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Effect of hormonal pre-treatment on sprouting and survival of different medicinal plant species

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Abstract. *Tiwari RKS, Mehta R, Kumar S. 2015. Effect of hormonal pre-treatment on sprouting and survival of different medicinal plant species. Nusantara Bioscience 7: 77-89.* In the present study, sprouting and survival of cuttings of ethnomedicinally important shrub species, i.e. *Argyreia nervosa, Gardenia gummifera, Helicteres isora, Hiptage madablota, Lippia javanica, Caesalpinia bonduc, Jasminum grandiflorum, Millingtonia hortensis, Putranjiva roxburghii, Stereospermum suaveolens, Vitex negundo, Vitex leucoxylon* and *Zanthoxylum armatum* were recorded through propagation. In vivo, experiment was conducted comprising treatments of cutting diameters i.e. thick (D_1-2.1 cm), medium (D_2-1.6 cm) and thin (D_3-0.8 cm) and pre-treatment of exogenous hormones viz., Rootex, α-Naphthalene Acetic Acid (NAA) and Indole 3 Butyric Acid (IBA) maintained at 1000 ppm in talc powder formulation. Results revealed a significant effect of cutting diameter and pre-hormonal treatment on sprouting and survival of medicinal plant species under greenhouse conditions. Species, i.e. *L. javanica, V. negundo, V. leucoxylon, H. isora, C. bonduc, G. gummifera,* and *S. suaveolens* had higher percent of sprouting (84.25-100.0) and survival (59.72-100.0). Effect of all three hormones on all the three diameters of plants cuttings for sprouting and survival was significant and clearly distinctive with maximum increase of 66.66 and 64.81 respectively in species *C. bonduc*. IBA had its more effect on sprouting and survival of most of the medicinal plant species in comparison of Rootex and NAA.

Keywords: α-NAA, ethnomedicinal herb, IBA, Rootex, stem cuttings.

INTRODUCTION

Prolonged usage of synthetic drugs commonly used in the conventional system of medicine, their associated side effects as well as the uncertainty concerning their safety has paved a way towards an era of alternative system of medicine, i.e. herbal medicine. A medicinal plant is the one, used in order to relieve, prevent or cure a disease or to alter physiological and pathological process. The present knowledge concerning the medicinal value of plants is gathered over the centuries through trial and error methods, and is often based on speculation and superstition (Hamayun 2006; Sen et al. 2011).

India is one of the world's top twelve nations having mega bio-diversity and it produces enormous plant-based raw materials for drugs, pharmaceuticals, and related industries. The forest of different regions is recognized as rich biological reservoir of many valuable medicinal and aromatic plants. However, the growing demand for raw material of medicinal and aromatic plants and continuous extraction from the forest area causing depletion of medicinal plant potential of the forests and very little has been done to protect them. Commercial cultivation of medicinal and aromatic plant species with standardized agro-techniques can fulfill the demand for raw materials and protect medicinal plants from depletion.

During investigation it was found that some of medicinal plant species are not only hard to propagate sexually but also show complexities and undesirable characters thus, it was observed that vegetative propagation through stem cuttings is the most vital and sole method to reproduce these plants species conserving their innate desirable characters (Nanda and Kochhar 1987; Tewary et al. 2004). Therefore, there is an urgent need to develop effective propagation methods for cultivation of these important medicinal floras, which will ultimately lead to their conservation as well as their supply for commercial use (Tiwari and Das 2010a,b). Establishment and growth rate of the stem cutting depends upon many factors, like seasonal and age variation, portion and diameter of stem, growing media, moisture level, nutrient status, and temperature, etc. (Kristiansen et al. 2005).

Improved cultivation practices include healthy propagating material with fast-sprouting and maximum survival, plant growth hormone can be used for purpose. Hormones are chemicals produced by plants that regulate the growth processes. In plant propagation, cuttings are dipped in a rooting hormone to stimulate root development. Bisht et al. (2014) and Chawdhary et al. (2000) performed growth performance study in *Acorus calamus* by treating with different concentrations of hormones and found significant results. Cuttings of *Tinospora crispa* have proved to be a good alternative in domestic propagation (Aminah et al. 2015). Auxins are a class of plant growth substances often called phytohormones or plant hormones. Among the auxins α-Naphthalene Acetic Acid (NAA) and Indole 3 Butyric Acid (IBA) are typically the principal auxins used for rooting and sprouting of cuttings and majority of plant species are responsive for rooting (Ercisli and Guleryuz 1999; Hopkins 1999). These chemicals are

available in commercial preparations, dispersed in concentrated liquid (liquid formulation), or in talc (powder formulation), that can be diluted with water (aqueous solution) to proper strength.

The objectives of this study was to investigate the propagation characteristics of medicinal plant species and to know the effect of growth hormone on sprouting and survival of stem cuttings of medicinal plants such as *Millingtonia hortensis* L.F., *Vitex negundo* L., *Caesalpinia bonduc* L., Roxb., *Jasminum grandiflorum* L., *Lippia javanica* (Burm.f.) Spreng, *Hiptage madablota* Gaertn., *Stereospermum suaveolens* (Roxb.) DC., *Vitex leucoxylon* L., *Putranjiva roxburghii* Wallich, *Argyreia nervosa* Sweetwere, *Helicteres isora* L., *Zanthoxylum armatum* DC., and *Gardenia gummifera* L.

MATERIALS AND METHODS

Experiment was conducted to 13 medicinal plant species under greenhouse conditions at T. C. B. College of Agriculture and Research Station, Bilaspur, Chhattisgarh, India during March-May 2012. Three plant growth regulators, i.e. Rootex, α-Naphthalene Acetic Acid (NAA) and Indole-3-Butyric Acid (IBA) were selected as exogenous hormones. Disease-free equally matured plant cuttings were collected at one length size, *i.e.* 15 cm from the medicinal plant nursery established in this center in three different diameter types *viz.* thick (2.1 cm), medium (1.6 cm) and thin (0.8 cm).

Nursery beds comprising soil and FYM (1:1) were prepared for the experiment. Powder formulations of hormones were prepared by mixing the growth hormones in required quantities to inert talc powder and adjusted to a required concentration (1000 ppm). For propagation of cuttings; stem cuttings were overlaid with respective hormone formulations and kept for overnight at room temperature followed by planting in the nursery beds. Cuttings dipped in distilled water without using growth hormones were kept as a control in the experiment for comparison (Hartmann and Kester 1983). Irrigation water was applied with overhead sprinklers during the experimental period. After 12-25 days of planting the number of sprouted cuttings were counted, whereas, their survival was recorded up to 60 days after plantation. All the recorded data were expressed in percentage.

The experimental design was randomized complete block design with ten replications for each treatment. Data gathered were analyzed statistically using analysis of variance (ANOVA) and CD was calculated at 5% to separate the treatment means (Table 9).

RESULTS AND DISCUSSIONS

Results indicated the wide spectrum of efficacy of growth hormones on percent sprouting and percent survival of stem cuttings. However, variable percent of sprouting and survival were recorded with respect to hormones, medicinal plant species, and diameter of stem cuttings. The data also represent a significant (CD 0.05) effect of cutting diameter on sprouting and survival. Interaction effect of pre hormonal treatment, cutting diameter and species on percent sprouting and survival was also significant. Table 1 represents a list of medicinal plants with their characteristics.

Data presented in Table 2 indicated the significant positive effects of NAA, IBA, Rootex in sprouting and survival of all studied medicinal plant species having thick, medium and thin diameter of stem cuttings. Among different hormones, IBA was found to be more effective in enhancing sprouting (66.56) and survival (60.19) of most of the medicinal plant species irrespective of diameter of stem cuttings compared to NAA (54.53 and 45.20) and Rootex (54.53 and 45.20). Moreover, all three hormones were significantly more effective than control (25.10 dan 17.48). There was decrease in sprouting and survival percent of stem cuttings from thick (2.1 cm) to medium (1.6 cm) and thin (0.8 cm).

In overall treatments with all diameters of stem cuttings, *L. javanica* showed highest sprouting (100.0) and survival (98.60) percent and was followed by *V. negundo*, *V. leucoxylon*, *C. bonduc*, *S. suaveolens*, *P. roxburghii* and *A. nervosa*. Whereas, lowest sprouting and survival percent was recorded in *Z. armatum* and *J. grandiflorum*. Cuttings of *M. hortensis* had poor survival percent (10.52) despite having higher sprouting percent (42.12). Higher percent of sprouting and survival was also reported by Nagaraja et al. (2011) in *L. javanica*. Among different species, stem cuttings of *L. javanica* and *V. leucoxylon* were found to be significantly superior in sprouting and survival over other medicinal plant species. Non significant difference recorded between treated and untreated stem cuttings of both species indicated that the *L. javanica* and *V. leucoxylon* do not require pre hormonal treatment. Whereas, there was significant difference between treated and untreated cuttings of other species with regard to sprouting and survival. Earlier higher percent of sprouting and survival was reported in *L. javanica*. Moreover, pre-hormonal treatment significantly enhanced the survival of most of the species that is rather more important compared to sprouting with regard to propagation and multiplication of medicinal plant species. None of hormones could able to induce sprouting in *Z. armatum* except IBA however, IBA failed to induce survival in treated cuttings. There is a need to investigate proper treatment for enhancing survival of sprouted cuttings in case of *Z. armatum*. There was positive correlation between sprouting and survival, which indicated that the species having higher percentage of sprouting may have higher percentage of survival. Similar findings reported by Chandramouli (2001), Madalageri et al. (1977), Tewary et al. (2004) and Chawdhary and Khan (2000).

Data presented in Tables 3, 4, and Figure 1 represent effect of NAA on sprouting and survival of stem cuttings having different diameters, i.e. thick (2.1 cm), medium (1.6 cm) and thin (0.8 cm). Result indicated that in most of the species except in *L. javanica*, sprouting and survival percent were in decreasing order from thick to thin diameters. Effect of NAA on enhancing sprouting and

survival of stem cuttings was significant in species, i.e. *V. negundo*, *V. leucoxylon*, *H. isora*, *S. suaveolens*, *G. gummifera*, and *C. bonduc* as compare to untreated cuttings. Data presented in Table 3 indicated that pre hormonal treatment with NAA resulted in 45.25% increase in sprouting and 36.77% increase in survival of medicinal plant species over control. Tiwari and Das (2010a) also reported the significant effect of NAA on sprouting and survival of stem cuttings of *Coleus forskohlii*. Significant difference was recorded on percent sprouting and survival between treated and untreated cuttings of most of medicinal plant species except in except *L. javanica*. However, NAA could not be able to induce sprouting and survival in species, i.e. *P. roxburghii* and *Z. armatum* (Table 4). Figure 1 indicates the importance of diameter in NAA treatment. Thick diameter stem cuttings having treatment of NAA had maximum percent of sprouting (63.003%) and survival (56.30%) followed by medium (53.311% and 43.90%) whereas, minimum sprouting (47.25%), survival (35.39%) was observed in stem cuttings having thin diameter. Similar findings reported by Akinyele (2010), Purohit and Vyas (2004), Nandi et al. (2002), Tripathi et al. (2003) and Tiwari and Das (2010a).

Data presented in Tables 5, 6 and Figure 2 represent effect of Rootex on sprouting and survival of stem cuttings having different diameters, i.e. thick (2.1 cm), medium (1.6 cm) and thin (0.8 cm). Data presented in Table 5 indicated the significant effect of Rootex on sprouting however, Rootex was not found effective in increasing survival of stem cuttings having thin diameter in most of the species. Moreover, Rootex was found highly effective in inducing sprouting and increasing survival percent of *P. roxburghii*. Sprouting and survival in species i.e. *L. javanica*, *V. leucoxylon* and *G. gummifera* was found to be at par irrespective of cuttings diameter. Thus, Rootex treatment may not be useful for these species. Data from Table 6 indicated that Rootex was found to be significantly effective in increasing sprouting of stem cuttings but found non-significant in increasing survival of sprouted cuttings. It is also evident from the table that survival percent in most of the species was 0.0%. Moreover, effect of Rootex on increasing sprouting and survival was significant on *G. gummifera*. There was 5.38 to 34.18% increase in sprouting and survival of stem cuttings of medicinal plant species treated with Rootex (Figure 2). Figure 2 also indicates the importance of diameter in Rootex treatment. D_1 (thick) observed maximum percent of sprouting (68.026%) and survival (37.28%) followed by D_2 and D_3. Same pattern followed in untreated condition. Similar result observed by Somappa (1979), Gupta (1995) and Singh (2001) in *Jasminum sambac*.

Data presented in Tables 7, 8 and Figure 3 represent effect of IBA on sprouting and survival of stem cuttings having different diameters i.e. thick (2.1 cm), medium (1.6 cm) and thin (0.8 cm). The maximum sprouting (100%) and survival (100%) was observed in *L. javanica* at par with *G. gummifera* whereas, sprouting and survival was not observed in *Z. armatum*. There was significant difference in sprouting and survival between treated and untreated cuttings however, survival percent was significantly at par between stem cuttings of different diameters treated with IBA. IBA could able to induce sprouting in stem cuttings of *Z. armatum* however, none of the cuttings survived later on, which indicates further study using higher and lower concentrations of IBA for the treatment of stem cuttings of *Z. armatum*. IBA was found effective and able to increase survival of stem cuttings of *M. hortensis*, *C. bonduc*, *J. grandiflorum*, *H. madablota*, *S. suaveolens*, *P. roxburghii*, *A. nervosa* and *H. isora* from 15.74 to 91.66% as compare to 0.0% in untreated stem cuttings. Butola and Badola (2004) have recommended IAA and IBA as promising treatments to improve rooting, growth and biomass in *A. glauca* and *Heracleum candicans*. Data presented in Figure 3 indicated the importance of diameter in IBA (indole-3-butyric acid) application. Treatment receiving IBA resulted in maximum sprouting and survival on D_1 than D_2 and D_3. Similar result experienced by Thimmappa and Bhattacharjee (1990), Gustafson and Kadman (1969), Kumar and Sreeja (1996), and (Hussein 2007).

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Table 1. List of medicinal plant species and their characteristics

Medicinal plant	Family	Local name	Flowering/ fruiting	Uses
Millingtonia hortensis	Bignoniaceae	Akashneem	November-March	The bark is considered as antipyretic and also used to relieve body ache.
Vitex negundo	Verbenaceae	Nirgundi	June-December	It has germicidal property, used against catarrhal fever, swelling of joints. Showed anti-cancer activity, hair tonic, possess tonic, febrifugal, expectorant and diuretic property, fever, diarrhea and liver complaints, headache, catarrh and watery eyes.
Caesalpinia bonduc	Caesalpinaceae	Gataran/ Latakaranja	July-December	Germicidal, blood purifier, digestive, stomachic, liver tonic, antipyretic, antiperiodic, febrifuge, aphrodisiac and anti-helmenitic, to heal ulcer, cure vomiting, hiccough, diabetes, leprosy, piles, asthma, and snake bite.
Jasminum grandiflorum	Oleaceae	Vanmogra	April-October	Used in burns, good for healing chronic ulcers, skin disease and poisonous affections, to cure ringworm, mouth ulcer, skin disease, headache, and weak eyes. Oil-gonorrhea
Lippia javanica	Verbenaceae	Hanumansand/ Bhui-okra	July-January	Cooling effect, febrifuge properties and is used in stoppage of bowels and pain in knee-joints. Useful in diseases of heart, eye, piles, wounds, ulcers.
Hiptage madablota	Malpighiaceae	Madhavilata/ Battery	January-April	Cardio-tonic, insecticidal, wound healing and used in burning sensation of the body, wound pruritus, foul ulcers, leprosy, skin diseases, cough, asthma, cardiac debility, rheumatism, hyperdipsia, obesity, intrinsic hemorrhage.
Stereospermum suaveolens	Bignoniaceae	Garud	April-January	Root-heating and used in cough, Vaat, inflammations, vomiting, asthma, fevers and diseases of blood, stomach. It is used in anorexia, difficult breathing, anasarca, piles, vomiting, and thirst. Bleeding diseases, diarrhea and high cough
Vitex leucoxylon	Verbenaceae	Mayurpakh	April-June	To treat anemia. Decoctions of leaves are being used for the control of malaria fever.
Putranjiva roxburghii	Euphorbiaceae	*Putranjiva*	March-February	Mainly used to increase fertility in women. It is one of the important ingredients of Dasmularishta.
Argyreia nervosa	Convolvulaceae	Samander-ka-pat	April-September	Leaves are used as poultice for wounds and skin diseases.
Helicteres isora	Sterculiaceae	Marorphali	July-January	In gripping of bowels and flatulence of children. Bark used in dysentery and diarrhea. Juice of root used in diabetes, emphysema, stomach affections and snake bite. Root and bark extract is demulcent, astringent and useful in scabies.
Zanthoxylum armatum	Rutaceae	Tejbal/ Tumbaru	April-October	Useful in rheumatism and skin diseases, used in muscular lameness, ovarian and uterine pains, leucorrhoea, skin erythematic with vesicles and intense itching, stinging, burning and dermatitis around knees. Stem stick useful in maintaining blood pressure.
Gardenia gummifera	Rubiaceae	Deekamali	March-December	Young leaves ground and applied to cattle wounds. It is also useful in snake bite. Sap used for sores on hands and feet. Fruits for pain in stomach. Externally it is antiseptic and stimulant. Root is used for piles and cancer treatment.

Table 2. Effect of NAA, IBA, and Rootex on sprouting and survival of different medicinal plant Species.

Species	Diam.	NAA		Rootex		IBA		Control		Mean	
	cm	Sprout.	Surv.	Sprout.	Surv.	Sprout.	Surv.	Sprout.	Surv.	Sprout.	Surv.
Argyreia nervosa	D_1	30.55	25.00	38.88	0.00	0.00	0.00	18.05	0.00	21.87	6.25
	D_2	47.22	0.00	8.33	0.00	0.00	0.00	5.55	0.00	15.27	0.00
	D_3	22.22	22.22	22.22	0.00	75.00	75.00	0.00	0.00	29.86	24.30
Caesalpinia bonduc	D_1	77.77	77.77	34.72	11.11	100.0	88.88	0.00	0.00	53.12	44.44
	D_2	58.33	58.33	74.99	0.00	72.22	72.22	0.00	0.00	51.38	32.63
	D_3	63.88	58.33	73.61	0.00	22.22	22.22	0.00	0.00	39.92	20.13
Gardenia gummifera	D_1	80.55	80.55	70.83	65.27	100.0	100.0	68.05	62.49	79.85	77.07
	D_2	84.72	84.72	69.44	69.44	100.0	100.0	47.22	36.11	75.34	72.56
	D_3	69.83	69.83	69.44	69.44	100.0	100.0	24.99	24.99	66.06	66.06
Hiptage madablota	D_1	59.72	43.53	77.77	77.77	75.00	63.88	0.00	0.00	53.12	46.29
	D_2	20.83	20.83	63.88	55.55	69.44	44.44	0.00	0.00	38.53	30.20
	D_3	08.33	8.33	5.55	5.55	11.11	11.11	0.00	0.00	6.24	6.38
Helicteres isora	D_1	100.0	83.33	100	0.00	72.05	72.05	19.44	0.00	72.87	38.84
	D_2	61.11	61.11	100	0.00	100.0	100.0	0.00	0.00	65.27	40.27
	D_3	91.66	66.66	74.99	0.00	80.55	49.99	0.00	0.00	61.80	29.16
Jasminum grandiflorum	D_1	22.22	0.00	0.00	0.00	100.0	100.0	0.00	0.00	30.55	25.00
	D_2	0.00	0.00	0.00	0.00	100.0	100.0	0.00	0.00	25.00	25.00
	D_3	0.00	0.00	0.00	0.00	75.00	75.00	0.00	0.00	18.75	18.75
Lippia javanica	D_1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.66	100.0	97.91
	D_2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	D_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.66	100.0	97.91
Millingtonia hortensis	D_1	54.16	38.88	84.72	0.00	38.88	38.88	61.11	0.00	59.71	19.44
	D_2	20.83	9.72	84.72	0.00	27.77	27.77	13.88	0.00	44.44	9.37
	D_3	19.44	5.55	58.33	0.00	5.55	5.55	5.55	0.00	22.21	2.77
Putranjiva roxburghii	D_1	0.00	0.00	91.66	61.10	27.77	27.77	0.00	0.00	29.85	22.21
	D_2	0.00	0.00	77.77	58.33	19.44	19.44	0.00	0.00	24.30	19.44
	D_3	0.00	0.00	52.77	44.44	0.00	0.00	0.00	0.00	13.19	11.11
Stereospermum suaveolens	D_1	94.44	83.33	100.0	0.00	100.0	100.0	12.50	0.00	76.73	45.83
	D_2	100.0	72.21	100.0	0.00	100.0	100.0	0.00	0.00	75.00	43.05
	D_3	38.88	36.11	100.0	0.00	60.10	60.10	0.00	0.00	49.74	24.05
Vitex negundo	D_1	100.0	100.0	88.88	69.44	100.0	100.0	63.88	26.38	88.19	73.95
	D_2	100.0	63.88	100.0	27.77	90.27	73.61	61.10	27.77	87.84	48.25
	D_3	100.0	15.27	65.27	0.00	80.55	47.22	15.27	0.00	65.27	15.62
Zanthoxylum armatum	D_1	0.00	0.00	0.00	0.00	68.05	0.00	0.00	0.00	17.01	0.00
	D_2	0.00	0.00	0.00	0.00	37.49	0.00	0.00	0.00	9.37	0.00
	D_3	0.00	0.00	0.00	0.00	15.27	0.00	0.00	0.00	3.81	0.00
Vitex leucoxylon	D_1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	D_2	100.0	100.0	94.44	94.44	100.0	100.0	94.44	94.44	97.22	97.22
	D_3	100.0	66.66	80.55	26.28	72.22	72.22	68.05	26.38	80.20	47.88
Mean		54.53	45.20	63.17	30.51	66.56	60.19	25.10	17.48	52.34	38.34

Note: Diam. = diameter, Surv. = Survival, Sprout.= Sprouting

Table 3. Effect of NAA on sprouting and survival of stem cuttings of medicinal plant Species having different diameters

Species	Sprouting (%)			Survival (%)			Mean (%)	
	D_1	D_2	D_3	D_1	D_2	D_3	Sprouting	Survival
Millingtonia hortensis	54.16	20.83	19.44	38.88	09.72	05.55	31.47	18.05
Vitex negundo	100.0	100.0	100.0	100.0	63.88	15.27	100.0	59.72
Caesalpinia bonduc	77.77	58.33	63.88	77.77	58.33	58.33	66.66	64.81
Jasminum grandiflorum	22.22	00.00	00.00	00.00	00.00	00.00	07.40	00.00
Lippia javanica	100.0	100.0	100	100.0	100	100	100.0	100.0
Hiptage madablota	59.72	20.83	8.33	43.05	20.83	8.33	29.64	24.07
Sterospermm suaveolens	94.44	100.0	38.88	83.33	72.21	36.11	77.77	63.88
Vitex leucoxylon	100.0	100.0	100.0	100.0	100.0	66.66	100.0	88.88
Putranjiva roxburghii	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Argyreia Nervosa	30.55	47.22	22.22	25.00	0.00	33.33	33.33	19.44
Helicteres isora	100.0	61.11	91.66	83.33	61.11	66.66	84.25	70.37
Zanthoxylum armatum	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Gardenia gummifera	80.55	84.72	69.83	80.55	84.72	69.83	78.36	78.36
Mean	6303	53.31	47.24	56.30	43.90	35.39	54.53	45.201

Table 4. Effect of NAA on sprouting and survival of species vs. treated/untreated

Treatment	Sprouting (%)		Species mean	Survival (%)		Species mean
	Treated	Untreated		Treated	Untreated	
Millingtonia hortensis	31.478	24.999	28.238	18.053	0.000	9.027
Vitex negundo	100.000	46.757	73.378	59.721	18.054	38.888
Caesalpinia bonduc	66.664	0.000	33.332	64.812	0.000	32.406
Jasminum grandiflorum	7.407	0.000	3.703	0.000	0.000	0.000
Lippia javanica	100.000	100.000	100.000	100.000	94.444	97.222
Hiptage madablota	29.629	0.000	14.814	24.073	0.000	12.037
Stereospermum suaveolens	77.777	4.167	40.972	63.886	0.000	31.943
Vitex leucoxylon	100.000	87.499	93.749	88.889	62.499	75.694
Putranjiva roxburghii	0.000	0.000	0.000	0.000	0.000	0.000
Argyreia nervosa	33.331	7.869	20.600	19.444	0.000	9.722
Helicteres isora	84.259	6.481	45.370	70.370	0.000	35.185
Zanthoxylum armatum	0.000	0.000	0.000	0.000	0.000	0.000
Gardenia gummifera	78.368	43.053	60.711	78.368	41.201	59.784
Mean	54.532	24.679	39.605	45.201	16.621	30.911

Table 5. Effect of Rootex on sprouting and survival of stem cuttings of medicinal plant species having different diameters

Species	Sprouting (%)			Survival (%)			Mean (%)	
	D_1	D_2	D_3	D_1	D_2	D_3	Sprouting	Survival
Millingtonia hortensis	84.72	84.72	58.33	0.00	0.00	0.00	75.92	0.00
Vitex negundo	88.88	100.0	65.27	69.44	27.77	0.00	84.72	32.40
Caesalpinia bonduc	34.72	74.99	73.61	11.11	0.00	0.000	61.10	3.70
Jasminum grandiflorum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lippia javanica	100	100	100	100	100	100	100	100
Hiptage madablota	77.77	63.88	5.55	77.77	55.55	5.55	49.07	46.29
Stereospermum suaveolens	100	100	100	0.00	0.00	0.00	100	0.00
Vitex leucoxylon	100	94.44	80.55	100	94.44	80.55	91.66	91.66
Putranjiva roxburghii	91.66	77.77	52.77	61.10	58.33	44.44	74.07	54.62
Argyreia nervosa	38.88	8.33	22.22	0.00	0.00	0.00	23.14	0.00
Helicteres isora	100	100	74.99	0.00	0.00	0.00	91.66	0.00
Zanthoxylum armatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gardenia gummifera	70.83	69.44	69.44	65.27	69.44	69.44	69.90	68.05
Mean							63.175	30.519

Table 6. Effect of Rootex on Sprouting and survival of Species vs. Treated/ Untreated

Treatment	Sprouting (%)		Species mean	Survival (%)		Species mean
	Treated	Untreated		Treated	Untreated	
Millingtonia hortensis	75.923	26.850	51.387	0.000	0.000	0.000
Vitex negundo	84.720	46.757	65.738	32.407	18.054	25.231
Caesalpinia bonduc	61.109	0.000	30.554	3.703	0.000	1.852
Jasminum grandiflorum	0.000	0.000	0.000	0.000	0.000	0.000
Lippia javanica	100.000	100.000	100.000	100.000	94.444	97.222
Hiptage madablota	49.071	0.000	24.536	46.293	0.000	23.147
Stereospermum suaveolens	100.000	4.167	52.083	0.000	0.000	0.000
Vitex leucoxylon	91.666	87.499	89.582	91.666	73.610	82.638
Putranjiva roxburghii	74.072	0.000	37.036	54.626	0.000	27.313
Argyreia nervosa	23.147	7.869	15.508	0.000	0.000	0.000
Helicteres isora	91.666	6.481	49.073	0.000	0.000	0.000
Zanthoxylum armatum	0.000	0.000	0.000	0.000	0.000	0.000
Gardenia gummifera	72.903	46.757	58.330	68.051	41.201	54.626
Mean	63.175	25.106	44.141	30.519	17.485	24.002

Table 7. Effect of IBA on sprouting and survival of medicinal plant species vs. diameter

Species	Sprouting (%)			Survival (%)			Mean (%)	
	D_1	D_2	D_3	D_1	D_2	D_3	Sprouting	Survival
Millingtonia hortensis	38.88	27.77	5.53	38.88	27.77	5.55	24.07	24.07
Vitex negundo	100	90.27	80.55	100	73.61	47.22	90.27	73.61
Caesalpinia bonduc	100.00	72.22	22.22	88.88	72.22	22.22	64.81	61.10
Jasminum grandiflorum	100	100	75.00	100	100	75.00	91.66	91.66
Lippia javanica	100	100	100	100	100	100	100	100
Hiptage madablota	75.00	69.44	11.11	63.88	44.44	11.11	51.85	39.81
Stereospermum suaveolens	100	100	60.10	100	100	60.10	86.70	86.70
Vitex leucoxylon	100	100	72.22	100	100	72.22	90.74	90.74
Putranjiva roxburghii	27.77	19.44	0.00	27.77	19.44	0.00	15.74	15.74
Argyreia Nervosa	0.00	0.00	75.00	0.00	0.00	75.00	25.00	25.00
Helicteres isora	72.22	100	80.55	72.22	100	49.99	84.25	74.07
Zanthoxylum armatum	68.05	37.49	15.27	0.00	0.00	0.00	40.27	0.00
Gardenia gummifera	100.00	100	100	100	100	100	100	100
Mean	75.53	70.51	53.65	68.58	64.42	47.57	66.569	60.194

Table 8. Effect of IBA on sprouting and survival of medicinal plant species vs. treated/untreated

Treatment	Sprouting (%)		Species mean	Survival (%)		Species mean
	Treated	Untreated		Treated	Untreated	
Millingtonia hortensis	24.072	26.850	25.416	24.072	0.000	12.036
Vitex negundo	90.277	46.757	68.517	73.610	18.054	45.832
Caesalpinia bonduc	64.813	0.000	32.407	61.109	0.000	30.554
Jasminum grandiflorum	91.667	0.000	45.833	91.667	0.000	45.833
Lippia javanica	100.000	100.000	100.000	100.000	94.444	97.222
Hiptage madablota	51.850	0.000	25.925	39.812	0.000	19.906
Stereospermum suaveolens	86.702	4.167	45.925	86.702	0.000	43.351
Vitex leucoxylon	90.740	87.499	89.119	90.740	73.610	82.175
Putranjiva roxburghii	15.740	0.000	7.870	15.740	0.000	7.870
Argyreia nervosa	25.000	7.869	16.413	25.000	0.000	12.500
Helicteres isora	84.258	6.481	45.369	74.072	0.000	37.036
Zanthoxylum armatum	40.276	0.000	20.138	0.000	0.000	0.000
Gardenia gummifera	100.000	46.757	73.378	100.000	41.201	70.601
Mean	66.569	25.106	45.837	60.194	17.485	38.839

Table 9. CD at 5% level of different treatments for hormone application in liquid and powder formulations

Treatments	C.D at 5% (NAA)		C.D at 5% (Rootex)		C.D at 5% (IBA)	
	Sprouting	Survival	Sprouting	Survival	Sprouting	Survival
Diameter	37.72	13.68	29.91	32.23	49.08	46.19
Treated/untreated	28.42	9.86	24.49	26.32	40.07	37.72
Species	46.19	28.48	24.37	26.48	28.30	28.42
Diameter x treated/untreated	9.84	13.68	42.42	45.58	69.41	65.33
Treated/untreated x species	13.65	28.48	8.44	7.49	9.80	9.84
Diameter x species	65.33	34.88	11.71	10.38	13.59	13.65
Species x diameter x species	49.22	49.33	42.42	37.45	49.02	49.22

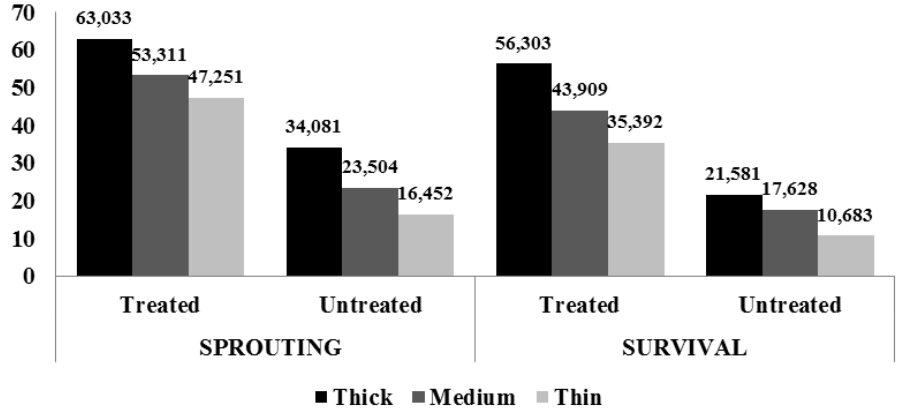


Figure 1. Effect of NAA on sprouting and survival of Diameter vs. Treated/Untreated

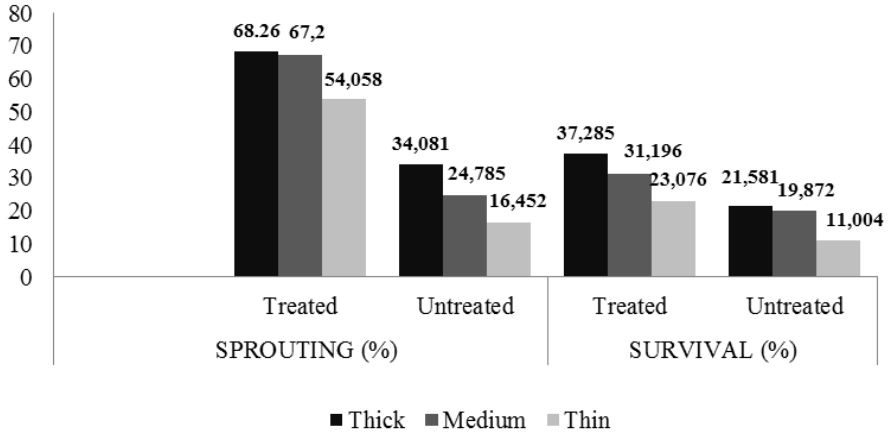


Figure 2. Effect of Rootex on sprouting and survival of diameter vs. treated/untreated

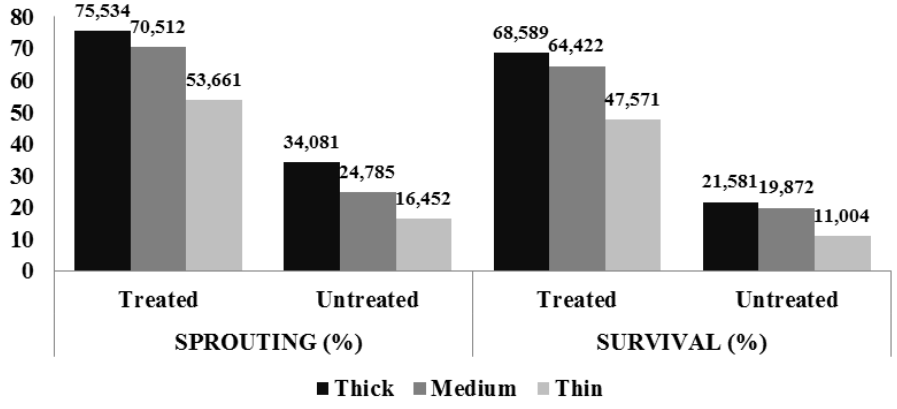


Figure 3. Effect of IBA on sprouting and survival of diameter vs. treated/untreated

A.1

A.2

A.3

A.4

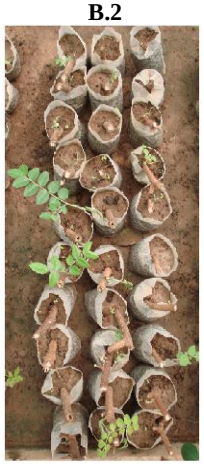
B.1

B.2

B.3

B.4

C.1



C.2

C.3

C.4

D.1

D.2

D.3

D.4

E.1

E.2

E.3

E.4

F.1

F.2

F.3

F.4

G.1

G.2

G.3

G.4

H.1

H.2

H.3

H.4

I.1 **I.2** **I.3** **I.4**

J.1 **J.2** **J.3** **J.4**

K.1 **K.2** **K.3** **K.4**

L.1 **L.2** **L.3** **L.4**

Figure 4. Effect of hormonal pre-treatment on sprouting and survival of different medicinal plant species. A. *Millingtonia hortensis*, B. *Vitex negundo*, C. *Caesalpinia bonduc*, D. *Jasminum grandiflorum*, E. *Lippia javanica*, F. *Hiptage madablota*, G. *Stereospermum suaveolens*, H. *Vitex leucoxylon*, I. *Putranjiva roxburghii*, J. *Argyreia nervosa*, K. *Helicteres isora*, L. *Zanthoxylum armatum*, M. *Gardenia gummifera*. 1. Control, 2. Rootex, 3. Naphthalene Acetic Acid (1000 ppm), 4. Indole-3-Butyric Acid (1000 ppm)

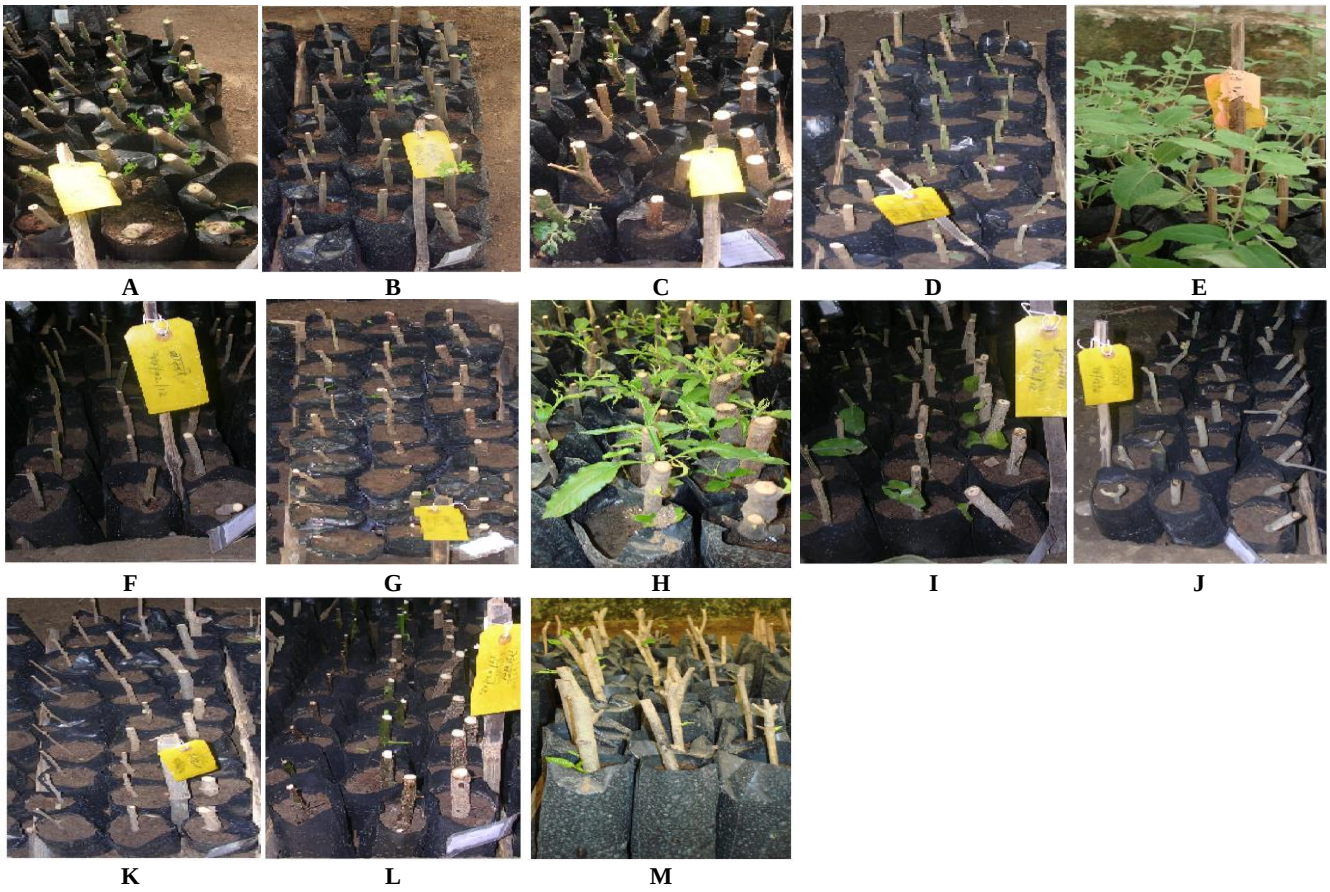


Figure 5. Growing behavior of different medicinal plant species. A. *Millingtonia hortensis*, B. *Vitex negundo*, C. *Caesalpinia bonduc*, D. *Jasminum grandiflorum*, E. *Lippia javanica*, F. *Hiptage madablota*, G. *Stereospermum suaveolens*, H. *Vitex leucoxylon*, I. *Putranjiva roxburghii*, J. *Argyreia nervosa*, K. *Helicteres isora*, L. *Zanthoxylum armatum*, M. *Gardenia gummifera*

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