"EFFECT OF IBA, BIOFERTILIZER, *Trichoderma* & *Pseudomonas* ON ROOTING OF POMEGRANATE (*Punica granatum* L.) CUTTING"

M.Sc. (Hort.) Thesis

by

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DEPARTMENT OF FRUIT SCIENCE

COLLEGE OF AGRICULTURE

INDIRA GANDHI KRISHI VISHWAVIDYALAYA

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"EFFECT OF IBA, BIOFERTILIZER, *Trichoderma* & *Pseudomonas* ON ROOTING OF POMEGRANATE (*Punica granatum* L.) CUTTING"

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CERTIFICATE – I

This is to certify that the thesis entitle **"Effect of IBA, Biofertilizers, *Trichoderma & Pseudomonas* on rooting of pomegranate (*Punica granatum* L.) cutting"** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Horticulture (Fruit Science)** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, (Chhattisgarh) is a record of the bonafide research work carried out by **Jayashri Rathore** under my/our guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate course). All the assistance and help received during the course of the investigations have been duly acknowledged.

Date: 22.7.2019

Dr. G.L. Sharma

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	**(Dr. G.L. Sharma)**	
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Member	**(Dr. Tapas Chowdhury)**	
Member	**(Dr. R.R. Saxena)**	

CERTIFICATE – II

This is to certify that the thesis entitled **"Effect of IBA, Biofertilizers, *Trichoderma & Pseudomonas* on rooting of pomegranate (*Punica granatum* L.) cutting"** submitted by **Jayashri Rathore** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfilment of the requirements for the degree of **M.Sc. (Horticulture)** in the **Department of Fruit Science** has been approved by external examiner and Student's Advisory Committee after oral examination.

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(Dr. Dinesh Kumar)

Date: 31/07/2019

Major Advisor 31.7.19

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Faculty Dean

Approved/Not approved

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LIST OF SYMBOLS

ºC	Degree Celcious
cm	Centimeter
ml	milliliter
mm	millimeter
Cv.	Cultivar
et al.	And others
ha	Hectare
etc.	and so on ; and other people
@	at the rate
hr.	Hour
g	Gram (s)
NAA	Naphthalene acetic acid
IBA	Indole -3- Butyric acid
N	Normal solution
i.e.	that is
kg	Kilogram (s)
NS	Non Significant
ANOVA	Analysis of Variance
m	meter
m²	Meter square
ppm	parts per million
Max.	Maximum
Min.	Minimum
/	Per
%	Per cent
qt	Quintal
RH	Relative Humidity
spp.	Species
Fig.	Figure
TSS	Total Soluble Solids
Temp.	Temperature
Var.	Variety
C.D	Critical Difference
S.Em±	Standard Error of Means
S.S	Sum of square
M.S.S	Mean Sum of Squares
S	Significant
Sec.	Second
viz	(vide licent) Namely

THESIS ABSTRACT

a) Title of the Thesis	: Effects of IBA, Biofertilizer, *Trichoderma & Pseudomonas* on rooting of pomegranate *(Punica Granatum L.)* Cuttings
b) Full Name of the Student	: Jayashri Rathore
c) Major subject	: Fruit Science
d) Name and Address of the Major Advisor	: Dr.G.L.Sharma, Associate Professor Major Advisor, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.)
e) Degree to be awarded	: M.Sc.(Hort) Fruite Science

Signature of the Student

Signature of Major Advisor

Date: _____ Signature of Head of the Department

ABSTRACT

The present experiment entitled **"Effects of IBA, Biofertilizer, *Trichoderma & Pseudomonas* on rooting of pomegranate *(Punica granatum l.)* cuttings"** was conducted at nursery, Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during the period of 2018-19.The present experiment was conducted to study the effect of growth regulators, biofertilizers, bio control agents, with eleven treatment (viz, control, IBA1000, IBA1500, IBA2000, IBA2500, PSB, *Azotobactor*, *Azospirilum*, Vermicompost, *Trichoderma*

viride, *Pseudomonas fluorescence*) combination with three replication in a complete randomized design (CRD), under shade net condition

The study revealed that significant differences were existed among the treatments for different rooting and shooting parameters. Among the different treatments the earliness in sprouting of cutting as well as significantly maximum success percentage, leaves count per shoot, root numbers per cutting, root length, root diameter and fresh root weight were observed in IBA 2500 ppm, on par with *Trichoderma viride* but the dry matter percentage of roots was found to be maximum in the treatment with *Trichoderma viride* on par with IBA2500 ppm. However, the performance cutting in treatment T_0 (control) was inferior. Among the four concentration of plant growth regulators used, maximum success percentage, leaves count per shoot, root diameter, root length, fresh root weight, percentage of dry matter of roots and root munbers per cutting was found to be maximum with application of IBA 2500 ppm followed by IBA 2000 ppm. Among the biofertilizers used PSB was significantly superior in comparison to *Azospirillum* and *Azotobactor* with respect to different root and shoot parameters *viz*, earliness of sprouting (days taken for first sprouting and sprouting of 50% of cuttings) success percentage of cutting, leaves count per shoot, roots numbers, root diameter, root length and percentage of dry matter of roots. As regards the bio control agents, used earliness of sprouting (days taken for first sprouting and sprouting of 50% of cuttings) success percentage of cutting, leaves count per shoot, roots numbers, root diameter, root length, root count and percentage of dry matter of roots was found to be maximum with application of *Trichoderma viride* followed by *Pseudomonas fluorescence.*

CHAPTER - I

INTRODUCTION

Pomegranate (*Punica granatum* L.) belonging to family Lythraceae, is an ancient fruit originated in Persia, Afghanistan and Baluchistan (De Candolle, 1967) Pomegranate is said to be native to modern-day Iran to northern India. Cultivation of Pomegranates are mainly concentrated in middle east and south east and Mediterranean region for many millennia, and also cultivated in California and Arizona, the place known for hotter or drier climate .Pomegranates comes in light in earlier days of 5th millennium BC, as they were one of the first fruit trees to be domesticated in the eastern Mediterranean region of the globe. Pomegranate is one of the important fruit crop of tropical and sub-tropical parts of the world. Pomegranate was widely cultivated in Spain and Iran. In consideration to world scenario, production of pomegranate was 1439.1 thousand tones, of which, contribution of India is about 743.1 thousand tonnes. In India, it is cultivated since ancient time in northern part and currently in an area of about 107.3 thousand hectares. It is commercially cultivated in the states of Maharashtra, Karnataka, and Gujarat and to limited extent in Andhra Pradesh, Tamil Nadu, Rajasthan, Uttar Pradesh and others states. Maximum area (82,000 ha.) under this crop is in Maharashtra. (National Horticulture Board, 2010-11)

The family of pomegranate Lythraceae earlier known as Punicaceae has only two members one of which is *Punica granatum*, the pomegranate of commerce. Order of the Lythraceae family is Myrtales which also includes *Corymbia torelliana*, (a plant used as a windbreak around citrus in some part of the earth), Eucalyptus (nilgiri in hindi), Melaleuca, Jaboticaba, and guava.

The pomegranate have some special botanical characteristics, let us have a look on some of them, the tree have a identical bushy shape having multiple-stems,

the bushiness in plant is because of suckers routinely arising from the base. The plant has an average height of 5-8 m, and either multi stem or single stem training method is adopted in the plants. The plant is normally deciduous in nature. The newly arrived shoots are thin and weepy caring thorns. The color of the leaves is dark green with a shiny appearance and the size of the leaves is small with alternate arrangement. The plant is monoecious with two types of conspicuous flowers which arise in the new grown stems in the spring season. Flowering may occur over several months with some flowers still being produced into late summer or early fall, but the major bloom period is the spring season.

Two types of flowers are present in pomegranate namely hermaphrodite and male flower, among them only the hermaphrodite flowers set fruits. Flower of both the types have some variation the hermaphrodite is mostly vase shaped and male flowers are more bell-shaped. Color of the flower is found to be very attractive with different shades, some of them having orange red, pinkish red to bright red colors. The major pollinator in pomegranate is bee and the type of ovary is inferior.

The fruit size in pomegranate is medium, usually with a diameter of 3 inches, and sometimes 4 to 5 inches, and 5 to 8 months are required by the fruits to develop completely, and the shape changes from round to a slightly squared round after attaining full maturity. A vast variation is present among the pomegranate cultivars with respect to color, taste, and certain other traits. Peel color ranges from a light yellow, orange to very dark red/purple. The calyx (petals + sepals) remains attached to the fruit even after the maturity and looks like a crown attached to the fruits. Internally, the fruit consists of a series of chambers known as locules which are separated by a membranous septum. The seeds remain intact in each chambers, seeds range in hardness from very hard which is not edible to soft which can be easily consumed. The edible part of the pomegranate is aril (fleshy outgrowth of the seeds) which contains juice. Variation is also present among arils for the color and flavor, the color varies from a light, virtually white, color to very dark red or purple and flavor of the juice can be indelibly tart to bland to sweet or sweet/tart

depending on acidity. Typical soluble solids values for fruit ranges from 15 to 18%. (University of florida)

The fruits of pomegranate can be consumed in different forms specially in fresh or in processed forms like bottled juice, syrup, jelly and it can be used in baking, cooking, meal garnishes, smoothies and alcoholic beverages. The juice derived from the fruits is also used to prepare soups, sorbets, sauces and to flavor cakes, baked apples, and other desserts.

The nutritive value of pomegranate fruits is very high and has several health benefits. Pomegranate fruits are rich in vitamin C, potassium and antioxidants. Nutritional value of 100g of edible arils is having 346KJ energy, 18.7 g carbohydrates, 13.7 g sugars, 1.7 g protein, 1.2 g fat, 236 mg potassium, 10 mg vitamin C, 0.07 mg thiamine and 4.0 g dietary fibre. The shelf life of the fruit is very high and it can be stored for a longer period as compared to other fruit crops ,the fruits also have therapeutic values accompanying considerable pharmacological properties like antimicrobial, antiviral and antimutagenic effects (Negi *et al.,* 2003; Seeram *et al.,* 2005). Presence of these properties made the fruit more attractive to the consumers and provides a good market value to the crop.

The beneficial effects of Pomegranate is uncountable and if helps to fight with several disease increasing in nowadays lifestyle. According to USDA National Nutrient Database the fruit help manage blood sugar level and is considered as a miracle for the patients suffering from diabetes, the fruit is well known to boost immunity, the peels of the fruits are responsible to improve digestion, and the arils contain high amount of iron which helps to increase blood hemoglobin level and also improves blood circulation in the human body. The pomegranate juice contains an abundant amount of certain ellagitannin compounds like Granatin B, and Punicalagin. Studies suggest that punicalagin and tannins can be effectively in reduce heart-disease risk factors by scavenging dangerous free radicals from the human body. Consumption of pomegranate in a regular basis has also been found

to be effective against prostate cancer, benign prostatic hyperplasia (BPH), diabetes, and lymphoma. (Channing, *et al*. 2017)

Pomegranate is propagated by both sexual andasexual means. Sexual propagation by means of seed results in a seedling with good germination which produces a vigorous tree but the method is not convenient by economical means as it do not produces true to the type plants and the size, color, sweetness and juiciness of the fruits will be unpredictable that's why vegetative propagation if preferred in pomegranate as it gives true to the type plants with less variation present among them for size, color, sweetness and juiciness of the fruits.

Rhizogenesis is the most habitually used organogenetic phenomenon in vegetative multiplication of pomrgranate. Propagation by means of cuttings is economically sound and cheap method. Pomegranates can be propagated using both softwood or hardwood cuttings, but hardwood cuttings are commercially adopted methods. Hardwood cuttings are taken from one year old wood or suckers, trimmed, and planted in polybags in nursery where they grow for one year before planting it in the open fields.

To reduce the extensive increase in death rate of rooted cuttings under field conditions, necessity to grow healthy and vigorous pomegranate which enable better field establishment of the trees by applying suitable plant growth regulators. Rooting ability of the plants mainly depends on the genetic trait (De Klerk and Brugge, 1992), environmental condition (Levitt, 1980), and the external and internal supply of biochemical components. Biochemical constituents present in cuttings act as a source of reserve energy and play an important role in the process of rooting. Several studies have thrown out that carbohydrates, phenolics and proteins were essential for rooting of the cuttings.(Druege *et al* ,2000). Understanding of biochemical and morphological phases combined with root initiation may heads toward development in rooting process, which could reduse losses, particularly towards the field establishment of the plants.

IBA and NAA are the most important plant growth regulators (PGR) generally employed for induction and development of rooting in cuttings. It is observed that optimum concentration of growth regulators used and biochemical constituents of mother plant would help in better survival and faster root development of pomegranate cuttings. So far, research work done on pomegranate propagation through cuttings including both cultivars and optimum concentration of plant growth regulators in a very large scale, but some biofertilizers also play important role in rooting of cuttings, by making the nutrients available to the growing roots.PSB is responsible for increasing the availability of phosphorus to the root zones of the plants. *Azotobactor* and *Azospirillum* helps to increase the uptake of nitrogen and other nutrients by making them available by the plants. Certain microorganism like *Trichoderma viride*, and *Psedomonas* also found to induce roots in pomegranate by suppressing the attacks of several disease causing pathogens and reducing biotic stress at the root zone. Further nowadays organic pomegranates production requires the cutting which are propagated by utilization of organic natural products, which can be done by using biofertilizers, organic compost and biocontrol agents.

In view with the above background, a study on propagation of pomegranate by using different concentrations of IBA, biofettilizers, vermicompost, *Trichoderma, Pseudomonas* is undertaken with the following objectives:

1. To assess the effect of IBA on rooting, growth & other parameters of Pomegranate cuttings.

2. To assess the effect of biofertilizers (PSB, *Azotobactor, Azospirillum*) on rooting growth & other parameters of pomegranate cuttings.

3. To assess the effect of *Trichoderma, Psedomonas* & vermicompost on rooting, growth and other parameters of pomegranate cuttings.

CHAPTER - II

REVIEW OF LITERATURE

Propagation is a science of creating a new life from the existing ones by different methods like sexual and asexual. Sexually propagated plants have several disadvantages like long gestation periods, not true to types plants, not uniform in growth, low yield and quality therefore asexual propagation or vegetative propagation is used for the propagation of fruit crops with having distinct advantages. In fruit crops vegetative propagation, regeneration by means of stem cutting is found most desirable, cheapest and beneficial one with several advantages like true to type plants and plants could be raised within shortest period and therefore it is practiced from prehistoric times. Keeping it in mind, propagation by stem cutting is considered as most preferable method in pomology and also in pomegranate. In cuttings, exogenously applied growth regulators are found to enhance early and good root formation with a strong root system. Various classes of plant growth hormones like auxin, cytokinins, gibberellins and ethylene is used in cuttings to boost up the formation of roots. Among all of these, auxin has greater effects in regeneration of roots in plants or stem cuttings. Among the several auxins available in market, especially IBA is commercially applied to stimulate root initiation of stem cuttings in pomology. Biofertilizers has also role in rooting of cuttings. *Azotobactor, Azospirillum* and phosphorus solubilizing bacteria etc are also found to be very usefull in stem cuttings of pomegranate. Certain microorganism like *Trichoderma viride,* and *Psedomonas* also found to induce roots in pomegranate. Further nowadays organic pomegranates production requires the cuttings which are propagated by utilization of organic natural products. A good number of works has done with regard to propagation of pomegranate and other fruit crops through cuttings using PGRs, biofertilizers and microoganisms or bio inoculants, which have reviewed in this chapter.

2.1 Effect of growth IBA

Doak (1941) found that the cutting percent was increased by the exogenous application of auxin, and they reported that reason behind it might be due to favorable impact of auxin in activation of natural reserves and their mobilization to the part of root formation.

Stoutemeyer (1942) insisted that among several auxins available for rooting of the cuttings, IBA is a powerful auxin, and is steadily destroyed by the auxin destroying enzyme system found in plants.

Stoutemeyer (1954) reported that rooting of cuttings is influenced by growth regulators, which might be due to the reason that growth regulators helps in hastening the formation of root primordial.

Mahlstede and Haber (1957) studied and found that the root formation in cuttings with the application of plant growth regulators is because of an interaction between the rhizocaline, an intermediary auxin specific for root initiation, and applied hormone.

Audus (1958) and Rao (1967) found that among the several growth hormones used for rooting of cutting IBA is chemically more stable and less mobile in plants which make them superior to other hormone available for cuttings.

Gautherest (1969) confirmed that the presence of auxin is a must for initiation of adventitious root on stem cuttings either natural or artificially applied.

Haissing (1972) noted that the division of the first root initial cells depends on auxin, either endogenous or exogenous auxin.

Purohit and Shekhareppa (1985) researched the impact of distinct stem portions of the plant with a diameter of 1.0 to 1.25 cm, treated with distinct IBA levels in cuttings of fruit crop *Punica granatum*.

Sharma and Sharma (1987) observed a significant difference in rooting pattern of hardwood cuttings of wild pomegranate and recorded maximum percentage with quick dip in 4000 ppm IBA.

Reddy and Reddy (1990) applied IBA and NAA each at 2500 ppm in hardwood cuttings of pomegranate cv. Bassein Seedless with. The cuttings were either left open or coated with polyethylene film and all cuttings remained in the shade. The highest percentage of rooting, root counts per cutting and average root length were observed with all the treatments covered polyethylene.

Panda and Das (1990) emphasized that significant outcomes have been achieved in respect of rooting in hardwood cuttings of pomegranate, treated with different concentrations of growth regulators. They recorded 76.1% rooting when applied with 5000 ppm IBA.

Sandhu *et al.* (1991) conducted rhizogenesis study in pomegaranate and insisted that cuttings of cultivars *viz.* Kandhari and Malas recorded maximum rooting percentage when applied with IBA 100 ppm.

Bankar and Prasad (1992) reported stem cuttings of pomegranate applied with IBA at 1000ppm resulted in highest dry weight of shoot, while maximum dry root weight was recorded in cuttings applied with IBA at 2000ppm.

Jain and Parmar (1993) disclosed that when IBA was absent in hard wood cuttings of pomegranate no rooting was seen. The cuttings were applied IBA 1000 + B at 50 ppm and planting of the cutting was done in river silt alone or blended with FYM. The root length, root count per cutting and diameter were more in FYM + river silt than in river silt alone.The cuttings treated with 1000 ppm IBA+ 50 ppm B generated the most of the root sprouts and survived most.

Singh (1994) noted that in pomegranate cuttings, best rooting (51.91 percent) was observed with the application of IBA @ 1000 ppm, followed by Seradix-B (46.15%) for rooting of the stem cutting. The maximum root length was observed in the treatment with Seradix-B.

Lakhani and Gajipara (1998) disclosed that pomegranate stem cuttings gave the highest survival proportion (89.96) when cuttings were applied with IBA at a concentration of 2000 ppm.

Navjot and Kahlon (2002) worked on the impact of type of cutting (basal, middle, and sub apical portion of the shoot) and IBA on rooting of cutting in pomegranate cv. Khandari. The middle cuttings applied with 100 ppm IBA was the most effective treatment combination in promoting rooting and plant growth. The plant girth was the best in basal cutting.

Nag and Shukla (2005) worked on the effect of planting and application of plant growth regulator on shooting and rooting behavior of pomegranate cuttings. The influence of time of cutting (September, October and November) and IBA at different concentrations maintained in water or coconut water along with and without bavistin on stem cutting of pomegranate cv. Ganesh for root generation, indicated that September planting with IBA at 2000 ppm maintained in coconut water along with bavistin was reported as best treatment for higher root formation, better shoot and root growth and final survival percentage. However, the rooting percentage recorded was significantly lower in the month of October followed by November planting of cuttings, owing to low temperature and humidity during the period.

Shirzadi (2007) stated that soft wood cuttings of pomegaranate IBA 5000 ppm produced highest rooting percent and growth of nodes.

Upadhyay and Badyal (2007) observed that, maximum survival percentage of 81.33% was recorded when hardwood cutting were treated with IBA at 2000 ppm closely followed by 1000 ppm NAA + 2000 ppm IBA under palamur condition in pomegranate.

Chalfun *et al.* (2008) observed that application of IBA to cuttings of fig, increased the dry matter weigth of shoots and roots.

Saroj *et al.*(2008) worked on root generation in pomegranate cuttings noticed maximum number of roots in hardwood and semi hardwood type of cuttings applied with 2500 ppm IBA.

Polat and Caliskan (2009) observed that pomegranate stem cuttings when applied with 1000 ppm IBA recorded highest rooting percentage.

Sharma *et al.* (2009) disclosed that vegetative propagation of pomegranate (*Punica granatum* L.) by means of cutting is found to be cheapest and the most convenient technique to obtain true to the type, full developed crops in significantly less time and in order to inhance the root formation and decrease the death of rooted cuttings, standardization of time of cuttings and use of plant growth regulators has done. Maximum root formation, root count and roots length was seen with applying IBA 500 ppm + Borax 1% both in hard wood and semi hard wood cuttings. Field survival of treatment with IBA 500 ppm + Borax 1%, IBA 300 ppm + Borax 2% and IBA 5000 ppm remained maximum. Compared to semi-hard-wood cuttings, hard wood cuttings react better to the treatment of hormones.

Barde *et al*. (2010) suggested that applied Indole-3-butyric acid at the rate of 2000 ppm gave maximum success cuttings (79.18%), shoot length (22.94 cm), shoot count (2.80), leaves count (38.09), width(1.55 cm) and length (4.88 cm) of leaves, percent of dry matter of leaves (46.7%) and roots (44.5%) and root counts per cutting (10.83). For peak rooting, development and achievement of Pomegranate cuttings, the mixture of PSB and 2000 ppm IBA was discovered best.

Saed (2010) treated two types of cuttings, i.e., hardwood and semi hardwood with five concentration of IBA, i.e., 3000, 6000, 9000 and 12000 ppm as quick dip. In this investigation they recorded the percentage of rooted cutting, roots count , the length and diameter of the root and the weight of the root per cut. It was clear that the rooting capacity of pomegranate is influenced both by the interactive impact of cuttings age, IBA concentration and variety and by the single impact of both.

Singh *et al.* (2014) studied on effect of IBA concentration on the rhizogenesis of pomegranate (*Punica granatum* L.) cultivar Ganesh hardwood cuttings under mist house chamber & cutting was applied with 1000,2000,3000,4000,5000 ppm of IBA ,they found that 5000ppm IBA was found best among all the concentration for early sprouting , maximum shoot length, maximum counts of leaves.

Kaur *et al.* (2016) worked on the impact of time of impacts and IBA,PHB on rhizogenesis of pomegranate (*Punica granatum* L.) cuttings cultivar Ganesh. The cuttings were treated with IBA 500,1000 & PHB 500,750 & there combinations and planted in August and January & they found that maximum percentage of sprouted cuttings(85.45%),survival percent (85.88%),maximum counts of roots (18.58&), highest length oh roots (11.13cm) & maximal root weight (1.80g) were recorded in IBA1000ppm + PHB 750 ppm. Month of August has proven to be the best time to plant *Punica granatum* cuttings for achievement.

Hakim *et al*. (2018) studied about the influence of Auxin and Biofertilizers on growth and rooting of pomegranate (*punica granatum* L.) cuttings and cuttings were treated with various doze of auxin(IBA+NAA) solution for 6 hours & planted in a media of sand, soil and FYM (1:1:1) equal proportions along with the biofertilizers (PGPR,PSB & Biomix) 10g/pot. They found that IBA 1500 ppm +NAA 1500 ppm +PSB +PGPR had significantly higher values on different shoot and root parameters in both cultivars.

2.2 Effect of Biofertilizers

Slankis (1973) indicated that biofertilizers can boost plant growth by generating plant growth regulators and vitamins.

Reich (1988) noted that when seedlings of apple was inoculated with a group of mycorrhizal fungi resulted in greater biomass production.

Rao and Das (1989) observed that *Azospirrillum brasilense* strains S-14, S-54 or *Azotobactor chroocommum* cause an increase in the height of the plants and

dry weight of budded plants of 6 month age in *Ziziphus mauritiana* (cultivar Seb and Gola) and rooted cuttings of pomegranate cultivar Jalore seedless grown in pots. *A. brasiliensis* strain S-14 had the biggest impact on dry weight plants of *Zizyphus.* Efficacy on S-54 had the biggest impact on the pomegranate plant's dry weight.

Gangwar and Thangavelu (1992) observed that the sprouting, rooting, survivability, height of the plant, leaf count, branches per plant and protein content of leaves increased in mulberry variety Kanva-2 inoculated with *A.chroococcum.*by using FYM as adherent and bulking medium.

Das *et al.* (1994) noted that *Azospirillum brasilense* enhanced development and growth of the plants, feeding response of silkworm and decreased the need for urea fertilizer.

Sonawane and Konde (1997) discovered that the use of *Azospirillim* in conjunction with the culture of the VAM improved root colonization of mycorrhiza and spore count, improved the leaf region and decreased grapevine sprouting time.

Wange and Ranawade (1997) worked on grape cuttings with 14 different chemicals, microbial and microphos treatments and they found that all of the treatment cause a significant increase in the count of roots in each cutting except the treatment with *Azospirrilum* alone and *Azospirrillum+microphos* at ninety days after planting. The maximum root count in each cutting and the length of the root were obtained under Phosphorus solubilizer+microphos, while all IBA treatments improved the dry weight of leaves relative to control.

Sharma and Bhutani (1998) discovered that in apple seedlings the inoculation of *Glomus fasciculatum* and *Azotobactor chrocooccum* generated bigger crops, higher leaf area, higher biomass and also increased chlorophyll content.

Nageswari *et al*. (1999) reported that in cinnamon cuttings highest % root formation with high length and count of roots per cutting was came by applying phoshobacteria through soil and slurry during planting.

Yadav *et al*. (2002) reported that PSB in slurry form significantly increased earliest sprouting and 50 % sprouting of cuttings of phalsa.

Esitken *et al.* (2003) studied on wild sour cherry cuttings and determined IBA + Bacteria mixture is extremely efficient in enhancing rooting capacity compare to control.

Joolka *et al.* (2004) reported maximal radial and linear growth with VAM + *Azotobacter t*reatment.

Karakurt *et al.* (2009) reported that rooting in hardwood cutting of MM 16 rootstock (Apple). *Bacillus subtilis* + sorbitol +IBA 2000 ppm treatments were obtained the highest rooting formation. The result indicate that combination of IBA, bacteria and carbohydrates are more effective increased rooting capacity when compared to control, carbohydrate, IBA and bacteria.

Baqual *et al.*(2015) Studied on co-inoculation nitrogen fixing bacteria, Phosphate Solubilizing micro-organisms, and VAM at various concentration and nitrogen sources and phosphorous on saplings of Mulberry under nursery conditions and they observed significant impact on the sub-plot impact of two varieties on the survival of Saplings. Highest survival % of saplings (90.47%) was appeared in the variety V_1 after 60 days of planting in nursery which was followed by S_{36} which showed (47.71%).

Hakim *et al*. (2018) studied the impact of Biofertilizers & Auxin on growth & rooting of pomegranate (*punica granatum* L.) cuttings & cuttings were treated to different concentration of auxin(IBA+NAA) solution for 6 hours & planted in a media of sand, soil & FYM (1:1:1) equal proportions along with the biofertilizers (PGPR, Phosphate Solubilizing bacteria & Biomix) 10g/pot and found that IBA

1500 ppm +NAA 1500 ppm +PSB +PGPR had significantly higher values on different shoot and root parameters in both cultivars.

2.2 Effect of *Trichoderma* & *Pseudomonas*

MacKenzie *et al*.(1995) found that Zero, 5, or 25 g of *Trichoerma harzianum* (isolate T-12) peat–bran amendment was added per kilogram medium to increase the root formation of four chrysanthemums cultivars [*Dendranthema* ×*grandiflorum* (Ramat.)Kitamura]. Among them two were easy to root ('Davis' and 'White Marble') and two were hard to root ('Dark Bronze Charm' and 'Golden Bounty'). Applying the *Trichoderma harzianum* amendment at both rates tested increased fresh weights shoot and root during 21 days of rooting, compared with control.

Patil *et al*. (2001) tried 4 microorganis viz, *Azospirillium lipoferum, A. brasilense, Trichoderma harzianum, & Azotobactor spp.* for rhizogenesis in stem cuttings of pomegranate. Among them *T.harzianum* resulted in higher rooting & survival of cuttings.

Jaganath *et al*. (2009a) noted the positive response of microbial inoculants on rooting of hard wood cuttings in 'Bhaguva' & 'ganesh' . innoculation of potting mixture with *Psedomonas fluorescence + Azotobactor choococcum+ T.harzianum* & subsequently planting of stem cuttings in medium recorded highest rooting percentage (70.56%) with better root parameters.

Jaganath *et al*. (2009b) found that use of 2000mg/l IBA+ *Trichoderma* inoculum with potting mixture improved rooting in stem cutting of cv.Ruby & Mridula.

Marina tucci *et al* (2011) studied that the favourable impacts of *Trichoderma* spp. on tomato is modulated by the genotype of the plant, they demonstrated that genetic variability between wild and grown tomato lines effects the result of the interaction with two ' elite ' biocontrol strains of *Trichoderma atroviride* and *Trichoderma harzianum*. For some, but not all, the tested lines, the positive reaction, which included improved development and systemic resistance to Botrytis cinerea, was obviously apparent.

Sanabria *et al* (2014) worked on propagation of asexual cape gooseberry (*Physalis peruviana* L.) using various doze of indole-3-butyric acid and *Trichoderma harzianum.* Impacts of 4 dose of indole-3-butyric acid (0, 800, 1,200, and 1,600 mg L-1) and 4 suspensions of *Trichoderma harzianum* (0, 2·106, 3·106, and 4·106 cfu/mL) on the growth of cape gooseberry cuttings was assessed by them & they reported that the 3·106 cfu/mL suspension of *T. harzianum* induced a higher accumulation of dry matter of roots and total dry matter and a higher leaf area in the plants. The most favourable interaction of the variables, which favors the development of crops acquired from cuttings, was noted with the implementation of 800 mg L-1 of IBA and 3·106 cfu/mL of *T. harzianum*.

CHAPTER - III

MATERIALS AND METHODS

The details of the materials and the techniques used in the present research entitled **"Effects of IBA, Biofertilizer, *Trichoderma & Pseudomonas* on rooting of pomegranate (*Punica granatum* L.) cuttings"** are described here under:

3.1 Experimental site

The above experiment was performed from September to February (kharif and rabi season), during the year 2018 -19, at the nursery of Horticulture Farm, college of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

3.2 Location and climate

Raipur is located in South-eastern part of Chhattisgarh, at a latitude of 21° 16' N and 81° 36' E longitude and at the height of 289.56 meters above from mean sea level. Raipur falls in sub-humid agro. Climatic zone with an average rainfall of 1200-1400 mm, most of which (about 85 per cent) is received during the season of Monsoon (from June to September) and the remaining during post monsoon and winter season. The weekly minimum and maximum, relative humidity, temperature, evaporation, rainfall and sunshine hours during the period of the above experiment (from 1st September to 28th February) are given in Appendix-I and illustrated in Fig.3.1.

3.3 Type and source of cutting

The type of cuttings used was hard wood cuttings with an uniform size (15-20 cm long) with 5-6 functional buds, were taken from healthy and vigorous plants of pomegranate variety Super Bhagva planted at Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

3.4 Experimental details

Name of Crop	: Pomegranate (*Punica granatum* L.)
Family	: Lythraceae
Variety	: Super Bhagva
Experimental design	: Complete Randomized Block Design (CRD)
Number of treatments	: 11
Number of replication	: 3
Number of plants per replication	: 10
Total number of plants	: 330
Length of cuttings	: 15-20 cm
Rooting media	: Soil, F.Y.M., Sand (1:1:1)
Ambient environment	: Shade net

3.4.1 Treatment details

S. No	Treatment details	Treatments
1	Control	T_0
2	IBA 1000 ppm	T_1
3	IBA 1500 ppm	T_2
4	IBA 2000 ppm	T_3
5	IBA 2500 ppm	T_4
6	Phosphate Solubilizing Bacteria @ 5% of rooting media	T_5
7	*Azotobacter* @ 5% of rooting media	T_6
8	*Azospirillum* @ 5% of rooting media	T_7
9	*Vermicompost* @ 5% of rooting media	T_8
10	*Trichoderma viride* @5% of rooting media	T_9
11	*Pseudomonas fluorescence* @5% of rooting media	T_{10}

3.5 Preparation of Growth regulators

The plant growth regulators solution was prepared at laboratory of Department of Fruit Science, College of Agriculture, IGKV, Raipur (Chhatisgarh). Electronic chemical balance was used, for the weighing of growth regulators. The required amount of IBA was weighed individually and after that, transferred to different volumetric flasks. These weighed, growth regulator specimen were dissolved by shaking carefully in 10 ml of ethyl alcohol (90%) after that volume makeup was done using measured amount (490ml) of distilled water. This yields 1000ppm, 1500ppm, 2000ppm and 2500ppm of IBA solutions. Pure water was regarded as control without any growth regulator *i.e.* at 0 ppm.

3.6 Biofertilizers and organic compost used

Commercially prepared biofertilizers for the treatment of pomegranate cuttings, namely *Azotobacter*, *Azosprillum*, Vermicompost and Phosphorus Solubilizing Bacteria (PSB), were drawn from the Agriculture Microbiology Department College of Agriculture, IGKV, Raipur.

3.7 Bio-control agents used

In this research, commercially prepared bio-control agents, namely *Trichoderma viride* and *Pseudomonas fluorescence*, were used and drawn from the bio-contol Laboratory, College of Agriculture, IGKV, in powder form for pomegranate cuttings treatment.

3.8 Filling of bags

Ten poly bags of 6”x3” size were taken in each treatment in each replication. Four tiny holes were produced on each bag for adequate drainage, after which bags were packed with rooting media as per treatment and kept replication wise for planting of cuttings.

3.9 Preparation of cuttings

For the preparation of cutting healthy, vigorous, disease free plant of pomegranate variety Super bhagwa was selected. The partially matured branches, 0.75-1.00 cm in thickness were taken for cuttings prepartion. The cuttings of 15-20 cm in length with 5-6 functional buds were prepared for planting and the leaves removed entirely.

3.10 Application of growth regulators, biofertilizers, bio-control agents and planting of cuttings

Shortly after their preparation, cuttings were kept in water to maintain the amount of moisture until planting time. Then, the basal portion of the cuttings was treated for 5 minutes with growth regulator (quick deep method). Whereas, Biofertilizers and Bio control agents @ 5% were mixed as per treatment in the rooting medium. Two third parts of the treated cuttings were placed in the rooting media at a slight angle (about 60^{o}) vertical to the plane. The rooting media was provided water to supply moisture to the cutting and soil around the cutting area was pressed lightly to fix the cutting in rooting media

3.11 After care

3.11.1 Irrigation

Just after the planting of the cuttings, irrigation was applied so that water soaked to the bottom of the bags. Irrigation was done at regular intervals to maintain the soil moisture for rest of the experiment.

3.11.2 Weeding

Weeds are very harmful for the proper growth of the cutting and fight for t nutrients, soil water and space with the cuttings, weeds and their roots were totally removed as quickly as they showed in the poly bags. Weeding was performed manually and the poly bags were always kept clean by removing the weed at periodic interval.

3. 12 Observations recorded

(i) Days taken to start sprouting.
(ii) Days taken to 50% sprouting.
(iii) Percentage of success of cutting.
(iv) Number of shoots per cutting.
(v) Length of shoots (cm)
(vi) Number of leaves per shoot.
(vii) Total number of leaves per cutting.
(viii) Survival percent.
(ix) Number of roots per cutting.
(x) Length of roots (cm).
(xi) Diameter of roots (mm)
(xii) Fresh weight of roots (g)

3.13 Procedure followed to record the observations under investigation

3.13.1 Days taken to start sprouting

After the cuttings were planted as per the treatments, the site of the experiment was daily visited and the cuttings under the investigation were observed minutely and the dates on which, first cutting was sprouted in each replication was noted carefully. Then the calculation of the days taken for initiation of sprouting after the planting of cutting was given by the difference between date of planting of cuttings and the date on which the pomegranate cuttings were started to sprout.

3.13.2 Days taken to 50 % sprouting

The observation was recorded by the difference between the cuttings planting dates to the date on which 50 percent or more than 50 percent cuttings were sprouted.

3.13.3 Percentage of success of cutting

The success percentage of the cutting was calculated 30 days after planting of cutting by using following formula:

$$\text{Percentage of sprouted cuttings} = \frac{\text{Number of sprouted cuttings}}{\text{Total number of cuttings}} \times 100$$

Five cuttings were selected randomly and tagged, for recording the following observations in each replication.

3.13.4. Number of shoots per cutting

For the calculation of the shoots number, the number of shoots of each tagged cutting was counted at 30, 60, 90, 120, 150 and 180 days after planting of the cuttings, and then mean number of shoots per cutting were calculated.

3.13.5. Length of shoots (cm)

With the help of scale, the longest shoots of each tagged cutting were measured and then the mean shoot length was calculated.

3.13.6. Number of leaves per shoot

For the calculation of leaf number per shoot, the number of leaves from the longest shoots of tagged cuttings was counted and then the mean number of leaves per shoot was calculated at 30, 60, 90, 120, 150 and 180 days after planting.

3.13.7. Total number of leaves per cutting

For the calculation of leaves number per cutting the total leaf numbers were counted on each tagged cutting and then mean numbers of leaves on per cutting was calculated at 30, 60, 90, 120, 150 and 180 days after planting.

3.13.8. Survival percent

The survival percentage was recorded at 60 days after planting of cutting and was calculated using the following formula:

$$\text{Survival \% of Cuttings} = \frac{\text{No of survived cuttings}}{\text{Total number of cuttings}} \times 100$$

3.13.9. Number of roots per cutting

The separation of roots from the cuttings was done using a sharp blade and root number of each tagged cuttings were counted, then average number of roots per cutting was calculated.

3.13.10. Length of roots (cm)

The longest roots of each tagged cutting were measured with the scale and then mean length of roots was calculated.

3.13.11. Diameter of roots (mm)

The diameter of longest root of each tagged cutting was measured replication wise with the help of vernier calipers and after that the average diameter of roots (mm) calculated in each treatment.

3.13.11. Fresh weight of roots (g)

The measurement of the fresh root weight of the cuttings was taken after separation of roots from sample cutting, by using sharp blade and then the fresh root weight was measured by electronic digital balance.

3.13.12. Dry matter percentage of roots (%)

For the measurement of dry root weight, electronic digital balance was used and percentage of roots dry matter was calculated by using the following formula:

$$\text{Percentage of roots dry matter} = \frac{\text{Dry weight of roots}}{\text{Fresh weight of roots}} \times 100$$

3.14 Statistical Analysis

Statistical design used for the experiment was complete random design (CRD). Analysis of Variance (ANOVA) of different variables was performed to know the degree of variation amongst all the treatments. The structure of analysis of variance table is given below:-

Source of variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F Value**	**F 5% or 1% table value**
Treatment	(t–1)	TrSS	TrMS=TrSS/df	TrMS/EMS	
Experimental Error	(rt-t)	ESS	EMS=ESS/df		
Total	rt-1	TSS			

Where,

r = Number of replications.

t = Number of treatments.

TrSS = Sum of Squares due to Treatments.

ESS = Sum of Squares due to Error.

3.14.1 Calculation of SEm, SEd, CD:

i. $SEm = \sqrt{EMS/r}$

ii. $SEd = \sqrt{2EMS/r}$

iii. CD = t at error d.f. × SEd

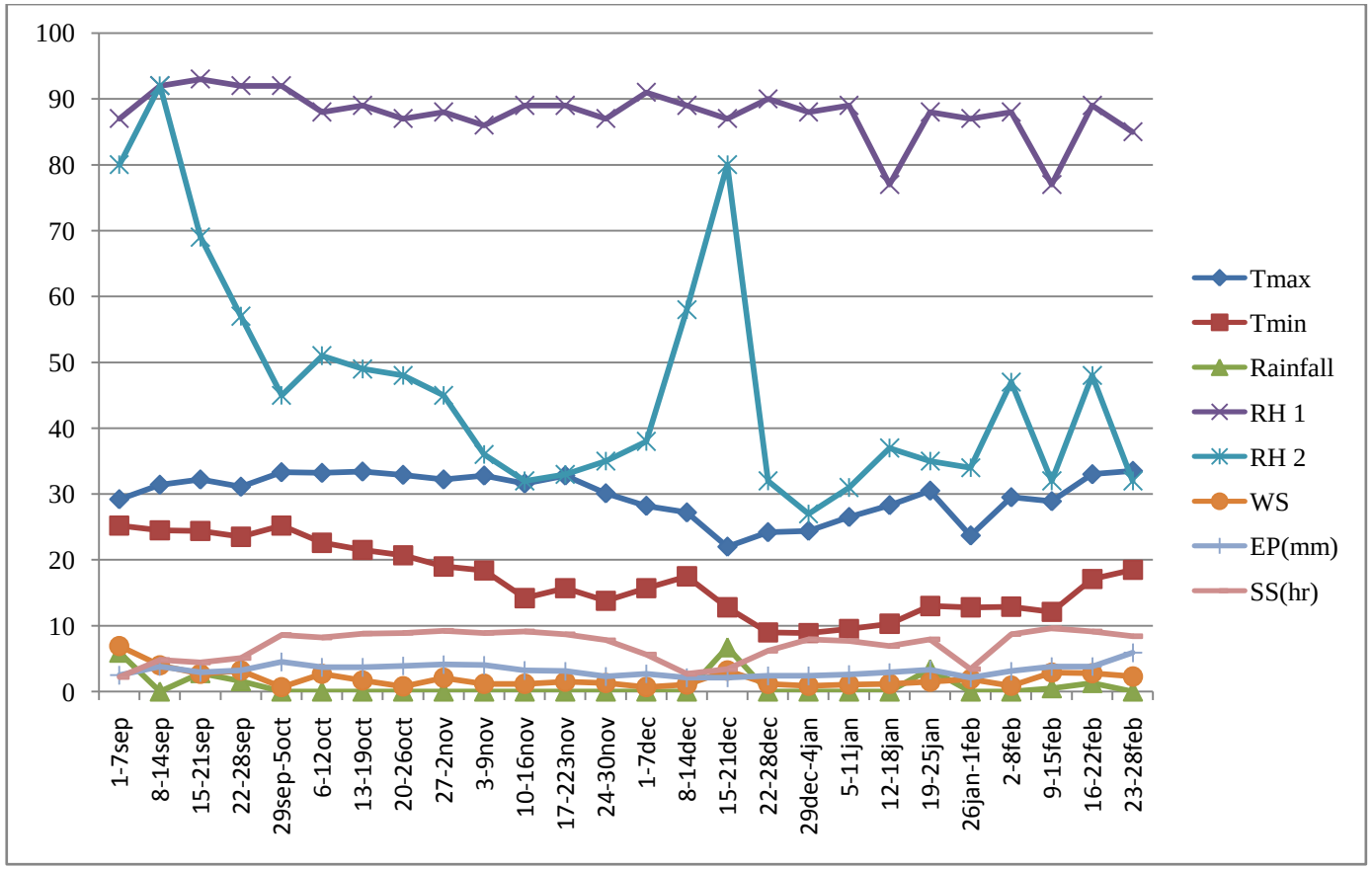


Figure 3.1: Weekly meteorological data during the period of experiment (from 1 September 2018 to 28 February 2019)

CHAPTER - IV

RESULTS AND DISCUSSION

The present experiment entitled **"EFFECTS OF IBA, BIOFERTILIZER, *Trichoderma & Pseudomonas* ON ROOTING OF POMEGRANATE *(Punica granatum L.)* CUTTINGS"** was conducted at nursery, Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during the period of 2018-19.

Observations were recorded on both shoot and root parameters for five cuttings in each treatment and in each replication. The data were statistically analyzed as per Complete Randomized Design (CRD). The observations recorded on various characters during the course of investigation have been presented in this chapter along with appropriate table and diagrams**.** The experimental findings of present work have been discussed under the following sub heads:

4.1 Shoot characters

4.2 Root characters

4.1 Shoot characters

4.1.1 Days taken to start sprouting of cuttings

Data presented in table 4.1.1 shows that there was a significance difference present between the treatments, for the days taken to start sprouting and the days taken for the initiation of sprouting of cuttings ranged from 7.33 days to 12.00 days. The earliest sprouting of cutting was recorded in IBA 2500 ppm (7.33 days) T_4 followed by *Trichoderma viride* @ 5% of rooting media (7.67 days) T_9 and pseudomonas @ 5% of rooting media (8.0 days) T_{10}. Whereas, late sprouting of cuttings (12.00 days) were recorded under control (T_o).

In case of growth regulators used, treatment of cuttings with IBA 2500 ppm was noted to be significantly superior to all other growth regulators, followed by

Table 4.1.1 Effect of IBA, bio-fertilizers and bio-control agents on days taken to start sprouting of cuttings

Notation	Treatments	Mean
T_0	Control	12.00
T_1	IBA 1000	10.00
T_2	IBA 1500	9.67
T_3	IBA 2000	8.33
T_4	IBA 2500	7.33
T_5	PSB	8.67
T_6	*Azotobactor* @ 5% of rooting media	9.67
T_7	*Azospirillum* @ 5% of rooting media	9.67
T_8	Vermicompost @ 5% of rooting media	9.33
T_9	*Trichoderma viride* @ 5% of rooting media	7.67
T_{10}	*Pseudomonas fluorescence* @ 5% of rooting media	8.00
	SE(m)	0.41
	C.D. @ 5 %	1.22

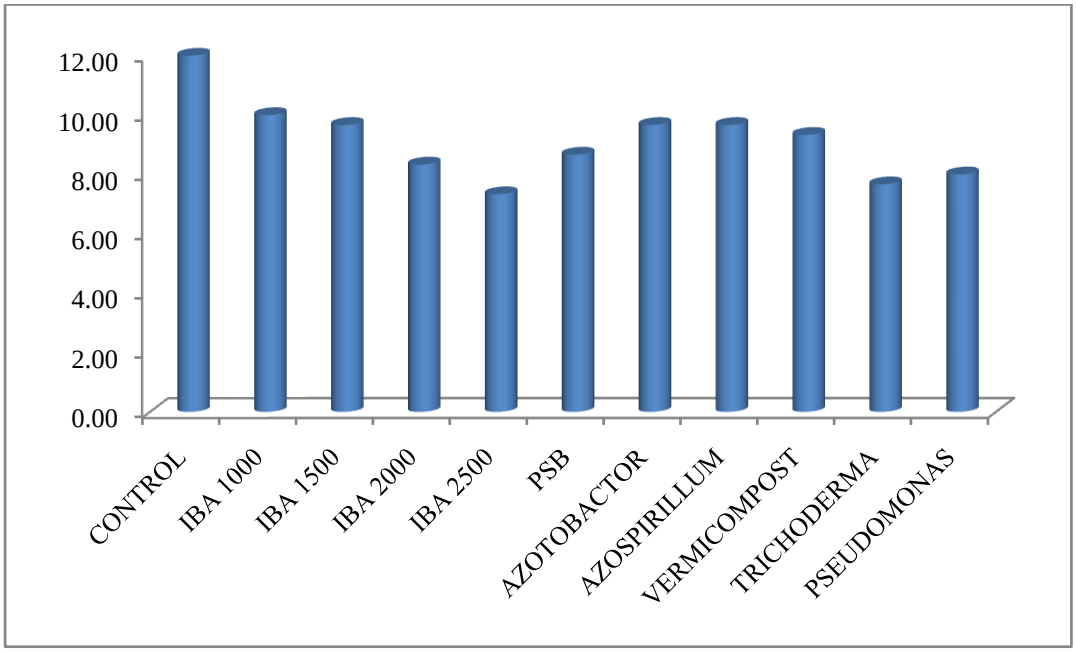


Figure 4.1: 1 Effect of IBA, bio-fertilizers and bio-control agents on days taken to start sprouting of cuttings

IBA 2000 (8.33days)$T_{3.}$

As regards the biofertilizers minimum days for sprouting of cuttings was recorded under PSB (8.66) $T_{5,}$ followed by *Azotobacter* (9.66days) T_6 and *Azospirillum*(9.66 days)T_7.

The treatment with PSB (T_5) was found significantly superior to *Azotobacter* and *Azospirillum.*

Days taken for the first sprouting in bio-control agents used was maximum under *Trichoderma viride* @ 5% of rooting media (7.67 days) T_9,followed by *Pseudomonas fluorescence* @ 5% of rooting media (8.0 days) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

Increasing the concentration of IBA results in a significant decrease in the number of days needed for the first sprouting of cuttings and earliness in sprouting, and it might be due to better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators. (Chandramouli *et al*., 2001) .Bud sprouting is mainly attributed to the carbohydrate stored in the cuttings (Wahab *et al*.,1999)

Biofertilizer also cuases an increase in the level of plant growth regulators in the plants, resulting in early sprouting.(Wahab *et al*.,1999)

Studies show that soil fungi *Trichoderma viride* produced considerable amount of auxins, which is essencial for initiation of sprouting in cuttings. (Manka *et al*.1997)

4.1.2 Days taken to 50% sprouting of cuttings

The Data presented in table 4.1.2 shows that the days taken to 50% sprouting of cutting ranged from 25.67 to 30.67 days. The minimum days taken to 50% sprouting of cuttings was observed under IBA 2500 ppm (25.67days) T_4 followed by *Trichoderma viride* @ 5% of rooting media (26.00 days) T_9 and IBA

Table 4.1.2 Effect of IBA, bio-fertilizers and bio-control agents on days taken for 50% sprouting of cuttings

Notation	Treatments	Days
T_0	Control	30.67
T_1	IBA 1000	28.00
T_2	IBA 1500	27.67
T_3	IBA 2000	26.67
T_4	IBA 2500	25.67
T_5	PSB	27.33
T_6	*Azotobactor @5%* of rooting media	27.67
T_7	*Azospirillum @5%* of rooting media	28.00
T_8	Vermicompost *@5%* of rooting media	28.00
T_9	*Trichoderma viride @5%* of rooting media	26.00
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	27.67
	SE(m)	0.47
	CD @ 5%	1.39

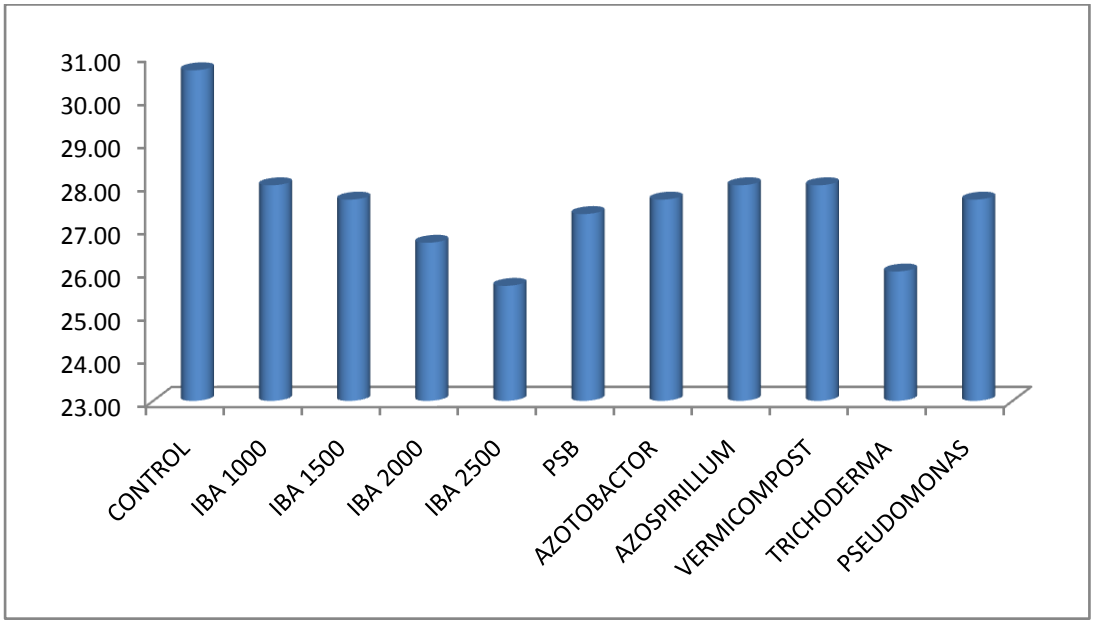


Figure 4.2: Effect of IBA, bio-fertilizers and bio-control agents on days takenfor 50% sprouting of cuttings

2000 ppm (26.67days) T_4 .Whereas, maximum days taken to 50% sprouting of cuttings (30.67 days) were recorded under control (T_0).

Treatment of cuttings with IBA 2500 ppm (T_4) was found to be superior than all other growth regulators, followed by IBA 2000 ppm (T_3).

As regards the biofertilizers minimum days (27.33) for 50% sprouting of cuttings was recorded under PSB (T_5) followed by *Azotobacter* (27.67days) T_8 and *Azospirillum* (28.00 days) T_9. Treatment with PSB (T_7) was noted to be superior than all other treatments with biofertilizers.

Days taken to 50% sprouting in *Trichoderma viride* @ 5% of rooting media (T_9) was (26 days), followed by *Pseudomonas fluorescence* @ 5% of rooting media (27.67 days) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

This result might be due to the fact that better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators. It is supported by the finding of Bhuva (2014) in fig, Dhakar *et al.*,(2011) in pomegranate, Divin *et al*.,(2012) in apple and Nitin *et al.*,(2015) in guava.

PSB causes a significant increase in earliness of sprouting and 50% sprouting of cuttings, (Yadav *et a*l., 2002) in phalsa. It might be due to increase in the level of endogenous auxin with the application of biofertiloizers.

4.1.3 Percentage of success of cuttings

The data presented in table 4.1.3 shows that the percentage of success of cuttings ranged from 66.67 to 86.67%. The maximum percentage of success of cutting was observed under IBA 2500 ppm (86.67%) T_4 followed by IBA 2000 ppm (83.33%) T_3 and *Trichoderma viride* @ 5% of rooting media (83.33%) T_9.

Whereas, minimum percentage (66.67%) of success of cuttings was recorded under control (T_0).

The treatment with IBA 2000 ppm (T_6) was found significantly superior than all other growth regulators, followed by IBA 2000 ppm (83.33 %)T_3.

As regards the biofertilizers highest percentage (76.67%) of success of cutting was observed under PSB (T_5), followed by *Azotobacter* (73.33%) T_6 and *Azospirillum* (73.33%) T_7. Among the biofertilizer treatments PSB (T_5) was noted to be significantly superior than *Azotobacter* and *Azospirillum.*

The percentage of success of cuttings in *Trichoderma viride* @ 5% of rooting media was (83.33%) T_9, followed by *Pseudomonas fluorescence* @ 5% of rooting media (80%) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

Success of cuttings depends on several factors like formation of adventitious roots, developments of healthy root system, presence of leaves, type of rooting media, presence of auxin etc. Supply of auxin either naturally or artificially is a must for the initiation of adventitious roots (Gautherest., 1969) . IBA applies artificially results in earlier completion of physiological processes in rooting and sprouting of cuttings and increases the percentage of success of cuttings.

Presence of leaves on cuttings, also play an important role in the initiation of roots in many plant species. Leaves considerably influence the rooting of cuttings because of their ability to produce endogenous auxins as well as, carbohydrates by means of photosynthesis. Newton *et al.*(1992), Krieken *et al*. (1993) reported that IBA might enhanced the rooting by increase of internal free IBA, or synergistically modify the action of IAA or due to synthesis of endogenous IAA. Melgarejo *et al*., (2000) opined that treatment of cuttings with increasing concentrations of IBA could combined with endogenous auxins already present in the cuttings which leads to optimization of auxin levels and consequently improved the percentage of rooting in cuttings.

The present results are in same line with the findings of Malik and Harnard (1983) in sour orange, Melgarezo *et al.* (2000) in pomegranate, Polat and Caliskan

Table 4.1.3 Effect of IBA, bio-fertilizers and bio-control agents on Percentage of success of cuttings.

Notation	Treatments	Percent
T_0	Control	66.67
T_1	IBA 1000	76.67
T_2	IBA 1500	80.00
T_3	IBA 2000	83.33
T_4	IBA 2500	86.67
T_5	PSB	76.67
T_6	*Azotobactor @5%* of rooting media	73.33
T_7	*Azospirillum @5%* of rooting media	73.33
T_8	Vermicompost *@5%* of rooting media	73.33
T_9	*Trichoderma viride @5%* of rooting media	83.33
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	80.00
	SE(m)	3.02
	C.D. @ 5%	8.90

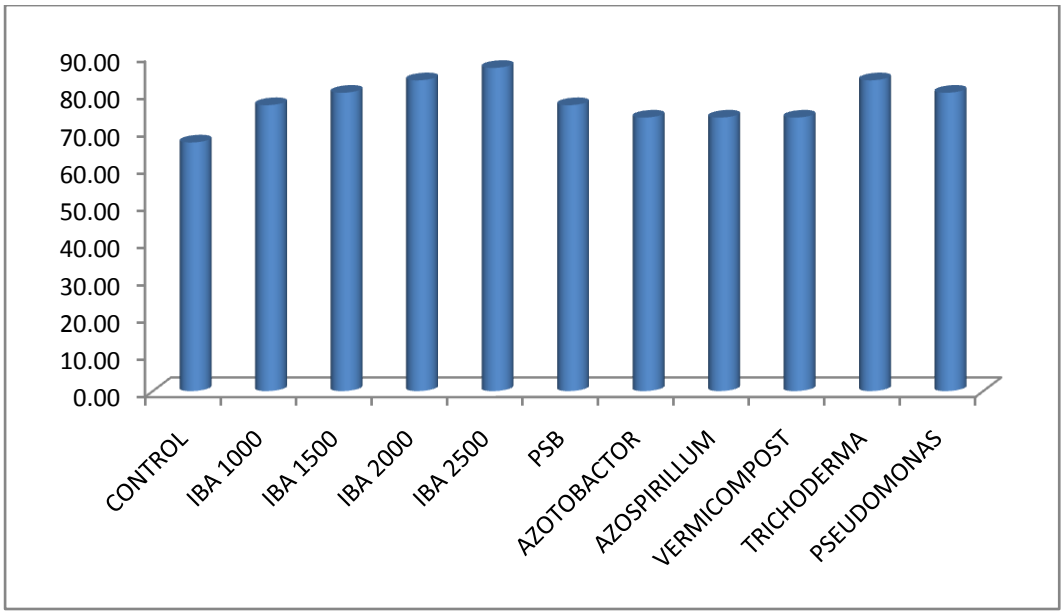


Figure 4.3 : Effect of IBA, bio-fertilizers and bio-control agents on Percentage of success of cuttings

(2009), Costa *et al.* (2010) in guava, Reddy and Singh (1988) in guava.

Biofertilizers have a tendancy to increase the level of nutrients , plant growth regulators and vitamins for the plants (Slankis 1973).

Trichoderma and *Pseudomonas* being biological agents provide resistance to biotic and abiotic stress, and increase the root growth, uptake and use of nutrients to the plants and increases the percentage of success of cuttings. The result obtained is in harmony with the results of Jaganath *et al* (2009), Patil *et al* (2001).

4.1.4 Number of shoots per cutting

The data presented in the table 4.1.4 at 30 DAP shows that the number of shoots per cutting ranged from 3.27 to 5.73. The maximum number of shoots per cutting was observed under *Trichoderma viride* @ 5% of rooting media (5.73) T_9 followed by IBA 2500 pppm (5.53) T_4 and IBA 1500 ppm (5.13) T_3.Whereas, minimum number of shoots per cutting were observed under Control (3.27) T_0.

However,treatments of the cutting with IBA 2500 ppm was significantly superior than other growth regulators.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under Azotobactor (4.07) T_6 followed by *PSB* (1.90) T_5 and *Azospirillum* (3.6) T_8. Treatment with Azotobactor (T_6) was found to be superior than other biofertilizers.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (5.73),followed by *Pseudomonas fluorescence* @ 5% of rooting media (3.6) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

At 60 DAP the number of shoots per cutting ranged from 4.20 to 6.20. The maximum number of shoots per cutting was observed under IBA 2500 pppm (6.20) T_4 , followed by *Trichoderma viride* @ 5% of rooting media (6.13) T_9 and IBA

1500 ppm (5.47) T_3.Whereas, minimum number of shoots per cutting were observed under Control (4.20) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under *Azospirillum* (5.07) T_7 , followed by Azotobactor (5.00) T_6 and *PSB* (5.00) T_5. Treatment with Azos*pirillum* was found to be superior than other biofertilizers at 60 DAP.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (6.13),followed by *Pseudomonas fluorescence* @ 5% of rooting media (4.27) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used

At 90 DAP the number of shoots per cutting ranged from 4.67 to 7.00 The maximum number of shoots per cutting was observed under IBA 2500 pppm (7.00) T_4, followed by *Trichoderma viride* @ 5% of rooting media (6.73) T_9 and IBA 2000 ppm (6.33) T_3.Whereas,minimum number of shoots per cutting were observed under Control (4.67) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under PSB (6.20) $T_{5,}$ followed by *Azotobactor* (5.87) T_6 and Azos*pirillum* (5.87) T_7. Treatment with PSB was found to be superior than other biofertilizers at 90 DAP.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (6.73), followed by *Pseudomonas fluorescence* @ 5% of rooting media (5.27) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

At 120 DAP the number of shoots per cutting ranged from 5.47 to 8.00 The maximum number of shoots per cutting was observed under IBA 2500 pppm (8.00) T_4 , followed by *Trichoderma viride* @ 5% of rooting media (7.60) T_9 and IBA 2000 ppm (7.20) T_3.Whereas,minimum number of shoots per cutting were observed under Control (5.47) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under PSB (7.07) T_5, followed by *Azotobactor* (7.00) T_6 and Azos*pirillum* (6.73) T_7. Treatment with PSB was found to be superior than other biofertilizers at 120 DAP.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (7.60),followed by *Pseudomonas fluorescence* @ 5% of rooting media (6.20) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used at 120 DAP.

At 150DAP the number of shoots per cutting ranged from 6.00 to 8.60. The maximum number of shoots per cutting was observed under IBA 2500 pppm (8.60) T_4, followed by *Trichoderma viride* @ 5% of rooting media (8.40) T_9 and IBA 2000 ppm (7.73) T_3.Whereas, minimum number of shoots per cutting were observed under Control (6.00) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under PSB (7.67) T_5, followed by *Azotobactor* (7.33) T_6 and Azos*pirillum* (7.33) T_7. Treatment with PSB was found to be superior than other biofertilizers at 150 DAP.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (8.40), followed by *Pseudomonas fluorescence*

@ 5% of rooting media (6.60) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used at 150 DAP.

At 180DAP the number of shoots per cutting ranged from 6.80 to 9.27. The maximum number of shoots per cutting was observed under IBA 2500 pppm (9.27) T_4 , followed by *Trichoderma viride* @ 5% of rooting media (9.07) T_9 and IBA 2000 ppm (8.40) T_3.Whereas, minimum number of shoots per cutting were observed under Control (6.80) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of shoots per cutting was observed under PSB (8.33) $T_{5,}$ followed by *Azotobactor* (8.27) T_6 and Azos*pirillum* (8.07) T_7. Treatment with PSB was found to be superior than other biofertilizers at 180 DAP.

In case of bio control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (9.07), followed by *Pseudomonas fluorescence* @ 5% of rooting media (8.20) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used at 180 DAP.

The cuttings treated with IBA 2500 ppm recorded greater number of shoots per cutting than the cuttings treated with other concentrations of IBA, which could be attributed to enhancement of physiological functions in the cuttings favourably (Iqbal *et al*., 1999) at this concentration. Earliness in sprouting, increase in number of sprouts and sprout length might be due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of growth regulators (Chandramouli, 2001)

These results are in harmony with the outcome of Ismail and Asghar (2007) in *Ficus hawaii*, Araujo *et al*. (2010) in wild passion fruit and Singh *et al.* (2013) in *citrus limon* L.

Increase in number of shoots per cutting may be due to the reason that auxins are produced in abundance in the growing regions which may enhance the growth. These results are in close conformity with the findings of Baghel and Saraswat (1989), Rohit *et al*. (2004), Ram *et al.* (2005) in pomegranate, Purohit and Shekhareppa (1985) and Husen (2012) in *Grewia optiva*. This may be due to vigorous root system which increased nutrients uptake under this treatment.

Table 4.1.4 Effect of IBA, bio-fertilizers and bio-control agents on number of shoots per cutting

Notation	Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T_0	Control	3.27	4.20	4.67	5.67	6.00	6.80
T_1	IBA 1000	4.333	4.533	5.467	6.133	7.133	7.933
T_2	IBA 1500	4.400	4.933	6.067	6.933	7.533	8.133
T_3	IBA 2000	5.133	5.467	6.333	7.200	7.733	8.400
T_4	IBA 2500	5.533	6.200	7.000	8.000	8.600	9.267
T_5	PSB	3.867	5.000	6.200	7.067	7.667	7.667
T_6	*Azotobactor*	4.067	5.000	5.867	7.000	7.333	8.267
T_7	*Azospirillum*	3.600	5.067	5.867	6.733	7.333	8.067
T_8	Vermicompost	3.867	4.867	5.667	6.533	7.200	7.933
T_9	*Trichoderma*	5.733	6.133	6.733	7.600	8.400	9.067
T_{10}	Pseudomonas	3.600	4.267	5.267	6.200	6.600	8.200
	SE(m)	0.245	0.259	0.252	0.230	0.230	0.265
	C.D. @ 5%	0.083	0.088	0.085	0.078	0.078	0.090

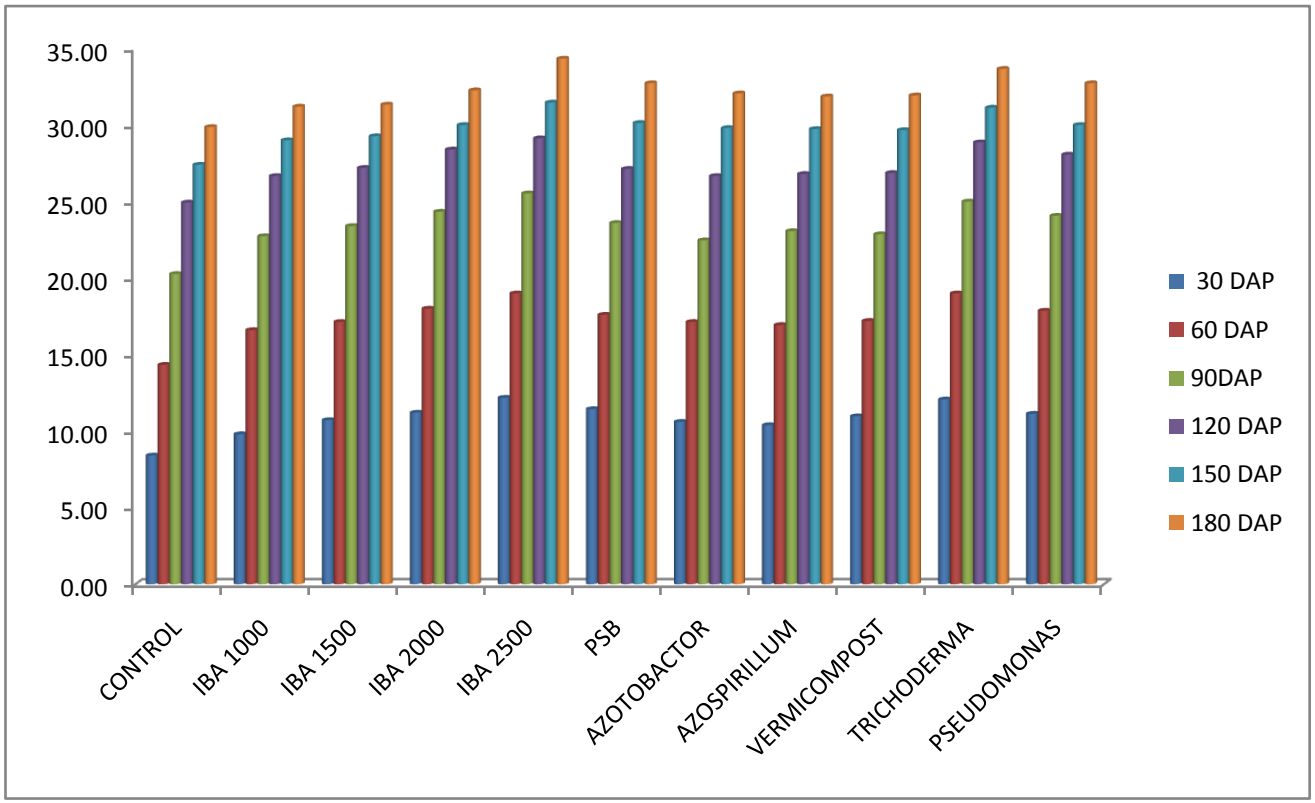


Figure 4.4; Effect of IBA, bio-fertilizers and bio-control agents on number of shoots per cuttings

4.1.5 Length of shoots (cm)

Data presented in the table 4.1.5 shows that, at 30 DAP the length of shoots per cutting ranged from 8.41 to 12.18. The maximum length of shoots per cutting was observed under IBA 2500 pppm (12.18) T_4 , followed by *Trichoderma viride* @ 5% of rooting media (12.07) T_9 and PSB @ 5% rooting media(11.44) T_5. Whereas, minimum number of shoots per cutting were observed under Control (8.40) T_o.

As regards the biofertilizers, the maximum length of shoots per cutting was observed under PSB (11.44) T_5 followed by *Azotobactor* (10.60) T_6 and *Azospirillum* (10.39) T_7. Treatment with PSB (T_5) was found to be superior than other biofertilizers.

In case of bio control agents used length of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (12.07),followed by *Pseudomonas fluorescence* @ 5% of rooting media (11.13) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

At 60, 90, 120, 150, 180 DAP the length of shoots per cutting ranged from 15.09 to 21.50, 20.47 to 26.31, 23.27 to29.49, 25.80 to31.70, 27.79 to 34.73 respectively. The maximum length of shoots per cutting was observed under IBA 2500 pppm (15.09, 20.47, 26.31, 29.49, 34.73 respectively) T_4, followed by *Trichoderma viride* @ 5% of rooting media (21.77, 25.80, 29.40, 30.75, 34.79 respectively) T_9 and IBA 2000 ppm (19.38, 24.38, 27.40, 30.31, 33.42 respectively) T_3.Whereas, minimum length of shoots per cutting were observed under Control (15.09, 20.47, 23.27, 25.80, 27.79 respectively) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior than other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum length of shoots per cutting at 60, 90, 120, 150, 180 DAP was observed under PSB (19.01, 21.88, 26.44, 29.72, 31.40 respectively) $T_{5,}$ followed by *Azotobactor* (17.68, 20.93, 26.43, 29.21, 30.43

respectively) T_6 respectively. Treatment with PSB was found to be superior than other biofertilizers.

In case of bio control agents used length of shoots in *Trichoderma viride* @ 5% of rooting media (T_9) at 60, 90, 120, 150, 180 DAP was (21.77, 25.80, 29.40, 30.75, 34.79), followed by *Pseudomonas fluorescence* @ 5% of rooting media (19.94, 23.45, 28.62, 30.30, 33.08) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

Table 4.1.5 Effect of IBA, bio-fertilizers and bio-control agents on length of Shoots (cm)

Notation	Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T_0	Control	8.41	15.09	20.47	23.25	25.81	27.79
T_1	IBA 1000	9.80	17.25	23.43	26.65	29.43	30.84
T_2	IBA 1500	10.72	18.59	24.12	26.37	29.22	31.46
T_3	IBA 2000	11.21	19.38	24.38	27.40	30.13	33.42
T_4	IBA 2500	12.18	21.50	26.31	29.49	31.69	34.73
T_5	PSB	11.44	19.01	21.89	26.44	29.72	31.41
T_6	*Azotobactor*	10.61	17.68	20.93	26.43	29.21	30.43
T_7	*Azotobactor*	10.39	17.22	21.51	25.34	29.26	30.57
T_8	Vermicompost	10.97	17.96	20.90	26.15	29.07	30.28
T_9	*Trichoderma*	12.07	21.77	25.80	29.40	30.75	34.79
T_{10}	Pseudomonas	11.13	19.94	23.45	28.61	30.29	33.08
	SE(m)	0.12	0.16	0.13	0.16	0.15	0.14
	C.D. @ 5%	0.36	0.47	0.37	0.46	0.45	0.40

Auxins activated shoot growth which might have resulted in elongation of stems and leaves through cell division accounting for more number of leaves and length of longest shoot. Between the four concentrations of IBA, IBA 2500 ppm recorded the maximum length of shoots per cutting enhanced the nutrient uptake and resulted in more photosynthate production. Foods in the form of

photosynthetates provide required energy for cell division and cell elongation and it results in maximum shoot length (Shahab *et al.*, 2013).

The results are in line with the findings of Purohit and Shekharappa (1985), Singh and Pande (1986) sweet lime, Leonel and rodrigues (1993) in pomegranate, Manfroi *et al*. (1997) kiwi, Iqbal *et al* (1999) in apple.

Trichoderma is responsible for increasing the length of shoots by providing a healthy root system and increasing the level of auxin. The results are in line with the findings of Patil *et al* (2001) in pomegranate, Jaganath *et al* (2009) in pomegranate, Marina tucci *et al* (2011) in wild tomato.

4.1.6 Number of leaves per shoot

Data in table 4.1.6 shows that, at 30DAP the number of leaves per shoots ranged from 8.73 to 12.67. The maximum number of shoots per cutting was observed under IBA 2500 pppm (12.67) T_4, followed by *Trichoderma viride* @ 5% of rooting media (12.53) T_9 and *Pseudomonas fluorescence* @ 5% of rooting media (11.40) T_5.Whereas, minimum number of leaves per shoots were observed under Control (8.40) T_o.

As regards the biofertilizers, the maximum number of leaves per shoots on selected shoots was observed under PSB (10.60) $T_{5,}$ followed by *Azospirillum* (10.33) T_7 and *Azotobactor* (10.27) T_6. Treatment with PSB (T_5) was found to be superior than other biofertilizers.

In case of bio control agents used, number of leaves per shoots in *Trichoderma viride* @ 5% of rooting media (T_9) was (12.67), followed by *Pseudomonas fluorescence* @ 5% of rooting media (11.40) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

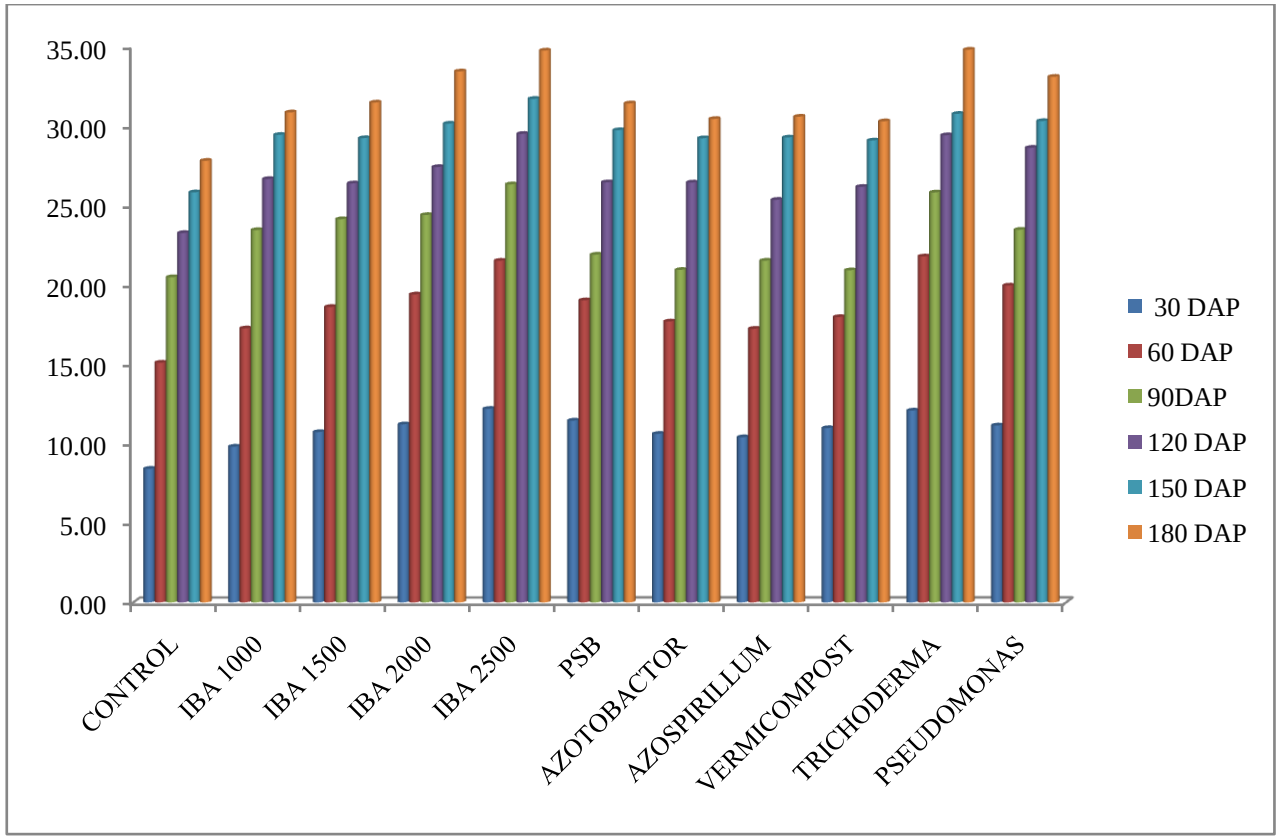


Figure 4.5: Effect of IBA, bio-fertilizers and bio-control agents on length of shoot

At 60, 90, 120, 150 and180 DAP the number of leaves on selected shoots ranged from 14.33 to 19.00, 20.67 to 25.53, 24.93 to 29.13, 27.40 to 31.47 and 29.87 to 34.33 respectively. The maximum number of leaves per shoot was observed under IBA 2500 ppm (19.00, 25.53, 29.13, 31.47 and 34.33 respectively) T_4, followed by *Trichoderma viride* @ 5% of rooting media (19.00, 25.00, 28.87, 31.13 and 33.67respectively) T_9 and IBA 2000 ppm (18.00, 24.33, 28.40, 30.00 and 32.27 respectively) T_3.Whereas, minimum number of leaves per cutting were observed under control (14.33, 20.27, 24.93, 27.40 and 29.87 respectively) T_o.

However, treatments of the cutting with IBA 2500 ppm were significantly superior to other growth regulators, followed by IBA 2000 ppm.

As regards the biofertilizers, the maximum number of leaves on selected shoots at 60, 90, 120, 150, 180 DAP was observed under PSB (17.60, 23.60, 27.13, 30.13, 32.73 respectively) T_5, followed by *Azotobactor* (17.13, 22.47, 26.67, 29.80, 32.06) T_6 respectively. Treatment with PSB was found to be superior to other biofertilizers.

In case of bio control agents used number of leaves on selected shoots in *Trichoderma viride* @ 5% of rooting media (T_9)at 60, 90, 120, 150, 180 DAP was (19.00, 25.00, 28.87, 31.13, 33.67 respectively),followed by *Pseudomonas fluorescence* @ 5% of rooting media (17.87, 24.07, 28.07, 30.00, 32.73 respectively) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

Maximum number of leaves was produced in cuttings treated with IBA 2500 ppm might be due to activation of shoot growth which probably increased the number of nodes that leads to development of more number of leaves. The increase in number of leaves per cutting might be due to the reason that the leaves which are one of the production sites of natural auxin in the plants beside their main activities in photosynthesis, respiration and transpiration (Wahab *et al.,* 2001). IBA at 2500 ppm produced healthier, lengthy roots which helps in absorbtion of water

and nutrients that have great influence on production of more number of leaves by the cuttings. The increase in number of leaves with IBA 2500 ppm might be due to

Table 4.1.6 Effect of IBA, bio-fertilizers and bio-control agents on number of leaves per shoots

Notation	Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T_0	Control	8.73	14.33	20.27	24.93	27.40	29.87
T_1	IBA 1000	10.00	16.60	22.73	26.67	29.00	31.20
T_2	IBA 1500	10.73	17.13	23.40	27.20	29.27	31.33
T_3	IBA 2000	11.27	18.00	24.33	28.40	30.00	32.27
T_4	IBA 2500	12.67	19.00	25.53	29.13	31.47	34.33
T_5	PSB	10.60	17.60	23.60	27.13	30.13	32.73
T_6	*Azotobactor*	10.27	17.13	22.47	26.67	29.80	32.07
T_7	*Azospirillum*	10.33	16.93	23.07	26.80	29.73	31.87
T_8	Vermicompost	10.47	17.20	22.87	26.87	29.67	31.93
T_9	*Trichoderma*	12.53	19.00	25.00	28.87	31.13	33.67
T_{10}	Pseudomonas	11.40	17.87	24.07	28.07	30.00	32.73
	SE(m)	0.11	0.10	0.13	0.10	0.15	0.12
	C.D. @ 5%	0.34	0.30	0.39	0.28	0.44	0.35

more number of roots, plant height and branches per cutting (Ismail and Asghar, 2007).

These results are in hormony with the findings of Shukla and Bist (1994) in Pear and Panwar *et al.,* (2001) in Pomegranate.

4.1.7 Total number of leaves per cutting

The data in table 4.1.7 shows that, at 30DAP the total number of leaves per cutting ranged from 31.40 to 40.47. The maximum number of leaves per cutting was observed under IBA 2500 pppm (40.47) T_4, followed by *Trichoderma viride@* 5% of rooting media (40.00) T_9 and IBA 2000ppm (38.87) T_5.Whereas, minimum number of leaves per cutting were observed under Control (31.40) T_o.

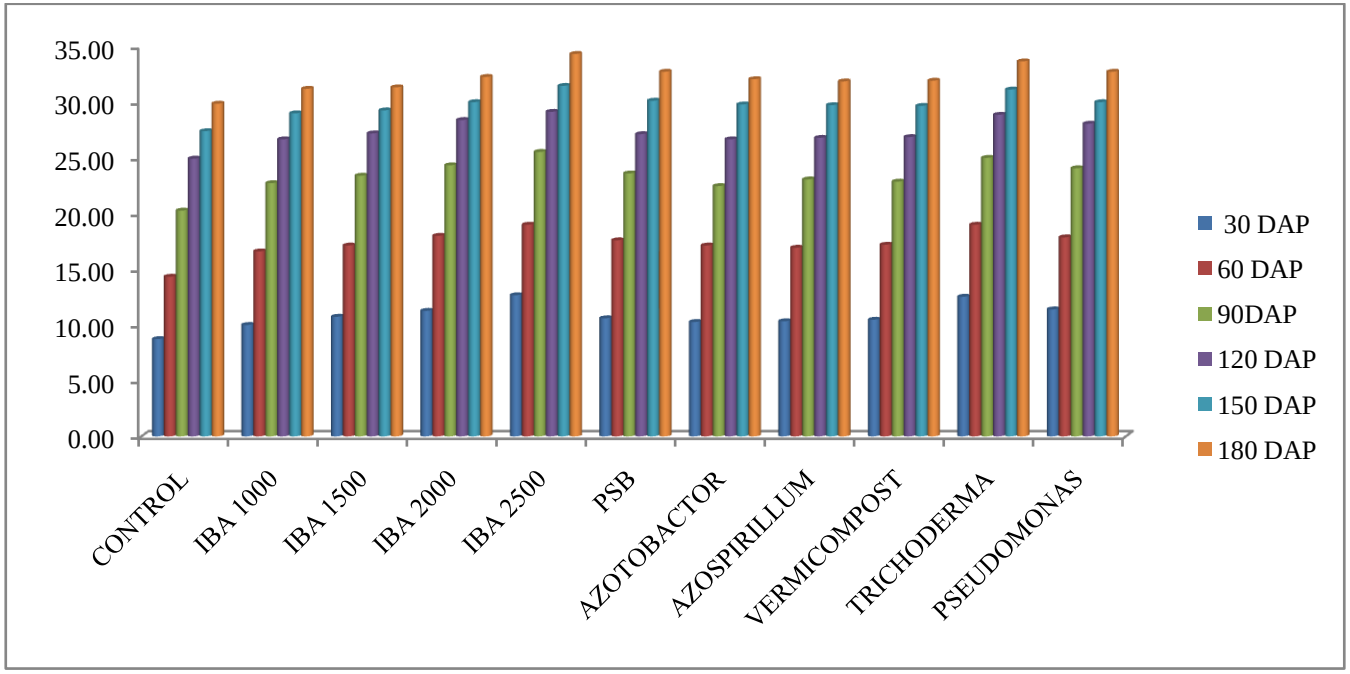


Table 4.1.6 Effect of IBA, bio-fertilizers and bio-control agents on number of leaves per shoots

As regards the biofertilizers, the maximum number of leaves per cutting was observed under PSB (38.00) T_5 followed by *Azotobactor* (37.00) T_6 *Azospirillum* (36.47) T_7. Treatment with PSB (T_5) was found to be superior than other biofertilizers.

In case of bio-control agents used number of leaves per cutting in *Trichoderma viride* @ 5% of rooting media (T_9) was (40.00),followed by *Pseudomonas fluorescence* @ 5% of rooting media (38.20) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

At 60 DAP the total number of leaves per cutting ranged from 65.33 to 78.93 The maximum number of leaves per cutting was observed under *Trichoderma viride* @ 5% of rooting media (78.93) T_9 , followed by IBA 2500 pppm (78.40) T_4 and IBA 2000ppm (75.93) T_5.Whereas, minimum number of leaves per cutting were observed under Control (65.33) T_o.

As regards the biofertilizers, the maximum number of leaves per cutting was observed under PSB (73.93) T_5 followed by *Azotobactor* (71.93) T_6 *Azospirillum* (70.93) T_7. Treatment with PSB (T_5) was found to be superior to other biofertilizers.

In case of bio control agents used total number of leaves per cutting in *Trichoderma viride* @ 5% of rooting media (T_9) was (78.93), followed by *Pseudomonas fluorescence* @ 5% of rooting media (75.33) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

At 90, 120, 150 and 180 DAP the total number of leaves per cuttings ranged from 75.33 to 90.27, 83.60 to 95.80, 86.67 to 99.47 and 89.40 to 101.33 respectively. The maximum number of leaves per cutting was observed under IBA 2500 ppm(78.40, 90.27, 95.80, 99.47 and 101.33 respectively) T_4 , followed by *Trichoderma viride* @ 5% of rooting media (89.60, 94.67, 98.73 and100.40) T_9 and IBA 2000 ppm (88.20, 92.53, 97.20 and 98.87) T_3.Whereas, minimum number

of leaves per cutting were observed under Control T_o (75.33, 83.60, 86.6 and 89.40) respectively.

However, treatments of the cutting with IBA 2000 ppm were significantly superior than other growth regulators, followed by IBA 2000 ppm

As regards the biofertilizers, the maximum number of leaves per cutting at 90, 120, 150, 180 DAP was observed under PSB (86.33, 90.40, 95.27 and 97.07) T_5 , followed by *Azotobactor* (82.53, 88.60, 93.33 and 95.93) T_6 respectively. Treatment with PSB was found to be superior to other biofertilizers.

In case of bio-control agents used number of shoots in *Trichoderma viride* @ 5% of rooting media (T_9)at 90, 120, 150 and 180 DAP was (89.60, 94.67, 98.73 and 100.40),followed by *Pseudomonas fluorescence* @ 5% of rooting media (86.20, 92.33, 95.47 and 97.93) T_{10} respectively. *Trichoderma* was found to be best among both of the bio-control agents used.

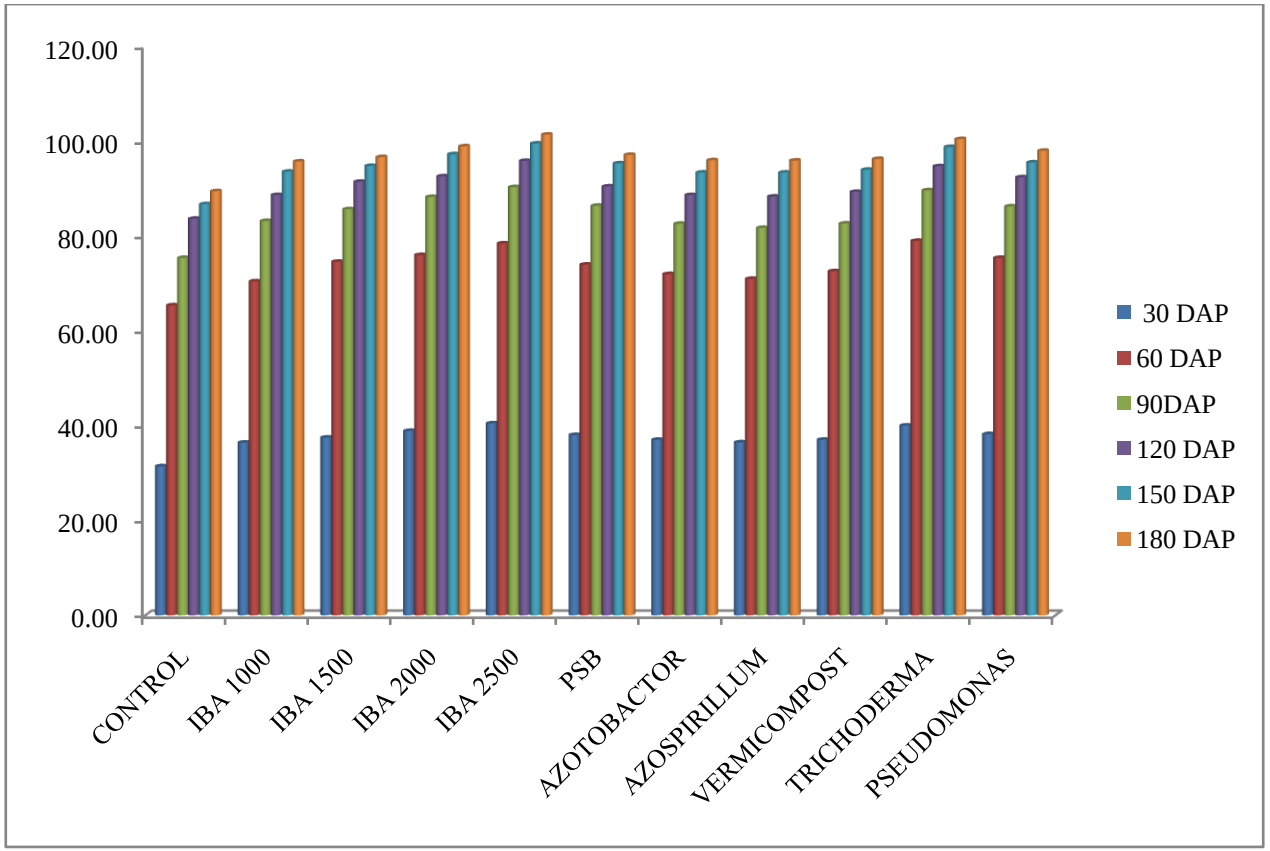
This might be due to the fact that higher number of shoots and maximum length of shoots resulted in more number of leaves. Increase in number of leaves might be due to the absorption of more nutrients produced more number of roots and maximum length of root which in turn increase in the production of more number of leaves. Similar results were observed by Chauhan and Maheshwari (1970) in peach.

The results obtained are in hormony with Wahab *et al* (2001) in guava, Thakur *et al* (2009) Mulbery, Barde *et al* (2010) in pomegranate.

The increased number of leaves in Trichoderma may be due to production of more number of roots, as roots may supply more nutrients from the media for the growth of the leaves. These results are in hormony with the findings of Jaganath *et al.*, (2009a) in Pomegranate.

Table 4.1.7 Effect of IBA, bio-fertilizers and bio-control agents on total number of leaves per cuttings

Notation	Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T_0	Control	31.40	65.33	75.33	83.60	86.67	89.40
T_1	IBA 1000	36.40	70.40	83.13	88.60	93.53	95.67
T_2	IBA 1500	37.47	74.53	85.60	91.40	94.73	96.60
T_3	IBA 2000	38.87	75.93	88.20	92.53	97.20	98.87
T_4	IBA 2500	40.47	78.40	90.27	95.80	99.47	101.33
T_5	PSB	38.00	73.93	86.33	90.40	95.27	97.07
T_6	*Azotobactor*	37.00	71.93	82.53	88.60	93.33	95.93
T_7	*Azospirillum*	36.47	70.93	81.67	88.27	93.33	95.87
T_8	Vermicompost	37.00	72.53	82.60	89.27	93.93	96.20
T_9	*Trichoderma*	40.00	78.93	89.60	94.67	98.73	100.40
T_{10}	*Pseudomonas*	38.20	75.33	86.20	92.33	95.47	97.93
	SE(m)	0.14	0.14	0.15	0.12	0.14	0.10
	C.D. @ 5%	0.42	0.40	0.45	0.37	0.40	0.30



Fifure 4.7 Effect of IBA, bio-fertilizers and bio-control agents on total number of leaves per cuttings

4.1.8 Survival percentage of cuttings

The data presented in table 4.1.8 shows that the survival percentage of cuttings ranged from 56.67 to 80.00 %. The maximum survival percentage of cutting was observed under IBA 2500 ppm (80.00%) T_4 followed by IBA 2000 ppm (76.67%) T_3 and *Trichoderma viride* @ 5% of rooting media (76.67%) T_9.Whereas, minimum percentage (56.67%) of success of cuttings was recorded under control T_0.

The treatment with IBA 2500 ppm (T_4) was found significantly superior than all four concentration of IBA applied, followed by IBA 2000 ppm T_3.

As regards the biofertilizers highest survival percentage (70.00%) of cuttings was observed under *Azotobacter* (T_6) and *Azospirillum*, followed by PSB (66.67) T_5.

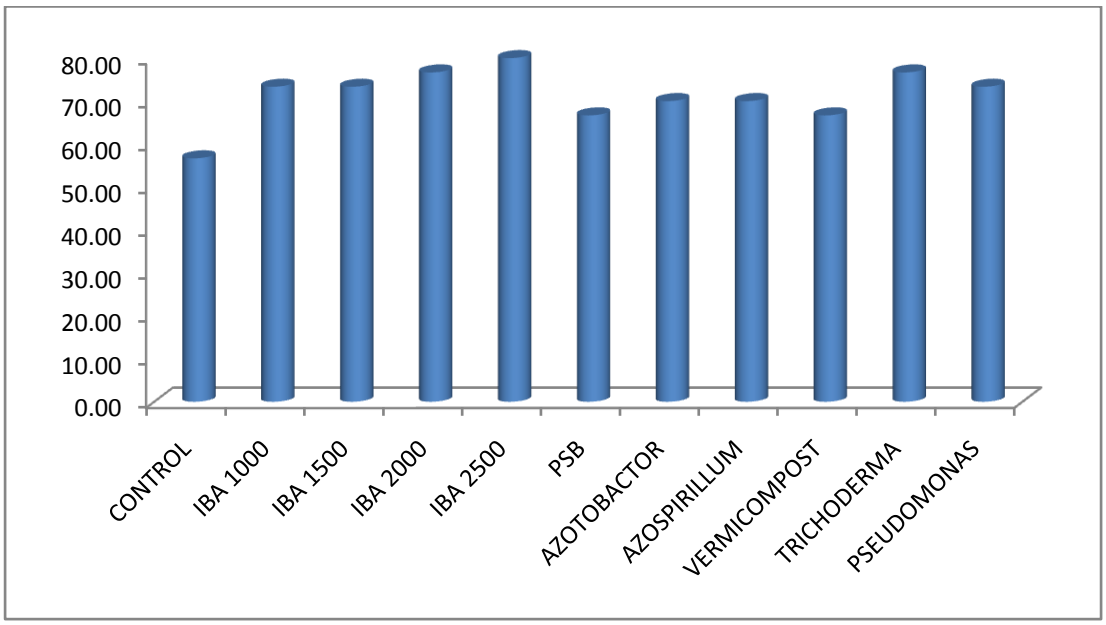
The survival percentage of cuttings in *Trichoderma viride* @ 5% of rooting media (T_9) was (76.67%), followed by *Pseudomonas fluorescence* @ 5% of rooting media (73.33) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

The result may be due to high carbohydrate reserves per cutting and optimum concentration of IBA. The same factors brought about maximum number of shoots and roots per cutting and root length which in turn contributed to high survival percentage (Purohit and Shekharappa, 1985). The results are in harmony with the findings of Doud and Carlson (1977) in peach, pear, apple, cherry and apricot, Lakhani and Gajapara (1998) and Saed, (2010) in pomegranate.

The highest survival percentage was recorded in cuttings treated with IBA 2500 ppm, it might due to development of effective root system and increase in number and length of roots per cutting as influenced by the uptake of nutrients and water (Reddy *et al*., 2008). The survival of the sprouted cuttings might be directly linked to the formation of adventitious roots on cuttings.

Table 4.1.8 Effect of IBA, bio-fertilizers and bio-control agents on survival percentage

Notation	Treatments	Mean
T_0	Control	56.67
T_1	IBA 1000	73.33
T_2	IBA 1500	73.33
T_3	IBA 2000	76.67
T_4	IBA 2500	80.00
T_5	PSB	66.67
T_6	*Azotobactor @5%* of rooting media	70.00
T_7	*Azospirillum @5%* of rooting media	70.00
T_8	Vermicompost *@5%* of rooting media	66.67
T_9	*Trichoderma viride @5%* of rooting media	76.67
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	73.33
	SE(m)	3.76
	C.D. @ 5 %	11.10



Figutre 4.8 Effect of IBA, bio-fertilizers and bio-control agents on total

number of leaves per cuttings

The results are in agreement with the earlier findings of Wahab *et al.* (2001) in guava, Gurjar and Patel (2007), Polat and Caliskan (2009) in pomegranate and Deless *et al*. (2013) in pineapple, Borah and Das (2000) in fig.

Trichoderma kills several major root fungi like pythium, Rizoctonia, Fusarium, and results in a healthy root development by decreasing the attack of soil born pathogens, which in turn results in increased survival of the cuttings. The results are in agreement with the earlier findings of Patil *et al* (2001) in pomegranate

4.2 Root characters

4.2.1 Number of roots per cutting

The data presented in table 4.2.1 shows that the number of roots per cutting ranged from 25.27 to 36.73. The maximum number of roots per cutting was observed under IBA 2500 ppm (36.73) T_4 which is on par with *Trichoderma viride* @ 5% of rooting media (36.47) T_9 , followed by IBA 2000 ppm (25.27) T_3.Whereas, minimum percentage (56.67%) of success of cuttings was recorded under control T_0.

The treatment with IBA 2000 ppm (T_6) was found significantly superior than all four concentration of IBA applied, followed by IBA 2000 ppmT_3.

As regards the biofertilizers highest number of roots per cuutings (31.67) was observed under PSB (31.67) T_5, followed by *Azospirillum* (30.67) T_7, *Azotobacter* (30.60) T_6. Among the treatments with biofertilizers PSB is found to be superior than others.

The number of roots per cuttings in *Trichoderma viride* @ 5% of rooting media (T_9) was (76.67%),followed by *Pseudomonas fluorescence* @ 5% of rooting media (73.33) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

Table 4.2.1 Effect of IBA, bio-fertilizers and bio-control agents on Number of roots per cutting

Notation	Treatments	Mean
T_0	Control	25.27
T_1	IBA 1000	28.60
T_2	IBA 1500	34.07
T_3	IBA 2000	35.27
T_4	IBA 2500	36.73
T_5	PSB	31.67
T_6	*Azotobactor @5%* of rooting media	30.60
T_7	*Azospirillum @5%* of rooting media	30.67
T_8	Vermicompost *@5%* of rooting media	31.53
T_9	*Trichoderma viride @5%* of rooting media	36.47
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	33.40
	SE(m)	0.14
	C.D. at 5%	0.41

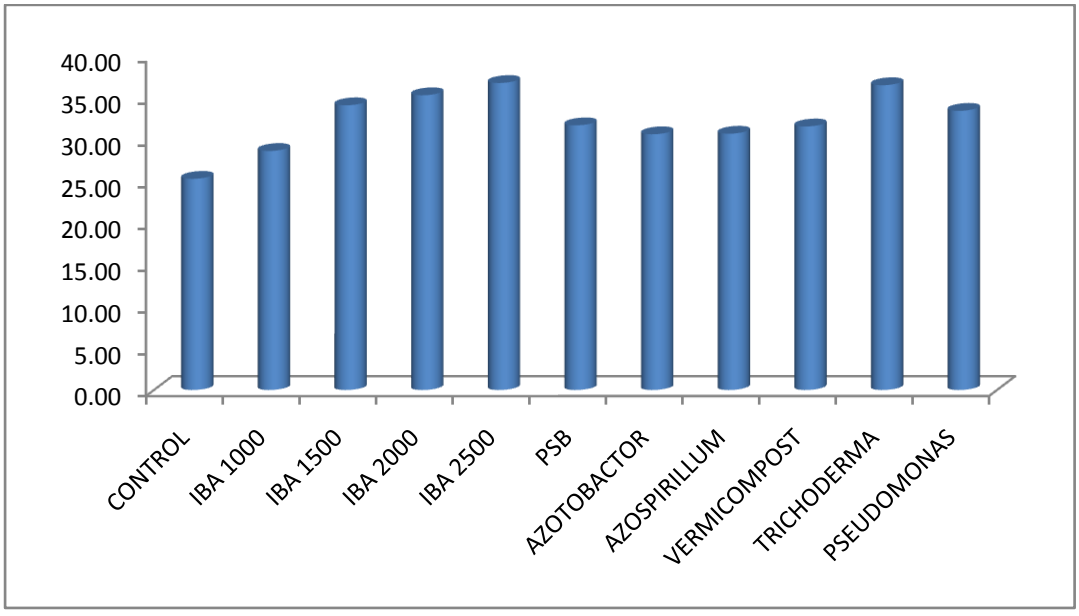


Figure 4.9: Effect of IBA, bio-fertilizers and bio-control agents on Number of roots per cuttings

The maximum number of roots was observed with IBA 2500 ppm which might be due to hormonal effect leading to accumulation of internal substances and their downward movement. Induction of maximum number of roots in IBA treated cuttings might be due to the fact that stimulation of cambial activity involved in root initiation by growth regulators in many species (Ullah *et al*., 2005). Auxins promote adventitious root formation by their ability to promote the initiation of lateral roots and also enhanced the transport of carbohydrates to basal portion of the cuttings. The result with this treatment might be due to it's effect on cell wall plasticity, which accelerates cell division stimulates callus development and root growths (Weaver, 1972).

Increased number of roots may be due to increased synthesis of growth promoting substances as well as availability of more phosphorus under the treatments with biofertiizers which enhance the rooting in cuttings. Wange and Ranawade (1997) also reported that maximum rooting in grapes cutting when they were treated with biofertilizers.

The results are in harmony with the findings of Hakim *et al* (2018) in pomegranate, Barde *et al* (2010) in pomegranate, Saroj *et al* (2008) in pomegranate, Tahseen *et al* (2005) in Guava, Polat (2006) in mulberry, (2001) in pomegranate.

4.2.2 Length of roots (cm)

The data presented in table 4.2.2 shows that the length of roots ranged from 20.96 to 28.59. The maximum length of roots was observed under IBA 2500 ppm (28.59) T_4 which is on par with *Trichoderma viride* @ 5% of rooting media (28.37) T_9 , followed by IBA 2000 ppm (27.31) T_3.Whereas, minimum length of roots (20.96) was recorded under control T_0.

The treatment with IBA 2500 ppm (T_4) was found superior than all four concentration of IBA applied, followed by IBA 2000 ppm T_3.

Table 4.2.2 Effect of IBA, bio-fertilizers and bio-control agents on length of the longest roots (cm) per cutting

Notation	Treatments	Mean
T_0	Control	20.96
T_1	IBA 1000	24.47
T_2	IBA 1500	26.44
T_3	IBA 2000	27.31
T_4	IBA 2500	28.59
T_5	PSB	26.39
T_6	*Azotobactor @5%* of rooting media	25.67
T_7	*Azospirillum @5%* of rooting media	25.44
T_8	Vermicompost *@5%* of rooting media	26.19
T_9	*Trichoderma viride @5%* of rooting media	28.35
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	26.19
	SE(m)	0.10
	C.D.	0.30

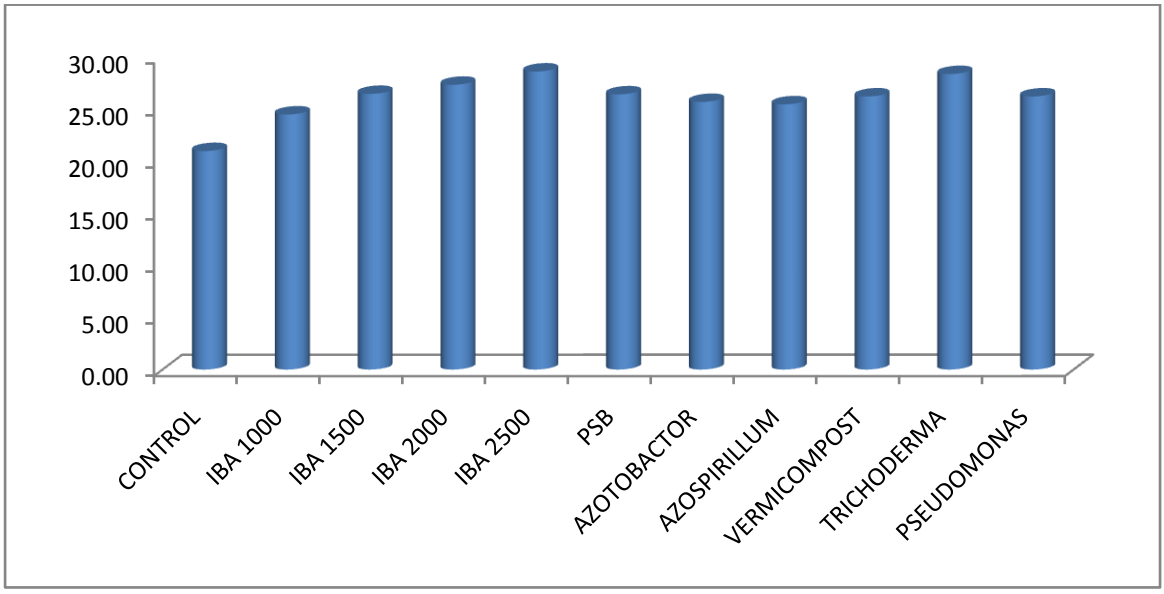


Figure 4.10: Effect of IBA, bio-fertilizers and bio-control agents on Length of the roots (cm) per cuttings

As regards the biofertilizers maximun length of roots was observed under PSB (26.39) T_5, followed by *Azotobacter* (26.67) $T_{6,}$ *Azospirillum* (25.44) T_7. Among the treatments with biofertilizers PSB is found to be superior to others.

The length of roots in *Trichoderma viride* @ 5% of rooting media (T_9) was (28.35),followed by *Pseudomonas fluorescence* @ 5% of rooting media (26.19) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

The result may due to the differences among auxins which could also be related to other factors such as higher stability and a slow rate of conjugation of IBA, so that the free IBA required to induce rooting will be available over a long period of time than IAA and NAA (Krisantini *et al.* 2006). The reason for recording longest root may be attributed to the action of auxin activity which might have caused hydrolysis and translocation of carbohydrates and nitrogenous substances towards the base of cuttings and resulted in accelerated cell division and cell elongation under suitable environment. Another possible reason may be due to the early formation of roots and more utilization of reserved food materials of the treated cuttings. (Ghatnatti, 1997). The earlier findings reported by several investigators are in accordance with the results obtained in the present study as Panda and Das (1990), Dhillon and Sharma (1992), Polat and Caliskan (2009), Srivastava *et al.* (2005) in kiwifruit and Hae and Funnah, (2011) in apple.

This also may be due to increased level of growth promoting substances, available P_2O_5 and other nutrients with the application of PSB. Since PSB increase available phosphorus in the nutrient medium through bacterial involvement. Phosphorus is very much important for root initiation through increased cell division and energy transfer as an ADP and ATP, which results better, and earliest root and growth. Nageswari *et al*. (1999) reported that maximum percentage of rooting with high length and number of roots per cutting was obtained by application of phosphobacteria through soil as well as slurry method at the time of planting of cinnamon cuttings.

4.2.3 Diameter of roots (mm)

The data presented in table 4.2.3 shows that the diameter of roots ranged from to 0.73 to 1.93 The maximum diameter of roots was observed under IBA 2500 ppm (1.93) T_4, followed by *Trichoderma viride* @ 5% of rooting media (1.73) T_9 , and IBA 2000 ppm (1.70) T_3.Whereas, minimum diameter of roots (0.73) was recorded under control T_0.

The treatment with IBA 2500 ppm (T_4) was found superior than all four concentration of IBA applied, followed by IBA 2000 ppm T_3.

As regards the biofertilizers maximun diameter of roots was observed under PSB (1.63) T_5, followed by *Azospirillum* (1.37) T_7 and *Azotobacter* (1.33) T_6. Among the treatments with biofertilizers PSB is found to be superior than others.

The diameter of roots in *Trichoderma viride* @ 5% of rooting media (T_9) was (1.73),followed by *Pseudomonas fluorescence* @ 5% of rooting media (1.53) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

The result obtained may be due to higher accumulation of photosynthates metabolites and nutrients under the treatment. Dhua *et al*. (1980) The result obtained is similar with the findings of Rawat et al.(2004) in grapes.

Plant pathogen suppressing microorganisms (eg. *Trichoderma viride, Pseudomonas flurescence*) are ecofriendly and secretes growth promoting hormones and secondary metabolites which help in mobilizing various micronutrients (Arshad, et al., 1998) which helps the plants to grow a healthy root system with an increased diameter of the roots. The results obtained are in accordance with the previous results of Patil *et al* (2001) in pomegranate, MacKenzie *et al*.(1995)in crysanthamum.

Table 4.2.3 Effect of IBA, bio-fertilizers and bio-control agents on diameter of the longest roots (mm) per cutting

Notation	Treatments	Mean
T_0	Control	0.73
T_1	IBA 1000	1.30
T_2	IBA 1500	1.40
T_3	IBA 2000	1.70
T_4	IBA 2500	1.93
T_5	PSB	1.63
T_6	*Azotobactor @5%* of rooting media	1.33
T_7	*Azospirillum @5%* of rooting media	1.37
T_8	Vermicompost *@5%* of rooting media	1.50
T_9	*Trichoderma viride @5%* of rooting media	1.73
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	1.53
	SE(m)	0.03
	C.D.	0.08

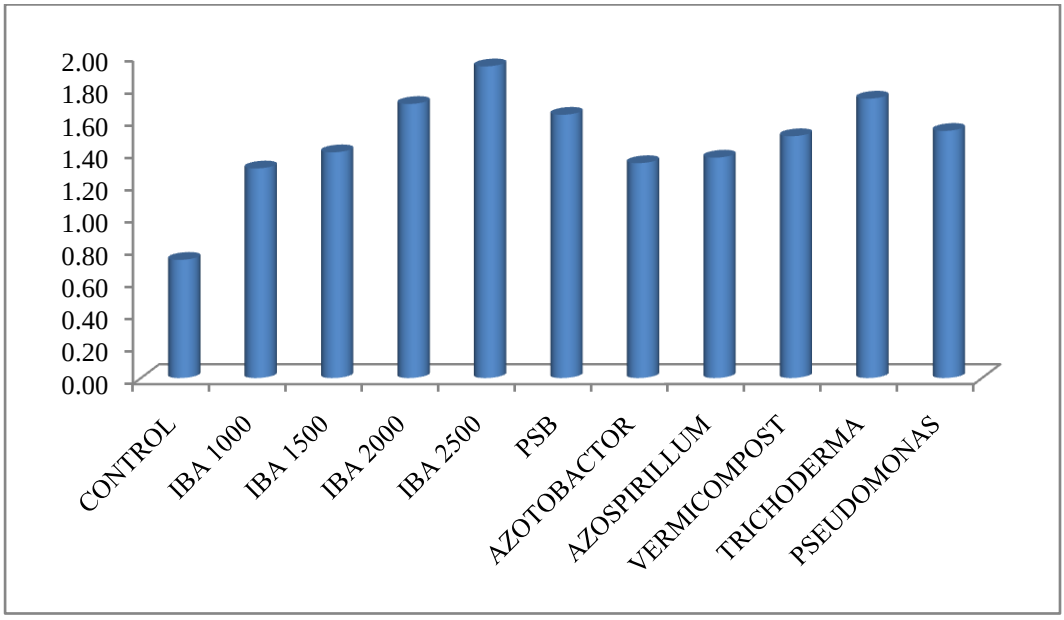


Figure 4.11: Effect of IBA, bio-fertilizers and bio-control agents on diameter of the roots (mm) per cutting

4.2.4 Fresh weight of roots (g)

The data presented in table 4.2.4 shows that the fresh weight of roots ranged from to 0.81 to 1.78 The maximum fresh weight of roots was observed under IBA 2500 ppm (1.78) T_4, followed by *Trichoderma viride* @ 5% of rooting media (1.69) T_9 , and IBA 2000 ppm (1.58) T_3. Whereas, minimum fresh weight of roots (0.81) was recorded under control T_0.

Table 4.2.4 Effect of IBA, bio-fertilizers and bio-control agents on fresh weight of roots (gm) per cutting

Notation	TREATMENTS	MEAN
T_0	Control	0.81
T_1	IBA 1000	1.31
T_2	IBA 1500	1.52
T_3	IBA 2000	1.58
T_4	IBA 2500	1.78
T_5	PSB	1.35
T_6	*Azotobactor @5%* of rooting media	1.26
T_7	*Azospirillum @5%* of rooting media	1.27
T_8	Vermicompost *@5%* of rooting media	1.30
T_9	*Trichoderma viride @5%* of rooting media	1.69
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	1.45
	SE(m)	0.01
	C.D. 5 %	0.04

The treatment with IBA 2500 ppm (T_4) was found superior than all four concentration of IBA applied, followed by IBA 2000 ppm T_3.

As regards the biofertilizers maximun fresh weight of roots was observed under PSB (1.35) T_5, followed by *Azospirillum* (1.27) T_7 and *Azotobacter* (1.26)

T_6. Among the treatments with biofertilizers PSB is found to be superior than others.

The fresh root weight in *Trichoderma viride* @ 5% of rooting media (T_9) was (1.69), followed by *Pseudomonas fluorescence* @ 5% of rooting media (1.45) T_{10}. *Trichoderma* was found to be best among both of the bio-control agents used.

The increased root weight is may be due to the production of more number of roots, increased length of roots, and diameter of roots which results in production of heavier roots which in turn results in increased root weight.

The result obtained is in harmony with the results of Shukla and Bist (1994) in pear, Manfroi et al (1997) in kiwi , chalfun et al (2008) in fig, Deb et al (2009) in lemon, Wande and Ranawade (1997) in grape, MacKenzie *et al*.(1995)

The result is in hormony with the findings of in Sanabria et al (2014) in cape gooseberry, Jaganath et al (2009a) in pomegranate.

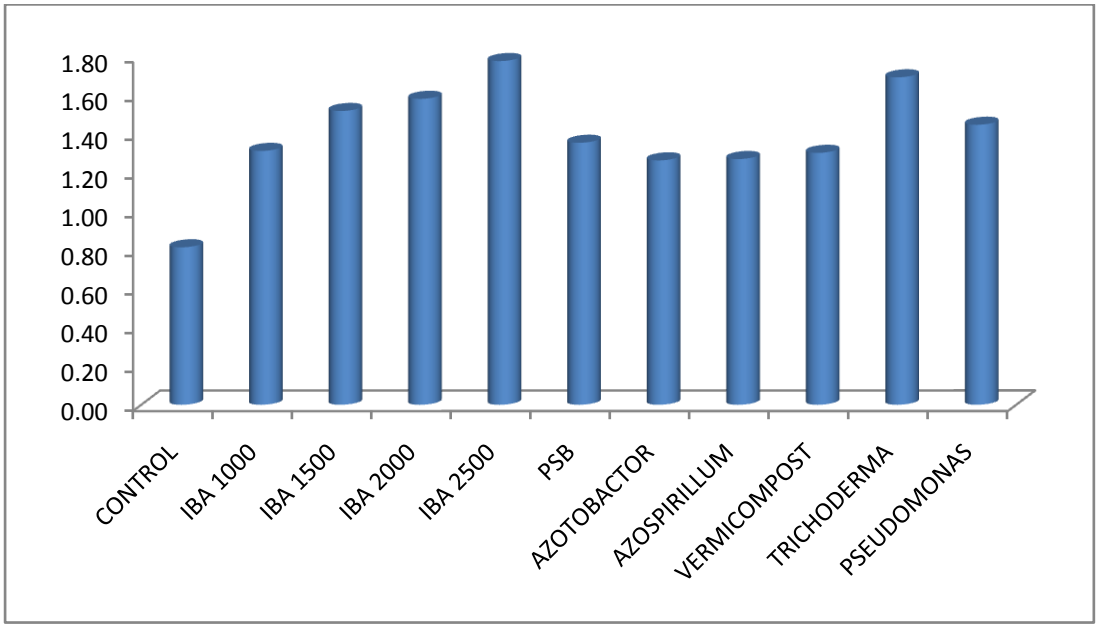


Figure 4.12: Effect of IBA, bio-fertilizers and bio-control agents on fresh weight of roots (gm) per cutting

4.2.5 Dry matter of roots (%)

The data presented in table 4.2.3 shows that the dry matter of roots ranged from to 36.30% to 54.50% The maximum length of roots was observed under *Trichoderma viride* @ 5% of rooting media (54.50%) T_9 which is on par with IBA 2500 ppm (54.47%) $T_{4,}$ followed by IBA 2000 ppm (51.57%) T_3. Whereas, minimum dry matter roots (36.30%) was recorded under control (T_0)

Table 4.2.4 Effect of IBA, bio-fertilizers and bio-control agents on Dry matter of roots (%)per cutting

Notation	Treatments	Mean
T_0	Control	36.30
T_1	IBA 1000	42.40
T_2	IBA 1500	46.43
T_3	IBA 2000	51.57
T_4	IBA 2500	54.47
T_5	PSB	46.63
T_6	*Azotobactor @5%* of rooting media	42.23
T_7	*Azospirillum @5%* of rooting media	43.50
T_8	Vermicompost *@5%* of rooting media	43.43
T_9	*Trichoderma viride @5%* of rooting media	54.50
T_{10}	*Pseudomonas fluorescence @5%* of rooting media	52.37
	SE(m)	0.14
	C.D.	0.40

The treatment with IBA 2500 ppm (T_4) was found superior than all four concentration of IBA applied, followed by IBA 2000 ppm $T_{3.}$

As regards the biofertilizers maximum dry matter of roots was observed under PSB (46.63%) T_5, followed by *Azospirillum* (43.50%) T_7 and *Azotobacter* (43.23%) T_6. Among the treatments with biofertilizers PSB is found to be superior than others.

The dry matter of roots of cuttings in *Trichoderma viride* @ 5% of rooting media (T_9) was (54.50%),followed by *Pseudomonas fluorescence* @ 5% of rooting media (52.37%) $T_{10.}$ *Trichoderma* was found to be best among both of the bio-control agents used.

The results are in consonance with those of Shukla and Bist (1994) in pear, and Karimi *et al*. (2012) in pomegranate.

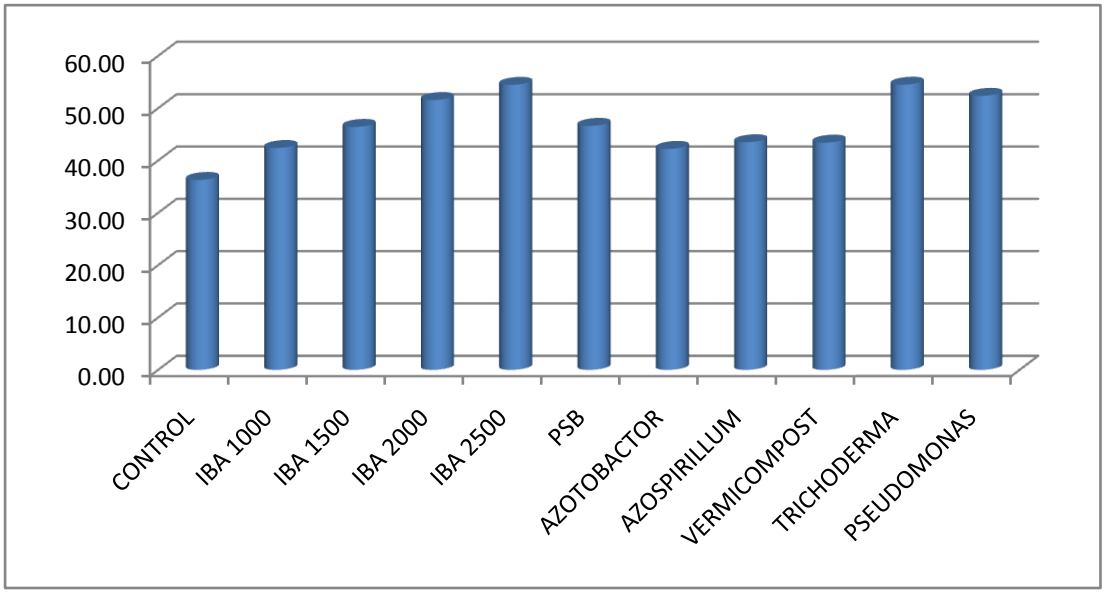


Table 4.2.4 Effect of IBA, bio-fertilizers and bio-control agents on Dry matter of roots (%)per cutting

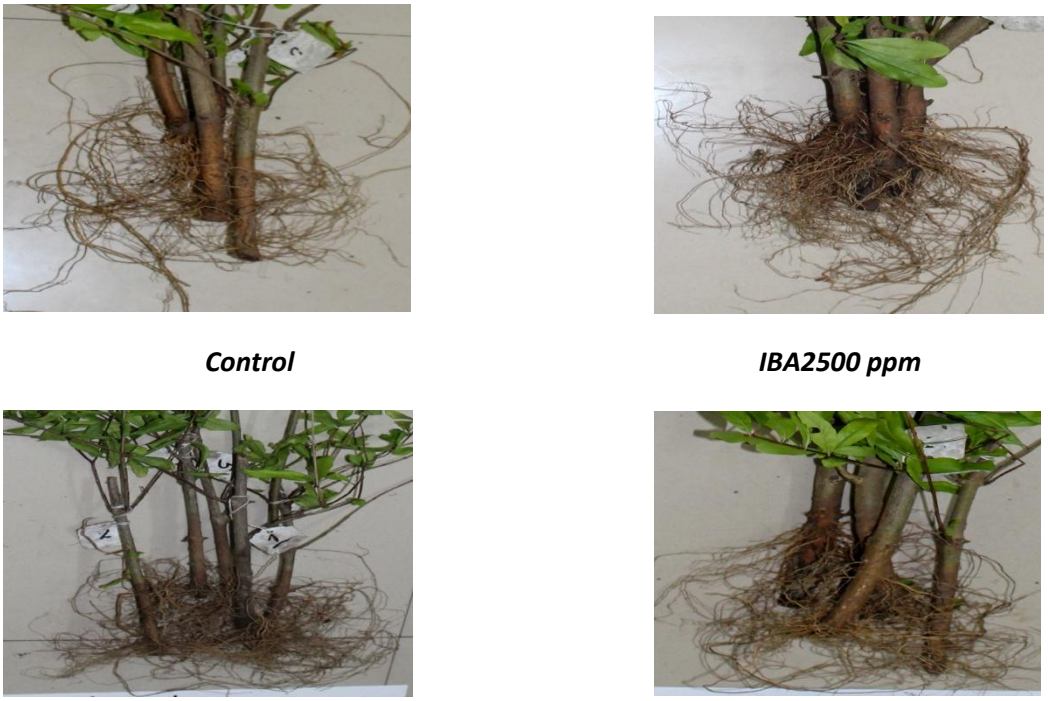
Figure 4.14: An overview of experimental site

Figure 4.15: Preparation of cuttings

Figure 4.16: Planting of cuttings

PSB **IBA2500 ppm** **Trichoderma**

Figure 4.17: Top view of some treatments (180 DAP)



Control ***IBA2500 ppm***

Trichoderma ***PSB***

Figure 4.18: Rooting of cuttings

CHAPTER - V

SUMMARY AND CONCLUSION

The present experiment entitled **"EFFECTS OF IBA, BIOFERTILIZER, *Trichoderma & Pseudomonas* ON ROOTING OF POMEGRANATE *(Punica granatum L.)* CUTTINGS"** was performed at nursery, Horticulture Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during the session 2018-19.

The experiment comprises of eleven combinations of treatments consisting of four treatments of IBA and one control that is IBA 1000 ppm, IBA 1500 ppm, IBA 2000 ppm, IBA 2500 and IBA 0 ppm.in case of the biofertilizers, three treatment combinations are Phosphorus Solubilizing Bacteria (PSB), *Azotobacter* and *Azospirillum* in powder form, and two treatments of bio control agents viz, *Trichoderma viride*, *Pseudomonas fluorescence* and one treatment of vermicompost at the rate of five percent of the rooting media each, with a replicated three in a complete randomized design (CRD). 15-20 cm long hardwood cuttings ten in numbers was taken for each treatment in each replication. Shortly after their preparation, cuttings were kept in the water to keep adequate humidity until the planting moment, the cutting was planted in individual poly bags with roting media, as per treatment. Two third parts of the treated cuttings were placed in the rooting media at a slight angle (about 60°) vertical to the plane. The rooting media was provided water to supply moisture to the cutting and soil around the cutting area was pressed lightly to fix the cutting in rooting media. The observations was recorded timely for both rooting and shooting parameters and analyzed for the improvement of growth and developmental parameters of the cuttings to find out the best performer for regeneration of roots in stem cuttings.

5.1 Summary

Data recorded indicate that the first sprouting of cutting, sprouting of 50 % of cuttings, highest success percent, root length, leaf count per longest shoot in each cutting, fresh root weight, root diameter and root count per cutting were

observed in treatment T_4 (IBA 2500 ppm), on par with *Trichoderma viride* but the dry matter percentage of roots was found to be maximum in the treatment with *Trichoderma viride* on par with IBA2500ppm. Whereas, late sprouting of cutting, sprouting of 50 % of cuttings, highest success percent, root length, leaf count per longest shoot, fresh root weight, root diameter and root count per cutting were recorded in control.

Among the different concentrations of the plant growth regulators used first sprouting of cutting, sprouting of 50 % of cuttings, highest success percent, root length, leaf count per longest shoot, fresh root weight, root diameter, dry matter content of root and root count per cutting was found to be maximum with application of IBA 2500 ppm followed by IBA 2000 ppm.

As regards the biofertilizers phosphorus solubilizing bacteria gave better results than *Azotobacter* and *Azospirillum* for different parameters like, first sprouting of cutting, sprouting of 50 % of cuttings, highest success percent, root length, leaf count per longest shoot, fresh root weight, root diameter, dry matter content of root and root count per cutting.

In case of the bio control agents used first sprouting of cutting, sprouting of 50 % of cuttings, highest success percent, root length, leaf count per longest shoot, fresh root weight, root diameter, dry matter content of root and root count per cutting was found to be maximum with application of *Trichoderma viride* followed by *Pseudomonas fluorescence.*

5.2 Conclusion

It was observed that use of various dose of IBA, bio control agents and biofertilizers resulted in better root and shoot development of pomegranate hardwood stem cutting in consideration with control.

The treatment combinations IBA 2500 ppm and *Trichoderma viride* was found best for maximum root formation, success, survivability and shoot parameters of cuttings followed by IBA 2000 ppm and *Pseudomonas fluorescence* under the studied experiment.

Use of *Trichoderma* can be recommended to the farmers as it was found to be on par with highest concentration of IBA used in the experiment.

Nowadays organic pomegranates production requires the cuttings which are propagated by utilization of organic natural products so use of PSB can be considered as a better option for regeneration in stem cuttings.

IBA at lower concentration also gave satisfactory results, so use of IBA at 1500 and 2000 ppm can also be recommended as lower concentrations of plant growth regulators will help to decrease the cost of cultivation.

Suggestions for future experiments

On the basics of this study, the following recommendations are produced, for further research work:

1. The present investigation should be performed again for the confirmation of the findings.

2. The investigation should be tested on a big amount of fruit crop species and varieties in which propagation by means of cuttings takes place.

3. The current research was performed at rainy and winter seasons. This research should therefore also be performed at spring season, to see the impact of growth regulators, biofertilizers and bio-control agents on the rooting and other growth parameters of cuttings of *Punica granatum*.

4. The current investigation should be performed to see impacts of IBA, *Trichoderma* and PSB in combinations on the root development of cuttings of *Punica granatum*.

5.In the current investigaton IBA @ 2500 ppm delivered the greatest output on Pomegranate cuttings rooting and growth. Since this dose (IBA @ 2500 ppm) was the highest IBA dose used in present work. Therefore, there is a scope for IBA dose improvement in upcoming time span to see the appropriate dose of IBA implementation, on Pomegranate cuttings quality and survivability.

6. The experiment should also combine VAM, to see the combine impact of VAM with PSB and *Trichoderma.*

7. Other strains of *Trichoderma* viz, *T.harzianum* can be included in the experiment.

8. The current experiment *Trichoderma and Pseudomonas* was used in powder form it can also be used as solution or slurry.

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Table 3.1: The weekly minimum and maximum temperature, evaporation, rainfall, relative humidity and sunshine hours during the experimental period

Parameters	Tmax	Tmin	Rainfall	RH I	RH 2	WS	EP(mm)	SS(hr)
1-7 sep	29.2	25.2	5.9	87	80	6.9	2.5	2.2
8-14 sep	31.4	24.5	0	92	92	4	3.8	4.8
15-21sep	32.2	24.4	2.8	93	69	2.7	2.9	4.4
22-28 sep	31.1	23.5	1.57	92	57	3.2	3.2	5.1
29-5 oct	33.3	25.2	0	92	45	0.7	4.5	8.6
6-12 oct	33.2	22.6	0	88	51	2.7	3.7	8.2
13-19oct	33.4	21.5	0	89	49	1.7	3.7	8.8
20-26oct	32.9	20.7	0	87	48	0.8	3.9	8.9
27-2 nov	32.2	19	0	88	45	2.1	4.1	9.2
3-9nov	32.8	18.4	0	86	36	1.2	4	8.9
10-16nov	31.6	14.2	0	89	32	1.2	3.2	9.1
17-23 nov	32.8	15.7	0	89	32	1.2	3.1	8.7
24-30nov	30.1	13.4	0	87	35	1.3	2.3	7.8
1-7dec	28.2	15.7	0	91	38	0.72	2.7	5.6
8-14dec	27.2	17.5	0	89	58	1.1	2.1	2.7
15-21dec	22	12.8	6.71	87	80	3.2	2.1	3.4
22-28dec	24.2	9	0	90	32	1.2	2.4	6.2
29dec-4jan	24.4	8.9	0	88	27	0.9	2.4	7.9
5-11jan	26.5	9.5	0	89	31	1.1	2.6	7.7
12-18jan	28.3	10.3	0	77	37	1.2	2.9	6.9
19-25jan	30.5	13	3.4	88	35	1.5	3.3	7.9
26jan-1feb	23.7	12.8	0	87	34	1.9	2.1	3.4
2-8feb	29.5	12.9	0	88	47	0.9	3.1	8.7
9-15feb	28.9	12.1	0.5	77	342	2.9	3.8	9.6
16-22feb	33	17.1	1.3	89	48	2.8	3.8	9.1
23-28feb	33.5	18.5	0	85	32	2.3	5.9	8.4

This is a Table of Chapter – III (Material and Methods)

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