

**STUDIES ON VEGETATIVE PROPAGATION OF
CHINESE CHASTE TREE (*Vitex negundo* L.)
BY STEM CUTTINGS**

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PHK 919

**DEPARTMENT OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU**

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Thesis submitted to

University of Agricultural Sciences, Bengaluru

*In partial fulfillment of the requirements
for the award of the Degree of*

MASTER OF SCIENCE (Horticulture)

in

PLANTATION, MEDICINAL, AROMATIC AND SPICE CROPS

BENGALURU

JULY, 2011



Affectionately Dedicated to

My Beloved Parents

Sisters

and

Guide

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**DEPARTMENT OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU-560 065**

CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON VEGETATIVE PROPAGATION OF CHINESE CHASTE TREE (VITEX NEGUNDO LINN.) BY STEM CUTTINGS**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Horticulture) in PLANTATION, MEDICINAL, AROMATIC AND SPICE CROPS** to the University of Agricultural Sciences, GKVK, Bengaluru, is a record of *bona-fide* research work carried out by **Ms. BHAGYA, H.P., ID No. PHK 919** under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associate-ship, fellowship or any other similar titles.

**Bengaluru
July, 2011**

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Place : Bengaluru

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(BHAGYA, H.P.)

**STUDIES ON VEGETATIVE PROPAGATION OF CHINESE CHASTE
TREE (*Vitex negundo* L.) BY STEM CUTTINGS**

ABSTRACT

A study on the vegetative propagation of Chinese chaste tree (*Vitex negundo* L.) was carried out at the Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during August, 2010 to December, 2010.

In the present experiment, the effect of growth regulators *viz.*, IBA and NAA singly and in combinations on rooting of hardwood cuttings was studied. The treatments comprised of control, IBA at 2000 and 3000 ppm, NAA at 2000 and 3000 ppm, IBA+NAA 2000 ppm each and IBA+NAA 3000 ppm each and keradix. The experiment was conducted in a four replicated Factorial Completely Randomized Design. Single, double and triple node hardwood cuttings were treated with the growth regulator solutions. Observations were recorded on various shoot and root parameters and the survival percentage of rooted cuttings was also studied. The shoot parameters such as days taken to sprout, number of sprouts, length of longest sprout and fresh and dry weights of sprouts (9 days, 3.23, 20.38 cm, 3.6 g and 0.88 g, respectively) and the root parameters like time taken to root, number of roots, length of longest root, fresh and dry weights of roots were significantly higher (30 days, 19.05, 21.75 cm, 2.37 g and 0.67 g, respectively) in three node stem cuttings treated with IBA 3000 ppm. The results of this investigation clearly brought out that, triple node hardwood cuttings should be treated with 3000 ppm IBA to obtain maximum rooting success and also for obtaining maximum survival of rooted cuttings in secondary nursery.

Signature of the Student
(BHAGYA, H.P.)

Signature of the Major Advisor
(B.S. SREERAMU)

ಕರಲಕ್ಕಿ (ವೈಟೆಕ್ಸ್ ನಿಗುಂಡೊ ಲಿನ್) ಸಸ್ಯವನ್ನು ಕಾಂಡದ ತುಂಡುಗಳಿಂದ ನಿರ್ಲಿಂಗ ರೀತಿಯಲ್ಲಿ
ಸಸ್ಯಾಭಿವೃದ್ಧಿ ಮಾಡುವ ಅಧ್ಯಯನ

ಪ್ರಬಂಧದ ಸಾರಾಂಶ

ಕರಲಕ್ಕಿ (ವೈಟೆಕ್ಸ್ ನಿಗುಂಡೊ ಲಿನ್) ಸಸ್ಯದ ಸಸ್ಯಾಭಿವೃದ್ಧಿ ಮಾಡುವ ಅಧ್ಯಯನವನ್ನು ತೋಟಗಾರಿಕೆ ವಿಭಾಗ, ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ, ಗಾಂಧಿ ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರ, ಬೆಂಗಳೂರಿನಲ್ಲಿ ಆಗಸ್ಟ್ 2010 ರಿಂದ ಡಿಸೆಂಬರ್ 2010ರವರೆಗೆ ಕೈಗೊಳ್ಳಲಾಗಿತ್ತು.

ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಐಬಿಎ 2000 ಮತ್ತು 3000 ಪಿ.ಪಿ.ಎಂ. ಎನ್‌ಎಎ 2000 ಮತ್ತು 3000 ಪಿ.ಪಿ.ಎಂ, ಐಬಿಎ 2000 ಪಿ.ಪಿ.ಎಂ. + ಎನ್‌ಎಎ 2000 ಪಿ.ಪಿ.ಎಂ, ಐಬಿಎ 3000 ಪಿ.ಪಿ.ಎಂ + ಎನ್‌ಎಎ 3000 ಪಿ.ಪಿ.ಎಂ ಮತ್ತು ಕೆರಡಿಕ್ಸ್ ಸಸ್ಯ ಚೋದಕಗಳ ಉಪಚಾರಗಳನ್ನು ಬಳಸಲಾಗಿತ್ತು. ಈ ಪ್ರಯೋಗವನ್ನು 4 ಪ್ರತಿಕ್ರಮಗಳಲ್ಲಿ ಫ್ಯಾಕ್ಟೋರಿಯಲ್ ಕಂಪ್ಲೀಟ್ ರ್ಯಾಂಡಮೈಸ್ಡ್ ಡಿಸೈನ್ ಬಳಸಿ ಕೈಗೊಳ್ಳಲಾಗಿತ್ತು. 1, 2 ಮತ್ತು 3 ಗೆಣ್ಣುಗಳುಳ್ಳ ಬಲಿತ ಕಾಂಡದ ತುಂಡುಗಳನ್ನು ಬೆಳವಣಿಗೆ ವೃದ್ಧಿ ನಿಯಂತ್ರಕ ಚೋದಕಗಳಿಂದ ಉಪಚರಿಸಲಾಗಿತ್ತು. ಈ ಪ್ರಯೋಗದಲ್ಲಿ ಮೂರು ಗೆಣ್ಣುಗಳುಳ್ಳ ಕಾಂಡದ ತುಂಡುಗಳನ್ನು ಐಬಿಎ 3000 ಪಿ.ಪಿ.ಎಂ ನಲ್ಲಿ ಉಪಚರಿಸಿದಾಗ ಬೇಗ ಚಿಗುರೋಡೆಯುವುದು, ಹೆಚ್ಚು ಸಂಖ್ಯೆಯ ಚಿಗುರುಗಳು, ಉದ್ದನೆಯ ಚಿಗುರು ಮತ್ತು ಹಸಿ ಹಾಗೂ ಒಣಗಿದ ಚಿಗುರುಗಳ ಗರಿಷ್ಠ ತೂಕ ಅನುಕ್ರಮವಾಗಿ 9 ದಿನ, 3.23, 20.38 ಸೆಂ.ಮೀ. 3.6 ಗ್ರಾಂ ಮತ್ತು 0.88 ಗ್ರಾಂ ಕಂಡುಬಂದಿದೆ. ಇದಲ್ಲದೆ ಕಡಿಮೆ ಅವಧಿಯಲ್ಲಿ ಬೇರು ಬಿಡುವುದು, ಹೆಚ್ಚು ಸಂಖ್ಯೆಯ ಬೇರುಗಳು, ಉದ್ದನೆಯ ಬೇರು ಮತ್ತು ಹಸಿ ಹಾಗೂ ಒಣಗಿದ ಬೇರುಗಳ ತೂಕ ಅಧಿಕವಾಗಿರುವುದು ಅನುಕ್ರಮವಾಗಿ 30 ದಿನ, 19.05, 21.75 ಸೆಂ.ಮೀ, 2.37 ಗ್ರಾಂ ಮತ್ತು 0.67 ಗ್ರಾಂ ದಾಖಲಾಗಿದೆ. ಈ ಅಧ್ಯಯನದಿಂದ ಕರಲಕ್ಕಿಯನ್ನು ಸಸ್ಯಾಭಿವೃದ್ಧಿ ಮಾಡಲು ಮೂರು ಗೆಣ್ಣುಗಳುಳ್ಳ ಕಾಂಡದ ತುಂಡುಗಳನ್ನು ಐಬಿಎ 3000 ಪಿ.ಪಿ.ಎಂ ದ್ರಾವಣದಿಂದ ಉಪಚರಿಸಿ ನಾಟಿ ಮಾಡುವುದರಿಂದ ಅಧಿಕ ಪ್ರಮಾಣದಲ್ಲಿ ಕಾಂಡದ ತುಂಡುಗಳು ಬೇರುಬಿಡುವುದು ಹಾಗೂ ಅಧಿಕ ಸ್ಥಿರಗೊಳ್ಳುವ ಪ್ರಮಾಣವನ್ನು ಪಡೆಯಬಹುದಾಗಿದೆ.

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(ಭಾಗ್ಯ, ಎಚ್.ಪಿ)

ಪ್ರಧಾನ ಮಾರ್ಗದರ್ಶಕರ ಸಹಿ
(ಬಿ. ಎಸ್. ಶ್ರೀರಾಮು)

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INTRODUCTION

I. INTRODUCTION

Herbal medicine is the oldest form of healthcare known to mankind and it will not be an exaggeration to say that use of herbal drugs for human healthcare is probably as ancient as mankind. A perfect example of a medicinal plant credited with innumerable medicinal qualities, used since ancient times and validated by the modern science is the *Vitex negundo* Linn. belonging to the family Verbenaceae. The genus *Vitex* consists of about 250 species, of which 14 are found in India and a few have commercial and medicinal importance (Tandon, 2005). *Vitex negundo* is commonly known as five-leaved Chaste tree in English, *Sambhalu* in Hindi, *Sindhuvara* in Sanskrit, *Karilakki* in Kannada, *Nirgundi* in Bengali, *Nochi* in Tamil, *Vavili* in Telugu, *Karinuchi* in Malayalam and *Nirgundi* in Marati (Gurudeva, 2001).

The plant is indigenous to Mediterranean region and Central Asia. It is found distributed in parts of India, Myanmar, Eastern Africa, Madagascar, Afghanistan, Pakistan, Sri Lanka, China, Japan, Taiwan, Thailand, Malaysia, Palau, Caroline and Mariana Islands. It has been widely cultivated in Europe, Asia, North America and West Indies (Anon., 2008).

It is a large aromatic shrub or a small tree with an irregular trunk, stem and branches are covered with grey bark. The branches are quadrangular with petiolate leaves. Flowers are bracteate and bluish or purple in colour. Fruits are aglobose, ovoid, four chambered and four seeded drupe (Anon, 1976).

Vitex negundo is very common in many parts of the country and often occurs gregariously, up to an altitude of 1500 m in the outer Himalayas. In Himachal Pradesh, it is found in almost all the districts. It is abundant along the banks of the rivers, in moist conditions, open-

waste lands and near the deciduous forests. It is widely planted as a hedge-plant along the roads and between the fields. It is useful for planting against soil-erosion and for afforestation. It has also been found suitable for planting as wind-breaks, inside or in outer rows. It grows wild or semi cultivated and frequently used for fuel purpose in Garhwal Himalaya (Anon, 1976).

The leaves contain two major alkaloids *viz.* nishidine and hydrocotylene. Besides, glucononitol, *p*-hydroxybenzoic acid, 5-hydroxyisophthalic acid, 3,4-dihydroxybenzoic acid (an amorphous glucoside), tannic acid, acubin, agnuside, casticin, orientin, isoorientin, chrysophenol-D, luteolin, α -D-glucoside of a tetrahydroxy-monomethylflavone, 5-hydroxy-3,6,7,3, '4'-pentamethoxyflavone, vitamin C (150mg/100g, on fresh wt. basis) and carotene (3,500 μ g/100g, on fresh wt. basis) are also present (Anon, 1976).

Although all parts of *V. negundo* are used as medicine in the indigenous system of medicine, the leaves are the most potent for medicinal use. The leaves are used for treatment of eye-diseases, toothache, inflammation, leucoderma, enlargement of the spleen, skin-ulcers, in catarrhal fever, rheumatoid arthritis, gonorrhoea and bronchitis. Leaves are also used as tonic, vermifuge, galactagogue, emmenagogue, antibacterial, antipyretic and antihistaminic agents (Chitra *et al.*, 2009). Decoction of leaves along with long pepper (*Piper longum*) is given in catarrhal fever with heaviness of head and impaired hearing. Dried leaves are also smoked for the relief of headache and catarrh and as mosquito repellent. Juice of leaves is said to be used for the treatment of foetid discharge. Ointment made from the juice is applied as a hair-tonic. Extract of the leaves shows anti-cancerous activity. The drug is also reported to possess tranquilizing property and is a constituent of *Ayurvedic* preparations such as *Vishagarbha thaila*

and other compound oils (Anon, 1976). Leaves are reported to possess insecticidal properties and are laid over stored grain to ward off insects (Tewary *et al.*, 2004). Leaf and twig extract are known to be effective against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* causing major ailments in human beings (Anon., 1976).

Roots are known to be useful as tonic, febrifuge, expectorant and diuretic. They are also used in dyspepsia and rheumatism and for boils. The powdered root is prescribed as an anthelmintic, demulcent in dysentery and also for piles. Flowers are astringent in nature and are used in fever, diarrhea and liver complaints. Fruits are prescribed in headache, catarrh, and watery eyes. An aqueous extract of the fruits was found to have good analgesic action (Anon., 1976). Dried fruits having pepper like aroma and flavor, are being used in western Herbalism (www.holisticonline.com).

Vitex negundo can be propagated through seeds, cuttings, root suckers and by micro propagation. Propagation through seeds is hindered due to its poor viability and the production of root suckers is strictly age dependent (Vadawale *et al.*, 2006). Under these circumstances, propagation of this plant through stem cuttings seems to be the best alternative for production of true to type plants on a large scale to meet the demand of planting material.

Hence, the present investigation was taken up with the following objectives,

- a. To evaluate hardwood node cuttings for commercial propagation,
- b. to study the effect of growth regulators on rooting of stem cuttings and
- c. to study survival of rooted cuttings in secondary nursery.



Plate 1: General view of chinese chaste tree

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Chinese chaste tree (*Vitex negundo* L.) perpetuates vegetatively and also by seed, but only in some areas it was reported to produce few fruits and seeds. The seeds require stratification to overcome dormancy and hence, raising of plants through cuttings is a simple, quick and economical method of propagation in this plant and it does not require technical skill as necessary in many other propagation methods. The requirement of large scale planting material and also its non seed setting nature under Bangalore conditions were the reasons for taking up the present study for standardizing the vegetative propagation by stem cuttings using different growth regulators.

The research work carried out on the propagation of Chinese chaste tree (*Vitex negundo* L.) is very much limited. Hence, the work done on similar aspects of medicinal and aromatic crops and other horticultural crops has been reviewed in this chapter and presented under the following headings.

2.1 Influence of length or number of nodes on rooting of cuttings

2.1.1 Medicinal and Aromatic crops

2.1.2 Other related Horticultural crops

2.2 Influence of plant growth regulators on rooting of cuttings

2.2.1 Medicinal and Aromatic crops

2.2.2 Other related Horticultural crops

2.3 Influence of combination of plant growth regulators on rooting of cuttings

2.3.1 Medicinal and Aromatic crops

2.3.2 Other related Horticultural crops

2.4 Interaction of length or number of nodes and growth regulators on rooting of cuttings

2.4.1 Medicinal and Aromatic crops

2.4.2 Other related Horticultural crops

2.1 Influence of length or number of nodes on rooting of cuttings

Went (1929) reported the importance of functional buds for initiation of rooting as they produce necessary chemical compounds and thus, effect the rooting. This indicates the significance of length of cutting, in turn number of buds in root induction.

2.1.1 Medicinal and Aromatic crops

Shenoy (1992) recorded significantly highest rooting percentage in 15-20 cm length basal stem cuttings of *Rosa damascena*.

Stem cuttings (25 cm length) of *Ruta graveolens* recorded the maximum rooting, fresh weight of the roots and best survival in the field (Niranjan Kumar, 1993).

The rooting in *Plumbago zeylanica* cuttings of 15 cm length was more successful under mist (Dhar, 1999).

Subhash (2000) observed maximum rooting under polyhouse condition in 15-20 cm long stem cuttings of *Gymnema sylvestre* having 3-4 nodes.

Nelson (2001) suggested 20 to 40 cm long cuttings for propagation of *Morinda citrifolia* which are manageable and effective. Vezhavendran and Ponnaiyan (2005) stated that hard wood cuttings of noni (*Morinda citrifolia*) with 4 nodes as best for rooting success (82 %). Three node cuttings of noni performed best with respect to rooting percentage as

compared to single node and double node cuttings (Srikantaprasad, 2009).

Nicoloso *et al.* (2001) evaluated the effect of length of shoot cuttings on the rooting of Brazilian ginseng (*Pfaffia glomerata*). The treatments consisted of cuttings of three lengths (10, 15 and 20 cm). Among these, cuttings of 20 cm length recorded the highest rooting percentage.

The stem cuttings of 25 cm length having 6-8 nodes recorded the maximum rooting percentage in *Bursera delpechiana* Poiss. (Swetha, 2005).

An experiment was conducted to elucidate the effects of cutting positions (apical, medial and basal) and length (15, 20 and 25 cm) on the regeneration of stem cuttings of Indian bedellium. The results of this investigation showed that rooting success was significantly ($p < 0.05$) higher with middle or apical cuttings and the longest cuttings (25 cm) gave highest rooting success as compared to shortest cuttings (15–20 cm). Therefore, medial or apical cuttings with 25 cm length could be used as planting material for regeneration of guggal (Dinesh Kumar *et al.*, 2006).

2.1.2 Other related horticultural crops

Stem cuttings of 12-15 cm length of *Duranta plumieri* Jacq. var. *Goldiana* recorded the maximum rooting percentage (Ghatnatti, 1997).

Anil Kumar *et al.* (1999) reported 90 per cent rooting success in single nodal cuttings from suckers of *Coffea arabica* cv. Cauvery and in *Coffea canephora* highest sprouting percentage was noticed in leafy half node cuttings at seven and fifteen weeks after planting, whereas, the

non-leafy half node cuttings had zero per cent of sprouting (Adeyemi *et al.*, 2005).

Eldaim (2009) found that, the hardwood cuttings of 20-25 cm length planted in winter season and grown under plastic tunnel with mist, resulted in more number of roots and longest length of roots in *Hamelia patens*.

Tatiane *et al.* (2009) indicated that, highest sprouting, rooting and sprout length of apical hard wood cutting of fig cv. Roxo de Valinhos can be obtained by using 20 cm long and 7 mm diameter cuttings.

2.2 Influence of plant growth regulators on rooting of cuttings

Among the synthetic root promoting chemicals, IBA and NAA have been found to induce rooting in a variety of horticultural species.

In nature, root formation by a plant has been shown to be possible only if there are developing buds or leaves on them. Dormant buds fail to induce rooting. Evidently the rooting in all such cases depends on the presence of a hormone. Auxins have been found to increase the rate of formation and final number of root initials (Verma, 2007).

2.2.1 Medicinal and Aromatic crops

Single nodal cuttings prepared from mature branches of Gamhar (*Gmelina arborea*) achieved 73.3 and 60 per cent rooting at 100 ppm and 1000 ppm IBA treatments, respectively (Surendran, 1990). Akbar (1994) carried out an investigation on *Gmelina arborea* shoot cuttings, which were treated with different concentrations of IBA with a control. Among, the treatments control had shown good rooting percentage compared to other treatments.

Thimmappa and Bhattacharjee (1990) showed that, IBA at 2000 ppm as optimum for good rooting in stem cuttings of rose geranium (*Pelargonium graveolens*). Terminal cuttings of rose geranium treated with 2000 ppm IBA produced more number of lengthier roots and were ready for planting much earlier compared to those untreated (Rajeswara Rao *et al.*, 1993). Single node stem cuttings of rose scented geranium treated with IBA at 2000 mg l⁻¹ recorded higher values for root and shoot parameters (Bhattacharya and Rajeshwar Rao, 1998).

Hardwood cuttings of *Jasminum grandiflorum* treated with 4000 ppm IBA had shown maximum rooting percentage, more number of roots and survival percentage of rooted cuttings under mist (Nagaraja *et al.*, 1991). The rooting percentage after 75 days of planting was highest in the cuttings of *J. auriculatum* treated with 4000 ppm IBA under mist, compared to *J. grandiflorum* treated with 2000 ppm IBA under open (Sreelatha *et al.*, 1991). Singh (2001) reported better rooting and survival percentage in cuttings of *Jasminum sambac* treated with 2000 ppm IBA.

Single node cuttings of *Dioscorea floribunda* dipped in seradix-B and IBA at 2000 ppm for 10 seconds produced the highest proportion of plantlets (98.6 %) while, it was only 40 per cent in untreated cuttings (Singh *et al.*, 1991).

The basal woody cuttings of damask rose (*Rosa damascena*) treated with IBA and NAA (300 ppm each) recorded the highest survival percentage of rooted cuttings than the middle semi hardwood cuttings (Shenoy, 1992). Basal woody cuttings of *Rosa damascena* treated with IBA at 300 ppm had highest percentage of rooting, more number of roots, higher fresh and dry weight, better shoot growth and survival of cuttings (Farooqi *et al.*, 1994). Rao *et al.* (1993), while, studying the rooting behavior of Damask rose (*Rosa damascena*) obtained root induction within ten days of treatment with 2000 ppm IBA and the treated cuttings

not only produced more number of lengthier roots but were also ready for planting much earlier compared to the untreated cuttings. Khan *et al.* (2006) reported that the cuttings of damask rose treated with 50 mg l⁻¹ NAA gave maximum shoot length and rooting percentage.

The effect of three growth regulators *viz.*, IAA, IBA and NAA on rooting of cuttings in *Glycyrrhiza glabra* were tested under mist. It was observed that the cuttings treated with NAA 0.5 g l⁻¹ advanced the initiation of sprouting and completion of rooting by 5.33 and 9 days, respectively. Application of IBA 0.5 g l⁻¹ also resulted in higher number of leaves per rooted cutting and exhibited higher survival percentage of rooted cuttings under field conditions (Massodi *et al.*, 1994).

Khosla and Pushpangadan (1995) proved cent per cent rooting in clocimum cuttings treated with 200 ppm IBA. Shakila *et al.* (2007) obtained better rooting percentage in basil cuttings treated with IBA at 2000 ppm as compared to IAA and NAA.

Kumar and Sreeja (1996) studied the influence of rooting hormone IBA on different types of cuttings in lavender (*Lavendula angustifolia*) and obtained the highest rooting percentage and more number of roots per rooted cutting in basal stem cuttings treated with IBA at 2000 ppm. Andrade *et al.* (1999) mentioned that the root growth was increased with the increased concentration of NAA in *Lavendula vera*. The highest rooting percentage, maximum number of roots per cutting and length of longest root in hard wood cuttings of Indian lavender were recorded in cuttings treated with 250 ppm IBA for 18 hours followed by 250 ppm NAA over control (Chandramouli, 2001).

Terminal cuttings of *Gymnema sylvestre* treated with 750 ppm IBA recorded the highest rooting percentage in the month of June under mist compared to middle and basal cuttings, whereas, in the untreated

cuttings only 5 per cent rooting was observed (Subbaraj *et al.*, 1997). Saraswathy *et al.* (1999) obtained higher percentage of rooting in terminal cuttings of *Gymnema sylvestre* treated with IBA at 700 ppm and planted during July. Subhash (2000) recorded the maximum rooting percentage in leafless cuttings of *Gymnema sylvestre* treated with IBA at 300 ppm and TRF at 200 ppm under polyhouse condition.

Rao *et al.* (1999) recorded higher rooting percentage in hardwood cuttings (8-10cm) of dryers oleander (*Wrightia tinctoria*) treated with IBA at 4000 ppm as compared to untreated cuttings.

Azamul Husen and Mishra (2001) noticed cent per cent sprouting in cuttings of *Vitex negundo* treated with IBA at 3000 ppm. The cuttings treated with stick (NAA with sodium as active ingredient) showed maximum effect on rooting at 500-1500 ppm followed by IAA at 1500 ppm (Tewary *et al.*, 2004).

Koyuncu and Senel (2003) obtained better rooting, more number of roots per rooted cutting and longest root in hardwood cuttings of black mulberry (*Morus nigra* L.) treated with 5 g l⁻¹ IBA.

The basal cuttings of *Bursera penicillata* treated with 250 ppm NAA and terminal cuttings treated with 250 ppm IBA recorded good rooting percentage (Chandramouli *et al.*, 2003). The stem cuttings of *Bursera delpechiana* Poiss. treated with 2000 ppm IBA recorded maximum rooting percentage (Swetha, 2005).

Treatment of softwood, semi hardwood and hardwood cuttings of stinking tree (*Nothopotydes nimmoniana*) with 2000, 3000 and 4000 ppm IBA resulted in the highest sprouting, rooting, root and shoot length, number of roots per cutting and survival percentage (Panneerselvam *et al.*, 2004).

Cuttings of Neem (*Azadirachta indica*) treated with IBA at 1000 ppm for 10 minutes gave the highest percentage of sprouting and rooting after 15 days of treatment and survival of rooted cuttings after 100 days. IBA at 1500 ppm adversely affected sprouting, rooting and survival percentage compared to the control (Devarnavadagi *et al.*, 2005).

Soundy *et al.* (2008) showed that IBA 0.3 per cent as optimum for better rooting in both apical and basal stem cuttings of fever tea (*Lippia javanica* L.).

The cuttings of *Tinospora cordifolia* treated with 100 ppm IBA recorded higher sprouting, rooting and root length as compared to control and other auxin treatments (Mishra *et al.*, 2010).

An investigation was carried out to study the effect of different growth regulators on rooting of *Premna integrifolia* cuttings (a rare medicinal plant species). The various root and shoot parameters recorded significantly higher values when the cuttings were treated with growth regulators as compared to control. The highest rooting percentage was noticed in the cuttings treated with 1000 ppm IBA as against control. The other parameters like number of roots per cutting, fresh and dry weights of roots, sprouting percentage, field establishment percentage *etc.* were also higher in the cuttings treated with IBA at 1000 ppm followed by IBA at 2000 ppm (Sharma *et al.*, 2011).

2.2.2 Other related horticultural crops

The basal cuttings of pomegranate treated with 5000 ppm IBA showed highest rooting per cent when compared to other concentrations of IBA (Shekarappa, 1983).

Prasad *et al.* (1988) reported best rooting in hardwood stem cuttings of guava treated with IBA at 2500 ppm.

The hardwood stem cuttings of guava treated with IBA at 2000 ppm recorded the highest rooting and survival percentage (Reddy and Singh, 1988).

Application of IBA at 5000 ppm resulted in maximum rooting in hardwood and semi-hardwood cuttings compared to NAA application in pomegranate (Ghose *et al.*, 1988).

Gautam and Chauhan (1990) obtained maximum rooting success in olive cuttings treated with IBA 5000 ppm in the month of spring (April) followed by summer (July). The minimum rooting was recorded in autumn planting.

Melanta and Sulladmath (1990) reported highest number of roots and longest length of roots in 20 cm long hardwood cashew cuttings treated with IBA at 2000 ppm.

Treatment of Bougainvillea cuttings with IBA or NAA at 3000 ppm resulted in highest percentage of survival of both hardwood and semi hardwood cuttings in the month of July (Singh, 1990).

Khan *et al.* (1991) obtained the highest percentage of rooting, root length, average number of roots and leaves per rooted cutting, dry weight of roots and stems in single nodal cuttings of tea with the 6000 ppm IBA treatment.

Sadiq *et al.* (1991) while, studying the effect of different concentrations of IBA (50-400 ppm) on root initiation in hardwood cuttings of peach cv. Early grand found that the cuttings treated with IBA at 400 ppm took lowest number of days to sprouting and recorded highest average shoot and root lengths.

Hardwood cuttings of oleander (*Nerium oleander*) treated with 2000 ppm IBA gave 100 per cent rooting, more number of roots and length of longest root compared to control (Patil and Shirol, 1991).

Battacharjee and Balakrishna (1992) carried out an investigation to standardize the propagation of two popular tropical ornamental shrubs *viz.* *Hemelia patens* and *Ixora singaporensis* through stem cuttings. The cuttings of both the species treated with IBA at 4000 ppm stimulated cent per cent rooting, survival and large number of roots.

Wamatu and King'oro (1992) reported 50 per cent rooting success in coffee cuttings treated with 500 ppm NAA. In mallet cuttings of coffee, better rooting, highest numbers of primary and secondary roots were obtained by treating the cuttings with 1000 ppm IBA as compared to other treatments and control (Anil Kumar and Srinivasan, 1993). Anuradha and Sreenivasan (1993) reported highest number of primary roots and leaves per cutting in *Coffea arabica* cv. Cauvery, by treating the basal portion of cuttings with 5000 ppm IBA + 10 % sucrose. Single node cuttings of *Coffea canephora* treated with 1000 ppm IBA showed compact, strong and healthy root system (Anil Kumar, 1994). Oloyede *et al.* (2005) reported significant influence of IBA at 1000 ppm on the root length of *Coffea canephora*.

Bhattacharjee and Balakrishna (1993) confirmed cent per cent rooting in stem cuttings of *Ixora singaporensis* treated with IBA and NAA at 4000 ppm each and IAA and IBA at 6000 ppm each.

Simly (1994) obtained the highest rooting percentage in hardwood cuttings of cinnamon (*Cinnamon zeylanicum*) treated with 2000 ppm of NAA.

Timla fig stem cuttings treated with 5000 ppm IBA recorded the highest rooting percentage (Sundaram and Rangaswamy, 1994).

Cuttings of *Bougainvillea peruviana* cv. 'Mary palmer' treated with IBA at 4000 ppm produced the highest per cent of root initiation, longest shoot and maximum number of roots per cutting (Chovatia *et al.*, 1995).

IBA at 4000 ppm concentration proved significantly effective in rooting, increasing the root length and number of roots per cutting in *Buddlea asiatica* (Gupta, 1995).

Pratap Reddy *et al.* (1996) obtained maximum rooting percentage and mean length of root with IBA at 1250 ppm in cuttings of grape hybrids.

Treatment of cuttings with IBA at 10000 ppm resulted in the highest percentage rooting and number of primary and secondary roots per cutting in *Bougainvillea* cv. Mahara. (Kanamadi *et al.*, 1997).

IBA at 4500 ppm exhibited best performance with respect to rooting success and survival in hardwood cuttings of guava (Bhagat *et al.*, 1998).

Bharadwaj *et al.* (1998) opined that the cuttings of *Acer oblongum* treated with IBA concentrations (1000, 3000 and 5000 ppm) had shown significant improvement in rooting per cent, root number and root length compared to control.

The stem cuttings of *Acacia spp.* treated with 1500 ppm IBA recorded higher percentage of rooting (Sai Ram Reddy *et al.*, 1998).

Vegetative propagation through stem cuttings of two species *viz.* sea mango (*Cerbera manghas*) and mangrove lime (*Merope angulata*) have

been tried under the regimes of different growth regulators IAA, IBA, NAA and commercially available rooting powders, rootex and keradix in low cost poly house. It was observed that the hormones IAA at 500 ppm, 1000 ppm and NAA at 500 ppm, 1000 ppm was effective in inducing rooting in both the species. However, both the species, showed delayed rooting response in commercial rooting powder (Thatoi *et al.*, 2000).

Singh and Singh (2002) reported maximum rooting percentage in the cuttings of *Bougainvillea spp.* treated with IBA at 2000 ppm as compared to control.

Prunus africana cuttings treated with 100-200 µg IBA per cutting gave good rooting percentage, while 300 µg IBA was graded as supra-optimal dosage (Tchoundjeu *et al.*, 2002).

In comparison with the control, soaking the base of hardwood cutting in 25 ppm IBA for 24 hr or dipping in 3000 ppm IBA for 5 seconds did not improve the rooting percentage in Japanese persimmon (*Diospyros kaki*) cv. Jiro and Nishimurawase (Tetsumura *et al.*, 2002).

Oliveira *et al.* (2003) carried out a study to test IBA at rates of 1500 and 3000 mg l⁻¹ (immersed 5 seconds) on the rooting potential of semi-hardwood and hardwood cuttings on six peach tree cultivars (BR 3, Chula, Coral, Eldorado, Marli and Sinuelo). The results revealed that, IBA increased the survival and the rooting percentage of all cultivars and types of cuttings. IBA at 1500 mg l⁻¹ was considered as the appropriate concentration for better rooting of hardwood cuttings.

Cuttings of *Euphorbia pulcherrima* treated with NAA at 2000 ppm and IAA at 2000 ppm recorded maximum rooting followed by IAA @1000 ppm (Tripathy *et al.*, 2003).

Muhammad *et al.* (2004) found no significant effect of IBA on the number of days for bud sprouting and sprouting percentage in stem cuttings of guava. But greatest survival percentage, number of leaves, number of branches per cutting, branch length, number of roots per cutting, root length, root weight and rooting percentage were recorded in IBA at 1000 ppm.

An experiment was carried out with the objective of estimating root system quality in semi-hardwood and hardwood cuttings of six peach cultivars (BR 3, Chula, Coral, Eldorado, Marli and Sinuelo) treated with IBA at rates of 1500 and 3000 mg l⁻¹ (immersion during 5 seconds). Indole-Butiric Acid of 1500 mg l⁻¹ concentration increased root system quality of all cultivars and cutting types. Root system of semi hardwood cuttings was found better in quality (number, length, root volume and dry matter) but both types are suggested for plant propagation (Oliveira *et al.*, 2005).

An attempt was made to induce rooting from single node cuttings of *Camellia sinensis* var. TV-20 under controlled conditions and to study its biochemical changes during rooting. The nodal cuttings were pretreated with different concentrations of IAA, NAA and IBA and were kept in a growth chamber (25±2 °C, white fluorescent lamps and 65% relative humidity) for 12 hrs. Among the three auxins used for pretreatment, IBA showed more positive response on rooting as compared to IAA and NAA within 2 weeks of transfer to potting medium. Among four concentrations of IBA tested, 75 ppm gave maximum percentage of rooting, number of roots and root length (Rout, 2006).

Hard wood cuttings of red pitaya (*Hylocercus undatus*) treated with 500 ppm IBA resulted in highest rooting whereas, 100 per cent rooting was observed in soft wood cuttings (Zhao ChunXiang *et al.*, 2006).

Hard wood cutting of pomegranate cv. Ganesh, treated with IBA at 4000 ppm had good sprouting of cutting, number of sprouts per cutting, length of sprout, number of roots per cutting, length and diameter of root and survival percentage of rooted cuttings (Gurjar and Patel, 2007).

Husen and Pal (2007) reported increased rooting and sprouting per cent with 4000 ppm IBA and also increase in mean number of leaves, shoots and roots per cutting in *Tectona grandis*.

Hardwood cuttings of Blueberry treated with different concentrations of IBA (0, 1000, 2000, 4000 or 8000 mg l⁻¹) showed good rooting percentage over control (Fischer *et al.*, 2008).

Oliveira (2008) carried out a study on the effect of IBA on rooting of hardwood cuttings of blueberry cultivars Powderblue, Delite, Climax, Bluebelle and Woodard. The cuttings of 15 cm were prepared and immersed for 15 seconds in a phyto regulator solution (IBA) at the following concentrations: 0, 1000, 2000, 4000 or 8000 mg l⁻¹. The percentage of rooted cuttings, average number of roots per cutting, length of the better-developed root, average number of shoots and length of the largest shoot were evaluated after eight months of experiment installation. The response of the blueberry cultivars to root varied with the IBA concentration. Regardless to IBA presence and cultivar, the percentage of rooting rating was higher than 55 per cent.

Reddy and Rajeswara (2008) noticed highest percentage of rooting, maximum number of roots, longest root length per cutting and maximum survival percentage of rooted cuttings treated with IBA at 2500 ppm + NAA at 2500 ppm followed by IBA at 2500 ppm in both hardwood and semi hardwood cuttings of fig (*Ficus carica* L.).

Saroj *et al.* (2008) reported that hardwood and semi-hardwood cuttings of pomegranate cultivar Jalore Seedless treated with IBA at 2500 ppm had highest root and shoot length with more number of roots per cutting.

Erturk and Cetin (2009) carried out a study on the influence of hydrogen peroxide, wounding and IBA on the rooting success of hardwood cuttings of chestnut. Cuttings of 14-16 cm length of chestnut genotypes 51111 (Sariaslama Clone -1) and 51205 (Sariaslama Clone -2) were treated with IBA at 0, 12000 ppm and H₂O₂ (3.5% w/v) solutions. Highest callus formation and rooting percentage were observed in the cuttings treated with 12000 ppm IBA.

Tatiane *et al.* (2009) indicated that, highest sprouting, rooting and sprout length of apical hard wood cutting of fig cv. Roxo de Valinhos can be obtained by treating the cuttings with IBA 2000 mg l⁻¹ for 10 seconds.

2.3 Influence of combination of plant growth regulators on rooting of cuttings

2.3.1 Medicinal and aromatic crops

Zaghiloul *et al.* (1990) recorded the highest rooting percentage with the combination of 750 ppm of NAA and 75 ppm kinetin in stem cuttings of *Jasminum sambac* as against 10 per cent rooting observed in control.

Maximum survival percentage of rooted cuttings was recorded in cuttings treated with IBA (1000 ppm) and IBA+IAA (250+250 ppm) in two *Rosa* species (Hussain and Khan, 2004).

Honey suckle cuttings treated with a combination of IBA at 150 + NAA at 300 ppm recorded the maximum rooting percentage (Pooja, 2010).

2.3.2 Other related horticultural crops

Battacharjee and Balakrishna (1992) reported cent per cent rooting and survival in stem cuttings of *Ixora singaporensis* treated with IAA at 4000 ppm + NAA at 4000 ppm and IAA at 6000 ppm + IBA at 6000 ppm.

Stem cuttings have been found to root well in *Duranta plumeri* Jacq. var. Goldiana. Higher percentage of rooting could be obtained by the application of equal proportion of 3000 ppm each of IBA and NAA (Ghatnatti, 1997).

Cuttings of *Bougainvillea* cv. Mahara treated with GA at 100 ppm + IBA at 2500 ppm + NAA at 2500 ppm recorded maximum number of leaves and length of the longest shoot per cutting (Kanamadi *et al.*, 1997).

Taxus buccata cuttings of 15 to 20 cm length treated with 0.75 per cent IBA + 5 per cent sucrose recorded the highest rooting percentage (Shamet *et al.*, 1999).

Basal stem cuttings may be used for mass multiplication of fig plant. The higher percentage of rooting could be obtained under green house by the application of 4500 ppm each of IBA and NAA (Ganta bhagyalakshmi, 2004).

Rajeswara Reddy *et al.* (2007) carried out a study on the effect of auxin synergists *viz.*, para hydroxy benzoic acid (PHBA), rutin, morin and phloroglucinol (PG) at 2000 ppm alone and in combination with IBA at 2500 ppm on rooting and root characters of hardwood and semi hardwood cuttings of fig. The interaction effect between type of cuttings and treatments showed that, hardwood cutting treated with IBA at 2500 ppm + PHBA at 2000 ppm was found superior with respect to percentage of rooting and other root characters like more number of

roots per cutting, longest root length per cutting and maximum survival percentage over other treatments.

Reddy and Rajeswara (2008) reported highest percentage of rooting, maximum number of roots, longest root length per cutting and maximum survival percentage of rooted cuttings in treated with IBA at 2500 ppm + NAA at 2500 ppm followed by IBA at 2500 ppm in both hardwood and semi hardwood cuttings of fig (*Ficus carica* L.).

Allspice (*Pimenta dioica* L.) is a hard to root hardwood species. The effect of different methods of vegetative propagation namely cuttings, air layering, approach grafting and stooling, various auxins and influence of season on rooting of cuttings and air layers were studied. All the propagation methods namely cuttings, air layering, approach grafting and stooling were successful and the auxin treatment with the combination of IBA and NAA each at 2500 ppm showed maximum rooting (Rema and Krishnamoorthy, 2008).

Vinay kumar *et al.* (2008) recorded the highest percentage of rooting in the cuttings of *Thunbergia grandiflora* treated with IBA+NAA at 2000 ppm each.

In *Arribidaea magnifica* significantly higher percentage of rooting was seen in IBA at 2000 ppm treatment followed by IBA at 1500 ppm and IBA + NAA at 2000 ppm (Vinay kumar *et al.*, 2008b).

2.4 Interaction effect of length or number of nodes and plant growth regulators on rooting of cuttings

2.4.1 Medicinal and aromatic crops

Shenoy (1992) obtained maximum rooting percentage in 15-20 cm basal woody cuttings of *Rosa damascena* treated with IBA at 300 ppm.

Patil (1993) obtained the highest rooting percentage in hard wood cuttings (20 cm) of *Jasminum species* (*J grandiflorum*, *J sambac* and *J auriculatum*) treated with 4000 ppm of IBA.

Stem cuttings of 12-15 cm of *Duranta plumieri* Jacq. var. Goldiana treated with a combination of 3000 ppm IBA and 3000 ppm NAA recorded the maximum rooting percentage (Ghatnatti., 1997).

Leafless, 4-5 nodal stem cuttings (15-20 cm) of *Gymnema sylvestre* treated with IBA at 300 ppm and TRF at 200 ppm gave best result in polyhouse condition with respect to maximum rooting percentage (Subhash, 2000).

Swetha (2005) recorded maximum rooting percentage in 25 cm hard wood cuttings of *Bursera delpechiana* Poiss. treated with IBA at 2000 ppm.

Srikantaprasad (2009) studied the influence of length of cuttings and growth regulators on rooting of cuttings in noni. Among the different treatments highest rooting percentage was recorded in triple nodal cuttings treated with IBA at 3000 ppm.

The influence of length of cuttings, growth regulators and their interactions on rooting of cuttings in honey suckle was studied. The highest rooting percentage was observed in two node cuttings treated with IBA at 100 ppm (Pooja, 2010).

2.4.2 Other related horticultural crops

Battacharjee and Balakrishna (1992) obtained the maximum rooting percentage in *Ixora singaporensis* (15 cm length) stem cuttings treated with 4000 ppm IBA.

Taxus buccata cuttings of 15 to 20 cm length recorded the highest rooting percentage treated with 0.75 per cent IBA + 5 per cent sucrose (Shamet *et al.*, 1999).

In two node cuttings of *Gardenia augusta* L. treated with 4920 μM IBA + 2685 μM NAA by basal quick-dip method, produced maximum roots per cuttings and root length (Blythe *et al.*, 2004).

Husen and Pal (2007) reported that, in teak, the cuttings taken from the middle portion of the hedged plants (20 cm) treated with 4,000 ppm IBA had maximum rooting compared to the cuttings taken from the basal and upper position of the hedged plants.

Reddy and Rajeswara (2008) reported highest percentage of rooting, maximum number of roots, longest root length per cutting and maximum survival percentage in 15-20 cm hardwood and semi hardwood cuttings of fig (*Ficus carica* L.) treated with IBA at 2500 ppm + NAA at 2500 ppm followed by IBA at 2500 ppm.

Blueberry hardwood cuttings of 15 cm length treated with different concentrations of IBA (0, 1000, 2000, 4000 or 8000 mg l^{-1}) showed good rooting percentage over control (Fischer *et al.*, 2008).

Tatiane *et al.* (2009) indicated that, highest sprouting, rooting and sprout length of apical hard wood cutting of fig cv. Roxo de Valinhos could be obtained by using 20 cm long and 7 mm diameter cuttings and treating with IBA at 2000 mg l^{-1} for 10 seconds.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation entitled 'Studies on vegetative propagation of Chinese chaste tree (*Vitex negundo* L.) by stem cuttings' was carried out during 2010-11 at the Garden of Fragrance, Department of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru. The details of materials used and methods followed during the course of investigation are presented here under.

3.1 Geographical location of the experimental site

The experimental site is situated at an elevation of 930 m above MSL and 12° 58" North latitude and 77°55" East longitude.

3.2 Climatic conditions of the experimental site

The meteorological data recorded during the experimental period is presented in Appendix-I. Mean maximum temperature during the period of experiment ranged from 25.7° C to 28° C, while, the mean minimum temperature ranged between 15.2° C to 19.2° C. Similarly, the maximum relative humidity of 95 per cent was recorded during November and lowest (53 %) was in December. So also, the rainfall varied from 9.8 mm (December) to 158.2 mm (August) in various months. The maximum sunshine hours (5.1 hr) was recorded during December, while it was lowest (3.2 hr) during August 2010.

3.3 EXPERIMENTAL DETAILS

The experiment was carried out to standardize the vegetative propagation of Chinese chaste tree by stem cuttings and the details are given below:

Design	: Factorial Completely Randomized Design
No. of main treatments	: 3
No. of sub treatments	: 8
No. of replications	: 4
No. of cuttings per treatment	: 15
Total number of cuttings used	: $3 \times 8 \times 4 \times 15 = 1440$
Method of growth regulators treatment	: Quick dip method (10 sec)

a) Main treatments (Hardwood cuttings)

M₁ - Single node cutting (approx. 10 cm)

M₂ - Double node cutting (approx. 15 cm)

M₃ - Triple node cutting (approx. 20 cm)

b) Sub treatments (Growth regulators)

T₁ - Control (Distilled water)

T₂ - IBA - 2000 ppm

T₃ - IBA - 3000 ppm

T₄ - NAA - 2000 ppm

T₅ - NAA - 3000 ppm

T₆ - IBA 2000 ppm + NAA 2000 ppm (in the ratio of 1:1)

T₇ - IBA 3000 ppm + NAA 3000 ppm (in the ratio of 1:1)

T₈ - Keradix (Commercial formulation used for rooting of cuttings)

3.3.1 Preparation of cuttings

One-year-old fully matured shoots of Chinese chaste tree grown in the herbal garden were selected for making stem cuttings required for the experiment. A slant cut was given at the basal end, whereas, a transverse cut was given at the top of each cutting. Single, double and triple node cuttings were prepared by leaving desired number of nodes. Basal ends



Single node cuttings



Double node cuttings



Triple node cuttings

Plate 2: Cuttings with different number of nodes used in the experiment

of the cuttings so prepared were dipped in 0.2 per cent Bavistin (Carbendazim 50 WP).

3.3.2 Preparation of rooting media

The rooting media was prepared by mixing sand, soil and FYM in the proportion of 1:6:2. Then, the prepared media was drenched with Bavistin (0.2%) and filled in seed pan leaving 2 cm of headspace.

3.3.3 Preparation of growth regulator solutions

3.3.3.1 Indolebutyric acid (IBA)

A stock solution of IBA (10,000 ppm) was prepared by dissolving 5 g of IBA in 50 ml of 50 per cent alcohol and the volume was made up to 500 ml using distilled water. This stock solution was used for the preparation of different concentrations (250 ml) of IBA required for treatment of cuttings.

3.3.3.2 Naphthaleneacetic acid (NAA)

A stock solution of NAA (10,000 ppm) was prepared by dissolving 5 g of NAA in 50 ml 1 N NaOH and the volume was made up to 500 ml using distilled water. This stock solution was used for the preparation of NAA solutions of different concentrations (250 ml) required for treating the cuttings.

Growth regulator	Quantity of Stock solution used
IBA 2000ppm	50ml
IBA 3000ppm	75ml
NAA 2000ppm	50ml
NAA 3000 ppm	75ml
IBA 2000 ppm + NAA 2000 ppm	IBA 50ml + NAA50ml
IBA 3000 ppm + NAA 3000 ppm	IBA 75ml + NAA75ml

3.3.3.3 Treatment of cuttings with growth regulators and planting in media

The basal portion of the cuttings (about 2.5-3 cm) was dipped in growth regulator solution for ten seconds and air dried. Then, the treated cuttings were planted in seed pans containing rooting media. Single node cuttings were planted in such a way that, the nodal portion was just below the surface of the media without covering the dormant bud. In case of double node and triple node cuttings, one basal node of the cutting was inserted into the media and pressed around gently. For keradix treatment, the basal end of the cuttings (2.5-3 cm) was dipped in water and the cuttings were tapped to the brim of the container to remove the excess water and later dipped in keradix powder taken in a beaker. Excess keradix powder on the cuttings was removed by tapping on the brim of the container. Using a pointed stick, a hole was made in the media and basal portion of the cutting was inserted and media around the cuttings was gently pressed to exclude air pockets. The seed pans with cuttings were kept under natural shade of Singapore cherry (*Muntingia calabura*) for rooting.

3.3.4 AFTERCARE

3.3.4.1 Watering

The seed pans were watered with a rose can immediately after planting. In the beginning, daily watering was done for a week and later the seed pans were watered at two days interval, depending on the prevailing weather conditions.

3.3.4.2 Weeding

Manual weeding was done in order to keep the seed pans weed free. First weeding was done after 15 days of planting of cuttings and



Plate 3: General view of chinese chaste tree experiment

a) Before rooting b) After rooting

later, at periodic intervals. In all, weeds were removed five times during the period of experimentation.

3.3.4.3 Plant protection

No serious incidence of pests or diseases was noticed during the rooting period. However, after 45 days of planting few sprouted cuttings showed wilting symptoms may be due to fungal infection which was controlled by drenching the seed pans with 0.1 per cent Bavistin.

3.3.5 OBSERVATIONS RECORDED

Observations on the following parameters were recorded in five randomly labelled cuttings in each treatment.

3.3.5.1 SHOOT PARAMETERS

3.3.5.1.1 Days taken for sprouting

Cuttings planted in the seed pans were observed daily and the number of days taken for sprouting was recorded.

3.3.5.1.2 Sprouting percentage

Number of cuttings sprouted in each treatment was recorded at 75 days of planting the cuttings. The sprouting percentage was calculated by taking the ratio of sprouted cuttings to the total number of cuttings planted and multiplied by 100.

3.3.5.1.3 Number of sprouts per rooted cutting

Number of sprouts per rooted cutting was recorded at 75 days after planting the cuttings. The total number of sprouts on five rooted cuttings (each replication) was counted and the mean was computed.

3.3.5.1.4 Average length of sprouts in rooted cutting

Length of all the sprouts in 5 rooted cuttings (each replication) was measured at 75 days of planting the cutting, and mean was computed and expressed in centimeter (cm).

3.3.5.1.5 Length of longest sprout in rooted cutting

Length of longest sprout in rooted cuttings was measured at 75 days after planting the cuttings and the mean was computed and expressed in centimeter (cm).

3.3.5.1.6 Thickness of longest sprouts in rooted cuttings

Thickness of longest sprout in 5 rooted cuttings was measured at 75 days after planting the cuttings and the mean was computed and expressed in millimeter (mm).

3.3.5.1.7 Fresh weight of sprouts per rooted cutting

For recording fresh weight of sprouts, cuttings were uprooted at 75 days after planting. Fifty per cent of the rooted cuttings but not more than five cuttings in each treatment and replication were utilized. The sprouts were separated from all the cutting and weighed and the mean was computed and expressed in g/cutting.

3.3.5.1.8 Dry weight of sprouts per rooted cutting

After recording the fresh weight the samples were dried in a hot air oven at 60°C until constant weight was attained. They were weighed and the mean was computed and expressed in g/ rooted cutting.



Plate 4: Close-up view of the *Vitex negundo* propagation experiment

3.3.5.2 ROOT PARAMETERS

3.3.5.2.1 Days taken for root initiation

For recording days to rooting, a separate set of 20 cuttings was maintained in four seed pans with five cuttings in each, representing a replication. Cuttings were taken out from rooting media at 15th, 25th, 35th, 45th, and 55th day after planting the cuttings. After recording the observations the cuttings were again planted in the respective seed pans. Mean of four replication was computed.

3.3.5.2.2 Rooting percentage

Number of cuttings rooted was recorded at 75 days of planting. The percentage (%) was calculated by taking the ratio of rooted cuttings to total number of cuttings planted and multiplied by 100.

3.3.5.2.3 Number of roots per cutting

Number of adventitious roots in five randomly picked rooted cuttings in each replication was counted at 75 days of planting the cuttings and the mean was calculated.

3.3.5.2.4 Length of longest root

Length of the longest root in five randomly picked rooted cuttings in each replication was measured at 75 days of planting the cuttings and the mean was calculated and expressed in centimeter (cm).

3.3.5.2.5 Thickness of longest root

After measuring the length, the thickness of the longest root in five rooted cuttings in each replication was measured using Vernier Callipers and the mean was computed and expressed in millimeter (mm).

3.3.5.2.6 Fresh weight of roots per rooted cutting

The cuttings utilized for recording fresh weight of sprouts were utilized for recording fresh weight of roots also. The root system was thoroughly washed the roots were separated from the cuttings, air dried and their fresh weight was recorded and the mean was computed and expressed in g/cutting.

3.3.5.2.7 Dry weight of roots per rooted cutting

After recording the fresh weight, the fresh root samples were dried in a hot air oven at 60° C until constant weight was attained. They were weighed, mean was computed and expressed in gram g/cutting.

3.3.5.3 Survival of rooted cuttings in secondary nursery (poly bags)

Fifty per cent of rooted cutting or maximum of five rooted cuttings were transferred to poly bags containing a mixture of FYM, sand and soil in the proportion 1:1:1. Observations on the survival of rooted cuttings were recorded after 30 days of planting in the poly bags. Per cent survival was calculated using the following formula,

$$\text{Per cent survival} = \frac{\text{Number of cuttings survived}}{\text{Total number of cuttings planted}} \times 100$$

3.3.6 Statistical analysis

Data pertaining to various shoot and root parameters were tabulated and statistically analyzed using Factorial Completely Randomized Design (FCRD). After analysis, Fisher and Yates' tables (1957) were referred for obtaining the tabulated 'Y' values and the inference was drawn after comparing the calculated F values with the table F values at 5 % (P= 0.05) level of significance.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Investigations were carried out to “Standardize the vegetative propagation of Chinese chaste tree (*Vitex negundo* Linn.) by stem cuttings” during, 2010-11 at the Garden of Fragrance, Department of Horticulture, University of Agricultural Sciences; Gandhi Krishi Vignana Kendra, Bengaluru. The results obtained during the course of the study are presented in this chapter.

4.1 Shoot parameters

4.1.1 Days taken for sprouting

The data pertaining to the days taken for the first sprout to appear as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 1 and depicted in Figure 1.

The days taken for the first sprout to appear differed significantly between cuttings of different number of nodes, growth regulators and their interactions.

Among the cuttings of different number of nodes, triple node cuttings (M_3) took significantly lowest number of days to sprout (10.81) as compared to double node cuttings (M_2 -11.13) and single node cuttings (M_1 -17.78). Among the different growth regulators used, earliest sprouting (12.42 days) was recorded in cuttings treated with IBA at 3000 ppm (T_3), which was *on par* with IBA at 2000 ppm (T_2 -12.67 days), while, significantly delayed sprouting was noticed in control (T_1 -14.33 days). With respect to the interaction effect, triple node cuttings treated with 3000 ppm IBA (M_3T_3) sprouted early (9 days) as against 19.75 days in control.

Table 1: Influence of varying number of nodes and growth regulators on days taken for sprouting in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	19.75	11.75	11.50	14.33
T ₂ - IBA - 2000	15.75	11.25	11.00	12.67
T ₃ - IBA - 3000	18.25	10.00	9.00	12.42
T ₄ - NAA - 2000	16.25	12.50	11.00	13.25
T ₅ - NAA - 3000	17.50	11.00	11.00	13.17
T ₆ - IBA 2000 + NAA 2000	17.50	11.00	11.00	13.17
T ₇ - IBA 3000 + NAA 3000	18.50	10.25	11.00	13.25
T ₈ - Keradix	18.75	11.25	11.00	13.67
Mean	17.78	11.13	10.81	13.24
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.11	0.31	*	
T (Sub treatment)	0.18	0.51	*	
M×T	0.31	0.88	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

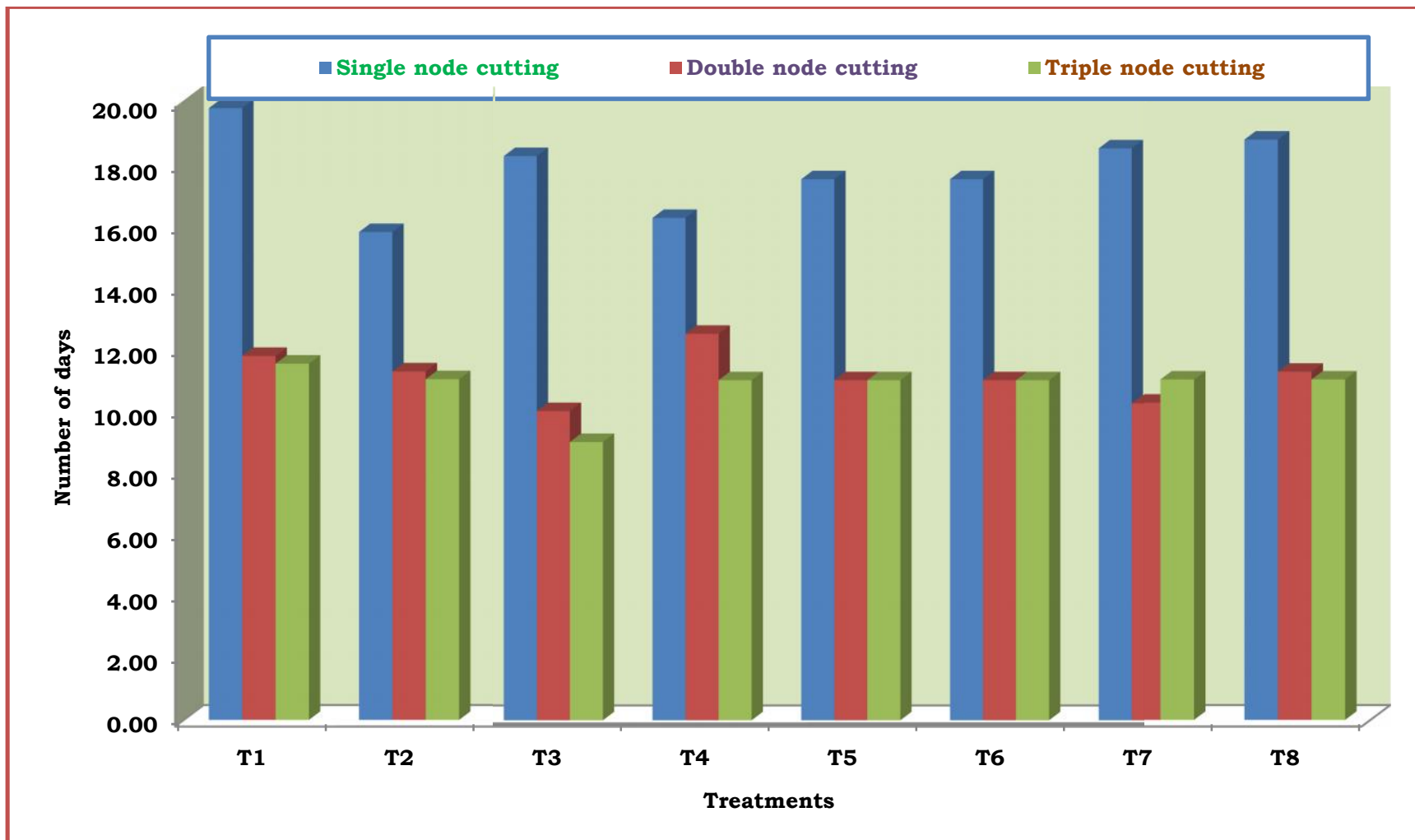


Fig 1: Influence of varying number of nodes and growth regulators on days taken for sprouting in *Vitex negundo* L. stem cuttings

4.1.2 Sprouting percentage

The data relating to the sprouting percentage as influenced by cuttings of different number of nodes, growth regulators, and their interactions are given in Table 2 and Figure 2.

Significant differences were observed in the sprouting percentage of cuttings due to the influence of cuttings of different number of nodes, growth regulators and their interactions.

The highest sprouting percentage was observed in triple node cuttings (M_3 -94.62) as compared to double node (M_2 -92.03) and single node (M_1 -58.75) cuttings. Among the different growth regulators tried, the cuttings treated with IBA at 3000 ppm (T_3) recorded the highest sprouting percentage (89.44) while, the lowest sprouting percentage was noticed in control (T_1 -67.78). In the interactions, triple node cuttings treated with 3000 ppm IBA showed highest (M_3T_3 -100) sprouting percentage, and it was *on par* with IBA at 3000 ppm + NAA at 3000 ppm (M_3T_7 -99.58), M_3T_8 (97.81), M_3T_2 (99.58), M_2T_6 (99.58) and M_2T_3 (96.67), while, the lowest sprouting percentage was noticed in single node cuttings under control (M_1T_1 -31.67).

4.1.3 Number of sprouts per rooted cutting

The data on the number of sprouts per rooted cutting as influenced by cuttings of different number of nodes, growth regulators and their interactions are furnished in Table 3 and illustrated in Figure 3.

Cuttings of different number of nodes, growth regulators and their interactions showed significant differences in number of sprouts per rooted cutting.

Table 2: Influence of varying number of nodes and growth regulators on sprouting percentage in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	31.67	85.00	86.68	67.78
T ₂ - IBA - 2000	65.00	93.33	99.58	85.97
T ₃ - IBA - 3000	71.67	96.67	100.00	89.44
T ₄ - NAA - 2000	78.33	90.00	90.00	86.11
T ₅ - NAA - 3000	65.00	95.00	88.33	82.77
T ₆ - IBA 2000 + NAA 2000	55.00	99.58	95.00	83.19
T ₇ - IBA 3000 + NAA 3000	45.00	88.33	99.58	77.64
T ₈ - Keradix	58.33	88.33	97.81	81.49
Mean	58.75	92.03	94.62	81.80
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.67	1.90	*	
T (Sub treatment)	1.10	3.10	*	
M×T	1.90	5.37	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

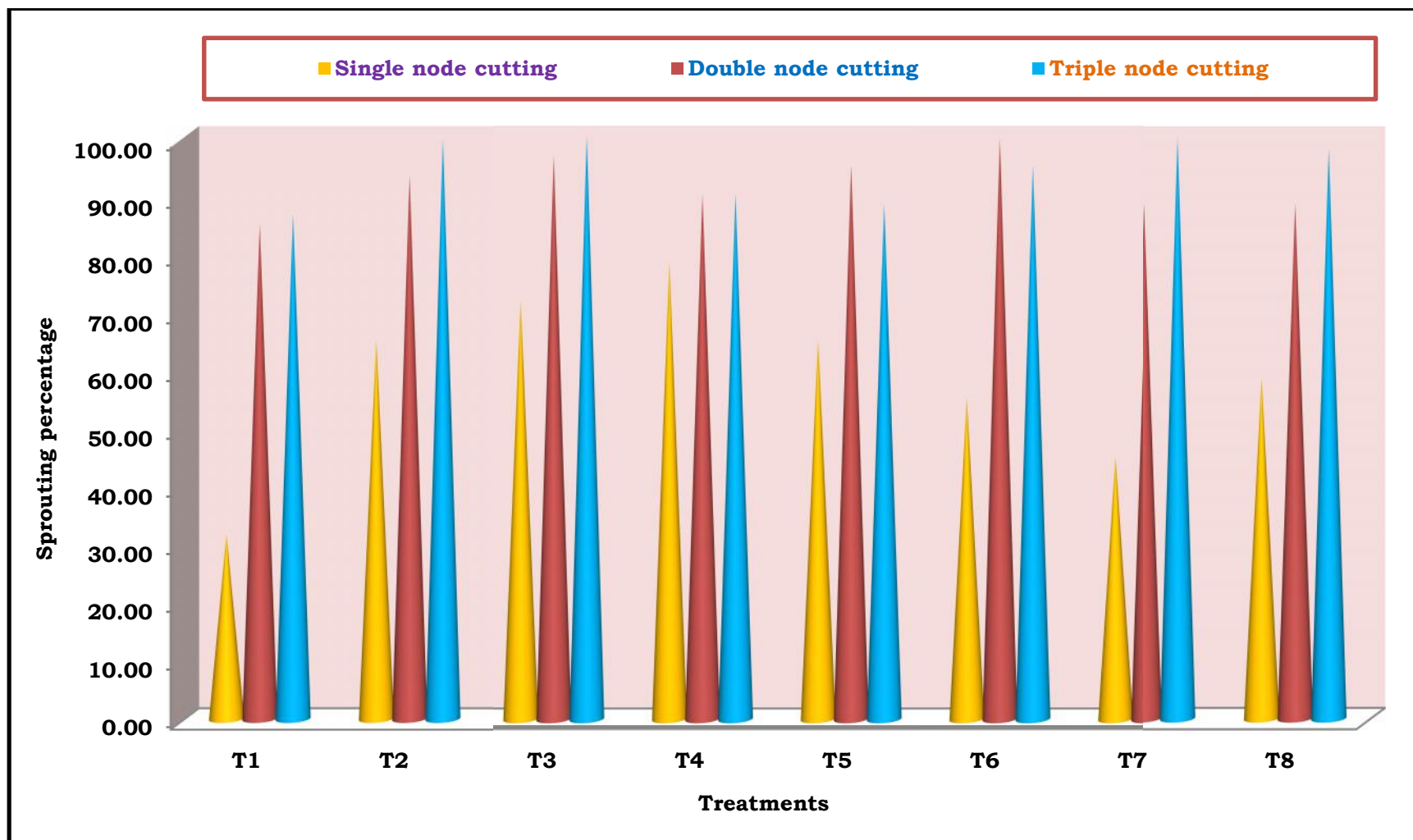


Fig 2: Influence of varying number of nodes and growth regulators on sprouting percentage in *Vitex negundo* L. Stem cuttings

Table 3: Influence of varying number of nodes and growth regulators on number of sprouts in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.93	1.93	2.17	1.67
T ₂ - IBA - 2000	1.00	2.04	2.87	1.97
T ₃ - IBA - 3000	1.21	1.92	3.23	2.12
T ₄ - NAA – 2000	1.38	1.82	2.29	1.83
T ₅ - NAA – 3000	1.34	2.04	2.64	2.01
T ₆ - IBA 2000 + NAA 2000	1.11	1.98	2.99	2.03
T ₇ - IBA 3000 + NAA 3000	1.03	2.00	2.58	1.87
T ₈ - Keradix	1.08	2.00	2.00	1.69
Mean	1.13	1.97	2.60	1.90
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.04	0.12	*	
T (Sub treatment)	0.07	0.19	*	
M×T	0.12	0.33	*	

*= Significant at 5%

Legend: M₁– Single node cutting (approx. 10 cm)

M₂–Double node cutting (approx. 15 cm)

M₃–Triple node cutting (approx. 20 cm)

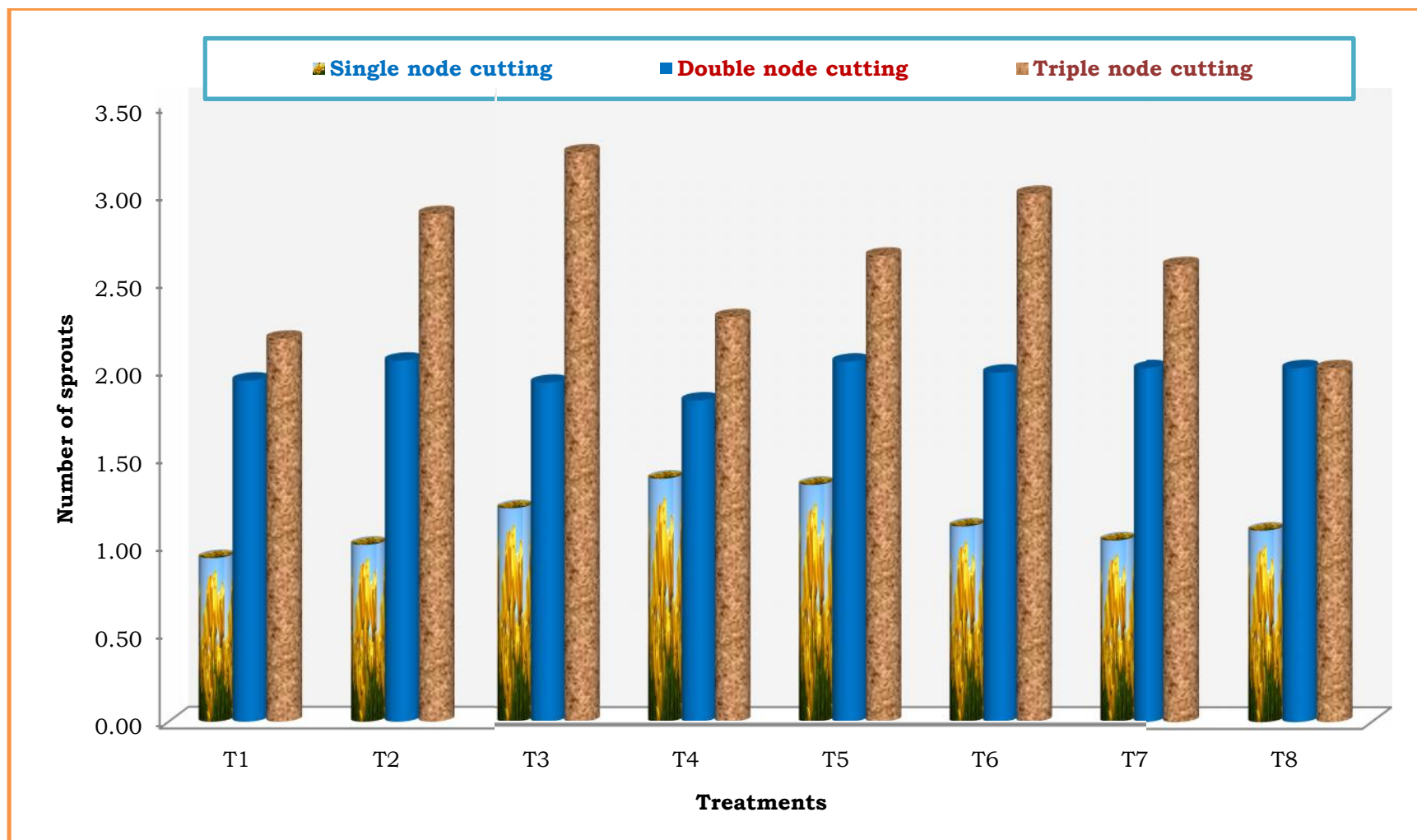


Fig 3: Influence of varying number of nodes and growth regulators on number of sprouts in *Vitex negundo* L. stem cuttings

The results revealed that, the triple node cuttings (M₃) had significantly higher number of sprouts (2.60) compared to double node (1.97) and single node cuttings (1.13). With respect to the different growth regulators used, more number of sprouts (2.12) were recorded in cuttings treated with 3000 ppm IBA (T₃), which was *on par* with T₅ (2.01), T₆ (2.03), and T₂ (1.97), while, significantly less number of sprouts (1.67) were noticed in control. The interaction effect of triple node cuttings with 3000 ppm IBA (M₃T₃-3.23) recorded more number of sprouts and it was *on par* with triple node cuttings treated with 2000 ppm IBA + 2000 ppm NAA (M₃T₆-2.99), while less number of sprouts were noticed in single node cuttings in control (M₁T₁-0.93) and it was *on par* with M₁T₇ (1.03), M₁T₃ (1.00), M₁T₈ (1.08), M₁T₆ (1.11) and M₁T₂ (1.21).

4.1.4 Average length of the sprouts in rooted cutting (cm)

The data on the average length of sprouts as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 4.

Significant differences were observed in average length of sprout among the cuttings of different number of nodes, growth regulators and their interactions.

It can be observed from the results that, triple node cuttings (M₃) had significantly highest sprout length (11.06 cm) as compared to double node (M₂-9.55 cm) and single node cuttings (M₁-8.81 cm). In case of growth regulators, the maximum sprout length (11.84 cm) was recorded in cuttings treated with IBA at 3000 ppm, while, the lowest sprout length was noticed in control (6.46 cm). Among the interactions, the triple node cuttings treated with IBA at 3000 ppm (14.28 cm) had the longest sprout, while, the shortest was noticed in single node cuttings under control (6.22 cm), which was *on par* with M₁T₈ (6.58 cm).

Table 4: Influence of varying number of nodes and growth regulators on average length of sprout (cm) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	6.22	6.29	6.86	6.46
T ₂ - IBA - 2000	9.62	11.01	11.38	10.67
T ₃ - IBA - 3000	10.08	11.18	14.28	11.84
T ₄ - NAA - 2000	8.90	8.69	10.43	9.34
T ₅ - NAA - 3000	9.48	10.15	11.61	10.41
T ₆ - IBA 2000 + NAA 2000	10.43	10.43	12.05	10.97
T ₇ - IBA 3000 + NAA 3000	9.17	9.74	11.50	10.14
T ₈ - Keradix	6.58	8.93	10.36	8.62
Mean	8.81	9.55	11.06	9.80
	SEm±	CD @ 5%		F test
M (Main treatment)	0.18	0.50		*
T (Sub treatment)	0.29	0.82		*
M×T	0.51	1.43		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

4.1.5 Length of the longest sprout in rooted cutting (cm)

The data regarding the longest sprout length per cutting as influenced by cuttings of different number of nodes, growth regulators and their interactions are furnished in Table 5 and Figure 5.

Significant differences in the length of longest sprout per cutting were observed among the cuttings of different number of nodes, growth regulators and their interactions.

The length of longest sprout was significantly maximum (17.44 cm) in triple node cuttings (M_3) as compared to double node (M_2 -14.22 cm) and single node cuttings (M_1 -10.44 cm). It was also observed that cuttings treated with IBA at 3000 ppm (T_3) had maximum (16.71 cm) length of longest sprout and it was *on par* with 3000 ppm IBA + 3000 ppm NAA (16.13 cm), 2000 ppm IBA (T_2 -15.64 cm). While, the lowest length of longest sprout was noticed in control (T_1 -8.99 cm). Among the interactions triple node cuttings treated with 3000 ppm IBA recorded the maximum length of longest sprout (M_2T_5 -20.38 cm) and it was *on par* with triple node cuttings treated with IBA at 3000 ppm + NAA at 3000 ppm (M_3T_7 -19.88 cm), M_3T_2 (19.63 cm) and M_3T_8 (18.50 cm) while, the minimum length of the longest sprout was observed in single node cuttings under control (7.13 cm) followed by M_1T_8 (8.13 cm).

4.1.6 Thickness of longest sprout in rooted cuttings (mm)

The data relating to the thickness of the longest sprout as influenced by cuttings of different number of nodes, growth regulators and their interactions are furnished in the Table 6.

Thickness of the longest sprout differed significantly between cuttings of different number of nodes, growth regulators and their interactions.

Table 5: Influence of varying number of nodes and growth regulators on length of longest sprout (cm) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	7.13	8.48	11.38	8.99
T ₂ - IBA - 2000	10.18	17.13	19.63	15.64
T ₃ - IBA - 3000	11.25	18.50	20.38	16.71
T ₄ - NAA - 2000	10.88	10.88	17.50	13.08
T ₅ - NAA - 3000	11.88	15.13	18.25	15.08
T ₆ - IBA 2000 + NAA 2000	13.00	13.25	14.00	13.42
T ₇ - IBA 3000 + NAA 3000	11.13	17.38	19.88	16.13
T ₈ - Keradix	8.13	13.00	18.50	13.21
Mean	10.44	14.22	17.44	14.03
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.24	0.67	*	
T (Sub treatment)	0.39	1.10	*	
M×T	0.68	1.90	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

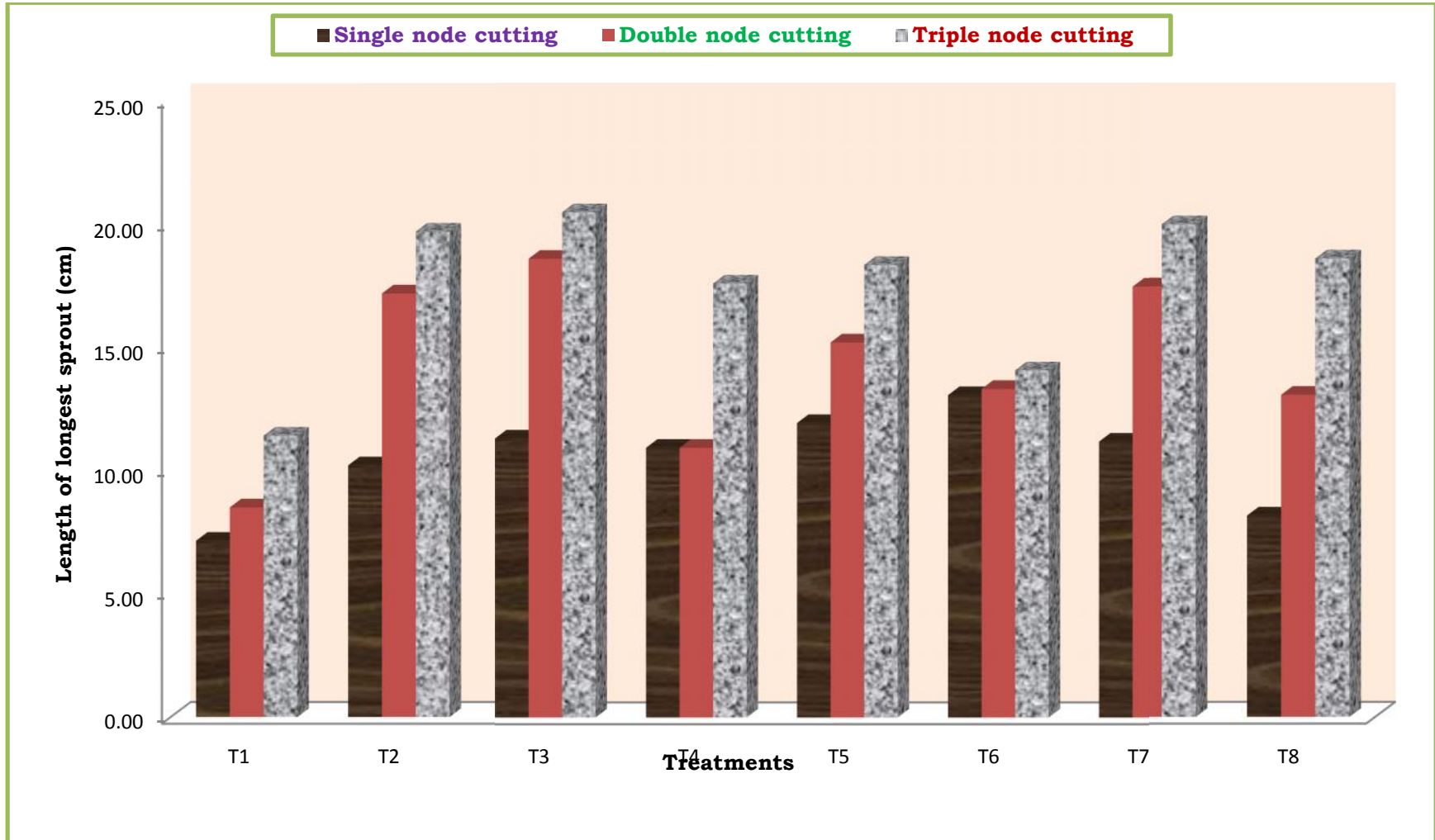


Fig 4: Influence of varying number of nodes and growth regulators on length of longest sprout (cm) in *Vitex negundo L.* stem cuttings

Table 6: Influence of varying number of nodes and growth regulators on thickness of longest sprout (mm) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	1.75	1.83	1.98	1.85
T ₂ - IBA - 2000	2.03	2.10	2.33	2.15
T ₃ - IBA - 3000	1.95	2.33	2.50	2.26
T ₄ - NAA - 2000	1.93	2.13	2.30	2.12
T ₅ - NAA - 3000	1.75	2.25	2.25	2.08
T ₆ - IBA 2000 + NAA 2000	2.03	2.28	2.38	2.23
T ₇ - IBA 3000 + NAA 3000	1.88	1.95	2.08	1.97
T ₈ - Keradix	1.93	1.98	2.23	2.04
Mean	1.90	2.10	2.25	2.09
	SEm±	CD @ 5%		F test
M (Main treatment)	0.02	0.06		*
T (Sub treatment)	0.03	0.09		*
M×T	0.06	0.16		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

It is seen from the table that, the triple node cuttings had significantly maximum thickness of the sprout (M_3 -2.25 mm) compared to double node (M_2 -2.10 mm) and single node cuttings (M_1 -1.9 mm). The maximum thickness of the sprout (2.26 mm) was recorded in cuttings treated with 3000 ppm IBA (T_3), while, significantly lowest thickness of the sprout was noticed in control (T_1 -1.85 mm). Among the interactions, cuttings of different number of nodes and growth regulators, the highest sprout thickness was observed in triple node cuttings treated with 3000 ppm IBA (M_3T_3 -2.5 mm), which was *on par* with the triple node cuttings treated with IBA at 2000 ppm + NAA at 2000 ppm (M_3T_6 - 2.38 mm) while, the sprout of lowest thickness was observed in single node cuttings under control (M_1T_1 -1.75 mm) and single node cuttings treated with 3000 ppm NAA (M_1T_5 -1.75 mm), which were *on par* with the single node cuttings treated with IBA at 3000 ppm + NAA at 3000 ppm (M_1T_7 -1.88 mm).

4.1.7 Fresh weight of the sprouts per rooted cutting (g)

Observations on the fresh weight of the sprouts as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 7.

Significant differences in fresh weight of the sprouts was noticed between cuttings of different number of nodes, growth regulators and their interactions.

It is evident from the table that, the triple node cuttings (M_3) had maximum (2.95 g) fresh weight of the sprout, whereas, the minimum (1.20 g) was recorded in M_1 . Among the different growth regulator treatments, the maximum fresh weight of the sprouts (2.64 g) was obtained in cuttings treated with T_3 level of treatment and it was *on par* with the T_6 (2.50 g) and the minimum was observed in T_1 (1.34 g). The

Table 7: Influence of varying number of nodes and growth regulators on fresh weight of sprouts (g/cutting) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.52	1.23	2.26	1.34
T ₂ - IBA - 2000	0.88	2.79	2.90	2.19
T ₃ - IBA - 3000	1.85	2.45	3.60	2.64
T ₄ - NAA - 2000	1.56	2.19	3.09	2.28
T ₅ - NAA - 3000	1.13	2.34	2.41	1.96
T ₆ - IBA 2000 + NAA 2000	1.95	2.41	3.14	2.50
T ₇ - IBA 3000 + NAA 3000	1.20	1.47	3.26	1.98
T ₈ - Keradix	0.54	1.72	2.95	1.73
Mean	1.20	2.07	2.95	2.08
	SEm±	CD @ 5%		F test
M (Main treatment)	0.03	0.08		*
T (Sub treatment)	0.05	0.14		*
M×T	0.09	0.24		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

interaction effect of triple node cuttings treated with IBA at 3000 ppm had the highest fresh weight of sprouts (3.6 g) whereas, the lowest was recorded in single node cuttings under control (0.52 g) and it was *on par* with M₁T₈ (0.54 g).

4.1.8 Dry weight of sprouts per rooted cutting (g)

The data on the dry weight of sprouts as affected by cuttings of different number of nodes, growth regulators and their interactions are furnished in Table 8.

Significant differences in the dry weight of sprouts were observed between cuttings of different number of nodes, growth regulators and their interactions.

The dry weight of sprouts was significantly maximum (0.71 g) in M₃ compared to M₂ (0.50 g) and M₁ (0.28 g). Among the different growth regulators used, the cuttings treated with T₃ level of treatments had the highest dry weight of sprouts (0.63 g) which was *on par* with T₆ (0.60 g) and the lowest was noticed in T₁ (0.31 g). Among the interactions, M₃T₃ (0.88 g) recorded highest dry weight of sprouts, while, the lowest was observed in M₁T₁ (0.12 g) and it was *on par* with M₁T₈ (0.13 g).

4.2 Root parameters

4.2.1 Time taken for root initiation

The data pertaining to the days taken for the root initiation as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 9.

Cuttings of different number of nodes and growth regulators showed significant differences in time taken for root initiation, but their interaction effect was shown non significant.

Table 8: Influence of varying number of nodes and growth regulators on dry weight of sprouts (g/cutting) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.12	0.29	0.53	0.31
T ₂ - IBA - 2000	0.19	0.67	0.70	0.52
T ₃ - IBA - 3000	0.42	0.59	0.88	0.63
T ₄ - NAA – 2000	0.38	0.53	0.75	0.55
T ₅ - NAA – 3000	0.28	0.56	0.58	0.47
T ₆ - IBA 2000 + NAA 2000	0.47	0.58	0.76	0.60
T ₇ - IBA 3000 + NAA 3000	0.29	0.35	0.79	0.48
T ₈ - Keradix	0.13	0.42	0.70	0.41
Mean	0.28	0.50	0.71	0.50
	SEm±	CD @ 5%		F test
M (Main treatment)	0.01	0.03		*
T (Sub treatment)	0.01	0.03		*
M×T	0.02	0.06		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

Table 9: Influence of varying number of nodes and growth regulators on days taken for initiation of rooting in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	50.50	47.75	45.75	48.00
T ₂ - IBA - 2000	38.75	36.50	34.25	36.50
T ₃ - IBA - 3000	36.75	33.50	30.00	33.42
T ₄ - NAA - 2000	46.50	44.25	42.25	44.33
T ₅ - NAA - 3000	47.75	45.25	42.75	45.25
T ₆ - IBA 2000 + NAA 2000	38.25	35.25	33.25	35.58
T ₇ - IBA 3000 + NAA 3000	37.50	34.75	32.50	34.92
T ₈ - Keradix	40.50	37.25	35.50	37.75
Mean	42.06	39.31	37.03	39.47
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.50	1.41	*	
T (Sub treatment)	0.82	2.30	*	
M×T	1.41	-	NS	

*= Significant at 5%

NS = Non Significant

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

Triple node cuttings (M_3) recorded early root initiation (37.03 days) than double node (M_2 -39.31 days) and single node cuttings (42.06 days). With respect to the effect of growth regulator treatments, the cuttings treated with T_3 level of treatment showed earlier initiation of rooting (33.42 days) and it was *on par* with the T_7 (34.92 days) and T_6 (35.58 days) whereas, delayed root initiation was noticed in control (T_1 -48 days).

4.2.2 Rooting percentage

The percentage of cuttings rooted at the end of 75 days as influenced by cuttings of different number of nodes and growth regulators are presented in Table 10 and Figure 5.

The rooting percentage differed significantly between cuttings of different number of nodes, growth regulators and their interactions.

The maximum percentage of rooting (79.37) was obtained in M_3 against M_2 (72.97 %) and M_1 (53.95 %). In case of growth regulator treatments, the maximum percentage of rooting (82.22) was observed in the cuttings treated with 3000 ppm IBA (T_3), while, the minimum rooting percentage (56.02) was noticed in control (T_1). Among the interactions, the triple node cuttings treated with 3000 ppm IBA recorded the maximum rooting percentage (M_3T_3 -91.67) and it was *on par* with the M_1T_8 (90.00), M_2T_3 (90.00) and M_3T_2 (88.33) whereas, the lowest rooting percentage was in M_1T_1 (48.33) and it was *on par* with the M_1T_6 (49.99), M_1T_7 (51.67), M_1T_2 (51.65), M_1T_8 and M_1T_4 (53.33).

4.2.3 Number of roots per cuttings

The data on the number of roots per cutting as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 11.

Table 10: Influence of varying number of nodes and growth regulators on rooting percentage in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	48.33	58.05	61.67	56.02
T ₂ - IBA - 2000	51.65	78.33	88.33	72.77
T ₃ - IBA - 3000	65.00	90.00	91.67	82.22
T ₄ - NAA - 2000	53.33	58.33	66.66	59.44
T ₅ - NAA - 3000	58.33	61.66	73.33	64.44
T ₆ - IBA 2000 + NAA 2000	49.99	83.33	85.00	72.77
T ₇ - IBA 3000 + NAA 3000	51.67	85.00	78.33	71.66
T ₈ - Keradix	53.33	69.06	90.00	70.80
Mean	53.95	72.97	79.37	68.76
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.83	2.33	*	
T (Sub treatment)	1.35	3.80	*	
M×T	2.34	6.59	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

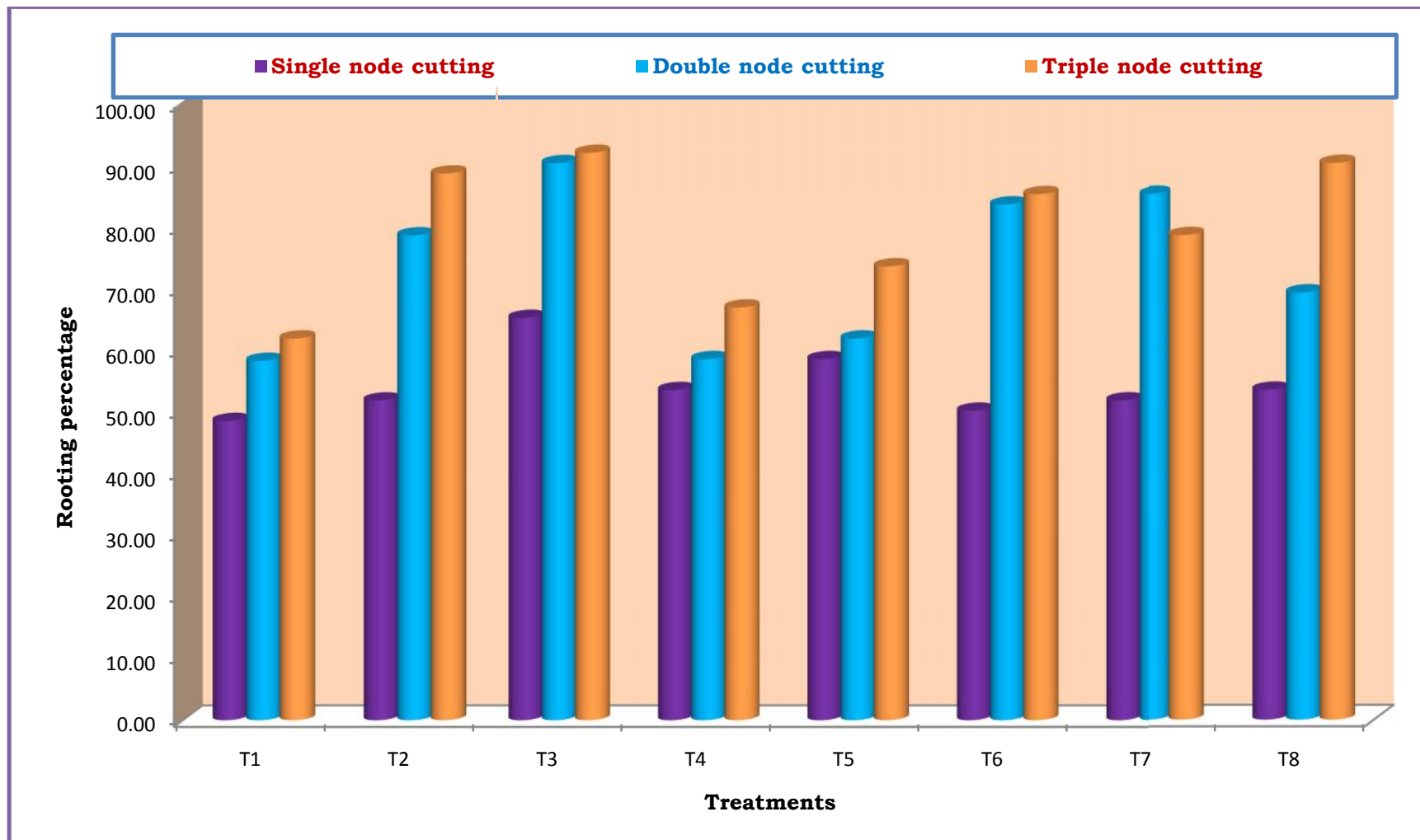


Fig 5: Influence of varying number of nodes and growth regulators on rooting percentage in *Vitex negundo* L. stem cuttings

Table 11: Influence of varying number of nodes and growth regulators on number of roots in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	4.20	5.45	11.55	7.07
T ₂ - IBA - 2000	7.10	8.08	18.40	11.19
T ₃ - IBA - 3000	12.46	15.25	19.05	15.59
T ₄ - NAA – 2000	5.95	7.80	16.80	10.18
T ₅ - NAA – 3000	5.53	7.36	14.65	9.18
T ₆ - IBA 2000 + NAA 2000	11.95	13.73	18.25	14.64
T ₇ - IBA 3000 + NAA 3000	10.80	12.49	22.65	15.31
T ₈ - Keradix	5.60	9.43	18.45	11.16
Mean	7.95	9.95	17.48	11.79
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.28	0.80	*	
T (Sub treatment)	0.46	1.30	*	
M×T	0.80	2.25	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)



Plate 5: Rooting of chinese chaste tree stem cuttings in different treatments

Significant difference in number of roots per cuttings was observed among cuttings of different number of nodes, growth regulators and their interactions.

Triple node cuttings showed more number of roots (M_3 -17.48) than double node cuttings (M_2 -9.95) and single node cuttings (M_1 -7.95). Among the different growth regulators experimented, the maximum number of roots (15.59) were recorded in cuttings treated with IBA at 3000 ppm (T_3) and it was *on par* with T_7 (15.31) and T_6 (14.64) whereas, the minimum number of roots were recorded in T_1 (7.07). The interaction of triple node cuttings with IBA at 3000 ppm + NAA at 3000 ppm (M_3T_7) recorded the maximum number of roots per cutting (M_3T_7 -22.65) while, the least number of roots were recorded in single node cuttings under control (M_1T_1 -4.20) and it was *on par* with M_1T_8 (5.60).

4.2.4 Length of the longest root (cm)

The data on the longest length of root as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 12 and depicted in Figure 6.

The length of longest root varied significantly between cuttings of different number of nodes, growth regulators and their interactions.

The length of longest root was significantly maximum (17.31 cm) in triple node cuttings (M_3) as compared to double node (M_2 -11.20 cm) and single node cuttings (M_1 -8.92 cm). Among the different growth regulator treatments, the length of longest root was maximum (15.31 cm) in cuttings treated with IBA at 3000 ppm (T_3) and it was *on par* with 3000 ppm IBA + 3000 ppm NAA (T_7 -14.46 cm), while, the lowest length of longest sprout was noticed in control (T_1 -8.18 cm). It was also found that, the interaction of triple node cuttings treated with IBA at 3000 ppm had the highest length of longest root (21.75 cm) compared to the single

Table 12: Influence of varying number of nodes and growth regulators on length of longest root (cm) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	5.28	6.42	12.85	8.18
T ₂ - IBA - 2000	10.74	10.39	15.40	12.17
T ₃ - IBA - 3000	11.79	12.39	21.75	15.31
T ₄ - NAA – 2000	7.46	9.06	14.85	10.46
T ₅ - NAA – 3000	6.99	13.01	16.30	12.10
T ₆ - IBA 2000 + NAA 2000	10.15	12.60	18.33	13.69
T ₇ - IBA 3000 + NAA 3000	11.78	12.10	19.50	14.46
T ₈ - Keradix	7.15	13.63	19.48	13.42
Mean	8.92	11.20	17.31	12.47
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.21	0.58	*	
T (Sub treatment)	0.34	0.95	*	
M×T	0.58	1.64	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

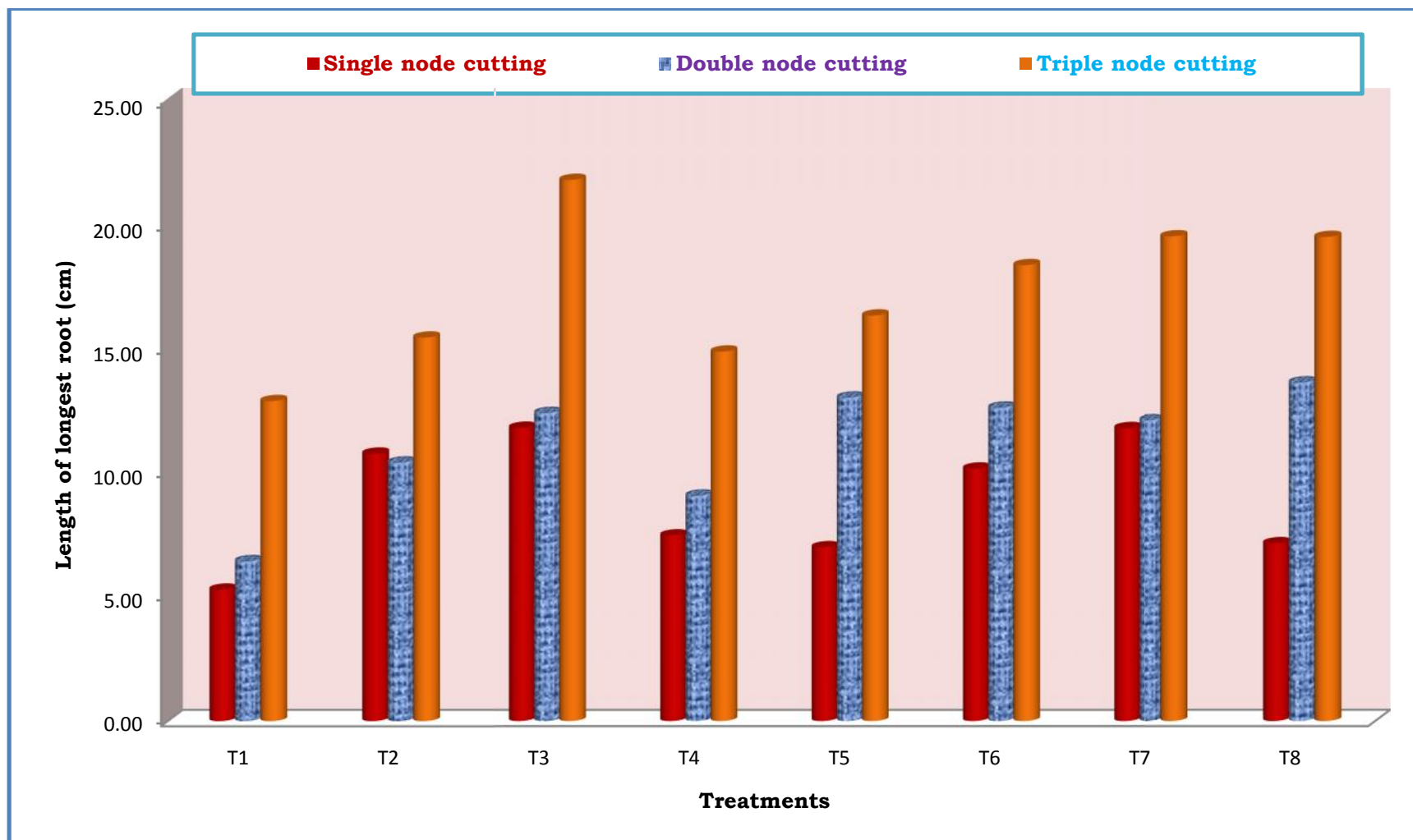


Fig 6: Influence of varying number of nodes and growth regulators on length of longest root (cm) in *Vitex negundo* L. stem cuttings

node cuttings under control which recorded the lowest length of longest root (5.28 cm).

4.2.5 Thickness of longest root (mm)

The data regarding the thickness of longest root as influenced by cuttings of different number of nodes, growth regulators and their interactions are furnished in the Table 13.

Thickness of longest root was significantly affected by cuttings of different number of nodes, growth regulators and their interactions.

The results indicated that, the triple node cuttings had significantly maximum thickness of the root (M_3 -0.94 mm) compared to double node cuttings (M_2 -0.87 mm) and single node cuttings (M_1 -0.76 mm). Among the different growth regulator treatments, the maximum thickness of the root (1.02 mm) was recorded in cuttings treated with 3000 ppm IBA (T_3) and it was *on par* with IBA at 3000 ppm + NAA at 3000 ppm (T_7 - 0.93 mm) while, significantly lowest thickness of root was noticed in control (T_1 - 0.64 mm). With respect to interaction effect of cuttings of different number of nodes and growth regulators, the highest root thickness was observed in triple node cuttings treated with 3000 ppm IBA (M_3T_3 -1.10 mm), which was *on par* with the M_3T_7 (1.03 mm), M_3T_8 (1.00 mm), M_3T_6 (1.00 mm), M_2T_2 (1.00 mm), M_2T_3 (1.00 mm), M_2T_5 (0.93 mm), M_2T_7 (0.88 mm), M_2T_8 (0.90 mm), M_1T_3 (0.95 mm), and M_1T_7 (0.88 mm) while, the lowest thickness of the root was noticed in single node cuttings in control (M_1T_1 -0.45 mm) treatment.

4.2.6 Fresh weight of roots per rooted cutting (g)

Observations on the fresh weight of roots as influenced by cuttings of different number of nodes, growth regulators and their interactions are presented in Table 14 and Figure 7.

Table 13: Influence of varying number of nodes and growth regulators on thickness of roots (mm) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.45	0.60	0.88	0.64
T ₂ - IBA - 2000	0.73	1.00	0.83	0.85
T ₃ - IBA - 3000	0.95	1.00	1.10	1.02
T ₄ - NAA - 2000	0.75	0.83	0.93	0.83
T ₅ - NAA - 3000	0.70	0.93	0.75	0.79
T ₆ - IBA 2000 + NAA 2000	0.78	0.83	1.00	0.87
T ₇ - IBA 3000 + NAA 3000	0.88	0.88	1.03	0.93
T ₈ - Keradix	0.83	0.90	1.00	0.91
Mean	0.76	0.87	0.94	0.85
	SEm±	CD @ 5%		F test
M (Main treatment)	0.02	0.06		*
T (Sub treatment)	0.04	0.10		*
M×T	0.06	0.18		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

Table 14: Influence of varying number of nodes and growth regulators on fresh weight of roots (g/cutting) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.06	0.11	0.86	0.34
T ₂ - IBA - 2000	0.20	0.45	1.17	0.60
T ₃ - IBA - 3000	0.43	0.26	2.37	1.02
T ₄ - NAA – 2000	0.15	0.16	0.95	0.42
T ₅ - NAA - 3000	0.11	0.33	1.05	0.50
T ₆ - IBA 2000 + NAA 2000	0.35	0.37	1.75	0.82
T ₇ - IBA 3000 + NAA 3000	0.45	0.27	2.24	0.99
T ₈ - Keradix	0.12	0.23	1.34	0.56
Mean	0.23	0.27	1.46	0.66
	SEm±	CD @ 5%		F test
M (Main treatment)	0.01	0.03		*
T (Sub treatment)	0.01	0.03		*
M×T	0.02	0.05		*

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

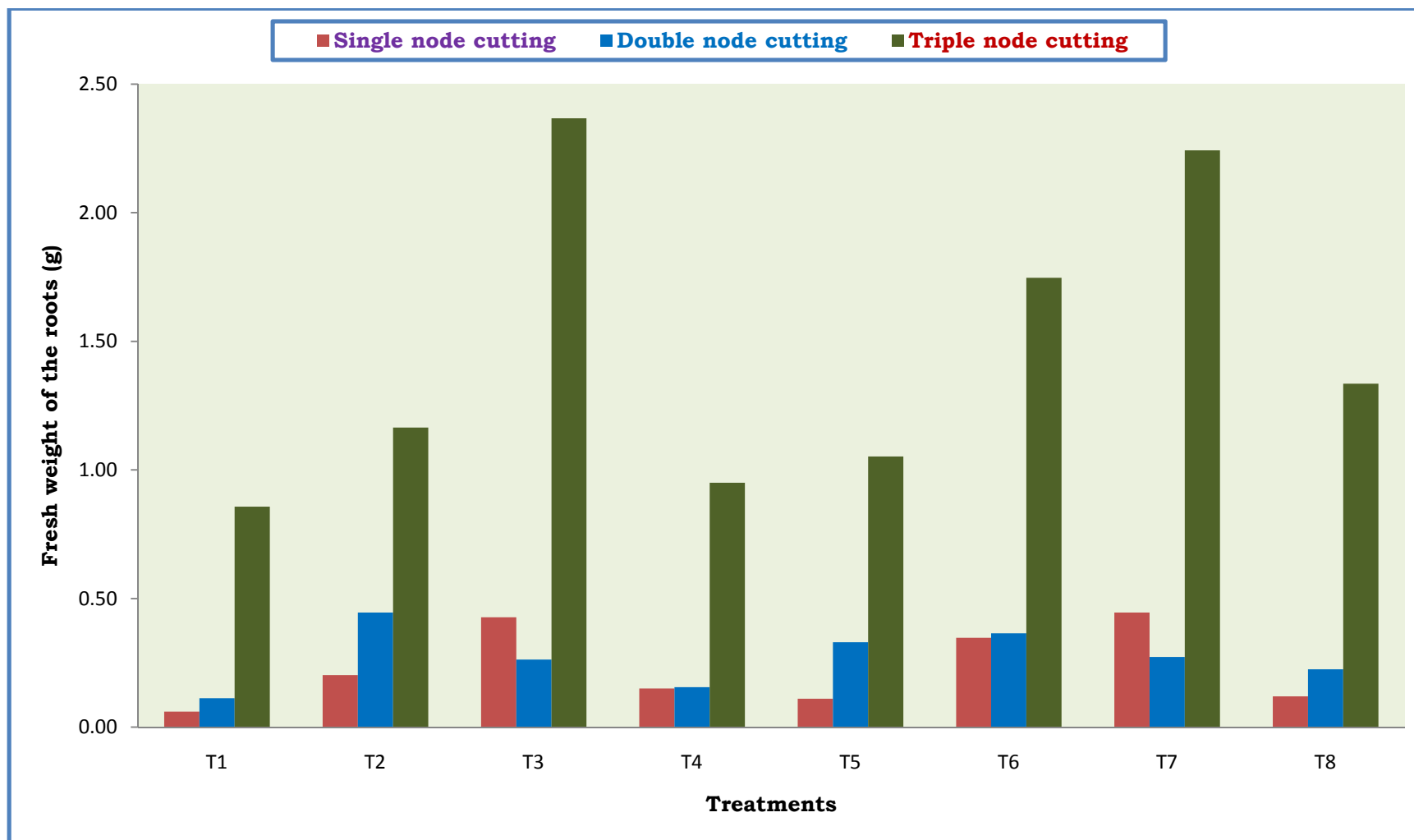


Fig 7: Influence of varying number of nodes and growth regulators on fresh weight of the root (g/cutting) in *Vitex negundo* L. stem cuttings

Significant difference in the fresh weight of roots was observed between cuttings of different number of nodes, growth regulators and their interactions.

The maximum (1.46 g) fresh weight of roots was recorded in M₃ and the minimum (0.23 g) was recorded in M₁. With respect to different growth regulators treatments, the maximum fresh weight of roots (1.02 g) was obtained in cuttings treated with T₃, which was *on par* with the T₇ (0.99 g), while, the minimum fresh weight of roots was observed in T₁ (0.34 g). In the interaction of cuttings of different number of nodes and growth regulators, the maximum fresh weight (2.37 g) was observed in M₃T₃, while the minimum fresh weight (0.06 g) of roots was observed in M₁T₁.

4.2.7 Dry weight of roots per rooted cutting (g)

The data on the dry weight of roots as influenced by cuttings of different number of nodes, growth regulators and their interactions are furnished in Table 15.

The dry weight of the roots differed significantly between the cuttings of different number of nodes, growth regulators and their interactions.

The maximum dry weight of the roots (0.41 g) was recorded in M₃ compared to M₂ (0.08 g) and M₁ (0.06 g). The maximum dry weight of roots (0.30 g) was obtained in cuttings treated with T₃ and it was *on par* with the T₇ (0.28 g) while, the lowest was noticed in T₁ (0.09 g). Among the interactions, M₃T₃ (0.67 g) recorded highest dry weight of roots, which was *on par* with the M₃T₇ (0.66 g), while, the lowest dry weight of roots was obtained in M₁T₁ (0.02 g) and it was *on par* with M₁T₈ (0.03 g) and M₁T₅ (0.03).

Table 15: Influence of varying number of nodes and growth regulators on dry weight of roots (g/cutting) in chinese chaste tree (*Vitex negundo* L.) stem cuttings

Sub treatments (ppm)	Main treatments			
	M ₁	M ₂	M ₃	Mean
T ₁ - Control	0.02	0.03	0.21	0.09
T ₂ - IBA 2000	0.05	0.11	0.34	0.17
T ₃ - IBA 3000	0.10	0.14	0.67	0.30
T ₄ - NAA 2000	0.04	0.04	0.28	0.12
T ₅ - NAA 3000	0.03	0.09	0.29	0.13
T ₆ - IBA 2000 + NAA 2000	0.09	0.09	0.47	0.22
T ₇ - IBA 3000 + NAA 3000	0.12	0.07	0.66	0.28
T ₈ - Keradix	0.03	0.06	0.39	0.16
Mean	0.06	0.08	0.41	0.18
	SEm±	CD @ 5%	F test	
M (Main treatment)	0.02	0.06	*	
T (Sub treatment)	0.01	0.03	*	
M×T	0.01	0.03	*	

*= Significant at 5%

Legend: M₁- Single node cutting (approx. 10 cm)

M₂-Double node cutting (approx. 15 cm)

M₃-Triple node cutting (approx. 20 cm)

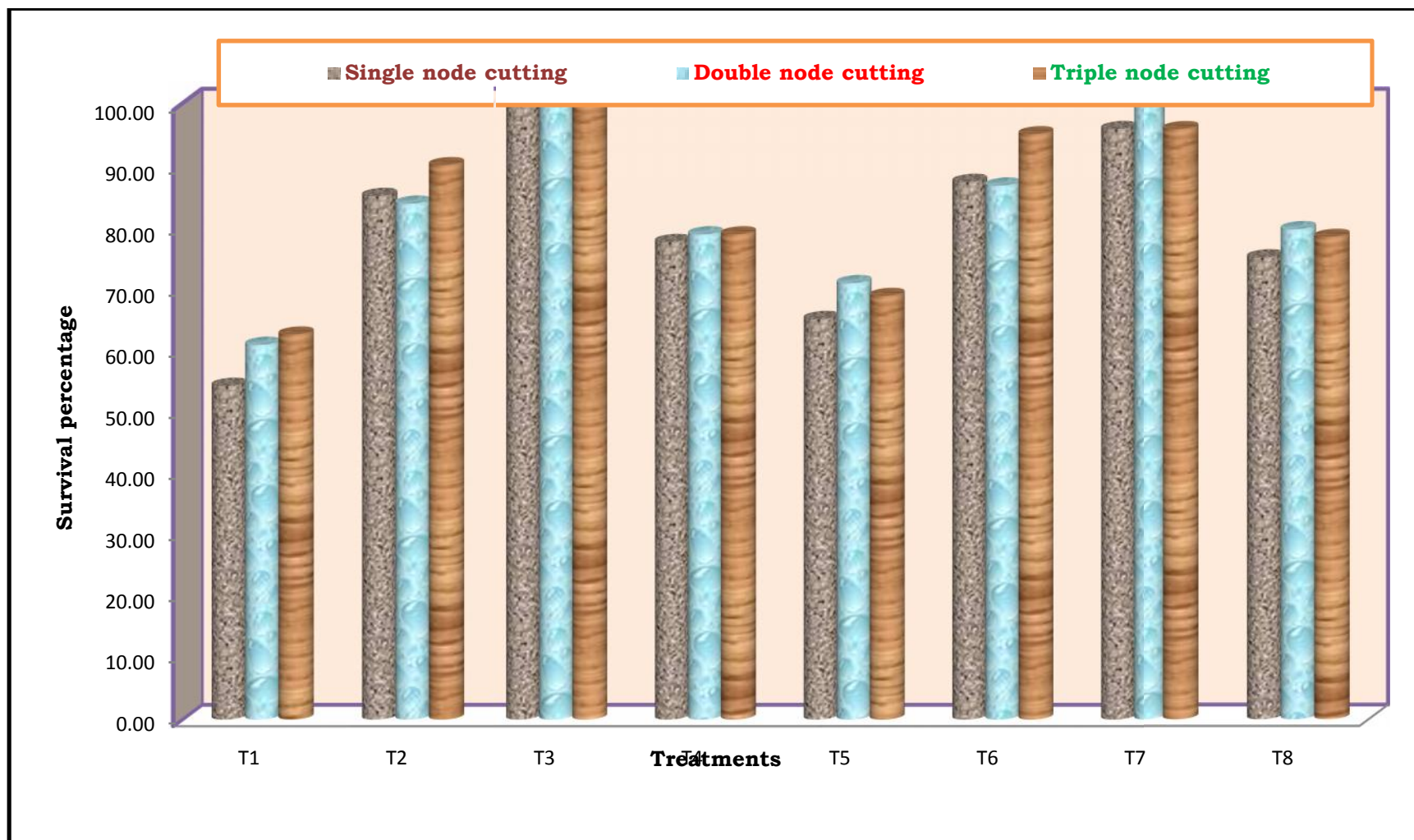


Fig 8: Influence of varying number of nodes and growth regulators on survival percentage of rooted cuttings in *Vitex negundo* L.



Plate 6: General view of *Vitex negundo* rooted cuttings in secondary nursery

4.3 Survival of rooted cuttings in secondary nursery

The data relating to the survival percentage of rooted cuttings of *Vitex negundo* Linn. after transplantation are presented in Table 16 and Figure 8.

Significant differences were observed in survival percentage of the rooted cuttings between different growth regulator treatments, whereas, the effect of cuttings of different number of nodes and their interactions was found non significant.

It has been confirmed from the table that, the cuttings treated with IBA at 3000 ppm and IBA at 3000 ppm + NAA at 3000 ppm had highest survival percentage (100), whereas, the least survival percentage was noticed in control (59.16).

DISCUSSION

V. DISCUSSION

Vitex negundo L. is a large aromatic shrub or a small tree. It is one of the common plant used in Indian system of medicine. Various parts of the plant used in bronchitis, asthma and gastric troubles. It is also known for reclamation of degraded soils to prevent soil erosion (Vadawale *et al.*, 2006). As seeds have low germination potential and the plant is best propagated by stem cuttings. Plant hormones play an integral role in faster and better growth and growth and development of plants (Tewary *et al.*, 2004).

Vegetative propagation of plants is essentially the reproduction of plant material from vegetative organs so that the offspring will contain the exact characteristics of the parent plant with regards to the genotype. Perpetuation of plants by vegetative means is sometimes the easiest, quicker and economical method. In several horticultural crops, different methods of vegetative propagation are employed depending upon its suitability in multiplying a particular plant species. Among the different methods of vegetative propagation followed propagation through cuttings is the most popular and widely used method. Propagating a plant by means of cutting is a simpler and the cheapest method wherein no complex interaction of stock and scion is involved.

The purpose of treating cuttings with auxins, which are plant growth regulators, is to increase the rooting percentage of cuttings, hasten root initiation and to increase uniformity of rooting. Some difficult to root species will not respond to auxin treatment. Plants whose cuttings root easily may not justify the additional expense and effort of using these materials. Best use of auxins is with moderately difficult to difficult-to-root species. The value of auxins in propagation is well established. The synthetic root-promoting chemicals that have been

found most reliable in stimulating adventitious root production in cuttings are the auxins like IBA and NAA, although others can be used. IBA is the best auxin for general use because it is nontoxic to plants over a wide concentration range, and is effective in promoting rooting of a large number of plant species (Hartmann and Kester, 2004).

In the present investigation an attempt was made to find out the optimum level of growth regulators and suitable nodal cutting in relation to plant growth and development. The results of the study are discussed under the following headings.

5.1 Influence of cuttings with different number of nodes and growth regulators on rooting of chinese chaste tree.

The experiment was carried out with three cuttings of different number of nodes (Single – approx. 10 cm; double – approx. 15 cm, and triple node – approx. 20 cm) and eight different growth regulator treatments (control, IBA - 2000 ppm, IBA - 3000 ppm, NAA - 2000 ppm, NAA - 3000 ppm, IBA – 2000 ppm + NAA - 2000 ppm, IBA-3000 ppm + NAA - 3000 ppm and keradix).

5.1.1 Shoot parameter

5.1.1.1 Effect of cuttings with different number of nodes

In the present study, cuttings having different number of nodes caused significant influence on various shoot parameters irrespective of growth regulators. It was observed that least number of days for sprouting was recorded in triple node cuttings (10.81), while, in double node and single node cuttings, it was 11.13 and 17.78 days after planting the cutting, respectively.

The maximum sprouting percentage (94.62), number of sprouts (2.60), average length of sprout (11.06), length (17.44 cm) of longest

sprout and thickness of longest sprout (2.25 cm), fresh weight (2.95 g) and dry weight (0.71 g) of sprouts in triple node cuttings as compared to double and single nodal cuttings. This can be attributed to high amount of stored food in the lengthier cuttings which provided sufficient food reserves for the cuttings to sprout (Hartmann and Kester, 2004). These results are in line with findings of Srikantaprasad (2009) in noni.

5.1.1.2 Effect of different growth regulators

The data clearly indicates the significant influence of growth regulators on all shoot parameters as compared to control. IBA was superior to NAA, keradix treatment and control.

Cuttings treated with growth regulators have recorded early sprouting, highest sprouting percentage, maximum number of sprouts, length of sprout, length of longest sprout and thickness of the longest sprout, fresh and dry weight of sprout compared to control and keradix treatment.

It is clear from the data (Table 1) that early sprouting (12.42 days) was observed in cuttings treated with IBA 3000 ppm treatment. The same treatment had a profound influence on sprouting percentage (89.44), maximum number of sprouts (2.12) and average sprout length (11.84 cm) per rooted cuttings. Earliness in sprouting and increase in number of sprouts may be due to better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators, which activates the shoot growth (Shiva Prasad *et al.*, 2001 in *Thymus vulgaris* L. and Panwar *et al.*, 1994 in bougainvillea). Similar findings were reported by Shirol and Patil (1992) in ixora and Rajarama (1997) in pomegranate,

Cuttings treated with IBA 3000 ppm have recorded maximum length of longest sprout (16.71 cm) when compared to control.

Maximum length of longest sprout could be due to the highest number of roots per cutting (15.59) which helps in absorption of nutrients and moisture. The auxins activated shoot growth which might have resulted in elongation of stems and length of sprout through cell division accounting in higher number of sprouts and longest sprout. Similar findings were also reported by Husen and Mishra (2001) in *Vitex negundo*.

Thickest sprout (2.26 mm) was observed in cuttings treated with 3000 ppm IBA (Table 6). The auxins activate shoot growth which might have resulted in the increased length and thickness of the longest sprout. This may be attributed to optimum auxin activity which might have caused hydrolysis and translocation of carbohydrate and nitrogenous substances at the base of the cuttings and has resulted in accelerated cell elongation and cell division in suitable environment (Singh *et al.*, 2003 in *Piper longum*). Singh (1979) working with *Jasminum sambac* was also of the same opinion.

Similarly, cuttings treated with growth regulators have recorded higher fresh and dry weights of sprouts compared with control. The fresh weight was related to number of sprouts, length of longest sprouts and thickness of longest sprouts per cutting (Singh, 2001 in *J. Sambac*). IBA at 3000 ppm recorded the maximum fresh (2.64 g) and dry weights (0.63 g) of sprouts, which is attributed to superior shoot characters (number, length and thickness of sprout). Similar response was noted by Singh *et al.* (2003) in long pepper.

Growth regulators had shown best results as mentioned above. This is due to persistence and dehydration of each synthetic auxin which varies among species because of variation in the levels of IAA oxidase.

5.1.1.3 Interaction effect of cuttings with different number of nodes and growth regulators

The interaction effect of cuttings having different number of nodes and the growth regulators had a significant and striking impact on all shoot parameters.

Triple node cuttings treated with IBA at 3000 ppm recorded minimum number of days (9.00) for first sprouting and maximum sprouting percentage (100). Same treatment had profound influence on more number of sprouts (3.23) and recorded higher values in respect of all shoot parameters such as length of sprout (14.28 cm), length (20.38 cm) and thickness of longest sprout (2.50 mm), fresh (3.60 g) and dry weights (0.88 g) of sprouts. Use of IBA helps in the accumulation of metabolites, synthesis of new proteins, cell enlargement and increase in nitrogen which might have resulted in early bud sprouting. The similar results have been reported by Singh *et al.*, 1986 in sweet lime and Srikantaprasad (2009) in *Morinda citrifolia*.

5.1.2 Root parameters

5.1.2.1 Effect of cuttings with different number of nodes

The present investigation revealed a significant influence of cuttings having different number of nodes on all root parameters such as number of days taken for root initiation, rooting percentage, number of roots per cutting, length of longest root (cm), thickness of longest root, fresh and dry weights of roots.

Early root initiation was observed in triple node cuttings (37.03 days), while in double node and single node cuttings, it was 39.31 and 42.06 days after planting the cuttings, respectively. All the root parameters such as rooting percentage, number of roots per cutting, length of longest root, thickness of longest root, fresh and dry weights of

roots (79.37, 17.48, 17.31 cm, 0.94 mm, 1.46 g and 0.41 g respectively) were found to be maximum in triple node cuttings and lowest values were observed in single node cuttings (53.95 %, 7.95, 8.92 cm, 0.76 mm, 0.23 g and 0.06 g, respectively).

The positive influence of triple node cuttings on all the root parameters could be attributed to many internal factors of cutting such as level of auxins, rooting co-factors, and carbohydrate storage which collectively influence the root initiation of cuttings (Hartmann and Kester, 2004). Another reason for better rooting in triple node cutting is more number of buds, since the buds are the source of many rooting co-factors, more number of buds in cuttings induced better rooting (Lek and Vander, 1925; Went, 1929). These results are in line with Srikantaprasad (2009) and Vezhavendran and Ponnaiyan (2005) in noni.

5.1.2.2 Effect of different growth regulators

It is well known fact that auxin plays an important role in induction of roots in cuttings. Among the growth regulators used in this experiment IBA induced better rooting. The probable reason for the better rooting cuttings by IBA treatment is due to its greater stability, low mobility and its slow degradation by enzymes (Hartmann and Kester, 2004).

Earliest rooting (33.42 days) and maximum rooting percentage (82.22) were observed in the cuttings treated with IBA at 3000 ppm and this treatment differed significantly from rest of the growth regulator treatments. Early and better rooting might be due to early sprouting and higher shoot parameters in initial stages (Table 9 and 10). Further, stored food materials with the aid of growth regulators have hastened the rooting (Haissig, 1984). Auxins are also known to induce greater metabolic activities and mobilization of sugars and nitrogenous

substance from leaves which may have influenced in the initiation of root primordial in cuttings (Singh *et al*, 1986). IBA applied at the base causes the downward transport of a substance rhizocaline, which is necessary for root formation (Cooper, 1938). These results are in conformity with Panwar (1994) in bougainvillea.

Regarding number of roots, the cuttings treated with IBA at 3000 ppm performed better (15.59) over other treatments and control. This may be due to enhanced hydrolysis of carbohydrates caused by auxin treatment (Rajarama, 1997 in Pomegranate). Further Krishnamurthy (1981) opined that auxins would bring about various physiological changes, but the mechanism by which these changes are brought about is not fully understood except for the effect of auxin on cell elongation. The better response to optimum concentration of IBA at 3000 ppm may be attributed to increased rate of respiration, accumulation of higher level of amino acids at the bases of cuttings than in untreated cuttings.

The maximum root length (15.31 cm) and thickest root (1.02 mm) was noted in cuttings treated with IBA at 3000 ppm. The length of the root increased with increase in the level of IBA and NAA. The increase in the length and thickness of root over control may be due to the enhanced hydrolysis of carbohydrates, auxin induced accumulation of metabolites, synthesis of new proteins, cell enlargement and cell division caused by treatment with auxin. The present finding is close agreement with of Shenoy (1992) in *Rosa damascena* and Sheror *et al*, (1985) in Grape vine.

The fresh (1.02 g) and dry weights (0.30 g) of roots per cutting were found to be significantly higher in the cutting treated with 3000 ppm. The fresh weight of the root is related to number of roots, length of roots and thickness of the roots, which were found to be maximum in 3000 ppm IBA. Similar effect has also been observed by Farooqi *et al*. (1994) in *Rosa damascena*. The higher dry weight of the roots may be attributed to

increased number of roots and fresh weight of roots. These results are in accordance with those of Patil and Shirol (1991) in oleander.

Increase in quality parameters of root in terms of more number of roots, maximum length of longest root, thickest root, higher fresh and dry weights of roots is due to early initiation and early establishment of roots compared to control.

5.1.2.3 Interaction effect of cuttings with different number of nodes and growth regulators

The complementary effect of cuttings having different number of nodes and growth regulators had a significant influence in respect of all the root parameters considered in the present investigation, except days taken for root initiation.

The notable complementary effect of cuttings having different number of nodes and growth regulators has been recorded and it was highly significant when triple node cutting of chinese chaste tree were treated with 3000 ppm IBA for rooting as compared to any other combinations. This clearly reveals that the efficacy of growth regulator IBA at 3000 ppm was much pronounced, when used for treating triple node cutting, rather than double node and single node cutting. Highest values in respect of almost all the root parameters such as rooting percentage (91.67), length and thickness of the longest root (21.75 cm and 1.10 mm, respectively) and fresh and dry weight of roots (2.37 and 0.67 g, respectively). All the above results are in comparison with report of Srikantaprasad (2009) in noni, Paul and Jhon (1992) in *Hydrangea macrophylla* and Venkatesh and Pandey (2006) in *Pterocarpus dalbergioides*.

The number of roots per rooted cutting were maximum (22.65) in triple node cutting treated with combination of IBA + NAA at 3000 ppm,

which may be due to synergistic effect of IBA and NAA (Patil and Shirol, 1991 in oleander). Similar results were obtained by Ghatnatti (1997) in *Duranta plumieri*.

From the interactions, it can be seen that triple node cutting with IBA at 3000 ppm recorded higher dry weight of roots due to the higher initial fresh weight of roots per rooted cuttings and higher number of roots. Similar trend has been reported by Husen and Mishra (2001) in *Vitex negundo*.

5.1.3 Survival of rooted cutting

Significant differences in the survival percentage of rooted cuttings were observed among different growth regulators, whereas, the effect of cuttings of different number of nodes and their interaction was found non-significant.

Maximum survival of rooted cuttings in the secondary nursery was observed in stem cuttings treated with growth regulators and keradix as compared to control. Among all growth regulators treatment cent per cent survival observed in 3000 ppm IBA and combinations of 3000 ppm IBA + 3000 ppm NAA, which may be due to the better rooting and other root parameters in these treatments, the treatments which recorded highest fresh and dry weights of roots were able to survive better under field condition. Similar results were observed by Pooja (2010) in japanese honey suckle and Shenoy (1992) in *Rosa damascena*.

Future line of work:

Future work on the propagation of Chinese chaste tree (*Vitex negundo* Linn.) can be focused on the following lines.

1. Standardization of season for multiplication of *Vitex negundo* L.
2. To test the effect of rooting media on rooting ability of cuttings.
3. To test the influence of environmental conditions for successful vegetative propagation of *Vitex negundo*.

SUMMARY AND CONCLUSION

VI. SUMMARY AND CONCLUSION

Studies on vegetative propagation of Chinese chaste tree (*Vitex negundo* Linn.) by stem cutting were carried out during 2010-11 at the Garden of Fragrance attached to the Department of Horticulture, University of Agricultural Sciences, Bengaluru.

The study was aimed at finding out the optimum size of the cutting and the kind and concentration of root inducing compounds, for maximizing the rooting success.

Single, double and triple node cuttings were treated with root inducing growth regulators IBA and NAA, applied either singly or in combination, at different concentrations ranging from 2000-3000 ppm. A commercial rooting hormone formulation *viz.* Keradix was also used to test its efficiency in comparison with growth regulators.

The salient findings of the study are summarized below:

Triple node cuttings were found to be significantly superior to double and single node cuttings with respect to shoot parameters like days taken for sprouting (10.81), sprouting percentage (94.62), number of sprouts (2.60), length of sprout (11.06 cm), length of longest sprout (17.44 cm), thickness of sprout (2.25 mm), fresh (2.95 g) and dry weights of the sprouts (0.71 g) and root parameters *viz.* days taken for root initiation (37.03), rooting percentage (79.37), number of roots (17.48), length of longest root (17.31 cm), thickness of the root (0.94 g), fresh (1.46 g) and dry weights (0.41 g) of roots per cutting.

Among the different growth regulators tried, stem cuttings treated with IBA at 3000 ppm recorded significantly higher values for all the shoot parameters such as days taken for sprouting (12.42), sprouting percentage (89.44), number of sprouts (2.12), length of the sprout (11.84

cm), length of longest sprout (16.71 cm), thickness of the sprout (2.26 mm), fresh and dry weights (0.63 g and 2.64 g, respectively) of sprouts and this treatment induced early root initiation (33.42 days), maximum rooting percentage (82.22), number of roots (15.59), length of root (15.31 cm), thickness of the root (1.02 mm), fresh (1.02 g) and dry weights of roots (0.29 g), and maximum survival percentage (100). On contrary, untreated stem cuttings recorded significantly least values in respect of all the shoot and root parameters.

Complementary effect of interactions between stem cuttings having different number of nodes and growth regulators was observed with regard to all shoot and root parameters. The triple node stem cuttings treated with IBA (3000 ppm) recorded significantly higher values for shoot parameters such as days to sprout (9), sprouting percentage (100), number of sprouts (3.23), length of sprout (14.28 cm), length (20.38 cm) and thickness (2.5 mm) of longest sprout and fresh (3.6 g) and dry weights (0.88 g) of sprouts and root parameters *viz.* days to root (30), rooting percentage (91.67), length (21.75 cm) and thickness (1.10 mm) of longest root, and fresh (2.37 g) and dry weight (0.67 g) of roots. But the more number of roots produced per cutting were found to be more in cuttings treated with combination of 3000 ppm IBA + 3000 ppm NAA and significantly lower values with regard to all shoot and root parameters were obtained in untreated cuttings.

CONCLUSION:

The results of this investigation clearly brought out that, triple node hardwood cuttings should be treated with 3000 ppm IBA to obtain maximum rooting success and survival in secondary nursery in Chinese chaste tree (*Vitex negundo* L.).

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VII REFERENCES

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* Originals not seen

APPENDICES

APPENDIX-1

Meteorological data recorded during the period of experimentation
from Agro meteorology unit, University of Agricultural Sciences,
GKVK, Bengaluru

Months	Temperature (° C)		Relative humidity (%)		Rain fall (mm)	Bright sunshine (hrs)
	Max	Min	I hr	II hr		
Aug-2010	27.1	19.2	94	58	158.2	3.2
Sept-2010	27.2	19.1	92	59	89.4	3.8
Oct-2010	28.0	19.0	93	54	119.2	5.0
Nov-2010	26.3	17.7	95	58	128.6	4.2
Dec-2010	25.7	15.2	92	53	9.8	5.1