BIBLIOGRAPHY

YOGAYOG, BENJIE G. APRIL 2007. Performance of Different Potting Media Mixtures on the Growth and Root Development of Batac Mulberry (*Morus alba* Linn.) Cuttings for Sapling Production. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted to determine the best potting media for the growth and development of Batac mulberry cuttings for sapling production and to find out what potting media produces the most vegetative parts, with the longest primary roots, with the heaviest vegetative and root weight. Likewise, the Return on Investment (ROI) for each potting media was taken for economic considerations. The different potting media were the mixtures of Sand, Sphagnum moss and Garden soil; Sand, Compost and Garden soil; Sand, Rice hull and Garden soil; Sand, Coir dusts and Garden soil; and Garden soil alone. The study was conducted from November 2006-March 2007 at the Benguet State University Sericulture Project in Ampasit, Puguis, La Trinidad, Benguet.

Results of the study revealed that the different potting media mixtures were effective on the growth and development of Batac mulberry. However, the potting media consisting of the mixture of Sand, Sphagnum moss and Garden soil appeared to be the best potting media mixture among the other potting media treatments. It significantly hastened root development of the mulberry cuttings giving vigorous growth with the most number of leaves formed having heaviest weight. In addition, this potting media mixture

gave the longest and thickest primary root having most number of secondary roots and root hairs. This indicated satisfactory performance when planted in the field.

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INTRODUCTION

Mulberry is a perennial plant attaining a height of fifteen (15) meters high. It is scientifically known as *Morus alba* L. Mulberry is the sole food plant of the mulberry silkworm (*Bombyx mori* L.). Thus, the foundation of sericulture lies in the growing of mulberry considering that the quality and quantity of silk produced depends on mulberry leaf quantity and yield plus several important factors like silkworm race, climate, temperature and humidity.

Mulberry is a deep rooted plant that requires soil capable of sufficient supply of nutrients, water and air up to where the root system penetrates (Boraiah, 1986). The same expert stated that the plantation soil should be fertile, deep friable, sandy loamy to loamy in the texture and porous with good water-holding capacity. Slightly acidic soil with pH ranging from 6.2-6.8 is ideal for the growth and development of the mulberry plants. On the other hand, Dandin (1994) sated that the suitable range of soil atmospheric temperature of a plantation is from 20^{o}C-35^{o}C.

Alvares and Kim (1994) stated that mulberry is a plant consisting of vegetative parts (roots, stem and leaves) and reproductive organs (flowers and fruits). Although the organs are different in form, structure and physiological function, they act on one another in a given condition and combined harmonious actions for existence. In addition, external conditions such as the application of organic fertilizers, method of cultivation and management can also cause changes in form, which could be an indicator of physiological growth and leaf quality. Propagation of mulberry can be made either by seeds or vegetative production. Hardwood cutting, one of the vegetative methods, is the most common in sub-tropical countries and tropical areas because of various advantages. It is simple, mortality is low and the saplings produced are of good quality.

Propagation of mulberry saplings includes sexual and vegetative reproduction. The vegetative reproduction contains grafting, cutting, and layering of these, means; grafting is the most cumbersome, time-consuming and expensive procedure whereas cutting is an easy, cheap, and least time consuming method. In temperate countries, most of the mulberry varieties do not respond to cutting method without pre-treatment. That is why grafting is the most common practice of propagation. Tropical varieties of mulberry, however, easily respond to cutting method without artificial treatment (Das, 1987). He also pointed out that cultivars with proven high yielding ability and good rooting capacity would not only alleviate the propagation problem but also generate new hopes among local farmers for easy and fruitful mulberry cultivation through cuttings in the field.

The rooting capacity of mulberry is one of the most important factors that contribute to a better production because greater roots will tend to supply more food nutrients to the crop for its growth and development. On the other hand, soil provides plant nutrients, water and air for root growth besides anchorage to mulberry plants. Mulberry is a deep-rooted, perennial, hardy and monoculture crop, hence, it is essential to select suitable soil for mulberry cultivation.

In asexual or vegetative propagation like cuttings, the inherited characteristics of the parent stock can be retained. In reality, the new plant is the continuation of the growth and development of the parent stock. This method allows the genetic traits of the mulberry to be used to keep the good characteristics of the good varieties, which allow many good varieties to be produced (FAO, 1988).

This study found ways to accelerate the vegetative reproduction of mulberry through cuttings by determining the best potting medium combination for the growth and development of the mulberry saplings.

The results of the study could help the local sericulture farmers, entrepreneurs, researchers, and the students on which is the good mixture of potting media for rapid mulberry propagation through cuttings.

The study determined the best potting media for the growth and development of Batac mulberry cuttings for sapling production and found out what potting media produces the heaviest roots and vegetative parts. Likewise, the Return on Investment (ROI) for each potting media was taken for economic considerations.

The study was conducted at Benguet State University Sericulture Project, Ampassit, Puguis, La Trinidad, Benguet from November 2006 to March 2007.

REVIEW OF LITERATURE

Economic Importance of Mulberry

Mulberry is the sole food for the silkworm (*Bombyx mori* L.). The quality of mulberry has a predominating influence on the development of the worm and the quality of the cocoons. Thus, if silkworm rearing and cocoon production is to be successful; it is very necessary that the mulberry leaves to be feed to the worms are high in quality (Omura, 1980).

Ray (1989) as cited by Cawa-it (2006) stated that aside from the sericultural importance of mulberry, this plant has medical properties for various human diseases. The mulberry leaves are considered to be diaphoretic and emollient while decoction of leaves is used as a gargle for the inflammation of the throat. The fruit is laxative and refrigerant and is used for sore throat, dyspepsia and melancholia. The juice of the black mulberry is a medicine for convalescence after febrile disease. It checks thirst and cools the blood. The root possesses astringent and anthelmintic properties while the bark is used as purgative and vermifuge. Finally, the *Morus nigra* Linn. or black mulberry is now in the headlines for its omnipotent medicinal properties which may even cure Acquired Immune Deficiency Syndrome (AIDS).

Asexual Propagation by cuttings

Hardwood cutting must be rooted under moist conditions that will prevent excessive drying as some species are hard to root, taking several months to a year as noted by Hartman et al. (1990). He further stated that after cuttings have been made and placed under environmental conditions favorable for rooting, callus would usually develop at the basal end of the cutting. The callus is irregular mass of parenchyma cells in various stages of lignifications. This callus growth arises from young cells in the region of the vascular cambium, although various cells of the cortex and pith may also contribute to its formation is essential for rooting.

Root formation in cutting is not only affected by chemical treatments alone but also by other factors like rooting medium, mechanical treatments as well as plant itself. For instance, some species root much easily than others or the age of the parent stock, cuttings taken from younger plants are usually more active in synthesis of food and cell development (Adriance and Brinson, 1975).

The mulberry rooting is specialized with deep and wide propagating nature, in other word, the rooting covers under ground with about 60 degree pilling cone form. This is why the soil condition acts the important role of the mulberry trees (Hee, N.D).

Bautista (1994) reported that when cuttings are placed in rooting medium, growth substances like auxins and other products of photosynthesis move from young leaves and concentrate in sites requiring repair or regeneration of tissue such as curing of the cuttings. She further stated that in leafless cuttings, auxins and other photosynthesis are also present in smaller amounts in the stem. These indigenous and inherent auxins interact with inherent factors in the stem cells to activate cell division, which later result in the formation of a mass of unidentified cells called callus. The callus cells eventually differentiate into root initials growth substances are manufacture from products of photosynthesis, while the energy as well as simple compounds needed for cell division, differentiation and formation of root initials came from respiration.

In Karnataka and West Bengal, India the normal practice is to plant the cuttings directly in the field; sometimes when the field is not ready for planting it becomes necessary to preserve the cuttings in sandbeds under shade for about a week before planting. This method of storage helps the formation of "callus" and such cuttings give better performance (Ullal and Narashimhanna, 1987).

Diaz (2000) as cited by Aladog (2004) recommended that a mixture of 1:1:1 ricehull + compost + sand could be recommended for the growing of "Nonstop Rose Peticoat (Begonia sp.)" under La Trinidad, Benguet conditions.

Potting Media

The potting soil, or medium in which a plant grows, must be of good quality. It should be porous for root aeration and drainage but also capable of water and nutrient retention. In order for a plant to form a new root system, it must have ready supply at the cut surface (Anonymous, N.D).

Hartman et al. (1990) also added that the medium must retain enough moisture so that watering does not have to be too frequent and sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the roots. An ideal propagation medium provides sufficient porosity to allow good aeration and has a high water-holding capacity. Water is required for major chemical reactions in plants (Anonymous, N.D). The more air that is allowed, the healthier will be the root system. This translates directly to the overall health and robustness of the plant (Birk, N.D).

Sphagnum Moss

Commercial sphagnum moss is the dehydrated young residue or living portions of acid-bog plants in the genus Sphagnum, such as *S. papillosum*, *S. scapillaceum* and *S. palustre*. It is relatively sterile, light in weight and has a very high water holding capacity being able to absorb 10-20 times its weight of water. The stem and leaf tissues of sphagnum moss consist largely of groups of water holding cells. This material is generally shredded either by hard or mechanically, before it is used in a propagating or growing medium. It contains a specific fungi static substance, which accounts for its ability to inhibit damping-off seedlings germinated in it (Hartman et al., 1990). In addition, sphagnum moss provides better aeration when wet (Handreck and Black, 1994).

Compost

Compost was once a major component of potting mixes. The term "potting mixes" in Britain for materials for pots showed that compost was an important potting mix. Mature compost contributes nutrients and increases the readily available water content otherwise very open mixes. Increasing the volume of compost made from general organic wastes mainly of garden origin, from sewage's sludge and from municipal solid wastes can suppress pathogens (Handreck and Black, 1994).

Brady (1996) stated that compost is also used as mulches in vegetable or flower gardens. This practice provides not only nutrients for the plants but soil cover for moist conservation as well. Indoor potted plants also thrive on a mixture of highly composted material.

Rice Hull

Whole rice hulls are moderately resistant to decomposition. They hold little water and improve aeration. They are useful lightweight component of mixes fro orchids and are also used to increase the porosity of bedding mixes based on peat (Handreck and Black, 1994).

Coir Dusts

Coir is the name given to the fibrous material that constitutes the thick mesocarp (middle layer) of the coconut fruit (*Cocos nucifera*). The long fibers of coir are extracted from the coconut husk and utilized in the manufacture of brushes, automobile seats, mattress stuffings, drainage pipe filters, twine and other products. Traditionally, the short fibers (2mm or less) and dusts ("pith") left behind have accumulated as a waste product for which no industrial use had been discovered. Coir dusts accumulate in large piles or "dumps" outside of the mills, which process the husks for extraction of the industrially valuable long fibers. The high lignin and cellulose content of the pith prevents the piles from breaking down further. It is this same characteristic that prevents oxidation and resultant shrinkage of coir dust when it is used as a growing medium (Hume, 1949).

Coir dusts are very similar to peat in appearance. It is light to dark brown in color and consists primarily of particles in the size range 0.2-2.0 mm (75-90%). Unlike sphagnum peat, there are no sticks or other extraneous matter.

Coir dusts tend to be high in both sodium and potassium compared to the other peats, but sodium is leached readily from the material under irrigation (Handreck, 1993). The high levels of potassium present in coir dust prove more a benefit than any detriment to plant growth. However, coir dust from other sources has also reportedly contained chlorides at levels toxic to many plants. Thus, it is very important that salinity in the raw material be monitored before processing into a horticultural amendment. It is evident, that chemical properties of this material can vary widely from source to source (Evans et al. 1996).

Sand

Sand consists of small rock particles, 0.05 to 5.0 mm in diameter, formed as the result of the weathering of various rocks, its mineral composition depending upon the type of rocks. Quartz sand, consisting chiefly of a silica complex, is generally used for propagation purposes. Sand is the heaviest of all rooting media being used, a cubic-foot dry sand weighs about 4.5 kg. It is preferred to be fumigated or steam pasteurized before use (Hartman et al., 1990).

Loam Soil

Denisen (1958) reported that loam soil can be used successfully especially if the cuttings are to remain in the propagating media for sometime after rooting. Mixtures of loam soil and sand are frequently used. He also stated that loam soil is high in nutrients and more retentive of water and is well aerated.

MATERIALS AND METHODS

The materials used in this study were mulberry cuttings of Batac variety, crowbar, pruning shears, different potting media, 15.24 cm x 15.24 cm x 30.48 cm black polyethylene bags, labeling materials and weighing scale.

The different rooting media served as the treatments with garden soil alone as the control check. The garden soil was taken at Benguet State University Sericulture Project at Ampassit, Puguis, La Trinidad, Benguet. Each composition of the media was equally weighed and mixed thoroughly as recommended by Diaz (2000). The 15.24 cm x 15.24 cm x 30.48 cm black polyethylene bags were filled up equally with each potting media. The treatments were replicated five times. The experiment was laid out by following the Complete Randomized Design (CRD).

The different treatments were as follows:

TREATMENT	POTTING MEDIA MIXTURE
T_0	Garden Soil (Control)
T_1	Sand + Sphagnum moss + Garden soil (1:1:1)
T_2	Sand + Compost + Garden soil (1:1:1)
T_3	Sand + Rice hull + Garden soil (1:1:1)
T_4	Sand + Coir dusts + Garden soil (1:1:1)

<u>Selection of Mulberry Cuttings</u>

The mulberry cuttings were selected from the healthy branches of Batac mulberry trees at the mulberry plantation of Benguet State University Sericulture Project. The size of the mulberry cuttings was 10-25 cm long and 1.27 cm in diameter having four (4) healthy nodes.

To ensure growth of mulberry saplings, mulberry cuttings were soaked in tap water for twelve hours and were kept under shade before planting. This aim to enhance the initiation of callus on the cut surface.

Figure 1. Potting media mixture preparation by the author

<u>Planting of Cuttings</u>

The cuttings were planted individually by first making a hole at the center of the prepared bags using a dibble, after which, the cuttings were planted in a slightly slanted position. The depth of planting depends on the internodes of the topmost bud. Hence, the cuttings were planted exposing only the topmost bud on the soil surface. Immediately after planting, the cut surface of the newly planted mulberry cuttings were covered with candle wax to prevent moisture loss. The planted mulberry cuttings were watered daily to make the media moist.

Figure 2. Planting of mulberry cuttings

Data Gathered

1. Growth increment (cm). This data was gathered one month after planting and it was done weekly thereafter. The shoots of the sample plants were measured from the point of leaf attachment to the tip of the leaf using a foot rule. This was done per treatment

2. Survival rate (%). Dead or wilted saplings and survived saplings were counted and recorded during the termination of the study. Afterwards, the percentage survival rate was computed following the formula:

$$\%\ \text{of Survival} = \frac{\text{No. of survived saplings}}{\text{Total no. of cuttings planted}} \times 100$$

3. No. of leaves formed. All the leaves that were formed were counted from the sample plants. The leaves were counted during the termination of the study.

4. Weight of leaves (g). The weight of the leaves was taken after the conduct of the experiment using a weighing scale.

5. Final length of primary root (cm). This was obtained by uprooting sample plants per treatment after the experiment. The length of the primary roots was measured from the base to the tip most part of the root using a foot rule.

6. Root weight (g). Weight of the roots was gathered after the study by weighing the root per sample treatment.

7. Return on Investment (ROI). The costs and returns of the treatment media and the projected sales of mulberry saplings was taken using the following formula:

$$\text{ROI} = \frac{\text{Net Income}}{\text{Total Investment}} \times 100$$

8. Soil pH. Soil samples were taken from the respective potted treatment before and after the experiment. The samples were tested at BSU Soils Laboratory to determine soil pH using pH meter.
9. Weather data. Weather data was gathered during the study at the PAG-ASA at Benguet State University Balili, La Trinidad, Benguet.
10. Other observations. Other important observations such as pests and diseases, and others were noted.

RESULTS AND DISCUSSION

Growth Increment of Mulberry Cuttings

Table 1 shows the growth increment of the mulberry saplings from first to sixth week after one month of planting. Statistical analysis showed highly significant differences among the treatments. Growth increment in the first week showed that mulberry plants grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest growth increment with a mean of 7.16 cm. On the other hand, no significant difference were observed on plants grown in the mixture of Sand, Compost and Garden soil (T_2); Sand, Rice hull and Garden soil (T_3); Sand, Coir dusts and Garden soil (T_4) and Garden soil alone (T_0). However, cuttings grown in Garden soil alone (T_0) gave the lowest growth increment with a mean of 4.36 cm.

Table 1. Final growth increment (cm) of the mulberry saplings from first to sixth week one month after planting

TREATMENTS	MEAN (cm)						AVERAGE
	1ST wk	2nd wk	3rd wk	4th wk	5th wk	6th wk	
T_0- Garden soil (control)	4.36 b	6.18 b	7.72 b	9.68 b	11.64 b	13.64 b	8.87 b
T_1- Sand + Sphagnum moss + Garden soil	7.16 a	9.96 a	12.60 a	16.96 a	21.48 a	27. 58 a	16.76 a
T_2- Sand + Compost + Garden soil	4.49 b	7.52 b	9.22 b	12.36 b	15.50 b	19.20 b	11.46 b
T_3- Sand + Rice hull + Garden soil	5.06 b	6.20 b	8.22 b	10.62 b	12.52 b	14.32 b	9.49 b
T_4- Sand + Coir dusts + Garden soil	4.70 b	5.86 b	7.04 b	9.08 b	11.62 b	12.70 b	8. 52 b

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

On the second week, one month after planting, statistical analysis revealed highly significant differences among the potting media treatments. The cuttings planted in a mixture of Sand, Sphagnum moss and Garden soil (T_1) recorded the highest growth increment with a mean of 9.96 cm. On the other hand, cuttings grown in the mixture of Sand, Coir dusts and Garden soil (T_4) gave the lowest growth increment with a mean of 5.86 cm. No significant differences, however, was shown among the other treatments applied with the mixture of Sand, Compost and Garden soil (T_2), Sand, Rice hull and Garden soil (T_3), Sand, Coir dusts and Garden soil (T_4) and Garden soil alone (T_0). These results imply that the different potting media particularly Sand + Coir dusts + Garden soil (T_4) enhanced the growth increment of the plants during the second week.

Growth increment in the third week showed highly significant results as revealed by statistical analysis. The highest mean of 12.60 cm was recorded on cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1). On the other hand, mulberry cuttings planted in the mixture of Sand, Coir dusts and Garden soil (T_4) exhibited the lowest growth increment with a mean of 7.04 cm. However, this potting media was not significantly different with plants grown in the mixture of Sand, Compost and Garden soil (T_2), Sand, Rice hull and Garden soil (T_3), and Garden soil alone (T_0). It was also observed that during this period that insect pests like spanworms and mulberry pyralids began to attack the mulberry plants affecting the growth.

Highly significant differences were noted on the growth increment of mulberry saplings as shown by statistical analysis at fourth week one month after planting. The mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest growth increment of the mulberry plants with 16.96 cm. This potting media gave better performance on the growth of mulberry saplings. This fortifies the findings of Hartman (1990) that sphagnum moss is relatively sterile, light in weight and has a very high water-holding capacity and provide better aeration when wet (Handreck and Black, 1994). This suits to the recommendation of Hartman et al. (1990) that a rooting media must be sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the roots, resulting to good plant growth. Meanwhile, cuttings grown in a mixture of Sand, Coir dusts and Garden soil gave the lowest growth increment with a mean of 9.08 cm.

Likewise, highly significant differences among the treatments were observed on the fifth week one month after planting. Mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest growth increment of 21.48 cm. Again, this observation confirms the findings of Hartman et al. (1990) that sphagnum moss has a very high water-holding capacity being able to absorb 10-20 times its weight of water which provides sufficient water to the roots. Water is required for major chemical reactions in plants (Anonymous, N.D). On the other hand, the cuttings grown in the mixture of Sand, Coir dusts and Garden soil (T_4) gave the lowest growth increment of 11.62 cm. The other potting media treatments had no significant differences from each other on the growth of mulberry plants.

The growth increment for the sixth week one month after planting also showed highly significant differences among the treatments. Mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest on the growth increment with a mean of 27.58 cm. The mulberry cuttings grown in this potting media gave the consistent best performance growth from one week after one month planting up to the sixth week. Meanwhile, the lowest growth increment was exhibited on plants grown in the mixture of Sand, Coir dusts and Garden soil (T_4) with a mean of 12.70 cm. The other media treatments were not significantly different from each other. Garden soil alone (T_0) gave a mean of 13.64 cm while a mean of 14.20 cm was taken from plants applied with the mixture of Sand, Rice hull and Garden soil (T_3) while the plants applied with the mixture of Sand, Compost and Garden soil (T_2) had a mean of 19.20 cm.

The final results on growth increment showed that mulberry cuttings grown in Sand, Sphagnum moss and Garden soil (T_1) gave the highest overall growth increment of 16.76 cm. It gave the best growth performance to the mulberry cuttings. This result agrees to the findings of Hartman (1990) that a medium must be sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the roots. Meanwhile, the mixture of Sand, Coir dusts and Garden soil grown cuttings gave the lowest overall average growth increment of 8.52 cm.

Figure 3. Differences in the mulberry sapling growth increment as affected by different potting media mixtures

Survival Rate of Mulberry Cuttings

Table 2 shows the survival rate of mulberry cuttings two months after planting. It shows that all mulberry cuttings planted in different potting media had a survival rate of 100%. This revealed the good characteristics and properties provided by the different rooting media mixtures to the mulberry cuttings.

Table 2. Survival rate (%) of the mulberry saplings two months after planting

TREATMENTS	Survival rate (%)
T_0- Garden soil (control)	100
T_1- Sand + Sphagnum moss + Garden soil	100
T_2- Sand + Compost + Garden soil	100
T_3- Sand + Rice hull + Garden soil	100
T_4- Sand + Coir dusts + Garden soil	100

Number of Leaves Formed by Mulberry Saplings

Table 3 shows highly significant results among the treatments as revealed by statistical analysis. Mulberry plants grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest number of leaves formed with a mean of 12.60. On the other hand, plants grown in the mixture of Sand, Coir dust and Garden soil gave the lowest number of leaves formed with 5.40. However, no significant differences was showed among the other treatments applied with the mixture of Sand, Compost and Garden soil (T_2), Sand, Rice hull and Garden soil (T_3), Sand, Coir dusts and Garden soil (T_4) and Garden soil alone (T_0). Meanwhile, the attack of insect pests like aphids and mulberry pyralid greatly affected the vegetative growth of mulberry plants observed during the study.

Table 3. Number of leaves formed by the mulberry saplings two months after planting

TREATMENTS	MEAN
T_0- Garden soil (control)	6.60 [b]
T_1- Sand + Sphagnum moss + Garden soil	12.60 [a]
T_2- Sand + Compost + Garden soil	8.40 [b]
T_3- Sand + Rice hull + Garden soil	7.00 [b]
T_4- Sand + Coir dusts + Garden soil	5.40 [b]

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

Weight of Leaves of Mulberry Saplings

Table 4 shows the weight of leaves of mulberry saplings two months after planting. Statistical analysis showed highly significant differences among the treatments. Mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the highest weight of leaves with a mean of 3.28 g. On the other hand, saplings applied with the mixture of Sand, Coir dust and Garden soil (T_4) had the lowest weight of leaves with a mean of 1.50 g. Meanwhile, no significant differences were observed on plants grown in the mixture of Sand, Rice hull and Garden soil (T_3), Sand, Compost and Garden soil (T_2) and Garden soil alone (T_0). The infestation of aphids, mulberry pyralid and other insect pests contributed to the low weight of leaves on the treatments.

Table 4. Weight of leaves (g) of the mulberry saplings two months after planting

TREATMENTS	MEAN (g)
T_0- Garden soil (control)	1.70 [b]
T_1- Sand + Sphagnum moss + Garden soil	3.28 [a]
T_2- Sand + Compost + Garden soil	2.10 [b]
T_3- Sand + Rice hull + Garden soil	1.66 [b]
T_4- Sand + Coir dusts + Garden soil	1.50 [b]

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

Final Length of Primary Roots of Mulberry Saplings

Statistical analysis showed significant differences among the treatments as shown in Table 5. The mixture of Sand, Sphagnum moss and Garden soil (T_1) grown cuttings registered the highest length of primary roots with a mean of 22.96 cm while cuttings applied with the mixture of Sand, Compost and Garden soil (T_2) gave the lowest in length with a mean of 14.64 cm. On the other hand, no significant differences were noted on treatments applied with the mixture of Sand, Coir Dust and Garden Soil (T_4); Sand, Rice hull and Garden soil (T_3) and Garden soil alone (T_0). It was also observed that the primary roots of mulberry plants grown in Garden soil alone (T_0) were thin and had less roots while more and thicker roots were produced in all the other potting media treatments.

Table 5. Final length of primary roots (cm) of the mulberry saplings two months after planting

TREATMENTS	MEAN (cm)
T_0- Garden soil (control)	21.220 [ab]
T_1- Sand + Sphagnum moss + Garden soil	22.960 [a]
T_2- Sand + Compost + Garden soil	14.640 [b]
T_3- Sand + Rice hull + Garden soil	18.260 [ab]
T_4- Sand + Coir dusts + Garden soil	17.580 [ab]

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

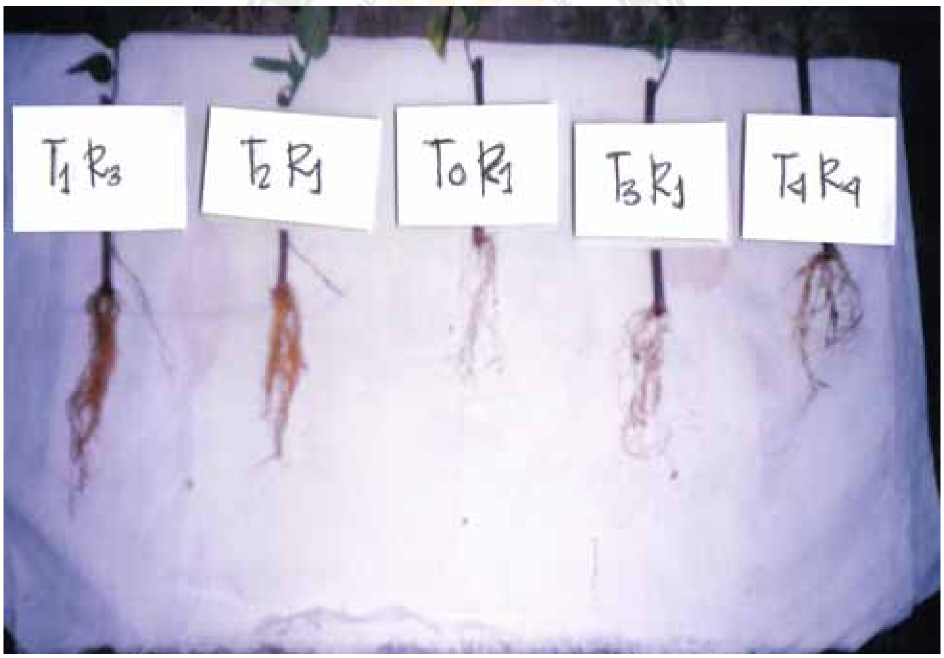

Figure 4. Differences in length of primary roots of the mulberry saplings as affected by different potting media mixtures

Root Weight of Mulberry Saplings.

Statistical analysis shows highly significant differences among the treatments as shown in Table 6. The highest root weight was taken from mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) with a mean of 2.32 g. On the other hand, cuttings grown in Garden soil alone (T_0) gave the lowest root weight having a mean of 0.96 g. It was also visually observed that roots of mulberry cuttings grown in Sand, Compost and Garden soil (T_2); Sand, Rice hull and Garden soil (T_3); and Sand, Coir dust and Garden soil (T_4) produces thick roots. However, the cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) produced more root hairs and thicker primary root. Meanwhile, the roots of mulberry cuttings grown in Garden soil alone (T_0) produced thin and less roots. These results could be attributed to the moisture holding capacity of the soil. On the other hand, sphagnum moss had a longer time to hold moisture because of its dead leaf tissues consisting largely water holding cells while garden soil alone does not retain enough moisture, thus, permitting the drying up of the potting media.

Table 6. Root weight (g) of the mulberry saplings after two months planting

TREATMENTS	MEAN (g)
T_0- Garden soil (control)	0.96 [b]
T_1- Sand + Sphagnum moss + Garden soil	2.32 [a]
T_2- Sand + Compost + Garden soil	1.30 [b]
T_3- Sand + Rice hull + Garden soil	1.00 [b]
T_4- Sand + Coir dusts + Garden soil	1.04 [b]

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

ROI of Each Potting Media

Table 7 shows the Return on Investment (ROI), Gross Return Sale, and Total Cost of Production of producing 1000 mulberry saplings each treatment.

Highest Return on Investment (ROI) of 179% was computed in mulberry cuttings grown in Garden soil alone (T_0) while the lowest ROI of 0.20% was realized in the mixture of Sand, Coir dust and Garden soil (T_4). Meanwhile, the ROI of 49% was obtained in cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1). However, this is appropriate for mulberry sapling production since it produced the longest primary roots with most roots hairs and vigorous growth among the other treatments. This assures satisfactory results on field performance of the mulberry cuttings grown in this media. The FAO Bulletin (1988) stated that the quality of saplings is important in determining a plantation's potential for quick high yields. The saplings chosen should be those that are fresh, strong, vigorous and not infected with pests. Their winter buds should be plump. Their root mass should be developmental. Finally, in newly developed areas, the saplings must be strictly quarantined to prevent diseases from spreading.

Table 7. Return on Investment (ROI) of each potting media projected at 1000 mulberry saplings for each treatment

TREATMENTS	Gross Return Sale (Php)	Total cost of prod'n (Php)	Net Income	ROI (%)	Rank
T_0- Garden soil (control)	5000	1790	3210	179	1
T_1- Sand + Sphagnum moss + Garden soil	5000	3365	1635	49	2
T_2- Sand + Compost + Garden soil	5000	4490	510	11	4
T_3- Sand + Rice hull + Garden soil	5000	3590	1410	39	3
T_4- Sand + Coir dusts + Garden soil	5000	4990	10	0.20	5

1 sapling = Php 5.00

Soil pH

Table 8 shows the soil pH of different potting media mixtures. The soil pH before the planting of the mulberry cuttings ranged from 5.7-7.0. This is within the soil pH range of mulberry which is 5.0-9.0 (Boraiah, 1986). It was observed that there was a decrease on the soil pH of different potting media after the experiment although they are still within the required soil pH for mulberry production. It was only the Garden soil alone (T_0) that gave a low soil pH of 4.4.

The soil pH obtained in a mixture of Sand, Sphagnum moss and Garden soil (T_1) and Sand, Compost and Garden soil (T_2) gave the ideal soil pH for mulberry production of 6.2-6.8 as stated by Boraiah (1986).

Table 8. Soil pH of each potting media before and after the experiment

TREATMENTS	BEFORE	AFTER
T_0- Garden soil (control)	5.7	4.4
T_1- sand + sphagnum moss + garden soil	6.8	6.2
T_2- sand + compost + garden soil	7.0	6.4
T_3- sand + rice hull + garden soil	6.5	6.1
T_4- sand + coir dust + garden soil	6.3	5.9

Weather Data

Table 9 shows the temperature, relative humidity and amount of rainfall during the conduct of the study.

The month of November 2006 had the highest temperature range of 15.4 ^{o}C-24.1 ^{o}C. On the other hand, the month of December 2006 gave 14-7 ^{o}C-23.3 ^{o}C. The lowest temperature range was given by January 2007 with 13.7 ^{o}C-23.2 ^{o}C. These temperature ranges were within the required temperature for mulberry production of 15 ^{o}C-24 ^{o}C as stated by Boraiah (1986). Meanwhile, the month of January 2007 had the highest relative humidity with 89.0% but lowest rainfall of 0.01 mm. This was followed by the month of November 2006 with 87% but with the highest rainfall of 72.4 mm.

Table 9. Meteorological condition during the conduct of the experiment taken at PAG-ASA, Balili, La Trinidad, Benguet

MONTH	TEMPERATURE (^{o}C)		Relative Humidity (%)	Amount of Rainfall (mm)
	Minimum	Maximum		
November 2006	15.4	24.1	87.0	72.4
December 2006	14.7	23.3	84.0	43.2
January 2007	13.7	23.2	89.0	0.01

The month of December 2006 had the lowest relative humidity of 84.0% with a rainfall of 43.2 mm.

Other Observations

The insect pests observed during the study were mulberry pyralids (*Margaronia phyloalis*), leaf hoppers (*Empoasca favae*), span worms (*Phthonandria atrilineata* Butler), aphids (*Cavariella aegoodii*), weevils (*Myllocerus favae*), snout beetles (*Sthenias grisator*) and tussock caterpillars (*Eucproctis fratterna* Moore). These pests damaged the mulberry plants by chewing and sucking the leaves and shoots of the mulberry plant. On the other hand, the diseases observed were mulberry red rust (*Aecidium mori* Barclay) and powdery mildew (*Phyllactinia moricola* P. Henn).

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted to determine the best potting medium/media for the growth and development of Batac mulberry cuttings for sapling production and to find out what potting medium gave vigorous sapling growth with longest and thickest primary root with most root hairs. Likewise, the Return on Investment for each rooting media was taken.

The Complete Randomized Design (CRD) was used in the experiment with five treatments namely: Garden soil (T_0); Sand + Sphagnum moss + Garden soil (T_1); Sand + Compost + Garden soil (T_2); Sand + Rice hull + Garden soil (T_3); and Sand + Coir dusts + Garden soil (T_4). Each treatment was replicated five times. Results showed that mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) significantly enhanced the growth of mulberry cuttings during the first to sixth week one month after planting, while mulberry cuttings grown in the mixture of Sand, Coir dusts and Garden soil (T_4) registered the lowest growth increment. The findings further revealed that the mixture of Sand, Sphagnum moss and Garden soil (T_1) grown saplings produces the thickest and longest roots. This was due to the high water-holding capacity of sphagnum moss and better aeration which provides plant roots sufficient oxygen for growth and development and enough water to supply the plant. Likewise, this potting medium provided the ideal soil pH required by mulberry plant. In addition, high number of leaves and high leaf weight were produced on the mulberry cuttings grown in this potting media.

Finally, this potting medium gave a 49% Return on Investment (ROI), the field performance will be better as compared to the other potting media treatments considering that their mixture lead better root development and vigorous plant growth.

Conclusion

The different potting media significantly enhanced the development of mulberry plants. However, the mulberry cuttings grown in the mixture of Sand, Sphagnum moss and Garden soil (T_1) gave the best results in all the parameters used to characterize the best potting media despite an ROI of 49%. This treatment gave the highest average mean of 16.76 cm, produced the highest number of leaves formed, the heaviest weight of leaves and the longest length of primary roots and thicker roots as compared to the mulberry cuttings planted in Garden soil alone (T_0); Sand + Compost + Garden soil (T_2); Sand + Rice hull + Garden soil (T_3); and Sand + Coir dusts + Garden soil (T_4).

Recommendation

The use of Sand + Sphagnum moss + Garden soil (T_1) as potting media mixture is recommended for mulberry sapling production despite an ROI of 49%. Although additional expenses was incurred it gave high results in growth increment, number of leaves formed, weight of leaves, length of primary roots and weight of roots. This insures better field performance when planted.

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APPENDICES

Appendix Table 1a. Growth increment (cm) of mulberry saplings on the first week one month after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	AVERAGE
T_0	4.4	4.0	4.7	4.6	4.1	21.80	4.36
T_1	6.1	6.2	10.7	5.6	7.2	35.80	7.16
T_2	4.9	5.6	4.2	5.8	4.2	24.70	4.94
T_3	6.1	4.1	4.9	4.2	5.4	24.70	4.94
T_4	5.9	4.5	4.4	4.2	4.5	23.50	4.70

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	24.3736	6.09340	5.14**	.87	4.43
Error	20	23.7280	1.18640			
TOTAL	24	48.1016				

**=highly significant coefficient of variance=20.77%

Appendix Table 1b. Growth increment (cm) of mulberry saplings on the second week one month after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	AVERAGE
T_0	6.9	5.2	5.9	6.5	6.4	30.90	6.18
T_1	8.8	8.7	13.4	8.2	10.7	49.80	9.96
T_2	7.1	8.8	5.7	10.1	5.9	37.60	7.52
T_3	7.1	5.7	6.4	5.5	6.8	31.50	6.30
T_4	7.3	5.6	5.4	5.3	5.7	29.30	5.86

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	56.7976	14.19940	7.26**	2.87	4.43
Error	20	39.1200	1.95600			
TOTAL	24	95.9176				

**=highly significant coefficient of variance=19.52%

Appendix Table 1c. Growth increment (cm) of mulberry saplings on the third week one month after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	AVERAGE
T_0	8.6	6.5	7.4	9.0	7.1	38.60	7.72
T_1	10.5	10.5	15.6	11.6	14.9	63.10	12.62
T_2	10.2	9.2	6.5	12.7	7.5	46.10	9.22
T_3	9.4	6.4	9.3	6.8	9.2	41.10	8.22
T_4	8.8	6.1	6.7	6.7	6.9	35.20	7.04

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	96.1736	24.04340	7.40**	2.87	4.43
Error	20	65.0040	3.25020			
TOTAL	24	161.1776				

**=highly significant coefficient of variance=20.11%

Appendix Table 1d. Growth increment (cm) of mulberry saplings on the fourth week one month after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	AVERAGE
T_0	10.3	7.9	8.9	11.2	10.2	48.50	9.70
T_1	13.9	13.4	24.3	14.6	18.6	84.80	16.96
T_2	12.8	14.1	7.9	16.4	9.6	60.80	12.16
T_3	13.6	7.9	11.4	8.2	12.0	53.10	10.62
T_4	10.5	8.4	8.8	8.5	9.2	45.40	9.08

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	201.0320	50.25800	5.99**	2.87	4.43
Error	20	167.7680	8.38840			
TOTAL	24	368.8000				

**=highly significant coefficient of variance=24.67%

Appendix Table 1e. Growth increment (cm) of mulberry saplings on the fifth week one month after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	AVERAGE
T_0	13.7	8.3	10.4	14.4	11.4	8.20	11.64
T_1	17.3	16.7	29.4	18.4	25.6	107.40	21.48
T_2	20.4	17.9	9.8	19.1	10.3	77.50	15.50
T_3	14.3	8.5	14.9	9.4	15.5	62.60	12.52
T_4	11.3	10.9	11.4	12.8	11.7	58.10	11.62

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	350.5064	87.62660	5.80**	2.87	4.43
Error	20	302.0560	15.10280			
TOTAL	24	652.5624				

**=highly significant coefficient of variance=26.71%

Appendix Table 1f. Growth increment (cm) of mulberry saplings on the sixth week one month after planting

TREATMENTS	REPLICATIONS					TOTAL	AVERAGE
	I	II	III	IV	V		
T_0	18.2	10.1	11.3	15.9	12.7	68.20	13.64
T_1	24.9	26.0	36.1	22.8	28.1	137.90	27.58
T_2	26.3	23.2	10.9	24.4	11.2	96.00	19.20
T_3	19.1	9.8	16.3	10.2	16.2	71.60	14.32
T_4	12.8	11.6	13.7	13.1	12.8	64.00	12.80

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	762.7384	190.68460	8.54**	2.87	4.43
Error	20	446.7680	22.33840			
TOTAL	24	1209.5064				

**=highly significant

coefficient of variance=27.03%

Appendix Table 1g. Overall average mean on the growth increment (cm) of mulberry saplings at one month after planting

TREATMENTS	MEAN
T_0	8.87
T_1	16.67
T_2	11.46
T_3	9.49
T_4	8.52

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	Tabulated $F_{0.01}$
Treatment	4	231.83086	57.957714	6.36**	2.87	4.43
Error	20	182.31888	9.115944			
TOTAL	24	414.149736				

**=highly significant coefficient of variance=27.40%

Appendix Table 2. Number of leaves formed of mulberry saplings two months after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	MEAN
T_0	10	4	7	7	5	33	6.60
T_1	10	15	15	9	14	63	12.60
T_2	11	10	3	11	7	42	8.40
T_3	9	4	8	4	10	35	7.00
T_4	7	5	5	4	6	27	5.40

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	155.2000	38.8000	5.59**	2.87	4.43
Error	20	138.8000	6.9400			
TOTAL	24	294.0000				

**=highly significant coefficient of variance=32.93%

Appendix Table 3. Weight of leaves (g) mulberry saplings two months after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	MEAN
T_0	2.6	1.2	1.3	2.0	1.4	8.5	1.70
T_1	2.5	3.4	4.2	2.8	3.5	16.4	3.28
T_2	2.6	2.4	1.1	2.6	1.8	10.5	2.10
T_3	2.2	1.2	1.9	1.1	1.9	8.3	1.66
T_4	1.7	1.3	1.5	1.6	1.4	7.5	1.5

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	10.4624	2.6156	8.93**	2.87	4.43
Error	20	5.8600	0.2930			
TOTAL	24	16.3224				

**=highly significant coefficient of variance=26.43%

Appendix Table 4. Final length of primary roots (cm) of mulberry saplings two months after planting

TREATMENTS	REPLICATIONS I	II	III	IV	V	TOTAL	MEAN
T_0	23.1	28.3	20.4	13.8	15.5	101.10	20.22
T_1	18.3	18.7	29.4	25.6	22.8	114.80	22.96
T_2	17.6	16.5	13.2	15.4	10.5	73.20	14.64
T_3	22.6	19.1	17.6	17.6	14.4	91.30	18.26
T_4	20.2	28.7	11.2	12.8	15.0	87.90	17.58

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated $F_{0.05}$	$F_{0.01}$
Treatment	4	210.8024	52.7006	1.94^{ns}	2.87	4.43
Error	20	542.2920	27.1146			
TOTAL	24	753.0944				

ns = not significant coefficient of variance=26.71%

Appendix Table 5. Root weight (g) of mulberry saplings two months after planting

TREATMENTS	REPLICATIONS					TOTAL	MEAN
	I	II	III	IV	V		
T_0	1.9	0.5	0.8	1.0	0.6	4.80	0.96
T_1	1.7	2.5	3.0	2.1	2.3	11.6	2.32
T_2	2.0	1.5	0.6	1.5	0.9	6.50	1.30
T_3	1.6	0.7	1.2	0.4	1.1	5.00	1.00
T_4	1.3	0.9	0.9	1.3	0.8	5.20	1.04

ANOVA

Source of variation	Degree of freedom	Sum of squares	Mean of squares	Tabulated F	Tabulated	
					$F_{0.05}$	$F_{0.01}$
Treatment	4	6.5536	1.6384	7.29**	2.87	4.43
Error	20	4.4920	0.2246			
TOTAL	24	11.0456				

**=highly significant coefficient of variance=35.80%

COLLEGE OF AGRICULTURE

MARCH 23, 2006
Date

APLLICATION FOR ORAL DEFENSE

Name: BENJIE G. YOGAYOG Major filed: SERICULTURE

Degree: BS AGRICULTURE Minor field: SERICULTURE

Title of Thesis: PERFORMANCE OF DIFFERENT POTTING MEDIA MIXTURES ON THE GROWTH AND ROOT DEVELOPMENT OF BATAC MULBERRY (*Morus alba* Linn.) CUTTINGS FOR SAPLING PRODUCTION

Endorsed: VALENTINO L. MACANES
Adviser (Name & Signature)

Date and Time of Defense: March 15, 2006 @ 2:30 pm

Place of defense: AGRICULTURAL COMPLEX 110

Approved:
AURORA D. ALBIS
Instructor/Professor
Name & Signature

Noted:
EULOGIO V. CARDONA JR.
Department Chairman

REPORT ON RESULT OF ORAL DEFENSE

Name and Signature	*Remarks
VALENTINO L. MACANES Adviser	______________________________
ARNOLD M. INUMPA Co-Adviser	______________________________
AURORA D. ALBIS Member, Advisory Committee	______________________________
EULOGIO V. CARDONA JR. Department Chairman	______________________________