**BIBLIOGRAPHY**

RUFINO, NOVERNITZ, B. OCTOBER 2009. Rooting of Blueberry *(Vaccinium spp.)* Shoot Tip Cuttings as Affected by Soaking Duration and Different ANAA Concentrations. Benguet State University, La Trinidad, Benguet.

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**ABSTRACT**

The study was conducted to determine the effect of duration and different concentrations of ANAA on the rooting of Blueberry Shoot tip cuttings and to evaluate the best concentration of ANAA that would enhance faster and uniform rooting of cuttings

Results on duration showed that there were no significant effect on the number of days to visible root formation, average number of roots produce per cutting, percentage survival, percentage of rooted cuttings, average root length and average shoot length.

Dipping of blueberry shoot tip cuttings with 500 ppm ANAA promoted higher percentage of survival, promoted the production of longer root and shoot length.

The interactions between duration and the different concentrations of ANAA were not significantly different in all parameters gathered.

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## INTRODUCTION

Blueberries are flowering plants belonging to genus *Vaccinium.* The species are native only to North America. The crop is considered as shrub in size varying from 10 cm to 4 m tall. The smaller species are known as “low bush blueberries”. The leaves can be deciduous or ever green, ovate to lanceolate and from 1-8 cm long and 0.5 to 9 3.5 cm wide. The flowers are bell-shaped, whiter, pale pink, or red, sometimes tinged with green. The fruit is a false berry 5 to 16 mm diameter with a flaved “crown” at the end; they are pale greenish at first then reddish purple and finally indigo at ripening. It has a sweet taste when matured with variable acidity. Blueberry bushes typically bear fruits from May to October in the Northern Hemisphere; “blueberry season” in July which is National Blueberry Month in United States.

For centuries, blueberries were gathered from the forest and bogs by the Native Americans and these are usually consumed fresh and also it can be preserved. The Northeast Native American Tribes revered blueberries and much folklore developed around them. The blossom ends of each berry, the calyx, forms a shaped of a perfect five-pointed star. Parts of the blueberry plant were also used as medicine for coughs and good for the circulation of the blood. Not only for medicine, the juice can also be made as an excellent dye for baskets and cloth. It can also used in other food preparation. Example, the dried berries were also crushed into a powder and a flavoring for meat; it can be processed into products such as jellies, jams, pies, muffins and snack foods.

For the early colonists, blueberries were probably one of the first familiar foods discovered on the North American continent, since they were similar to other berry varieties found in Europe. Their abundance, natural sweetness and visibility immediately welcome addition at a time when fresh food was in short supply, and sugar was scarce and expensive. Blueberry were canned and shipped to union troops during the civil war in the 1860's.

Blueberries have gained increasing recognition from health professionals for their very high antioxidant properties. Studies of the anthocyanin and phytochemicals found in the blueberries have shown that they provide a wide range of benefits, including reducing eye strain, counteracting environmental carcinogens, promoting urinary tract health, calories, low in fat and have no cholesterol, in addition to being a good source of dietary fiber and is packed with other vitamins (A, C, E) and minerals (potassium, manganese and magnesium).

Blueberries have the potential of being grown commercially in the locality. However, mass production of planting materials could become a problem under high demand because it takes time to produce seedlings from seeds. It is therefore imperative to conduct this study to be able to determine the best soaking duration and concentration of ANAA on blueberry that provides the shoot tip cuttings, the stimulus for earlier and uniform rooting; and reduces the longer duration and intervals of waiting time leading to higher percentage of survival of the seedlings; and to be able to grow or to produce more blueberries in our community for economic, medicinal and food purposes. The results of this study will provide baseline information to researchers interested to work on blueberry production and to encourage more farmers to produce blueberry that is considered as having medicinal properties and has great potential in the market as a fresh fruit or in processed form.

The study was conducted to determine the best soaking duration of ANAA concentration rooting of blueberry shoot tip cuttings; and to determine the best concentration of ANAA that will enhance faster and uniform rooting of blueberry shoot tip cuttings.

The study was conducted at the nursery of the Pomology Project, Benguet State University, La Trinidad, Benguet from November 2008 to February 2009.

## REVIEW OF LITERATURE

Rooting Hormone

Hartmann and Kester (1968) reported that the application of growth regulators to cuttings is important for the quality of roots formed and the stimulating of rooting period of cuttings.

Wilkins (1969) also mentioned that the most common plant growth regulators are gibberillic acid, napthalene acetic acid, indole butyric acid, cytokinins and abscissic acid. The absence of deficiency or indolence in the supply these hormones, therefore, creates the necessity of applying them to plants exogenously for faster growth and development.

Hartmann and Kester (1975) recommended that the use of ANAA and IAA for general use in rooting stem cuttings for the majority of plant species. Several investigations had demonstrated the use of these materials in stimulating root formation of cuttings.

Hormone Concentration

Adriance and Brison (1955) mentioned that root formation in cuttings is not only affected by hormones alone but also by other factors like environment, rooting medium, chemical treatments, mechanical treatments as well as plant itself as a factor. For instances, cuttings from younger stems usually are more active in the synthesis of food and cell development.

Weaver (1972) mentioned that high concentration of growth regulators do not produce abnormalities in root formation necrosis on tissues.

Janick (1972) stated that the natural auxins produced in younger leaves and buds move naturally down the plant and accumulated at the cut base along with the sugars and other food materials. Auxins level is closely associated with adventitious rooting in the stem. This normal rooting of the stem appears to be triggered by the accumulation of auxin at the base of the cuttings.

Bleasedale (1973) stated that hormones may be used to overcome the inherent difficulties encountered in rooting cuttings but also can inhibit the growth of the cuttings if applied in accurate concentration. Although hormones are known to promote rooting in various kinds of cuttings, it is also necessary that these are applied at specific concentration just below the toxic level. Furthermore, Halfacre and Barden (1979) stated that high concentrations may injure or kill cuttings and too much concentration may be ineffective.

Furthermore, Anderson and Ellison (1969) mentioned that stem cuttings from asparagus cultured aseptically initiated roots on a range of ANAA and IBA and that he optimum amount of ANAA was 5mg/l and 10mg/l of IBA.

Gonzales (1980) recommended 1000 ppm ANAA for hastening root inhibition of rose cv. Queen Elizabeth. It was further observed that cuttings treated with 1000 ppm ANAA produced the highest number of roots, had rapid root elongation and earliest root formation. Likewise, Amlos (1989) recommended 1000 ppm ANAA in enhancing root initiation of the stem cuttings as shown in the findings of Gonzales (1980).

In the study of Bayeng (1999) he found that one-half strength of ANAA was more effective in promoting root initiation in mum cuttings than full strength ANAA.

Indolebuteric acid solution in full strength ANAA accelerated production of more roots but initiated root elongation.

Rooting in the Relation to Plant Age

Ali and Fletcher (1979) stated that the effectiveness of any of the growth regulator applied on promoting growth is independent on the stage of plant growth. Likewise, Leopold and Kriedman (1975) claimed that with increasing root growth rate very lens calinari roots give small positive growth response while older roots age not stimulated to added auxins.

Hartmann and Kester (1975) reported that root initials, which developed roots primordial that later developed into an adventitious roots in younger plants, originated deeper often near the vascular cambium. They also added the naturally occurring auxins as a controlling factor for rooting is synthesize in apical buds and younger leaves. Furthermore, they stated that cuttings from young seedling plant roots much more readily than those taken from old mature plants. This was confirmed by Ingles (1994) and called as the juvenility factor". The main advantage of propagation from cuttings is the relative simplicity of the operations. Therefore, it is a method of propagation which is highly practical and economic importance of plants is economically propagated by vegetative means.

Apnoyan (1981) stated that propagation by cuttings has the advantage in producing plant genetically identical to the mother plant in contrast to the wide genetic variations found in seeds.

<u>Misting</u>

Bautista *et al*., (1983) for instance stated that in the propagation of plants by cuttings, the main problem is to keep the cuttings from decaying or until the missing organs are regenerated resulting into new individual plants. Cuttings can absorb small amounts of water through its cut ends. The amounts absorbed are not enough to replace the amount normally lost through the process of transpiration. Thus, transpiration has to be slowed down by keeping the relative humidity high in the vicinity which can be increased by misting or with the application of water through sprinkling

## MATERIALS AND METHODS

Materials

The materials used were the following: blueberry shoot tip cuttings 20cm, distilled water, ANAA, containers, measuring and labeling materials, pruning shear, cutter, graduated cylinder, sandy soil, PEP bags (2.5 x 4).

Methods

Experimental design and treatments. The experimental was laid out following the Randomize Complete Block Design (RCBD) with four replications and seven sample cuttings per treatment.

The treatments will be as follows:

| Factor A | Time Duration |
|---|---|
| $T_1$ | 30 minutes |
| $T_2$ | 60minutes |
| **Factor B** | **ANAA Concentration (ppm)** |
| $C_1$ | 0 (control) |
| $C_2$ | 500 |
| $C_3$ | 750 |
| $C_4$ | 1000 |

Preparation of cuttings. The shoot tips cutting of the blueberry with a length of 20cm were taken from existing mother plants. The cuttings were cleaned and only the four upper leaves were retained per cuttings. The stem ends of the samples were cut into a slanting manner before dipping in a 250ml plastic containing 100ml of the different rooting solution concentrations. After the soaking treatment, the cuttings were rooted to a depth of 2.5 cm in a sandy loam soil previously placed on individual polyethylene plastic for rooting.

Data Gathered

The data gathered were the following;

1. Number of days to visible root formation. This was taken by counting the number days from sticking the cuttings to visible root formation.

2. Average number of root produce per cutting. This was taken by counting all the roots produce in each individual stem two months from sticking the cuttings.

$$\text{Average Number of Roots} = \frac{\text{Total Number of Roots}}{\text{Total Number of roots per Cutting}} \times 100$$

3. Percentage Survival (%). This was determined by using the formula:

$$\text{Survival (\%)} = \frac{\text{Cuttings Survival}}{\text{Total Number of Cutting}} \times 100$$

4. Percentage of rooted cuttings (%). This was obtained one month after sticking of the cuttings in the rooting media using the formula:

$$\text{\% of Rooted Cuttings} = \frac{\text{Number of Rooted Cuttings}}{\text{Total Number of Cuttings}} \times 100$$

5. Average length of shoots (cm). This was done by measuring the base of the plant to the shoot tip after two months.

6. Average length of root (cm). This was taken by measuring all the roots developed two months from sticking of cuttings.

7. Documentation. This was taken through pictures of the study.

## RESULTS AND DISCUSSION

### Number of Days to Visible Root Formation

Effect of soaking duration. The effect of duration on the number of days to visible root formation is shown in table 1. Results shows that the dipping of blueberry shoot tip cuttings in different duration such as 30 minutes soaking and 1 hour soaking shows the same mean which is 26 days.

Table 1. Number of days to visible root formation

| TREATMENT | DAYS TO ROOT FORMATION |
|---|---|
| Soaking Duration (minutes) | |
| 30 minutes | 26 |
| 60 minutes | 26 |
| ANAA Concentration (ppm) | |
| O | $26^{ab}$ |
| 500 | $24^{b}$ |
| 750 | $27^{a}$ |
| 1000 | $27^{a}$ |
| T x C | ns |
| CV (%) | 6.16 |

*Means with the same letter are not significantly different at 5% level by DMRT.

Effect of ANAA concentration. The number of days to visible root formation is presented in table 1. Results shows that the blueberry shoot tip cuttings treated with 500ppm ANAA initiated roots earlier followed by cuttings treated with 750 ppm with a mean of 26 days. Longer days to root formation were noted in cuttings treated with 1000 ppm and control.

. Interaction effect. There were no significant interaction effects observed on the number of days to visible root formation of blueberry shoot tip cuttings as affected by duration of soaking and ANAA concentrations

Average Number of Roots per Cutting

Effect of soaking duration. Table 2 presents the average number of roots produced per cutting as affected by the different soaking duration used. Results show that 30 minutes soaking time promoted the production of more roots in blueberry shoot tip cutting with a mean of 6.0 roots per cutting, compared to 60 minutes soaking time which produced a lower number of roots of 5.0 roots per cutting.

Effect of ANAA concentration. The influence of different ANAA concentration used on the number of roots produced per cutting is shown in Table 2.

Shoot tip cutting of blueberry treated with 500 ppm ANAA produced the highest number of roots with a mean of 7.0 roots per cutting followed by those treated with 1000 ppm ANAA with a mean of 6.0 roots per cutting, while shoot tip cutting of blueberry treated with 750 ppm produced fewer roots on all treated cuttings with a mean of only 5.0 roots per cutting.

Table 2. Average number of roots produced per cutting

| TREATMENT | NUMBER OF ROOTS |
|---|---|
| Soaking Duration (minutes) | |
| 30 | 6[a] |
| 60 | 5[a] |
| ANAA Concentration (ppm) | |
| 0 | 4[b] |
| 500 | 7[a] |
| 750 | 5[a] |
| 1000 | 6[a] |
| T x C | ns |
| CV (%) | 40.16 |

*Means with the same letter are not significantly different at 5% level by DMRT.

Interaction effects. Results show that there were no significant interactions on the average number of roots per cuttings s affected by soaking durations and ANAA concentrations.

Percentage Survival

Effect of soaking duration. Table 3 shows the effect of duration on the percentage survival of shoot tip cuttings of blueberry.

Result shows that the shoot tip cuttings that were dipped for 30 minutes in ANAA showed the highest percentage of survival with a mean of 72%, compared to 60 minutes soaking showing time a percentage of survival with a mean of 69%.

Effect of ANAA concentration. The effect of ANAA concentration on the percentage survival of blueberry shoot tip cuttings rooted is shown in Table 3.

Results show that blueberry shoot tip cuttings treated with 500 ppm ANAA had the highest percentage of survival with a mean of 76 % followed by those applied with 750 ppm and 1000 ppm both having the same means of 69%.

Interaction effect. There were no significant interaction effects of soaking duration and different ANAA concentrations on the percentage of survival of blueberry shoot tip cuttings recorded 60 days from sticking in the rooting media.

Table 3. Percentage survival

| TREATMENT | SURVIVAL (%) |
|---|---|
| Soaking Duration (minutes) | |
| 30 | $72^a$ |
| 60 | $69^a$ |
| ANAA Concentration (ppm) | |
| 0 | $68^b$ |
| 500 | $76^a$ |
| 750 | $69^b$ |
| 1000 | $69^b$ |
| T x C | ns |
| CV (%) | 8.94 |

*Means with the same letter are not significantly different at 5% level by DMRT.

Percentage of Rooted Cuttings

Effect of soaking duration. The effect of duration on the percentage of rooted blueberry shoot tip cuttings is shown in table 4. Result show that there were no significant differences on the percentage of survival. It shows that cuttings treated with 30 minutes soaking and 1hour shows the same mean which is 49%.

Effect of ANAA concentration. The table shows that there were significant differences observed on the effect of different ANAA concentrations applied before planting on the percentage of rooted blueberry shoot tip cuttings two months from sticking on the rooting media. It was observed that the highest percentage of rooted cuttings was obtained from those soaked in 500ppm ANAA concentration which promoted the production of longer roots produced with means of 54% followed by those

Table 4. Percentage of rooted cuttings

| TREATMENT | ROOTED CUTTINGS (%) |
|---|---|
| Soaking Duration (minutes) | |
| 30 | 49[a] |
| 60 | 49[a] |
| ANAA Concentration (ppm) | |
| 0 | 46[b] |
| 500 | 54[a] |
| 750 | 49[b] |
| 1000 | 48[b] |
| T x C | ns |
| CV (%) | 22.75 |

*Means with the same letter are not significantly different at 5% level by DMRT.

treated with 750 ppm, 1000 ppm ANAA, and control with a mean of 49%, 48%, and 46% respect.

Interaction effect. There were no significant interaction effects obtained between the combined effects of soaking duration and ANAA concentrations on the percentage of rooted cuttings in blueberry.

Average Root Length

Effect of soaking duration. Table 5 represents the effects of soaking duration on the average root length in blueberry shoot tip cuttings. Results show that there were no significant statistical differences on the length of roots. However, numerical figures reveals that 30 minutes soaking time promoted the production of slightly longer root with

Table 5. Average root length

| TREATMENT | ROOT LENGTH (cm) |
|---|---|
| Soaking Duration (minutes) | |
| 30 | 0.58[a] |
| 60 | 0.51[a] |
| ANAA Concentration (ppm) | |
| 0 | 0.30[b] |
| 500 | 1.04[a] |
| 750 | 0.36[b] |
| 1000 | 0.33[b] |
| T x C | ns |
| CV (%) | 62.62 |

*Means with the same letter are not significantly different at 5% level by DMRT.

a mean of 0. 58 cm root length, compared to 60 minutes soaking time that showed shorter roots with a mean of 0.51 cm root length two months from the sticking in the media.

Effect of ANAA concentration. There were slight significant differences observed on the average number of roots after sticking on the rooting media as affected by different concentrations of ANAA used on blueberry shoot tip cuttings

Shoot tip cuttings of blueberry treated with 500 ppm ANAA produced the highest number of roots with a mean of 1.04 cm roots per cutting two months from sticking in the rooting media followed by those treated with 750 ppm ANAA with mean of 0.36 roots per cutting while shoot tip cuttings of blueberry treated with 1000 ppm ANAA produced significantly fewer roots with a mean of 0.33 cm roots per cutting. The lowest number of roots was obtained in the untreated cuttings with a mean of 0.30 roots per cutting.

Table 6. Average shoot length

| TREATMENT | SHOOT LENGTH (cm) |
|---|---|
| Soaking Duration (minutes) | |
| 30 | 12.66[a] |
| 60 | 12.61[a] |
| ANAA Concentration (ppm) | |
| 0 | 11.54[a] |
| 500 | 13.21[a] |
| 750 | 12.21[a] |
| 1000 | 12.59 |
| T x C | ns |
| CV (%) | 6.66 |

*Means with the same letter are not significantly different at 5% level by DMRT.

These findings corroborate with the statement of Devlin (1977) as cited by Relliota (1982), that auxins are very effective in initiating root formation in many plant species. Hormones may be used to overcome the inherent difficulties encountered in rooting of cuttings but many also inhibit the growth of the cuttings if applied at the wrong concentrations (Bleasedale 1973).

Interaction effect. The combined effects of duration and ANAA concentrations did not significantly affect roots produced by the blueberry cuttings two months after sticking.

Average Shoots Length (cm)

Effect of duration. The average shoot length as affected by different durations and concentration of rooting hormone is presented in Table 6.

Result show that dipping the cuttings for 30 minutes has the highest shoot length with a mean of 12.66 cm while 1hour soaking had the shortest shoot length with a mean of 12.61 cm. However, both treatments are statistically comparable with each other.

Effect of ANAA concentration. Results show that there were no significant differences on the length of shoots produced as affected by different ANAA concentrations measured 60 days from treatment. Nevertheless, dipping of cutting in 500 ppm ANAA prior to rooting produced the longest shoot with a mean of 13.21 cm, while the untreated cuttings had the shortest shoots of 11.54 cm.

These findings conform with the earlier study by Amlos (1989), wherein the application of ANAA at lower rates effected no significant differences on the number of days from sticking of cuttings to opening lateral buds, final length of shoots, leaf number of rooted cuttings.

Interaction effect. There were no significant interaction effects obtained between the duration and different ANAA concentration with regards to the average shoot length.

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was conducted at the Pomology Project, Benguet State University, La Trinidad, Benguet from January 2009 to March 2009 to determine the effects of soaking duration and ANAA concentrations applied on the root development and initial growth of blueberry shoot tip cuttings and the best concentrations of ANAA to promote root initiation of blueberry shoot tip cuttings.

Effect of soaking duration. Result shows that there were no significant differences observed on the number of days to visible root formation, average number of roots per cutting, percentage survival, percentage of rooted cuttings, average of root length, and average of shoot length as affected by the different soaking durations of blueberry cuttings in ANAA solutions.

Effect of ANAA concentration. Treating of blueberry cuttings with a rooting hormone at concentrations to 500 ppm, generally promoted earlier callus formation. Likewise, the application of 500 ppm ANAA was more effective in promoting faster roots formation. Cuttings treated with this concentration produced higher number of roots, had higher percentage of survival and had longer roots and shoots.

Interaction effect. The interaction between soaking duration and concentrations were not significant in all the parameters gathered.

Conclusions

Based on the result of the study, it is concluded that on duration, it was observe that there were no significant different effects on the number of days to visible root formation, average number of roots per cutting, percentage survival, percentage of rooted cuttings, average root length and average shoot length but in terms of concentration, basal ends treated with 500ppm ANAA concentration can be used to enhance faster rooting producing longer roots and higher percentage of rooted cuttings.

Recommendations

Based on the findings, it is recommended that treatment of basal stem ends with 500 ppm ANAA for 30 minutes can be used for blueberry shoot tip cuttings because it was observed to promote higher percentage of survival, rooting and root length. However, a follow up study is recommended with treatment modifications to really establish the effects of ANAA on the rooting of blueberry cuttings

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## APPENDICES

Appendix Table 1. Number of days to visible root formation

| TREATMENT | REPLICATION I | II | III | IV | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| 30 minutes | | | | | | |
| 0 ppm | 26 | 23 | 25 | 30 | 104 | 26 |
| 500 ppm | 23 | 21 | 23 | 25 | 92 | 23 |
| 750 ppm | 25 | 27 | 25 | 30 | 107 | 27 |
| 1000 ppm | 27 | 27 | 28 | 28 | 110 | 28 |
| 1 hour | | | | | | |
| 0 ppm | 26 | 25 | 25 | 28 | 104 | 26 |
| 500 ppm | 22 | 24 | 25 | 26 | 97 | 24 |
| 750 ppm | 23 | 25 | 30 | 28 | 106 | 27 |
| 1000 ppm | 23 | 26 | 28 | 30 | 107 | 27 |
| TOTAL | 195 | 198 | 209 | 225 | 827 | 208 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN SQUARE | COMPUTED F | TABULATED F 0.05 | 0.01 |
|---|---|---|---|---|---|---|
| Replication | 3 | 69.094 | 23.031 | | | |
| Factor A | 1 | 0.031 | 0.031 | $0.01^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 57.594 | 19.198 | 7.58** | 3.07 | 4.87 |
| A x B | 3 | 4.344 | 1.448 | $0.57^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 53.156 | 2.531 | | | |
| TOTAL | 31 | 184.219 | | | | |

* = Significant Coefficient of Variation = 6.16%

Appendix Table 2. Average number of root per cutting

| TREATMENT | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| 30 minutes | | | | | | |
| 0 ppm | 6 | 1 | 2 | 7 | 16 | 4 |
| 500 ppm | 5 | 8 | 8 | 9 | 30 | 8 |
| 750 ppm | 5 | 6 | 5 | 6 | 22 | 6 |
| 1000 ppm | 5 | 6 | 10 | 5 | 26 | 7 |
| 1 hour | | | | | | |
| 0 ppm | 6 | 2 | 2 | 7 | 17 | 4 |
| 500 ppm | 4 | 7 | 3 | 10 | 24 | 6 |
| 750 ppm | 5 | 4 | 5 | 4 | 18 | 5 |
| 1000 ppm | 2 | 4 | 7 | 8 | 21 | 5 |
| TOTAL | 38 | 38 | 51 | 56 | 194 | 41 |

ANALYSIS OF VARIANCE

| SOURCEOF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARE | MEAN SQUARE | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Replication | 3 | 23.375 | 9.125 | | | |
| Factor A | 1 | 6.125 | 6.125 | $1.28^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 30.625 | 10.208 | $2.14^{**}$ | 3.07 | 4.87 |
| A x B | 3 | 3.625 | 1.208 | $0.25^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 100.125 | 4.768 | | | |
| TOTAL | 31 | 167.875 | | | | |

ns = not significant　　Coefficient of Variation = 40.16

Appendix Table 3. Percentage Survival

| TREATMENT | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| 30 minutes | | | | | | |
| 0 ppm | 60 | 70 | 80 | 70 | 280 | 70 |
| 500 ppm | 80 | 80 | 70 | 80 | 310 | 78 |
| 750 ppm | 70 | 60 | 70 | 70 | 270 | 68 |
| 1000 ppm | 70 | 70 | 80 | 70 | 290 | 72 |
| 1 hour | | | | | | |
| 0 ppm | 60 | 60 | 70 | 80 | 270 | 68 |
| 500 ppm | 70 | 80 | 70 | 80 | 300 | 75 |
| 750 ppm | 70 | 70 | 70 | 70 | 280 | 70 |
| 1000 ppm | 70 | 70 | 60 | 60 | 260 | 65 |
| TOTAL | 550 | 560 | 570 | 580 | 2240 | 562 |

ANALYSIS OF VARIANCE

| SOURCEOF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARE | MEAN SQUARE | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Replication | 3 | 62.500 | 20.833 | | | |
| Factor A | 1 | 50.000 | 50.000 | $1.25^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 337.500 | 112.2 | $2.82^{ns}$ | 3.07 | 4.87 |
| A x B | 3 | 100.000 | 33.333 | $0.83^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 837.500 | 39.881 | | | |
| TOTAL | 31 | 1387.500 | | | | |

ns = not significant

Coefficient of Variation = 8.94%

Table 4. Percentage of rooted cuttings

| TREATMENT | REPLICATION I | II | III | IV | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| 30 minutes | | | | | | |
| 0 ppm | 50 | 40 | 40 | 60 | 190 | 48 |
| 500 ppm | 50 | 70 | 50 | 50 | 220 | 55 |
| 750 ppm | 40 | 50 | 50 | 50 | 190 | 48 |
| 1000 ppm | 40 | 50 | 50 | 50 | 180 | 45 |
| 1 hour | | | | | | |
| 0 ppm | 40 | 40 | 40 | 60 | 180 | 45 |
| 500 ppm | 60 | 60 | 50 | 40 | 210 | 53 |
| 750 ppm | 40 | 30 | 80 | 50 | 200 | 50 |
| 1000 ppm | 50 | 50 | 50 | 50 | 200 | 50 |
| TOTAL | 380 | 390 | 400 | 410 | 1570 | 394 |

ANALYSIS OF VARIANCE

| SOURCEOF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARE | MEAN SQUARE | COMPUTED F | TABULATED F 0.05 | 0.01 |
|---|---|---|---|---|---|---|
| Replication | 3 | 109.375 | 36.459 | | | |
| Factor A | 1 | 3.125 | 3.125 | $0.02^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 259.375 | 86.458 | $0.69^{ns}$ | 3.07 | 4.87 |
| A x B | 3 | 84.375 | 28.125 | $0.22^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 2615 | 124.554 | | | |
| TOTAL | 31 | 3071.875 | | | | |

ns = not significant    Coefficient of Variation = 22.75

Appendix Table 5. Average root length

| TREATMENT | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| 30 minutes | | | | | | |
| 0 ppm | 0.7 | 0.21 | 0.25 | 1.3 | 1.82 | 0.46 |
| 500 ppm | 0.35 | 1.4 | 1.3 | 1.3 | 4.35 | 1.09 |
| 750 ppm | 0.4 | 0.4 | 0.5 | 0.35 | 1.65 | 0.41 |
| 1000 ppm | 0.4 | 0.25 | 0.75 | 0.06 | 1.46 | 0.37 |
| 1 hour | | | | | | |
| 0 ppm | 0.06 | 0.15 | 0.2 | 0.75 | 1.75 | 0.44 |
| 500 ppm | 0.25 | 1.4 | 1.4 | 0.9 | 3.95 | 0.99 |
| 750 ppm | 0.2 | 0.25 | 0.3 | 0.45 | 1.2 | 0.30 |
| 1000 ppm | 0.4 | 0.25 | 0.35 | 0.1 | 1.2 | 0.30 |
| TOTAL | 2.14 | 4.3 | 5.05 | 5.21 | 17.38 | 4.36 |

ANALYSIS OF VARIANCE

| SOURCEOF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARE | MEAN SQUARE | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Replication | 3 | 0.943 | 0.314 | | | |
| Factor A | 1 | 0.043 | 0.043 | $0.36^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 2.663 | 0.88 | $7.66^{**}$ | 3.07 | 4.87 |
| A x B | 3 | 0.011 | 0.004 | $0.03^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 2.432 | 0.116 | | | |
| TOTAL | 31 | 6.092 | | | | |

ns = not significant

** = significant

Coefficient of Variation = 62.62%

Appendix Table 6. Average shoot length

| TREATMENT | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| 30 minutes | | | | | | |
| 0 ppm | 12.25 | 12.65 | 11.95 | 13.65 | 50.5 | 12.63 |
| 500 ppm | 12.75 | 12.85 | 13.75 | 12.85 | 52.20 | 13.05 |
| 750 ppm | 12.15 | 13.35 | 10.6 | 13.65 | 49.75 | 12.44 |
| 1000 ppm | 11.75 | 13.5 | 13.05 | 11.85 | 50.15 | 12.54 |
| 1 hour | | | | | | |
| 0 ppm | 11.75 | 12.5 | 12.8 | 3.1 | 49.80 | 11.99 |
| 500 ppm | 13.8 | 13.25 | 14.1 | 12.25 | 53.45 | 13.36 |
| 750 ppm | 11.5 | 12.00 | 11.2 | 13.25 | 47.95 | 12.45 |
| 1000 ppm | 11.75 | 12.065 | 13.3 | 12.9 | 50.60 | 12.65 |
| TOTAL | 97.7 | 102.4 | 100.8 | 103.5 | 397.95 | 101.11 |

ANALYSIS OF VARIANCE

| SOURCEOF VARIATION | DEGREES OF FREEDOM | SUM OF SQUARE | MEAN SQUARE | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Replication | 3 | 2.338 | 0.796 | | | |
| Factor A | 1 | 0.020 | 0.020 | $0.03^{ns}$ | 4.32 | 8.02 |
| Factor B | 3 | 4.128 | 1.376 | $1.94^{ns}$ | 3.07 | 4.87 |
| A x B | 3 | 0.667 | 0.222 | $0.31^{ns}$ | 3.07 | 4.87 |
| Error | 21 | 14.897 | 0.709 | | | |
| TOTAL | 31 | 22.100 | | | | |

ns = not significant

Coefficient of Variation = 6.66%