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Effect of Integrated Nutrient Management on Growth and Yield of Stevia (*Stevia rebaudiana* Bertoni)

A.K. Baghat, L.M. Gupta*, Meenakshi Gupta, S.K. Gupta and N.S. Raina

Sher-e-Kashmir University of Agricultural Sciences and Technology
Main Campus, Chatha, Jammu-180 009, India
**E-mail: guptalm@gmail.com*

***Abstract*:** Field experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu to study the integrated nutrient management technique suitable for increasing growth and yield in *Stevia rebaudiana* Bertoni. At the inception of the experiment, the soil was sandy-clay loam in texture, slightly alkaline in reaction having low status of available N with medium in available P and K. Application of vermicompost @ 1.5t/ha along with half of recommended dose of nitrogen(30kg N/ha) and Azotobacter significantly increased the growth and yield parameters over control and resulted in maximum plant height (66.17cm), number of branches per plant (24.87), number of leaves per plant (284.68), fresh leaf yield (23.35gm) and dry leaf yield per plant (5.98gm) compared to other fertilizer combinations, but it is at par with leaf yield in 30 kgN +vermicompost (VC) @1.5t/ha. Higher values of yield parameters are observed in vermicompost @ 1.5 t/ha in combination with 30 kg N and Azotobacter and 30kgN +vermicompost@1.5t/ha} with estimated dry leaf yield of 4.78q ha^{-1} and 4.32q ha^{-1}, respectively. Maximum contents of NPK in soil after harvest of crop were in FYM @ 12t/ha and Azotobacter followed by VC @ 3t/ha alongwith Azotobacter. Integrated nutrient management comprising the use of VC or FYM in combination with inorganic fertilizers and biofertilizer was best combination of nutrient management compared to sole application of organic or inorganic to increase the leaf yield in stevia under Jammu subtropics. The combination of organic, inorganic and biofertilizers is not only superior over application of manures or fertilizers alone for achieving higher growth and yield but also in maintaining the fertility status of soil.

***Keywords*:** *Stevia rebaudiana,* Integrated nutrient management, Nitrogen, Azotobacter, Vermicompost

Widespread use of medicinal plants for health providing elements has generated bulk demand which cannot be met from their wild source. Cultivation of medicinal plants is the only alternative to conserve their natural diversity with sustainable supply. *Stevia rebaudiana* Bertoni,a sweet herb with low calorie sweetener, natural sweetener, cheeni tulsi or mau tulsi, a native of Northern Eastern Paraguay was introduced in India in last decade of 20^{th} century and is widely used for various purposes. Its leaves consist of two important secondary metabolites (steviol glycoside) namely stevioside and rebaudioside A and C which make it 30 times sweeter than cane sugar surprisingly without any calorie. The sweet compounds pass through the digestive process of the body without chemically breaking down, hence making safe food substance for consumption by people who need to regulate their blood glucose level. It is also used for treating cancer, obesity, hypertension, fatigue, depression and in cosmetics and dental problems. Stevia is in high demand due to its food and medicinal uses. Before undertaking its commercial cultivation, it is necessary to increase yield of economic part which is possible through fertilization and identification of superior lines among the existing population. Though the production can be increased by supplying the nutrient through chemical fertilizers alone but long term use of chemical fertilizers may result in deterioration of soil health. In this endeavour, a blend of organic and inorganic fertilizers (integrated nutrient management) is important not only for increasing yield but also for sustaining soil health (Larney and Hao 2007, Kumar et al 2007). The present study was proposed with the objective to study the effect of Integrated Nutrient management on the growth and yield of *Stevia rebaudiana.*

MATERIAL AND METHODS

The present investigation was carried out at Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu. The experiment was conducted under randomized block design with eight treatments and three replications. To meet the requirement of N through organic sources, the doses of manures [Farm yard manure (FYM) and vermicompost] were calculated based upon their individual nitrogen content. Nitrogen (N) was given in the form of urea and was applied with farm yard manure and vermicompost at the time of planting. *Azotobacter* was applied twice during the growth period of crop i.e., 200gm/acre at the time of planting and 200 gm/acre before onset of monsoon. The details of various treatments are in Table 1. Observations were recorded on 5 randomly selected plants per treatment in each replication. The observations were recorded for plant height (cm), number of branches per plant, stem diameter (mm), number of leaves per plant, fresh leaf yield per plant (gm), dry leaf yield per plant (gm), estimated fresh leaf yield per hectare (q), estimated dry leaf yield per hectare (q). After the termination of fertilization trial**,** concentration of major nutrients (NPK, %) was determined in the plants of each treatment using standard methods given by Subbiah and Asija (1956) (nitrogen), Olsen et al 1954 (phosphorus) and Jackson 1967 (potassium). The nutrient status of soil was also determined after the harvest of crop. The data was subjected to statistical analysis of randomized block design using OPSTAT package.

RESULTS AND DISCUSSION

Growth and yield parameters: The fertilization significantly influenced the growth and yield characters (Table 1). The results indicate that application of organic fertilizers is necessary to achieve good growth and yield. Use of chemical fertilizer shows improvement in growth and yield over control, but proved inadequate compared with Integrated Nutrient Management (INM) i.e. organic manures (vermicompost or FYM) in conjunction with inorganic and biofertilizer (Azotobacter). Among the different combinations of fertilizers and manures, application of vermicompost @ 1.5t/ha alongwith ½ of RDN (30kg N/ha) and Azotobacter (T_8) has significantly increased the growth and yield parameters over control (Table 1) and resulted in maximum plant height (66.17cm), number of branches per plant (24.87), number of leaves per plant (284.68), fresh leaf yield (23.35gm) and dry leaf yield per plant (5.98gm) compared to other fertilizer combinations, but is at par with leaf yield recorded in T_6{30kgN (½T_2) +VC @1.5t/ha}. Higher values of yield parameters are observed in T_8 (vermicompost @ 1.5 t/ha in combination with 30kg N and *Azotobacter*) and T_6 {30kgN (½T_2) +VC @1.5t/ha} with estimated dry leaf yield of 4.78q ha^{-1} and 4.32q ha^{-1}, respectively. Integrated nutrient management (vermicompost or FYM in combination with inorganic fertilizers and biofertilizer) was found better than application of organic or inorganic alone to increase the leaf yield in stevia under Jammu subtropics. The reason for higher growth under integrated nutrient management may be due to sustainable/continuous availability of nutrients especially nitrogen throughout the growth period coupled with lesser leaching losses of nutrients. Application of Azotobacter although increased the growth parameters but the increase is non-significant compared to treatment which don't received Azotobacter. The results are of Das et al (2007), Patil (2010), Liu et al (2011) and Kumar et al (2013) also recorded higher growth parameters in *Stevia rebaudiana* under combined application of manures, inorganic fertilizers and biofertilizer.

NPK uptake by plants and fertility status of soil after crop harvest: N, P and K concentrations (%) in plants though increased with the addition of manures and fertilizers but are not significantly different from each other and varies from 1.29-1.44, 0.27-0.32 and 2.23-2.41 per cent, respectively (Table 2). The increase in NPK concentrations (%) might be due to the efficient supply of macro and micro nutrients under integrated nutrient management *vis-a-vis* organic manures act as a source of plant nutrient and humus, which improves the soil physical condition by increasing its capacity to absorb and store water, improving aeration and favouring microbial activity, thereby making conditions favourable for nutrient uptake (Joy et al2005).After the harvest of the crop, the available N in soil is increased significantly due to fertilization

Table 1. Effect of fertilizers and manures on growth and yield parameter

Treatments	Plant height (cm)	Branches $plant^{-1}$	Stem diameter (mm)	Leaves $plant^{-1}$	Leaf yield $plant^{-1}$ (gm)		Estimated leaf yield ha^{-1}(q)	
					Fresh	Dry	Fresh	Dry
T_1 (Control)	48.08	11.86	8.34	157.73	12.82	3.03	10.25	2.42
T_2 [N@ 60 kg ha^{-1}(RDN*)]	59.09	18.19	8.82	216.56	17.88	4.76	14.30	3.81
T_3 [FYM @ 12 tha^{-1} +Azotobacter]	54.33	15.03	8.93	184.21	15.05	3.98	12.03	3.18
T_4 [VC @ 3t ha^{-1}+ Azotobacter]	56.58	18.08	9.30	214.72	17.57	4.53	14.05	3.62
T_5 [30 kg N (½T_2) + FYM @ 6 t ha^{-1}]	62.14	19.06	9.59	228.07	18.25	4.59	14.60	3.67
T_6 [30 kg N (½T_2) + VC @ 1.5 t ha^{-1}	65.25	24.25	10.31	274.62	22.28	5.41	17.82	4.32
T_7 [30 kg N (½T_2) + FYM @ 6 t ha^{-1}+ Azotobacter]	62.60	19.12	9.81	233.94	18.72	4.70	14.98	3.76
T_8 [30 kg N(½T_2)+VC @ 1.5 t ha^{-1}+ Azotobacter]	66.17	24.87	10.56	284.68	23.35	5.98	18.68	4.78
CD (p=0.05)	8.35	4.54	NS	31.41	3.52	0.64	2.82	0.51

*Recommended dose of nitrogen

Table 2. Effect of fertilizers and manures on NPK (%) concentration in plant and on soil fertility status after harvest of crop

Treatments	NPK (%) concentration in plant			Soil fertility status after harvest		
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	1.29	0.27	2.23	197.73	14.10	154.94
T_2	1.32	0.29	2.32	255.50	14.62	157.91
T_3	1.28	0.28	2.34	262.07	17.14	168.02
T_4	1.36	0.29	2.38	254.77	15.32	160.34
T_5	1.39	0.30	2.30	244.84	15.06	159.81
T_6	1.42	0.30	2.41	248.15	16.12	161.23
T_7	1.40	0.29	2.39	247.26	15.31	160.35
T_8	1.44	0.32	2.40	250.49	16.18	160.83
CD (p=0.05)	NS	NS	NS	5.42	NS	NS
			Initial status	254.54	16.18	166.39

See Table 1 for treatment details

over control. Application of FYM @ 12t/ha and Azotobacter has resulted in increased available N (262.07 kg/ha) over the initial of 254.54 kg/ha (Table 2). However, T_8 and T_6 treatments, in which higher yields are obtained, the available N is recorded to be 250.49 kg/ha and 248.15kg/ha, respectively but are slightly lower (non-significant) than their initial status. Available P and K in soil are not significantly influenced by fertilization.

The increase in available N may be ascribed to mineralization of partially or fully immobilized N by farm yard manure in soil, nitrogen fixation by *Azotobacter*. The increase in N content could also be due to inability of micro-organisms to decompose the organic manures applied and make it available for the plant. These results are in close conformity with those reported by Joy et al (2005), Naik and Babu (2007), Kumar et al (2012) and Kumar et al (2013).

CONCLUSION

Combination of organic, inorganic and biofertilizers is superior over application of manures or fertilizers alone for higher growth and yield in *Stevia rebaudiana*. Application of vermicompost @ 1.5 t/ha along with 30kgN per hectare (½ of recommended dose) and *Azotobacter* is beneficial not only to increase the leaf yield but also in maintaining the fertility status of soil.

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