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Performance of different Nitrogen Levels and Spacing on Physiological Parameters and Economics of Stevia (*Stevia rebaudiana* Bertoni)

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ABSTRACT
A field experiment was conducted during Zaid2018 in clayey soil under irrigated conditions to assess the response of natural sweetner plant stevia (Stevia rebaudianaBertoni) to the levels of nitrogen nutrient and different inter-row spacings under eastern humid sub tropical conditions. In the experiment three levels of nitrogen i.e., 50, 75 and 100 kg ha^{-1} and different inter-row spacing i.e.,30 cm x 20 cm, 40 cm x 20 cm and 50 cm x 20 cm. Application of nitrogen @ 100 kg ha^{-1} with planting geometry of 50 cm x 20 cm recorded significantly higher plant height (51.24 cm) and dry matter accumulation (40.74 g plant^{-1}). The yield parameters viz.,fresh biomass yield (24.35 t ha^{-1}), fresh leaf yield (10.54 t ha^{-1}) anddry leaf yield (2.63 t ha^{-1}) were significantly higher with 100 kg nitrogen ha^{-1} at 30 cm x 20 cm spacing. Different treatments influenced economics of stevia significantly. Highest gross return(₹ 5,26,000ha^{-1}), net return(₹ 2,21,864 ha^{-1}) and B:C ratio (1.72) was recorded with 100 kg nitrogen ha^{-1} at 30 cm x 20 cm spacing.
***Key words** :Stevia, Nutrient management, Inter-row spacing, Yield*

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INTRODUCTION

Stevia (*Stevia rebaudiana*Bertoni) is a herbaceous perennial plant of compositae family. It is native to Paraguay [15]. It is a low calorie natural sweetner herb grown as a crop in many countries including Japan, China, India, USA, Canada, Mexico, Paraguay, Brazil and Argentina [9]. Stevia has been successfully cultivated in recent years in many Indian states: Rajasthan, Andhra Pradesh, Maharastra, Kerala, Punjab and Orisaa. *Stevia rebaudiana* (2n= 22), the nature's sweetest gift really stands out in that it has numerous health benefits [10]. Stevia sweetner extracts have beneficial effect on human health including anti-hypersensitive, anti-hyperglycemic, anti-carcinogenic activities. It has been used to help control diabetes, weight in obese persons etc. It is also known by the name of sweet leaf, honey leaf, sweet herb, candy leaf etc. It is often referred to as "the sweet herb of Paraguay". There are nearly 300 species in the genus of Stevia scattered all over the world. Only *Stevia rebaudiana* contains the secret of stevioside, which makes it the sweetest herb in the world [11, 12]. Leaves of stevia accumulate sweet tasting diterpene glycosides such as steviosides (1-3%) and rebudiosides (10-20%) which are up to 100-300 times sweeter than sucrose. The glycosides are extracted from the stevia leaves as natural zero calorie sweetners. Hence, stevia has been named as calorie free bio- sweetner of high quality with non- fermentable, non-dicoloring, maintain heat stability at 100 ^{o}C. It is extremely for food industry in products such as seafood, soft drinks, sweets, pickles and candies. Global stevia market is rapidly increasing, in 2014, the global consumption of stevia as food ingredient was estimated at 5,100 tonnes and it is projected to reach 8,507 tonnes by 2020 [14, 7]. Stevia can play an important role in India which tops the diabetic population in the world with 30 million patients, and this is expected to increase to 80 million by 2025 as per the reports of world health organization. Since, it is a newly adopted crop there is not much information available on the cultivation and agronomic requirements of stevia *viz.*, plant population, planting geometry, fertilizer doses, irrigation requirement etc.Therefore, in view of the above, the present fact finding were undertaken with an aim to find out N requirement and planting density of stevia inorder to achieve high crop yields, high quality level, balanced use of fertilizers, low environmental impact, suitable adaptation and mitigation strategies able to encourage responsible sustainable development under eastern Uttar Pradesh condition.

MATERIAL AND METHODS

The experiment was carried out during *Zaid* season 2018, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) which is located at 25° 39' 42"N latitude, 81° 67' 56" E longitude and 98 m altitude above the mean sea level (MSL). In the experiment, effect of different levels of nitrogen and spacing were evaluated on the clayey loam soil which was basic in reaction (pH 7.8), low in organic carbon content (0.3 %), available nitrogen (183.50 Kg ha^{-1}), available phosphorus (15.63 Kg ha^{-1}) and available potassium (197.63 Kg ha^{-1}). The experiment was laid out in randomized block design with three replication and nine treatments. Details of treatment were as first factor levels of nitrogen (N_1 = 50 kg ha^{-1}, N_2 = 75 kg ha^{-1}, N_3 = 100 kg ha^{-1}) and second factor three different inter-row spacing (S_1 = 30 x 20 cm, S_2 = 40 x 20 cm, S_3 = 50 x 20 cm) and their treatment combinations as T_1= 50 kg ha^{-1} nitrogen at 30 cm x 20 cm; T_2 = 50 kg ha^{-1} nitrogen at 40 cm x 20 cm; T_3 = 50 kg ha^{-1} nitrogen at 50 cm x 20 cm; T_4= 75 kg ha^{-1} nitrogen at 30 cm x 20 cm; T_5 = 75 kg ha^{-1} nitrogen at 40 cm x 20 cm; T_6 = 75 kg ha^{-1} nitrogen at 50 cm x 20 cm; T_7= 100 kg ha^{-1} nitrogen at 30 cm x 20 cm; T_8= 100 kg ha^{-1} nitrogen at 40 cm x 20 cm; T_9 = 100 kg ha^{-1} nitrogen at 50 cm x 20 cm. The experiment was laid out randomized block design with replicated three times. One month old seedlings were used for transplanting as per designs in their respective plots. Inorganic nutrients were applied at the time of transplanting *viz*; urea (N 46%), single super phosphate (P_2O_5 16%), and muriate of potash (K_2O 60%). Half dose of Nitrogen at the time of transplanting and the remaining half was applied in two equal splits; 1st half 30 days after transplanting and 2nd half 60 days after transplanting, whereas, the full doses of phosphorus and potassium were applied at the time of transplanting. Need based irrigation was supplied at an interval of 5-7 days. In the experiment biometric observation were recorded at 20 days interval upto 80 DAT. Three plants/plot were randomly selected for recording observations. The crop was harvested at 90 DAT from the bottom leaving 5 cm up to the ground level and dried under shade for 4-5 days. The dried stevia leaves were stripped off from the stem and dried separately under sunlight for a day and stored in clean bags which were used for selling. Observation on growth during the experimental period includes plant height (cm), dry matter accumulation (g plant^{-1}), Absolute growth rate (g plant^{-1} day^{-1}), Crop growth rate (g m^{-2} day^{-1}) and Relative growth rate (g g^{-1} day^{-1}). Observation at the harvest was done to measure the yield components (fresh biomass yield, fresh leaf yield and dry leaf yield) and then the economics was evaluated. The data were statistically analyzed as procedures given by Panse and Sukhatme [8].

RESULTS AND DISCUSSION

Plant height

Plant height during the period of growth has shown significant interaction due to various treatments is presented in Table 1. Nitrogen level and spacing has significant effect on plant height at 60 and 80 DAT. Significantly highest plant height (45.10 cm, 51.24 cm) was reported at 60 and 80 DAT in treatment T_9 *i.e.,* 100 kg ha^{-1} nitrogen at (50 cm x 20 cm) spacing. The results are in agreement with the findings of Inugraha *et al.* [5] with proper nutrient management and geometry achieves the maximum plant response.

Dry matter accumulation

Data pertaining to dry matter accumulation is presented in Table 1.The dry matter accumulation of crop in different plant parts during the growth period is important for determination of economic yield. Application of nitrogen @ 100kg ha^{-1} at (50 cmx20 cm) spacing in treatment T_9, helped for high dry matter accumulation (23.74, 40.74 g $plant^{-1}$) compared to other treatments at 60 and 80 DAT.This was in conformity with the results of Chalapathi [4] who reported that plant height and dry matter accumulation were increased due to application of higher levels of nutrients. The similar finding was observed by Aladakatti *et al.* [1] who reported that dry matter tended to increase with increase in row spacing from 30 cm to 50 cm.

Absolute growth rate (g $plant^{-1}day^{-1}$), Crop growth rate (g m^{-2} day^{-1}) and Relative growth rate (g $g^{-1}day^{-1}$)

There were non significant difference among the treatments in terms of Absolute growth rate (AGR, g $plant^{-1}day^{-1}$), Crop growth rate (CGR, g m^{-2} day^{-1}) and Relative growth rate (RGR, g $g^{-1}day^{-1}$) but at 60-80 DAT shown significant result in AGR and CGR (Table 2.). The highest absolute growth rate (AGR) was observed under treatment combination T_8 i.e. 100 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing, while lowest in T_1*viz*50 kg ha^{-1} nitrogen at 30 cm x 20 cm which was closely followed by treatment T_4 i.e., 75 kg ha^{-1} nitrogen at (30 cm x 20 cm), T_5i.e., 75 kg ha^{-1} nitrogen at (40 cm x 20 cm), T_6i.e., 75 kg ha^{-1} nitrogen at (50 cm x 20 cm), T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm), T_9 *i.e.,* 100 kg ha^{-1} nitrogen at (50 cm x 20 cm) at 60-80 DAT.

The crop growth rate also influenced significantly during 60-80 DAT (Table 2.). Treatment T_7*i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) observed maximum crop growth rate as compare with treatments but it closely followed by treatment T_4 i.e., 75 kg ha^{-1} nitrogen at (30 cm x 20 cm). The variation among the treatments was due to variation in planting geometry and nutrient application. The result are inconformity with findings of Rashid *et al.* [10] who reported that after 30 DAT the crop growth rate increase sharply until 80 DAT due to better management.

Relative growth rate (RGR) of different treatments exposed non significant variation at both stages. The high value of RGR at 40-60 DAT was observed under in treatment T_9 i.e. 100 kg ha^{-1} nitrogen at (50 cm x 20 cm) and at 60-80 DAT under treatment T_5 i.e., 75 kg ha^{-1} nitrogen at (40 cm x 20 cm). The minimum relative growth rate was recorded under T_1 i.e., 50 kg ha^{-1} nitrogen at (30 cm x 20 cm).

Fresh biomass yield

The data in relation to the fresh biomass yield as affected by spacing and N levels are shown in Table 3. The analysis of variance suggested that the fresh biomass yield of stevia was significantly ($P<0.05$) influenced. Treatment T_7 i.e., 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing recorded highest biomass yield (24.35 t ha^{-1}) over all other treatments except treatment T_4 i.e., 75 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing which was found at par with treatment T_7 whereas the lowest (12.17 t ha^{-1}) was observed under treatment T_3 i.e., 50 kg ha^{-1} nitrogen at (50 cm x 20 cm) spacing. The results are in conformity with the findings of Tadesse Btru *et al.* [13].

Fresh leaf yield

The results showed that fresh leaf yield was much influenced under various treatments at harvest. Among different treatments, T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing gave higher fresh leaf yield (10.54 t ha^{-1}) and the lowest fresh leaf yield (5.15t ha^{-1})was observed under treatment T_3*i.e.,* 50 kg ha^{-1} nitrogen at (50 cm x 20 cm) spacing. Treatment T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing was found to be 51.13% higher than treatment T_3. However, treatment T_4 *i.e.,* 75 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing was found at par with treatment T_7. This finding is also in line with the works on stevia spacing was reported by Basuki [2] and Carnerio *et al.* [3]

Dry leaf yield

The results presented in Table 3 about the analysis of variance indicated that the dry leaf yield was significantly ($P<0.05$) affected by nitrogen levels and spacing. Significantly higher dry leaf yield (2.63 t ha^{-1}) was obtained under treatment T_7 i.e., 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing which was at par with treatment T_4 i.e., 75 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing and lower dry leaf yield (1.29 t ha^{-1}) was recorded under treatment T_3*i.e.,* 50 kg ha-1 nitrogen at (50 cm x 20 cm) spacing. Kumar *et al.* [6] also reported a higher value of dry leaf yield with narrow spacing in stevia.

Table 1.Growth of Stevia affected by spacing and nitrogen levels.

Treatment No.	Treatment Combinations	Plant height (cm)		Dry matter accumulation (g plant^{-1})	
		60 DAT	80 DAT	60 DAT	80 DAT
1	50 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	34.17	39.11	16.92	26.02
2	50 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	38.28	41.42	17.13	28.08
3	50 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	39.86	43.97	18.14	28.71
4	75 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	38.88	43.73	19.81	36.36
5	75 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	40.40	48.00	20.18	37.24
6	75 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	42.83	48.13	21.91	38.04
7	100 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	41.51	47.71	21.97	38.78
8	100 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	43.06	48.31	22.58	40.17
9	100 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	45.10	51.24	23.74	40.74
	F-test	S	S	S	S
	SEm±	1.35	1.15	0.76	1.02
	CD (P = 0.05)	4.04	3.44	2.28	3.05

Table 2.Physiological parameters of Stevia affected by spacing and nitrogen levels.

Treatment No.	Treatment Combinations	AGR (g plant^{-1} day^{-1})		CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})	
		40-60DAT	60-80 DAT	40-60DAT	60-80 DAT	40-60DAT	60-80 DAT
T_1	50 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	0.29	0.45	4.75	7.59	0.0205	0.0216
T_2	50 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	0.22	0.55	2.76	6.84	0.0157	0.0247
T_3	50 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	0.25	0.52	2.51	5.29	0.0160	0.0230
T_4	75 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	0.30	0.82	4.98	13.79	0.0188	0.0303
T_5	75 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	0.40	0.85	5.00	10.66	0.0253	0.0305
T_6	75 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	0.45	0.81	4.54	8.06	0.0268	0.0277
T_7	100 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	0.37	0.84	6.19	14.01	0.0206	0.0283
T_8	100 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	0.40	0.88	5.03	11.00	0.0220	0.0287
T_9	100 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	0.54	0.85	5.38	8.50	0.0301	0.0270
	F-test	NS	S	NS	S	NS	NS
	SEm±	0.06	0.06	0.91	0.72	0.004	0.002
	CD (P = 0.05)	0.21	0.19	2.76	2.17	0.014	0.006

Cost of cultivation (₹ ha^{-1})

The results pertaining to days to cost of cultivation as influenced by spacing and nitrogen levels are presented in Table 4.

The minimum cost of cultivation (₹1,90,172ha^{-1}) was obtained in treatment T_3 *i.e.,* 50 kg ha^{-1} nitrogen at (50 cm x 20 cm) spacing which was found to be 37.47% less than treatment T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing.

Gross return (₹ ha^{-1})

Highest Gross return(₹5,26,000 ha^{-1}**)** was recorded in treatment T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing which was 50.95% higher than in treatment T_3*i.e.,* 50 kg ha^{-1} nitrogen at (50 cm x 20 cm) spacing.

Net return (₹ ha^{-1})

Treatment T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing recorded 78.03% higher net return than treatment T_1 *i.e.,* 50 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing.

Benefit cost ratio (B:C)

Maximum Benefit cost ratio (1.72) was recorded in treatment T_7 *i.e.,* 100 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing whereas the lowest value (1.16)was obtained in treatment T_1 *i.e.,* 50 kg ha^{-1} nitrogen at (30 cm x 20 cm) spacing.

Table 3.Yield and Yield attributes of Stevia affected by spacing and nitrogen levels.

Treatment No.	Treatment Combinations	Fresh biomass yield (t ha^{-1})	Fresh leaf yield (t ha^{-1})	Dry leafyield (t ha^{-1})
1	50 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	17.91	7.04	1.76
2	50 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	15.01	6.10	1.53
3	50 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	12.17	5.15	1.29
4	75 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	22.85	9.98	2.50
5	75 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	15.71	6.55	1.64
6	75 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	13.32	5.37	1.34
7	100 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	24.35	10.54	2.63
8	100 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	17.96	7.18	1.79
9	100 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	15.56	6.28	1.57
	F-test	S	S	S
	SEm±	0.51	0.25	0.06
	CD (P = 0.05)	1.55	0.75	0.18

Table 4. Economics of Stevia affected by spacing and nitrogen levels.

Treatment No.	Treatment Combinations	Cost of Cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net Return (₹ha^{-1})	B:C ratio
1	50 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	303272	352000	48728	1.16
2	50 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	227672	306000	78328	1.34
3	50 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	190172	258000	67828	1.35
4	75 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	303704	500000	196296	1.64
5	75 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	228104	328000	99896	1.43
6	75 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	190604	268000	77396	1.40
7	100 kg ha^{-1} nitrogen at 30 cm x 20 cm spacing	304136	526000	221864	1.72
8	100 kg ha^{-1} nitrogen at 40 cm x 20 cm spacing	228536	358000	129464	1.56
9	100 kg ha^{-1} nitrogen at 50 cm x 20 cm spacing	191036	314000	122964	1.64

CONCLUSION

The research study showed that the highest economic fresh biomass yield (24.35 t ha^{-1}), Fresh leaf yield (10.54 t ha^{-1}) and dry leaf yield (2.63t ha^{-1}) was recorded from Treatment T_7 i.*e.,*100 kg ha^{-1} N at (30x20) cm spacing.

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