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Effects of different cultivation methods on growth, yield and nutrient content of stevia

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ABSTRACT

The experiment was conducted to study the effects of different cultivation methods on growth, yield and nutrient content of stevia at the experimental farm of Bangladesh Sugarcrop Research Institute, Pabna, Bangladesh. The treatments were T_1: Field cultivation, T_2: Under mango tree cultivation and T_3: Pot cultivation. The experiment was laid out in Complete Randomized Design (CRD) with five (5) replications. Data were recorded on the following parameters plant height (cm), number of branch plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (cm^2), fresh weight plant^{-1} (g), dry weight plant^{-1} (g), fresh leaf yield plant^{-1} (g), dry leaf yield plant^{-1} (g), N (%), P (%), K (%), S (%), Ca (%), Mg (%) and Zn (µg g^{-1}) contents of Stevia leaf. Significant different was recorded among different cultivation methods. Significantly the highest plant height was obtained in T_2 (under mango tree cultivation) treatment (127.93 cm) at 147 DAT. The highest primary and secondary branches at 147 DAT were recorded in T_1 (field cultivation) treatment (12.72) and (31.83), respectively. The number of leaf plant^{-1} and leaf area plant^{-1} of stevia were significantly influenced by different cultivation methods and the highest was recorded in T_1 treatment. The highest fresh weigh (165.92 g plant^{-1}) and dry (44.15 g plant^{-1}) plant^{-1} were obtained from T_1 treatment. Significantly the highest fresh leaf yield (91.37 g plant^{-1} and 4512.12 kg ha^{-1}) and dry leaf yield (24.83 g plant^{-1}and 1226.17 kg ha^{-1}) were obtained from T_1 treatment also. The N content in stevia leaf ranged from 1.62 to 1.71%. The highest (0.128%) and the lowest (0.085%) Phosphorus content was obtained in T_1 and T_2 treatment, respectively. The K content in stevia leaf ranged from 0.13 to 0.14%. The highest Sulphur content was recorded in T_1 treatment (0.25%).The Ca and Mg content in stevia leaf ranged from (1.12 to 1.24%) and (0.102 to 0.104%), respectively. The highest Zn content was recorded in field cultivation (62.87 µg g^{-1}). Results indicated the strong possibilities of field cultivation of stevia in Bangladesh.

Keywords: Stevia, method, leaf area and leaf yield.

INTRODUCTION

Stevia (*Stevia rebaudiana* Bertoni) is a natural sweetener plant having medicinal and commercial importance is being used all over the world. It is a perennial herbaceous plant native to Paraguay and Brazil (Sivaram and Mukundab 2003, Jain et al. 2009) and grown commercially in many parts of Brazil, Paraguay, Central America, Thailand, Korea and China (Megeji et al. 2005). The leaves of stevia are the source of steviol glycosides, stevioside and rebaudioside, which estimated to be 300 times sweeter than sugar besides have no effect on blood sugar. (Soejorto 2002, Ramesh et al. 2006). It nourishes pancreas and thereby helps to

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restore its normal function. Furthermore, stevia contains high percentage of phenol, flavonoid which causes stevia to have a high antioxidant activity (Tadhani et al. 2007, Shukla et al. 2009), cause the cardiac and cancer diseases to be decreased (Dragovi-Uzelac 2010). It is commonly used as a natural sweetener in beverages and foods, being preferred over other non-caloric sucrose substances as it is heat-stable, somewhat resistant to acid hydrolysis, and non-fermentable (Kinghorn and Soaejarto 1991). The global market size and business of medicinal plant materials including stevia and health care products based on this herbs comes to around 62 billon US $ and is likely to cross 5 trillion by 2050 (Patra and Khanuja 2005). Stevioside content varies with the dry weight of the leaves depending growing condition (Nepovim et al. 1998 and Guens 2003). Hence, it is necessary to improve agro techniques for increasing the biomass yield and stevioside of stevia.

Influence of methods of planting and fertilizer levels on growth, yield, nutrient uptake of stevia was reported by Chalapthi et al. (1997), Chalapthi et al. (1999) and Benhmimou et al. (2017) but no such comparative study of agro technique so far been reported till. Therefore, the present study has been undertaken with the following objectives: to find out the suitable method for stevia cultivation and indicate morphophysiological features best for higher yield and nutrient content.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the Bangladesh Sugarcrop Research Institute, Pabna, Bangladesh. The site is located at $24^0 8'$ North latitude and $89^0 04'$ East longitude and situated about 15.5 m above the mean sea level. The experimental site represents the High Ganges River Flood Plain soils under the AEZ 11. The experiments were done in calcareous high land soil with having good internal drainage. The land category was medium high land. The soil belongs to Sara series of calcareous soil. The test crop was stevia. The seedlings were healthy and vigorous in growth 20-22 cm in height 60 days old.

Land preparation: The land was opened by a tractor drawn disc plough and final preparation was made by ploughing and cross-ploughing with a tractor plough and harrow followed by laddering. The layout of the field was made 27 March after final land preparation.

Under mango tree planting: Under mango tree land was opened by hand with spade and final preparation was made by spade. Weeds and stubble were removed and cleaned from individual plot accordingly. The basal doses of fertilizers were applied during final land preparation. Urea, TSP, MOP were applied @ 152, 50 and 40 kg ha^{-1}, respectively. Full dose of TSP was applied in final land preparation. The basal dose of urea (1/3rd) was applied as top dressing at 30 days after transplanting. The rest amount of urea and MOP were applied as top dressing in two equal splits at 60 and 90 DAT.

Preparation of pots: Medium size pots (35 cm × 25 cm) were used in the experiment. Each pot was filled with 10 kg of sun-dried soil. Plant propagates, inert materials, visible insects and pests were removed from the soil. Urea, TSP and MOP were applied @ 7.6 g, 2.5 g and 2.0 g pot^{-1}, respectively. Total TSP were applied as basal dose during final soil preparation. The basal dose of urea (1/3rd) was applied as side dressing at 30 DAT. The rest amount of urea and MOP were applied as top dressing in two equal splits at 60 and 90 DAT.

Experiment treatments and design: The present research work was conducted in three cultivation methods. The cultivation methods are as follows: T_1: Field cultivation, T_2: Under mango tree cultivation and T_3: Pot cultivation. The experiment was laid out in Complete Randomized Design (CRD) with five (5) replications.

Intercultural operations: Intercultural operations like weeding, irrigation drainage etc. was done as and when necessary considering the situation of the field, under mango tree plantation and pot cultivation was done 15–20 days interval and flooding irrigation was applied at 7–10 days intervals considering rainfall.

Harvest: The crop harvested 147 days after transplanting when it attained maturity. The vegetative part of the plant especially laves were plucked carefully and washed briefly to removed soils and other foreign materials. The fresh leaves were then weighted as $plant^{-1}$.

Data collection: Data were recorded on the following parameters plant height (cm), number of branch $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$ (cm^2), fresh weight $plant^{-1}$ (g), dry weight $plant^{-1}$ (g), fresh leaf yield $plant^{-1}$ (g) and dry leaf yield $plant^{-1}$ (g).

Plant height (cm): Plant height was measured from the base of the plant (ground level) to the tip of the upper most leaf and was expressed in cm. It was done just before harvesting.

Number of branch plant^{-1}: The number of branches of each plant was counted by hand counting. It was performed at the time of height measurement.

Number of leaves plant^{-1}: Number of leaves of each plant was counted by hand counting and recorded it.

Leaf area plant^{-1} (cm^2): Leaf area of all separated leaves from each plant was measured with the help of leaf area meter (AM 350 Portable leaf Area Meter, ADC BioScence Ltd, England). It was performed soon after harvesting to avoid curling of the leaves.

Fresh weight plant^{-1} (g): Weighing was done just after harvesting the total plant.

Dry weight plant^{-1} (g): Total plant dry weight was obtained after sun followed by oven drying.

Fresh leaf yield plant^{-1} (g): Weighing was done just after harvesting the total leaves.

Dry leaf yield plant^{-1} (g): Leaf dry weight was obtained after sun followed by oven drying.

Field cultivation: Stevia settlings were transplanted 45 cm plant to plant spacing and 45 cm row to row spacing. Number of stevia plant were 49,383 ha^{-1}.

Under mango tree cultivation: Totalamropali mango tree were 400 ha^{-1} where need 400 m^2 area and also need 9600 m^2 area for stevia plant cultivation in which stevia plants were 34,075**.**

Pot cultivation: Leaf fresh/dry weight (kg ha^{-1}) and total fresh/dry weight plant^{-1}(g) respectively with appropriately 36.39 {as the upper ground surface area of the pot was = $\pi r^2 = \pi \times 35$ cm $\times$ 25 cm = 2747.5 cm^2 and each pot comprises one plant. So, the conversion factor 36,396.72 in each of yield in g ha^{-1} was obtained dividing 10,00,00,000 cm^{-2} (1 ha) with 2747.5 cm^{-2} which is equivalent to approximately 36.39 in case of yield in Kg ha^{-1}}.

Plant analyses: The collected plant samples from each plot pot^{-1} was dried at 60^{0}C for about 48 hours and they were ground to pass through a 20-mesh sieve in a grinding mill. The prepared sampled were then put into paper bags and kept in desiccators until further use.

Nitrogen determination: The estimation of N was done by Micro- kjeldahl method (Bremner and Mulvaney 1982), which depends on the fact that organic N, when digested with concentrated sulphuric acid was converted into ammonium sulphate. Ammonia liberated by making the solution alkaline was distilled into a known volume of standard boric acid, which was then back titrated.

Procedures: Exactly 0.5 g oven dried grind sample was wrapped in a piece of qualitative filter paper and dropped as a package into a 500 mL kjeldahl flask in presence of 5 g potassium sulphate, 1 g copper sulphate and 15 mL concentrated H_2SO_4 and 2 glass beads in the digestion tube. The sample mixture was heated at 390^{0}C for an hour. After the completion of digestion the flask was cooled at room temperature and added about 25 mL of distilled water. Then the flask was swirled to bring any insoluble material into the solution and it was made volume to 100 mL. For performing distillation 10 mL of the digested solution was taken in a distillation unit with 10 mL of 40% NaOH. The distillate was collected in 25 mL 2% boric acid containing mixed indicator to adjust the pH at 5.0 and was titrated against 0.1N sulphuric acid. A blank was simultaneously to avoid the N either already present in chemicals or atmospheric nitrogen absorbed during digestion. The percentage was calculated by the following formula with the help of titration value:

$$\% N = (T-B) \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight (g)

Preparation of leaf sample: Exactly 1 g of finely ground leaves were taken into a 250 ml conical flask and 10 ml of di-acid mixture (HNO_3:$HCIO_4$ = 2:1) was added to it. Then it was placed on an electric hot plate for heating at 180-200^{0}C until the solid particles disappeared and white fumes were evolved from the flask. After that it was cooled at room temperature, washed with distilled water and filtered into 100 ml volumetric flask through filter paper Whatman No. 1 making the volume up to the mark with distilled water following wet oxidation method as described by Jackson (1973). The solution was used for the analysis of P, K, Ca, Mg, Zn, B, Cu and Na.

Phosphorus content: Phosphorus was determined colorimetrically by stannous chloride method. Stannous chloride ($SnCl_2$. H_2O) was used as a reducing agent to form molybdophosphoric blue complex with sulphomolybdate. Exactly 10 ml aliquot was in a 50 ml volumetric flask followed by the addition of 10 ml of sulphomolybdic acid and 2 ml of stannous chloride solution. The volume was made up to the mark with distilled water and was shaken thoroughly. Finally the intensity of blue color was measured with the help of spectrophotometer (Supertonic® GENESYS ^{TM} 5 336001 CAT) at 660 nm within 15 minutes after the addition of stannous chloride reagent (Jackson 1973).

Potassium content: Potassium content of the leaf sample was determined by flame photometer and the intensity of light emitted by potassium at 768 nm wave lengths measured by Jackson (1973).

Sulphur content: Sulphur content was determined turbidimetrically as $BaSO_4$ from leaf sample with the help of a spectrophotometer (Supertonic® GENESYS ™ 5 336001 CAT). Turbidity was developed by using barium chloride ($BaCl_2$. $2H_2O$) and the solution was transferred to a spectrophotometer tube. The reading was taken in spectrophotometer at 420nm incident light within 2 to 8 minutes as described by Black (1965).

Calcium and Magnesium contents: Five ml leaf sample was transferred into 50 ml volumetric flask using a pipette and 5 ml of $LaCl_3$ solution was added. The volume was made up to the mark with distilled water and was shaken thoroughly. Then the contents of Ca and Mg were measured by Atomic Absorption Spectrometer (AAS).

Zinc content: From the leaf extract, Zn content was directly analyzed by atomic absorption spectrophotometer.

Statistical analysis: Analysis of variance was done following the Completely Randomized Design (CRD) with the help of computer package program M-STAT developed by Russel (1986). The mean differences of the treatments adjusted by least significant difference (LSD) test.

RESULTS AND DISCUSSION

Plant height: The height of stevia plants was markedly influenced by cultivation methods (Table 1). The plant height at 21 DAT ranged from 33.13 to 35.57 cm in different cultivation methods. The highest plant height was recorded in T_2 (under mango tree cultivation) treatment and the lowest was in T_1 (field cultivation) treatment which was not statistically different. This was probably due to the delay in establishment of the seedling in the field significantly ($P<0.05$) the highest plant height (52.13, 72.83, 81.51, 92.35, 110.02 and 127.93 cm) was obtained in T_2 (under mango tree cultivation) treatment at 42, 63, 84, 105, 126 and 147 DAT, respectively. On the other hand, the lowest plant height (41.32, 58.42, 74.63, 80.02, 96.37 and 105.54 cm) was observed in T_3 (pot cultivation) treatment. Different cultivation methods were shown significantly variation and stevia plant height at 42 DAT have been shown in plate 1, plate 3, plate 5 and significantly variation in plant height at 147 DAT of stevia plant plate 2, plate 4 and plate 6. The results are in agreement with the findings of Hawke (2003) who reported that the mature stevia plant height 65-180 cm when cultivated in field condition. Zaman et al. (2015) reported that significantly influenced grown in stevia at different soil type of Bangladesh and reported that stevia plant height varies from 75.33 to 91.33 cm.

Table 1. Effects of different cultivation methods on plant height (cm) of Stevia at different days after transplanting (DAT)

Treatments	21 DAT	42 DAT	63 DAT	84 DAT	105 DAT	126 DAT	147 DAT
Field cultivation	33.13	44.42 b	65.26 ab	77.34 ab	87.52 ab	103.82 ab	112.31 b
Under mango tree cultivation	35.57	52.13 a	72.83 a	81.51 a	92.35 a	110.02 a	127.93 a
Pot cultivation	33.18	41.32 b	58.42 b	74.63 b	80.02 b	96.37 b	105.54 b
Level of significant	NS	**	**	*	*	**	**
CV (%)	5.90	5.54	7.78	4.64	7.93	6.07	5.82
LSD (5%)	-	3.455	6.883	4.496	9.323	8.511	9.106

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT. NS = Non significant, ** indicates 1 % level of significant. * indicates 5 % level of significant.

Number of primary branches: Effects of different cultivation methods were shown non-significant variation in primary branches at 21 DAT of stevia (Table 2). The highest primary branches (4.99, 6.21, 7.41, 8.71, 9.98, 11.63, 12.72 at 42, 63, 84, 105, 126 and 147 DAT, respectively was observed in T_1 (field cultivation) treatment. The lowest number of primary branches (4.60, 5.47, 6.37, 8.08, 8.87, 9.13 and 10.21) observed in T_3 (pot cultivation) treatment at 42, 63, 84, 105, 126 and 147 DAT, respectively.

Number of secondary branches: It appears from the data presented in Table 3 that the number of secondary branches at 21 DAT was shown non-significant variation. The highest secondary branches (12.92, 13.45, 24.28, 26.91, 28.48 and 31.83) at 42, 63, 84, 105, 126 and 147 DAT, respectively was observed in T_1 (field cultivation) treatment. The lowest number of secondary branches (9.04, 10.84, 12.08, 19.57, 22.03 and 22.32) observed in T_3 (pot cultivation) treatment at 42, 63, 84, 105, 126 and 147 DAT, respectively.

Plate 1. Field cultivation at 42 days after transplanting (DAT)

Plate 2. Field cultivation at 147 days after transplanting (DAT)

Plate 3. Under mango tree cultivation at 42 days after transplanting (DAT)

Plate 4. Under mango tree cultivation at 147 days after transplanting (DAT)

Plate 5. Pot cultivation at 42 days after transplanting (DAT)

Plate 6. Pot cultivation at 147 days after transplanting

Number of leaf plant^{-1} and leaf area plant^{-1}: The number of leaf of stevia was significantly influenced by different cultivation methods shown in Table 4. It was also seen from the Table 4 that the highest number of leaf was recorded in T_1 (field cultivation) treatment (1215.32) and the lowest number of leaf T_3 (pot cultivation) treatment (659.73). The leaf area plant^{-1} of stevia was significantly influenced by different cultivation methods. The results on leaf area plant^{-1} have been shown in the Table 4. It was seen that the highest leaf area plant^{-1} was obtained T_1 (field cultivation) treatment (3621.32 cm^2).The lowest leaf area plant^{-1}was observed in T_3 (pot

cultivation) treatment (1834.04 cm^2). Zaman et al. (2015) reported that the area of total leaves $plant^{-1}$ was significantly affected by different soil types. Maximum leaf area (2010 cm^2 $plant^{-1}$) was measured from the plant grown in non-calcareous soil which was statistically identical with the leaf area of the plants grown in acid (1865 cm^2 $plant^{-1}$) and calcareous (1555 cm^2 $plant^{-1}$) soils.

Table 2. Effects of different cultivation methods on number of primary branches of stevia at different days after transplanting.

Treatments	21 DAT	42 DAT	63 DAT	84 DAT	105 DAT	126 DAT	147 DAT
Field cultivation	4.99	6.21 a	7.41 a	8.71 a	9.98 a	11.63 a	12.72 a
Under mango tree cultivation	4.77	5.93 ab	7.24 a	8.42 ab	9.61 ab	11.26 a	12.25 a
Pot cultivation	4.60	5.47 b	6.37 b	8.08 b	8.87 b	9.13 b	10.21 b
Level of significant	NS	*	*	**	*	**	**
CV (%)	-	5.70	8.66	4.94	5.83	4.69	4.94
LSD (5%)	-	0.4519	0.8206	0.6831	0.7504	0.6796	0.7875

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT. NS = Not significant, ** indicates 1 % level of significant, * indicates 5 % level of significant.

Table 3. Effects of different cultivation methods on number of secondary branches of Stevia at different days after transplanting (DAT)

Treatments	21 DAT	42 DAT	63 DAT	84 DAT	105 DAT	126 DAT	147 DAT
Field cultivation	10.42	12.92 a	13.45 a	24.28 a	26.91 a	28.46 a	31.83 a
Under mango tree cultivation	9.31	11.08 b	11.84 b	19.65 b	23.43 b	24.12 b	25.06 b
Pot cultivation	8.12	9.04 c	10.84 b	12.08 c	19.57 c	22.03 b	22.32 b
Level of significant	NS	**	**	**	**	**	**
CV (%)	8.42	8.23	7.85	6.93	7.48	9.40	7.86
LSD (5%)	-	1.230	1.282	1.754	2.365	3.172	2.816

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT.NS = Not significant, ** indicates 1 % level of significant, * indicates 5 % level of significant.

Number of leaf $plant^{-1}$ and leaf area $plant^{-1}$: The number of leaf of stevia was significantly influenced by different cultivation methods shown in Table 4. It was also seen from the Table 4 that the highest number of leaf was recorded in T_1 (field cultivation) treatment (1215.32) and the lowest number of leaf T_3 (pot cultivation) treatment (659.73). The leaf area $plant^{-1}$ of stevia was significantly influenced by different cultivation methods. The results on leaf area $plant^{-1}$ have been shown in the Table 4. It was seen that the highest leaf area $plant^{-1}$ was obtained T_1 (field cultivation) treatment (3621.32 cm^2).The lowest leaf area $plant^{-1}$was observed in T_3 (pot cultivation) treatment (1834.04 cm^2). Zaman et al. 2015 reported that the area of total leaves $plant^{-1}$ was significantly affected by different soil types. Maximum leaf area (2010 cm^2 $plant^{-1}$) was measured from the plant grown in non-calcareous soil which was statistically identical with the leaf area of the plants grown in acid (1865 cm^2 $plant^{-1}$) and calcareous (1555 cm^2 $plant^{-1}$) soils.

Fresh and dry biomass yield: Different cultivation methods were significantly effects on fresh weight $plant^{-1}$ of stevia (Table 4). The highest fresh weight $plant^{-1}$(165.92 g) was obtained from T_1 (field cultivation) treatment. The lowest fresh weight $plant^{-1}$ (104.63 g) was recorded from pot cultivation. The effect of different cultivation methods on fresh weight ha^{-1} (kg) was found significant at 5% level of probability (Table 4). The results on fresh weight ha^{-1} (kg) have been shown in the Table 4. It is seen from the Table 4 that the highest fresh weight ha^{-1} was obtained in T_1 (8193.62 kg) and lowest in T_3 (3807.48 kg). It appears from the data presented in Table 6 that the dry weight $plant^{-1}$ranged 25.13 g to 44.15 g in different cultivation methods. The highest in T_1 44.15 g (field cultivation) and lowest was in T_3 25.13 g (pot cultivation). There was significantly variation among cultivation methods in respect to dry weight $plant^{-1}$. Different cultivation methods have significant effect on dry weight ha^{-1} (kg) at 1% level of probability. The Table 4 shows that highest dry weight was found in T_1 (2180.25 kg) followed by T_2 (1269.63 kg), while the lowest in T_3 (914.48 kg) treatment.

Table 4. Effects of different cultivation methods on number of leaf plant^{-1}, leaf area plant^{-1}, fresh wt. plant^{-1}(g), fresh wt.ha^{-1} (kg), dry wt.plant^{-1}(g) and dry wt.ha^{-1} (kg) of Stevia

Treatments	Number of leaf plant^{-1}	leaf area plant^{-1}	Fresh wt. plant^{-1} (g)	Fresh wt.ha^{-1} (kg)	Dry wt.plant^{-1} (g)	Dry wt.ha^{-1} (kg)
Field cultivation	1215.32 a	3621.32 a	165.92 a	8193.62 a	44.15 a	2180.25 a
Under mango tree cultivation	841.58 b	2465.33 b	147.62 b	5030.15 b	37.26 a	1269.63 b
Pot cultivation	657.68 c	1834.04 c	104.63 c	3807.48 c	25.13 a	914.48 c
Level of significant	**	**	**	**	**	**
CV (%)	7.26	12.34	8.36	8.64	9.94	7.78
LSD (5%)	89.23	441.90	15.84	665.8	47.79	153.8

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT.NS = Not significant, ** indicates 1 % level of significant, * indicates 5 % level of significant.

Fresh and dry leaf yield: The fresh leaf yield plant^{-1} was significantly influenced by different cultivation methods (Table 5). The highest fresh leaf yield was produced in T_1 (field cultivation) treatment (91.37 g plant^{-1}). The lowest fresh leaf yield was recorded in T_3 (pot cultivation) treatment (47.74 g plant^{-1}) (Table 5). Mengesha et al. (2014) reports, the dry weight of the leaves can vary from 15 to 35 g plant^{-1}. Different cultivation methods showed significantly variation in fresh leaf yield ha^{-1} (Table 5). The highest fresh leaf ha^{-1} (4512.12 kg ha^{-1}) was obtained from T_1 (field cultivation) treatment. The lowest fresh leaf yield was recorded from T_3 (pot cultivation) (1738.30 kg ha^{-1}).In the present investigation significantly difference in dry leaf yield plant^{-1} have been presented in the Table 5. Significantly highest dry leaf yield was recorded in T_1 (field cultivation) treatment (24.83 g plant^{-1}). The lowest dry leaf yield was produced from T_3 (pot cultivation) treatment (12.86 g plant^{-1}). The results on dry leaf yield ha^{-1} production have been shown in the Table 5. It was seen that the highest dry leaf yield was obtained T_1 (field cultivation) treatment (1226.17 kg ha^{-1}). The lowest dry leaf yield was observed in T_3 (pot cultivation) treatment (468.06 kg ha^{-1}). Mengesha et al. (2014) observed that an estimated 6,000 kg ha^{-1} dried leaf yield can be obtained. Midmore and Rank (2002) reported that dry leaf yield 1,600 – 2,000 kg ha^{-1}.

Table 5. Effects of different cultivation methods on fresh leaf yield plant^{-1} (g), fresh leaf yield ha^{-1} (kg), dry leaf yield plant $^{-1}$ (g) and dry leaf yield ha^{-1}(kg) of Stevia

Treatments	Fresh leaf yield plant^{-1} (g)	Fresh leaf yield ha^{-1} (kg)	Dry leaf yield plant $^{-1}$ (g)	Dry leaf yield ha^{-1} (kg)
Field cultivation	91.37 a	4512.12 a	24.83 a	1226.17 a
Under mango tree cultivation	68.92 b	2212.14 b	18.56 b	632.43 b
Pot cultivation	47.74 c	1738.30 c	12.86 c	468.06 c
Level of significant	**	**	**	**
CV (%)	7.24	7.05	8.01	7.81
LSD (5%)	6.819	269.8	2.038	82.14

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT.NS = Not significant, ** indicates 1 % level of significant, * indicates 5 % level of significant.

Nutrient content of stevia leaf:

Nitrogen content (%): The treatment had non-significant effects on nitrogen content of stevia leaves (Table 6). The N content in stevia plant ranged from 1.62 to1.71%. The highest concentration on N in stevia plant (1.71%) was obtained from T_1 (field cultivation) treatment. The second highest concentration on N in stevia plant (1.65%) was obtained from T_3 (pot cultivation) treatment. The lowest concentration on N in stevia plant (1.62%) was obtained from T_2 (under mango tree cultivation) treatment (Table 6). Present findings agree with Katayama et al.(1976) who also obtained stevia plants consist of 1.4% N.

Phosphorus content (%): The results indicated that different cultivation methods significantly influenced the Phosphorus content of stevia (Table 6). It is seen from the Table 6 that the highest Phosphorus content was obtained in T_1 (field cultivation) treatment (0.128%) and lowest in T_2 (under mango tree cultivation) treatment (0.085%). Katayama et al. 1976 reported that stevia plants consist of 0.3% P.

Potassium content (%): The K content was

non-significant with different cultivation methods (Table 6). The K content in stevia plant ranged from 0.13 to 0.14%. The highest concentration on K in stevia plant (0.14%) were obtained from T_1 (field cultivation) and T_3 (pot cultivation) treatments. The lowest concentration on K in stevia plant (0.13%) was obtained from T_2 (under mango tree cultivation) treatment (Table 6).

Sulphur content: Sulphur content of stevia was significantly influenced by different cultivation methods shown in Table 6. The highest Sulphur content was recorded in T_1 (field cultivation) treatment (0.25%), followed by T_2 (pot cultivation) treatment (0.21%), while the lowest Sulphur content T_2 (under mango tree cultivation) treatment (0.14%) (Table 6).

Calcium content (%): The results revealed that different cultivation methods non-significant influenced the content of Ca in stevia (Table 6). The Ca content in stevia leaf ranged from 1.12 to 1.24%. The highest concentration on Ca in stevia plant (1.24%) were obtained from T_1 (field cultivation) and the lowest concentration on Ca in stevia leaf (1.12%) was obtained from T_2 (under mango tree cultivation) treatment (Table 6).

Magnesium content (%): The treatment had non significant effect on Mg content of stevia leaves. It was also seen from the Table 6 that the Mg content in stevia leaf ranged from 0.102 to 0.104%. The highest concentration on Mg in stevia plant (0.104%) was obtained from T_1 (field cultivation) and the lowest concentration on Mg in stevia leaf (0.102%) was obtained from T_2 (under mango tree cultivation) treatment.

Zinc content (µg g^{-1}): Zinc content of stevia was non-significant influenced by different cultivation methods shown in Table 6. Zn content in stevia leaf ranged from 55.52 to 62.87%. The highest Zn content was recorded in T_1 (field cultivation) treatment (62.87 µg g^{-1}) and the lowest Zn content T_2 (under mango tree cultivation) treatment (55.52 µg g^{-1}). The results are in agreement with the findings of Nasrin (2008) who reported that the Zn content in stevia leaf (100.46 µg g^{-1}).

Table 6. Effects of different cultivation methods on N (%), P (%), K (%), S (%), Ca (%), Mg (%) and Zn (µg g^{-1}) contents of Stevia leaf.

Treatments	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Zn (µg g^{-1})
Field cultivation	1.71	0.128a	0.14	0.25a	1.24a	0.104	62.87
Under mango tree cultivation	1.62	0.085c	0.13	0.14c	1.12b	0.102	55.52
Pot cultivation	1.65	0.107b	0.14	0.21b	1.17ab	0.103	57.84
Level of significant	NS	**	NS	**	*	NS	NS
CV (%)	7.02	3.85	11.57	10.00	5.41	1.68	9.06
LSD (5%)	-	0.013	-	0.004	0.085	-	-

Mean values in a column having the same letter (s) do not differ significantly at 5% level of DMRT.NS = Not significant, ** indicates 1 % level of significant, * indicates 5 % level of significant.

CONCLUSION

It is concluded that growth, yield and nutrient content of stevia yield was increased field condition. Most of the yield and yield contributing parameters quantitatively increased by the concentration of field condition of stevia. In regard to all parameters, field cultivation performed the best regarding the growth, yield and nutrient components. It is concluded that field condition and may be recommended for the farmers' level to increase stevia production for farm management practices.

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