancy was 100, 200, 300, 400 and 500 ppm. The result revealed that fresh seed of papaya recorded low percentage of germination (9%) and the germination increased with storage period upto two months (92%) and thereafter it declined. Seed treatment with gibberellic acid at various concentrations had a positive association with germination and GA_3 @ 500 ppm recorded maximum germination and seedling quality characters.

Papaya cultivars Honey Dew, Coorg Honey Dew, Farm Selection-1 and Hybrid Madhu were subjected to pre sowing dip treatments of GA_3 at four different concentrations (25, 50, 100 and 200 ppm) for 24 hrs by Meena and Jain (2005). They noted that dipping papaya seeds in an aqueous solution of GA_3 @ 100 ppm for 24 hours significantly increased the seedling height (17.83 cm), stem diameter (0.417 cm), number of leaves (10.08), leaf area (23.02 cm^2) and fresh as well as dry weight of stem (11.54 g and 1.30 g respectively).

Palanisamy and Ramamoorthy (1987) studied the effect of GA_3 (100 and 500 ppm), KNO_3 (0.2%), thiourea (200 ppm) and citric acid (0.5%) on seed germination in papaya cv. CO 5. They observed that GA_3 @ 100 ppm was found most effective in breaking seed dormancy in papaya. It recorded the maximum germination percentage (98), shoot length (16.0 cm), root length (6.8 cm) and dry weight of seedlings (0.036 g) as compared to other chemicals and untreated control.

Aonla:

An investigation on seed germination of aonla was carried out at Marathwada Agricultural University, Parbhani during the year 2007- 08 by Manekar *et al.*, (2011). Among the various seed soaking treatments given to aonla seeds, GA_3 @ 200 ppm for 24 hour was found best for early germination and gave maximum germination percentage, survival percentage, longest tap root, plant height and highest number of leaves at 130 days after sowing.

Dabhi (2000) reported that various concentrations of GA_3 and thiourea significantly increased germination percentage in aonla. Among all the treatments under study, GA_3 @ 200 ppm was found most effective in reducing the number of days taken for initial germination (8.67) and highest germination percentage (78.0%) and seedling height (23.36 cm).

Aonla seeds of a local cultivar were soaked in water and different concentrations of GA_3 (250, 500 and 700 ppm), thiourea (0.5, 1.0 and 1.5%) and KNO_3 (0.5, 1.0 and 1.5%) solution for 24 hours. Pre-sowing seed treatment of 500 ppm GA_3 was found to be the most effective resulting in a significant increase in seed germination (75.50%), increase in seedling height (72.94), seedling girth (0.63 cm) and early germination (8 days) followed by 1% thiourea. (Rashmi Kumari *et al.*, 2007).

Rajamanickam *et al.* (2002) assessed the effect of chemicals and growth regulators on seed germination in aonla (*Emblica officinalis* G.). They recorded the highest germination (46.00 %) in one year old seeds treated with 200 ppm GA_3 for 8 hrs.

An experiment was conducted to study the effect of plant growth regulators on seed germination and seedling growth of aonla at Akola by Gholap *et al.* (2000). Amongst the three growth regulators tried GA_3 @ 200 ppm was observed significantly superior over all other treatments with respect to early initial germination, germination per cent, height, stem girth and number of roots per seedling at 60 days after sowing.

Citrus:

Patil *et al.* (2012) carried out an experiment to study the influence of some chemicals on germination and growth of Rangpur lime (*Citrus limonia* O.) seeds under shade net condition. Seeds were treated with different concentrations of GA_3 (50, 100 and 150 ppm), potassium nitrate (1.0, 1.5 and 2.0%) and thiourea (1.0, 1.5 and 2.0%). They observed that Rangpur lime seeds when treated with GA_3 @ 150 ppm recorded the highest germination (92.99%), shoot length (5.33 cm), root length (10.36 cm), fresh weight (96.25 mg), dry weight (14.68 mg) and seedling vigour index (705.19). It also registered the minimum days taken for germination (11.66).

An experiment was conducted on influence of gibberellic acid on seedling growth of *Khasi* mandarin by Pandey (1992). He noticed that freshly extracted seeds treated with GA_3 @ 50 ppm for 12 hour gave maximum germination percentage (84.50 %) in minimum duration (29.67 days) and better growth of seedlings with respect to shoot length, stem girth, number of leaves and girth of root.

Gupta (1989) carried out an experiment on effect of gibberellic acid on seed germination in lime at R.H.R.S., Udheywalla Jammu during 1988-89. He observed earliness in germination (52.33%) under GA_3 500 ppm and 36 hour soaking duration. He also found that with every increase in the concentration of GA_3 survival percentage of seedling was reduced singnificantly.

An investigation on effect of seed treatment in Ragpur lime was undertaken by Choudhari and Chakrawar (1982).

They reported that seeds soaked in 40 ppm GA_3 and NAA for 12 hour resulted in increased height of seedling, number of leaves, fresh and dry weight of shoot.

Misra *et al.* (1982) studied the effect of plant growth regulators and ascorbic acid on germination and growth of Malta seedlings (*Citrus sinensis* Osbeck). The freshly extracted seeds were separately treated with GA_3 (50, 100 and 200 ppm), IAA (25, 50 and 100 ppm) and ascorbic acid (25, 50 and 100 ppm) for 6, 12 and 18 hours, respectively. They found that GA_3 @ 200 ppm + 12 hours soaking treatment recorded the highest values for germination percentage (53.70), plant height (50.80 cm), number of leaves (55.16) and leaf area per plant (537.95 cm^2).

A study on citrus seed germination as affected by GA_3, IBA and KNO_3 was carried out at Allahabad Agricultural University, Naini. The result revealed that maximum germination percentage (61.30 %) in Jambheri was recorded when seeds were soaked in GA_3 @ 500 ppm for 24 hrs. (Singh *et al.,* 1979)

Karonda

Nimbalkar *et al.* (2012) carried out an experiment on effect of different seed treatments on germination and growth of karonda seedling at Dapoli and they observed that seeds soaked in GA_3 @ 100 ppm for 24 hrs resulted in maximum germination per cent, seedling height, seedling girth and number of leaves as compared to control.

Bankar (1987) evaluated the influence of gibberellic acid (25, 50, 75 and 100 ppm) on seed germination

and vigour of karonda (*Carissa carandas* L.) seedlings. He noted that seeds treated with GA_3 @ 100 ppm for 24 hours resulted in maximum germination percentage (68%). Whereas, seedling height was maximum (20.20 cm) under GA_3 @ 50 ppm.

Custard apple

A study was undertaken to analyse the effect of various concentrations of GA_3 and soaking period on seed germination of custard apple at Marathawada Agricultural University, Parbhani by Gharge *et al.* (2011). The results revealed that seed treatment of GA_3 at 400 ppm for 12 hrs gave maximum germination percentage and seedling height.

Sapota

Effect of growth regulators on germination of sapota seeds was studied by Farooqui *et al.* (1971) at Dharwad and revealed that maximum germination percentage was obtained when seed treated with GA_3 @ 50 ppm.

Guava

Studies on certain seed technological aspects in guava was carried out at college of Horticulture, Periyakulam by Kumar *et al.* (1991). They reported that seeds soaked in GA_3 @ 100 ppm improved germination as compared to control and also gave maximum root length (5.03 cm), shoot length (5.08 cm) and vigor index (60.0).

An experiment was conducted to find out the effect of pre-sowing seed treatments like water soaking, gibberellic

acid (1000, 2000 and 3000 ppm), thiourea (2000, 4000 and 6000 ppm), ethrel (2000 and 4000 ppm) and concentrated acid treatments (HCL and H_2SO_4) on germination of guava cv. Allahabad Safeda at Research Complex for North Eastern Himalaya Region, Meghalaya by Chandra and Govind (1990). They noted the highest germination (83.18%), plant height (13.15 cm) and number of leaves per plant (16.70) when seeds were soaked in GA_3 @ 3000 ppm for 12 hrs.

Jackfruit

Influence of growth regulators on germination of jackfruit (*Actocarpus heterophyllus* Lam.) seed was carried out at RHRS, NAU, Navsari by Prajapati Dixita (2013). She reported that seeds soaked for 12 hour and GA_3 100 mg/l gave maximum germination percentage with optimum vegetative growth and survival percentage of jack fruit seedling.

An investigation was carried out during 2010-2011 at Horticultural Research Station, Venkataramannagudem, Andhra Pradesh by Harshavardhan and Rajasekhar (2012) to study the effect of pre-sowing seed treatments on seedling growth of jackfruit. They found that soaking seeds in gibberellic acid @ 200 ppm for 24 hours recorded tallest seedlings with more absolute growth rate and less number of days taken for attaining graftable size.

Tamarind

Vasantha *et al.* (2014) evaluated the effect of growth regulators and biofertilizers on seed germination and seedling growth of tamarind (*Tamarindus indica* L.). They noticed that seeds subjected to mechanical scarification and

GA_3 @ 200 ppm showed the highest germination percentage (97.78%). The maximum plant height (40.57 cm), seedling girth (1.99 cm), number of leaves (49.40), fresh and dry weight of shoots (23.99 g and 8.07 g, respectively), fresh and dry weight of roots (7.90 g and 4.80 g, respectively), root length (41.67 cm), vigour index-I (8039.24) and vigour index-II (1260.61) were also recorded in GA_3 @ 200 ppm at 150 days after sowing.

Passion fruit

Gurung *et al.* (2014) investigated the effect of chemicals and growth regulators on germination, vigour and growth of passion fruit (*Passiflora edulis* Sims.). They used different treatments like water soaking, vermiwash (1:5), thiourea (1%), cow urine (1:1) and cow dung slurry for 24 hours, GA_3 (250 and 500 ppm) for 10 minutes with control. They found the maximum germination percentage (84) in thiourea (1%). Whereas, maximum seedling height, number of leaves, shoot length, root length, vigour index-I, vigour index-II, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight were recorded in GA_3 @ 500 ppm.

2.2 Effect of media on seed germination and seedling growth:

Media plays an important role in seed germination and subsequent vegetative growth of seedlings. Media has proved effective in several horticultural crops and considerable

research work has been carried out in this regard. The effect of media on seed germination and seedling growth has been workout by various workers under different agro-climatic conditions.

Papaya

Kumawat *et al.* (2014) studied the seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Coorg Honey Dew as influenced by different media and revealed that use of rooting media, soil + compost + cocopeat (1:1:1) was found superior for early as well as higher germination percentage, better shoot growth, better growth of tap root, secondary root production and chlorophyll content.

Anjanawe *et al.* (2013) conducted an experiment during 2009-10 at College of Horticulture, Mandsaur (M.P.) to study the effect of growing media on seed germination and growth vigour of papaya (*Carica papaya* L.) seedling cv. Barwani Red. They observed that maximum seed germination (65.4 %) and seedling growth under the media FYM: soil: sand (1:1:1).

The research was conducted at Sirohi by Bhardwaj (2013) to study the effect of growing media on seed germination and seedling growth of papaya cv. Red Lady. They observed that the medium of vermicompost + sand + pond soil (1:1:1) with 2 cm cocopeat on top of the poly bags gave maximum emergence, germination percentage (92.71 %), seed vigour (89.33) and minimum germination period (3.22 days). This medium was also found to be the best for papaya seedlings as it gave the highest value of growth parameters of seedling growth like seedling height (23.05 cm), stem

diameter (3.32 mm), root length (9.93 cm), root/ shoot ratio (0.24) and leaf area (339.26 cm^2).

Suketi and Imanda (2011) studied the influence of growing media on seed germination and seedlings growth of papaya (IPB 3, IPB 4 and IPB 9) genotypes. The highest seed germination (70 per cent) was observed in growing media soil, manure, rice husk and charcoal (1:1:1:1).

Okeyo and Ouma (2007) studied the effect of washing of seeds and rooting media in papaya (*Carica papaya* L.) seeds. They found the highest germination percentage and growth of papaya seedling with top soil used as rooting media and washing of seeds compared to without washing of seeds and other rooting media.

Effect of substrates, boron and humic acid on the growth of papaya was studied by Payan and William (2003) and pointed out that the best overall papaya seedling was found either in sandy soil + bovine manure (1:1) substrate, sandy soil + bovine manure + sphagnum moss (1:1:1), or coconut coir + bovine manure (1:1) substrate at 35 days after emergence.

Pomper *et al.* (2002) investigated the growth enhancement of container grown papaya seedlings as influenced by different rooting media type, root-zone temperature and fertilization regime and they concluded that among the different growing media, sand and sphagnum peat (1:1) was good for plant height, leaf number, dry weight of roots, dry weight of shoots and total plant weight.

Mango

Parasana *et al.* (2013) investigated the different growing media effect on germination and seedling growth of mango (*Mangifera indica* L.) under net house conditions. The results revealed that among the different growing media, soil + sand + FYM (2: 1: 1) was found to be the most effective for better germination of mango stone as well as growth of mango seedling with respect to height, number of leaves, length of root and shoot, stem girth, fresh and dry weight of seedlings and survival per cent of seedlings.

An experiment was conducted to study the effect of environmental condition, planting media and scion storage on epicotyl grafting of mango cv. Kesar at RHRS, NAU, Navsari by Abhilasha (2012). The result revealed that significantly maximum graft survived, leaf area and growth of grafts were recorded in laterite soil + cocopeat + vermicompost (1:1:1).

Savani (2009) studied the effect of growing condition, time of grafting and media on epicotyl grafting of mango cv. Kesar and observed that growing media of soil + FYM gave the highest number of graft survival, leaf area and growth of graft.

Kaur and Malhi (2006) carried out an experiment on effect of growing medium on the success of epicotyl grafting in mango at Punjab Agricultural University, Ludhiana and observed that highest sprouting of graft scion was recorded in soil + FYM + sand (1:1:1).

Citrus

Yadav (2012) studied the effect of media on germination and growth of acid lime (*Citrus aurantifolia* Swingle) with or without *Azotobacter*. He recorded higher height of seedling (13.75 cm), number of leaves per seedling (22.46), diameter of stem (3.35 mm), fresh weight (2.77 g) and dry weight of seedling (1.18 g) under the media combinations of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with *Azotobacter*.

Khan *et al.* (2006) studied the effect of different potting media on growth of rough lemon (*Citrus jambhiri* L.) rootstock and recorded maximum height of seedling, stem diameter and numbers of leaves per seedling when seed were raised in sand + soil (1:1).

An investigation was carried out at Barapani, Meghalaya to study the standardization of suitable potting media for raising seedling of *Khasi* mandarin by Govind and Chandra (1993). They observed that soil + Sand + FYM in equal ratio was found to be suitable potting medium for seedling vigour with fair amount of germination.

Aonla

Bharti *et al.* (2009) conducted an experiment on effect of growing media on seed germination, rate of seed germination, transplanting success and seedling mortality in aonla (*Emhlica officinalis* Garten.). They found that soil, sand and FYM (1:1:1) was best for highest percentage (74.00) of seed germination.

Custard apple

Chopde *et al.* (1999) recorded the higher shoot and root growth in the rooting media combination soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) in custard apple (*Anona squamosa* L.) as compared to rest of the media.

Pineapple

The research was conducted at the Aripan Experimental Field of Indonesian Tropical Fruit Research Institute to study the influence of media on pineapple seedling growth by Indriyani *et al.* (2011). The result showed that the medium of soil + manure (1:1) gave higher growth of the pineapple seedlings as it gave the highest parameters in terms of plant height, leaf length, leaf width, leaf numbers, and seedling wet weight than the other media consistently started from three months after planting.

Pomegranate

An investigation was carried out by Baghel and Saraswat (1989) to study the effect of different rooting media on the rooting & growth of hardwood cuttings of pomegranate (*Punica granatum* L.). They revealed that river silt was the best media for the maximum percentage of success as well as survival of cuttings, while soil + FYM proved superior for most of the shoot and root character of the cutting.

Phalsa

Baghel *et al.* (2004) studied the effect of biofertilizer and rooting media on rooting and growth of phalsa and recorded significantly highest percentage of success, survival

percentage, no. of leaves per shoot, total no. of leaves, length of root and diameter of root when river silt was used as rooting media followed by soil + sand + FYM and loam soil.

Walnut

Sharma and Dhuria (1981) studied the standardization of suitable media *viz*., saw dust, soil, FYM and soil for walnut propagation under controlled conditions. They observed higher success of graft and survival percentage under saw dust media compare to other media and control.

Nutmeg

Abirami *et al*. (2010) studied the nutmeg seeds germination to different nursery media at Calicut, Kerala and found maximum seed germination, seedling height, girth, number of leaves, shoot length and root length under media of soil: coir dust: sand: vermicompost in (1:1:1:1).

Litchi

Seed germination of *Litchi chinensis* Sonn. in different growing media *viz*. vermiculite, washed sand, filter paper, rice hull and sphagnum was studied by Andrade *et al*. (2011). The early and highest seed germination was observed with the combination of washed sand and rice hull used as a rooting media.

Peach

Kumar and Arora, (2007) reported 100 per cent survival of plantlets in earthen containers filled with media composited of vermicompost + sand + vermiculite + cocopeat with ratio 1:1:1:1 in peach crop.

An experiment was conducted to study the effect of different media on seed germination and seedling growth of peach by Rahman *et al.* (2007). They noted the highest per cent of seed germination (26.66%) in combination of saw dust + canal silt.

MATERIAL AND METHOD

III. MATERIAL AND METHODS

The details of experimental materials used, methods followed, observations taken and the techniques adopted during the course of the investigation on "Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu" are described in this chapter.

3.1 Experimental site

The present investigation was carried out at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during 2014-15.

3.2 Geographical Location

Geographically, Navsari which is situated at 20° 57' N latitude and 72° 54' E longitude and on altitude of about 10 meter above the mean sea level. This station is about 11 km away in the East from Arabian Sea shore, the historical place Dandi, famous for *Salt Satyagrah* in Indian freedom history. Navsari Agricultural University, Navsari is 3 km away from Navsari town.

3.3 Climate and Weather conditions

According to agro-climatic situation, Navsari falls in South Gujarat heavy rainfall zone-1. The climate of this zone is

Plate 1. General view of experimental site at 45 days after sowing

typically tropical, characterized by humid and warm monsoon with heavy rainfall, moderately cold winter and fairly hot and humid summer. In general monsoon commences by the second week of June and ceases by September end. The average annual rainfall of the tract is about 1500 mm. The rainfall is distributed over the entire *kharif* season but, the concentration of rain is more during the months of July and August. The winter season start from November and ends by the middle of February. The coldest months are December and January, whereas the hottest month is April.

The meteorological data for the period of this investigation recorded at meteorological observatory of the Navsari Agricultural University, Navsari are presented in the appendix I.

3.4 Source of seed

Healthy seeds of papaya cv. Madhu Bindu was obtained from Fruit Research Station, Junagadh Agricultural University, Junagadh, Gujarat.

3.5 Experiment Details

The experiment was laid out in Completely Randomized Design with Factorial concept using 4 media and 7 seed treatment chemicals at different concentrations comprising of 28 treatments combinations as shown in table 3.1.

1. **Experimental design** :Completely Randomized Design with factorial concept
2. **Crop/variety** :Papaya cv. Madhu Bindu
3. **Number of seeds/treatment** :30
4. **Treatment combinations** :28
5. **Number of repetitions** :3

6. Treatments:

Factor I: Media (M)

M_1	Red laterite soil + Vermicompost (1:1)
M_2	Red laterite soil + Cocopeat (1:1)
M_3	Red laterite soil + Vermicompost + Cocopeat (1:1:1)
M_4	Red laterite soil + Vermicompost + Sand (1:1:1)

Factor II: Chemical (C)

C_1	GA_3 100 mg/l for 12 h
C_2	GA_3 200 mg/l for 12 h
C_3	NAA 100 mg/l for 12 h
C_4	NAA 200 mg/l for 12 h
C_5	Thiourea 1000 mg/l for 12 h
C_6	Thiourea 2000 mg/l for 12 h
C_7	Without chemical (control)

Table- 3.1: Treatment combinations:

1.	$M_1 C_1$	15.	$M_3 C_1$
2.	$M_1 C_2$	16.	$M_3 C_2$
3.	$M_1 C_3$	17.	$M_3 C_3$
4.	$M_1 C_4$	18.	$M_3 C_4$
5.	$M_1 C_5$	19.	$M_3 C_5$
6.	$M_1 C_6$	20.	$M_3 C_6$
7.	$M_1 C_7$	21.	$M_3 C_7$
8.	$M_2 C_1$	22.	$M_4 C_1$
9.	$M_2 C_2$	23.	$M_4 C_2$
10.	$M_2 C_3$	24.	$M_4 C_3$
11.	$M_2 C_4$	25.	$M_4 C_4$
12.	$M_2 C_5$	26.	$M_4 C_5$
13.	$M_2 C_6$	27.	$M_4 C_6$
14.	$M_2 C_7$	28.	$M_4 C_7$

3.6 Preparation of Media

Four growing media were used in this experiment are as follows.

3.6.1 Red laterite soil + Vermicompost (1:1)

Equal proportion of red laterite soil and vermicompost in 1:1 ratio were mixed properly and filled in black polythene bag.

Red laterite soil

Vermicompost

Cocopeat

Sand

Plate 2. Different media under study

3.6.2 Red laterite soil + Cocopeat (1:1)

Equal proportion of red laterite soil and cocopeat in 1:1 ratio were mixed properly and filled in black polythene bag.

3.6.3 Red laterite soil + Vermicompost + Cocopeat (1:1:1)

Equal proportion of red laterite soil, vermicompost and cocopeat in 1:1:1 ratio were mixed properly and filled in black polythene bag.

3.6.4 Red laterite soil + Vermicompost + Sand (1:1:1)

Equal proportion of red laterite soil, vermicompost and sand in 1:1:1 ratio were mixed properly and filled in black polythene bag.

3.7 Preparation of seed treatment chemicals solution

3.7.1 GA_3

Papaya seeds were soaked in 100 and 200 ppm GA_3 solution for 12 h which were prepared by dissolving 100 and 200 ppm GA_3 (GA_3 was completely dissolved by addition of small quantity of NaOH pellets) in 1 liter of water.

3.7.2 NAA

Papaya seeds were soaked in 100 and 200 ppm NAA (Naphtalic Acetic Acid) solution for 12 h which were prepared by dissolving 100 and 200 ppm NAA (NAA was completely dissolved by addition of small quantity of NaOH pellets) in 1 liter of water.

GA_3

NAA

Thiourea

GA_3 100 and 200 mg/l for 12 h

NAA 100 and 200 mg/l for 12 h

Thiourea 1000 and 2000 mg/l for 12 h

Plate 3. Seed treatment to papaya seeds

Plate 4. Sowing of papaya seeds

3.7.3 Thiourea

Papaya seeds were soaked in 1000 and 2000 ppm thiourea solution for 12 h which were prepared by dissolving 1000 and 2000 mg thiourea (thiourea was completely dissolved by addition of small quantity of NaOH pellets) in 1 liter of water.

3.8 Sowing of Seed

Seeds were sown 1 cm deep in the poly bag of size 12×10 cm and 50 micron filled with prepared medium on 3rd May, 2014 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari. All the poly bags were kept under net house condition.

3.9 After care

The poly bags were watered daily with the help of watering cane during the period of experiment. Weeding was carried out at regular interval. Drenching of bavistin was done @ 1 g/l of water to get healthy seedling.

3.10 Observations Recorded:

The following observations were recorded during the experimental period. The observations pertaining to germination and vegetative growth characters viz. height of seedling, numbers of leaves per seedling and stem diameter were recorded at 10 days interval after 25 days of sowing for a total period of 45 days of experiment. While, the leaf area, chlorophyll content

in leaf, fresh weight of seedling, dry weight of seedling and root parameters were recorded once at the end of experiment.

3.10.1 Germination Attributes:

1. Days required for initiation of germination
2. Germination percentage

3.10.2 Growth Attributes:

1. Height of seedling (cm)
2. Number of leaves per seedling
3. Stem diameter (mm)
4. Leaf area (cm^2)
5. Fresh weight of seedling (g)
6. Dry weight of seedling (g)
7. Length of longest tap root (cm)
8. Diameter of tap root (mm)
9. Root/shoot ratio

3.10.3 Biological Analysis:

1. Chlorophyll content in leaf (mg/g)

3.11 Methodology used for observation:

(A) Germination Attributes:

1. Days required for initiation of germination:

In each treatment the day on which first germination of seed was initiated from the date of sowing considered as days required for initiation of germination. The number of days

required for initiation of germination was calculated.

2. Germination percentage:

After completion of entire germination the percentage of germination was calculated. The germinated seeds in each treatment were counted at an interval of two days and after completion of germination, the total numbers of germinated seeds were subtracted from total number of seeds sown and percentage of germination was calculated.

(B) Growth Attributes:

1. Height of seedling (cm):

Height of the seedling was measured at 25, 35 and 45 days after sowing from base to growing tip in centimeter with the help of meter scale. It was measured for all the five seedling which were tagged and later on averaged.

2. Number of leaves per seedling:

The total number of fully grown leaves per seedling was counted at 25, 35 and 45 days after sowing for all the five tagged seedlings and average was calculated.

3. Stem diameter (mm):

Stem diameter of five tagged seedling was measured separately with the help of digital verniear caliper at 25, 35 and 45 days after sowing the seed and average was calculated.

4. Leaf area (cm^2):

Leaf area was calculated using a leaf area meter in which 5 fully grown leaves were randomly selected from each tagged seedling and mean values were calculated and expressed in centimeter square.

5. Fresh weight of seedling (g):

Five seedlings were selected in each treatment and fresh weight was measured by electronic balance and average weight was calculated.

6. Dry weight of seedling (g):

The seedlings which were selected for fresh weight were dried in oven at 60^{o} C for 48 hours. After drying, the dry weight of seedling was measured by electronic balance and average weight calculated.

7. Length of longest tap root (cm):

The length of longest tap root was measured for five tagged seedlings from the point of initiation of roots to the tip of the root with the help of a meter scale and average length was calculated.

8. Diameter of the tap root (mm):

The diameter of tap root in each of five seedlings was measured near the point of initiation of root with the help of verniear caliper and average was calculated.

9. Root/shoot ratio:

The fresh weight of root and shoot were weighted separately and their ratio was calculated.

C. Biological analysis:

1. Chlorophyll content in leaf (mg/g):

Chlorophyll content of leaf was measured as per method suggested by Sadasivam and Manickam (1997). The details of procedure followed are mentioned here as under:

i. The representative sample of leaf was prepared by grinding it into a clean mortar. 1 g of finely grind leaves was weighted and well mixed.
ii. The sample was centrifuged (5000 rpm for 5 min.), by adding 20 ml of 80 % acetone and the supernatant was transferred to a 100 ml volumetric flask.
iii. The process of centrifuging was repeated until the appearance of colourless residue. The mortar and pestle was washed thoroughly with 80 % acetone to get the clear extract of leaves.
iv. The volume was made up to 100 ml with 80 % acetone.
v. The absorbance of the solution was read at 645, 663 and 652 nm against the blank solution of 80 % acetone.

The amount of chlorophyll present in the extract was calculated using the following equations-

Total chlorophyll mg/g tissue =

$$20.2(A645) – 8.02\ (A663) \times V/1000 \times W$$

Where-

A= Absorbance at specific wavelength

V= Final volume of chlorophyll extract in 80 % acetone

W= Fresh weight of tissue extracted

3.9 Statistical analysis:

The data pertaining to various investigations on germination and growth of papaya seedlings were subjected to statistical analysis in the Department of Agricultural Statistics, N.M. College of Agriculture, Navsari as per CRD with Factorial concept suggested by Panse and Sukhatme (1967). The significance of various treatment effects was judged with the help of “F” value (test) at 5% level of significance. The critical difference was calculated to assess the significant differences between treatment means.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The present investigation entitled "Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu" was carried out at Regional Horticultural Research Station, Navsari Agricultural University, Navsari during the year 2014-2015. The data collected during experimentation on various parameters were subjected to statistical analysis using Completely Randomized Design with Factorial concept. The results along with statistical inferences are presented in this chapter.

The results are presented under the following heads:

4.1 Germination Attributes:

4.1.1. Days required for initiation of germination

4.1.2. Germination percentage (%)

4.2 Growth Attributes:

4.2.1. Height of seedling (cm)

4.2.2. Number of leaves per seedling

4.2.3. Stem diameter (mm)

4.2.4. Leaf area (cm^2)

4.2.5. Fresh weight of seedling (g)

4.2.6. Dry weight of seedling (g)

4.2.7. Length of the longest tap root (cm)

4.2.8. Diameter of tap root (mm)

4.2.9. Root/shoot ratio

4.3 Biological analysis:

4.3.1. Chlorophyll content in leaf (mg/g)

4.1 Germination Attributes:

4.1.1 Days required for initiation of germination

The data on days required for initiation of germination of papaya seed as influenced by different media, seed treatment chemicals and their interaction are presented in table 4.1 and depicted through fig. 4.1.

4.1.1.1 Effect of media on days required for initiation of germination

The number of days required for initiation of germination of papaya seed was significantly affected by different media (table 4.1). The media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) required minimum number of days (6.83) for initiation of germination. The maximum number of days (8.52) for initiation of germination was recorded in media red laterite soil + vermicompost (1:1) (M_1).

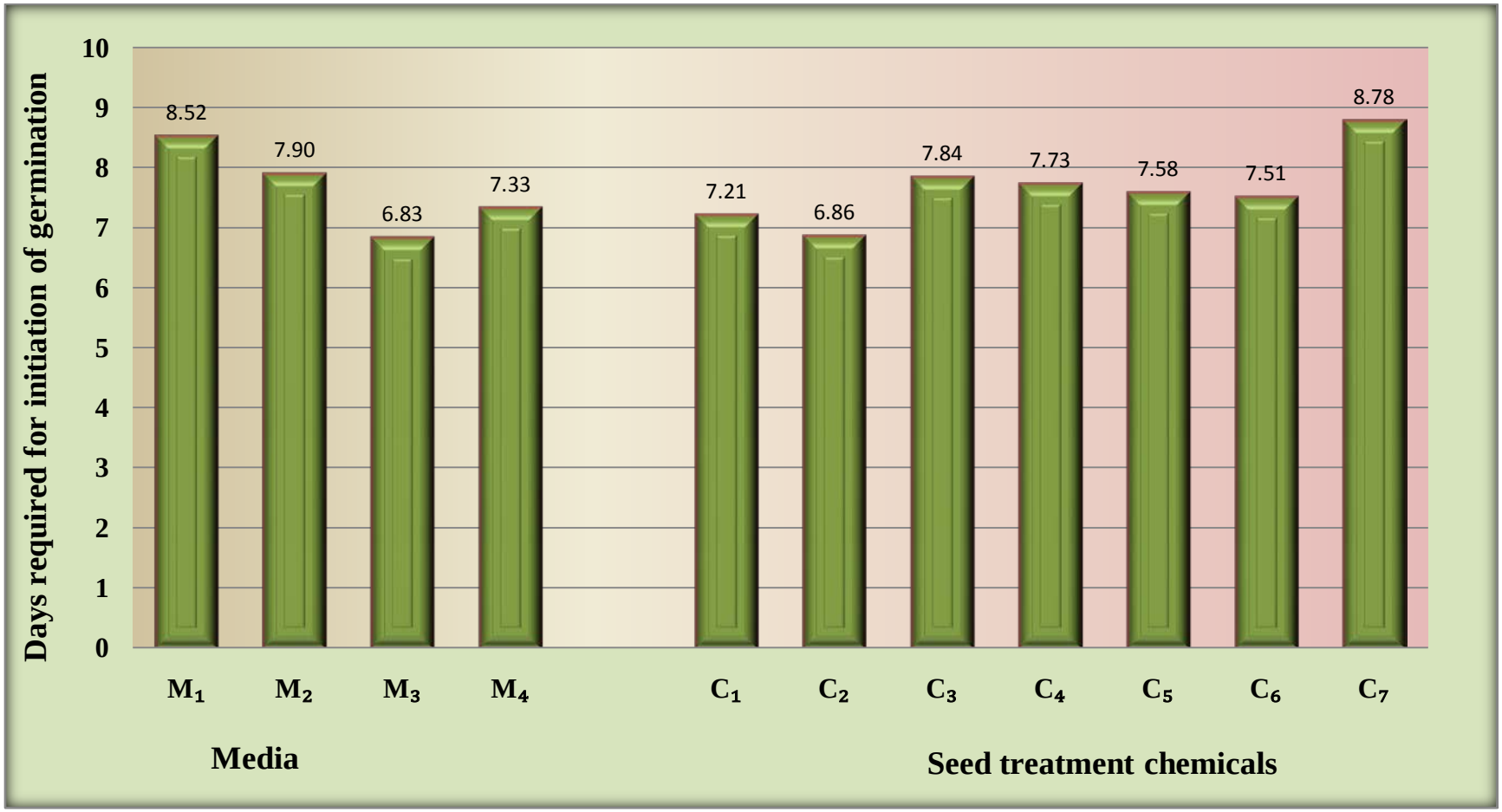
4.1.1.2 Effect of different seed treatment chemicals on days required for initiation of germination

The perusal of data presented in table 4.1 clearly indicated that the number of days taken for initiation of seed germination was significantly altered by use of different

Table 4.1: Effect of media and seed treatment chemicals on days required for initiation of germination of papaya seed cv. Madhu Bindu

Treatments	Days required for initiation of germination
Media	
M_1 (Red laterite soil + vermicompost)	8.52
M_2 (Red laterite soil + cocopeat)	7.90
M_3 (Red laterite soil + vermicompost + cocopeat)	6.83
M_4 (Red laterite soil + vermicompost + sand)	7.33
S.Em. $\pm$	0.084
C. D. at 5 %	0.238
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	7.21
C_2 (GA_3 200 mg/l for 12 h)	6.86
C_3 (NAA 100 mg/l for 12 h)	7.84
C_4 (NAA 200 mg/l for 12 h)	7.73
C_5 (Thiourea 1000 mg/l for 12 h)	7.58
C_6 (Thiourea 2000 mg/l for 12 h)	7.51
C_7 (Control)	8.78
S.Em. $\pm$	0.111
C. D. at 5 %	0.315
Interaction M × C	
S.Em. $\pm$	0.223
C. D. at 5 %	NS
C. V. %	5.05

Fig. 4.1-Effect of media and seed treatment chemicals on days required for initiation of germination of papaya seed cv. Madhu Bindu



chemicals. Significantly the minimum number of days taken for initiation of seed germination (6.86) was recorded when papaya seeds were treated with GA_3 200 mg/l (C_2). Whereas, the significantly maximum number of days taken for initiation of germination (8.78) was noted in control (C_7).

4.1.1.3 Interaction effect of media and seed treatment chemicals on days required for initiation of germination

The interaction effect of media and seed treatment chemicals failed to produce any significant differences on days required for initiation of seed germination in papaya.

4.1.2. Germination percentage (%)

The data regarding germination percentage of papaya seeds as affected by different media, seed treatment chemicals and their interaction have been presented in table 4.2 and graphically depicted in fig 4.2.

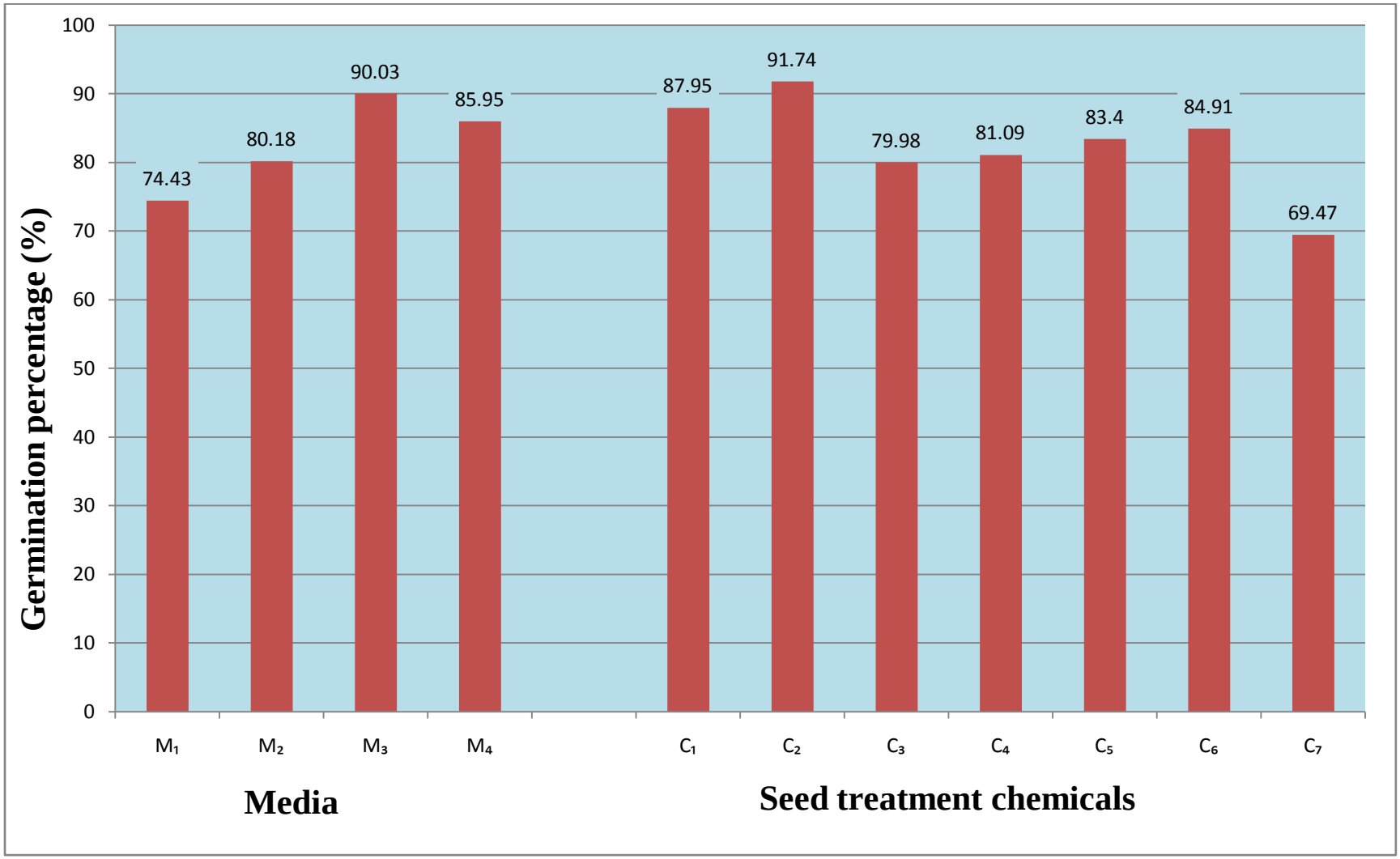
4.1.2.1 Effect of media on germination percentage

It is evident from the table 4.2 that the germination percentage of papaya seeds was significantly influenced by different media. Significantly the maximum germination percentage (90.03) of papaya seeds was found in treatment red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) which was followed by the treatment red laterite soil + vermicompost + sand (1:1:1) (M_4). The minimum germination percentage (74.43) was noted in media red laterite soil + vermicompost (1:1) (M_1).

Table 4.2: Effect of media and seed treatment chemicals on seed germination percentage of papaya cv. Madhu Bindu

Treatments	Germination percentage (%)
Media	
M_1 (Red laterite soil + vermicompost)	74.43
M_2 (Red laterite soil + cocopeat)	80.18
M_3 (Red laterite soil + vermicompost + cocopeat)	90.03
M_4 (Red laterite soil + vermicompost + sand)	85.95
S.Em. $\pm$	0.647
C. D. at 5 %	1.834
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	87.95
C_2 (GA_3 200 mg/l for 12 h)	91.74
C_3 (NAA 100 mg/l for 12 h)	79.98
C_4 (NAA 200 mg/l for 12 h)	81.09
C_5 (Thiourea 1000 mg/l for 12 h)	83.40
C_6 (Thiourea 2000 mg/l for 12 h)	84.91
C_7 (Control)	69.47
S.Em. $\pm$	0.856
C. D. at 5 %	2.426
Interaction M × C	
S.Em. $\pm$	1.712
C. D. at 5 %	4.851
C. V. %	3.59

Fig. 4.2-Effect of media and seed treatment chemicals on seed germination percentage of papaya cv. Madhu Bindu



4.1.2.2 Effect of seed treatment chemicals on germination percentage

The germination percentage of papaya seeds was significantly affected by different seed treatment chemicals. Significantly the maximum average germination percentage (91.74) was found with GA_3 200 mg/l (C_2) which was followed by GA_3 100 mg/l (C_1). Whereas significantly the minimum germination per cent (69.47) was observed in without control (C_7).

4.1.3.3 Interaction effect of media and seed treatment chemicals on germination percentage

The interaction effect of media and seed treatment chemicals (table 4.2(a)) was also found significant with respect to germination percentage. The maximum germination percentage (97.38) was recorded with media red laterite soil + vermicompost + cocopeat (1:1:1) + GA_3 200 mg/l (M_3C_2) which was statastically at par with treatments red laterite soil + vermicompost + cocopeat (1:1:1) + GA_3 100 mg/l (M_3C_1), red laterite soil + vermicompost + cocopeat (1:1:1) + Thiourea 1000 mg/l (M_3C_5) and red laterite soil + vermicompost + cocopeat (1:1:1) + Thiourea 2000 mg/l (M_3C_6). The minimum germination percentage (64.00) was noted in treatment combination of media red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7).

Table 4.2 (a): Interaction effect of media and seed treatment chemicals on seed germination percentage of papaya cv. Madhu Bindu

Media/chemical	M_1	M_2	M_3	M_4
C_1	84.20	84.27	94.99	88.34
C_2	86.27	90.84	97.38	92.46
C_3	68.90	75.01	90.53	85.47
C_4	70.48	76.74	91.27	85.88
C_5	71.16	82.22	92.75	87.48
C_6	76.02	82.61	93.47	87.53
C_7	64.00	69.54	69.82	74.49
S.Em. $\pm$		1.712		
C. D. at 5 %		4.851		
C. V. %		3.59		

4.2 Growth Attributes:

4.2.1 Height of seedling (cm)

The data pertaining to height of papaya seedlings as influenced by different media, seed treatment chemicals and their interaction are presented in table 4.3 and graphically depicted through fig. 4.3.

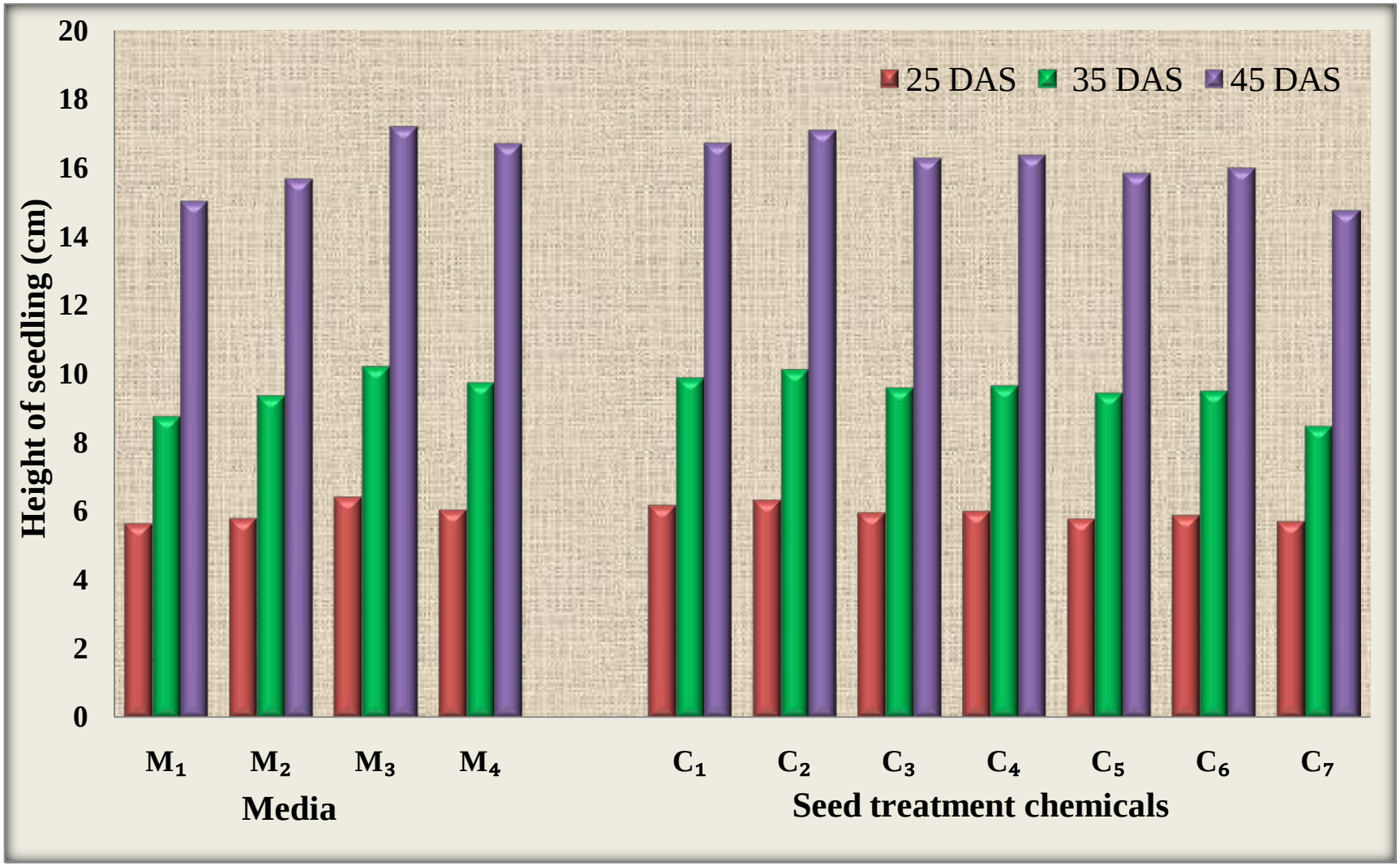
4.2.1.1 Effect of media on height of seedling (cm)

The height of papaya seedling was affected by different media and found significant at all the stages of growth *i.e.* 25, 35 and 45 days after sowing. The media consisting of red laterite soil + vermicompost + cocopeat (1:1:1) *i.e.* M_3 resulted in maximum height (6.41 cm) of seedling after 25 days of sowing which was significantly higher over all other media while, the minimum height of seedling (5.63 cm) was noted in media red laterite soil + vermicompost (1:1) (M_1) at 25 days. At 35 and 45 days after seed sowing significantly the maximum

Table 4.3: Effect of media and seed treatment chemicals on height of papaya seedlings cv. Madhu Bindu

Treatments	**Height of seedling (cm)**		
Media	**25 DAS**	**35 DAS**	**45 DAS**
M_1 (Red laterite soil + vermicompost)	5.63	8.77	15.04
M_2 (Red laterite soil + cocopeat)	5.79	9.37	15.68
M_3 (Red laterite soil + vermicompost + cocopeat)	6.41	10.22	17.22
M_4 (Red laterite soil + vermicompost + sand)	6.02	9.74	16.71
S.Em. $\pm$	0.049	0.080	0.115
C. D. at 5 %	0.140	0.228	0.325
Seed treatment chemicals			
C_1 (GA_3 100 mg/l for 12 h)	6.16	9.88	16.73
C_2 (GA_3 200 mg/l for 12 h)	6.31	10.13	17.11
C_3 (NAA 100 mg/l for 12 h)	5.95	9.59	16.29
C_4 (NAA 200 mg/l for 12 h)	5.99	9.66	16.39
C_5 (Thiourea 1000 mg/l for 12 h)	5.77	9.44	15.85
C_6 (Thiourea 2000 mg/l for 12 h)	5.87	9.51	16.00
C_7 (Control)	5.69	8.47	14.77
S.Em. $\pm$	0.065	0.106	0.152
C. D. at 5 %	0.185	0.301	0.430
Interaction M × C			
S.Em. $\pm$	0.131	0.213	0.303
C. D. at 5 %	0.371	0.603	0.860
C. V. %	3.80	3.87	3.25

Fig. 4.3-Effect of media and seed treatment chemicals on height of papaya seedling cv. Madhu Bindu



Treatment M_3C_1

Treatment M_3C_2

Plate 5. Papaya seedling height

height of seedling (10.22 cm and 17.22 cm) was observed in the media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3). The minimum height of seedling at the same stages of growth 35 and 45 days after seed sowing (8.77 cm and 15.04 cm) was recorded in media red laterite soil + vermicompost (1:1) (M_1).

4.2.1.2 Effect of seed treatment chemicals on height of seedling (cm)

It is apparent from the data given in table 4.3 that height of seedling was significantly influenced by different seed treatment chemicals at 25, 35 and 45 days after sowing. After 25 days of sowing, the maximum height of seedling (6.31 cm) was found with treatment of GA_3 200 mg/l (C_2) which was statistically at par with treatment GA_3 100 mg/l (C_1). Whereas minimum height of seedling (5.69 cm) was observed in without chemical-control (C_7). This trend was continued at 35 and 45 days of sowing of seeds with maximum height of seedlings (10.13 cm and 17.11 cm) obtained in treatment GA_3 200 mg/l (C_2) which was statistically at par with treatment GA_3 100 mg/l (C_1) and minimum height of seedlings (8.47 cm and 14.77 cm) obtained in without chemical-control (C_7).

4.2.1.3 Interaction effect of media and seed treatment chemicals on height of seedling (cm)

The interaction of media and seed treatment chemicals had the significant effect on height of seedlings at every stage of observation *i.e.* 25, 35 and 45 days after sowing which are shown in table 4.3 (a), table 4.3 (b) and table 4.3 (c). At 25 days after seed sowing the maximum height of seedling (6.70 cm) was noted in treatment combination of rooting media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200

mg/l (M_3C_2) which was statistically at par with treatment M_3C_1, M_3C_3, M_3C_4, M_3C_6 and M_4C_2. While, the minimum seedling height (5.15 cm) was observed in the treatment combination of media red laterite soil + vermicompost + sand (1:1:1) with without chemical-control (M_4C_7). The maximum height of seedling was noticed in same treatment M_3C_2 (11.17 cm) at 35 days after sowing of seeds which was statistically at par with treatment M_3C_1. While, the minimum height of seedling (8.26 cm) was recorded in the treatment media red laterite soil + vermicompost + sand (1:1:1) and without chemical-control (M_4C_7) after 35 days of sowing. At the last date of observation *i.e.* 45 days of sowing the maximum height of seedling (18.31 cm) was observed with media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) which was at par with treatment M_3C_1, M_3C_3, M_3C_4, M_4C_1 and M_4C_2 and the minimum height of seedling (14.46 cm) in the treatment combination of media red laterit soil + vermicompost (1:1) and without chemical-control (M_1C_7).

Table 4.3 (a): Interaction effect of media and seed treatment chemicals on height of papaya seedling at 25 days after sowing.

Media/chemical	M_1	M_2	M_3	M_4
C_1	5.95	5.88	6.59	6.22
C_2	5.99	6.19	6.70	6.35
C_3	5.44	5.76	6.47	6.12
C_4	5.47	5.79	6.52	6.20
C_5	5.34	5.67	6.05	6.02
C_6	5.36	5.71	6.33	6.09
C_7	5.89	5.51	6.21	5.15
S.Em. $\pm$			0.131	
C. D. at 5 %			0.371	
C. V. %			3.80	

Table 4.3 (b): Interaction effect of media and seed treatment chemicals on height of papaya seedling at 35 days after sowing

Media/chemical	M_1	M_2	M_3	M_4
C_1	9.05	9.63	10.67	10.16
C_2	9.12	9.90	11.17	10.34
C_3	8.75	9.36	10.36	9.90
C_4	8.82	9.39	10.45	9.97
C_5	8.60	9.18	10.25	9.74
C_6	8.68	9.24	10.29	9.82
C_7	8.35	8.92	8.36	8.26
S.Em. $\pm$		0.213		
C. D. at 5 %		0.603		
C. V. %		3.87		

Table 4.3 (c): Interaction effect of media and seed treatment chemicals on height of papaya seedling at 45 days after sowing

Media/chemical	M_1	M_2	M_3	M_4
C_1	15.35	16.07	18.02	17.49
C_2	15.83	16.53	18.31	17.76
C_3	15.23	15.62	17.65	16.64
C_4	14.96	15.75	17.79	17.07
C_5	14.66	15.35	17.00	16.37
C_6	14.76	15.49	16.86	16.90
C_7	14.46	14.93	14.94	14.73
S.Em. $\pm$		0.303		
C. D. at 5 %		0.860		
C. V. %		3.25		

4.2.2 Number of leaves per seedling

The data related to the effect of media, seed treatment chemicals and their interaction on number of leaves per seedling at all the stages of growth *i.e.* 25, 35 and 45 days after seed sowings are presented in table 4.4 and depicted through fig. 4.4.

4.2.2.1 Effect of media on number of leaves per seedling

It is apparent from data presented in table 4.4 that there was significant difference with respect to number of leaves per seedling for different media at all the stages of growth *i.e.* 25, 35 and 45 days after sowing. After 25 days of sowing the media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) exhibited significantly the maximum number of leaves per seedling (6.05) while significantly, the least number of leaves per seedling (4.87) was found in media red laterite soil + vermicompost (1:1) (M_1). At 35 days after sowing of seed, the same media (M_3) continued to exhibit significantly the maximum number of leaves per seedling (8.61). The minimum number of leaves per seedling (7.31) was observed with the use of media (M_1) red laterite soil + vermicompost (1:1). At the last date of observations *i.e.* 45 days of sowing significantly the maximum number of leaves (13.34) was recorded in the media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) while, the least number of leaves per seedling (11.03) was noted in the media red laterite soil + vermicompost (1:1) (M_1).

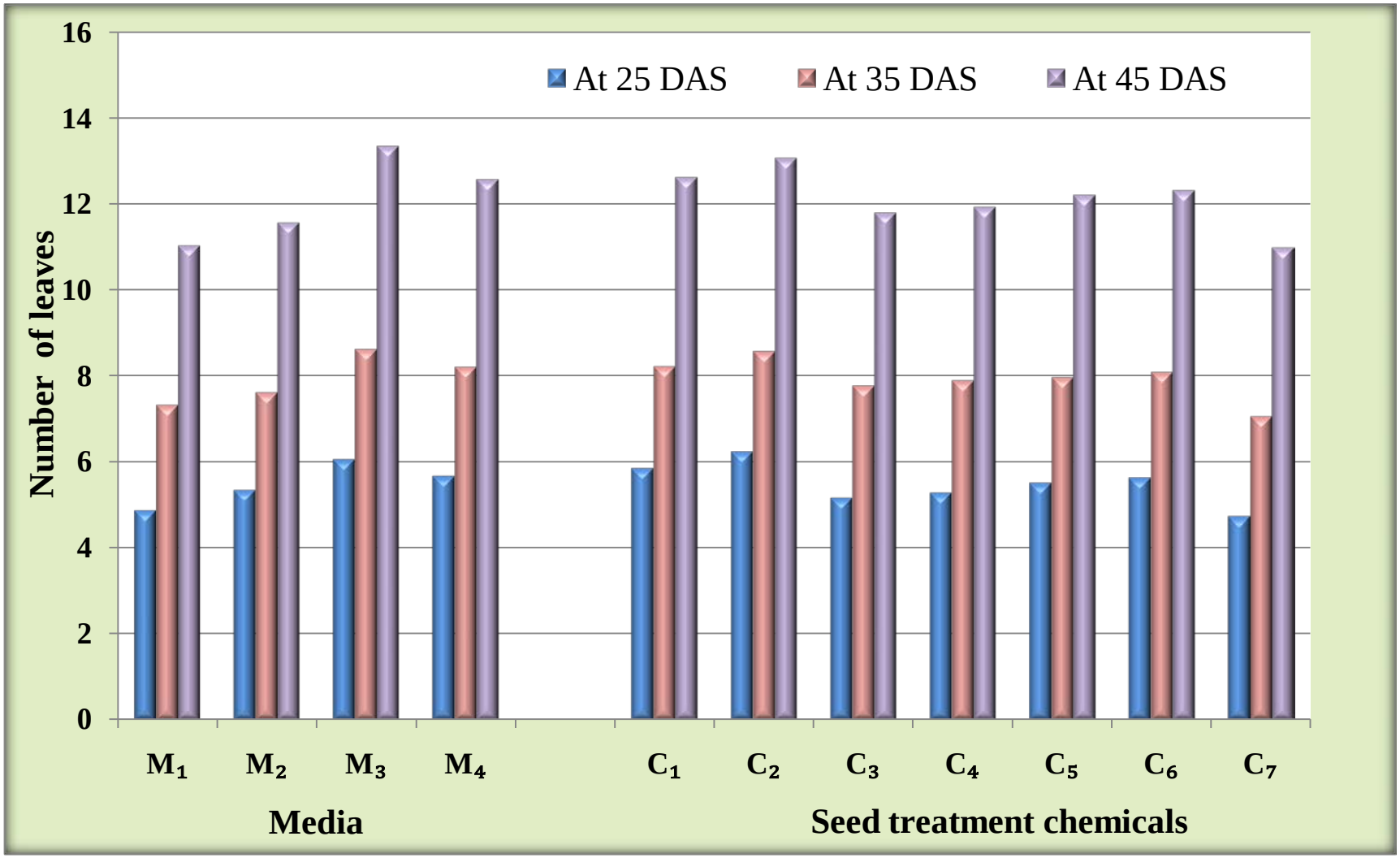
4.2.2.2 Effect of seed treatment chemicals on number of leaves per seedling

There was a significant impact of seed treatment chemicals on the number of leaves of papaya seedling at all the stages of growth *viz*., 25, 35 and 45 days of sowing (table 4.4). After 25 and 45 days of sowing significantly the more number of leaves (6.23 and 13.06) were counted in the treatment GA_3 200

Table 4.4: Effect of media and seed treatment chemicals on number of leaves of papaya seedling cv. Madhu Bindu

Treatments	**Number of leaves**		
Media	**25 DAS**	**35 DAS**	**45 DAS**
M_1 (Red laterite soil + vermicompost)	4.87	7.31	11.03
M_2 (Red laterite soil + cocopeat)	5.34	7.60	11.56
M_3 (Red laterite soil + vermicompost + cocopeat)	6.05	8.61	13.34
M_4 (Red laterite soil + vermicompost + sand)	5.66	8.19	12.57
S.Em. $\pm$	0.050	0.112	0.103
C. D. at 5 %	0.141	0.318	0.291
Seed treatment chemicals			
C_1 (GA_3 100 mg/l for 12 h)	5.85	8.21	12.61
C_2 (GA_3 200 mg/l for 12 h)	6.23	8.56	13.06
C_3 (NAA 100 mg/l for 12 h)	5.15	7.76	11.79
C_4 (NAA 200 mg/l for 12 h)	5.27	7.88	11.92
C_5 (Thiourea 1000 mg/l for 12 h)	5.51	7.95	12.21
C_6 (Thiourea 2000 mg/l for 12 h)	5.63	8.07	12.31
C_7 (Control)	4.73	7.04	10.98
S.Em. $\pm$	0.066	0.149	0.136
C. D. at 5 %	0.186	0.422	0.385
Interaction M × C			
S.Em. $\pm$	0.132	0.298	0.272
C. D. at 5 %	0.372	NS	0.770
C. V. %	4.16	6.51	3.88

Fig. 4.4-Effect of media and seed treatment chemicals on number of leaves of papaya seedling cv. Madhu Bindu



mg/l (C_2) and significantly the least number of leaves per seedling (4.73 and 10.98) were noted in without chemical-control (C_7). At 35 days after sowing the maximum number of leaves (8.56) was recorded when seeds was treated with GA_3 200 mg/l which was statistically at par with the treatment GA_3 100 mg/l (C_1), whereas lowest number of leaves (7.04) was found in without chemical-control (C_7).

4.2.2.3 Interaction effect of media and seed treatment chemicals on number of leaves per seedling

The interaction of media and seed treatment chemicals significantly affected the number of leaves per seedling at 25 and 45 days after sowing. Whereas at 35 days after sowing, the result of interaction was found non significant (table 4.4). At 25 days after sowing significantly the maximum number of leaves per seedling (6.88) was counted in the treatment combination of media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2). The minimum number of leaves per seedling (4.36) was recorded in treatment combination of media red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7) (table 4.4 (a)). After 45 days of seed sowing the maximum number of leaves per seedling (14.28) was noted in the same treatment M_3C_2 which was statically at par with the treatments M_3C_1 and M_3C_6. The least number of leaves per seedling (10.53) was observed in the treatment media red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7) (table 4.4 (b)).

Table 4.4 (a): Interaction effect of media and seed treatment chemicals on number of leaves of papaya seedling at 25 days after sowing

Media/chemical	M_1	M_2	M_3	M_4
C_1	5.31	5.73	6.43	5.91
C_2	5.60	5.94	6.88	6.49
C_3	4.38	4.92	5.90	5.38
C_4	4.38	5.20	5.85	5.66
C_5	5.01	5.26	6.11	5.65
C_6	5.02	5.47	6.19	5.84
C_7	4.36	4.86	5.00	4.68
S.Em. ±		0.132		
C. D. at 5 %		0.372		
C. V. %		4.16		

Table 4.4(b): Interaction effect of media and seed treatment chemicals on number of leaves of papaya seedling at 45 days after sowing

Media/chemical	M_1	M_2	M_3	M_4
C_1	11.50	11.48	14.00	13.45
C_2	11.87	12.58	14.28	13.50
C_3	10.59	10.91	13.34	12.31
C_4	10.66	11.24	13.41	12.35
C_5	10.99	11.79	13.43	12.65
C_6	11.09	11.90	13.52	12.72
C_7	10.53	10.98	11.44	10.99
S.Em. ±		0.272		
C. D. at 5 %		0.770		
C. V. %		3.88		

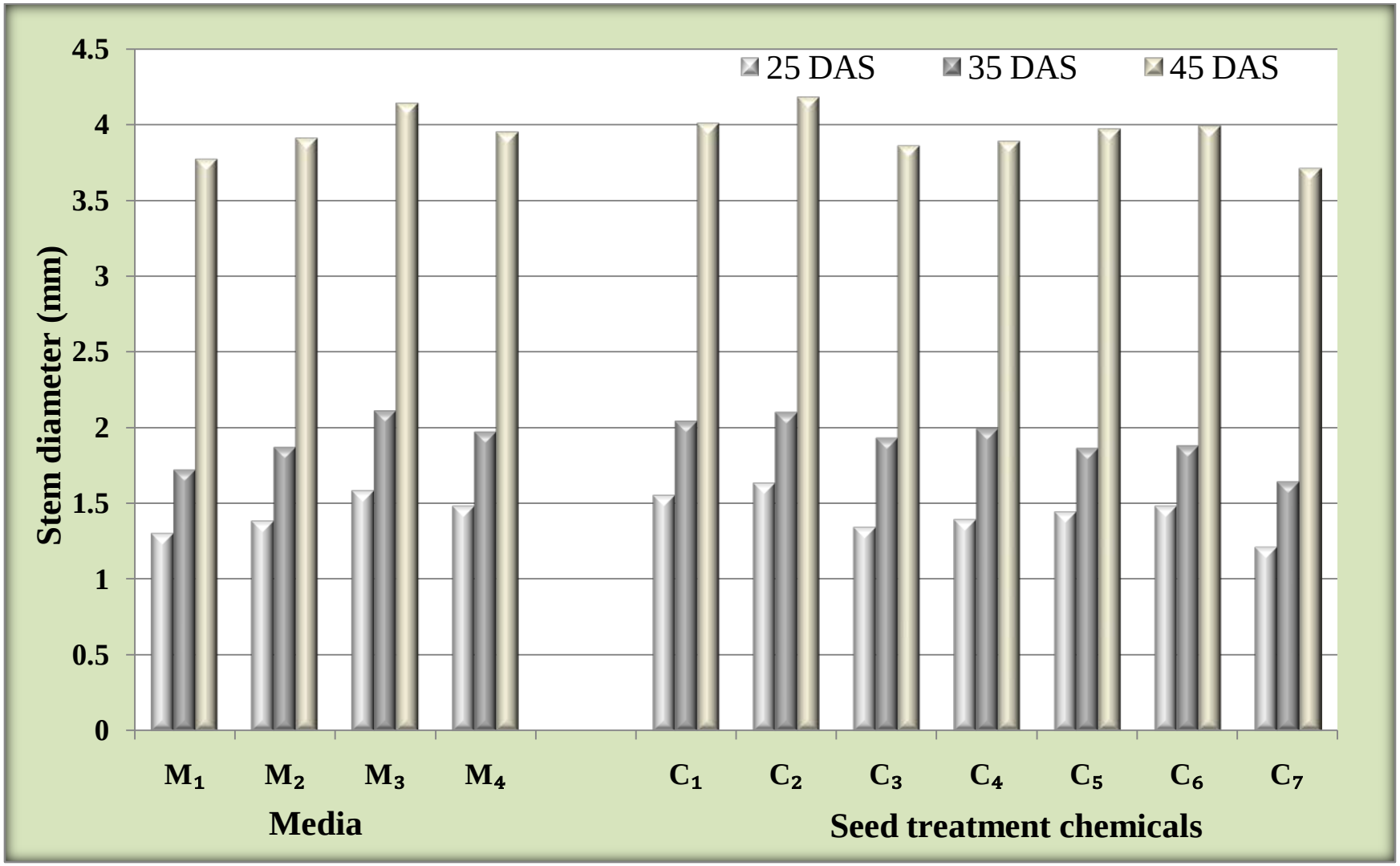
4.2.3 Stem diameter (mm)

The data indicating the stem diameter of papaya seedling as influenced by different treatments containing media, seed treatment chemicals and their interaction at all the days of observation *i.e.* 25, 35 and 45 days after sowing of seed are

Table 4.5: Effect of media and seed treatment chemicals on stem diameter of papaya seedling cv. Madhu Bindu

Treatments	Stem diameter (mm)		
Media	**25 DAS**	**35 DAS**	**45 DAS**
M_1 (Red laterite soil + vermicompost)	1.30	1.72	3.77
M_2 (Red laterite soil + cocopeat)	1.38	1.87	3.91
M_3 (Red laterite soil + vermicompost + cocopeat)	1.58	2.11	4.14
M_4 (Red laterite soil + vermicompost + sand)	1.48	1.97	3.95
S. Em. ±	0.015	0.015	0.039
C. D. at 5 %	0.042	0.042	0.110
Seed treatment chemicals			
C_1 (GA_3 100 mg/l for 12 h)	1.55	2.04	4.01
C_2 (GA_3 200 mg/l for 12 h)	1.63	2.10	4.18
C_3 (NAA 100 mg/l for 12 h)	1.34	1.93	3.86
C_4 (NAA 200 mg/l for 12 h)	1.39	1.99	3.89
C_5 (Thiourea 1000 mg/l for 12 h)	1.44	1.86	3.97
C_6 (Thiourea 2000 mg/l for 12 h)	1.48	1.88	3.99
C_7 (Control)	1.21	1.64	3.71
S. Em. ±	0.020	0.020	0.051
C. D. at 5 %	0.056	0.055	0.145
Interaction M × C			
S. Em. ±	0.039	0.039	0.102
C. D. at 5 %	NS	0.110	NS
C. V. %	4.73	3.51	4.50

Fig. 4.5-Effect of media and seed treatment chemicals on stem diameter of papaya seedling cv. Madhu Bindu



presented in table 4.5 and graphically depicted in fig 4.5.

4.2.3.1 Effect of media on stem diameter (mm)

It is evident from the data given in table 4.5 that stem diameter was significantly influenced by different media at 25, 35 and 45 days after sowing. At 25, 35 and 45 days after seed sowing significantly the maximum stem diameter (1.58 mm, 2.11 mm and 4.14 mm) was observed with the media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) and the minimum stem diameter (1.30 mm, 1.72 mm and 3.77 mm) of papaya seedling was recorded in the media red laterite soil + vermicompost (M_1).

4.2.3.2 Effect of seed treatment chemicals on stem diameter (mm)

There were significant differences in stem diameter of papaya seedling at 25, 35 and 45 days after sowing with respect to different seed treatment chemicals. After 25, 35 and 45 days of seed sowing significantly the maximum stem diameter of seedling (1.63 mm, 2.10 mm and 4.18 mm) was observed when seeds treated with GA_3 200 mg/l (C_2) as compared to (1.21 mm, 1.64 mm and 3.71 mm) without chemical treatment (control) on same day of observation.

4.2.3.3 Interaction effect of media and seed treatment chemicals on stem diameter (cm)

The combinations of media and seed treatment chemicals did not have any significant effect on the stem

diameter of papaya seedling at 25 and 45 days after sowing. Whereas at 35 days after sowing it was found significant. After 35 days of sowing significantly the maximum seedling diameter (2.37 mm) was measured in treatment combination of red laterite soil + vermicompost + cocopeat (1:1:1) with GA_3 200 mg/l (M_3C_2) whereas minimum stem diameter (1.52 mm) was found in treatment combination of red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7) (table 4.5 (a)).

Table 4.5 (a) Interaction effect of media and seed treatment chemicals on stem diameter of papaya seedling at 35 days after sowing

Media/chemical	M_1	M_2	M_3	M_4
C_1	1.83	1.98	2.19	2.14
C_2	1.86	2.01	2.37	2.16
C_3	1.78	1.93	2.14	1.89
C_4	1.81	1.96	2.17	2.01
C_5	1.63	1.78	2.09	1.94
C_6	1.65	1.81	2.11	1.96
C_7	1.52	1.65	1.70	1.68
S.Em. $\pm$		0.039		
C. D. at 5 %		0.110		
C. V. %		3.51		

4.2.4. Leaf area (cm^2)

The leaf area (cm^2) of papaya seedlings as influenced by different media, seed treatment chemicals and their interaction are presented in table 4.6 and graphically depicted through fig. 4.6.

4.2.4.1 Effect of media on leaf area (cm^2)

Leaf area was significantly altered due to media and significantly larger leaf area (113.92 cm^2) was noted in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) and minimum leaf area (71.16 cm^2) was recorded in media red laterite soil + vermicompost (M_1) at the end of experiment.

4.2.4.2 Effect of seed treatment chemicals on leaf area (cm^2)

It is seen from the data that seed treatment with different chemicals significantly affected on leaf area. The maximum leaf area (113.35 cm^2) of papaya seedling was noted in treatment GA_3 200 mg/l (C_2) which was significantly higher as compared to without chemical-control (71.02 cm^2) (C_7).

4.2.4.3 Interaction effect of media and seed treatment chemicals on leaf area (cm^2)

The interaction of media and seed treatment chemicals appeared to have significant effect on leaf area (table 4.6 (a)). Significantly the maximum leaf area (136.16 cm^2) of papaya seedling was noted in the media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) while the lowest leaf area (58.54 cm^2) was recorded in treatment red laterite soil + vermicompost (1:1) and NAA 100mg/l (M_1C_3).

Table 4.6: Effect of media and seed treatment chemicals on leaf area of papaya seedling cv. Madhu Bindu

Treatments	Leaf area (cm^2)
Media	
M_1 (Red laterite soil + vermicompost)	71.16
M_2 (Red laterite soil + cocopeat)	88.41
M_3 (Red laterite soil + vermicompost + cocopeat)	113.92
M_4 (Red laterite soil + vermicompost + sand)	101.16
S.Em. $\pm$	0.854
C. D. at 5 %	2.421
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	103.96
C_2 (GA_3 200 mg/l for 12 h)	113.35
C_3 (NAA 100 mg/l for 12 h)	83.77
C_4 (NAA 200 mg/l for 12 h)	89.48
C_5 (Thiourea 1000 mg/l for 12 h)	94.76
C_6 (Thiourea 2000 mg/l for 12 h)	99.30
C_7 (Control)	71.02
S.Em. $\pm$	1.130
C. D. at 5 %	3.203
Interaction M × C	
S.Em. $\pm$	2.261
C. D. at 5 %	6.405
C. V. %	4.18

Fig. 4.6-Effect of media and seed treatment chemicals on leaf area of papaya seedling cv. Madhu Bindu

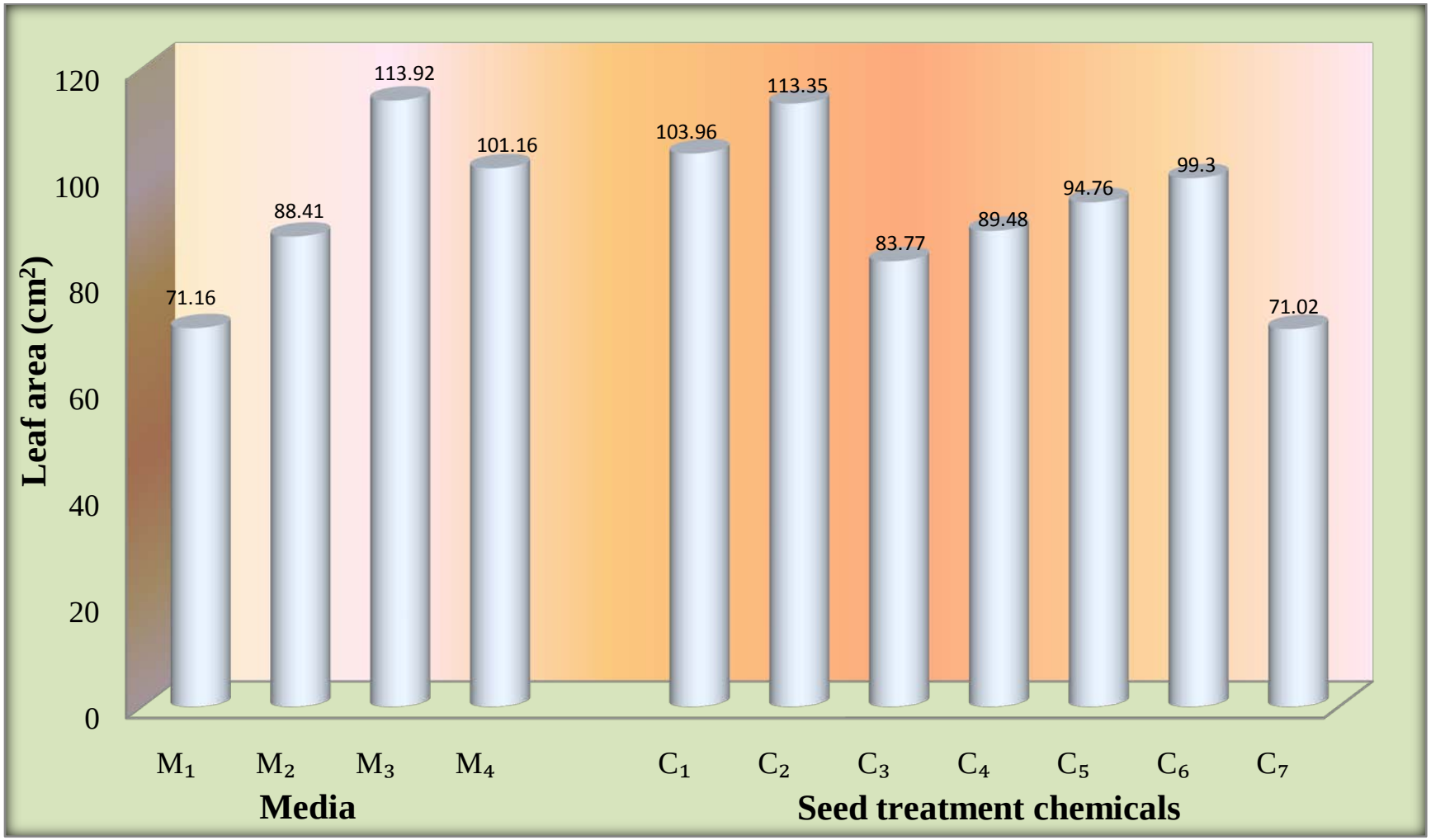


Table 4.6 (a): Interaction effect of media and seed treatment chemicals on leaf area of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	79.98	94.30	127.94	113.62
C_2	88.20	102.52	136.16	126.52
C_3	58.54	82.86	106.48	87.18
C_4	66.76	91.08	109.62	90.45
C_5	67.10	86.12	120.08	105.74
C_6	75.32	89.64	123.28	108.96
C_7	62.22	72.33	73.88	75.67
S.Em. ±		2.261		
C. D. at 5 %		6.405		
C. V. %		4.18		

4.2.5. Fresh weight of seedling (g)

The data concerning the effect of different media, different seed treatment chemicals and their interaction on fresh weight of papaya seedling are presented in table 4.7 and graphically depicted through fig. 4.7.

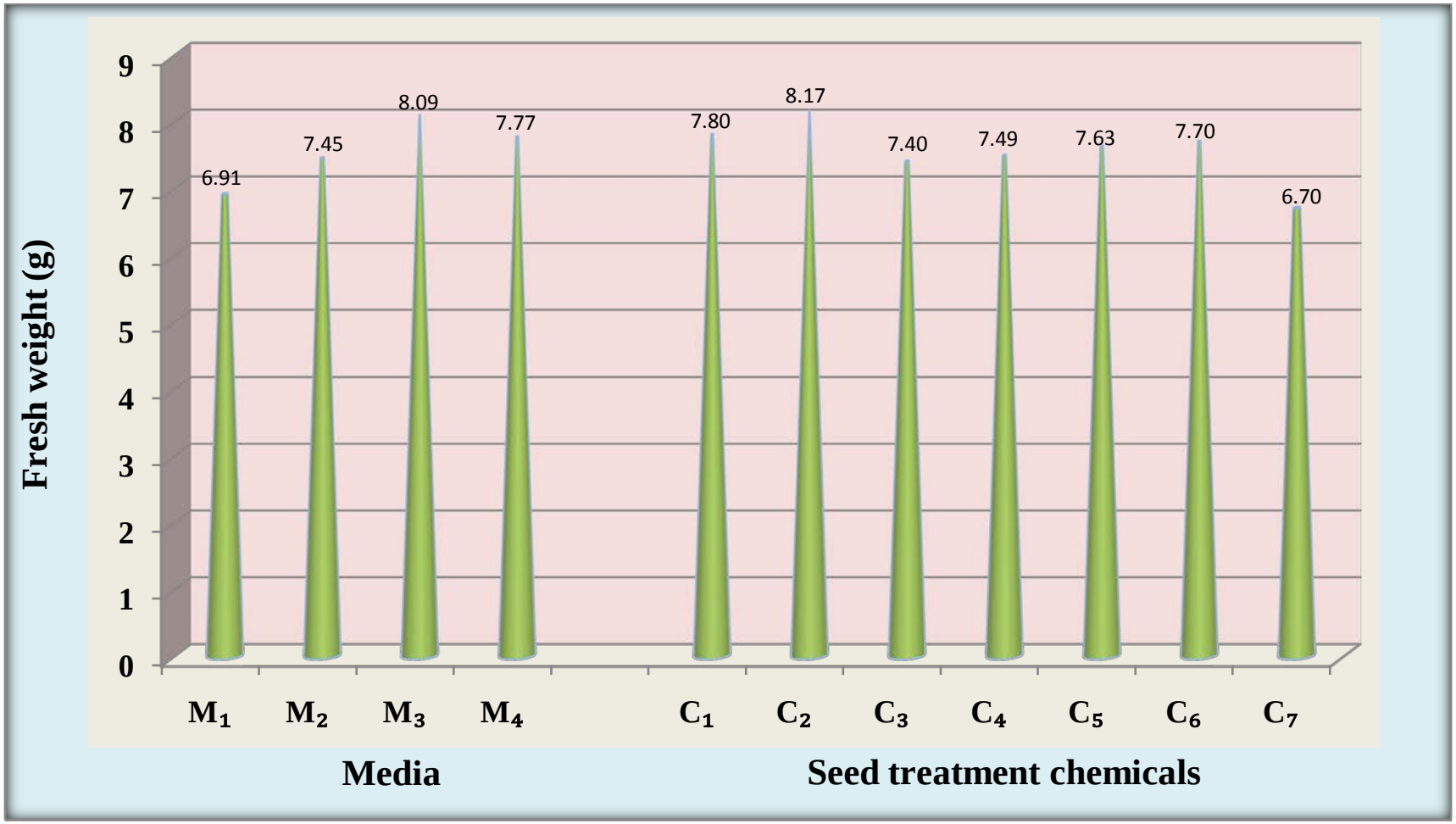
4.2.5.1 Effect of media on fresh weight of seedling (g)

The perusal of data presented in table 4.7 clearly indicated that fresh weight of papaya seedling was significantly influenced by different media. Significantly the maximum fresh weight of papaya seedling (8.09 g) was recorded in media consisting of red laterite soil + vermicompost + cocopeat (1:1:1) (M_3). While, the minimum fresh weight (6.91 g) was noted in media red laterite soil + vermicompost (1:1) (M_1).

Table 4.7: Effect of media and seed treatment chemicals on fresh weight of papaya seedling cv. Madhu Bindu

Treatments	Fresh weight (g)
Media	
M_1 (Red laterite soil + vermicompost)	6.91
M_2 (Red laterite soil + cocopeat)	7.45
M_3 (Red laterite soil + vermicompost + cocopeat)	8.09
M_4 (Red laterite soil + vermicompost + sand)	7.77
S.Em. $\pm$	0.069
C. D. at 5 %	0.194
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	7.80
C_2 (GA_3 200 mg/l for 12 h)	8.17
C_3 (NAA 100 mg/l for 12 h)	7.40
C_4 (NAA 200 mg/l for 12 h)	7.49
C_5 (Thiourea 1000 mg/l for 12 h)	7.63
C_6 (Thiourea 2000 mg/l for 12 h)	7.70
C_7 (Control)	6.70
S.Em. $\pm$	0.091
C. D. at 5 %	0.257
Interaction M × C	
S.Em. $\pm$	0.181
C. D. at 5 %	0.514
C. V. %	4.16

Fig. 4.7-Effect of media and seed treatment chemicals on fresh weight of papaya seedling cv. Madhu Bindu



4.2.5.2 Effect of seed treatment chemicals on fresh weight of seedling (g)

Regarding the effect of different seed treatment chemicals, significantly the maximum fresh weight of seedling (8.17 g) was weighted when papaya seeds were treated with GA_3 200 mg/l. Whereas, the least fresh weight of seedling (6.70 g) was recorded in without chemical treated seedling (control) (C_7).

4.2.5.3 Interaction effect of media and seed treatment chemicals on fresh weight of seedling (g)

Data indicated that the fresh weight of papaya seedling was positively influenced due to the interaction effect of media and seed treatment chemicals (table 4.7 (a)). The result indicated that the treatment combination of M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l) were found better with respect to fresh weight of seedling (8.93 g). However it was statistically at par with the treatment combination M_3C_1 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 100 mg/l). The lowest fresh weight (6.48 g) was recorded under the treatment combination M_1C_7 (red laterite soil + vermicompost (1:1) and without chemical-control).

Table 4.7 (a): Interaction effect of media and seed treatment chemicals on fresh weight of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	6.66	7.76	8.63	8.15
C_2	7.40	7.95	8.93	8.38
C_3	6.97	7.36	7.73	7.54
C_4	6.88	7.24	7.91	7.93
C_5	6.95	7.41	8.38	7.79
C_6	7.03	7.48	8.36	7.94
C_7	6.48	6.98	6.69	6.64
S.Em. $\pm$		0.181		
C. D. at 5 %		0.514		
C. V. %		4.16		

4.2.6. Dry weight of seedling (g)

The dry weight of papaya seedlings was influenced by different media, seed treatment chemicals and their interaction are shown in table 4.8 and graphically depicted through fig. 4.8.

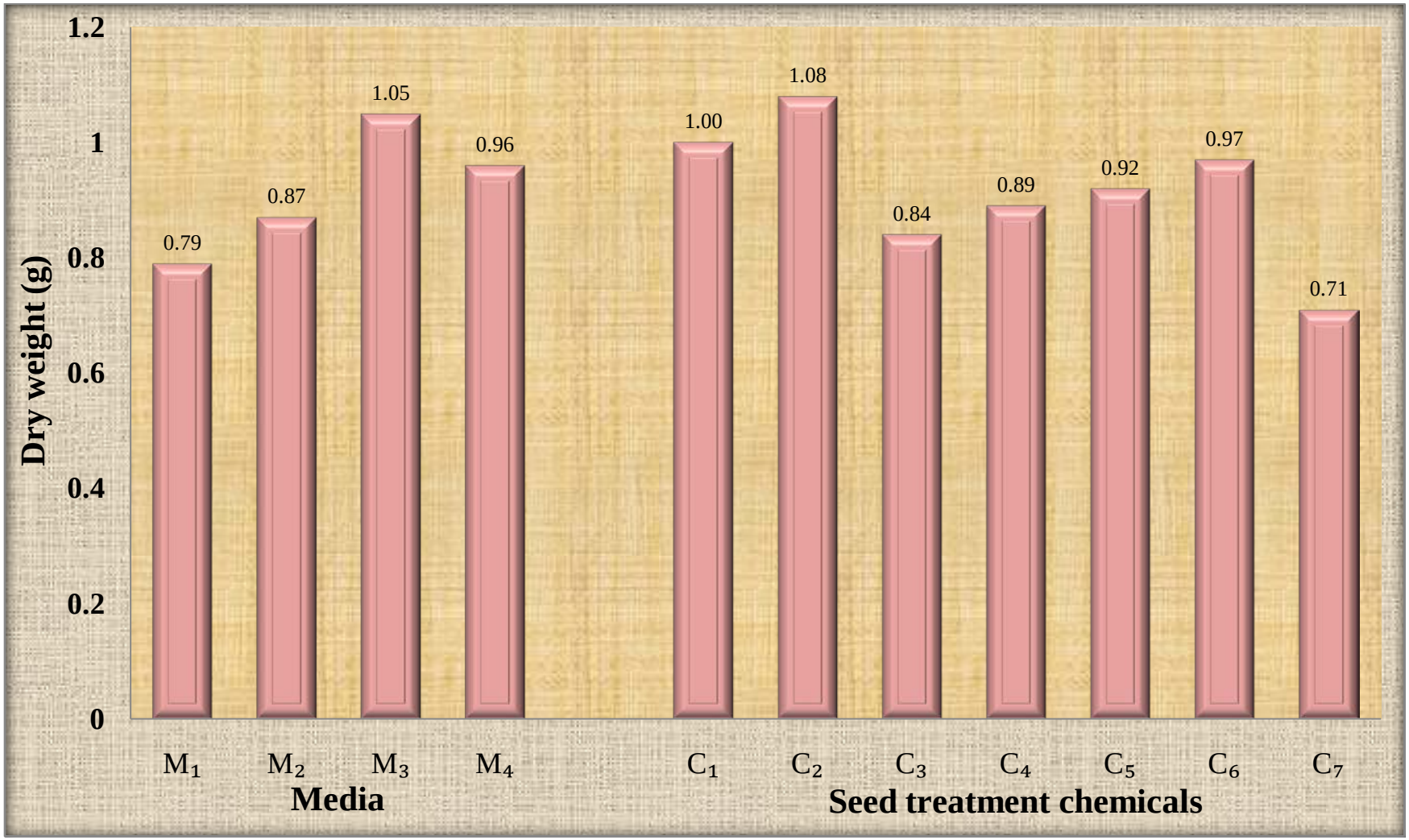
4.2.6.1 Effect of media on dry weight of seedling (g)

The dry weight of papaya seedling as affected by different media revealed that it had significant effect on dry weight of papaya seedling. Significantly the maximum dry weight of papaya seedling (1.05 g) was noted when seeds were sown in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3). The minimum dry weight of seedling (0.79 g) was recorded when seeds were sown in red laterite soil + vermicompost (1:1) (M_1).

Table 4.8: Effect of media and seed treatment chemicals on dry weight of papaya seedling cv. Madhu Bindu

Treatments	Dry weight (g)
Media	
M_1 (Red laterite soil + vermicompost)	0.79
M_2 (Red laterite soil + cocopeat)	0.87
M_3 (Red laterite soil + vermicompost + cocopeat)	1.05
M_4 (Red laterite soil + vermicompost + sand)	0.96
S.Em. $\pm$	0.009
C. D. at 5 %	0.026
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	1.00
C_2 (GA_3 200 mg/l for 12 h)	1.08
C_3 (NAA 100 mg/l for 12 h)	0.84
C_4 (NAA 200 mg/l for 12 h)	0.89
C_5 (Thiourea 1000 mg/l for 12 h)	0.92
C_6 (Thiourea 2000 mg/l for 12 h)	0.97
C_7 (Control)	0.71
S.Em. $\pm$	0.012
C. D. at 5 %	0.035
Interaction M × C	
S.Em. $\pm$	0.024
C. D. at 5 %	0.069
C. V. %	4.61

Fig. 4.8-Effect of media and seed treatment chemicals on dry weight of papaya seedling cv. Madhu Bindu



4.2.6.2 Effect of seed treatment chemicals on dry weight of seedling (g)

The data regarding dry weight of papaya seedling presented in table 4.8 indicated significant differences due to different seed treatment chemicals. Significantly the maximum dry weight of papaya seedling (1.08 g) was observed when seed treated with GA_3 200 mg/l (C_2) while minimum dry weight (0.71 g) was noted in without chemical-control (C_7).

Table 4.8 (a): Interaction effect between media and seed treatment chemicals on dry weight of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	0.82	0.96	1.15	1.06
C_2	0.99	1.01	1.22	1.12
C_3	0.69	0.78	1.02	0.88
C_4	0.71	0.80	1.04	0.99
C_5	0.83	0.85	1.04	0.95
C_6	0.80	0.95	1.11	1.00
C_7	0.67	0.71	0.74	0.73
S.Em. $\pm$			0.024	
C. D. at 5 %			0.069	
C. V. %			4.61	

4.2.6.3 Interaction effect of media and seed treatment chemicals on dry weight of seedling (g)

The dry weight of papaya seedling was significantly influenced by interaction effect of media and seed treatment chemicals (table 4.8 (a)). The maximum dry weight (1.22 g) of papaya seedling was weighted in the treatment red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2)

which was statistically at par with treatment M_3C_1. The minimum dry weight of seedling (0.67 g) was noted in the treatment red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7).

4.2.7. Length of the longest tap root (cm)

The data regarding the length of longest tap root of papaya seedling as affected by different media, seed treatment chemicals and their interaction are presented in table 4.9 and graphically depicted through fig. 4.9.

4.2.7.1 Effect of media on the length of longest tap root (cm)

The data on length of longest tap root of seedling as affected by different media revealed that it had significant effect on length of longest tap root. The seedling grown in media consisting of red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) had showed maximum length of longest tap root (11.48 cm) which was significantly maximum over all other treatments. The minimum length of tap root (9.33 cm) was observed in the media red laterite soil + vermicompost (1:1) (M_1).

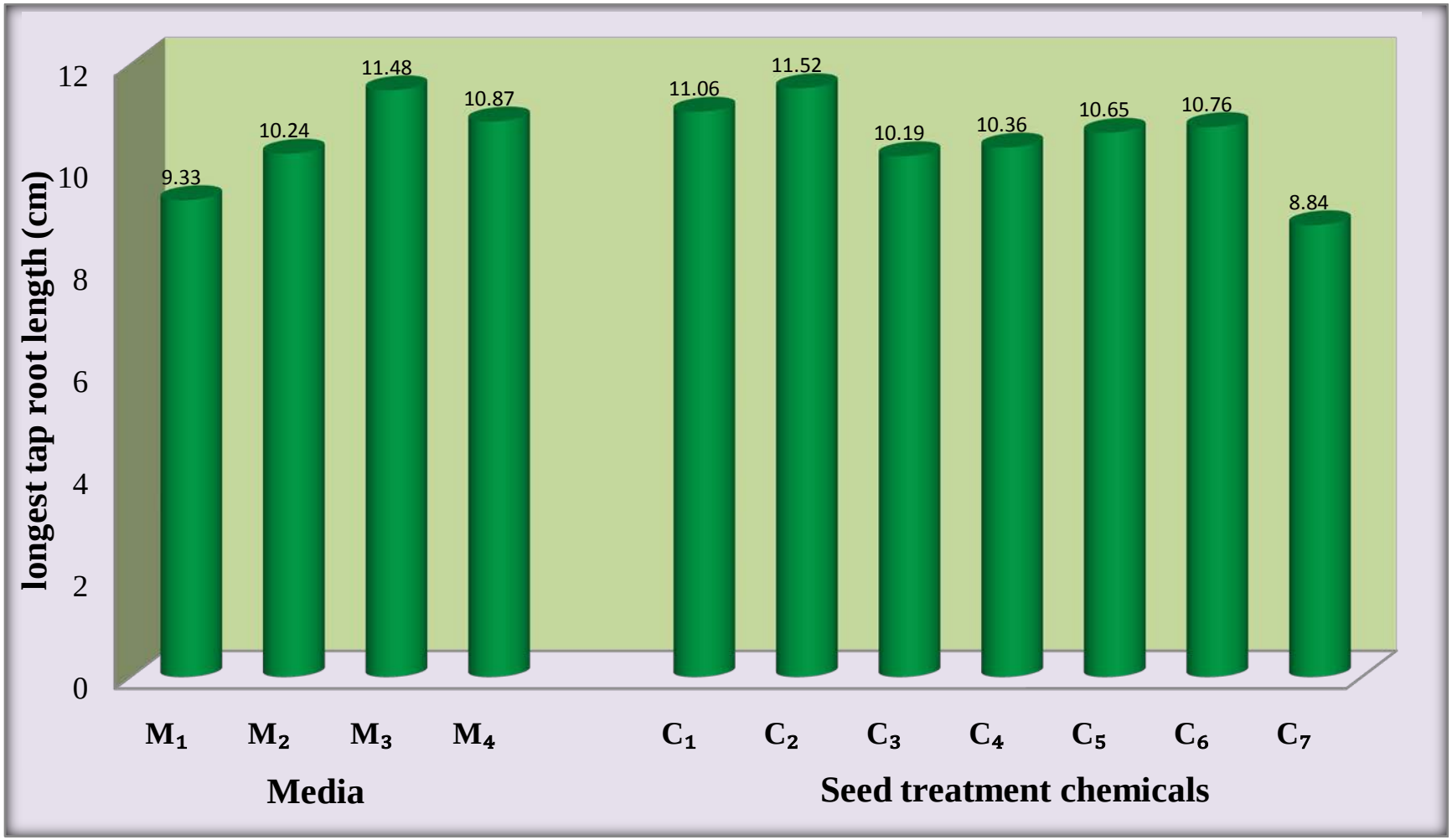
4.2.7.2 Effect of seed treatment chemicals on the length of longest tap root (cm)

Seed treatment with different chemicals gave a significant effect on the length of longest tap root. Significantly the maximum length of longest tap root (11.52 cm) was noted with the seed treatment of GA_3 200 mg/l (C_2) whereas significantly the minimum length of longest tap root (8.84 cm) was observed in without chemical treatment (control) (C_7).

Table 4.9: Effect of media and seed treatment chemicals on length of longest tap root of papaya seedling cv. Madhu Bindu

Treatments	Tap root length (cm)
Media	
M_1 (Red laterite soil + vermicompost)	9.33
M_2 (Red laterite soil + cocopeat)	10.24
M_3 (Red laterite soil + vermicompost + cocopeat)	11.48
M_4 (Red laterite soil + vermicompost + sand)	10.87
S.Em. $\pm$	0.098
C. D. at 5 %	0.278
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	11.06
C_2 (GA_3 200 mg/l for 12 h)	11.52
C_3 (NAA 100 mg/l for 12 h)	10.19
C_4 (NAA 200 mg/l for 12 h)	10.36
C_5 (Thiourea 1000 mg/l for 12 h)	10.65
C_6 (Thiourea 2000 mg/l for 12 h)	10.76
C_7 (Control)	8.84
S.Em. $\pm$	0.130
C. D. at 5 %	0.368
Interaction M × C	
S.Em. $\pm$	0.260
C. D. at 5 %	0.736
C. V. %	4.30

Fig. 4.9-Effect of media and seed treatment chemicals on length of longest tap root of papaya seedling cv. Madhu Bindu



4.2.7.3 Interaction effect of media and seed treatment chemicals on length of longest tap root (cm)

The detail in table 4.9 (a) on the interaction of media and seed treatment chemicals showed the significant effect on length of longest tap root. The maximum length of the longest tap root (12.85 cm) of seedling was measured in treatment with GA_3 200 mg/l and use of media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3C_2) which was stastically at par with M_3C_1 and M_4C_2. While the minimum length of longest tap root (8.69 cm) was observed in treatment media red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7).

Table 4.9 (a): Interaction effect between media and seed treatment chemicals on length of longest tap root of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	9.20	11.28	12.19	11.57
C_2	10.12	10.97	12.85	12.13
C_3	9.15	9.93	11.24	10.45
C_4	9.28	10.10	11.34	10.72
C_5	9.38	10.29	11.83	11.11
C_6	9.51	10.33	11.94	11.25
C_7	8.69	8.79	8.99	8.89
S.Em. ±		0.260		
C. D. at 5 %		0.736		
C. V. %		4.30		

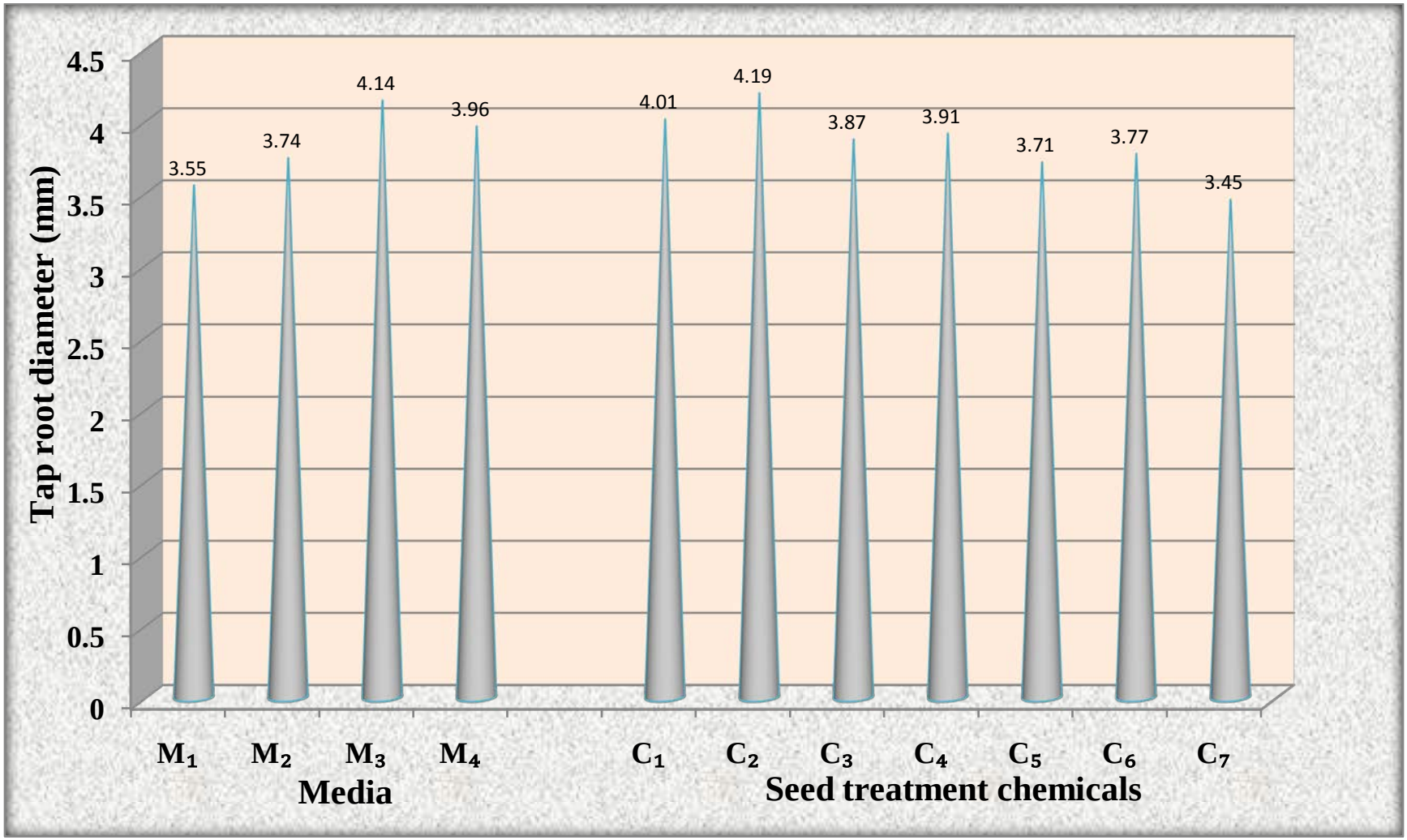
4.2.8. Diameter of tap root (mm)

The data on tap root diameter of papaya seedling as influenced by different media, different seed treatment chemicals and their interaction are presented in table 4.10 and graphically depicted through fig. 4.10.

Table 4.10: Effect of media and seed treatment chemicals on diameter of tap root of papaya seedling cv. Madhu Bindu

Treatments	Tap root diameter (mm)
Media	
M_1 (Red laterite soil + vermicompost)	3.55
M_2 (Red laterite soil + cocopeat)	3.74
M_3 (Red laterite soil + vermicompost + cocopeat)	4.14
M_4 (Red laterite soil + vermicompost + sand)	3.96
S.Em. $\pm$	0.042
C. D. at 5 %	0.118
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	4.01
C_2 (GA_3 200 mg/l for 12 h)	4.19
C_3 (NAA 100 mg/l for 12 h)	3.87
C_4 (NAA 200 mg/l for 12 h)	3.91
C_5 (Thiourea 1000 mg/l for 12 h)	3.71
C_6 (Thiourea 2000 mg/l for 12 h)	3.77
C_7 (Control)	3.45
S.Em. $\pm$	0.055
C. D. at 5 %	0.156
Interaction M × C	
S.Em. $\pm$	0.110
C. D. at 5 %	0.312
C. V. %	4.96

Fig. 4.10-Effect of media and seed treatment chemicals on tap root diameter of papaya seedling cv. Madhu Bindu



4.2.8.1 Effect of media on diameter of tap root (mm)

Among the different media, significantly the maximum diameter of tap root (4.14 mm) was registered in treatment M_3 (red laterite soil + vermicompost + cocopeat) (1:1:1). While, treatment M_1 (red laterite soil + vermicompost) (1:1) gave the minimum diameter of tap root (3.55 mm).

4.2.8.2 Effect of seed treatment chemicals on diameter of tap root (mm)

It is evident from the data presented in table 4.10 that the effect due to various seed treatment chemicals was found significant. The papaya seeds treated with GA_3 200 mg/l (C_2) resulted in significantly higher tap root diameter (4.19 mm). Whereas, significantly lowest taproot diameter (3.45 mm) was obtained in without chemical-control (C_7).

Table 4.10 (a): Interaction effect of media and seed treatment chemicals on tap root diameter of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	3.50	3.95	4.42	4.18
C_2	3.85	3.97	4.63	4.30
C_3	3.53	3.65	4.33	3.98
C_4	3.57	3.70	4.36	4.03
C_5	3.46	3.68	3.85	3.87
C_6	3.50	3.71	3.99	3.88
C_7	3.43	3.49	3.44	3.45
S.Em. ±		0.110		
C. D. at 5 %		0.312		
C. V. %		4.96		

4.2.8.3 Interaction effect of media and seed treatment chemicals on diameter of tap root (mm)

The diameter of tap root showed in table 4.10 (a) was significantly influenced by combination of different media and seed treatment chemicals. The treatment media red laterite soil + vermicompost + cocopeat (1:1:1) with GA_3 200 mg/l (M_3C_2) had reported maximum diameter of tap root (4.63 mm) of papaya seedling which was at par with treatments media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 100 mg/l (M_3C_1), red laterite soil + vermicompost + cocopeat (1:1:1) and NAA 100 mg/ l (M_3C_3) and red laterite soil + vermicompost + cocopeat (1:1:1) and NAA 200 mg/ l (M_3C_4). While the minimum diameter of tap root (3.43 mm) was recorded in treatment combination M_1C_7.

4.2.9. Root/shoot ratio

The data on root/shoot ratio was affected by different media, seed treatment chemicals and their interaction are presented in table 4.11 and graphically depicted through fig. 4.11.

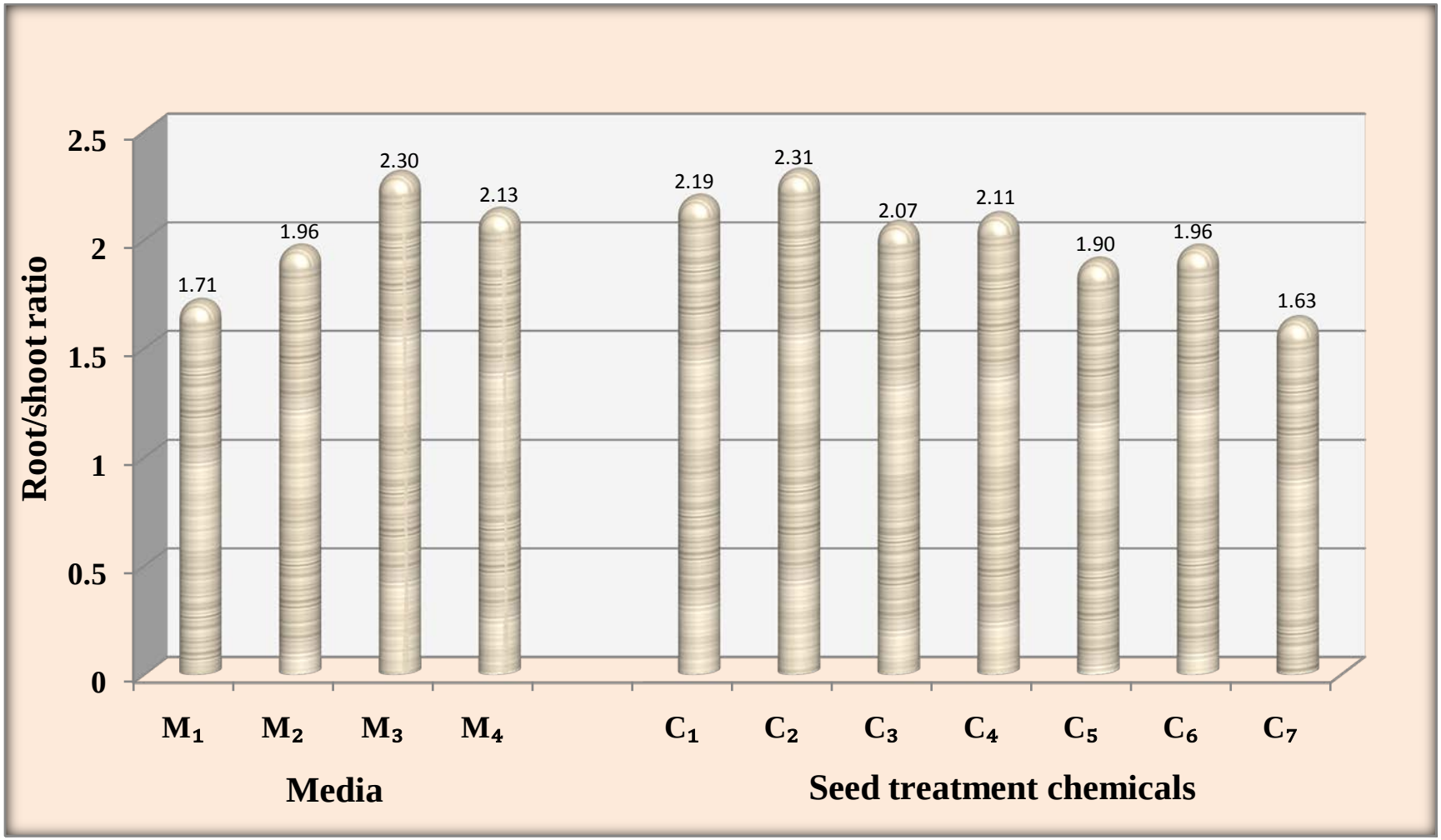
4.2.9.1 Effect of media on root/shoot ratio

Data presented in table 4.11 revealed that root/shoot ratio was significantly influenced by different media. The highest root/shoot ratio (2.30) was recorded when papaya seeds were sown in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3). While, the minimum root/shoot ratio (1.71) was noted in M_1 (red laterite soil + vermicompost) (1:1).

Table 4.11: Effect of media and seed treatment chemicals on root/shoot ratio of papaya seedling cv. Madhu Bindu

Treatments	Root/shoot ratio
Media	
M_1 (Red laterite soil + vermicompost)	1.71
M_2 (Red laterite soil + cocopeat)	1.96
M_3 (Red laterite soil + vermicompost + cocopeat)	2.30
M_4 (Red laterite soil + vermicompost + sand)	2.13
S.Em. $\pm$	0.021
C. D. at 5 %	0.061
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	2.19
C_2 (GA_3 200 mg/l for 12 h)	2.31
C_3 (NAA 100 mg/l for 12 h)	2.07
C_4 (NAA 200 mg/l for 12 h)	2.11
C_5 (Thiourea 1000 mg/l for 12 h)	1.90
C_6 (Thiourea 2000 mg/l for 12 h)	1.96
C_7 (Control)	1.63
S.Em. $\pm$	0.028
C. D. at 5 %	0.080
Interaction M × C	
S.Em. $\pm$	0.057
C. D. at 5 %	0.160
C. V. %	4.84

Fig. 4.11-Effect of media and seed treatment chemicals on root/shoot ratio of papaya seedling cv. Madhu Bindu



4.2.9.2 Effect of seed treatment chemicals on root/shoot ratio

With regard to statistical analysis, the seed treatment chemical was found significant for root/shoot ratio (table 4.11). Significantly the maximum root/shoot ratio (2.31) was noted in GA_3 200 mg/l. While, the lowest root/shoot ratio (1.63) was recorded in without chemical-control (C_7).

4.2.9.3 Interaction effect of media and seed treatment chemicals on root/shoot ratio

The interaction of media and seed treatment chemicals had significant effect on root/shoot ratio. The maximum root/shoot ratio (2.62) of papaya seedling was obtained in the treatment combinations of media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) which was statistically at par with media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 100 mg/l (M_3C_1). The minimum root/shoot ratio (1.46) was recorded in the treatment combination of media red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7).

Table 4.11 (a): Interaction effect of media and seed treatment chemicals on root/shoot ratio of papaya seedling

Media/chemical	M_1	M_2	M_3	M_4
C_1	1.68	2.14	2.59	2.36
C_2	2.05	2.17	2.62	2.40
C_3	1.73	1.96	2.41	2.19
C_4	1.77	2.00	2.45	2.22
C_5	1.56	1.88	2.14	2.01
C_6	1.70	1.92	2.17	2.05
C_7	1.46	1.64	1.72	1.68
S.Em. ±		0.057		
C. D. at 5 %		0.160		
C. V. %		4.84		

4.3 Biological analysis:

4.3.1. Chlorophyll content in leaf (mg/g tissue):

The data on chlorophyll content of leaf as influenced by various media, seed treatment chemicals and their interaction are presented in table 4.12 and graphically depicted through fig. 4.12.

4.3.1.1 Effect of media on chlorophyll content in leaf (mg/g tissue)

Regarding effect of media, significantly the maximum chlorophyll content in leaf (1.334 mg/g) was noted when seeds were sown in media consisting of red laterite soil + vermicompost + cocopeat (1:1:1) (M_3). Minimum chlorophyll content in leaf (1.278 mg/g) was recorded in red laterite soil + vermicompost (M_1).

4.3.1.2 Effect of seed treatment chemicals on chlorophyll content in leaf (mg/g tissue)

It is evident from the data that seed treatment chemicals influenced significantly on chlorophyll content in leaf. Significantly the highest chlorophyll content (1.345 mg/g) was noted when seed was treated with GA_3 200 mg/l (C_2). Whereas, the minimum chlorophyll content (1.262 mg/g) was found in without chemical-control (C_7).

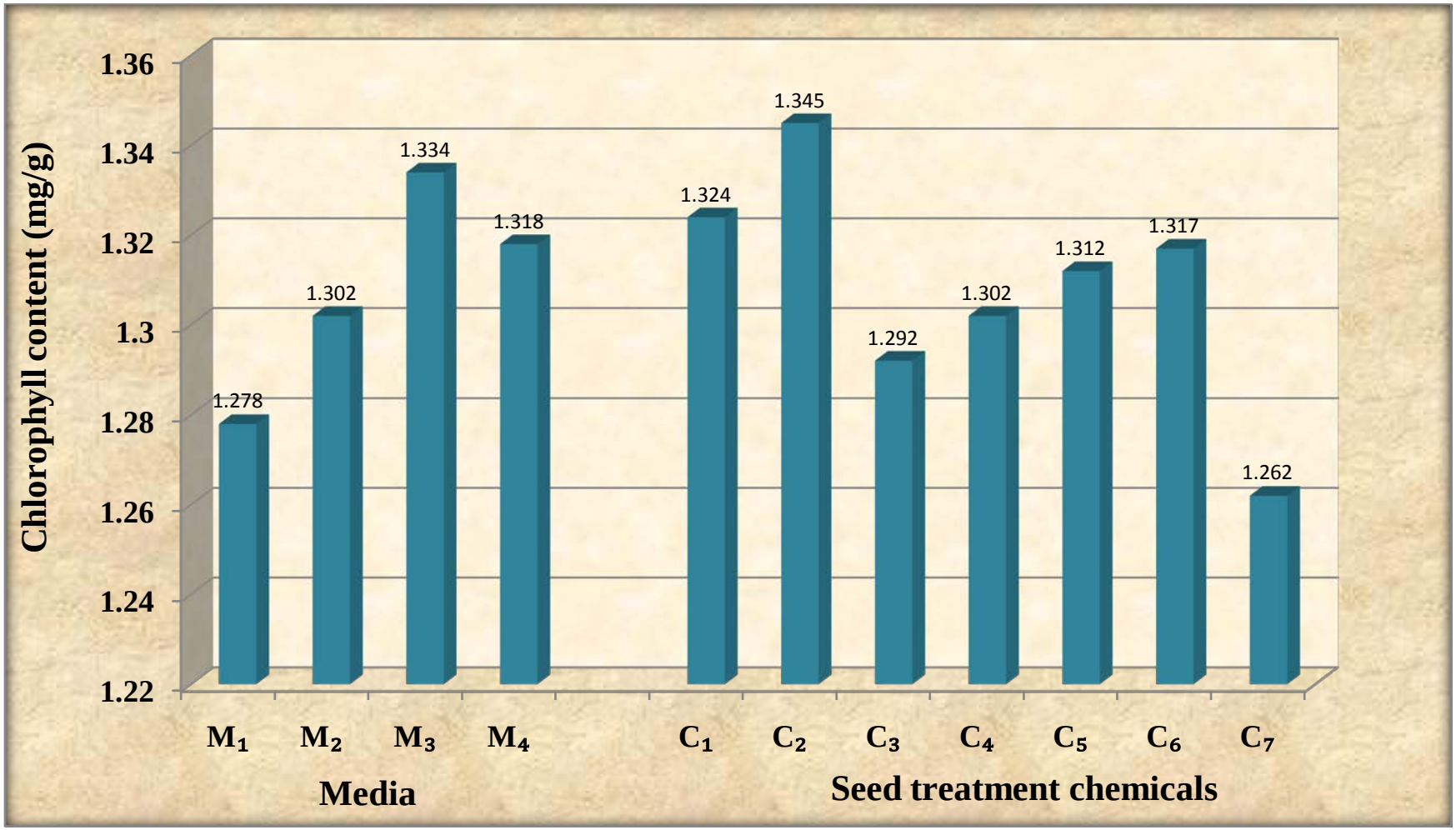
4.3.1.3 Interaction effect of media and seed treatment chemicals on chlorophyll content in leaf (mg/g tissue)

The interaction of media and seed treatment chemicals did not showed any significant effect with respect to chlorophyll content in leaves of papaya seedling.

Table 4.12: Effect of media and seed treatment chemicals on chlorophyll content in leaf of papaya seedling cv. Madhu Bindu

Treatments	Chlorophyll content (mg/g)
Media	
M_1 (Red laterite soil + vermicompost)	1.278
M_2 (Red laterite soil + cocopeat)	1.302
M_3 (Red laterite soil + vermicompost + cocopeat)	1.334
M_4 (Red laterite soil + vermicompost + sand)	1.318
S.Em. $\pm$	0.008
C. D. at 5 %	0.024
Seed treatment chemicals	
C_1 (GA_3 100 mg/l for 12 h)	1.324
C_2 (GA_3 200 mg/l for 12 h)	1.345
C_3 (NAA 100 mg/l for 12 h)	1.292
C_4 (NAA 200 mg/l for 12 h)	1.302
C_5 (Thiourea 1000 mg/l for 12 h)	1.312
C_6 (Thiourea 2000 mg/l for 12 h)	1.317
C_7 (Control)	1.262
S.Em. $\pm$	0.011
C. D. at 5 %	0.032
Interaction M × C	
S.Em. $\pm$	0.022
C. D. at 5 %	NS
C. V. %	2.95

Fig. 4.12-Effect of media and seed treatment chemicals on chlorophyll content in leaf of papaya seedling cv. Madhu Bindu



DISSCUSION

V. DISCUSSION

The use of growth regulators for improving the germination of seeds has been known from a long time. However poor growth and development of seedlings restricts the availability of healthy planting material on large scale. Therefore it is highly essential to accelerate the rate of seed germination and growth by treating the seed with growth substances to obtain high germination percentage and good size of seedling within a short period.

The present experiment titled “Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu” was undertaken during the year 2014-15 at Regional Hortcultural Research Station, NAU, Navsari, with two factors having seven seed treatment chemicals and four media.

The results presented in the preceding chapter indicated many significant variations in the different characters, due to the effect of media and seed treatment chemicals. In this chapter it is contemplated to these variations with possible explanation and available evidences and literature. For brevity the entire discussion has been divided into following sub heads.

5.1. Germination attributes

5.2. Shoot parameters

5.3. Root parameters

5.4. Biochemical analysis

5.1 Germination attributes:

Result of research work proved that different rooting media and seed treatment chemicals significantly affected the germination attributes viz., days required for initiation of germination and total germination percentage (%) of papaya seed.

Regarding different media under study, the minimum days required for initiation of germination (6.83 days) and maximum total germination percentage (90.03 %) were recorded in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) and maximum days required for initiation of germination (8.52 days) and minimum total germination percentage (74.43 %) were recorded in media red laterite soil + vermicompost (1:1) (M_1). This might be due to beneficial effect of medium combination in improving physical, biological and chemical properties of media. Soil provides natural support to plant, cocopeat given warm condition, high water holding capacity and vermicompost as a source of organic manure provided better nutrition to the germinating seedlings (Hartmann and Kester, 1997). The well decomposed vermicompost may preserve soil humidity, increase nutrient content and improve soil structure which increase water absorption and maintains the cell turgidity, cell elongation and increase respiration at optimum level, leading

to favourable for seed sprouting. Vermicompost mixed with red laterite soil affects properties of soil physics, chemistry and biology, since organic matter acts as glue for soil aggregate and source of soil nutrient (Soepardi, 1983). Vermicompost granules may develop soil aggregate and it's granulating. Soil aggregation will improve permeability and airflow in the polybags. Vermicompost and red laterite soil may decrease fluctuation of soil temperature. Organic matter may also improve nutrient availability and improve phosphorus absorption (Karama and Manwan, 1990). All these factors are favorable for seed germination and ultimate by increase seed germination per cent. The similar results reported by Bhardwaj (2013) in papaya, Bisla *et al*., (1984) in ber as they observed highest germination of ber seeds with media sand + soil + organic manure in 1:1:1 proportion and Lima *et al*., (2007) in annatto (*Bixa orellana*) observed maximum percentage of germination in sand + soil + organic manure (1:1:1) media substrate. Govind and Chandra (1993) in Khasi mandarin, Negi and Singh (1995) in pines, Prabhu (1978) in nutmeg, Biradar *et al*., (2001) in neem and Yadav *et al*. (2012) in acid lime had also obtained the similar results.

All the seed treatment chemicals showed remarkable improvement in germination parameters. The papaya seeds treated with GA_3 200 mg/l for 12 h (C_2) took minimum days (6.86) for initiation of germination and gave significantly maximum germination percentage (91.74%) followed by GA_3 100 mg/l for 12 h (C_1). Whereas maximum

days required for initiation of germination (8.78 days) and minimum germination percentage (69.47 %) was observed in control (C_7). It might be due to the involvement of GA_3 in the activation of cytological enzymes along with increase in cell wall plasticity and better water absorption. GA_3 acts directly on embryo relieving them from dormancy through promoting protein synthesis and elongation of coleoptiles and leaves and also helps in the production of ethylene. This ethylene invokes the synthesis of hydrolases, especially amylase, which favours the seed germination (Stewart and Freebairn, 1969). Another reason that GA_3 stimulates seed germination by formation of a-amylase enzymes which converts insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks as suggested by Gillard and Walton (1973). Similar findings on germination enhancement in papaya due to GA_3 treatment was reported by Veeraragavathatham *et al.* (1980), Anburani and Shakila (2010), Meena and Jain (2005) in papaya, Venkatrao and Reddy (2005) and Shaban (2010) in mango, Rajamanickam *et al.* (2002) in aonla and Harshavardhan and Rajasekhar (2012) in Jackfruit, Patil *et al.* (2012) and Gupta (1989) in Rangpur lime, Ghosh and Sen (1988) in ber, Farooqui *et al.* (1971) in sapota, Singh *et al.* (1979) in citrus, Chandra and Govind (1990) and Kumar *et al.* (1991) in guava.

Result presented in previous chapter further revealed that the interaction effect of media and seed treatment chemicals was found significant with respect to

germination percentage. The rooting media red laterite soil + cocopeat + vermicompost and seed treatment chemical GA_3 200 mg/l (M_3C_2) recorded maximum germination percentage (97.38) while, minimum germination percentage (64 %) was found under the treatment M_1C_7 (red laterite soil + vermicompost (1:1) and without chemical-control). The promising effect of GA_3 on seed germination might be due to its participation in the activity of alpha-amylase, which catalyzes the starch conversion into simple carbohydrates and chemical energy is liberated which is used in the activation of embryo. Growing media has appropriate cation exchange capacity for retention of nutrients and having the properties of good water holding capacity as well as sufficient porous, so that adequate moisture and exchange of gases between the germination growth media and embryo. The activity of GA_3 is more effective with the growth media, i.e. red laterite soil + vermicompost + cocopeat (1:1:1). These results are in conformity with those reported by Anjanawe *et al.* (2013) and Kumawat *et al.* (2014) in papaya.

5.2 Shoot parameters:

In this research study, different shoot parameters of papaya seedling viz., height of seedling (cm), number of leaves per seedling, stem diameter (mm), leaf area (cm^2), fresh weight of seedling (g) and dry weight of seedling (g) were significantly influenced by different media, seed treatment chemicals and their interaction.

Considering the effect of rooting media, the maximum height of seedling (6.41 cm, 10.22 cm and 17.22 cm) number of leaves per seedling (6.05, 8.61 and 13.34), stem diameter (1.58 mm, 2.11 mm and 4.14 mm) was noted in M_3 (red laterite soil + vermicompost + cocopeat (1:1:1)) at 25, 35 and 45 days after seed sowing. The similar media M_3 (red laterite soil + vermicompost + cocopeat (1:1:1)) was found effective and resulted in maximum leaf area (113.92 cm^2), fresh weight of seedling (8.09 g) and dry weight of seedling (1.05 g) at 45 days of sowing which was followed by media red laterite soil + vermicompost + sand (1:1:1) (M_4). Combined application of vermicompost and cocopeat showed significant effect on seedling growth parameters and plant biomass probably due to the synergistic combination of both the factors in improving the physical conditions of the media and nutritional factors. The conducive effect of media composition on water holding capacity, porosity, soil aeration and supplying substantial amount of nutrient specially nitrogen and micro nutrients for good root and shoot growth over soil alone (Chopde *et al.* 1999). Increase in number of leaves might be mainly due to corresponding increase in plant height (Govind and Chandra, 1993). The leaves of seedling raised in this media (M_3), also has higher leaf chlorophyll content due to presence of nitrogen in vermicompost which might certainly improved the photosynthetic rate, dry matter production and their by more dry weight and fresh weight of shoot (Awasthi *et al.*, 1996). Vermicompost provides adequate

nutrients and enhances both the physical properties and water holding capacity (Soegiman, 1982). Therefore, the medium with vermicompost and cocopeat is more suitable than vermicompost alone because of the better physical properties and enhanced nutrient level. The results of study are in close agreement with the findings of Wong and Lee (2000) in *Nepenthes ampullaria*, Kumar and Arora (2007) in peach, Pio, *et al.*, (2007) in pears, Lopes, *et al.*, (2007) in passion fruit, Li *et al.*, (2008) in *Phoebe chekiangensis* and Venkatesh *et al.*, (2009) in *Casuarina equisetifolia*.

Among the different seed treatment chemicals, GA_3 200 mg/l for 12 h (C_2) gave maximum seedling height (6.31 cm, 10.13 cm and 17.11 cm), number of leaves per seedling (6.23, 8.56 and 13.06), stem diameter (1.63 mm, 2.10 mm and 4.18 mm) after 25, 35 and 45 days of sowing. Significantly the maximum leaf area (113.35 cm^2), fresh weight of seedling (8.17 g) and dry weight of seedling (1.08 g) was obtained when seeds was treated with GA_3 200 mg/l for 12 h (C_2) as compared to other treatments at 45 days after sowing. The increase in seedling height with GA_3 treatments was due to the fact that this hormone increased osmotic uptake of nutrients, causing cell elongation and thus increased height of the plant (Shanmugavelu, 1966) and stem diameter also increased due to greater cell division and elongation at the stem portion (Sen *et al.*, 1990). The increase in number of leaves and leaf area might be due to activity of GA_3 at the apical meristem resulting in more synthesis of nucleoprotein responsible for

increasing leaf initiation and area (Sen and Ghunti, 1976), whereas increase in fresh and dry weight of stem and leaves were due to fact that GA_3 improves the rate of photosynthesis and cause greater accumulation of photosynthates (Chacko and Singh, 1966). Such effect is in accordance with the finding of Anburani and Shakila (2010), Meena and Jain (2005), Sehrawat *et al.* (2010) and Babu *et al.* (2010) in papaya, Prajapati Dixita (2013) in jackfruit, Dabhi (2000), Gholap *et al.* (2000), Rajmanickam and Anbu (2001), Rajamanickam *et al.* (2002), Rashmi Kumari *et al.*(2007) and Manekar *et al.* (2011) in aonla; Pandey (1992) in *Khasi* Mandarin; Shalini *et al.* (1999) in mango; Krishnan and Kulasekaran (1984) in ber; Misra *et al.* (1982) and Singh *et al.* (1989) in citrus and Nimbalkar *et al.* (2012) in karonda.

Among different treatments (M_3C_2) *i.e.* combination media viz., red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l for 12 h (M_3C_2) had significantly improved height of seedling (18.31 cm), number of leaves per seedling (14.28), diameter of stem (4.41 cm), leaf area (136.16 cm^2), fresh weight of seedling (8.93 g) and dry weight of papaya seedling (1.22 g) after 45 days of sowing. The better results in respect to plant height, stem diameter and number of leaves was observed in M_3C_2 might have occurred due to cell division and cell elongation, which in turn would have increased the internodal length and overall vegetative growth as suggested by Shanmugavelu (1970). These types of results were previously noted by Anjanawe *et al.* (2013) and Kumawat *et*

al. (2014) in papaya and Choudhari and Chakrawar (1980) in Kagzi lime.

5.3 Root parameters:

There were significant differences in root parameters viz. length of longest tap root (cm), tap root diameter (mm) and root/shoot ratio by different media, seed treatment chemicals and their interaction in present investigation.

In case of media, the maximum length of longest tap root (11.48 cm), tap root diameter (4.14 mm) and root/shoot ratio (2.30) was found in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) as compared to rest of media. The beneficial effect on root parameters due to application of the medium treatment consisting of red laterite soil + vermicompost + cocopeat (1:1:1) might be due to improved soil structure, porosity, water holding capacity, activity of useful soil micro fauna and flora, maintained soil temperature and improved soil health and nutrient status of media (Hartmann and Kester, 1997). Further the vermicompost and soil also provides close contact between seed and media, increases stable moisture supply facilitates, root respiration and encourages overall root growth (Chatterjee and Choudhari 2007). Vermicompost is reported to have bioactive principles which are considered to be beneficial for root growth and this has been hypothesized to result in greater root initiation (Bachman and Metzger, 2008). The findings of this experiment

are in close conformity of Dayanand Yadav(2015), Kumawat *et al*. (2014) and Anjanawe *et al*. (2013) in papaya, Baghel *et al.* (2004) in phalsa, Baghel and Saraswat (1989) in pomegranate and Nawa Bahar (2008) in *Cupaniopsis anacardioides*

Regarding the effect of different seed treatment chemicals on root parameters, GA_3 200 mg/l for 12 h resulted in maximum length of longest tap root (11.52 cm), diameter of tap root (4.19 mm) and root/shoot ratio (2.31). However, minimum length of longest tap root (8.84 cm), diameter of tap root (3.45 mm) and root /shoot ratio (1.63) was recorded in without chemical-control. This improvement in root parameters due to GA_3 treatment might have resulted into increased production of photosynthates and their translocation through phloem to the root zone might be responsible for increasing the root length (Vachhani *et al.*, 2014). The seeds treated with GA_3 might be accelerates the translocation and assimilation of auxins, reasons for better root growth and vegetative characters are due to overall assimilation and redistribution of materials with in plants enhance the growth attributes (Pandiyan *et al.*, 2011). Moreover, GA_3 also induced the activity of gluconeogenic enzymes during early stages of seed germination and vigour characteristics that is reflect in terms of increase in root length. These results are in close agreement with Anburani and Shakila (2010) in papaya; Shaban (2010) in mango; Pampanna and Sulikeri (1999) in sapota; Brijwal and Kumar (2013) in guava; Mankar *et al.*

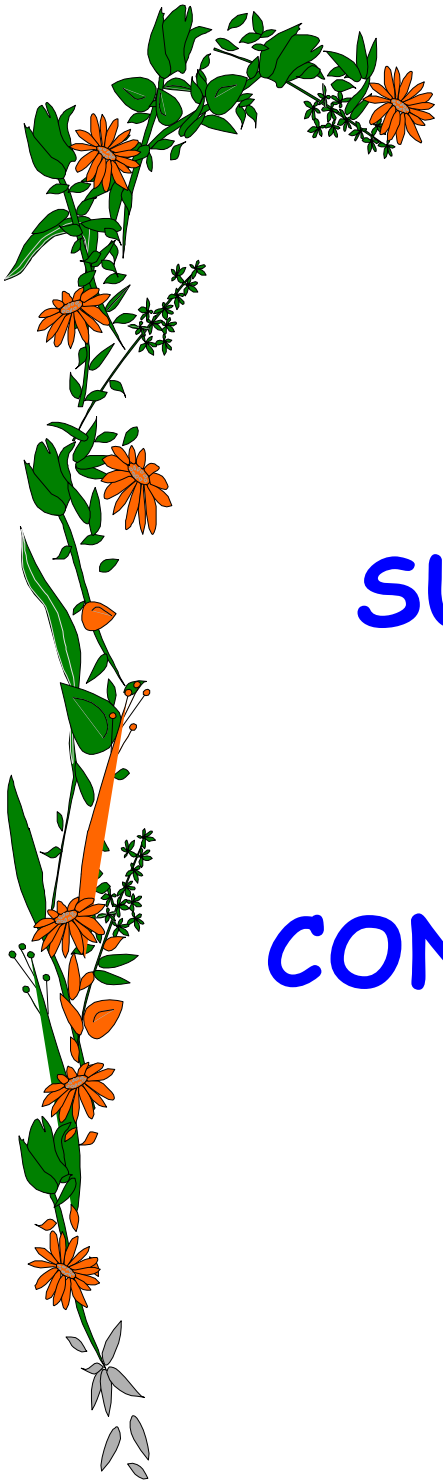
(1997) in ber; Manekar (2011) in aonla and Vasantha *et al.* (2014) in tamarind.

The different root parameters of papaya seedling viz., length of longest tap root (cm), diameter of tap root (mm) and root/shoot ratio was altered by interaction between different media and seed treatment chemicals. Root parameters were recorded at 45 days after seed sowing. The maximum length of longest tap root (12.85 cm), diameter of tap root (4.63 mm) and root/shoot ratio (2.62) were noted in treatment M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l) compared to rest of the treatments. GA_3 might have promoted more root formation through root cell elongation and more nutrient uptake as suggested by Shanmugavelu (1970). Moreover, vermicompost with cocopeat may improve soil porosity, water content, pore of drainage, soil permeability and water availability. This may develop soil aggregation and moreover it improves permeability and air flow in the soil, this type condition sharply reduce damping off disease in nursery stage and provide support to fast growth of the seedling due to availability of better nutrition with water and air in root zone of the seedling (Bhardwaj, 2013). These results are close conformity with those reported by Anjanawe *et al.* (2013) and Kumawat *et al.* (2014) in papaya.

5.4 Biochemical analysis:

The result of research work revealed that biochemical parameters *i.e.* chlorophyll content was

significantly affected by different media and seed treatment chemicals. Significantly maximum chlorophyll content in leaf of papaya was noted under media M_3 (red laterite soil + vermicompost + cocopeat (1:1:1)) and seed treatment chemical GA_3 200 mg/l (C_2). The increase in nitrogen content in leaves of papaya seedling with application of media and GA_3 may be due to stimulated nutrient uptake specially nitrogen and synthesis of chlorophyll which have role in the assimilation of numerous amino acids that are in subsequently incorporated in proteins and nucleic acid, which provides framework for chloroplast results into better chlorophyll content in leaves of treated plant (Awasthi *et al.*, 1996). These results further get support from from Kumawat *et al.* (2014) and Dayanand Yadav (2015) in papaya and Yadav *et al.* (2012) in acid lime.



SUMMARY

&

CONCLUSION

VI. SUMMARY AND CONCLUSION

The present study "Influence of media and seed treatment chemicals on the enhancement of germination and seedling growth of papaya (*Carica papaya* L.) cv. Madhu Bindu" was carried out during the year 2014-15 at Regional Horticultural Research Station, NAU, Navsari. The experiment was laid out in Completely Randomized Design with two factors repeated three times. The treatment comprised of four different media viz. red laterite soil + vermicompost (M_1), red laterite soil + cocopeat (M_2), red laterite soil + vermicompost + cocopeat (M_3) and red laterite soil + vermicompost + sand (M_4) and seven different seed treatment chemicals viz. GA_3 100 mg/l (C_1), GA_3 200 mg/l (C_2), NAA 100 mg/l (C_3), NAA 200 mg/l (C_4), thiourea 1000 mg/l (C_5), thiourea 2000 mg/l (C_6) and control (C_7). Total 28 treatment combinations are employed in this experiment. The effect of different media and seed treatment chemicals on germination, growth, root and biochemical characters of papaya seedling were studied. The salient findings of the study are summarized and concluded in this chapter.

1. Days required for initiation of germination and germination percentage was significantly affected by different media and seed treatment chemicals. Minimum days required for initiation of germination and maximum germination percentage were observed when seeds were sown in medium comprised of red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) which was followed by red laterite soil + sand + cocopeat (1:1:1) (M_4). Papaya seeds

treated with GA_3 200 mg/l (C_2) taken significantly minimum days required for initiation of germination (6.86) and gave significantly maximum germination percentage (91.74). An interaction effect between media and seed treatment chemicals was found non significant with respect to days required for initiation of germination. However for germination percentage interaction effect was found significant. Treatment combination M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l) gave highest germination percentage (97.38) which remained at par with the treatment combinations M_3C_1, M_3C_5 and M_3C_6.

2. Different media, seed treatment chemicals and their interaction were found significant for height of seedling at 25, 35 and 45 days after sowing. Seeds were sown in red laterite soil + vermicompost + cocopeat (1:1:1) as a media and GA_3 200 mg/l as a seed treatment chemicals were observed better for maximum height of seedling at 25, 35 and 45 days after sowing. Treatment combination M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l) registered maximum seedling height at 25, 35 and 45 days after seed sowing.

3. Similar trend was noted with number of leaves per seedling and stem diameter of seedling at 25, 35 and 45 days after seed sowing. Maximum number of leaves and stem diameter was recorded in red laterite soil + vermicompost + cocopeat (1:1:1) as a media and GA_3 200 mg/l as a seed treatment chemical and interaction between red laterite soil + vermicompost + cocopeat

(1:1:1) and GA_3 200 mg/l (M_3C_2) at 25, 35 and 45 days after sowing.

4. Leaf area of papaya seedling was found significant with respect to different media, seed treatment chemicals and their interaction. Red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) as a media noted maximum leaf area followed by red laterite soil + vermicompost + sand (1:1:1) (M_4). Leaf area was observed significantly the maximum when seeds were treated with GA_3 200 mg/l. An interaction of red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) was recorded maximum leaf area as compared to other treatment combination.

5. Among the different media, maximum fresh weight and dry weight of seedling was registered in media red laterite soil + vermicompost + cocopeat (1:1:1) (M_3) followed by red laterite soil + vermicompost + sand (1:1:1) (M_4). While in different seed treatment chemicals, GA_3 200 mg/l rank first with maximum fresh weight and dry weight of seedling. An interaction between M × C was also found significant and the maximum fresh weight and dry weight of seedling was recorded in red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2). Minimum fresh weight and dry weight of seedling was noted in red laterite soil + vermicompost (1:1) and without chemical-control (M_1C_7).

6. Different media, seed treatment chemicals and their interaction were found significant for length of longest tap root and tap root

diameter of papaya seedling. Media M_3 (red laterite soil + vermicompost + cocopeat) (1:1:1) gave significantly the maximum length of longest tap root and tap root diameter compare to other media. While maximum length of longest tap root and tap root diameter was recorded when seeds treated with GA_3 200 mg/l. Treatment combination M_3C_2 (red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l) was registered superior with respect to length of longest tap root and tap root diameter.

7. Root/shoot ratio was significantly altered due to different media, seed treatment chemicals and their interaction. Regarding media, maximum root/shoot ratio was noted in red laterie soil + vermicopost + cocopeat (1:1:1) (M_3). With respect to seed treatment chemicals, GA_3 200 mg/l (C_3) was found significantly superior then other seed treatment chemicals. Red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) interaction was noted maximum root/shoot ratio which was statistically at par with treatment combination M_3C_1.
8. Chlorophyll content was found significant with respect to different media and seed treatment chemicals. However, maximum chlorophyll content was observed in media red laterite soil + vermicompost + cocopeat (1:1:1). Among different seed treatment chemicals, GA_3 200 mg/l recorded significantly maximum chlorophyll content. An interaction effect between media and seed treatment chemicals failed to produce any significant differences on chlorophyll content of leaf.

CONCLUSION

From the above summary, it can be concluded that among the different media, red laterite soil + vermicompost + cocopeat (1:1:1) was found better for germination, growth, root and biochemical parameters of papaya seedling cv. Madhu Bindu. While in case of different seed treatment chemicals, GA_3 200 mg/l was found effective with respect to germination, growth, root and biochemical parameters as compared to other seed treatment chemicals. Regarding interaction between media and seed treatment chemicals, red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l (M_3C_2) was remained better for all these parameters of papaya seedling cv. Madhu Bindu.

Based on investigation use of media red laterite soil + vermicompost + cocopeat (1:1:1) and GA_3 200 mg/l as seed treatment chemical can be used for better germination and growth of papaya seedling cv. Madhu Bindu.

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APPENDIX

Appendix-I: Month-wise meteorological data during the experimental period.

Month	Week	Date	Temperature (°C)		Relative Humidity (%)		Wind velocity (km/hr)	Sun Shine (hr)	Rain Fall (mm)	Evaporation (mm)
			Max	Min	Morning	Evening				
May	1	07-13	35.2	25.7	80	51	5.3	10.0	0.0	7.3
	2	14-20	35.2	25.6	83	51	4.2	9.5	0.0	7.2
	3	21-27	35.7	26.6	86	62	5.4	9.6	0.0	7.4
	4	28-03	34.0	29.2	81	67	8.5	9.5	0.0	7.3
June	5	04-10	34.3	28.9	80	62	9.7	9.0	0.0	7.4
	6	11-17	33.6	26.0	83	67	8.5	7.6	28.0	6.4
	7	18-24	33.0	28.2	82	66	11.6	6.1	8.0	6.1
	8	25-01	33.8	28.2	76	59	11.1	8.7	0.0	6.9

Source: Agricultural Meteorological Observatory, Agricultural Experimental Station, Navsari Agricultural University, Navsari.

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