**BIBLIOGRAPHY**

DIWAYAN, MERJIL B. APRIL 2010. Rooting Characteristics of Saint John's-Wort (*Hypericum androsaemum L.)* Stem Cuttings as Affected by ANAA Concentration and Rooting Media. Benguet State University, La Trinidad, Benguet.

Adviser: Araceli G. Ladilad, PhD

**ABSTRACT**

This study was conducted at the Ornamental Horticulture Research Area at Benguet State University, La Trinidad Benguet from November 2009 to January 2010 to determine the optimum concentration of Alpha Naphthalene Acetic Acid (ANAA) that would enhance root formation of stem cuttings of Saint John's- Wort; and to determine the best rooting media that will promote earlier and uniform rooting of Saint John's-Wort stem cuttings.

Form the results obtained in the study untreated stem cuttings had earlier root formation, and earlier readiness for transplanting Saint John's- Wort stem cuttings. Higher percentage of rooted cutting and higher percentage of survival were obtained from untreated stem cuttings of Saint John's- Wort two months from sticking. Moreover, longer roots were produced in untreated cuttings two months from sticking. However, higher average numbers of roots were produced per cutting when treated with half strength ANAA concentration two months from sticking.

Stem cuttings rooted in sand were the earliest to produced visible roots at 0.5 cm root primordial and reached earlier readiness for transplanting at 3 cm root length.

Stem cuttings that were not treated with ANAA and rooted in sand reached earlier readiness for transplanting at 3 cm root length and higher average root length.

TABLE OF CONTENTS

## INTRODUCTION

*Hypericum* is a genus of about 400 species of flowering plants in the family *Clusiaceae*, subfamily *Hypericoideae* (formerly often considered a full family *Hypericaceae*). The genus has a nearly worldwide distribution, missing only from tropical lowlands, deserts and Polar Regions. All members of the genus may be referred to as St. John's-wort, though they are also commonly just called *Hypericum*, and some are known as tutsan. The marsh St. John's-worts are nowadays separated in Triadenum (Schempp, 2009).

St. John's-worts vary from annual or perennial herbaceous herbs 5–10 cm tall to shrubs and small trees up to 12 m tall. The leaves are opposite, simple oval, 1–8 cm long, either deciduous or evergreen. The flowers vary from pale to dark yellow, and from 0.5–6 cm in diameter, with five (rarely four) petals. The fruit is usually a dry capsule which splits to release the numerous small seeds; in some species it is fleshy and berry-like.

*Hypericum androsaemum*, commonly known as tutsan, is a plant in the genus *Hypericum* native to open woods and hillsides in Eurasia. It is a perennial shrub reaching up to 1.5 m in height. The common name tutsan appears to be a corruption of toute saine literally meaning all-healthy. This is probably in reference to its healing properties. The leaves are used applied to wounds, and as a stomachache. Nicholas Culpeper, in his 1653 publication Culpeper's Complete Herbal, says "Tutsan purgeth choleric humours ... both to cure sciatica and gout, and to heal burnings by fire." It will also stop bleeding and heal wounds and sores. Apparently it works just as well if it swallowed or used as a salve or ointment. The berries which turn from white/green, to red, to black are poisonous.

This tutsan cultivar is a stoloniferous, deciduous shrub which typically grows 1.5-

3' tall. Best ornamental features are: (1) oval to oblong, dark plum-purplish green leaves (to 4" long) which emit a mildly resinous scent when bruised, (2) clusters of rose-like, 5-petaled, yellow flowers (3/4" diameter) with bushy center clumps of yellow stamens in summer and (3) red-aging-to-black berries in fall. Stems are distinctively 2-edged. Tutsan comes from the French words "tout" (meaning all) and "sain" (meaning healthy) in reference to various old medicinal uses for species plants, particularly the roots. This cultivar is synonymous with and sometimes also sold as 'Tedbury Purple'.

*Hypericum androsaemum* easily grown in any reasonably good well-drained but moisture retentive soil that can tolerates a wide range of pH it succeeds in sun or semi-shade but flowers better in a sunny position. Succeeds in dry shade and is drought tolerant when established. Hardy to about -20°C, but if cut back by cold weather plants can resprout from the base. Plants often self-sow freely. A number of named forms have been developed for their ornamental value. Plants in this genus are notably resistant to honey fungus. The leaves are covered in pellucid dots which, when touched, release a resinous smell somewhat like goats.

*Hypericum androsaemum* are good ground cover plant. Although it is clump forming rather than spreading it increases freely by self-sowing. Plants are best spaced about 90 cm apart each way. Habitats of *Hypericum androsaemum* are Woodland Garden; Dappled Shade; Shady Edge; Ground Cover; Hedgerow.

Saint John’s- Wort is susceptible to nematodes which can cause root rot. Leaf spot, mildew and rust are less threatening. Wilt and root rot can be significant problems, particularly in hot and humid climates of the South.

In propagating Saint John’s- Wort, Seed - sow spring in a greenhouse and only just cover the seed. The seed usually germinates in 1 - 3 months at 10°C. When they are large enough to handle, prick the seedlings out into individual pots and grow them on in the greenhouse for their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts. Cuttings of half-ripe wood 10 - 12 cm with a heel are used for propagating during July to August in a frame. Plant out in the following spring careful division of old suckering shrubs in the dormant season. Take softwood cuttings in late spring; greenwood or semi-ripe cuttings in summer.

Cuttings are still the most important means of propagating ornamental shrubs. Auxins generally stimulate rooting and had been confirmed in several findings.

The study is important for future researchers for it will surely provide appropriate information in the researches regarding Saint John's- Wort. The result also of the study is important as it will serve as a guide to the people such as farmers, producers and prospective growers who would like to plant Saint John's- Wort in their backyard or in their farms. If the result of the study be conducive, it will be extended to the Saint John's-Wort growers or producers as well as in the community to encourage more production of this plant.

The study was conducted to: (1) to determine the optimum concentration of Alpha Naphthalene Acetic Acid (ANAA) that would enhance root formation of stem cuttings of Saint John's- Wort; and (2) to determine the best rooting media that will promote earlier and uniform rooting of Saint John's- Wort stem cuttings.

This study was conducted at the Ornamental Horticulture Research Area at Benguet State University, La Trinidad Benguet from November 2009 to January 2010.

## REVIEW OF LITERATURE

Cutting 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 asexually 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 the plants are possible due to their capacity for regeneration. Stem cuttings (form 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 faster rooting time. Growth regulators may alter the type of roots formed as well as the numbers of roots produced (Brown, 1996). Reiley and Shry (1991) 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 ANNA was already tested for its activity in promoting roots in stem segments. It is now well 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 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 hormone to root satisfactorily (Ingles, 1980).

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/l would suffice in most of the cases. Bleasedale in 1973 added that, rooting could be inhibited if auxins are applied at wrong concentration.

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

Rooting Media

According to Hartman (1975), the rooting medium has three functions: (a) to hold the cutting in place during the rooting period, (b) to provide moisture for the cutting, and (c) to permit penetration of air to the base of the cutting.

Furthermore he stated that an ideal rooting medium provides sufficient porosity to allow good aeration, has a high water- holding capacity, and yet is well drained. For tender softwood and semi- hardwood cuttings, it should be free from harmful fungi and bacteria.

Hartman also stated that the rooting medium can affect the type of root system arising from cuttings. Cuttings of some species, when rooted in sand, produce long unbranched, coarse, and brittle roots, but when rooted in a mixture, such as sand and peat moss, or perlite and peat moss, develop roots that are well branched, slender, and flexible, a type much more suited for digging and repotting.

Misting

Root formation in cuttings is only affected by hormones but also by other factors like environment, rooting medium, chemical treatment as well as 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 replace the amount normally lost through the process of transpiration. Thus transpiration has to be slowed down by keeping the relative humidity high in vicinity of the cuttings and keeping the temperature relatively lower. Misting or sprinkling water can increase relative humidity.

**MATERIALS AND METHODS**

The materials used in the study were stem cuttings of Saint John's-wort about 15 cm long, ANAA, transparent plastic bags (5x8), cutter, pruning shear, graduated cylinder, watering can, measuring materials and the rooting media.

Experimental design and treatments. The experiment was laid out in a Complete Randomized Design (CRD) in factorial arrangement with ANAA concentrations as Factor A and rooting media as Factor B. There were three replications per treatment having three samples per treatment. The treatments were as follows:

| Factor A- ANAA Concentration | Factor B- Rooting Media |
|---|---|
| $A_1$ –without ANAA treatment (Control) | $M_1$ – garden soil (Control) |
| $A_2$ – full strength (1000 ppm) | $M_2$ – sand |
| $A_3$ – half strength (500 ppm) | $M_3$ – alnus compost |
| | $M_4$ – 1:1 garden soil + sand |
| | $M_5$ – 1:1 garden soil + alnus compost |
| | $M_6$ - 1:1 sand + alnus compost |
| | $M_7$ – 1:1:1 garden soil + sand + alnus compost |

Preparation of stem cuttings. The stem cuttings were cut 15 centimeters in length. The cuttings were cleaned and only leaves from the lower half were removed. At the stem end of the samples were cut into a slanting manner before dipping for 30 minutes in the ANAA concentrations as Factor A, prior to planting in the rooting media as Factor B.

Care and maintenance was done to all sample cuttings throughout the duration of the study. Figure 1 shows an overview of the experiment.

Figure 1. Overview of the experiment

Data Gathered

The data gathered were the following:

1. Days from sticking to visible root formation (0.5cm root primordia ). This was gathered by counting the number of days from treatment to visible root formation.

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

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

3. Average root length (cm). The length of the roots for every cutting was measured and the average root length will be 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. Days from sticking cuttings to transplanting stage (3cm root length). This was gathered by counting the number of days from sticking to transplanting stage at 3cm root length.

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

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

7. Documentation. This was taken through pictures of the experiment during data gathering.

## RESULTS AND DISCUSSION

Number of Days from Sticking
to Visible Root Formation

Effect of ANAA concentration. The number of days from sticking to visible root formation is presented in Table 1. Results show that Saint John's- Wort stem cuttings that were not treated with ANAA concentration significantly initiated roots earlier with a mean of 18.00 days from sticking to visible root formation. Longer days to root formation were noted in stem cuttings treated with full strength ANAA concentration with a mean of 20.52 days from sticking to visible root formation and the half strength ANAA concentration with a mean of 21.95 days from sticking to visible root formation.

Table 1. Number of days from sticking to visible root formation

| TREATMENT | NUMBER OF DAYS |
|---|---|
| ANAA Concentration | $18.00^{b}$ |
| Without ANAA (Control) | $20.52^{a}$ |
| Full strength (1000 ppm) | $21.95^{a}$ |
| Half strength (500 ppm) | |
| | |
| Rooting Media | |
| Garden soil (Control) | $24.11^{a}$ |
| Sand | $16.89^{d}$ |
| Alnus compost | $18.33^{cd}$ |
| 1:1 garden soil + sand | $20.78^{bc}$ |
| 1:1 garden soil + alnus compost | $21.22^{b}$ |
| 1:1 sand + alnus compost | $19.22^{bcd}$ |
| 1:1:1 garden soil + sand + alnus compost | $20.56^{bc}$ |

Means with a common letter are not significantly different at 5% level by DMRT

Effect of rooting media. Highly significant differences were obtained on the number of days from sticking to visible root formation. Significantly, earlier rooting was observed in cuttings rooted in sand with a mean of 16.89 days from sticking to visible root formation followed by those rooted in alnus compost with a mean of 18.33 days from sticking to visible root formation. Longer days to root formation were noted in stem cuttings rooted in garden soil with a mean of 24.11days from sticking to visible root formation.

Interaction effect. There were no significant interaction effects observed between the different ANAA concentrations and the various rooting media with regards to the number of days from sticking to visible root formation.

Percentage of Rooted Cuttings

Effect of ANAA concentration. Significantly higher percentage of rooted cuttings was obtained from cuttings that were not treated with ANAA concentration with a mean of 90.48 % as shown in Table 2. Lower percentage of rooted cuttings was noted in those treated with full strength ANAA concentration with a mean of 51.11 %.

Effect of rooting media. There were no significant differences were noted on the percentage of rooted cuttings two months from sticking as affected by the different rooting media (Table 2). However, cuttings rooted in alnus compost tend to have higher rooting percentage with a mean of 85.19 %.

Interaction effect. There were no significant interaction effects obtained between the different ANAA concentrations and different rooting media on the percentage of rooted cuttings two months from sticking.

Table 2. Percentage of rooted cuttings

| TREATMENT | PERCENTAGE |
|---|---|
| ANAA Concentration | |
| Without ANAA (Control) | 90.48[a] |
| Full strength (1000 ppm) | 51.11[c] |
| Half strength (500 ppm) | 73.02[b] |
| Rooting Media | |
| Garden soil (Control) | 71.11[a] |
| Sand | 66.67[a] |
| Alnus compost | 85.19[a] |
| 1:1 garden soil + sand | 66.67[a] |
| 1:1 garden soil + alnus compost | 66.67[a] |
| 1:1 sand + alnus compost | 81.43[a] |
| 1:1:1 garden soil + sand + alnus compost | 62.96[a] |

Means with a common letter are not significantly different at 5% level by DMRT

Average Root Length

Effect of ANAA concentration. Table 3 shows that without ANAA treatment prior to rooting, Saint John's-Wort cuttings have significantly longer roots were produce two months from sticking compared to those treated with half strength and full strength ANAA concentrations.

Effect of rooting media. There were highly significant differences were noted on the average root length two months from sticking as affected by the different rooting media (Table 3). Stem cuttings rooted in sand produce the longest roots with a mean of 19.02 cm. The shortest roots were measured in stem cuttings rooted in garden soil with a mean of 12.62 cm. Figure 2 shows the rooted cuttings in the three ANAA treatments with the different rooting media 60 days from sticking.


Figure 2. Overview of the rooted cuttings in the three ANAA treatments with the different rooting media 60 days from sticking

Interaction effect. The combined effects of the different ANAA concentrations and the different rooting media on the average root length of Saint John's- Wort were highly significant.

Figure 3 showed that stem cuttings without ANAA treatment that were rooted in sand statistically higher average root length with a mean of 22.20 cm two months from sticking. Stem cuttings treated with full strength ANAA concentrations that were rooted in garden soil have lower average root length two months from sticking with a mean of 11 cm.

Table 3. Average root length

| TREATMENT | ROOT LENGTH (cm) |
|---|---|
| ANAA Concentration | |
| Without ANAA (Control) | 17.78[a] |
| Full strength (1000 ppm) | 13.17[c] |
| Half strength (500 ppm) | 16.18[b] |
| Rooting Media | |
| Garden soil (Control) | 12.62[d] |
| Sand | 19.02[a] |
| Alnus compost | 16.18[b] |
| 1:1 garden soil + sand | 16.36[b] |
| 1:1 garden soil + alnus compost | 15.47[cb] |
| 1:1 sand + alnus compost | 16.01[b] |
| 1:1:1 garden soil + sand + alnus compost | 14.51[c] |

Means with a common letter are not significantly different at 5% level by DMRT

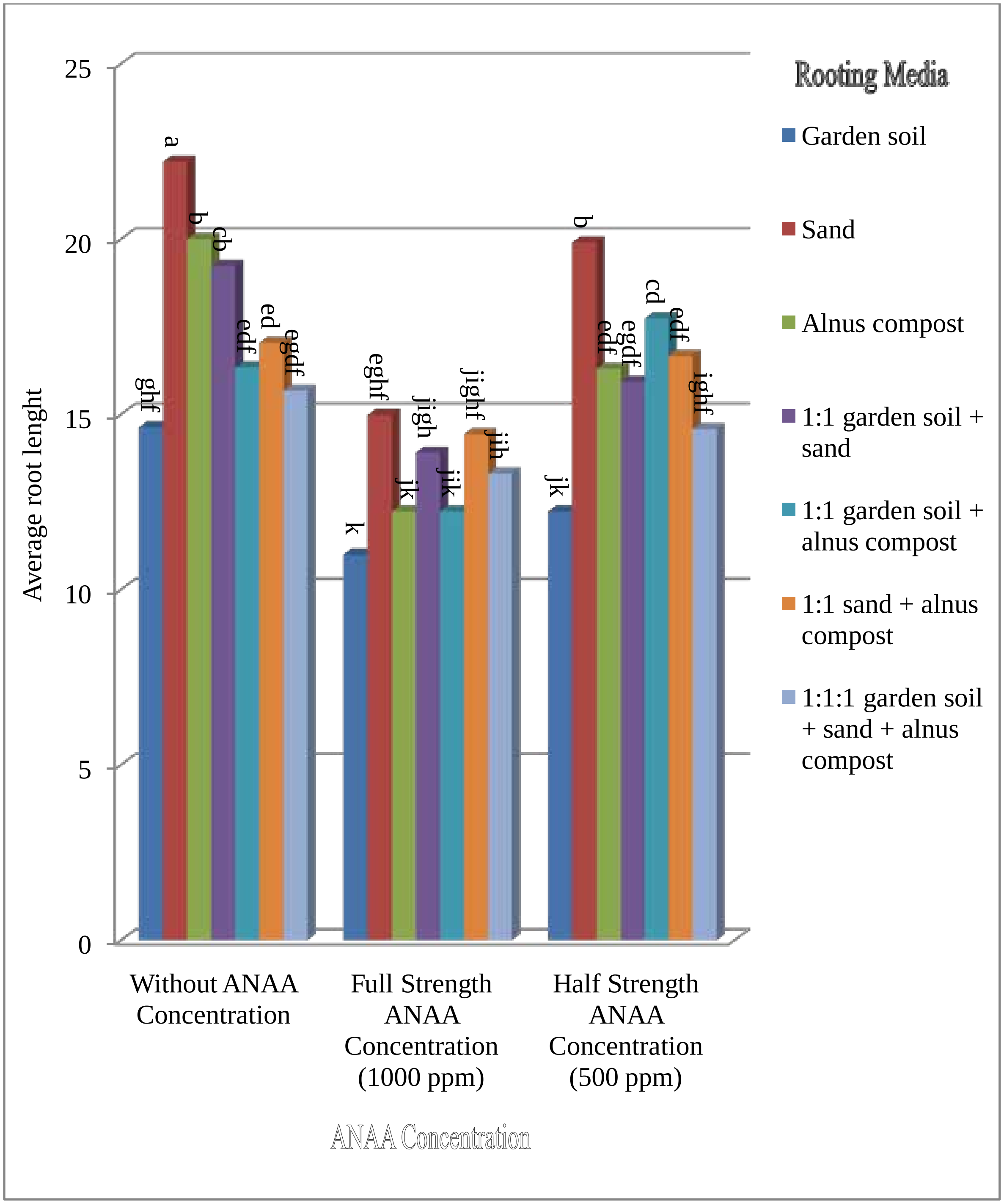


Figure 3. Average root length two months from sticking as affected by ANAA concentration and rooting media

Average Number of Roots
Produced Per Cuttings

Effect of ANAA concentration. Significantly higher average numbers of roots per cuttings were obtained from cuttings treated with full strength ANAA concentration with a mean of 30.25 roots but was statistically comparable to those treated with half strength ANAA concentration with a mean of 29.87 roots two months from sticking compared with the untreated cuttings (without ANAA concentration) as shown in Table 4.

Effect of rooting media. Table 4 shows that the average numbers of roots produce per cuttings two months from sticking were significantly affected by the different rooting media used. Stem cuttings planted in sand produced higher average number of roots per cutting with a mean of 35.59 roots. The lowest average number of roots produced per cuttings was noted in those rooted in garden soil with a mean of 22.11 roots two months from sticking.

Table 4. Average number of roots produced per cutting

| TREATMENT | NUMBER OF ROOTS |
|---|---|
| ANAA Concentration | |
| Without ANAA (Control) | $22.11^{b}$ |
| Full strength (1000 ppm) | $30.25^{a}$ |
| Half strength (500 ppm) | $29.87^{a}$ |
| Rooting Media | |
| Garden soil (Control) | $23.00^{c}$ |
| Sand | $35.59^{a}$ |
| Alnus compost | $29.59^{b}$ |
| 1:1 garden soil + sand | $25.67^{bc}$ |
| 1:1 garden soil + alnus compost | $24.52^{c}$ |
| 1:1 sand + alnus compost | $26.18^{bc}$ |
| 1:1:1 garden soil + sand + alnus compost | $27.33^{bc}$ |

Means with a common letter are not significantly different at 5% level by DMRT

Interaction effect. There were no significant interaction effects between the different ANAA concentrations and the different rooting media on the average number of roots produced per cutting two months from sticking.

Days From Sticking of Cuttings to Transplanting Stage

Effect of ANAA concentration. Table 5 shows that without ANAA treatment, rooted cuttings significantly reached transplanting stage earlier with a mean of 24.76 days. On the other hand, significantly longer duration to readiness for transplanting was observed on cuttings treated with half strength ANAA concentration with a mean of 29.71 days.

Table 5. Days from sticking cuttings to transplanting stage (3 cm root length)

| TREATMENT | DAYS |
|---|---|
| ANAA Concentration | |
| Without ANAA (Control) | 24.76[c] |
| Full strength (1000 ppm) | 28.05[b] |
| Half strength (500 ppm) | 29.71[a] |
| Rooting Media | |
| Garden soil (Control) | 32.22[a] |
| Sand | 23.78[c] |
| Alnus compost | 27.44[b] |
| 1:1 garden soil + sand | 26.78[b] |
| 1:1 garden soil + alnus compost | 28.00[b] |
| 1:1 sand + alnus compost | 26.33[b] |
| 1:1:1 garden soil + sand + alnus compost | 28.00[b] |

Means with a common letter are not significantly different at 5% level by DMRT

Effect of rooting media. Stem cuttings rooted in sand had significantly earlier readiness for transplanting with a mean of 23.78 days from sticking while those rooted in garden soil had the longest duration with a mean of 32.22 days from sticking.

Interaction effect. The combined effects of the different ANAA concentrations and the different rooting media on the duration from sticking to transplanting stage were significant.

Figure 4 showed that stem cuttings without ANAA treatment prior to rooting and that had rooted in sand reached transplanting stage significantly earlier showing 3cm root length after 20 days compared to those stem cutting rooted in garden soil and those stem cuttings treated with full strength and half strength ANAA concentrations rooted in garden soil and 1:1 garden soil + alnus compost.

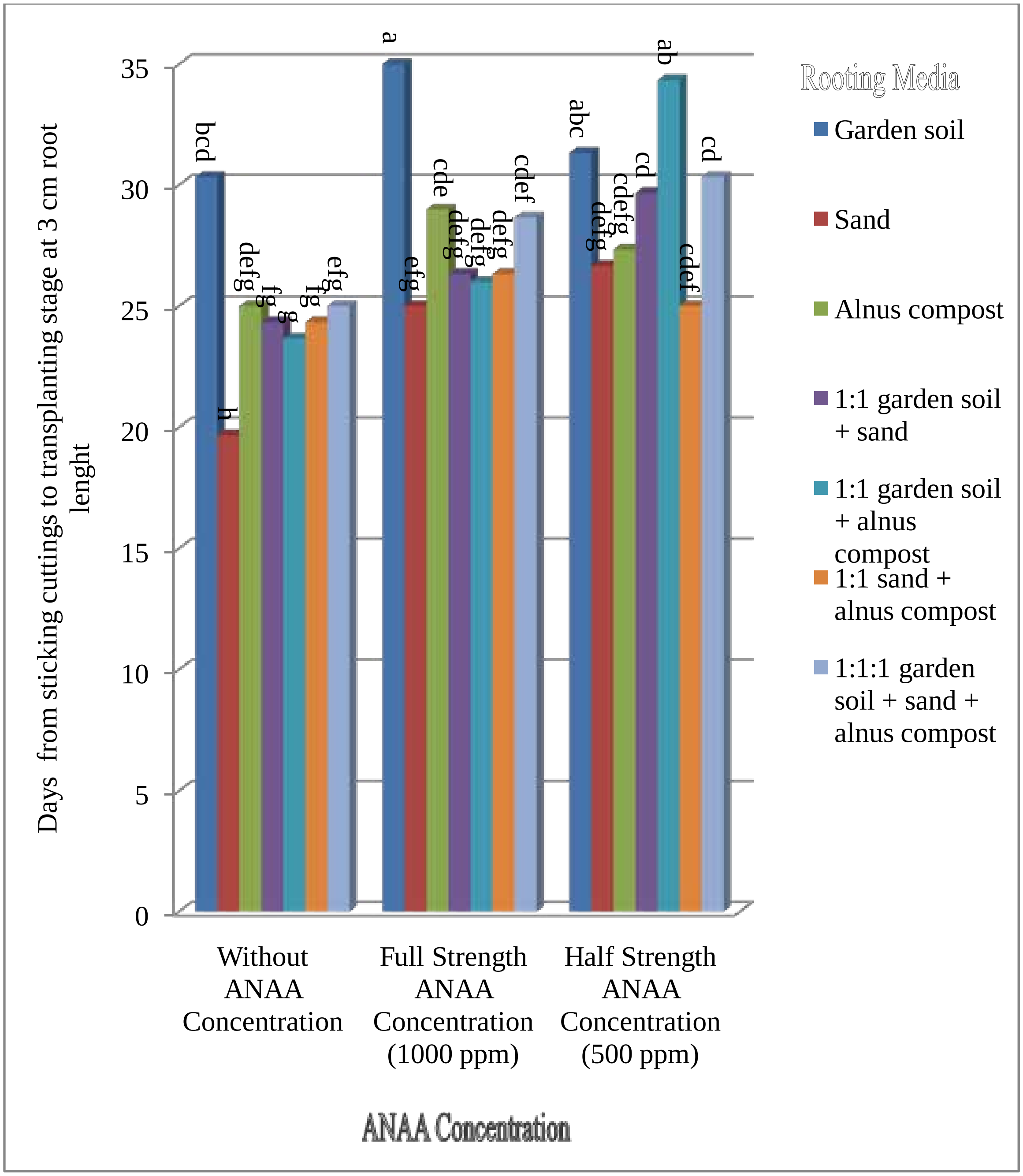


Figure 4. Days from sticking cuttings to transplanting stage at 3cm root length as affected by ANAA concentration and rooting media

Percentage Survival

Effect of ANAA concentration. The effect of ANAA treatment on the percentage survival of cuttings is shown in Table 6.

Results shows that stem cuttings without ANAA concentration had the highest percentage survival with a mean of 90.48 %. However, cuttings treated with full strength ANAA had lower percentage survival with a mean of 48.73%.

Effect of rooting media. There were no significant differences were noted on the percentage of rooted cuttings two months from sticking as shown in Table 6. However, cuttings rooted in alnus compost had higher percentage of survival with a mean of 85.17% while stem cuttings s rooted in garden soil + sand + alnus compost had lower percentage of survival with a mean of 62.96%.

Table 6. Percentage survival

| TREATMENT | PERCENTAGE SURVIVAL |
|---|---|
| ANAA Concentration | |
| Without ANAA (Control) | 90.48[a] |
| Full strength (1000 ppm) | 48.73[c] |
| Half strength (500 ppm) | 73.02[b] |
| Rooting Media | |
| Garden soil (Control) | 66.67[a] |
| Sand | 66.67[a] |
| Alnus compost | 85.19[a] |
| 1:1 garden soil + sand | 66.67[a] |
| 1:1 garden soil + alnus compost | 65.56[a] |
| 1:1 sand + alnus compost | 81.48[a] |
| 1:1:1 garden soil + sand + alnus compost | 62.96[a] |

Means with a common letter are not significantly different at 5% level by DMRT

Interaction effect. There were no significant interaction effects obtained between the different ANAA concentrations and the different rooting media with regards to the percentage of survival of stem cuttings 60 days from sticking as shown in Figure 5.

Rooted cuttings without ANAA treatment (control) before rooting 60 days from sticking

Rooted cuttings treated with full strength ANAA concentration before rooting 60 days from sticking

Rooted cuttings treated with half strength ANAA concentration before rooting 60 days from sticking

Figure 5. Overview of the rooted stem cuttings from the different ANAA concentration as affected by different rooting media

## SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

This study was conducted at the Ornamental Horticulture Research Area, Benguet State University, La Trinidad Benguet from November 2009 to January 2010 to determine the optimum concentrations of Alpha Naphthalene Acetic Acid (ANAA) that would enhance root formation of stem cuttings of Saint John's- Wort; and to determine the best rooting media that will promote earlier and uniform rooting of Saint John's-Wort stem cuttings.

Results revealed that there were significant differences obtained on the number of days from sticking to visible root formation (0.5cm root primordia) on stem cuttings as affected by the different ANAA concentrations. Untreated cuttings had earlier root formation, and earlier readiness for transplanting Saint John's- Wort stem cuttings compared to those treated with the full strength and half strength ANAA concentrations. Significantly higher percentage of rooted cutting and higher percentage of survival were obtained from untreated stem cuttings of Saint John's- Wort two months from sticking. Moreover, longer roots were produced in untreated cuttings two months from sticking. However, significantly higher average numbers of roots were produced per cuttings when treated with half strength ANAA concentration although statistically comparable to those treated with full strength ANAA concentration two months from sticking of cuttings compared to the untreated stem ones.

Stem cuttings rooted in sand were significantly the earliest to produce visible roots at 0.5 cm root primordia but was comparable to the other treatments. However, there were no significant effects of the different rooting media on the percentage of

rooted cuttings and the percentage of survival. Saint John's- Wort stem cuttings rooted in sand had significantly higher average number of roots produced per cuttings and highly significant average root length compared to the other treatments. Moreover, cuttings rooted in sand reached significantly earlier readiness for transplanting at 3 cm root length; two months from sticking.

Stem cuttings that were not treated with ANAA and rooted in sand were significantly ready for transplanting earlier at 3 cm root length and significantly higher average root length compared to those planted in garden soil and that of stem cuttings treated with full strength and half strength ANAA concentrations. However, there were no significant interaction effects between the different ANAA concentrations and the different rooting media on the number of days from sticking to visible root formation (0.5cm root primordia ), percentage of rooted cuttings, average root length, average number of roots produced per cuttings and the percentage survival .

Conclusion

Form the results obtained in the study, it is concluded that untreated stem cuttings of Saint John's- Wort rooted in sand were the earliest to produce visible roots, higher average root length and earlier duration from sticking of cuttings to transplanting stage at 3cm root length. However, stem cuttings treated with half strength ANAA concentration promoted the higher production of higher average number of roots per cuttings when rooted in sand.

Recommendation

Based from the results of the study, rooting of stem cuttings of Saint John's- Wort is recommended using sand as the rooting medium for earlier root formation, earlier readiness for transplanting and higher average root length. Further study with the use of lower concentration of ANAA in rooting stem cuttings of Saint John's- Wort is recommended.

## LITERATURE CITED


ADRIANCE, G. I. V and F. R. BRISON. 1955. Propagation of Horticultural Plants. New York. McGraw- Hill Rook Co, Inc. pp. 119-131.

BLEASEDALE, J. K. 1973. Plant Physiology in Relation to Horticulture, London: The McMillan Press Ltd. pp. 150-155.

BROWN, L. V. 1996. Applied Principles of Horticulture Science. Oxford. Butterworth Heinemann. p. 202.

DELARGY, J. A. and C. E. WRIGHT. 1979. Root formation in cuttings of apple in relation to auxin application and etiolation. New Phytol. pp. 314- 347.

EDMUND, J. B. , F. S. ANDREW and T. L. SEN. 1978. Fundamentals of Horticulture. New York. McGraw- Hill Book Co., Inc. p. 167.

GRIFFITH, B. G. 1940. Effect of indolebutyric acid, indoleacetic acid, and alpha naphthalene acetic acid on rooting of cutting Douglas fir and sitka spruce. J. Forestry. pp. 496- 501.

HALFACRE, R. G. and J. A. BARDEN. 1979. Plant Propagation Principles and Practices. New Delhi, India: Prentice Hall of India Dvt. Ltd. pp. 305- 578.

HARTMAN, H. T. 1975. Plant Propagation: Principles and Practices. London: Prentice Hall International Inc. p. 256.

HARTMAN, H.T. and D.E. KESTER. 1975. Plant Propagation: Principles and Practices. Englewoods cliffs. New Jersey: Prentice Hall, Inc. pp. 305- 307.

INGLES, R. A. 1980. Introduction to Floriculture Academic Press Inc., New York. pp. 237- 241.

JANICK, J. 1972. Horticultural Science. San Francisco. N. H. Freeman and Co. pp. 346 351.

KRISHNAMOORTHY, H. H. 1981. Plant Growth Substances. Tata McGraw- Hill Publishing Company, Ltd. New Delhi. pp. 163- 167.

REILEY, E. H. and SHRY JR. 1991. Introductory Horticulture. New York: Delma Publisher. pp. 196- 198.

SCHEMPP, C. M. 2009. *Hypericum*. From Wikipedia, the free encyclopedia. Retrieved October 10, 2009. URL: http://en.wikipedia.org/wiki/Hypericum#cite_ref-0.

WEAVER, R. T. 1972. Plant Growth Substance in Agriculture. San Francisco, California.W. H. freeman and Co. p. 128.

**APPENDICES**

Appendix Table 1. Days from sticking to visible root formation (0.5cm root primordia )

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | |
| $A_1M_1$ | 23 | 23 | 21 | 67 | 22.33 |
| $A_1M_2$ | 14 | 16 | 14 | 44 | 14.67 |
| $A_1M_3$ | 15 | 18 | 18 | 51 | 17.00 |
| $A_1M_4$ | 18 | 18 | 19 | 55 | 18.33 |
| $A_1M_5$ | 18 | 17 | 17 | 52 | 17.33 |
| $A_1M_6$ | 17 | 19 | 18 | 54 | 18.00 |
| $A_1M_7$ | 17 | 19 | 19 | 55 | 18.33 |
| | | | | | |
| $A_2M_1$ | 28 | 26 | 25 | 79 | 26.33 |
| $A_2M_2$ | 13 | 20 | 15 | 48 | 16.00 |
| $A_2M_3$ | 23 | 21 | 19 | 63 | 21.00 |
| $A_2M_4$ | 20 | 19 | 26 | 65 | 21.67 |
| $A_2M_5$ | 20 | 19 | 22 | 61 | 20.33 |
| $A_2M_6$ | 19 | 19 | 22 | 60 | 20.00 |
| $A_2M_7$ | 19 | 23 | 23 | 65 | 21.67 |
| | | | | | |
| $A_3M_1$ | 29 | 23 | 19 | 71 | 23.67 |
| $A_3M_2$ | 20 | 22 | 18 | 60 | 20.00 |
| $A_3M_3$ | 21 | 19 | 21 | 61 | 20.33 |
| $A_3M_4$ | 20 | 26 | 21 | 67 | 22.33 |
| $A_3M_5$ | 29 | 26 | 23 | 78 | 26.00 |
| $A_3M_6$ | 21 | 19 | 19 | 59 | 19.67 |
| $A_3M_7$ | 22 | 22 | 21 | 65 | 21.67 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Factor A | 2 | 168.222 | 84.111 | 14.9689** | 3.22 | 5.15 |
| Factor B | 6 | 289.746 | 48.291 | 8.5942** | 2.32 | 3.26 |
| AB | 12 | 94.444 | 7.870 | 1.4007ns | 1.90 | 2.64 |
| Error | 42 | 236.000 | 5.619 | | | |
| TOTAL | 62 | 788.413 | | | | |

ns = Not significant; ** = Highly significant          Coefficient of variation= 11.76 %

Appendix Table 2. Percentage of rooted cuttings

| TREATMENT | REPLICATION | | | TOTAL | MEAN (%) |
|---|---|---|---|---|---|
| | I | II | III | | |
| $A_1M_1$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_2$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_3$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_4$ | 100 | 66.67 | 66.67 | 233.34 | 77.78 |
| $A_1M_5$ | 66.67 | 100 | 100 | 266.67 | 88.89 |
| $A_1M_6$ | 100 | 66.67 | 100 | 266.67 | 88.89 |
| $A_1M_7$ | 100 | 66.67 | 66.67 | 233.34 | 77.78 |
| $A_2M_1$ | 66.67 | 33.33 | 40 | 140 | 46067 |
| $A_2M_2$ | 30 | 35 | 35 | 100 | 33.33 |
| $A_2M_3$ | 100 | 33.33 | 66.67 | 200 | 66.67 |
| $A_2M_4$ | 33.33 | 66.67 | 66.67 | 166.67 | 55.56 |
| $A_2M_5$ | 50 | 33.33 | 50 | 133.33 | 44.44 |
| $A_2M_6$ | 66.67 | 66.67 | 33.33 | 166.67 | 55.56 |
| $A_2M_7$ | 66.67 | 66.67 | 33.33 | 166.67 | 55.56 |
| $A_3M_1$ | 33.33 | 66.67 | 100 | 200 | 66.67 |
| $A_3M_2$ | 66.67 | 66.67 | 66.67 | 200.01 | 66.67 |
| $A_3M_3$ | 100 | 66.67 | 100 | 266.67 | 88.89 |
| $A_3M_4$ | 66.67 | 33.33 | 100 | 200 | 66.67 |
| $A_3M_5$ | 100 | 50 | 50 | 200 | 66.67 |
| $A_3M_6$ | 100 | 100 | 100 | 300 | 100 |
| $A_3M_7$ | 33.33 | 66.67 | 66.67 | 166.67 | 55.56 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Factor A | 2 | 16340.570 | 8170.285 | 21.6835** | 3.22 | 5.15 |
| Factor B | 6 | 3869.994 | 644.999 | 1.7118ns | 2.32 | 3.26 |
| AB | 12 | 4311.652 | 359.304 | 0.9536ns | 1.90 | 2.64 |
| Error | 42 | 15825.481 | 376.797 | | | |
| TOTAL | 62 | 40347.698 | | | | |

ns = Not significant; ** = Highly significant Coefficient of variation= 27.14 %

Appendix Table 3. Average root length

| TREATMENT | REPLICATION | | | TOTAL | MEAN (cm) |
|---|---|---|---|---|---|
| | I | II | III | | |
| $A_1M_1$ | 16.00 | 13.40 | 14.50 | 43.90 | 14.63 |
| $A_1M_2$ | 22.10 | 23.70 | 20.80 | 66.70 | 22.20 |
| $A_1M_3$ | 20.70 | 20.00 | 19.30 | 60.00 | 20.00 |
| $A_1M_4$ | 19.70 | 19.30 | 18.70 | 57.70 | 19.23 |
| $A_1M_5$ | 15.90 | 17.10 | 16.00 | 45.00 | 16.33 |
| $A_1M_6$ | 15.80 | 18.20 | 17.10 | 51.10 | 17.03 |
| $A_1M_7$ | 14.20 | 16.00 | 16.80 | 47.00 | 15.67 |
| $A_2M_1$ | 11.20 | 10.00 | 11.80 | 33.00 | 11.00 |
| $A_2M_2$ | 16.70 | 13.00 | 15.20 | 44.90 | 14.97 |
| $A_2M_3$ | 11.50 | 12.00 | 13.20 | 36.70 | 12.23 |
| $A_2M_4$ | 12.70 | 14.30 | 14.70 | 41.70 | 13.90 |
| $A_2M_5$ | 12.00 | 11.80 | 13.20 | 370 | 12.33 |
| $A_2M_6$ | 13.80 | 15.50 | 14.00 | 43.30 | 14.43 |
| $A_2M_7$ | 15.40 | 13.00 | 11.50 | 39.90 | 13.30 |
| $A_3M_1$ | 11.20 | 12.50 | 13.00 | 36.70 | 12.23 |
| $A_3M_2$ | 20.60 | 19.50 | 19.60 | 59.70 | 19.90 |
| $A_3M_3$ | 15.10 | 17.80 | 16.00 | 48.90 | 16.30 |
| $A_3M_4$ | 14.10 | 17.90 | 15.80 | 47.80 | 15.93 |
| $A_3M_5$ | 18.70 | 16.00 | 18.50 | 53.20 | 17.73 |
| $A_3M_6$ | 15.70 | 16.50 | 17.50 | 49.70 | 16.57 |
| $A_3M_7$ | 1 3.00 | 14.70 | 16.00 | 43.70 | 14.57 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F 0.05 | TABULAR F 0.01 |
|---|---|---|---|---|---|---|
| Factor A | 2 | 238.46 | 119.23 | 78.75** | 3.22 | 5.15 |
| Factor B | 6 | 204.50 | 34.08 | 22.51** | 2.32 | 3.26 |
| AB | 12 | 65.05 | 5.42 | 3.58** | 1.90 | 2.64 |
| Error | 42 | 63.59 | 1.51 | | | |
| TOTAL | 62 | 571.61 | | | | |

ns = Not significant; ** = Highly significant        Coefficient of variation= 7.82 %

Appendix Table 4. Average number of roots produced per cutting

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | |
| $A_1M_1$ | 17.67 | 26.00 | 16.33 | 60.00 | 20.00 |
| $A_1M_2$ | 36.33 | 31.00 | 30.67 | 98.00 | 32.67 |
| $A_1M_3$ | 20.00 | 30.33 | 19.33 | 69.66 | 23.22 |
| $A_1M_4$ | 23.33 | 29.00 | 17.33 | 69.66 | 23.22 |
| $A_1M_5$ | 1.67 | 22.00 | 18.33 | 52.00 | 17.33 |
| $A_1M_6$ | 13.33 | 12.00 | 28.67 | 54.00 | 18.00 |
| $A_1M_7$ | 31.67 | 24.00 | 25.33 | 81.00 | 27.00 |
| $A_2M_1$ | 18.33 | 31.33 | 25.00 | 74.66 | 24.89 |
| $A_2M_2$ | 40.00 | 43.00 | 41.00 | 124.00 | 41.33 |
| $A_2M_3$ | 31.33 | 29.33 | 33.67 | 94.33 | 31.44 |
| $A_2M_4$ | 27.00 | 27.67 | 28.33 | 83.00 | 27.67 |
| $A_2M_5$ | 30.00 | 28.00 | 32.67 | 90.67 | 30.22 |
| $A_2M_6$ | 30.33 | 32.33 | 27.33 | 89.99 | 30.00 |
| $A_2M_7$ | 27.33 | 18.00 | 23.33 | 68.66 | 22.89 |
| $A_3M_1$ | 20.33 | 26.33 | 25.67 | 72.33 | 24.11 |
| $A_3M_2$ | 38.33 | 36.33 | 33.67 | 108.33 | 36.11 |
| $A_3M_3$ | 37.33 | 32.67 | 32.33 | 102.33 | 34.11 |
| $A_3M_4$ | 29.67 | 23.00 | 25.67 | 78.34 | 26.11 |
| $A_3M_5$ | 30.33 | 29.00 | 28.67 | 88.00 | 29.33 |
| $A_3M_6$ | 29.00 | 31.67 | 31.00 | 91.67 | 30.56 |
| $A_3M_7$ | 27.00 | 28.67 | 30.67 | 86.34 | 28.78 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F 0.05 | TABULAR F 0.01 |
|---|---|---|---|---|---|---|
| Factor A | 2 | 886.931 | 443.465 | 21.3725** | 3.22 | 5.15 |
| Factor B | 6 | 936.625 | 156.104 | 7.5233** | 2.32 | 3.26 |
| AB | 12 | 406.868 | 33.906 | 1.6341ns | 1.90 | 2.64 |
| Error | 42 | 871.474 | 20.749 | | | |
| TOTAL | 62 | 3101.897 | | | | |

ns = Not significant; ** = Highly significant     Coefficient of variation= 16.62 %

Appendix Table 5. Days from sticking cuttings to transplanting stage (3cm root length)

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | |
| $A_1M_1$ | 31 | 31 | 29 | 91 | 30.33 |
| $A_1M_2$ | 19 | 21 | 19 | 59 | 19.67 |
| $A_1M_3$ | 24 | 29 | 25 | 78 | 26.00 |
| $A_1M_4$ | 24 | 23 | 26 | 73 | 24.33 |
| $A_1M_5$ | 22 | 23 | 26 | 71 | 23.67 |
| $A_1M_6$ | 23 | 26 | 24 | 73 | 24.33 |
| $A_1M_7$ | 23 | 26 | 26 | 75 | 25.00 |
| $A_2M_1$ | 37 | 33 | 35 | 105 | 35.00 |
| $A_2M_2$ | 25 | 26 | 24 | 75 | 25.00 |
| $A_2M_3$ | 29 | 27 | 31 | 87 | 29.00 |
| $A_2M_4$ | 26 | 24 | 29 | 79 | 26.33 |
| $A_2M_5$ | 25 | 24 | 29 | 78 | 26.00 |
| $A_2M_6$ | 26 | 26 | 27 | 79 | 26.33 |
| $A_2M_7$ | 26 | 29 | 31 | 86 | 28.67 |
| $A_3M_1$ | 37 | 31 | 26 | 64 | 31.33 |
| $A_3M_2$ | 27 | 29 | 24 | 80 | 26.67 |
| $A_3M_3$ | 29 | 26 | 27 | 82 | 27.33 |
| $A_3M_4$ | 27 | 33 | 29 | 89 | 29.67 |
| $A_3M_5$ | 37 | 35 | 31 | 103 | 34.33 |
| $A_3M_6$ | 29 | 29 | 27 | 75 | 25.00 |
| $A_3M_7$ | 31 | 31 | 29 | 91 | 30.33 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F 0.05 | TABULAR F 0.01 |
|---|---|---|---|---|---|---|
| Factor A | 2 | 266.698 | 133.349 | 25.2282** | 3.22 | 5.15 |
| Factor B | 6 | 346.857 | 57.810 | 10.9369** | 2.32 | 3.26 |
| AB | 12 | 164.190 | 13.683 | 2.58886* | 1.90 | 2.64 |
| Error | 42 | 222.000 | 5.286 | | | |
| TOTAL | 62 | 999.746 | | | | |

* = Significant; ** = Highly significant Coefficient of variation= 8.36 %

Appendix Table 6. Percentage survival

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | (%) |
| $A_1M_1$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_2$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_3$ | 100 | 100 | 100 | 300 | 100 |
| $A_1M_4$ | 100 | 66.67 | 66.67 | 233.34 | 77.78 |
| $A_1M_5$ | 66.67 | 100 | 100 | 266.67 | 88.89 |
| $A_1M_6$ | 100 | 100 | 100 | 266.67 | 88.89 |
| $A_1M_7$ | 100 | 66.67 | 66.67 | 233.34 | 77.78 |
| $A_2M_1$ | 36.67 | 33.33 | 30 | 100 | 33.33 |
| $A_2M_2$ | 35 | 30 | 35 | 100 | 33.33 |
| $A_2M_3$ | 100 | 33.33 | 66.67 | 200 | 66.67 |
| $A_2M_4$ | 33.33 | 66.67 | 66.67 | 166.67 | 55.56 |
| $A_2M_5$ | 40 | 33.33 | 50 | 123.33 | 41.11 |
| $A_2M_6$ | 66.67 | 66.67 | 33.33 | 166.67 | 55.56 |
| $A_2M_7$ | 66.67 | 66.67 | 33.33 | 166.67 | 55.56 |
| $A_3M_1$ | 33.33 | 66.67 | 100 | 200 | 66.67 |
| $A_3M_2$ | 66.67 | 66.67 | 66.67 | 200.01 | 66.67 |
| $A_3M_3$ | 100 | 66.67 | 100 | 266.67 | 88.89 |
| $A_3M_4$ | 66.67 | 33.33 | 100 | 200 | 66.67 |
| $A_3M_5$ | 50 | 50 | 100 | 200 | 66.67 |
| $A_3M_6$ | 100 | 100 | 100 | 300 | 100 |
| $A_3M_7$ | 33.33 | 66.67 | 66.67 | 166.67 | 55.56 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIANCE | DEGREES OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARE | COMPUTED F | TABULAR F 0.05 | TABULAR F 0.01 |
|---|---|---|---|---|---|---|
| Factor A | 2 | 18462.300 | 9231.150 | 25.5394** | 3.22 | 5.15 |
| Factor B | 6 | 4150.487 | 691.748 | 1.9138ns | 2.32 | 3.26 |
| AB | 12 | 4967.722 | 413.977 | 1.1453ns | 1.90 | 2.64 |
| Error | 42 | 15180.814 | 361.448 | | | |
| TOTAL | 62 | 42761.323 | | | | |

ns = Not significant; ** = Highly significant Coefficient of variation= 26.88 %