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BANWA, ALBASTRO C. APRIL 2010. Effect of Different ANAA Concentration on the Rooting and Growth of Tamarillo (*Solanum betaceum L.*) Shoot Tip Cuttings. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted at the Pomology Project, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from November 2009 to January, 2010 to find out the effect of the different concentration of ANAA on the shoot tip cuttings of tamarillo and to determine the best concentration of ANAA that will promote earlier and uniform rooting of tamarillo shoot tip cuttings.

Result show that cuttings treated with 250 ppm ANAA had the highest percentage of rooted cuttings with a mean of 57.14%, it also obtained the longest root length which has a mean of 13.9. After 60 days observation it also obtained the highest number of roots produced per cutting, percentage of survival, number of leaves per plant and longest shoot with mean of 10.75, 57.14%, 6.75 and 19.25 cm respectively. However, cuttings treated with 500 ppm ANAA rooted earlier with a mean of 21.5 days while cuttings treated with 1000 ppm ANAA the earliest to show appearance of leaves with a mean of 15.75 days.

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INTRODUCTION

The tamarillo, tree tomato, or *tomate de arbol* is the edible fruit of *solanum betaceum*, a species of small tree or shrub in the flowering plant family *Solanaceae*. It is egg-shape, with a thin deep or yellow skin and a soft flesh (when ripe), with dark-colored seeds occupying about one third of the interior. Prior to 1967, the tamarillo was known as the "tree tomato" in New Zealand, but a new name was chosen by the New Zealand Tree Tomato Promotion Council in order to distinguish it from the ordinary garden tomato and increase its exotic appeal. The choice is variously explained by similarity to the word "tama" for "leadership". It is still called Tree Tomato in the rest of the world (Morton, 1987).

The tamarillo is a small, attractive, half-woody, evergreen or partially deciduous, shrub or small tree. It is also brittle and shallow-rooted, growing to a height of 10 to 18 ft. (rarely as much as 25 ft). The alternate, evergreen leaves are muskily odorous and more or less heart-shaped at the base and ovate, pointed at the apex. They are 4 to 13-1/2 inches long and 1-1/2 to 4-3/4 inches broad, thin, and softly hairy, with conspicuous veins. The leaves are fairly easily tattered by strong winds. The fragrant ½ to ¾ inch flowers are borne in small, loose clusters near the branch tips. They have 5 pale pink or lavender, pointed loves, 5 prominent yellow stamens and green purple calyx. Tamarillo flowers are normally self-pollinating. If wind is completely cut off so as not to stir branches, this may adversely affect pollination unless there are bees to transfer the pollen. Unpollinated flowers will drop prematurely. Flowers are usually borne in late summer or fall, but may appear at any time. The long-stalked, dangling fruit, borne singly or in clusters of 3 to 12, is smooth egg-shaped but pointed at both ends. It ranges in size from

2 to 4 inches long and 1-1/2 to 2 inches in width. Skin color may be solid deep purple, blood red, orange or yellow, or red and yellow, and may have faint dark longitudinal stripes. Flesh color varies accordingly from orange-red or orange to yellow or cream-yellow. While the skin is somewhat tough and unpleasant in flavor, the outer layer of the flesh is slightly firm, succulent and bland, and the pulp surrounding the seed in two lengthwise compartments is soft, juicy and sweet/tart. The yellow types are usually a little sweeter. The pulp is black in dark purple and red fruits and yellow in yellow and orange fruits. The edible seeds are thin, nearly flat, circular, larger and harder than those of the true tomato (Morton, 1987).

The tamarillo is generally believed to be native to the Andes of Peru and probably also, of Chile, Ecuador and Bolivia. It is cultivated and naturalized in Argentina, Brazil, Columbia and Venezuela. It is widely grown in New Zealand as a commercial crop. Seed from Argentina were imported by the U.S. Dept. of Agriculture in 1913 and a plant was fruiting at the Plant Introduction Station at Chico, Calif. in 1915 (Morton, 1987).

The tamarillo is subtropical rather than tropical and flourishes between 5,000 and 10,000 ft. in its Andean homeland. In cooler climates it succeeds at lower elevations, but does best where the temperature remains above 50^{o}F. The plant is grown casually in California and occasionally in Florida. Tamarillos have been successfully grown in such northern California locations at San Rafael and Santa Rosa. Frost at 28^{o}F kills small branches and foliage of mature trees but not the largest branches and main stem. The tree will recover if such frosts are not prolonged or frequent. However, seedlings and cuttings are readily killed by frost during their first year (Morton, 1987).

Seeds and cuttings may be used for propagation. Seeds produces a high-branched, erect tree, while cuttings develop into a shorter, bushy plant with low –lying branches. The tree does not always come true from seed, but is most likely to if one is careful to take seed from red fruits with black seed pulp or freezer for 2 4 hours before planting out. Cuttings should be 1 to 2 year old wood 3/8 to 1 inch thick and 18 to 30 inches long. The leaves are removed and the base cut square below a node. Cuttings can be planted directly in the ground, but should not be permitted to fruit the first year (Morton, 1987).

Cuttings are still the most important means of propagating ornamental shrubs, deciduous species as well as the broad leaf plant. Auxins generally stimulate rooting and had been confirmed in several research findings.

The study was conducted to evaluate the rooting and growth of the cuttings as affected by different concentrations of ANAA and its significant effects on the rooting characteristics of the plant.

The study is important to future researchers for it will surely provide appropriate information in the researches regarding tamarillo. The result also of the study is important as it will serve as a guide to the people such as farmers, producers and prospective g rowers who would like to plant tamarillo in their backyard or in their farms. If the result of the study be conclusive, it will be extended to the tamarillo growers or producers as well as in the community to encourage more production of the commodity.

The study aimed to determine the effects of the different concentration of ANAA on the rooting and shoot growth of shoot tip cuttings of tamarillo; and to determine the

best concentrations of ANAA that will promote earlier and uniform rooting and growth of tamarillo shoot tip cuttings.

The study was conducted at the Pomology project, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from November 2009 to January 2010.

REVIEW OF LITERATURE

Cuttings as Propagules

Hartman and Kester (1975) stated that softwood cuttings generally root easier and quicker than hardwood cuttings because they readily respond to treatments with root promoting substances. They stated further that stem cutting is the most practical and economical method of propagating ornamental shrubs.

Greater uniformity is obtained from asexual propagation through the absence of variation where by parent plants reproduce exactly with no genetic change (Hartman and Kester, 1975). Cuttings from the vegetative part of plants are possible due to their capacity for regeneration. Stem cuttings (from vegetative part of plants) have the ability to form adventitious roots which can regenerate a new school system.

Edmund et al., (1978) pointed out that propagating plants through cuttings and other vegetative means prevent many advantages to the growers. They noted that same plants are more economically propagated by vegetative means than by seeds. Some seeds also germinate with difficulty and the resulting plants are not true to their parents.

Rooting Hormones

Rooting hormones help in the stimulation of root initiation with a larger percentage of roots formed in cuttings and a f aster rooting time. Growth regulators may alter the type of roots formed as well as the numbers of roots produced (Brown, 1996). Rieley and Shry (1999) stated that the development of rooting hormones made the possibility of rooting certain plant cuttings that were considered impossible to root before. This chemical also shortened the length of time required to root cuttings.

Hartman and Kester (1975) recommended the use of ANAA and IBA for general use in rooting stem cuttings of most plant species. They added that ANAA was already tested for its activity in promoting roots in stem segments. It is not well accepted and had been accepted and had been confirmed that auxin, naturally or exogenously applied, is requirement for the initiation of the adventitious roots in stem cuttings. Weaver (1972) however, mentioned that among the several auxin derivatives used to induce rooting, the best so far is IBA because it is retained near the site application due to its low translocation. The IAA, on the other hand, has also a similar effect but it is also unstable and is easily translocated, thus IBA is more preferred. Auxins promotes root but inhibits root elongation (Strave and Moser, 1984) and that IBA is more effective than ANAA in the promotion of rooting cuttings (Griffith, 1940. Delargy and Wright, 1979).

Janick (1972) mentioned that the rooting of cuttings positively influenced by auxins. The auxin level is closely related with adventurous rooting of stem cuttings. It was also noted that in the variety in such compounds, the greatest degree of success have been achieved with IBA.

Rooting hormones are generally used to aid root formation. Some plants root more easily than others because they produce higher level of natural hormones. These plants need less synthetic rooting hormones to root satisfactorily (Ingles, 1994).

Hormone Concentration

According to Krishnamoorthy (1981) the optimum concentration of auxin required for a particular species under the prevailing condition to work out as this depend upon the number of factors. Toxic concentration would inhibit rooting and very low concentration would be ineffective. Concentration of 10-100mg/1 would suffice in most

of the cases. Bleasedale in 1973 added that, rooting could be inhibited if auxin are applied at wrong concentration.

Adriance and Brison (1955) stated that the best stimulation of root formation is usually obtained from concentrations just below the toxic level. This is because high concentrations may injure or kill the cuttings, and low concentrations may eb effective (Halfacre and Barden, 1979), root formation, however, is more stimulated at lower concentration than shoot.

Conquist (1982) stated that roots are typically the organs that anchor the plant into soil and absorb water and minerals. Riely and Shry (1999) stated that roots are usually underground and hence are not easily visible.

Misting

Root formation in cuttings is not only affected by hormones but also by other factors like environment, rooting medium, chemical treatment as well as the plant itself as a factor Adriance and Brison, (1955). Cuttings can absorb small amount of water through its cut end but the amount of water absorbed is not enough to replaced 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 of the cuttings and keeping the temperature relatively lower. Misting or sprinkling water can increase relative humidity.

MATERIALS AND METHOD

Materials

The materials used in the study was PEP bags (8x8x14) ANAA, shoot tip cuttings of tamarillo about 15 cm, cutter, pruning shear, compost, graduated cylinder, watering can and measuring materials.

Methodology

The cutting was obtained from healthy mother plants and it was obtained by measuring the length at least 15 cm before it is cut by using pruning shear or detached from the mother plant. Before rooting, all expanded leaves were remove leaving of those at the tip and the basal ends of the cuttings was cut again in slanting manner before soaking in the different concentrations of rooting hormones (ANAA) for thirty minutes. After the soaking treatment, the cuttings was rooted in a well prepared rooting medium 1:1 alnus leaves compost and sandy loam soil placed in polyethylene plastic bags.

There were seven sample cuttings per treatment replicated four times and was laid out in a Randomized Complete Block Design (RCBD). Watering was done everyday to prevent wilting of cutting until roots was formed.

The treatment was as follows:

Treatment	ANAA Concentration (ppm)
T_1	Control
T_2	250
T_3	500
T_4	750
T_5	1000

The data gathered are the following:

1. Days from sticking to visible root formation. This was gathered by counting the number of days from treatment to visible root formation through destructive sampling method. There were two (2) samples per treatment using white plastic.

2. Percentage of rooted cuttings. This was obtained two months after sticking of the cuttings in the rooting media using the formula:

$$\% \text{ of root cuttings} = \frac{\text{Number of rooted cuttings}}{\text{Total Number of Cuttings}} \times 100$$

3. Average root length (cm). The length of roots for every cutting was measured two months after planting and the average root length was computed as follows:

$$\text{Average root length} = \frac{\text{Length of roots}}{\text{Total root number}}$$

4. Average number of roots produced per cuttings. This was taken by counting all the roots produced in each individual stem cutting two months from sticking of cutting using the formula:

$$\text{Average number of roots} = \frac{\text{Number of roots}}{\text{Number of cuttings}}$$

5. Percentage survival (%). This was obtained by using the formula:

$$\% \text{ Survival} = \frac{\text{Number of cuttings survive}}{\text{Total number of cuttings}} \times 100$$

6. Number of days to first appearance of leaves. This was taken by counting the number of days from planting to first appearance of leaves.

7. Average number of leaves per plant. This was obtained by counting the leaves per plant after two months.

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

9. Photo documentation. This was taken during the experiment. Figure 1 shows an overview of the study at the termination of data collection.

Figured 1. Overview of the study at the termination of data collection

RESULTS AND DISCUSSION

Days from Sticking to Visible Root Formation (1 cm. root size)

Statistical analysis show highly significant differences among the treated and untreated on the number of days from sticking to visible root formation as shown in Table 1.

Tamarillo shoot tip cuttings treated with 500 ppm ANAA were observed to roots earlier with a mean of 21.5 days from sticking. Cuttings treated with 250 ppm ANAA initiated visible roots after 26 days; however, it was comparable to cuttings treated with 750 ppm ANAA having a mean of 27.75 days. The cuttings treated with 1000 ppm ANAA initiated visible roots after 29.5 days while the untreated cuttings had the longest duration of root formation with a mean of 44.5 days from sticking. Figure 2 shows roots and shoots formed in tamarillo shoot tip cuttings two months after sticking in the rooting media as affected by different ANAA concentrations.

Based on these results the application of rooting hormones like ANAA was effective in enhancing earlier formation of visible roots of tamarillo shoot tip cuttings.

Table 1. Days from sticking to visible root formation

TREATMENT	DAYS
0	44.50a
250 ppm	26.00c
500 ppm	21.50d
750 ppm	27.75c
1000 ppm	29.50b

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

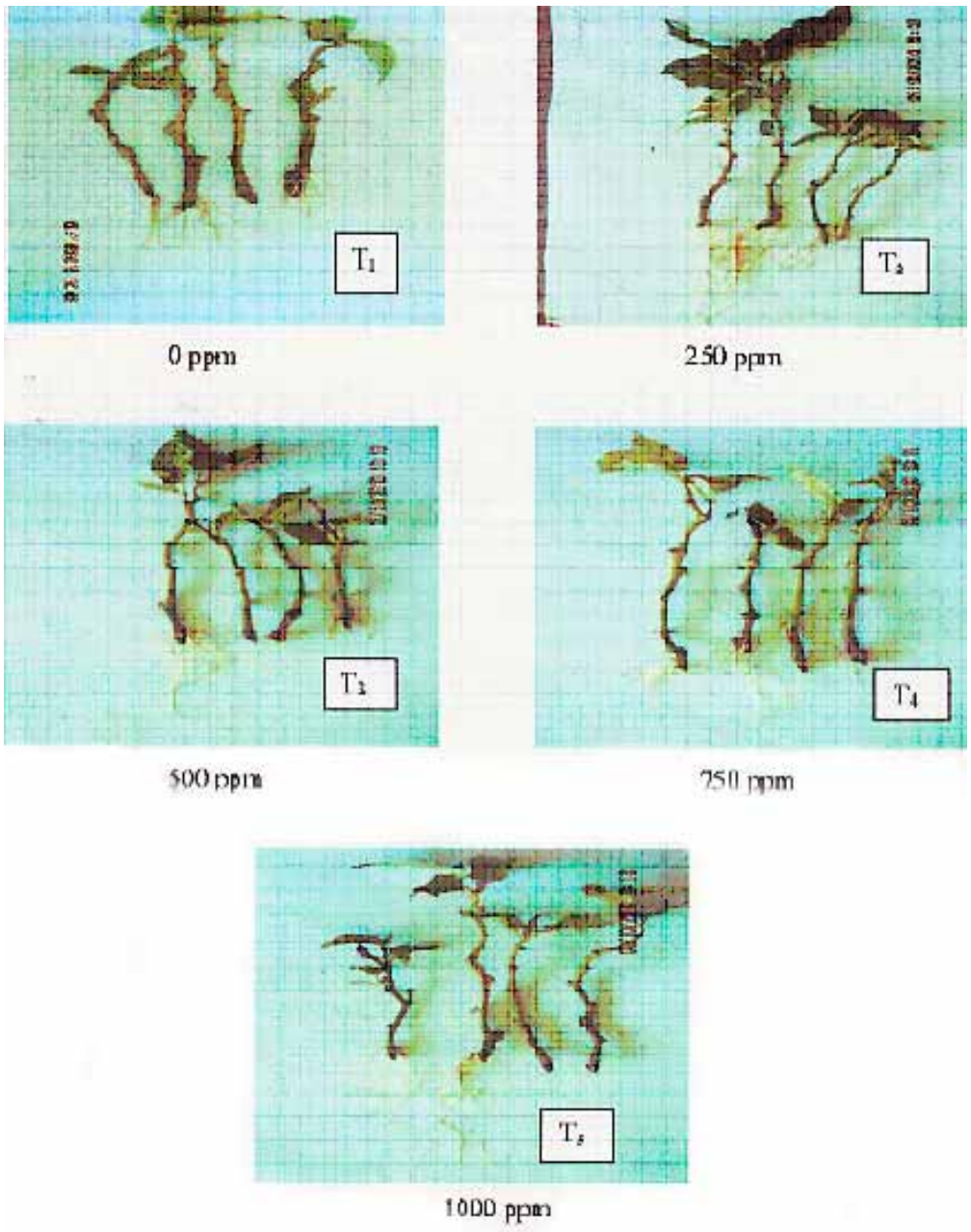

Figure 2. Roots and shoots formed in tamarillo shoot tip cuttings two months after sticking in the rooting media as affected by different ANAA concentrations

These results agree with the statement of Bleasedale (1973) that although hormones were known to promote earlier rooting of various kinds of cuttings, it is important to take into consideration the individual plant species and different cultivar needs specific concentration to be used.

The results in Table 2 show significant differences on the percentage of rooted cuttings as affected by the different ANAA concentrations.

It was observed that the highest numerical percentage of rooted cuttings was obtained from those treated with 250 ppm ANAA with a mean of 57.14% followed by the cuttings treated with 750 ppm and 1000 PPM ANAA having the same means of 53.57% then followed by the cuttings treated with 500 ppm ANAA and the untreated (control) with mean of 50% and 32.14%; respectively. Statistically, all the treated cuttings were statistically comparable with each other.

Adriance and Brison (1955) concluded that it is important to use the lowest concentration of rooting hormones that will give the minimum percentage of rooting and number of roots per cutting.

Table 2. Percentage of rooted cuttings

TREATMENT	PERCENTAGE
0	32.14b
250 ppm	57.14a
500 ppm	50.00a
750 ppm	53.57a
1000 ppm	53.57a

Mean with the same letter are not significantly different at 5% level of DMRT

Based on these results, the use of ANAA as a rooting hormone ensures higher percentage of rooted cuttings of tamarillo as compared to the untreated cuttings.

Related to these statements, the results of this study is comparable to the earlier findings which show that using lower concentrations of ANAA gave the highest percentage of rooted cuttings.

Statistical analysis shows the average root length of roots produced by the shoot tip cuttings of tamarillo had no significant statistical differences observed as affected by the different concentrations of ANAA as shown in Table 3.

However, numerical results showed that the application of 250 ppm ANAA promoted the longest roots produced with a mean of 13.4 cm followed by cuttings treated with 1000 ppm, 500 ppm ANAA and the control with means of 11.98 cm, 10.35 and 8.2 cm; respectively. Cuttings treated with 750 ppm ANAA had the shortest average root length having a mean of only 5.05 cm.

According to Devlin and Jackson (1961) the real stimulation of root elongation maybe achieved if enough concentrations are used.

Table 3. Average root length

TREATMENT	AVERAGE ROOT LENGTH (cm)
Control	8.20a
250 ppm	13.40a
500 ppm	10.35a
750 ppm	5.05a
1000 ppm	11.98a

Mean with the same letters are not significantly different at 5% level of DMRT

Akyapat (2009), found that ANAA enhances the growth of the main axis not only increased cell division and elongation but also increased the length of the lateral roots.

Reiley and Shry (1999) stated that some plants root easily from hard wood. In addition, they stated that cuttings require essentially the same conditions that seeds need to germinate; moisture oxygen and warmth {%^{o}F (%^{o}C)} or above for them to root.

The average number of roots produced per cutting as affected by the different ANAA concentrations on the shoot tip cuttings of tamarillo are shown in Table 4.

Results show that there were no significant statistical differences among the treated and untreated cuttings. However, numerical figures showed that the cuttings treated with 250 ppm ANAA obtained the highest mean of 10.75 followed by the cuttings treated with 750 ppm ANAA, the untreated (control) and cuttings treated with 1000 ppm ANAA with means of 9.25, 9.0 and 7.5. The least mean was noted on the cuttings treated with 500 ppm ANAA.

Table 4. Average number of roots produced per cuttings

TREATMENT	NUMBER OF ROOTS
Control	9.00a
250 ppm	10.75a
500 ppm	6.75a
750 ppm	9.25a
1000 ppm	7.50a

Mean with the same letters are not significantly different at 5% level of DMRT

Krishnamoorthy (1981) stated that toxic concentration would inhibit rooting and very low concentrations would be ineffective. Concentrations of 10-100 g/l would suffice most of the cases. In addition, Adriance and Brison (1955) noted that the best stimulation of root formation is usually obtained from concentrations just below the toxic level.

According to Bleasedale (1973), 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 concentration. These chemical not only speed up the healing of the wound and the production of roots, but they also induce the development of a large number of roots and are now used widely propagation of several plants.

Table 5 shows the effect of the different concentrations of ANAA used on the percentage of survival of the rooted shoot tip cuttings of tamarillo.

Table 5. Percentage of survival

TREATMENT	PERCENTAGE (%)
Control	32.14b
250 ppm	57.14a
500 ppm	53.57a
750 ppm	53.57a
1000 ppm	53.57a

Mean with the same letters are not significantly different at 5% level OF DMRT

Statistically, there were significant differences observed among the treatment means as shown in the results. Findings shows that treated and untreated cutting were not the same with regards to the percentage of survival which means that their effect on the survival of cuttings differed significantly. However, among the treated cuttings, the differences were not statistically significant; but numerically, it was observed that cuttings treated with 250 ppm ANAA had the highest percentage of survival with a mean of 57.14%. It was followed by cuttings treated with 500 ppm, 750 and 1000 ppm ANAA with a mean of 53.57% and the lowest percentage were obtained from the untreated cuttings with a mean of 32.14%.

Based on these results, the use of the ANAA at different concentrations ensures higher percentage of survival of tamarillo cuttings.

Bleasedale in 1973 reported that, many investigations have shown that the application of certain chemicals promoted the development of roots of stem cuttings. Of the numerous chemicals which have been tested IBA, IAA and NAA have produced the most striking results. These chemicals not only speed up the healing of the wound and the production of roots, but they also induce the development of a large number of roots and are now used widely in propagation of several plants.

Bir and Bilderback (2004), stated that it is important to use the lowest concentration of rooting hormones that will give the maximum percentage of rooting and number of roots per cutting.

The influence of the different concentrations of ANAA on the number of days to first appearance

Table 6. Number of days from sticking to first appearance of leaves

TREATMENT	NUMBER OF DAYS
Control	30.75a
250 ppm	19.25d
500 ppm	25.75b
750 ppm	24.75c
1000 ppm	15.75e

Mean with the same letters are not significantly different at 5% level OF DMRT

It was observed that the cuttings treated with 1000 ppm ANAA with a mean of 15.75 days were the earliest to show of leaf initials. It was followed by cuttings soaked in 250 ppm ANAA with a mean 19.25 days. The cuttings treated with 750 ppm ANAA and 500 ppm ANAA had comparable means of 24.75 and 25.27 days respectively. The untreated cuttings had again the longest duration of leaf appearance with a mean of 30.75 days from sticking.

Based on this result, the use of the different ANAA concentrations had effectively enhanced faster shoot development and the first appearance of leaves in the cuttings of tamarillo.

These findings collaborate with the findings from earlier study of Amlos (1998), that application of ANAA at lower rates had no significant effect on the number of days to opening of lateral buds, final length of shoots, leaf number and percentage of rooted cuttings.

Table 7 shows the significant differences on the average number of leaves per plant as affected by different concentrations of ANAA.

The shoot tip cuttings of tamarillo treated with 250 ppm ANAA had the highest average number of leaves produced with mean of 6.75 leaves per plant two months from sticking. It was followed by cuttings treated with 1000 ppm and 750 ppm ANAA with means of 4.25. The lowest numbers of leaves were obtained from the untreated cutting or control having a mean of 3.5.

Results of the study, shows that applications of rooting hormone like ANAA had a significant effect producing the highest average number of leaves per plant in the shoot tip cuttings of tamarillo.

Hartman and Kester (1975) recommended the use of ANAA and IBA for general use in rooting stem cuttings of most plant species. They added that ANAA was already tested for its effectivity in the promotion of roots in stem segments.

Table 7. Average number of leaves per plant

TREATMENT	AVERAGE NUMBER OF LEAVES
0	3.50b
250 ppm	6.75a
500 ppm	21.75ab
750 ppm	21.25ab
1000 ppm	4.50ab

Mean with the same letters are not significantly different at 5% level OF DMRT

As shown in Table 8 the length of shoots produced as affected by the different ANAA concentration showed that there were no significant statistical differences among the treatment.

Numerically, figures showed that cuttings treated with 250 ppm ANAA obtained the highest mean of 19.25 cm followed by cuttings treated with 1000 ppm ANAA with a mean of 17.50 cm. It was also followed by the cuttings treated with 750 ppm ANAA and the control with a mean of 16.98 and 16.83 cm while cuttings treated with 500 ppm ANAA has the least mean of 15.95 cm.

According to Weaver (1972), that among the several auxins derivatives used to induce rooting, the best so far is IBA because it is retained near the site of application due to its slow translocation. The ANAA, on the other hand, has also a similar effect but it is very unstable and is easily translocated, thus IBA is more preferred.

Table 8. Shoot length

TREATMENT	SHOOT LENGTH (cm)
0	16.83a
250 ppm	19.25a
500 ppm	15.93
750 ppm	16.98a
1000 ppm	17.50a

Mean with the same letters are not significantly different at 5% level of DMRT

Adriance and Brison (1955) stated that the best stimulation of root formation is usually obtained from concentrations just below the toxic level. This is because high concentrations may injure or kill the cutting and low concentration maybe effective in root formation (Harfacre and Barden, 1979).

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was conducted at the Pomology Project, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from November 2009 to January 2010.

The study was conducted to find out the effect of the different ANAA concentration on the growth of shoot tip cuttings of tamarillo and to determine the best concentration of ANAA that will promote earlier and uniform rooting and growth of tamarillo shoot tip cuttings.

Result show that cuttings treated with 500 ppm ANAA rooted earlier with a mean of 21.5 days while untreated cuttings had the longest duration to initiate visible root formation with a mean of 44.5 days. Cuttings treated with 250 ppm ANAA had the highest percentage of rooted cuttings with a mean of 57.14% which had the lowest percentage of rooted cuttings. Longest root length were obtained from cuttings treated with 250 ppm ANAA with a mean of 13.9 cm while the shortest root length were obtained from cuttings treated with 750 ppm ANAA with a mean of 5.05 cm. The highest number of roots produced per cuttings were derived from cuttings treated with 250 ppm ANAA while cuttings treated with 500 ppm ANAA had the lowest number of roots produced per cutting with a means of 57.14% had the highest percentage of survival while untreated cuttings with a mean of 32.14% had the lowest percentage of survival. The earliest to show appearance of leaves were observed from cuttings treated with 1000 ppm ANAA with a mean of 15.75 days while untreated cuttings had the longest duration in appearance of leaves with a mean of 30.75 days. Cuttings treated with 250 ppm

ANAA with a mean of 6.75 had the highest number of leaves per plant while untreated cuttings with a mean of 3.5 had the lowest number of leaves per plant. Longest length of shoots were obtained from cuttings treated with 250 ppm ANAA while shorter root length were obtained from cuttings treated with 500 ppm ANAA with means of 19.25 cm and 15.93 cm.

Conclusions

Based from the results, it is therefore concluded that the use of rooting hormone was effective especially in the shoot tip cuttings of tamarillo propagation. The use of 250 ppm ANAA produced the highest percentage of rooted cuttings, highest average of root length, highest percentage of survival and production of more roots and leaves. Treating shoot tip cuttings of tamarillo also with rooting hormones could be done to shorten the time to produce roots and leaves and to increase the percentage of survival.

Recommendations

From the proceeding results and discussions, the use of low concentration of ANAA as a rooting hormone at 250 ppm, is recommended in the propagation of tamarillo shoot tip cuttings since it promoted the highest percentage of rooted cutting and highest percentage of survival. It also induced production of longer roots, and shoots and enhanced the production of more roots and leaves.

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APPENDICES

Appendix Table 1. Days from sticking to visible root formation

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	44	45	43	46	178	44.50
250 ppm	25	26	27	26	104	26.00
500 ppm	21	22	20	23	86	21.50
750 ppm	27	28	27	29	111	27.75
1,000 ppm	29	30	28	31	118	29.50
TOTAL	146	151	145	155	597	149.25

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	19.40	6.47			
Treatment	4	1229.20	307.30	317.90**	3.26	5.41
Error	12	11.60	0.47			
TOTAL	19	1260.20				

** - Highly significant

Coefficient of variation = 3.31%

Appendix Table 2. Percentage of rooted cuttings

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	3	1	2	3	9	32.14
250 ppm	2	5	6	3	16	57.14
500 ppm	3	6	3	2	14	50.00
750 ppm	4	5	4	2	15	53.57
1,000 ppm	3	6	2	4	15	53.57
TOTAL	17	23	17	14	67	246.42

ANALYSIS OF VARIA NCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	9.75	3.25			
Treatment	4	7.70	1.93	0.91*	3.26	5.41
Error	12	25.50	2.13			
TOTAL	19	42.95				

* - Significant

Coefficient of variation = 2.96%

Appendix Table 3. Average root length

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	16.8	7.5	2.2	6.3	32.8	8.2
250 ppm	22.8	21.3	8.5	3.0	55.6	13.90
500 ppm	6.6	10.9	5.4	18.5	41.4	10.35
750 ppm	6.7	6.6	4.5	2.4	20.2	5.05
1,000 ppm	4.1	25.3	3.5	15.0	47.9	11.98
TOTAL	57	71.6	24.1	45.2	197.90	49.48

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	241.66	80.55			
Treatment	4	187.68	46.92	0.45^{ns}	3.26	5.41
Error	12	592.63	49.49			
TOTAL	19	1021.41				

Ns – not significant

Coefficient of variation = 42.71%

Appendix Table 4. Average number of roots produced per cuttings

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	15	4	5	12	36	9.00
250 ppm	14	12	7	10	43	10.75
500 ppm	14	2	14	7	37	6.75
750 ppm	6	11	16	4	37	9.25
1,000 ppm	7	13	5	5	30	7.5
TOTAL	56	42	47	38	183	43.25

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	46.15	15.38			
Treatment	4	39.30	09.83	0.42^{ns}	3.26	5.41
Error	12	274.10	23.26			
TOTAL	19	366.55				

Ns – not significant Coefficient of variation = 35.16%

Appendix Table 5. Percentage of survival (%)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	3	1	2	3	9	32.14
250 ppm	2	5	6	3	16	57.14
500 ppm	3	7	3	2	15	53.57
750 ppm	4	5	4	2	15	53.57
1,000 ppm	3	6	2	4	15	53.57
TOTAL	15	24	17	14	70	249.99

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	12.20	4.07			
Treatment	4	08.00	2.00	.83%	3.26	5.41
Error	12	28.80	2.40			
TOTAL	19	49.00				

* - Significant

Coefficient of variation = 3.10%

Appendix Table 6. Number of days to first appearance of leaves

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	30	32	30	31	123	30.75
250 ppm	19	20	18	20	77	19.25
500 ppm	25	27	25	26	103	25.75
750 ppm	24	25	24	26	99	24.25
1,000 ppm	15	16	15	17	63	15.75
TOTAL	113	120	112	120	465	116.25

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	11.35	3.78			
Treatment	4	548.00	137.00	685.00**	3.26	5.41
Error	12	2.40	.20			
TOTAL	19	561.75				

** - Highly significant

Coefficient of variation = 1.92%

Appendix Table 7. Average number of leaves per plant

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	9	3	6	1	14	3.50
250 ppm	8	6	6	7	27	6.75
500 ppm	4	4	7	4	19	4.75
750 ppm	5	4	4	4	17	4.25
1,000 ppm	8	3	4	4	18	4.50
TOTAL	29	20	27	20	95	23.75

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	12.15	4.05			
Treatment	4	23.50	5.88	2.51^{ns}	3.26	5.41
Error	12	28.10	2.34			
TOTAL	19	63.75				

Ns = not significant

Coefficient of variation = 32.22%

Appendix Table 8. Shoot length (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
0 ppm	16.2	18.0	16.0	17.1	67.3	16.83
250 ppm	24.0	18.0	16.0	19.0	77.0	19.25
500 ppm	20.4	12.2	13.0	18.0	63.7	15.93
750 ppm	16.8	18.0	13.0	20.1	67.9	16.98
1,000 ppm	21.0	14.0	16.7	18.3	70.0	17.50
TOTAL	98.4	80.2	74.7	92.5	345.9	86.49

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULAR F 0.05	0.01
Replication	3	71.31	23.77			
Treatment	4	24.53	6.13	1.13^{ns}	3.26	5.41
Error	12	65.16	5.43			
TOTAL	19	161.00				

Ns = not significant

Coefficient of variation = 13.48%