Herbage Yield of Stevia (*Stevia rebaudiana* Bert.) in Response to Organic Growing Media

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Abstract- Stevia (*Stevia rebaudiana* Bert.) is a fast rising horticultural herb with many therapeutic and economic benefits. The study was conducted at the Nursery House of the City Agriculture Office, Casisang, Malaybalay City, Bukidnon, Philippines from November 2015 to January 2016 to evaluate the herbage yield of Stevia shoot tip cuttings in response to various growing media. The study was laid-out in a Completely Randomized Design (CRD) with five treatments and replicated three times with twenty sample plants per replication. The different treatments are: T_1 – pure garden soil, T_2 – ½ garden soil + ½ vermicast, T_3 – pure vermicast, T_4 – ½ sand + ½ vermicast, and T_5 – 1/3 garden soil + 1/3 sand + 1/3 vermicast. Results showed that Stevia shoot tip cuttings in T_5 (1/3 garden soil + 1/3 sand + 1/3 vermicast) grown in polyethylene pots consistently had the tallest plants 48.64 cm); highest survival rates (100%); least incidence of leaf curling (1.33 rating) and leaf dark spot (1.33); most number of leaves (226.41) and branches (21.13); and highest percentage of expanded leaves (69%). It also obtained significantly the heaviest fresh and oven-dried herbage, leaf and stem weights. It also attained the highest herbage yield and oven-dried leaf yield in hectare basis with 3,903.50 kg and 355.01 kg, respectively, thus, obtaining the highest gross sale of US $37,767.44 per hectare and a net income of US $ 25,980.21 with an ROI of 220.41%.

Index Terms- Stevia, herbage, leaf curling and dark spot, return on investment, oven-dried

I. Introduction

Diabetes is one of the most alarming dreadful killer diseases in the world today especially in the Philippines which ranks eight in terms of prevalence in the world and second to Malaysia in Southeast Asia (NSO, 2014; DOH, 2014; https://reginabengco.wordpress.com/tag/diabetes-in-the-philippines/). This situation stems from sugar with low calorie sweeteners which may effectively alleviate obesity and diabetes related health problems. The consumption of too much sugar as well as carbohydrates has led to obesity, heart diseases, hypertension and diabetes (Sattigeri, 2012).

Sugar substitutes like saccharin, sucralose and aspartame have currently gained importance in reducing calorie intake as artificial substitutes. However, prolonged use of artificially sweetened beverages or use of aspartame lead to increased frequency of brain tumors in humans (Fowler et al., 2008). Moreover, studies showed that patients of phenylketonuria (PKU) cannot use aspartame in their diet due to the formation of phenylalanine during its metabolism (Butchko et al., 2001). Likewise, saccharin is considered to be associated with bladder cancer (Pearson, 2001) while cyclamate has a major metabolite, cyclohexylamine, which causes testicular atrophy and at high doses, it has unwanted cardiovascular effects (Bopp and Price, 2001).

Stevia (*Stevia rebaudiana* Bertoni) is a natural and healthy alternative to sugar and artificial sweeteners. It is extensively grown in the subtropical regions, Stevia has long been widely used as sweetener in beverages in several countries like Brazil, Japan, Paraguay, etc. (Ghanta et al., 2007), however, it is not well known in the Philippines.

Its leaves are great sources of stevioside, a natural sweetener and is 250-300 times sweeter than sucrose, heat stable, pH stable, non-fermentable and has no effect on blood sugar (Geuns, 2003; Goyal and Samsher, 2010); hence considered and allowed to be called as sweetener by the Food and Drug Administration (FDA) of the US in 2008.

The stevioside once broken down into glucose during digestion is not absorbed in the blood stream, but instead is being absorbed by good bacteria in the gut; hence, prevents obesity and diabetes. Stevia alleviates hypoglycaemia and type 2 diabetes (Soejorto et al., 2002; Ramesh et al, 2006), nourishes pancreas and thereby helps restore its normal function. It also contains high percentage of phenols that reduce the cardiac and cancer diseases (Dragovi-Uzelac et al., 2010) and flavonoids which have high antioxidant activity (Tadhani et al., 2007; Shukla et al., 2009).

Stevioside related compounds such as rebaudioside A and steviol offer therapeutic benefits like antihypertensive, antidiabetic, anti-inflammatory, anti-tumor, antioxidant, antidiarrheal, diuretic and immunomodulatory actions. Steviol interacts with the drug transporters, hence proposed as drug modulator (Goyal and Samsher, 2010).

The economic importance, health benefits and high demand of Stevia in both local and export market provide great production, income and livelihood opportunities for farmers, hobbyists and households. Moreover, the crop is adapted over a wide range of climatic conditions in the country and apparently been successfully grown abroad (Qui et al., 2000).

At present, only few Filipinos are aware about Stevia as well as its propagation, post-harvest handling and processing practices. There are no protocols on rapid clonal propagation of the plants grown in organic growing media. Likewise, no enough research has been available on the herbage yield as well as the cost and return analysis venturing into production of this plant.

Thus, this study attempted to evaluate growth and yield of the two months old Stevia shoot tip cuttings grown in different organic media.

II. MATERIALS AND METHODS

The study was conducted at the Nursery House of the City Agriculture Office, Casisang, Malaybalay City, Bukidnon, Philippines for two (2) months starting November 2015 to January 2016.

The study utilized two (2) month-old Stevia propagated through shoot tip cuttings, B-net screened nursery structures (9.5 m long x 5.5 m wide x 3 m high) with 50-60% shade, cutting propagation tools, hose, garden soil, sand, vermicast, water sources, sprinklers, garden tools, wooden sticks, scissors/cutting tools, plastic twines, rulers/meter stick, weighing scales, cent-o gram balance, polyethylene pots/bags #150, stevia leaves and stems, blender, empty sacks/mesh nets, packaging/processing tools and equipment.

This study was, then, laid-out using a simple Completely Randomized Design (CRD) with five treatments and replicated three times with 20 sample plants per replication as follows:

T_1 - Pure Garden Soil (Control)
T_2 - ½ Garden Soil + ½ Vermicast
T_3 - Pure Vermicast
T_4 - ½ Sand + ½ Vermicast
T_5 - 1/3 Garden Soil + 1/3 Vermicast + 1/3 Sand

The experimental lay-out of the study utilized the same area in cemented boxes of 10 sq. m. (10 m long and 1 m wide) as in Study I inside the B-net screened nursery. The area was divided into 15 plots of equal sizes (1 m x 0.75 m or an area of 0.75 sq.m. each plot) corresponding the five treatments and an alleyway between plots of 0.30 m as well as 0.5 m from plots to the nursery wall.

The same growing media and their combinations as in Phase I were utilized in this study. Hence, same data from laboratory analysis were considered.

A total of 300 polyethylene pots #150 were used in the study. These pots were filled with 1.5 kg of each growing medium corresponding the different treatments. The two months old Stevia plants propagated using shoot tip cuttings in Phase I were prepared for this phase.

The prepared plants were then transplanted to polyethylene pots #150 corresponding all the treatment plots utilizing the same growing media and/or their combinations. Labeling of respective treatments was done accordingly.

Watering was done twice a day, morning and afternoon or as needed by the plants. The plant environment was kept moist all the time but not water soaked, especially those grown in the sand.

Removal of weeds was done manually and using bolos since the plants were grown in pots. Cultivation of the media was also done to prevent them from compaction.

Since the plants were grown in a controlled environment under a nursery condition, only few symptoms of pest attacks or deficiency symptoms such as leaf curling and leaf dark spots were observed in some parts of plant leaves.

Since stems and branches of stevia are succulent, they are prone to lodging. Propping of the main stem for support using sticks would ensure their quality growth performance (Todd, 2010). Propping was done in every plant using bamboo sticks with attached pliable wire to support the growing branches of the plants. This was done when the branches of the plants started to lodge.

Harvesting of the herbage was done after four (4) months before or prior to flower bud opening so that the presence of sweet taste compound is at its peak of production. Harvesting was done in the late afternoon using scissors by cutting the main stem or stalk 5 cm above the ground. The harvested parts were then labeled accordingly and placed in plastic bags.

The herbage parts including the stems and leaves were weighed (in grams) using a Cent-o gram balance according to treatments and replications in determining their fresh weights. Weighing was done once only at the termination of the phase.

All fresh leaves of stevia were separated from the stems per treatments per replication manually. After separation, leaves and stems were then weighed to determine their respective fresh weights.

After separating the leaves from the stems or branches, they were air-dried for 2 days. After air-drying, they were oven-dried for 48 hours at 65^{o}C.

Air-dried leaves were stored in plastic lined cardboard boxes, sealed, strapped and labeled for further processing. The labeled dried samples were then powdered using grinder and were stored in polyethylene bags at 4^{o}C for further laboratory analysis.

Among the data gathered were plant height; survival rate; leaf curling and dark spot incidence; number of branches and leaves; percent expanded leaves; fresh, oven dried and percent moisture content for the total herbage, leaf and stem of Stevia; fresh herbage yield and oven-dried leaf yield per hectare; and the cost and return analysis.

The analysis of variance (ANOVA) using Factorial Arrangement in Completely Randomized Design (CRD) in Phase I and a simple CRD in Phase IIA were used to determine the level of significance. The Tukey Test was used to compare significant differences among treatment means.

III. RESULTS AND DISCUSSION

Average Plant Height

The average plant height of Stevia propagated though shoot tip cuttings using different growing media is shown in Table 1. Statistical analysis revealed no significant differences observed among treatment means.

Stevia shoot tip cuttings obtained the height ranging from 45.35 cm for those grown in pure garden soil to 49.24 cm in the growing media combination of T_2 (½ garden soil and ½ vermicast) four months and one week after planting. Those grown in T_5 (1/3 garden soil + 1/3 sand + 1/3 vermicast) had the second tallest height with 48.64 cm, while those grown in T_4 (½ sand and ½ vermicast) with 47.65 cm and pure vermicast with 47.36 cm. However, their differences were not that statistically significant from each other. This means that as the plants approached reproductive stage, their growth seemed to slower down (Hartman and Kester, 2013). Since Stevia plants don't

need so much nitrogen as well as other macroelements, they can still thrive well even in a garden soil as long as soils are not compact. Stevias only need as low as 10 kg per hectare NPK (Todd, 2010).

Table 1. Average plant height (cm) and survival rate (%) of Stevia (*Stevia rebaudiana* Bert.) in response to growing media

TREATMENTS	AVE. PLANT HEIGHT(cm)	SURVIVAL RATE (%)
T1 - Pure Garden Soil	45.35	98.33
T2 - ½ Garden Soil +½ Vermicast	49.24	100
T3 - Pure Vermicast	47.36	100
T4 - ½ Sand + ½ Vermicast	47.65	98.33
T5 -1/3 Garden Soil+1/3 Sand+1/3 Vermicast	48.64	100
F-test	ns	ns
C.V. (%)	6.82	1.84

ns – non significant

Survival Rate

The survival rate of Stevia shoot tip cuttings grown in different growing media revealed no significant difference from among the treatments compared (Table 1). The survival rate of the cuttings was very high regardless of the growing media used. Shoot tip cuttings grown in T_2 (½ garden soil + ½ vermicast), T_3 (pure vermicast) and T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) had 100% survival rate, while those grown in T_1 (pure garden soil) and T_4 (½ vermicast + ½ sand) obtained both 98.33% survival rate. Thus, propagating Stevias using shoot tip cuttings is the best method because only little mortality was achieved.

As Kassahun et al. (2013) emphasized that top cuttings or shoot tip cuttings with three nodes demonstrated significantly higher values of survival rate compared from those cuttings taken from the bottom. Pradeep (2005) supported that shoot tip culture can mass propagate Stevia very fast in a short period of time. Cells in the shoot tips are actively-dividing or meristematic and have higher concentrations of auxins (Hartman and Kester, 1997).

Leaf Curling and Leaf Dark Spot Incidence

Table 2 reveals the leaf curling and leaf dark spot incidence of Stevia shoot tip cuttings in response to growing media. Statistical analysis showed that growing media did not significantly affect the incidence of leaf curling and lead dark spot on Stevia plants.

The incidence of insect pests was not a problem among Stevia since the study was confined inside a B-net nursery with 50-60% shade in an elevated environment. No insect pest was observed attacking the plants during the entire duration of the study. Only few symptoms of leaf curling and dark leaf spots were seen in some plants but in negligible amount in most of the treatments except for those grown in pure garden soil. According to UK Extension Service (2010), field-grown Stevia as well as those confined in nurseries is not known to have serious insect pest problems and is often reported as exhibiting insect-repellant qualities.

The agro-climatic condition of Malaybalay City is also favorable for growing Stevia with a mean temperature of 22.85 ^oC in September, 23.01 ^oC in October, 23.25 ^oC in November, 23.05 ^oC in December and 22.6 ^oC in January . Favorable precipitation had also been experienced by the plants in the entire duration of the study with 128. 8 mm in November, 158.9 mm in December and 53.3 mm in January and the constant watering of the plants daily.

On leaf curling significant differences were not found between treatment means. It showed that T_2 and T_5 had obtained both the least number of leaf curling occurrences with 1.33 from 20 sampled plants, while the most with an average of 2 as observed in T_1 (pure garden soil) . For the leaf dark spot, there was no significant difference observed among treatment means. Treatment 5 consistently showed the least number of plants infected with the symptom which had 1.33 occurrences, followed by those in T_2 and T_3 with both 1.67 and the least was obtained in T_1 and T_3 with both 2 occurrences from among the 20 sampled plants per plot.

Table 2. Leaf curling and dark spot incidence of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	LEAF CURLING	LEAF DARK SPOT
T1 - Pure Garden Soil	2.00	2.00
T2 - ½ Garden Soil +½ Vermicast	1.33	1.67
T3 - Pure Vermicast	1.67	1.67
T4 - ½ Sand + ½ Vermicast	2.00	2.00
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	1.33	1.33
F-test	ns	ns
C.V. (%)	26.83	25.80

ns– non significant

Average Number of Branches per Plant

Statistical analysis revealed that the number of branches per plant was not affected regardless of the growing media used (Table 3). Four months and one week after planting, the differences on the total number of branches per plant were not that significant, contrary to the branches produced by the plants two months after planting (Table 6) wherein differences were observed from among the treatment means. Treatment 5 showed the most number with 21.13, while the least by T_1 with 13.04. Treatment 3 was third with 17.87, T_2 with 17.17 and T_4 with 14.54 average branches per plant.

The declining growth of the plant when reaches to reproductive stage has resulted to less production of plant organs, as the number of cells have declining increase but however, become differentiated (Hartman and Kester, 1997). At this stage on the growth of stevia cuttings, the differences of their heights did not statistically matter regardless of the kind of the growing media used.

Table 3. Average number of branches per plant of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	AVE. NO. OF BRANCHES PER PLANT
T1 - Pure Garden Soil	13.04
T2 - ½ Garden Soil +½ Vermicast	17.17
T3 - Pure Vermicast	17.83
T4 - ½ Sand + ½ Vermicast	14.54
T5 -1/3 Garden Soil+1/3 Sand+1/3 Vermicast	21.13
F-test	ns
C.V. (%)	21.30

ns – non significant

Average Number of Leaves per Plant

The average number of leaves per plant regardless of the sizes was influenced by growing media in propagating Stevias through shoot tip cuttings (Table 4). Significant differences were observed among treatment means with T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) obtaining the most average number of leaves at 226.41 per plant. It was, however, not significantly different from those in T_3, T_4 and T_2 with 211.87, 176.53 and 171.60 leaves per plant, respectively. The control treatment, T_1 (pure garden soil) had the least with 135.03 average leaves.

Treatments 2, 3, 4 and 5 with the combinations of vermicast, garden soil and sand as growing media contributed to the maximization of the production of leaves of Stevias given the nutrients available for the use of the plants especially in the proliferation of various plant parts such as leaves (Hartman and Kester, 1997). Treatment 1 using only pure garden soil with no application of any fertilizer resulted to lesser production of leaves as compared to the rest of the treatments. Full maximization of the leaves was attained especially in T_5 due also to the fertile media in vermicast, proper drainage and aeration for sand, and with slight water holding capacity as exhibited by the use of garden soil which is favorable for the growth of the plants.

Table 4. Average number of leaves per plant of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	AVE. NO. OF LEAVES PER PLANT
T1 - Pure Garden Soil	135.03[b]
T2 - ½ Garden Soil +½ Vermicast	171.60[ab]
T3 - Pure Vermicast	211.87[ab]
T4 - ½ Sand + ½ Vermicast	176.53[ab]
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	226.41[a]
F-test	*
C.V.(%)	17.03

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey's Test. *- *significant*

Percent Expanded Leaves

Table 5 shows the percent expanded leaves over the total leaves borne per plant per plot showing highly significant results among treatment means with growing media combinations. Thus, growing media as treatments highly influenced the production of expanded leaves of Stevia plants.

Treatment 5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) produced 69% of the total leaves per plant and considered as expanded sizes. It was significantly different from the rest of the treatments (Fig. 7). Treatment 2 (½ garden soil + ½ vermicast) was second with 58% and was not significantly different from T_4 and T_3. Treatment 4 (½ vermicast + ½ sand) was third with 57.67% and T_3 (pure vermicast) in fourth with 49.33%. The least was obtained in T_1 (pure garden soil) with 42.33%.

The standard large or expanded leaves among Stevia plants have at least a dimension of 2 cm wide and 3 cm long (Abou-Arab et al., 2010; http://www.thriftyfun.com/Growing-and-Harvesting-Stevia.html). Large leaves are heavier than the small ones, thus higher content of herbage material. They have fully developed chemical compounds especially the natural sweeteners called stevioside (Abdullateef and Osman, 2012). Hence, used for herbage production.

Table 5. Percent expanded leaves of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	PERCENT LARGE LEAVES (%)
T1 - Pure Garden Soil	42.33[c]
T2 - ½ Garden Soil +½ Vermicast	58.00[b]
T3 - Pure Vermicast	49.33[bc]
T4 - ½ Sand + ½ Vermicast	57.67[b]
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	69.00[a]
F-test	**
C.V. (%)	6.47

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey's Test. **- *highly significant*

Fresh and Oven-Dried Herbage Weights and Percent Herbage Moisture Content

The average fresh herbage weights of Stevia leaves were taken from each Stevia plant in the plot by cutting the main stem 5 cm above the surface using scissors, leaving 2 to 3 nodes in the stem from the base of the plants.

The fresh herbage weights, oven-dried weights and the percent herbage moisture content of Stevia propagated through shoot tip cuttings using different growing media are shown in Table 6. Statistical analysis showed that fresh herbage weights of Stevia highly varied from each other depending upon the growing media used. The oven-dried weight and the percent moisture content in the dry herbage were not significantly affected by the growing media used in the study.

On fresh herbage weights, it showed that T (1/3 garden soil + 1/3 vermicast + 1/3 sand) obtained the heaviest average weight with 171.23 g per plot (Fig. 1). It was not, however, significantly different from T_2 (½ garden soil + ½ vermicast) with 161.83 g, T_3 (pure vermicast) and T_4 (½ sand + ½ vermicast) with 140.99 g; but were statistically different from those in T_1 (pure garden soil) with 111.70 g. Treatment 4 (½ sand + ½ vermicast) was not significantly different from T_1 (pure garden soil).

The heavier fresh herbage weight obtained in T_5 was attributed to the consistent good growth performance of Stevia under this treatment such as high survival rate (100%), more branches (21.13), most number of leaves (226.41) and highest in percent large leaves per plant (69%). Treatments 2, 3 and 4 are likewise good performing treatments whose growing media were effective in producing heavier fresh herbage weights. The complexity of all growth parameters has been contributory to the development of the plant (Hartman and Kester, 1997; Bautista, 1994). Treatment 1 (pure garden soil) was the least performing treatment, showing the lightest fresh herbage weight of all.

Table 6. Fresh and oven-dried herbage weights (g) and percent herbage moisture content (%) of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	FHW (g)	ODHW (g)	PERCENT HMC (%)
T1 - Pure Garden Soil	111.70[b]	21.86	19.57
T2 - ½ Garden Soil +½ Vermicast	161.83[a]	30.61	18.91
T3 - Pure Vermicast	157.67[a]	28.69	18.20
T4 - ½ Sand + ½ Vermicast	140.99[ab]	26.80	19.01
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	171.23[a]	33.29	19.44
F-test	**	ns	ns
C.V. (%)	9.41	15.42	12.41

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey's Test. ** *highly significant, ns – non significant,*

FHW – fresh herbage weight, ODHW – oven dried herbage weight, HMC – herbage moisture content

For the oven-dried herbage weight, T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) obtained a slightly heavier weight of 33.29 g per plot, while the slightly lighter weight was in T_1 (pure garden soil) with 21.86%. Treatment 2 (½ garden soil + ½ vermicast) weighed 30.61 g, T_3 (28.69 g) and T_4 (26.80 g) (Table 6). However, their differences were not that significant from each other. All the sampled treatments were equally oven-dried for 72

hours at 40°C causing all the moisture in the samples to be equally removed in all treatments.

The corresponding percent herbage moisture content revealed that T_1 (pure vermicast) had the highest with 19.57% followed by T_5 (1/3 garden soil, 1/3 vermicast + 1/3 sand) with 19.44 %, followed by T_4 (19.01 %) and T_2 (18.91 %) (Table 6). The lowest was garnered in T_3 (pure vermicast) with 18.20% moisture content. However, their differences were not significantly different from each other.

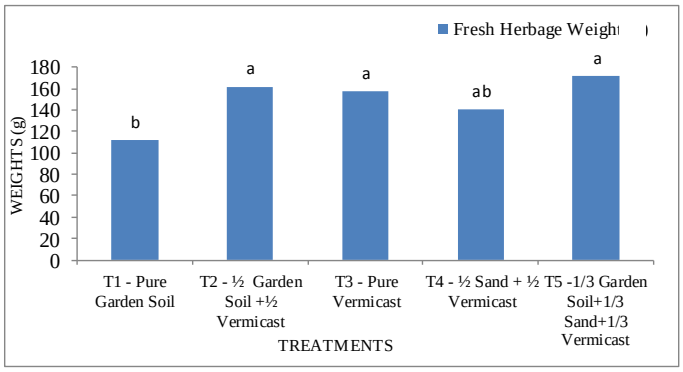

Fig. 1. Fresh herbage weight (g) of Stevia shoot tip cuttings in response to growing media

Fresh and Oven-Dried Leaf Weight and Percent Leaf Moisture Content

The fresh and oven-dried leaves of Stevia from the herbage and their respective percent leaf moisture content are shown in Table 7. Statistical analysis revealed that fresh leaf weight of stevia was highly influenced by the various effects of growing media. However when oven-dried for 3 days at 40°C, differences among treatment means did not significantly vary regardless of the growing media used.

Consistent with those in the fresh herbage weights, the fresh leaf weight in T_5 (1/3 garden soil + 1/3 vermicast +1/3 sand) obtained 97.78 g per plot as the heaviest, but was not significantly different from those in T_2 (½ garden soil + ½ vermicast), T_3 (pure vermicast) and T_4 (½ sand + ½ vermicast) with 86.46 g, 80.45 g and 74.21 g, respectively (Fig. 2). Treatment 1 (pure garden soil) had the lightest of all with 56.70 g per plot which in turn not significantly far from those in Treatments 3 and 4. Treatment 5, on the other hand, was the heaviest since it has the most number of leaves (Table 4) as compared to the rest of the treatments. The proper and balance nutrient uptake provided in T_5 for plant utilization has resulted to good growth and development of the plants especially the leaves.

Table 7. Fresh and oven dried leaf weights (g) and percent moisture content (%) of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	FLW (g)	ODLW (g)	PERCENT LMC (%)
T1 - Pure Garden Soil	56.70^{b}	12.22	21.55
T2 - ½ Garden Soil +½ Vermicast	86.46^{a}	15.37	17.78
T3 - Pure Vermicast	80.45^{ab}	14.37	17.86
T4 - ½ Sand + ½ Vermicast	74.21^{ab}	12.46	16.79
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	97.87^{a}	15.73	16.07
F-test	**	ns	ns
C.V. (%)	12.31	16.24	15.22

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey's Test.

***- highly significant, ^{ns} – non significant*

FLW –fresh leaf weight, ODLW – oven dried leaf weight, LMC – leaf moisture content

Consistent also with those in the oven-dried herbage weights, the oven-dried leaf weight in T_5 was the heaviest with 15.57 g per plot, followed by T_2 with 15.37 g, T_3 with 14.37 g and T_4 with 12.46 g (Fig. 2). Treatment 1 with pure garden soil had the ODW of 12.22 g. Their differences were, however, not significantly different from each other. At 48 hours oven-drying at 65°C temperature, all moisture content in all treatments was removed thus, leaving the dry weight of the leaves alone.

For the percent leaf moisture content, it showed that T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) had the lowest percentage of moisture content from the fresh weight with 16.07 %, followed by T_4 (16.79 %), T_2 (17.78 %) and T_3 (17.86 %). The highest was obtained in T_1 (pure garden soil) with 21.55 %. Their differences were, however, not significantly far from each other. Thus, the percent moisture content of the oven-dried leaf weight of stevia grown in this media would range from 16.07 % to 21.55 %. This further implies that the lower the moisture content, the higher is the dry matter for processing utilization.

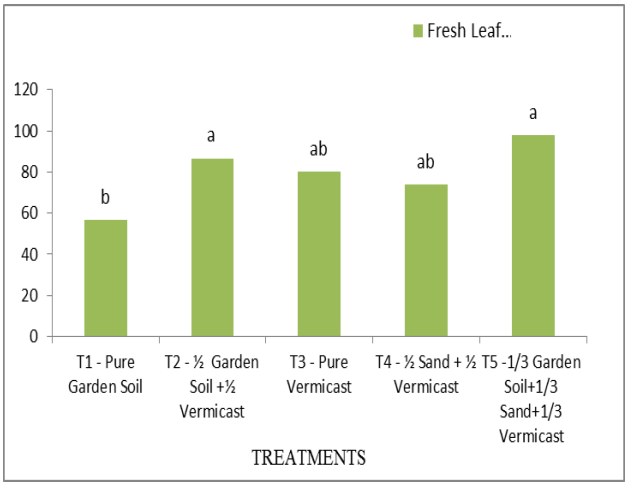

Fig. 2. Fresh leaf weight (g) of Stevia shoot tip cuttings in response to growing Media

Fresh and Oven-Dried Stem Weight and Percent Stem Moisture Content

The fresh and oven-dried weights of Stevia stems or branches as well as their respective percent moisture content are revealed in Table 8. Statistical analysis showed no significant differences found among treatment means on fresh stem weights and the percent stem moisture content. However, the oven-dried weights of all treatments were significantly influenced by the growing media used.

On fresh stem weights, T_3 (pure vermicast) obtained the heaviest weight with 77.14 g per plot and followed by T_2 (½ garden soil + vermicast), T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) with 73.35 g and T_4 (½ sand + ½ vermicast) with 66.48 g. The lightest was observed in T_1 (pure garden soil) with 54.95 g . Their differences were said to be not significant from each other. Treatment 5 which exhibited best growth performance among the treatments had lighter fresh stem weight at 73.35 g. This is a good indication since more concentration of food reserves or photosynthates are in stored in the leaves than in the stems or branches. The good and balance media combinations for T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) have resulted to the production of more and heavier leaves as compared to T_1 (pure garden soil) with fewer and lighter leaves, but heavier stem weights.

Table 8. Fresh and oven-dried stem weights (g) and percent moisture content (%) of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media

TREATMENTS	FSW (g)	ODSW (g)	PERCENT SMC (%)
T1 - Pure Garden Soil	54.95	10.29[b]	18.73
T2 - ½ Garden Soil +½ Vermicast	75.34	15.24[ab]	20.23
T3 - Pure Vermicast	77.14	15.69[ab]	20.34
T4 - ½ Sand + ½ Vermicast	66.48	14.34[ab]	21.57
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	73.35	17.71[a]	24.14
F-test	ns	*	ns
C.V. (%)	12.46	14.06	12.21

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey Test.

***- highly significant, ^{ns} – non significant*

FSW – fresh stem weight, ODSW – oven dried stem weight, SMC - stem moisture content

The respective oven-dried stem weights of various treatments were significantly influenced by the growing media used. Treatment 5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) had the heaviest oven-dried stem weight with 17.71 g per plot. It was, however, not significantly different from those in T_3 (pure vermicast), T_2 (½ garden soil + ½ vermicast) and T_4 (½ sand + ½ vermicast) with 15.69 g, 15.24 g and 14.34 g per plot, respectively. The lightest was observed in T_1 (pure garden soil) with 10.29 g per plot. Treatments 1, 2, 3 and 4 were not statistically different from each other. This also implies that T_5 had the highest dried weight recovery from the rest of the treatments, while T_1 had the least (Table 8).

Thus, the percent stem moisture content of stevias from the fresh weight showed the highest in T_5 (1/3 garden soil + 1/3 vermicast + 1/3 sand) with 24.14%, while the least in T_1 with 18.73%. However, their differences were statistically insignificant from each other with the percent stem moisture content of all the treatments ranges from 18.73% to 24.14%.

Fresh Herbage and Oven-Dried Leaf Yield (kg/ha)

The fresh herbage yield and the oven-dried leaf yield of Stevia shoot tip cuttings propagated in different growing media are presented in Table 9. Fresh herbage yield was highly influenced by the different growing media; however, the oven-dried leaf yield was otherwise.

On the fresh herbage yield, it showed that T_5 with 1/3 garden soil + 1/3 vermicast + 1/3 sand obtained the highest herbage yield of 3,903.495 kg/ha, but was not significantly different from those in Treatments 2, 3 and 4 with 3,689.209; 3,567.558 and 3,213.981 kg/ha, respectively. It is however statistically far from those in T_1 (pure garden soil) with 2,546.353 kg. Treatment 5 obtained the highest herbage yield due to the fact that it had the heaviest herbage weight per plot. As Hartman and Kester (1997) emphasized that growth parameters are contributory to the yield of the crops.

For the oven-dried leaf yield, it showed that the combinations of different growing media did not significantly affect the yield of Stevia plants. Statistical analysis revealed no significant differences observed among treatment means. It showed that T_5 still obtained the highest leaf yield with 355.01 kg/ha as compared to the control, T_1 with 278.57 kg/ha . However, their respective weights were not that far from each other the fact that they were subjected to oven-drying where all the moisture contained in the leaves was removed, thus leaving only their respective dry matter contents.

Table 9. Fresh herbage and oven-dried leaf yield (kg/ha) of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings propagated in different growing media

TREATMENTS	FRESH HERBAGE YIELD (kg/ha)	OVEN-DRIED LEAF YIELD (kg/ha)
T1 - Pure Garden Soil	2,546.35[b]	278.57
T2 - ½ Garden Soil +½ Vermicast	3,689.21[a]	350.46
T3 - Pure Vermicast	3,567.56[a]	327.58
T4 - ½ Sand + ½ Vermicast	3,213.98[ab]	287.76
T5 - 1/3 Garden Soil+1/3 Sand+1/3 Vermicast	3,903.50[a]	355.01
F-test	**	ns
CV(%)	9.22	16.50

Means within the same column followed by common letters are not significantly different at 5% level of significance based on Tukey's Test.

***- highly significant, ns – non significant*

Cost and Return Analysis

Table 10 shows the cost and return analysis for the first cropping of oven-dried Stevia leaves. Treatment 5 (1/3 garden soil +1/3 sand+1/3 vermicast) obtained the highest gross sales of US $37,767.45, T_2 had US $37,282.55, T_3 with US $ 34,849.36 and T_4 with US $30,613.09. The lowest was garnered in T_1 (control, pure garden soil) with US $29,635.21. For the incurred operational expenses, it revealed that T_3 (pure vermicat) had the highest with US $13,297.87and T_5 with US $11,787.23, while the lowest at T_1 at US $9,765.96with only pure garden soil. Thus, T_5 obtained the highest net income of US $25,980.21, while the lowest in T_4 with US $18,336.49. Treatment 5 likewise showed the highest return on investment (ROI) with 220.41%.

Investing Stevias for powdered leaf production is quite viable. In just four months' time for the first cropping season, the ROI could reach as much as 203.45% even if no fertilizer applied, how much more if 1/3 garden soil + 1/3 sand + 1/3 vermicast will be used as growing media would yield as much as 200.41% ROI.

The second cropping season revealed that the ROIs of all the treatments were more or less doubled from the first, showing consistently T_5 with 671.77% as the highest ROI and T_4 with 525.57% as the lowest, while the T_1 had 566.44%. The addition of ¼ volume of vermicast in T_2, ½ volume in T_3 and ¼ volume in T_4 in the third cropping had increased the expenses incurred, thus, lowering the respective ROIs from the first cropping season. However, T_5 had the highest ROI also in the third and fourth cropping seasons, respectively with 610.03% and 671.77%, respectively.

Table 10. Cost and return analysis (US $) of oven-dried leaves of Stevia (*Stevia rebaudiana* Bert.) shoot tip cuttings in response to growing media (First Cropping)

TREATMENTS	GROSS SALES	EXPENSES	NET INCOME	ROI (%)
T1 - Pure Garden Soil	29,635.21	9,765.96	19,869.26	203.45
T2 - ½ Garden Soil + ½ Vermicast	37,282.55	13,212.76	24,069.79	182.17
T3 - Pure Vermicast	34,849.36	13,297.87	21,551.49	162.07
T4 - ½ Sand + ½ Vermicast	30,613.09	12,276.60	18,336.49	149.18
T5 - 1/3 Garden Soil + 1/3 Sand+1/3 Vermicast	37,767.45	11,787.23	25,980.21	220.41

Adjusted Prices: US $ 106.38/kg (Source: http://www.aliexpress.com/price/stevia-dry-leaves_price.html)
US $287.23 – US $478.72/ kg (Source: UK Coop. Extension Service, 2010)

IV. Conclusion

It is therefore concluded that propagating Stevias using shoot tip cuttings in combination with 1/3 garden soil + 1/3 sand + 1/3 vermicast media mixture either in polyethylene pots for four months showed the best growth and yield performance as well as increased profitability in hectare basis.

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