Development of Component Technology for High Yield and Quality Stevia *(Stevia rebaudiana* Bertoni*)*

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ABSTRACT

Two experiments conducted at the experimental field station of the Nueva Vizcaya State University from August 2013 to December 2013 aimed to develop a technology in the production of Stevia propagules using different stem cuttings and planted in different substrates. Field performance in terms of growth, yield, percent survival and quality were also studied. The first experiment was laid in 2 x 4 factorial in Completely Randomized Design (CRD) with three replications and the second experiment was laid in a 4 x 3 factorial in Randomized Complete Block Design (RCBD).

Based on the results of the study, the best substrate for stevia propagule production is 1:1 carbonized rice hull and garden soil. Economic and biological yield is best attained in the application of inorganic fertilizer (14-14-14, 46-0-0) or processed chicken manure (PCM). Sweeter taste is attained when the plant is applied with fertilizer inputs. Greener color is attained at planting distance of 30 cm x 20 cm.

INTRODUCTION

The Stevia plant (*Stevia rebaudiana* Bertoni) belongs to the Asteraceae or Compositae family. It is known as sweet leaf, sweet herb, honey leaf and candy leaf (Carakotas *et al.*, 2010). Stevia is a natural non-calorie sweetener and is indigenous to the northern regions of South America. Centuries ago, natives of Paraguay used the leaves to sweeten their bitter drinks. The plant made its way to Pacific Rim countries where in recent decades it became cultivated domestically, used in its raw leaf form and now is commercially processed into sweetener (Todd, 2010). Here in the Philippines, it is already grown in nurseries in Antipolo, Cavite, Quezon and Bicol. Just recently, it has been introduced in Nueva Vizcaya.

The main source of sugar has long been cane sugar and beet sugar but these sugars along with sweetening qualities have been found to contribute calories which can lead to various chronic diseases. The Stevia leaves have a history of use as sweeteners due to the presence of sweet crystalline glycoside called stevioside which is 200-300 times sweeter than sucrose. Stevioside is non caloric, non fermentable, non-discoloring, heat stable at 95 °C and has a lengthy shelf life. In addition to the mentioned features, there are more properties that make Stevia an attractive compound for industrialists. Sweetness caused by Stevia lasts longer, for more than 40 seconds in comparison to sugar. Its high water absorption capacity makes it an advantageous ingredient of viscous food stuffs. Similarly, it has a higher tendency of fat absorption that retains flavor for a longer duration. Products containing Stevia have lower glycemic index that is beneficial for diabetic persons (Savita *et al.*, 2004).

The plant is also considered a healing herb. It has anti-bacterial, anti-fungal, anti-inflammatory, anti-viral, anti-yeast, cardiotonic, diuretic and hypoglycaemia properties. It regulates blood pressure, fights cavities and induces pancreas to produce more insulin (World Health Organization).

The worldwide demand for high-potency sweetener is expected to increase, especially with the new practice of blending different sweeteners. Stevia offers the best alternative considering that a hectare planted with Stevia is equivalent to 60-90 hectares of sugar cane. The added advantage of Stevia sweeteners are natural plant products. (Todd, 2010). Stevia is likely to become not only a major source of high potency sweetener for the growing natural food market but also as medicine for treatment against various diseases like diabetes, dental caries, obesity, and stomach infections (Debnath, 2008).

Although there is greater interest in this plant now as a natural alternative to artificial sweeteners like saccharin, aspartame and asulfam-K, progress towards large scale commercialization of Stevia has been rather slow, largely due to difficulties in propagating the crop. Stevia is propagated either through seeds or cuttings. However, low and erratic seed germination (owing to its small seed size and related bottlenecks in nutrition) and slow establishment of seedlings warrant its propagation through vegetative means. Among different vegetative means, stem cutting is a cheaper and better alternative (Smitha and Umesha, 2012).

Vegetative propagation needs suitable substrates for rooting. Likewise, when these rooted propagules are planted and established in the field, appropriate cultural management should be employed. To encourage production and utilization of Stevia in the province of Nueva Vizcaya, package of technology (POT) on clonal or vegetative propagation including Stevia production in the field should be available, hence this research.

The general objective of the study was to generate benchmark information on the effects of stem cutting type and substrates for rooting on clonal propagation of Stevia as well as effects of distance of planting and fertilizer inputs on field production of stevia plants which would serve as guide in the development of appropriate component production technology for high yield and good quality Stevia. Specifically, the study tried to: 1) evaluate the growth of Stevia using stem cuttings in different growth substrates; 2) determine the most appropriate stem cutting type and rooting substrate for Stevia propagation; 3) evaluate the growth, yield and leaf quality of Stevia as affected by fertilizer inputs, planting distances and their combination under field conditions; and 4) determine the most appropriate fertilizer input, planting distance and their combination for Stevia production.

MATERIALS AND METHODS

Experiment 1: Clonal Propagation of *Stevia rebaudiana* Using Stem Cuttings in Different Growth Media

The first experiment was laid out in 4 x 2 factorial arranged in a Completely Randomized Design (CRD) with three replications. The following were the treatments of the study:

Factor A (Potting Media, 1:1 v/v)

A1- Vermicompost (VC) + Garden soil
A2- Processed chicken manure (PCM) + Garden soil
A3- Carbonized rice hull (CRH) + Garden soil
A4- Garden soil alone (Control)

Factor B (Type of Stem Cutting)

B1- 3 to 4 nodes from the tip to the base (apical portion of the stem)
B2- 3 to 4 nodes from the base to the tip (basal portion of the stem)

Ten (10) pots of six-month old-fully grown Stevia mother plants were purchased from the Manila Seedling Bank. Stem cuttings were taken from the Stevia mother plants following the prescribed treatments. These cuttings were dipped in hormex with dilution of 10 ml per gallon of water for 15 minutes before planting.

Black plastic containers with perforations underneath having a height of 10.16 cm; length of 30.48 cm; and width of 15.24 cm were used as growth containers in the study. Each container was filled with the prescribed mixture of substrates up to at least one-inch below the brim. Each container had 15 stem cuttings totaling to 180 cuttings per type for a total of 360 cuttings used in the experiment. The containers were kept in a humid condition for 35 days or until the plants produced new shoots which was an indication that roots were already established.

The containers were arranged in the screenhouse where a three-layered black net was installed above the containers to prevent exposure of propagules from high light intensity of the sun.

Observations on root length (mm), root number, leaf length, number of leaves, and percentage survival (%) were recorded at 35 days after planting.

All gathered data were statistically analyzed. Based on significance of treatment as described by the Analysis of Variance (ANOVA), mean treatment differences were tested using Least Significant Difference Test (LSD) and Duncan's Multiple Range Test (DMRT). The statistical analysis System (SAS) program was used for ANOVA and DMRT tests.

Experiment 2. Field Performance of Stevia Grown at Different Planting Distances and Fertilizer Inputs

The second experiment was laid in a 4x3 factorial in Randomized Complete Block Design (RCBD) with three replications. The following were the treatments of the study:

Factor A (Fertilizer Input)

A1- Inorganic fertilizer (Complete-14-14-14 and Urea- 46-0-0)
A2-Vermi-compost at 3.5 t/ha
A3- Chicken manure at 3.5 t/ha
A4- No fertilizer input

Factor B (Planting Distance, R x H)

B1- 30cm x 10cm
B2- 30cm x 15 cm
B3- 30cm x 20 cm

An experimental area of 80 square meters was prepared. The area was divided into 3 blocks and each block was further sub divided into 12 plots totaling to 36 plots. Each plot had definite number of 20 stem cuttings for planting due to the limited supply. Hence, each plot area varied in measurement according to prescribed planting distance treatment. For B1 (30 cm x10 cm), the total area was 0.6 m2; B2 (30 cm x 15 cm) required a total area of 0.9 m2 and B3 (30 cm x20 cm) had a total area of 1.2 m^2. The distance between plots and blocks was 0.5 meters.

The type of stem cutting that was found to be more appropriate for clonal propagation from experiment 1 was used as planting material in this experiment. Hence, five (5) week-old rooted stem cuttings obtained from apical position of the stem (3 to 4 nodes from the tip to base) were planted to the prepared plots following the required planting distance (Factor B). Twenty rooted or sprouted stem cuttings were planted in each plot for a total of 720 propagules.

Planting was done late in the afternoon at one propagule per hill.

The plants were applied with water once a week using a plastic hose connected from an installed faucet in the study area.

Fertilizers were applied according to prescribed treatments as presented in the fertilizer application schedule in Table 1.

Manual weeding of the plants was done once a week. The plants were not applied with insecticides during the entire duration of the

Table 1. Fertilizer application schedule*

Treatment	Recommended Amount	Area (m^2)	Schedule of Application		
			Basal	Side Dress	
				1st	2nd
A1= Inorganic Fertilizer	(90-30-30 kg/ha)				
Urea (45-0-0)	60-0-0 (60/0.45 = 133 kg/ha)	0.6		3.99g	3.99g
		0.9		5.98g	5.98g
		1.2		7.98g	7.98g
Complete (14-14-14)	30-30-30 (30/0.14 = 214 kg/ha)	0.6	12.80g		
		0.9	19.26g		
		1.2	25.68g		
A2= Vermicompost	3.5 t/ha	0.6	210g		
		0.9	315g		
		1.2	420g		
A3= Chicken manure	3.5 t/ha	0.6	210g		
		0.9	315g		
		1.2	420g		
A4= No fertilizer	-	-	-	-	-

** Carbonized Rice Hull (CRH) was applied in all treatment plots (blanket application) at 6 t/ha.*

experiment.

Harvesting was done before the flower buds appeared. All plants in the treatment plots were carefully uprooted from the soil. Fresh leaves were stripped from stems using fingers then placed in plastic containers for data gathering.

The following data were gathered and recorded accordingly during the conduct of the experiment: 1) percentage survival (%); 2) plant height (cm); 3) biological yield (g); 4) economic yield (g); 5) number of branches; 6) root weight (g); 7) root length (mm); 8) root number; 9) leaf length (cm); 10) leaf width (cm); and 11) occurrence of insect pests and diseases.

An evaluation on general acceptability in terms of leaf color and taste of the test crop in various treatments was conducted. Ten personnel of the Research, Extension and Business for Development Program (REBD) of the Nueva Vizcaya State University were selected as evaluators or panelists. Prior to the evaluation activity, leaf samples were placed in coded plates and presented to each evaluator. Evaluation was done following the hedonic rating scale for taste acceptability (Table 2) and rating scale preference for leaf color (Table 3).

Table 2. Hedonic rating scale

Rating Scale	Degree of Acceptability
1	Dislike extremely
2	Dislike very much
3	Dislike moderately
4	Dislike slightly
5	Neither like nor dislike
6	Like slightly
7	Like moderately
8	Like very much
9	Like extremely

All gathered data were statistically analyzed. Based on significance of treatment

Table 3. Rating scale for leaf color preference

Rating Scale	Degree of Preference
4	Dark green (Preferred extremely)
3	Green (Preferred very much)
2	Light green (Preferred moderately)
1	Yellow green (Preferred slightly)

as described by the Analysis of Variance (ANOVA), mean treatment differences were tested using Least Significant Difference Test (LSD) and Duncan's Multiple Range Test (DMRT). The statistical analysis System (SAS) program was used for ANOVA and DMRT tests.

RESULTS AND DISCUSSIONS

Experiment 1: Clonal Propagation of *Stevia rebaudiana* Using Stem Cuttings in Different Growth Media

The summary data on sprouting response of Stevia which is exhibited by root and leaf growth parameters including percent survival to different growth media and type of stem cuttings are presented in Table 4.

Percent Survival (%)

Potting media had a highly significant influence on the percentage survival of Stevia propagules. Percentage survival however, remained stable regardless of type of stem cutting and the interaction between the two employed treatments.

Results revealed that the addition of organic substrates in garden soil gave significant percent survival advantage to the stem cuttings. Data show that a 1:1 ratio of carbonized rice hull (CRH) and garden soil gave the highest significant survival percentage of 58.89%. This was followed by vermicompost (VC) + garden soil with a survival percentage of 27.78%. The lowest survival was exhibited by plants grown in processed chicken manure + garden soil at 4.45% that was comparable with garden soil alone with 0% survival. All stem cuttings in garden soil alone did not sprout and exhibited 100% mortality which could be attributed to higher bulk density of the soil that restricted root growth. Moreover, during this period more rains and even typhoons occurred that resulted to retention of more water in pure garden soil that could have allowed build up of fungal population that resulted in rotting of the cuttings (Figure 1). The better growth performance of stem cuttings under CRH + garden soil can be attributed to CRH's attributes as a very good soil fertilizer and conditioner. According to PCAARRD (2014), CRH is a hydrophilic material made from the incomplete or partial burning of rice hull, CRH contains potassium, phosphorus, calcium, magnesium, and other microelements needed for growing crops. As soil conditioner, it replenishes air and retains water in the soil. Because of the heat it undergoes, it is sterile and thus, free from pathogens. As such, it makes an excellent host for beneficial microorganisms.

Root Growth

The root growth was characterized in terms of length and number. Root length varied from zero to 47.23 mm. Root number ranged from zero to 8 pieces. Both length and number of roots were significantly affected by potting media but not with type of stem cutting and the interaction of the two treatments.

Data showed that no roots developed in potting media containing pure garden soil. When organic substrates were mixed with garden soil, roots were produced and subsequently stem cuttings sprouted. The potting media consisting of CRH + garden soil gave better root growth than all other potting media treatments. Specifically, longest roots at 47.23 mm was exhibited by Stevia stem cuttings planted in CRH + garden soil. In terms of root number, stem cuttings planted in growth media containing CRH + garden soil exhibited the highest number of six (6) roots per cutting compared to significantly lesser number from the other media.

Leaf Growth

Leaf growth in terms of leaf length and leaf number significantly increased with the addition of organic substrates. For leaf length, Carbonized Rice Hull (CRH) plus Garden Soil yielded the highest mean of 14.83 millimeters which is significantly different from the other growth substrates. The last two substrates however exhibited comparable effect.

For number of leaves, Carbonized Rice Hull (CRH) plus Garden Soil yielded the highest mean of 12.00 which made it very significantly different from the other growth substrates.

Generally, table 4 shows that Carbonized Rice Hull (CRH) plus garden soil had the best performance over all the other growth substrates in terms of all the growth parameters. Considering that there was a heavy rainfall after the transplanting of the propagules as shown in the climatological data (Figure 1), except for carbonized rice hull, the other growth substrate had the tendency to retain more moisture which eventually lead to the rotting of the plants. Therefore Stevia plants require certain moisture requirement in order to grow.

Table 4. Summary table on growth and survival of *Stevia r.* propagules as affected by the different treatments*

Treatment	Percentage Survival (%)	Growth Parameters			
		Root Length (mm)	Root Number	Leaf Length (cm)	Leaf Number
Factor A (Growth Media)					
A_1 = Vermicompost + Garden Soil	27.78^b	6.80^b	2.00^b	5.34^b	4.67^b
A_2 = Processed Chicken Manure + Garden Soil	4.45^c	0.87^c	1.00^c	1.00^c	0.84^c
A_3 = Carbonized Rice Hull + Garden Soil	58.89^a	47.23^a	6.00^a	14.83^a	12.00^a
A_4 = Garden Soil Alone (Control)	0.00^c	0..00^c	0.00^c	0.00^c	0.00^c
Factor B (Type of Stem Cutting)					
B_1 = 3 to 4 nodes from the tips to the base (apical position of stem)	26.67	19.28	3.00	6.75	9.75
B_2 = 3 to 4 nodes from the base to the tip (basal position of the stem)	18.89	8.18	1.00	3.83	6.00
A x B					
A_1B_1	28.98	6.37	2.00	6.00	5.00
A_1B_2	26.67	7.23	2.00	4.47	4.33
A_2B_1	8.89	1.73	1.00	2.00	1.67
A_2B_2	0.00	0.00	0.00	0.00	0.00
A_3B_1	68.89	69.00	8.00	19.00	15.67
A_3B_2	48.89	25.47	3.00	10.67	8.33
A_4B_1	0.00	0.00	0.00	0.00	0.00
A_4B_2	0.00	0.00	0.00	0.00	0.00
C.V. (%)	54.28	33.18	36.85	36.85	36.61

**means within a column with similar letter superscript(s) are not significantly different by DMRT.*

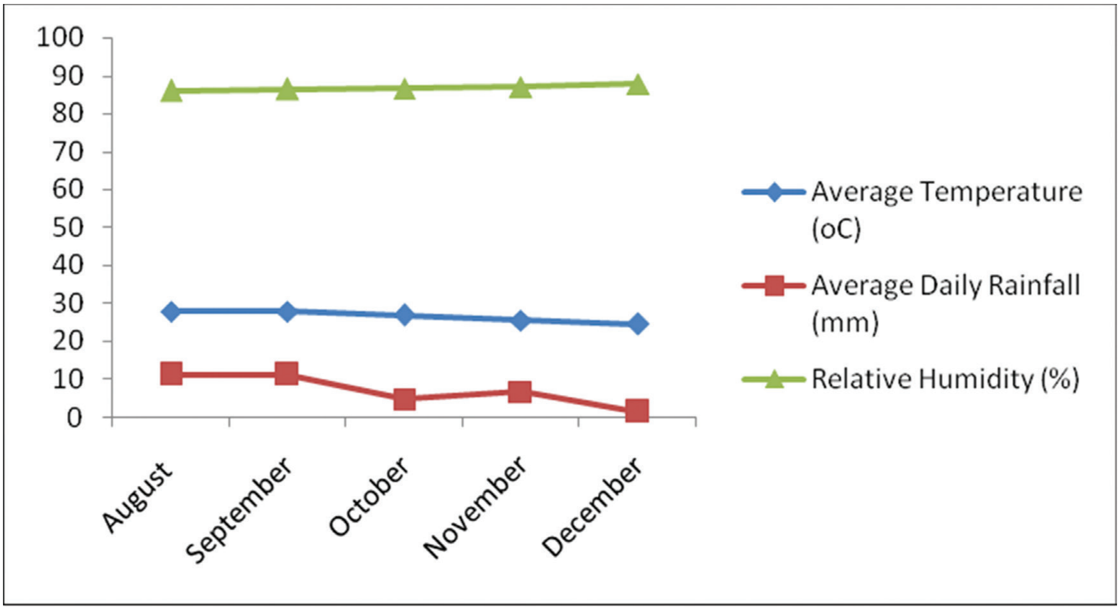

Figure 1. Climatological data during the study period

Effects of Using Stem Cutting in the Production of Stevia Propagules

In terms of the effects of using stem cutting in the production of Stevia propagules, the two stem cutting parts were not significantly different with each other in terms of percent survival, root growth, and leaf growth.

Effects of the Interaction of the Different Substrates and Stem Cuttings in the Production of Stevia Propagules

As to the effects of the interaction of the different substrates and stem cuttings in the production of Stevia propagules, the interactions of the different treatments were comparable in terms of percent survival, root growth, and leaf growth.

Experiment II. Field Performance of Stevia Grown at Different Planting Distances and Fertilizer Inputs

The summary data on the growth and yield response as well as the percentage survival and quality of Stevia grown at different planting distances and fertilizer inputs are presented in tables 5 to 7.

Horticultural Characteristics

Maturity. All plants treated with fertilizer inputs had reached the flowering stage at 35 days after transplanting. This means that regardless of the kind of fertilizer inputs applied, the plant would still continue its growth and development.

Further, when subjected to different planting distances, the plants had reached the flowering stage at 35 days after transplanting, which implies that regardless of the planting distances applied, the plant would still continue its growth and development.

The combination of all the treatments, fertilizer inputs and planting distances in the growth of stevia produced the same maturity days of 35 days from transplanting. The interaction of the treatments did not significantly influence the flowering stage of the plant suggesting that regardless of the planting distances and fertilizer inputs applied, the plant would still continue its growth and development.

Plant height (cm). The height of the plant when applied with fertilizer inputs varied from 25.02 cm to 28.15 cm (Table 5). These observed variations were not significant, implying that stevia plant had similar height characteristics exhibiting an average height of 27.74 cm.

When subjected to planting distances, the observed variations were not however significant, implying that stevia plant when planted in planting distances of 30 cm x 10 cm, 30 cm x 15 cm and 30 cm x 20 cm had similar height characteristics exhibiting an average height of 26.74 cm (Table 5).

The interaction of the two treatments, fertilizer input, and planting distance varied from 23.10 cm to 30.61 cm (Table 5). These observed variations were not however significant, implying that Stevia planted in various planting distances of 30 cm x 10 cm, 30 cm x 15 cm and 30 cm x 20 cm and applied with fertilizer inputs, had similar height characteristics exhibiting an average height of 27.74 cm.

Table 5. Maturity, percent survival and growth of *Stevia r.* as affected by the different treatments under field conditions*

Treatment	Maturity (DAP)	% Survival	Plant Height (cm)	Root Number	Root Length (cm)	Root Weight (g)
Factor A (fertilizer Input)						
A_1 = Inorganic Fertilizer	3t5	100	28.15	13.00[a]	90.04	17.05[a]
A_2 = Vermicompost	35	100	26.18	14.00[a]	89.97	14.39[a]
A_3 = Processed Chicken Manure	35	100	27.63	15.00[a]	93.69	16.50[a]
A_4 = No Fertilizer Input	35	100	25.02	10.00[b]	72.02	9.00[b]
Factor B (Planting Distance)						
B_1 = 30cm x 10cm	35	100	28.12	13.00	77.63[b]	12.92
B_2 = 30cm x 15cm	35	100	26.31	13.00	85.78[ab]	14.50
B_3 = 30cm x 20cm	35	100	25.80	14.00	95.89[a]	15.54
A x B						
A_1B_1	35	100	27.23	14.00	79.33	15.33
A_1B_2	35	100	28.25	12.00	81.40	15.00
A_1B_3	35	100	28.98	14.00	109.40	20.83
A_2B_1	35	100	26.70	12.00	86.87	13.67
A_2B_2	35	100	26.63	13.00	90.73	15.83
A_2B_3	35	100	25.22	16.00	92.30	13.67
A_3B_1	35	100	30.61	15.00	84.80	14.33
A_3B_2	35	100	26.36	14.00	96.80	17.17
A_3B_3	35	100	25.95	15.00	99.47	18.00
A_4B_1	35	100	27.95	9.00	59.50	8.33
A_4B_2	35	100	24.01	11.00	74.20	10.00
A_4B_3	35	100	23.10	10.00	82.37	9.67
C.V. (%)			16.56	22.38	26.94	28.59

**means within a column with similar letter superscript(s) are not significantly different by DMRT.*

Yield and Yield Components

Number of branches. Number of branches produced by the Stevia plant ranged from 7-9. These differences in the number of branches were however not significant.

Under planting distances, the plant stevia produced the same number of branches of 8 (Table 6). It implies that the three different planting distances (30 cm x 10 cm, 30 cm x 15 cm and 30 cm x20 cm) had no significant effect in the number of branches on the stevia plant.

The combination of the two treatments, fertilizer inputs and planting distance did not show significant differences in the yield and yield components of the Stevia plant. This suggests that the combination of the two factors is just comparable with one another.

Root number. Number of roots produced by Stevia plants in terms of fertilizer input ranged from 13-15. These observed differences had no significant effect with each other.

Similarly, number of roots produced by Stevia plants in terms of planting distance ranged from 13-14. This observed data had no significant differences with each other.

Root length (mm). Under the fertilizer input, root length ranged from 72.02 cm to 93.69 cm. These observed data had no significant differences with each other implying that root length of stevia plant was not affected by the application of fertilizer inputs.

For the treatment planting distance, the highest root length was observed on planting distance of 30 cm x 20 cm (B3) with 95.85 cm. which was significantly different with planting distance 30 cm x 10cm with 77.63 cm, however the later is comparable with planting distance 30 cm x 15 cm with 44.94 cm. This difference suggests that planting distances had significant effect in the root length of Stevia. This result could be attributed to mutual shading. Closer plants have the tendency to shade one another, thus preventing the absorption of sunlight which is a very important factor for photosynthesis.

Leaf length (cm). Leaf length produced by Stevia plants in terms of fertilizer input ranged from 42.34 cm-45.90 cm. These observed differences had no significant effect. This implies that leaf length of stevia is not affected by the application of fertilizer inputs.

Planting distance of 30 cm x 20 cm (B3) produced the highest leaf length of 45.87 cm, followed by planting distances of 30cm x15 cm (B2) and 30 cm x 10 cm (B1) with leaf lengths of 44.94 cm and 42.22 cm, respectively. Planting distance B3 had a very significant difference with planting distance B1 but the later is comparable to planting distance B2. This implies that planting distances had significant effect in the leaf length of stevia. This further proved that proper absorption of sunlight through proper distancing of plants is vital.

Leaf width (cm). The application of fertilizer inputs had a very significant effect in the leaf width of the plant stevia. The application of inorganic fertilizer (A1) with leaf width of 18.02 cm had a very significant difference from vermi-compost (A2) and the no fertilizer application (A4) with leaf width of 16.42 cm and 16 cm respectively. Inorganic fertilizer application had however comparable effect with chicken manure with a leaf width of 17.13 cm and vermi-compost (A2) had a comparable effect to that of no fertilizer application (A4).

Table 6 also shows the data on individual leaf width of the plant stevia when subjected to planting distances. Leaf width ranged from 16.62 cm-17.07 cm. These differences however were not significantly different with one another.

Root weight (g). The application of fertilizer inputs had a very significant effect in the root weight of the plant stevia. Inorganic fertilizer with root weight of 17.05 grams had a very significant difference with no fertilizer input (A4) of 9 grams. Vermi-compost and chicken manure with root weights of 14.39 grams and16.50 grams respectively had a comparable effect with inorganic fertilizer.

The individual root weight per planting distances ranged from 12.92 g – 15.54 g. These differences had no significant effect in the root weight of the stevia plant.

Economic yield (g). The application of fertilizer inputs had a very significant effect in the economic yield of Stevia (Table 6). Application of inorganic fertilizer produced the highest economic yield of 195.22 grams and is significantly different from vermi-compost with economic yield of151.50 grams and no fertilizer application with 104.83 grams. Inorganic fertilizer had however comparable effect with processed chicken manure with economic yield of 169.22 grams. Vermi-compost on the other hand had a comparable effect to no fertilizer application.

Planting distance (B3) produced the highest economic yield of 186.71 grams. This observed yield was highly different with observed yield under planting distance (B1) of 99.92 grams. Planting distance (B3) is however comparable to planting distance (B2)

Table 6. Yield and yield components of *Stevia r.* as affected by the different treatments under field conditions*

Treatment	No. of Branches	Leaf Length (cm)	Leaf Width (cm)	Biological Yield (g)	Economic Yield (g)
A_1 = Inorganic Fertilizer					
A_2 = Vermicompost	9.00	45.59	18.00[a]	393.33[a]	195.22[a]
A_3 = Processed Chicken Manure	9.00	43.55	16.00[bc]	340.56[a]	151.50[b]
A_4 = No Fertilizer Input	8.00	45.90	17.13[ab]	362.22[a]	169.22[ab]
Factor B (Planting Distance)	7.00	42.34	16.42[c]	262.78[b]	104.83[c]
B_1 = 30cm x 10cm					
B_2 = 30cm x 15cm	8.00	42.22[b]	16.62	265.42[b]	99.92[b]
B_3 = 30cm x 20cm	8.00	44.94[a]	17.07	363.34[a]	178.96[a]
A x B	8.00	45.87[a]	16.99	390.42[a]	186.71[a]
A_1B_1					
A_1B_2	9.00	40.90	17.23	290.00	118.50
A_1B_3	9.00	47.07	18.20	391.67	212.50
A_2B_1	10.00	48.80	18.63	498.33	254.67
A_2B_2	9.00	42.53	16.03	265.00	107.83
A_2B_3	10.00	44.70	16.23	385.00	183.67
A_3B_1	7.00	43.43	15.73	371.67	163.00
A_3B_2	8.00	43.93	17.27	291.67	95.67
A_3B_3	7.00	45.83	17.13	371.67	187.67
A_4B_1	9.00	47.93	17.00	423.33	224.33
A_4B_2	6.00	41.53	15.93	215.00	77.67
A_4B_3	7.00	42.17	16.73	305.00	132.00
A4B3	7.00	43.33	16.60	268.33	104.83
C.V. (%)	26.67	6.99	5.49	17.96	23.06

** Means within a column with similar letter superscript(s) are not significantly different by DMRT.*

with observed yield of 178.96 grams. This suggests that planting distances mentioned had very significant effect in the economic yield of Stevia. The importance of photosynthesis again explains the result. Proper distancing is vital to avoid shading for optimum sunlight absorption.

Biological yield (g). The application of fertilizer input had a very significant effect in the biological yield of Stevia plant (Table 6). Inorganic fertilizer had the highest biological yield of 393.33 grams which is very significantly different from no fertilizer application with biological yield of 262.78 grams. The application of inorganic fertilizer however had a very comparable effect with the application of vermi-compost and processed chicken manure with biological yields of 340.56 grams and 362.22 grams respectively.

The trend of data observed under biological yield was similar to that of the economic yield. Planting distance (B3) produced the highest biological yield of 390.42 grams. This observed yield was highly different with observed yield under planting distance (B1) of 265.42 grams. Planting distance (B3) was however comparable to planting distance (B2) with observed yield of 363.34 grams. This suggests that planting distances mentioned had very significant effect in the biological yield of Stevia plant.

Percentage survival and number of plant stand. The Stevia plant had a 100 percent survival and complete number of plant stand (Table 5). This observation indicates that the plant could survive and could complete its growth and development regardless of the kind of fertilizer inputs applied and regardless of planting distances employed.

Quality and Acceptability

Taste. Table 7 shows the extent of acceptability of the different treatments. Under the fertilizer inputs, A1 (inorganic fertilizer), A2 (vermi-compost) and A3 (processed chicken manure) were adjudged as like moderately. No fertilizer input (A4) was adjudged as neither like nor dislike. In the planting distances, B1 (30 cm x 10 cm) was adjudged as like moderately, B2 (30 cm x 15 cm) and B3 (30 cm x 20 cm) were adjudged as like slightly. The combination of inorganic fertilizer with planting distance of 30 cm x 10 cm (A1B1) was adjudged as like very much. Treatment (A4B1), combination of no fertilizer input and planting distance of 30 cm x 10 cm was adjudged as like slightly; treatment (A4B2), combination of no fertilizer input and planting distance of 30 cm x 15 cm was adjudged as neither like nor dislike and treatment (A4B3), combination of no fertilizer input and planting distance of 30 cm x 20 cm was adjudged as dislike slightly. The remaining treatments were adjudged as like moderately. From this result, it shows that fertilizer input and planting distance had something to do with taste of the crop. The wider the planting distance without fertilizer resulted in unacceptable taste. The two combinations suggest that nutrients taken by the plant contribute to its palatability.

Leaf color. Table 7 shows the extent of acceptability in terms of color. Fertilizer input treatments A1 (inorganic fertilizer), A2 (vermin-compost) and A3 (processed chicken manure) exhibited the same color green and A4 (no fertilizer application) exhibited a color light green. For planting distances, all the three treatments exhibited the same color green. Combination treatments (A1B1), inorganic fertilizer and planting distance of 30cm x 10cm; (A2B1), vermin- compost and planting distance of 30 cm x 10 cm and (A4B2) no fertilizer input and planting distance of 30 cm x 15 cm and (A4B3), no fertilizer input and planting distance of 30cm x 20cm were adjudged as light green. The rest of the treatments were adjudged as green. Generally, the results show that fertilizer input had a great effect on the color pigmentation of the plant stevia.

Table 7. Acceptability on taste and preference on leaf color of *Stevia r.* as affected by the different treatments

Treatment	Taste		Color	
	Rating (1-9)	Acceptability	Rating (1-4)	Preference
A_1 = Inorganic Fertilizer				
A_2 = Vermicompost	7.30	Like moderately	2.60	Preferred very much
A_3 = Processed Chicken Manure	6.90	Like moderately	2.87	Preferred very much
A_4 = No Fertilizer Input	6.90	Like moderately	2.77	Preferred very much
Factor B (Planting Distance)	4.80	Neither like nor dislike	2.26	Preferred moderately
B_1 = 30cm x 10cm				
B_2 = 30cm x 15cm	6.75	Like moderately	2.50	Preferred very much
B_3 = 30cm x 20cm	6.45	Like slightly	2.60	Preferred very much
A x B	6.32	Like slightly	2.78	Preferred very much
A_1B_1				
A_1B_2	8.00	Like very much	2.30	Preferred moderately
A_1B_3	6.90	Like moderately	2.70	Preferred very much
A_2B_1	7.10	Like moderately	2.90	Preferred very much
A_2B_2	7.30	Like slightly	2.40	Preferred moderately
A_2B_3	6.60	Like slightly	3.00	Preferred very much
A_3B_1	7.00	Like moderately	3.20	Preferred very much
A_3B_2	7.20	Like moderately	3.00	Preferred very much
A_3B_3	6.70	Like moderately	2.70	Preferred very much
A_4B_1	6.90	Like moderately	2.60	Preferred very much
A_4B_2	5.60	Like slightly	2.40	Preferred moderately
A_4B_3	4.50	Neither like nor dislike	2.30	Preferred moderately
A4B3	4.30	Dislike slightly	2.40	Preferred moderately

** Means within a column with similar letter superscript(s) are not significantly different by DMRT.*

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the result of the study, the following are the conclusions:

1. The best substrate for Stevia propagule production is 1:1 carbonized rice hull and garden soil.
2. Economic and biological yield is best attained in the application of inorganic fertilizer (14-14-14, 46-0-0) or PCM.
3. Sweeter taste was attained when the plant was applied with fertilizer inputs.
4. Greener color was attained at planting distance of 30cm x 20 cm.

Recommendations

1. For best propagule production of Stevia, a ratio of 1:1 carbonized rice hull plus garden soil should be used.
2. To attain the best economic yield and better taste of the Stevia plant,

inorganic fertilizer, 14-14-14 and 46-0-0 should be used. Processed chicken manure could also be used since the two fertilizer inputs had similar performance.

3. Planting distance of 30cm x 20 cm should be used to attain the best color of the stevia leaves.
4. A similar study should be conducted during the dry season to evaluate the differences since this study was conducted during the wet season.
5. Further study on micro propagation of *Stevia r*. seedling production should also be conducted to test its survivability and its performance when planted in the field.
6. If similar study would be conducted, soil properties, nutrient contents, PH and soil moisture contents should be considered.
7. A study on the processing of *Stevia r.* leaves is also recommended.

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