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Effect of indole-3-butyric acid concentrations and rooting media on growth and survival of stem cutting of lemon (*Citrus limon* Burm) Cv. pant lemon-1 under net house condition

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Abstract
The research work was conducted during the 2019-20 and 2020-21 at Agricultural Farm, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, 305004. The research work experiment was laid in Randomized Block Design (RBD) with three replications. The Treatment-6 (T_6) 800ppm IBA + Garden Soil + Sand + Vermicompost (1:1:1) was gave significant results on rooting of stem cuttings and survival percentage of lemon (*Citrus limon* Burm) cv. Pant Lemon-1 as compared to control under shade house conditions.

Keywords: Lemon stem cutting, IBA, vermicompost, sand

Introduction
Citrus belong to Rutaceae family, the genera Citrus (oranges, mandarins, pomelos, grapefruit, lemons, limes and citrons), Fortunella (kumquats) and Poncirus (trifoliate oranges) contain the principal commercial species (Swingle and Reese, 1967) [1]. It is originating in tropical and subtropical Southeast Asia; these plants are among the oldest fruit crops to be domesticated. India ranks sixth in the production of citrus fruit in the world. It is of particular interest because of its high content of vitamin C (Katz and Weaver, 2003) [2].

Citrus fruits are cultivated in more than 100 countries, making them as one of the most important commercial fruit crops of the world. Fruits have the great utility regarding the medicinal properties, social value, religious value and food security in most developing countries. Fruits are rich source of essential nutrients i.e., carbohydrates, vitamins, proteins, fats and minerals etc. for proper growth and development of human body. The essential nutrient plays a vital role for correction of nutrient deficiency diseases in human beings. Most of fruits are consumed as table purposes and as processed food. In general, citrus has wide adaptability with respect to Agro-climatic conditions and is a rich source of vitamin C, hence, citrus fruits have a great socio-economic importance to fruit grower community for better living of standard. In developing countries like India, deficiency of vitamin C is quite common in human beings. This vitamin is useful in healing of wounds, developing stronger blood vessels and gums, gives strength to bones and protecting from cold and cough etc. Similarly, lemon is a good source of vitamin C to compensate the deficiency symptoms of this vitamin through the plenty availability in fruits like lemon.

Lemon trees put on new growth as series of discrete growth cycles or flushes. There is a major flush of new growth in spring season, which produces most of the flowers and some new leaves on shoot tips at mature branches. There is great variation in initiation of growth, flushes and its behaviour depending upon a number of factors such as environmental, type of soil, species, varieties and age of tree etc.

Vegetative propagation of plants by stem cuttings is the most commonly used method for producing herbaceous and woody plant in many parts of the world. A cutting is a piece of the part of plants used to propagate which regenerate there missing part is called cutting. Stem cutting can be classified as follows: hardwood cuttings, semi hardwood cuttings, softwood cutting and herbaceous cuttings.

In present investigation, three doses of Indole-3-butyric acid (IBA) $C_{12}H_{13}NO_2$ (1H-indole-3-butanoic acid) is a native compound in Arabidopsis that exhibits a number of auxin activities particularly with respect to roots.

IBA and IAA are inter-converted by a variety of plants, so IBA and IAA conjugates may play overlapping roles in the plant, with regard to inactivation of IAA or IBA could act as an auxin directly and three combinations of rooting media (garden soil, sand, FYM and vermicompost) were used to prepare ideal rooting media in a definite proportion. The organic nature of FYM and vermicompost favours the friable condition of media for better water holding capacity, resulting flourish development of roots in cuttings. Garden soil is topsoil, enriched with compost and other organic matter so it's nutritious for plants. It has a heavier texture and holds water longer than potting mixes. It's more affordable than potting soil because it doesn't have pricier ingredients like perlite, vermiculite or moss. It's mostly soil, and soil is dirt cheap. (en.wikipedia.org)

Sand is a granular material composed of finely divided rock and mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass. Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left-over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P_2O_5 and .0.5 per cent K_2O.The present method of preparing farmyard manure by the farmers is defective. Urine, which is wasted, contains one per cent nitrogen and 1.35 per cent potassium.

Vermicompost (vermicompost) is the product of the decomposition process using various species of worms, usually red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast. This process is called vermicomposting, while the rearing of worms for this purpose is called vermiculture. Vermicompost has been shown to be richer in many nutrients than compost produced by other composting methods. It has also outperformed a commercial plant medium with nutrients added, but levels of magnesium required adjustment, as did pH. It is rich in microbial life which converts nutrients already present in the soil into plant-available forms. Unlike other compost, worm castings also contain worm mucus which helps prevent nutrients from washing away with the first watering and holds moisture better than plain soil. Increases in the total nitrogen content in vermicompost, an increase in available nitrogen and phosphorus, as well as the increased removal of heavy metals from sludge and soil have been reported. The reduction in the bioavailability of heavy metals has been observed in a number of studies. (en.wikipedia.org)

Methods and Material

The research work was conducted during the 2019-20 and 2020-21 at Agricultural Farm, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, 305004. The Ajmer comes under semi-arid zone and is situated at a latitude of 26.4499° N and longitude of 74.6399° E. The altitude of the place is 484 meters from mean sea level. The mean annual precipitation on the basis of last fifteen years is 473 mm, which receives almost from South- West monsoon during June to October. The mean annual minimum and maximum temperatures are 10.80°C and 41.1°C, respectively. The average humidity ranges from 29.75 per cent in summer and 51.23 per cent in rainy season. Thus, Ajmer has hot and dry summer with moderate cold winter. The experiment was conducted in Randomized Block Design (RBD) with three replications. Total ten treatments including control i.e., T1-400ppm IBA + garden soil + sand (1:1), T2- 400ppm IBA + garden soil + sand + FYM (1:1:1), T3- 400ppm IBA +garden soil + sand + vermicompost (1:1:1), T4-800ppm IBA + garden soil + sand (1:1), T5- 800ppm IBA + garden soil + sand + FYM (1:1:1), T6- 800ppm IBA + garden soil + sand + FYM (1:1:1), T7-1200ppm IBA + garden soil + sand (1:1), T8- 1200ppm IBA + garden soil + sand + FYM (1:1:1), T9-1200ppmIBA + garden soil + sand + vermicompost (1:1:1) and T10- Control (Garden soil) were used. Cutting is obtain from the 10 months old shoots of Pant Lemon-1 cultivar of lemon. According to treatment combinations, the different rooting media were prepared and filled in black colour poly-bags. The 22 cm long and pencil thickness sized cuttings were made and treated with prepared IBA solution according to different doses of IBA. Thereafter, cuttings were planted in poly-bags and placed in shade net-house during third week of July month. The various observation like Number of shoots per cutting, Length of primary root (cm), Diameter of primary root (cm), Longest root (cm) and Survival percentage (%) were recorded with proceeding of experiment. The recorded data were statistically analysed by using randomized block design (RBD) as suggested by Gomez and Gomez (1996) [4].

Result and Discussion

Results from the Table-1 showed that each increment in IBA concentration significantly affected in terms of days taken to sprouting as compared to control and other treatments. The Maximum number of shoots per cutting was recorded with the application of 800 ppm IBA +garden soil + sand +vermicompost (1:1:1) (8.12 and 8.22) in both the years which was found significantly superior over rest of the treatments and the minimum number of shoots per cutting (1.90 in 2019-20 and 1.97 in 2020-21) was observed in control. The maximum vegetative growth might be due to the fact that lemon crop had observed maximum nutrients and used these nutrients for good vegetative growth. Similar findings were reported by Singh *et al.* (2006), Kamble *et al.* (2007) [5] and Awasthi *et al.* (2008) [6]. The maximum length of primary root (7.91 cm and 7.95 cm) was recorded with the application of 800 ppm IBA +garden soil + sand + vermicompost (1:1:1). However, minimum length of primary root (2.16 cm and 2.20 cm) was measured in control treatment during 2019-20 and 2020-21, respectively. It may be due to the IBA treated cuttings planted in vermicompost containing rooting medium, the root growth was found to be significantly better than root growth of those treated cuttings grown in FYM containing rooting medium. Significant increase in root growth of stem cutting in terms of number of root when treated with moderate concentration of IBA action of auxins in terms of hydrolysis and translocation of carbohydrate and nitrogen substances at the base of cutting and resulted in accelerated cell elongation and cell division in suitable environment. It enhances texture and porosity of rooting media by using sand and vermicompost. Similar results were also reported earlier by Singh, G. *et al.* (2017) [7], Patel B. *et al.* (2018) [10] and Malakar, A. (2019) [8]. The significantly maximum diameter of primary root (0.42 cm and 0.42 cm) was recorded with the application of 800 ppm IBA + garden soil + sand + vermicompost (1:1:1) during 2019-20 and 2020-21, respectively. However, minimum diameter of primary root

(0.15 cm and 0.16 cm) was measured in control treatment during 2019-20 and 2020-21, respectively. The increases in root and shoot characters in lower portion of ringed branch might be due to optimum increase in the endogenous auxins level, phenols, carbohydrate and other bio compounds which stimulate cell division and growth Similar result were also obtained by Singh, G. *et al.* (2017) [7], Patel Babloo *et al.* (2018) [10] and Malakar, A. (2019) [8]. Length of longest root (9.56 cm and 9.59 cm) was recorded with the application of 800 ppm IBA +garden soil + sand + vermicompost (1:1:1). However, shortest length of longest root (3.90 cm and 3.98 cm) was measured in control treatment during 2019-20 and 2020-21, respectively. The improved root formation and root growth in this rooting medium could be due to better aeration and drainage and water maintenance capacity of the substrate which are critical for the first phase of root initiation. Unlike other growing media, vermicompost contains good amount of 'plant available nutrients' and appears to increase and retain more of them for longer period of time. Therefore, lemon cuttings grown in polybag mixture containing vermicompost had better root growth. The enhanced hydrolytic activity in presence of applied IBA coupled with appropriate rooting medium might be responsible for the increased percentage of rooted cuttings in the present study. Similarly, views were held by Farah *et al*. (2009) [11], Singh, G. *et al.* (2017) [7], Patel B. *et al.* (2018) [10] and Malakar, A. (2019) [8].

The application of 800 ppm IBA + garden soil + sand + vermicompost (1:1:1) showed tremendous enchantment in the survival percentage of seedlings. Maximum survival percentage i.e. 89.20 and 89.90 were recorded with 800 ppm IBA + garden soil + sand + vermicompost (1:1:1). While minimum survival percentage of seedlings 58.39 and 59.07 were recorded in control during 2019-20 and 2020-21, respectively. In addition to that when using growth regulator boosting the rooting can be attributed to the favorable conditions like high temperature (30-35^{0}C) and high relative humidity (80-90%) with higher photosynthetic activity which promoted better rooting in cutting and survival percentage. These results are in close conformity with those of the earlier workers Fraternale *et al.*, (2010) [12], Chayanika *et al.*, (2011) [13], Tallon *et al*. (2012) [14], Singh, V. P. *et al.* (2015) [15], Patel B. *et al.* (2018) [10] and Dinesh Raj Tanwar *et al.* (2020) [16].

Table 1: Effect of Indole 3-Butaric Acid Concentrations and Rooting Media on Survival and Growth of Stem Cutting of Lemon (*Citrus Limon* Burm) Cv. Pant Lemon-1 Under Net House Condition

Notation	Treatments	Number of shoots per cutting		Length of primary root (cm)		Diameter of primary root (cm)		Longest root (cm)		Survival percentage (%)	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	400 ppm IBA + Garden Soil + Sand (1:1)	2.46	2.49	2.80	2.82	0.17	0.18	4.60	4.63	60.43	60.57
T_2	400 ppm IBA + Garden Soil + Sand + FYM (1:1:1)	3.12	3.19	3.39	3.49	0.21	0.21	5.23	5.27	64.47	64.58
T_3	400 ppm IBA + Garden Soil + Sand + Vermicompost (1:1:1)	4.06	4.09	4.17	4.20	0.27	0.28	6.16	6.16	67.22	67.56
T_4	800 ppm IBA + Garden Soil + Sand (1:1)	5.58	5.66	5.62	5.64	0.31	0.31	7.65	7.70	73.88	73.96
T_5	800 ppm IBA + Garden Soil + Sand + FYM (1:1:1)	6.24	6.36	6.38	6.43	0.36	0.37	8.21	8.24	81.25	82.22
T_6	800 ppm IBA +Garden Soil + Sand + Vermicompost (1:1:1)	8.12	8.22	7.91	7.95	0.42	0.42	9.56	9.59	89.20	89.90
T_7	1200 ppm IBA + Garden Soil + Sand (1:1)	5.89	5.96	5.78	5.82	0.36	0.37	7.01	7.05	79.39	79.94
T_8	1200 ppm IBA + Garden Soil + Sand + FYM (1:1:1)	4.45	4.49	4.76	4.79	0.29	0.30	6.63	6.72	71.10	71.95
T_9	1200 ppm IBA + Garden Soil + Sand + Vermicompost (1:1:1)	3.17	3.24	3.55	3.58	0.26	0.27	5.78	5.82	66.61	66.97
T_{10}	Control (Garden Soil)	1.90	1.97	2.16	2.20	0.15	0.16	3.90	3.98	58.39	59.07
SEM ±		0.07	0.04	0.05	0.05	0.00	0.01	0.06	0.06	0.22	0.30
CD		0.21	0.12	0.16	0.15	0.01	0.02	0.17	0.17	0.65	0.88

Conclusion

In present investigation different IBA concentrations and rooting media were applied for rooting of cuttings of lemon cv. Pant Lemon-1. In this respect a total ten treatments were tried. Out of these, the treatment 800ppm IBA + garden soil + sand + vermicompost (1:1:1) was found to be the most significant treatment for rooting of stem cuttings and survival percentage of lemon (*Citrus limon* Burm) cv. Pant Lemon-1 as compared to control under the net house conditions.

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