

Nanotechnology in Cutting Propagation of Ornamental Trees and Shrubs in Egypt and South Africa

Nanotechnology in Cutting Propagation of Ornamental Trees and Shrubs in Egypt and South Africa

By

Amira Shawky Soliman

Cambridge
Scholars
Publishing



Nanotechnology in Cutting Propagation of Ornamental Trees and Shrubs
in Egypt and South Africa

By Amira Shawky Soliman

This book first published 2026

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Copyright © 2026 by Amira Shawky Soliman

All rights for this book reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner.

ISBN: 978-1-0364-6250-5

ISBN (Ebook): 978-1-0364-6251-2

CONTENTS

List of Tables.....	vi
List of Figures.....	xiv
Preface.....	xv
Introduction	1
Review of Literature.....	7
Materials and Methods	35
Results and Discussion	42
References	171

LIST OF TABLES

No.	Title	Page
1	Some physical and chemical properties of the used peatmoss in both seasons.	37
2	Some physical and chemical properties of the used sand during the two studied seasons.	37
3	ISSR primer names, sequence and annealing temperature (Ta) for each plant species.	41
4	Effect of traditional and nano-Fe auxins and their interactions on rooting percentage and roots number of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	44
5	Effect of traditional and nano-Fe auxins and their interactions on root and branch lengths of <i>Bougainvillea spectabilis</i> Wild transplants during 2020 and 2021 seasons.	45
6	Effect of traditional and nano-Fe auxins and their interactions on number of branches and leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	47
7	Effect of traditional and nano-Fe auxins and their interactions on branches and roots fresh weight of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	48
8	Effect of traditional and nano-Fe auxins and their interactions on branches and roots dry weight of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	50
9	Effect of traditional and nano-Fe auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	51

10	Effect of traditional and nano-Fe auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	52
11	Effect of traditional and nano-Fe auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	53
12	Effect of traditional and nano-auxins and their interactions on rooting percentage and roots number of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	56
13	Effect of traditional and nano-auxins and their interactions on root and branch lengths of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	57
14	Effect of traditional and nano-auxins and their interactions on number of branches and leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	59
15	Effect of traditional and nano-auxins and their interactions on branches and roots fresh weight of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	60
16	Effect of traditional and nano-auxins and their interactions on branches and roots dry weight of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	61
17	Effect of traditional and nano-auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	63
18	Effect of traditional and nano-auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	64
19	Effect of traditional and nano-auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Bougainvillea spectabilis</i> 'White' Wild transplants during 2020 and 2021 seasons.	66

20	ISSR primer name, total number of amplicons, and size of amplified fragments.	67
21	The matrices of primer 841 as revealed by <i>Bogenvillia</i> plant treatments using primer 841.	67
22	Effect of traditional and nano-Fe auxins and their interactions on rooting percentage and roots number of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	78
23	Effect of traditional and nano-Fe auxins and their interactions on root and branch lengths of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	79
24	Effect of traditional and nano-Fe auxins and their interactions on number of branches and leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	81
25	Effect of traditional and nano-Fe auxins and their interactions on branches and roots fresh weight of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	82
26	Effect of traditional and nano-Fe auxins and their interactions on branches and roots dry weight of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	84
27	Effect of traditional and nano-Fe auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	87
28	Effect of traditional and nano-Fe auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	88
29	Effect of traditional and nano-Fe auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	89
30	Effect of traditional and nano-auxins and their interactions on rooting percentage and roots number of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	92

31	Effect of traditional and nano-auxins and their interactions on root and branch lengths of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	93
32	Effect of traditional and nano-auxins and their interactions on number of branches and leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	95
33	Effect of traditional and nano-auxins and their interactions on branches and roots fresh weight of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	96
34	Effect of traditional and nano-auxins and their interactions on branches and roots dry weight of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	97
35	Effect of traditional and nano-auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	100
36	Effect of traditional and nano-auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	101
37	Effect of traditional and nano-auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Hibiscus rosa-sinensis</i> L. transplants during 2020 and 2021 seasons.	102
38	ISSR primer name, total number of amplicons, size of amplified fragments and percentage of polymorphism.	103
39	The matrices of primer 834 as revealed by Hibiscus plant treatments.	104
40	The matrices of primer 842 as revealed by Hibiscus plant treatments.	104
41	Effect of traditional and nano-Fe auxins and their interactions on rooting percentage and roots number of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	110

42	Effect of traditional and nano-Fe auxins and their interactions on root and branch lengths of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	111
43	Effect of traditional and nano-Fe auxins and their interactions on number of branches and leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	113
44	Effect of traditional and nano-Fe auxins and their interactions on branches and roots fresh weight of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	115
45	Effect of traditional and nano-Fe auxins and their interactions on branches and roots dry weight of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	116
46	Effect of traditional and nano-Fe auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	118
47	Effect of traditional and nano-Fe auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	119
48	Effect of traditional and nano-Fe auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	120
49	Effect of traditional and nano-auxins and their interactions on rooting percentage and roots number of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	124
50	Effect of traditional and nano-auxins and their interactions on root and branch lengths of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	125

51	Effect of traditional and nano-auxins and their interactions on number of branches and leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	126
52	Effect of traditional and nano-auxins and their interactions on branches and roots fresh weight of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	128
53	Effect of traditional and nano-auxins and their interactions on branches and roots dry weight of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	130
54	Effect of traditional and nano-auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	132
55	Effect of traditional and nano-auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	133
56	Effect of traditional and nano-auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Jasminum multiflorum</i> (Burn.F.) Andrews transplants during 2020 and 2021 seasons.	134
57	ISSR primer name, total number of amplicons, and size of amplified fragments.	137
58	Effect of traditional and nano-Fe auxins and their interactions on rooting percentage and roots number of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	141
59	Effect of traditional and nano-Fe auxins and their interactions on root and branch lengths of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	142
60	Effect of traditional and nano-Fe auxins and their interactions on number of branches and leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	144

61	Effect of traditional and nano-Fe auxins and their interactions on branches and roots fresh weight of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	145
62	Effect of traditional and nano-Fe auxins and their interactions on branches and roots dry weight of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	147
63	Effect of traditional and nano-Fe auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	149
64	Effect of traditional and nano-Fe auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	150
65	Effect of traditional and nano-Fe auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	151
66	Effect of traditional and nano-auxins and their interactions on rooting percentage and roots number of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	154
67	Effect of traditional and nano-auxins and their interactions on root and branch lengths of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	155
68	Effect of traditional and nano-auxins and their interactions on number of branches and leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	156
69	Effect of traditional and nano-auxins and their interactions on branches and roots fresh weight of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	158

70	Effect of traditional and nano-auxins and their interactions on branches and roots dry weight of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	159
71	Effect of traditional and nano-auxins and their interactions on chlorophyll a and b concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	161
72	Effect of traditional and nano-auxins and their interactions on carotenoids and total sugars concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	162
73	Effect of traditional and nano-auxins and their interactions on total indoles and total phenols concentration in the leaves of <i>Simmondsia chinensis</i> (Link) Schneider transplants during 2020 and 2021 seasons.	163
74	ISSR primer name, total number of amplicons, size of amplified fragments and percentage of polymorphism.	165
75	The matrices of primer 842 as revealed by Jojoba plant treatments.	166

LIST OF FIGURES

No.	Title	Page
1	Bougenvillia ISSR banding pattern	68
2	Hibiscus ISSR banding pattern	106
3	Full ISSR banding pattern.	137
4	Jojoba ISSR banding pattern	167

PREFACE

The independent experiments were conducted at the conservation glasshouse Egyptian National Gene Bank, Giza in 2020 and 2021 to study, in the first experiment, the effect of both 1-naphthalenacetic acid (NAA) and indole-3-butyric acid (IBA) auxins loaded on nanoFe (nFe-NAA and nFe-IBA) at concentrations of 0, 1000, 2000, and 4000 ppm for each, the traditional form of IBA (t-IBA) at 0, 1000, 2000, and 4000 ppm concentrations and their interactions on stem cuttings of *Bougainvillea spectabilis* Wild “White”, *Hibiscus rosa-sinensis*, L. and *Jasminum multiflorum* (Burn F.) Andrews and joboba *Simmondsia chinensis* (Link) as well as the growth and chemical composition of the new resulted transplants. The second experiment, however, aims to study the effect of nanoforms of either NAA (n-NAA) or IBA (n-IBA) at 0, 100, 200, and 400 ppm concentrations for each, the traditional form of IBA (t-IBA) concentrations of 0, 1000, 2000, and 4000 ppm and their interactions on rooting traits of cuttings of the aforementioned plant species, as well as the other characters. The previous concentrations of the different formulas of both NAA and IBA were prepared well as aqueous solutions, and the bases of cuttings were dipped in distilled water. The layout of each experiment, for each plant in every season, was factorial in a complete randomized design with three replicates. The results obtained in the first experiment showed that the single and combined treatments used in this experiment improved the mean values of different rooting parameters (rooting%, No. roots/cutting and root length), growth traits of the new transplants (branch length, No. branches and leaves/transplant, as well as fresh and dry weights of branches and roots) and concentrations of some constituents in their leaves (chlorophyll a, b carotenoids, total sugars, total indoles and total phenols) in the four plant species under study, with few exceptions in the two seasons. However, the dominance in all cases was for the combined treatments, which gave higher means (sometimes doubled) than the single ones, especially combining between either 200 or 400 ppm nFe-NAA and either 200 or 400 ppm nFe-IBA single treatments, as the replacement of these four combinations gave the best results in both seasons. Moreover, combining any concentration of t-IBA and n-NAA at 200 or 400 ppm concentrations gave better results in some characters. Thus, it can be recommended to use both IBA and NAA auxins together in the form of nanoparticles (n-IBA and

n-NAA) at 200 or 400 ppm concentrations for each, either loaded or nonloaded on nano-iron (nFe) to obtain the best rooting and highest quality of the new resulted transplants from cuttings of the four ornamental shrubs used in the study.

Keywords: Ornamental shrubs, Bougainvillea, Hibiscus, Jasmine, Jojoba, Rooting parameters, IBA, NAA, Traditional, and Nano auxins.

INTRODUCTION

Plant cloning is the process of creating identical plants. Although cloning is associated with a loss of genetic diversity, it provides new approaches to genetic conservation. Propagation by cuttings is one of the easiest, quickest, simplest, cheapest, and most effective approaches for plant cloning, i.e. maintaining desirable features of plant matrices and uniformity (**Hilgert, Lazarotto, Florida and Souza 2021**). Propagation by cuttings is the alternative way to address the low uniformity problem caused by seed propagation, as a simple and fast method for generating individuals identical to the parent plant, maintaining the agronomic traits (**Guasso, Marodin, Altmann, Silveria and Souza 2021**). **Hamidon, Shah, Razali and Lob (2020)** mentioned that propagation by seeds does not produce true-to-type plants and can be affected by dormancy, low germination ability, and delayed production, while affective multiplication by stem cuttings is mostly preferred for large-scale production of uniform planting materials from mother plants.

However, some cuttings are hard to root and need to be treated with a specific auxin (rooting-promotive hormone) at a special concentration to enhance root emission. Auxins, as a class of phytohormones, are included in many aspects of plant growth and development, mainly the induction of root primordials (**Bala, Laura and Beniwal 2020**). Recent studies implied that such rooting-promotive hormones also affect plant defense against trip herbivory and leaf miners (**Mouden, Leiss, Uthe and Klinkhamer 2020**). Not only are auxins used for the propagation of common and economic plants, but they are also used for preserving the whole plant wealth, by rooting the cuttings of plants already entered in the red data book as endangered species (**Qiang, DeJa, Yan, HongLang and Lu 2021**); important medicinal plants such as *Taxus baccata* (F. Taxaceae) which produces an anticancer drug, called Taxol (**Sahai and Sinha, 2022**), the red willow (*Salix purpurea*, F. Salicaceae) as a multi-purpose, ornamental-medical tree (**Solgi and Sahraei, 2022**) and *Quercus nuttallii* (F. Fagaceae) as a monumental and historical tree (**Ting, Xiaol, XiaoHua, ZhiBiao, Ting and ShuXian 2022**). Until recently, traditional auxins have performed their role in agricultural development, till the innovation of nanotechnology, which revolutionized the different fields of modern industries. At present, nanomaterials (NMs) have considerable applications

in pharmaceuticals, electronics, food and agriculture. Nanotechnology is the matter manipulating, transforming it into Nanoparticles (NPs) measurable in nanometers (1-100 nm) at least in one direction (**Grover, Singh and Venkateswarlu 2012**). The surface area of such particles is very large relative to their small size, which can make them very reactive. Owing to the very small size and high reactivity, these particles are able to easily penetrate the roots and transfer freely to the aerial parts of the plants (**Banijamali, Feizian, Bidabadi and Mehdipour 2019**). Several nano-based products, including Nano Hormones, are already in the local market, manufactured by specialized companies, with or without proper labeling.

The four ornamental shrubs used in this study are: *Bougainvillea spectabilis* “White”, *Hibiscus rosa-sisensis*, *Jasminum multiflorum*, and *Simmondsia chinensis*.

The first is a Paper flower (*Bougainvillea spectabilis* “White” Wild). A strong-growing, evergreen, woody-stemmed, scrambling climber of the Nyctaginaceae family. Stems usually have a few spines, and are up to 7 – 12 m in height. Elliptic to ovate leaves and in summer, large trusses of white floral bracts. Native to Brazil and distributes in tropical and subtropical regions (**Bailey, 1976**). Grows well in any rich, well-drained, and acidic soil, thriving best in full sun, high-light intensity is required for good flowering, while under low light and in shade, the plants will drop their bracts. *Bougainvillea* in general is drought tolerant, salt tolerant, and wind resistant. Propagated mainly by cuttings with some difficulty. However, terminal softwood cuttings are easy to root, while mature hardwood ones are difficult to root and need to be treated with rooting hormone (IBA) at 2000 – 6000 ppm concentration (**Kent, James and Griffis 2007**).

Owing to its showy bracts, *bougainvillea* has become a popular ornamental plant in most warm climates, including the Mediterranean Basin. It is used in mass plantings, for hedges, barriers, and slopes. It may be grown as a pot plant, over arbors, into espaliers, onto pergolas and walls, and gives a spectacular sight when cascading from balconies and overhead bridges (**Kong and Lum, 1996**). Some active compounds such as pinitol, β -cyanine, flavonoids, tannins, and alkaloids are present in *Bougainvillea* plants, and their leaves are used as anti-inflammatory, anthelmintic and antibacterial (**Kent, James and Griffis 2007**).

The second is Rose of China, Chinese hibiscus (*Hibiscus rosa-sisensis*, L.). A large beautiful evergreen shrub of 5-7m in height, nearly glabrous, leaves usually simple, ovate, glossy, dark green to 8-10 cm long, not lobed, but

toothed or nearly entire, belongs to fam. Malvaceae, native to China, but grown mostly in subtropical and tropical regions for its profuse large very-showy flowers, which are borne solitary on the leaf axils and also in glasshouses for the summer bloom. The shrubby species may be grown from seeds, but the named cultivars of *H. rosa-sinensis* and *H. syriacus* are propagated by cuttings, grafting, or layering since they don't come true from seed (**Bailey, 1976**).

It is cultivated as a solitary specimen in gardens as a hedge or fence plant, and also in a container or above-ground planter. Flowers, leaves, and roots have medicinal properties as an oral contraceptive, laxative, aphrodisiac, and hemorrhagic and the flowers possess anti-fertility activity. The aqueous ethanolic extract of aerial parts is used in constipation and diarrhea, and leaves are used in fatigue and skin disease. Other uses in folk medicine are reported (**Sarje, Narwade, Thakur and Ghiware 2019**).

The third species is Jasmine (*Jasminum multiflorum* (Burn. f.) Andrews). A rusty-hairy evergreen climber up to 6 m in length (Fam. Oleaceae). Native to India and widely distributed in warm parts of Europe, Asia, Africa, and the Pacific region, nearly absent from America. Leaves opposite, very short-petiole, rather thick, ovate-acute, calyx-teeth usually 10.5 – 1.7 cm long, with spreading yellow hairs, flowers white, unscented to slightly fragrant, the lobes broad and often half-double, stand some frost and can be a good dwarf glasshouse (**Bailey, 1976**).

Because it is a weak climber, it usually grows over arbors, into steak or espalier, and may be potted in the presence of steaks. The dried leaves are used for indolent ulcers, while the flowers are useful in vitiated conditions of pitta, inflammation, rheumatism, and cephalalgia, and the root is an antidote to cobra venom (**Sharma and Devi, 2013**).

The fourth one is Jojoba (*Simmondsia chinensis* (Link) Schneider), a multipurpose, drought-resistant, evergreen shrub that belongs to the Simmondiaceae family. A dioecious shrub, native to South-western North America. The only species in fam. Simmondiaceae, which gains huge importance due to its unusual oil, has many usages depending on the site where the modification is being done. Jojoba oil is a liquid wax (esters of long-chain acids and alcohols rather than glyceride fats), and can be modified via hydrogenation, sulfurization, halogenation, sulfurhalogenation, phosphosulfurization, ozonization, hydrolysis, amidation, and many other techniques to be suitable for production of cosmetics, pharmaceuticals, lubricants and petrochemicals (**Arya and Khan, 2016**), making jojoba have

a unique place in the plant kingdom (**Weiss, 1983**). Jojoba oil is also like sperm whale oil, thus it can be used as food and in medicine for the remedy of cancer, kidney disorders, stomach aches and for easing childbirth and tending wounds, and also for making seeds cake. Because of the different utilization of agro-technology related to this shrub and profitable yields, it is named the “Desert Gold” (**Kureel, Gupta and Panday 2008**).

Jojoba is a perennial shrub that has a multi-stemmed woody growth and a natural life span of up to 200 years. It can reach up to 3 m in height and can vary in width, from being almost prostrate with lateral branches to being an upright shrub. Stems are yellowish and have no distinctive smell. Leaves are lanceolate, deep green, span for 2 or 3 seasons, and vary from 2.5 – 5.0 cm long and 1.5 – 2.5 cm wide. Leaf blades are stiff, thick, leathery, and erect. Male and female plants grow separately and are wind-pollinated. Staminate flowers are small (about 0.4 cm), yellow, and borne in the leaf axils in clusters, while pistillate ones grow solitary, pale green, or colorless without nectaries or scent glands and are borne also in the leaf axils (**Thomson, 1982**). It has a well-developed taproot system that can grow to a depth of 30 – 45 cm, by the time the shoot starts to penetrate the soil, and then, this system in a mature plant can grow up to 15-25 m underground giving many taproots frequent forking below the crown. At a depth of about 60 – 100 cm, small hairy rootlets have been developed. This substantial network of roots permits jojoba to absorb water and nutrients from a large area of soil allow it to survive well under harsh growth conditions (**Weiss, 1983**). Seeds of jojoba are acorn (roughly triangular) in shape, 12 – 18 mm long, and a breadth of 6-12 mm, every 1600 seeds weigh 1 kg, and oil content ranges from 44 – 59%. Since the seeds don't have a period of dormancy, they can be germinated soon after harvesting (**Kureel, Gupta and Panday 2008**).

Propagation of jojoba can be achieved by sowing seeds directly, air layering, grafting, by cuttings, and tissue culture techniques. Sexual propagation by seeds is easy and seeds have shown good viability, even after 11 years with a 38% germination rate (**Thomson, 1982**). However, plants produced by the sexual propagation method are less productive, weak, and disease-prone. Also, when first grown as potted nursery stock, they don't transplant well. It is also difficult to analyze the sex as male plants outnumber the females and large genetic heterogeneity affects yield, physiological characters, yearly bearing, and growth uniformity (**Harsh, Tewari, Patwal and Meena 1987**). On the other hand, vegetative propagation techniques are much better to use as they can achieve high and

uniform yield, early fruiting, reduced post-harvesting costs, and development of desirable clonal varieties (**Hogan and Palzkill, 1983**).

Abramovich, Forti and Hausner (1985) mentioned that the standard treatment for the vegetative propagation of jojoba included dipping the basal portion of cuttings in 1500 ppm K-indole butyrate solution + a mixture of 0.5 ppm boric acid + 500 ppm NAA or 1000 ppm vit. C or a 30-sec. pretreatment with 1 N H₂SO₄ for maximum rooting percentage.

In 4 individual experiments (a) softwood, semi-hardwood, and hardwood cuttings of the difficult to root *Jasminum auriculatum* cv. Parimullai were treated with IBA and NAA at different concentrations, (b) cuttings were treated with hot water or wounded at the base and treated as in (a), (c) parent plant were treated with IBA or NAA, and (d) whole parent plants were etiolated with block polyethylene which was later removed, individual shoots were etiolated and girdled, severed from the parent plant after 36 days and treated with IBA or NAA. **Veerarayathatham, Rao and Shanmugavelu (1985a)** stated that cuttings in all treatments were rooted under intermittent mist, but the best rooting (60%) was obtained in (d) by treating the cuttings for 10 seconds with IBA at 1000 ppm concentration. Another experiment compared Parimullai (a hard-to-root cv.) and *J. sambac* cv. Gundumalli (an easy-to-root cv.). Etiolated and non-etiolated shoots were assessed for the activities of IAA oxidase and peroxidase and other indices, **Veerarayathatham, Rao and Shanmugavelu (1985b)** found that Parimullai cv. had higher levels of IAA oxidase and peroxidase activities, and etiolation process reduced the activities of both enzymes in Parimullai cv., consequently reducing lignification and stimulated rooting.

Bhattahchorjee and Balakrishna (1986) reported that the best rooting of *Hibiscus rosa-sinensis* stem cuttings (93.3%) was obtained with IBA at 4000 ppm concentration. Cuttings treated with 4000 ppm IBA rooted and survived better than those treated with 9000 ppm NAA.

Arce and Jordan (1988) implied that the nodal segment of jojoba cultured on Nitsch+Nitsch medium supplemented with 0.3, 0.1, and 0.01 mg/l of NAA, BA, and GA₃, respectively gave 100% callus formation and 25% rooting, while propagation with cuttings showed that IBA and NAA could induce approximately 56 and 26% root formation, successively. On *Bougainvillea glabra* cuttings 3, 5, 7, and 12 mm in diameter and 20 cm long dipped in 0, 3000, or 6000 ppm IBA, **Awad, Kamel and Attya (1988)** stated that the largest diameter and highest auxin concentration resulted in the rooting % and No. roots/cutting.

Bisaria (1988) conducted a set of field experiments to study the influence of IBA at 10, 25, 50, 100, 150, and 200 ppm on the regeneration of stem cuttings and leaves of *Hibiscus cannabinus*. The results indicated that IBA induced early differentiation of adventitious roots and stimulated the sprouting of buds on the stem cuttings. It also increased the number of roots/cutting and their length. IBA caused root formation on the basal ends of the petioles of leaves, but no axillary buds were differentiated. However, leaves with axillary buds treated with IBA showed differentiation of roots and axillary buds. Generally, 100 ppm IBA was the optimum treatment for regeneration. Moreover, Widiastoety and Soebijanto (1988) noted that the best rooting and survival (96.6%) of *Hibiscus rosa-sinensis* stem cuttings was achieved by IBA at 50 and 100 ppm concentrations against 70% for control cuttings.

Therefore, this study aims to study the effect of conventional and nano forms of IBA solution, and nano NAA solution, both alone or loaded on iron oxide nanoparticles (nFe-IBA and nFe-NAA) at various concentrations and their interactions on rooting of stem cuttings of four ornamental shrubs, common in Egypt and South Africa, as well as growth and chemical composition of the new transplants resulted from each species.

REVIEW OF LITERATURE

Many types of commercial auxins are used on a large scale and in different preparations, with the majority of indole-3-butyric acid (IBA), indole-3-acetic acid (IAA), and 1-naphtalene acetic acid (NAA), either as a solution or as a powder in talc at various concentrations suitable for rooting promotion and good growth of the new transplants. The different effects of such auxins on rooting aspects and growth performance of the newly formed transplants were last reviewed by several scientists as shown in the following literature:

1. Effect of traditional auxins on survival and rooting parameters

Many cultivars of *Hibiscus rosa-sinensis*, *Jasminum auriculatum*, and *J. grandiflorum* fail to root from cuttings or show low percentages of rooting under ordinary propagation facilities. **Bose, Mondal and Pramanik (1973)** found that cuttings of these cultivars developed roots under intermittent mist and treatment with IBA and NAA further increased the rooting % and number of roots. Also, the rooted cuttings exhibited high survival and satisfactory growth after transplanting into pots.

Bryzgalova (1974) stated that treatment of *Jasminum sambac*, *J. humile* and *J. humile* f. *wallichianum* cuttings with heteroauxin improved rooting % and root number.

Maurya, Singh and Lal (1974) reported that treating hardwood cuttings of *Bougainvillea* cv. *Mary Palmer*, with either IAA or NAA at 400 ppm for each for 12 h., had the highest rooting success (more than 70%), whereas untreated cuttings failed to root.

Bose, Mukherjee and Roy (1975) treated basal, mid-shoot and tip cuttings, each at 15 cm long and retaining 2 leaves, taken from 10-year-old shoots of *Bougainvillea spectabilis*, *Hibiscus rosa-sinensis* and *Jasminum multiflorum* with IBA at 3000 ppm concentration and noticed that 100% rooting was obtained with semi-woody mid-shoot cuttings of both *B. spectabilis* and *H. rosa-sinensis* with the highest root number/cutting, while the best results for *J. multiflorum* was also attained with mid-shoot cuttings that gave only 85%

rooting. Besides, **Gandotra, Nair and Dubey (1975)** observed that the best rooting aspects were obtained with 4 node hardwood cuttings of bougainvillea var. Mary Palmer was treated with IBA at 6000 ppm compared to treating them with NAA or IAA at 6000 -10000 ppm concentrations. On the contrary, **Kachecheba (1976)** showed that the use of auxin (1000 ppm IBA) and extra light tended to lessen the number of roots and the proportion of rooted cuttings of both *Hibiscus rosa-sinensis* and *H. schizopetalus*.

In a trial to study the effects of IBA and IAA, each at 1000 – 2500 ppm, Alar [daminozide] at 100 – 1000 ppm, and Seradex (containing IBA) on the rooting of *Jasminum sambac* var. Gundumalli softwood stem cuttings, **Pappiah and Muthuswamy (1976)** cited that the highest rooting percentage (85%) was obtained by IAA at 2000 ppm, followed by Alar at 500 ppm (80% rooting). The number of primary and secondary roots that developed was also greatest with these two treatments. On *Jasminum sambac* cv. Motia semi-hardwood cuttings dipped for 10 seconds in IBA at 1000 – 4000 ppm concentrations, **Singh (1976)** revealed that the highest % of rooted cuttings was recorded by IBA at 4000 ppm treatment. Likewise, **Singh (1979)** on the same cultivar (*J. sambac* cv. Motia) emphasized that the highest rooting % (95%) was achieved by treating the semi-hardwood cuttings with 4000 ppm IBA and inserting them in the coarse sand.

In an experiment, **Singh and Motial (1981)** treated softwood, semi-hardwood, and hardwood cuttings of *Jasminum sambac* cv. “Madanban” with IBA at 1000- 4000 ppm and stuck them in coarse sand under intermittent mist and found that the best rooting (97.5 – 100%), survival of rooted cuttings (100%), the number of roots/cutting and the length and thickness of the longest root of the three types of cuttings were obtained with IBA at 4000 ppm concentration.

Bansal and Nanda (1989) mentioned that either 10 or 100 ppm IAA treatments had little effect on *Hibiscus rosa-sinensis* cuttings which were rooted slowly and exhibited low IAA oxidase activity before treatment, whereas *Salix tetrasperma* and *Populus robusta* stem cuttings rooted well and exhibited high IAA oxidase activity before and after treatment. On the other side, **Mukhupadhyay and Gain (1982)** elicited that leafless stem cuttings of *Hibiscus tiliaceus* taken from 1-year-old shoots and treated with 1000 ppm NAA gave 100% rooting against 40% for control.

On bougainvillea cultivars, **Philip and Gopalakrishnan (1982)** indicated that the best rooting (100%) of bougainvillea cv. “Mahara” hardwood stem

cuttings was recorded by 6000 ppm IBA, which was followed by 1000 – 2000 ppm NAA (83.3 – 86.7%) versus 37.5% for control. Further, **Singh (1982)** showed that basal dipping of bougainvillea cvs. Mary Palmer and thima stem cuttings in 100 ppm + NaOH at pH 10.5 gave the highest rooting percentage and number of roots and the best root growth.

Bhattacharjee and Balakrishna (1983a) pointed out that 80% rooting and 100% survival of bougainvillea cv. Usha stem cuttings were the best by both NAA at 4000 ppm or IBA at 4000 and 6000 ppm concentrations. In another trial with 25 cultivars of bougainvillea, **Bhattacharjee and Balakrishna (1983b)** postulated that 4 cultivars responded well to NAA at 4000 ppm (Glabra Sanderiana, Golden Glow, Isobal Green Smith and Roosevelt's Delight) scoring the greater rooting and survival percentage, while the rest cultivars responded better to IBA (4000 ppm).

On 15 cm long jojoba stem cuttings, wounded with 1 or 2 basal incisions or not and dipped to 1 cm depth 4000 ppm IBA potassium salt solution before planting, **Howard, Banho and Milbohear (1984)** decided that IBA application increased the rooting %, and a further increase was obtained by IBA+ wounding. Wounding alone did not increase rooting % significantly above untreated controls. Rooting of non-wounded nodal cuttings was higher (58%) than that of internodal cuttings (28%). Wounding nodal cuttings increased rooting % by only 7% over non-wounded nodal cuttings, while wounding internodal cuttings gave a 39% increase, although the interaction failed to reach statistical significance. In addition, **Lee and Palzkill (1984)** demonstrated that Double-eye (DE) and single-eye (SE) single-node semi-hardwood jojoba cuttings treated with 2000 ppm IBA were rooted successfully under intermittent mist and rooting % varied from 30 to 97% for DE cuttings and from 43 to 95% for SE cuttings.

Jordan (1988) found that whole jojoba plants were regenerated via callus of nodal segments in Nitsch+Nitsch medium supplemented with 0.3 mg NAA, 0.1 mg BA, and 0.01 mg GA₃/l at a frequency of 15%. **Czekalshi (1989)** revealed that the highest rooting % of semi-hardwood cuttings taken from young stock *Bougainvillea glabra* plants was obtained with commercial preparations containing 0.2% NAA. On 15 cm long semi-hardwood cuttings of *Hibiscus rosa-sinensis* cv. snow flake, **Gupta (1989)** reported that the best results of rooting (80%) and plant survival (95.8%) were obtained by the quick dip in IBA solution at 4000 ppm. Rooting in the untreated control was 40% and plant survival was 75%.

Joshi, Mahorkar and Sadawarte (1989) claimed that the percent of rooted cutting in some bougainvillea cultivars was highest (70.9%) with IAA at 4000 ppm, followed by IBA at 6000 ppm (52.9%) and the average rooting in the control was 43.2%. Meanwhile, **Stilinovic and Grbic (1989)** declared that the best increment in growth of roots and shoots formed on hardwood cuttings of *Hibiscus syriacus* and *Jasminum nudiflorum* was acquired by 0.3 and 0.6 % Biolor (NAA), respectively.

On 20 cm-long hardwood cuttings of *Hibiscus rosa-sinensis* immersed for 24 h IAA or IBA solutions at 10 or 100 mg/l concentration, **Pal (1990)** observed that IBA at 100 mg/l, not IAA, increased rooting % to 100%, especially in cuttings collected in June.

Gupta and Kher (1991) affirmed that IBA at 4000 ppm gave the best rooting (highest root number and greatest root length) in the tip cuttings of Bougainvillea sp. Cv. "Garnet Glory". On semi-hardwood cuttings of Bougainvillea cultivars Akola, Shubra, Refulgence, Formosa and Magnifica dipped in IBA or NAA at 100, 200, or 400 ppm for 12 h in a mist chamber, Harris and Singh emphasized that the highest rooting % across cultivars and No. roots/cutting was obtained with 100 ppm IBA, followed by 100 ppm NAA in both seasons. Similar results were also detected by **Nagaraja, Rai and Guruprasad (1991)** on *Jasminum grandiflorum* and **Sreelatha, Gopikumar and Aravindakshan (1991)** on *Jasminum auriculatum* and *J. grandiflorum*.

In a trial to study the effect of IBA concentration + treatment duration + rooting medium temperature interactions on the rooting of 3 cultivars of *Hibiscus rosa-sinensis* stem cuttings, **Carpenter and Cornell (1992)** found that rooting was rapid with extensive root development for "Pink Versicolor" cv., the average for "Jim Hendry" cv. and slow with few roots/cutting for "Silver Anniversary". The concentration and duration of IBA treatment that cuttings required to reach maximum rooting declined with an increase in rooting-medium temperature (from 18 to 34 °C). Pink Versicolor cuttings receiving 4 to 6 minutes of basal dips required 8000 ppm IBA with the medium at 18 °C, 6000 ppm at 26 °C and 2500 ppm at 34 °C to achieve 100% rooting Pink Versicolor cuttings had the most roots at 1000 ppm IBA, with 10 minutes stem dips best at 18 °C, 4-8 minutes at 26 °C and 7-8 minutes at 34 °C. Maximum DW/root was achieved at 6000 ppm IBA, with longer basal stem dip durations needed at 18°C than at 26 °C or 34 °C. Accordingly, the benefits in rooting-medium temperature. **Nanda, Behera and Sahoo (1996)** supposed to dip stem cuttings of *H. rosa-sinensis* in 50-400 ppm IAA for 24 h. and kept them in polyethylene bags filled with acid-

washed sand under laboratory conditions (26 °C and diffuse sunlight) to get the highest rooting %, survival %, number of roots/cuttings and longest root length.

Mishra and Sharma (1995) elicited that 2000 ppm IBA concentration significantly increased rooting parameters of stem cuttings of *Bougainvillea* cvs. Dr. R.R. Pal and Mrs. H.C. Buck which are difficult to root. Hardwood stem cuttings of *Bougainvillea alba* were soaked for 24 h in 250 or 500 ppm IBA, after which some were dipped for 5 seconds in 10 or 20 ppm Co solution. **Sohair and Abo-Taleb (1995)** noticed that all treatments increased rooting and survival percentages, the number and length of roots, and their fresh and dry weights. The highest rooting % was obtained with 250 ppm IBA + 20 ppm Co (70.00% in the 1st season and 63.33% in the 2nd one) and 500 ppm IBA + 10 ppm Co (70.00% in the 1st season and 59.00% in the 2nd one). The largest roots were obtained in response to 500 ppm IBA. The highest survival %, 75 days after transplanting, which was 86 and 85% in both seasons, respectively, was achieved by 500 ppm IBA + 100 ppm Co combined treatment.

Kanamadi, Patil, Ryagi, Shirol and Kumar (1997) demonstrated that 1000 ppm IBA treatment resulted in the highest rooting %, maximum rooting zone and number of primary and secondary roots/cutting of *Bougainvillea* cv. “Mahara”. **Karaguzel (1997)** elucidated that the rooting percentage and number of roots/ cuttings in *Bougainvillea glabra* and *B. spectabilis* progressively increased with increasing IBA concentrations (0, 2000, and 4000 ppm). On tap and basal sections taken from the cuttings of *Jasminum sambac* soaked for 24 h in various concentrations of IAA, NAA, KMnO₄, IBA, and BA, **Zhang, Lai, Chen and Chen (1997)** revealed that the top sections of the cuttings rooted easily, but the basal ones showed the poorest rooting. The best rooting was gained from 300 mg IAA, 50 mg NAA, 1000 mg KMnO₄, 300 mg IBA, and 15 mg BA/l. IAA, NAA and KMnO₄ were the most effective in promoting rooting. Also, **Mahros (1999)** found that IAA at 100 ppm concentration was the most effective at promoting the rooting of *Jasminum sambac* taken from the middle portion of branches, while NAA at the same concentration (100 ppm) inhibited the rooting process.

Chen and chang (1999) suggested that propagation of *Bougainvillea glabra* (cvs. Purple Flower and Taipei Red) from cuttings must be carried out in spring or autumn in Taiwan, using either 6000 ppm IBA or 7500 ppm aminobenzotriazole (ABT) No.1 powder treatments which raised rooting ratio and roots number to the maximum above other treatments, either as a

powder or as solutions. In a greenhouse trial on *Bougainvillea villeda* × *butiana* “Mrs Butt” stem cuttings rooted under intermittent mist after being subjected to wounding and/or treatment with 5000 ppm IBA as a quick dip, **Hosni, El-Gendy, Shedeed and Ebrahim (2000)** concluded that wounding alone led to a 54.2% and a 71.5% increase in number of roots/cutting in the 1st and 2nd seasons, respectively. Dipping in IBA alone boosted No. of roots/cutting by 167.6% and 75% in both seasons. When the cuttings were treated with wounding and IBA, No. of roots/cutting increased by 108.5% and 45% compared to control, while the percentage of rooted cuttings increased by 45% and 15%, respectively. Thus, the rooting capacity of “Mrs. Butt” cuttings can be increased by wounding, especially if these cuttings dipped afterward in 5000 ppm IBA solution. Besides, **Mahros (2000)** studied the ability of tip, middle, and basal cuttings of three bougainvilleas (*B. glabra* cv. *sanderiana*, *B. glabra* cv. *variegata* and *B. spectabilis* cv. *Snow White*) treated with IBA at 0 and 100 ppm concentrations, and found that IBA at 100 ppm increased rooting % root numbers and lengths of the three species compared to control.

Panwar, Gupta, Saini and Sharma (2001) postulated that rooting %, number of roots and root length of semi-hardwood and hardwood *Bougainvillea* sp. cv. “Mary Palmer” cuttings increased with increasing concentrations of auxins (IBA, NAA, and IAA), with superiority 2000 ppm IBA treatment which recorded the most marked effect. **Singh (2001a)** declared that IBA at 2000 ppm concentration resulted in the highest rooting%, root length, root number and fresh weight of roots when hardwood cuttings of *Bougainvillea peruviana* were used for propagation. Also, 2000 ppm IBA induced a mark early in sprouting and gave the maximum rooting percentage which was at par with that of 2000 ppm NAA. Similarly, **Singh (2001b)** noticed that 2000 ppm IBA treatment recorded the highest rooting %, root length, root number and fresh weight of roots of *Jasminum sambac* cv. “Double Morga” stem cuttings. The best root characters were achieved by IBA treatments, followed by NAA and IAA. The highest survival % of rooted cuttings was obtained with IBA at 2000 and 3000 ppm, and NAA at 3000 ppm.

Many reports were published in the year 2002 on the rooting of bougainvillea cuttings; among them the report of **Ahmed, Ishtiaq and Nabi (2002)** investigated the response of soft, semi-hard, and hardwood cuttings of *Bougainvillea glabra* cv. “Varigata” to the quick dipping for 5 seconds in IBA solutions at 0, 1000, 2000, 3000, 4000, or 5000 ppm concentration, and found that maximum rooting %, survival %, number of roots (15.00), root length (11.73 cm) and root thickness (3.53 mm) were recorded by

hardwood cuttings treated with 4000 ppm of IBA. The softwood cuttings and those kept as a control completely failed to grow. In another report, **Gupta, Banerji and Datta (2002)** detected the dipping of bougainvillea cv. *Los Banos Variegata* cuttings in 1000 ppm for 24 h. resulted in 100% rooting, whilst dipping in 750 ppm IBA solution for 24 h. gave the height length of roots, and in 500 ppm IBA one maximized the number of roots/cutting. On soft, hard, and semi-hardwood cuttings of *B. spectabilis*, **Reddy, Angadi, Murgod and Praveen (2002)** reported that the highest No. of roots (24) were obtained from hardwood cuttings treated with NAA at 1000 ppm followed by treatment with IBA at 1000 ppm. Tip cuttings showed the lowest No. of roots. The maximum root length was scored by tip cuttings dipped in NAA at 500 ppm. Semi-hardwood cuttings treated with NAA at 1000 ppm showed the highest rooting % (80%).

In addition, **Singh (2002)** pointed out that terminal cuttings of bougainvillea cv. Thimma dipped for 5 seconds in 2000, 4000, and 6000 ppm solutions of either IBA, or NAA (separately or in combination) showed promotion of root growth, and development. However, dipping in 4000 ppm IBA, or NAA gave higher rooting %, No. of primary roots, length of the longest primary root and length of root collar than 2000 and 6000 ppm of the same growth regulator. Profuse callusing was also obtained by 4000 ppm IBA treatment. On the same bougainvillea cv. Thimma, **Singh and Singh (2002)** observed that hardwood cuttings treated with 2000 ppm IBA recorded the highest rooting %, number of roots/cutting, length and diameter of root, fresh weight of roots/cutting, and survival %. IBA at 2000 ppm treatment induced early and maximum rooting, which were at par with 2000 ppm NAA.

Yan (2002) cited that the rooting rates of cuttings taken from old female jojoba (*Simmondsia chinensis*) shoots and treated with IBA, NAA, and IAA (each at 100 mg/l) were 82, 80, and 76%, respectively. Likewise, **Bing and HanDong (2003)** noted that the rooting ratio of jojoba semi-hardwood cuttings was increased by plant hormone treatments, especially 1000 ppm IBA treatment that raised the rooting ratio and No. of roots to maximum.

On *Bougainvillea buttiana* cv. Mahara, **Deshmukh and Barad (2006)** doped the basal and of cuttings quickly in solution of IBA and NAA, each at 3000, 4000, 5000, and 6000 ppm, and concluded that IBA at 6000 ppm concentration was significantly superior to NAA for increasing rooted cuttings %, number of roots, length of root, and fresh and dry weight of roots. **Habib, Alam, Khanam, Islam and Choudhury (2007)** found that planting of *Bougainvillea spectabilis* hardwood cuttings treated with IBA

(4000 ppm) produced the maximum percentage of success (61.7%), number of roots (15.2%) per cutting and length of the longest roots (4.8 cm).

On stem cuttings of *Hibiscus syriacus* received a basal quick-dip in solutions Dip'N Grow at concentrations of 0+0, 50+25, 500+250, 750+375 and 1000+500 ppm IBA+ NAA prepared with and without 13.5 g/l sodium cellulose glycolate (SCG) as a thickening agent. **Blythe and Sibley (2007)** pointed out that stem cuttings of this plant showed an increase on rooting % by all treatments, with an increase in root number and/or total root length with inclusion of SCG. This is because the greater viscosity of solutions prepared with SCG can help reduce the possibility of spillage and evaporation of alcohol during the use of the auxin solutions.

Kumar, Bisla and Chharina (2008) examined the effect of IAA, IBA, and NAA, each at 0, 250, 500, and 1000 ppm on rooting of juvenile and mature cuttings of jojoba, and found that rooting % after 90 days of planting significantly increased by the auxin treatments over control, with the mastership of 500 ppm IBA treatment that showed the best result of rooting %, which was followed by a 250 ppm IBA one. At 500 ppm concentration of IBA, the maximum rooting % was 36.3% in juvenile cuttings compared to 10.83% in mature ones.

El-Sayed, Ahmed and Shahin (2010a) decided that the highest rooting %, No. of root/cutting, root length and the percent of rooting efficiency index (REI%) were obtained with *Hibiscus rosa-sinensis* semi-hardwood cuttings soaked in 20 ml/l humic acid solution for 1 h and then the quick dip in 1.5 g IBA/100 g talc powder. Analogous response was also obtained by **El-Sayed Ahmed and Shahin (2010b)** on *Bougainvillea glabra* semi-hardwood stem cuttings, where the same combined treatment mentioned before attained the maximum records of rooting %, No. of roots/cutting, root length, and REI %.

Lai, Zhong, Zhang, Lin, Su and Xie (2010) discovered that soaking the remaining leaf of *Bougainvillea spectabilis* cuttings in 500×10^{-6} IBA solution gave higher rooting %, No. of roots, root length, root mass growth, and survival % than those in defoliated cutting treatment. **Amissoh and Monney (2012)** indicated that rooting % in *Bougainvillea glabra* and *B. spectabilis* semi-hardwood stem cuttings were highest when treated with 2500 ppm of IBA solution (55.2%) versus 25.9% for control, there was no significant difference in rooting % between cuttings treated with 2500 ppm IBA (55.2%) and those treated with 4000 ppm (50.0%). Number of roots/cuttings was twice as much in *B. glabra* cuttings (8 roots) compared