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Influence of Biofertilizers on the Growth of Stevia (*Stevia rebaudiana*) and Stevioside Content under Drip Irrigation

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ABSTRACT

The experiment was laid out in split plot design, replicated thrice. There were three methods of irrigation, Drip irrigation (I_1), Furrow irrigation (I_2), Flood irrigation(I_3) and five sources of nutrients Biofertilizers (F_1), Vermicompost (F_2), Bio+Vermi (F_3), Foliar application of NPK@15 kg/ha in six equal splits (F_4) and Control (F_5). Other required cultural practices were followed to get maximum productivity. The results revealed that growth parameters like number of branches, number of leaves, leaf area index, fresh weight, dry weight and leaf : Stem ratio were recorded maximum in Drip irrigation with Foliar application of NPK @15kg/ha in six equal splits. Maximum yield of dry leaves was obtained through Drip irrigation (1312.4 kg/ha) and foliar application of NPK @ 15 kg/ha in six equal splits (1306.2 kg/ha). Quality parameters like stevioside content and stevioside yield was recorded maximum in Drip irrigation with Vermicompost. Maximum B:C ratio was found in Drip irrigation and with NPK foliar spray.

Key words : *Stevia, Drip irrigation, Biofertilizers, Vermicompost, NPK*

Introduction

Stevia (*Stevia rebaudiana)* is a sweet herb belonging to Asteraceae family. It is native to regions of South America (Paraguay and Brazil) where its leaves have been known for sweet tasting and is a natural non caloric bio-sweetener, which offers a solution for complex diabetic problems and obesity in humans (Dushyant *et al.*, 2014). The leaves of stevia contain around ten sweetening glycosides, of which stevioside (3-10%), rebaudioside-A (13%), rebaudioside-B, rebaudioside-C, and rebaudioside-D are important. The Indian farmers have also started cultivation of natural sweetener due to large demand foremerging diabetic market. Total annual production of stevia in India is reported to be 600 tonnes (Agriculture and Industry Survey, 2005). Since stevia leaves has medicinal values and required continuous soil moisture regime free from water stress which may deteriorate the quantity and quality of foliage. Further, stevia not required heavy doses of NPK to avoid chemical residual load, rather balanced nutrition through different organic sources may enhance the quality of stevia leaves. Therefore, production technology of stevia under different irrigation methods and sources of nutrition were studied in Punjab.

Materials and Methods

A field experiment was carried out under field conditions at farms of Department of Agronomy, students' farm, Khalsa College, Amritsar during 2019-2020 and weekly mean meteorological data re-

corded during crop season (Aug 2019- Dec 2019). The soil of the experimental site was sandy loam with irrigated conditions having pH ranges 7.9, low available N (160-154 kg ha^{-1}), medium available phosphorus (16.8-18.5 kg ha^{-1}), high available potassium (330-356 kg ha^{-1}). The experiment consisted of fifteen treatment combinations, comprising of three methods of irrigation Drip irrigation, Furrow irrigation, Flood irrigation and five sources of nutrients; Biofertilizers, Vermicompost, Bio+Vermi, Foliar application of NPK@15 kg/ha in six equal splits and Control and were laid out in Split plot design with three replications.Field was prepared by ploughing twice with disc harrow followed by planking. Planting of root cuttings were done manually on 29 Aug 2019 at a spacing 25 × 30 cm. First irrigation was given immediately after planting and subsequent irrigation was applied as per crop requirement through the growing season. Six weeding operations were done at 15 days interval. Plant protection was done with heeng (asafoetida). Three plants were tagged at random in each plot for recording various growth and yield components. Different growth parameters like branches per plant, leaves per plant, leaf area, fresh and dry weight (g $plant^{-1}$) were recorded. The crop was harvested manually with sickles 10 cm above the base of the stem on (6 Dec 2019) and tied in bundles with tags from each plot and after washing left for shade drying. Leaves and stem were separated and used for further analysis. The yield of every net plot was put in separate bags with specific tags. Dried leaves were grinded and 250g sample was used to determine the stevioside content through column chromatography as mentioned in procedure described by Kumari *et al.* (2017). The data on various parameters were statistically analysed by using CPCS-1, software developed by Department of Statistics, Punjab Agricultural University, Ludhiana

Results and Discussion

Growth Parameters

Number of branches

Number of branches and number of leaves are interdependent and collectively formed the photosynthetically active area which inturn determines the yield. At harvest maximum number of branches was observed under Drip irrigation (I_1) followed by Furrow irrigation (I_2) and Flood irrigation (I_3) Table 1. All the irrigation treatments were significantly varied with each other. It was observed that I_1 produced 39.1 percent more branches than I_3. Maximum number of branches was produced under Drip irrigation may be due to continuous supply of moisture near the root zone with minimum run off losses as compared to Furrow and Flood irrigation. Similar findings were in agreement with the earlier reported by Behera *et al.* (2013). Among the sources of nutrients, maximum number of branches was observed under foliar application of NPK@15 kg/ha in six equal splits (F_4) followed by Vermicompost (F_2), Bio+Vermi (F_3), Biofertilizers (F_1) and Control (F_5).Foliar application of NPK @15 kg/ha in six equal splits and Vermicompost were remained at par with each other. Foliar application of NPK@15 kg/ha in six equal splits produced 54 percent more

Table 1. Effect of irrigation and nutrition sources on the growth parameter of Stevia.

Treatment	Number of branches per plant	Number of leaves per plant	Fresh weight (g/plant)	Dry weight (g/plant)
Irrigation				
Drip (I_1)	36.6	327.9	38.1	9.2
Furrow (I_2)	32.3	295.9	35.2	8.8
Flood (I_3)	26.3	246.5	23.1	5.3
CD (p=0.05)	1.62	23.7	2.20	0.57
Source of nutrients				
Biofertilizers (F_1)	30.3	285.0	31.3	7.7
Vermicompost (F_2)	35.2	322.2	36.3	8.9
Bio+Vermi (F_3)	32.8	304.0	33.8	8.3
NPK Foliar Spray (F_4)	36.5	333.6	37.6	9.1
Control (F_5)	23.7	205.6	21.6	4.8
CD (P=0.05)	1.59	16.4	1.65	0.48

branches than Control. These result might be due to the slow release of nutrients from organic sources & Biofertilizers and their absorption by plants moreover mineralization require more time than foliar application of NPK, consequently, more number of branches with the foliar application of NPK. Similar findings were observed by Rashwan *et al.* (2017).

Number of leaves Number of leaves showed significant variation under irrigation methods. Maximum number of leaves was recorded in Drip irrigation (I_1) followed by Furrow (I_2) and Flood irrigation (I_3). The percent increase with I_1 was 33 over I_3. Higher numbers of leaves were observed under Drip irrigation which may be due to higher number of branches under Drip irrigation. Similar findings were earlier reported by Behera *et al.* (2013). Among sources of nutrients, maximum number of leaves was recorded under foliar application of NPK @15 kg/ha in six equal splits (F_4) followed by Vermicompost (F_2), Bio+Vermi (F_3), Biofertilizers (F_1) and Control (F_5) Table 1. $F_4$and F_2 were at par with each other. Foliar application of NPK produced 62.2 percent more leaves than Control. Maximum number of leaves were observed under the split doses of foliar application of NPK as compared to organic sources in soil which might be due to high concentration and quickly availability of nutrients. The result were in agreement with the findings of Benhminou *et al.* (2018).

The results are in close conformity with Behera *et al.* (2013). Maximum dry yield of leaves was observed under foliar application of NPK@15 kg/ha in six equal splits followed by Vermicompost, Bio+Vermi, Biofertilizers and Control. However, $F_4$was at par with F_2. Foliar application of NPK produced 12.3 percent more dry leaf yield than Control. Maximum leaf yield under the split doses of foliar application of NPK might be due to efficient and better utilization of nutrition. The results are in close conformity with Behera *et al.* (2013).

Fresh weight of the plant

Fresh weight is an index of water content of plant cell. Since plants have a high composition of water in a plant depends on the amount of water in its environment. Maximum fresh weight was observed under Drip irrigation (I_1) followed by Furrow (I_2) and Flood irrigation (I_3). All the irrigation methods were significantly varied with each other. The corresponding percent increase with I_1 was 64.9 over I_3 Table 1. All growth parameters i.e number of branches and leaves might have contributed in fresh weight. These finding are in accordance with findings of Behera *et al.* (2014). As regards to source of nutrients, maximum fresh weight of leaves was observed under Foliar application of NPK @15 kg/ha in six equal splits (F_4) followed by Vermicompost (F_2), Bio+Vermi (F_3), Biofertilizers (F_1) and Control (F_5) Table 1. The percent increase with $F_4$was 74 over F_5. However, F_4 and F_2were statistically at par. Maximum weight was observed under the foliar application of NPK which might be due to efficient and better utilization of nutrition. Aladkatti *et al.* (2012) also reported the similar results.

Dry weight of plant

Dryweight is a more reliable and accurate measure of weight as it excludes the water content. Maximum dry weight was observed under Drip irrigation (I_1) followed by Furrow (I_2) and Flood irrigation (I_3). All the irrigation methods were significantly varied with each other. The percent increase with I_1 was 73.5 over I_3. Optimum availability of moisture throughout the crop growing period under Drip irrigation might have improve the nutrient absorption, soil environment and ultimately plant growth which determine recovery of dry weight. Duarte *et al.*(2016) also reported that maximum dry weight under Drip irrigation. Among sources of nutrients, the maximum dry weight was observed under the treatments NPK@15 kg/ha in six equal splits (F_4) and followed by Vermicompost (F_2), Bio+ Vermi (F_3), Biofertilizers (F_1), Control (F_5). However, F_4 and F_2 were statistically at par. The percent increase with F_4 was 89.5 over F_5. Foliar application of NPK enhanced growth and biomass production as nutrients are released in a form which can be easily assimila-

Treatments	Stevioside Content (%)	Stevioside Yield (Kg/ha)
Irrigation		
Drip (I_1)	7.76	101.8
Furrow (I_2)	7.62	94.3
Flood (I_3)	7.49	87.3
CD (P=0.05)	NS	5.2
Source of nutrient		
Biofertilizers(F_1)	7.51	90.3
Vermicompost (F_2)	7.98	102.7
Bio+Vermi(F_3)	7.73	95.4
NPK Foliar spray (F_4)	7.60	99.2
Control (F_5)	7.23	84.0
CD (P=0.05)	0.37	3.7

tive by plants and may result in higher plant dry weight. Aladkatti *et al.* (2012) also reported the maximum dry weight under the foliar application of NPK.

Quality Parameters

Stevioside content

Stevioside are the main glycosides which are responsible for the quality of stevia. Irrigation methods and had a non-significant effect on the stevioside content. Maximum stevioside content was observed under Drip irrigation (I_1) followed by Furrow (I_2) and Flood irrigation (I_3). Among source of nutrients, maximum content was Vermicompost, Bio+Vermi, Biofertilizers, NPK@15 kg/ha in six equal splits and Control. F_3 with both F_4 and F_2 at par with each other. The percent increase was 9.7 with F_2 over F_5. Beneficial effects of Vermicompost on soil microbial activity as well as soil nutrient status might have improved the content and yield of stevioside compound.

Stevioside yield

Stevioside is the compound extracted from stevia. Stevioside yield is an economic parameter for the stevia crops. Maximum stevioside yield was observed under Drip irrigation (I_1) followed by Furrow (I_2) and Flood irrigation (I_3). All the treatments were significantly varied with each other. The percent increase with I_1 was 16.6 over I_3. Optimum availability of water and nutrients might have increased the stevioside yield. Behera *et al.* (2014) also reported the similar findings. Among the sources of nutrients, maximum content was found under the application of Vermicompost. However, F4 and F2 was statistically at par with each other. The percent increase with F_2 was 22.2 over F_5. Vermicompost contains several micronutrients in proper balanced amount which might have increased the yield and quality of stevia. Zaman *et al.* (2015) also reported the similar findings.

Conclusion

It was concluded that highest yield (shade dry leaves) and growth were better under Drip irrigation and foliar application of NPK @15 kg/ha in six equal splits whereas stevioside content and stevioside yield were better under Drip irrigation and Vermicompost for Stevia cultivation under the agro-climatic conditions of Amritsar (Punjab).

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