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DM Chaudhari
Department of Agronomy, N.M.C.A, N.A.U, Navsari, Gujarat, India

Sonal Tripathi
Department of Soil Science, N.A.U, Navsari, Gujarat, India

Narendra singh
Department of Soil Science, N.A.U, Navsari, Gujarat, India

MS Dudhat
Main Sugarcane Research Station, N.A.U, Navsari, Gujarat, India

JN Zala
Sardar Smruti Kendra, N.A.U., Navsari, Gujarat, India

Corresponding Author:
DM Chaudhari
Department of Agronomy, N.M.C.A, N.A.U, Navsari, Gujarat, India

Nutrient acquisition of sugarcane planted through single eye budded settling as influenced by integrated nutrient management under south Gujarat condition

DM Chaudhari, Sonal Tripathi, Narendra singh, MS Dudhat and JN Zala

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Abstract
An experiment was conducted for three consecutive years 2021-22, 2022-23 and 2023-24 at the Main Sugarcane Research Station Farm, Navsari Agricultural University, Navsari, to study the effect of nutrient management on sugarcane planted through single eye budded settling under South Gujarat conditions. The experiment consisted of 16 treatments laid out in a factorial randomized block design with three replications. The experiment consisted of two levels of organic manure, 25 t/ha FYM (M_1) and 15 t/ha bio compost (M_2); four levels of recommended dose of fertilizers, 75% of RDF (F_1), 100% of RDF (F_2), 125% of RDF (F_3), 150% of RDF (F_4); and two levels of bio-fertilizer, without (B_1) and with bio fertilizers (B_2) (*Acetobacter* + PSB+ KMB applied two times as basal and before final Earthing up @ 2.5 l/ha each both time). Based on the pooled analysis of the three-year study, it can be concluded that cane yield, available N, P, and K status of soil, soil properties, and uptake of major nutrients of sugarcane were not significantly affected by different nutrient management practices. Application of FYM@ 25 t/ha or biocompost 15 t/ha and application of fertilizer @188-94-94 kg N-P_2O_5-K_2O/ha with biofertilizer were found to be superior for saving 25% fertilizer dose.

Keywords: Sugarcane, INM, FYM, bio-compost, bio-fertilizer, cane yield, nutrient content, nutrient uptake

1. Introduction
Sugarcane is widely cultivated throughout the Indo-Gangetic plains of South Asia. More than 4.2 million hectares are under sugarcane cultivation in India alone, with an average cane yield of 60 t/ha (Singh *et al*., 2007) [8]. In India, sugarcane occupies an area of 5.098 million hectare with a production of 430.50 million tons and an annual average productivity of approximately 84.44 t/ha. Although India is the second largest producer of sugarcane and the highest consumer of sugar, the productivity of the crop is low and the cost of production is high, resulting in a low income for the 50 million cane growers depending on sugarcane cultivation. Sugarcane is an important cash crop in Gujarat and is the most popular among farmers. During the year 2024-25 in Gujarat State, the area of sugarcane was 1.89 lakh hectare, production of sugarcane was 135.16 lakh tonnes, and yield of sugarcane was 71.292 t/ha.

Sugarcane, a long-duration crop with C_4 metabolism, requires large amounts of moisture, nutrients, and sunlight for optimum productivity. It is an exhaustive crop, producing heavy tonnage and depleting more nutrients from the soil. Sugarcane is a very exhaustive and extracting crop that removes about 205 kg N, 55 kg P_2O_5, 275 kg K_2O, 30 kg S, 3.5 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from the soil for a cane yield of 100 t/ha (Singh *et al*., 2007) [8].With intensive cultivation, soils are becoming depleted in the availability of nutrients, hence becoming less fertile; the low fertility of soil is one of the important limiting factors in sugarcane productivity. Insufficient or ill-timed supply of N-fertilizer applied to sugarcane would result in poor growth, such as narrow leaves, thin stems, short internodes, and yield (Bell *et al*., 2014) [3]. However, the potassium requirement of the crop is generally greater than that of nitrogen or phosphorus. It is required for maintaining cell turgidity, photosynthesis, root development, and other processes. It has a balancing effect on both nitrogen and phosphorus levels (Lakshmi *et al*., 2020) [6]. The phosphorus requirement is relatively lower than that of N and K. Phosphorus is necessary for the synthesis of phosphorylated compounds, and a lack of

this nutrient immediately disturbs plant metabolism and development (Santos *et al*., 2014) [7].

Sugarcane crop required 3-5 weeks to germinate, and the time of planting is most important for farmers, as well as considering growth under the specific environmental requirements of the crop. Under the concept of Sustainable Sugarcane Intensification (SSI) techniques, the use of settling as planting material has been reported to be promising, with savings in seed material and time for the initial one month as well as established settling use for planting. This holds great potential for boosting national sugarcane production sustainably. Nutrient management is crucial for the growth and economic production of sugarcane crops. This experiment was proposed to determine the appropriate nutrient management for sugarcane planting through single eye budded settling.

2. Materials and Methods

2.1 Experimental Site

The experimental site was located in Agro-Ecological Zone-III of the South Gujarat Heavy Rainfall Zone. The soil of the experimental sites is classified under the order "*Inceptisols*" according to the 7th Approximation, which includes members of the fine, montmorillonitic, *isohypethermic* great soil group of *Vertic Ustrochrepts* and soil series Jalalpur by the soil survey officer, Navsari, Department of Agriculture, Gujarat State (Desai and Patel 1970) [4], having poor drainage capacity and good water holding capacity.

2.2 Treatments and Experimental Design

A field experiment was conducted during three consecutive cropping years, *viz.*, 2021-22, 2022-23 and 2023-24 at the Main Sugarcane Research Station Farm, Navsari Agricultural University, Navsari. The experiment was laid out in a Factorial Randomized Block design with three replications. The experiment comprised a total of 16 treatments, which were combinations of two levels of organic manure, that is, 25 t/ha FYM (M_1) and 15 t/ha bio compost (M_2); four levels of recommended dose of fertilizers (250 N + 125 P2O5 + 125 K2O kg/ha) at 75% of RDF (F_1), 100% of RDF (F_2), 125% of RDF (F_3), 150% of RDF (F_4); and two levels of bio-fertilizer, that is, without (B_1) and with bio fertilizers (B_2) (*Acetobacter* + PSB + KMB applied two times as basal and before final earthing up @ 2.5 l/ha each both time). The sugarcane variety CoN 13072 was sown with a spacing of 120 cm × 45 cm with a seed rate of 18519 settling/ha.

2.3 Experimental Procedures

The experimental plot was set according to the treatments and design. Single eye buds of sugarcane variety CoN 13072 were carefully cut from healthy canes manually and used for raising nursery. The raised polybag seedlings were transplanted into the main field at a distance of 45 cm.

2.4 Analysis of Soil and Plant Samples

Soil samples were collected from 0-15 cm depth of the experimental field before the commencement of the experiments for analysis. Following the crop harvest, soil samples were collected from each plot to study the chemical changes after the experiment. The soil samples were collected, air-dried, ground, sieved through a 2 mm sieve, labeled, and stored for further analysis. The soil of the experimental plot was medium in organic carbon (0.60, 0.72, and 0.60), low in available nitrogen (225.69, 260.82, and 297 kg/ha), medium in available phosphorus (50.18, 52.62, and 54.63 kg/ha), and high in available potash (377.59, 382.16, and 367.18 kg/ha). The soil was slightly alkaline (7.81, 7.90, and 8.00) in nature with high electrical conductivity (0.41, 0.65, and 0.66 dS/m) during the year 2021-22 and 2022-23 and 2023-24, respectively.

3. Results and Discussion

3.1 Cane Yield

A close surveillance of data presented in Table 1 showed that various INM treatments on cane yield were not influenced significantly during all the years of study as well as in pooled data. In the case of manure treatments, the application of 25 t FYM/ha resulted in a numerically higher cane yield (105.50 t/ha) on a pooled basis. In fertilizer-treated plots, 150% RDF treatment recorded a numerically higher cane yield (106.4 t/ha) than the other treatments in the pooled analysis, and in the case of bio-fertilizer treatments, application with bio-fertilizers recorded a numerically higher cane yield (105.32 t/ha) than without bio-fertilizer application. It can be concluded that all the treatments of integrated nutrient management had equal effects on yield attributes and yield. This finding corroborates that of Kumar *et al.* (2017) [5].

3.2 Effect on Available NPK Status

The data indicate that different nutrient management practices of manures, fertilizers, and bio-fertilizers did not show a significant effect on soil available nitrogen, P, and K (kg/ha) status after the harvest of sugarcane in all the years.

3.3 Effect on Soil Properties

The data presented in Table 2 and graph 1 indicate that various INM treatments on soil organic carbon (%) and bulk density (mg/m^3) were also found to have a non-significant effect in all the years except for the effect of manure treatment during the year of 2022-23 where, soil organic carbon (%) and bulk density (mg/m^3) were found to be significant in manure and fertilizer treatments. In the case of organic carbon under manure treatments, the application of 25 t/ha FYM recorded significantly higher organic carbon (0.77%) than the application of 15 tonnes of bio compost/ha treatment (0.72%). In the case of bulk density under manure treatments, the application of 25 t/ha FYM recorded significantly lower bulk density (1.34 Mg/m^3) than the application of 15 tonnes of bio compost/ha treatment (1.42 Mg/m^3). In the case of fertilizer treatments, the application of 125% RDF recorded significantly lower bulk density (1.32 Mg/m^3) than the rest of the treatments. A lower bulk density in the soil is generally beneficial for plant growth and overall soil health. This indicates a more porous soil structure, allowing for better water infiltration, aeration, and root development.

3.4 Effect on Uptake of Nutrients

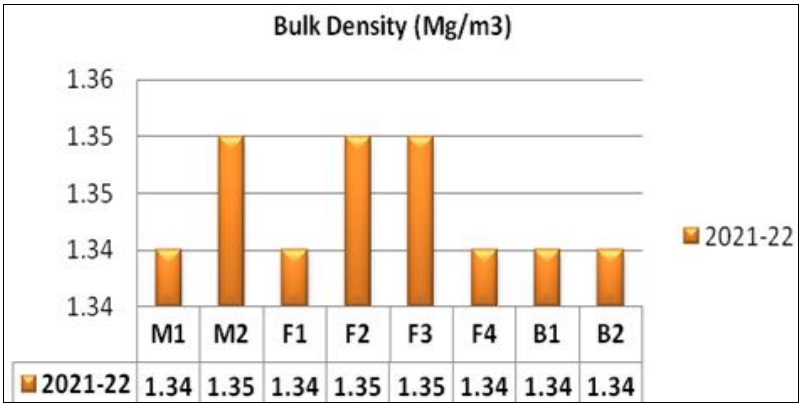
Sugarcane is a highly nutrient-exhaustive crop, as evident from the nutrient removal (uptake) data presented for a pooled period of three years. The N, P, and K content (%) in leaves and cane was found to have a non-significant effect on manure, fertilizer, and bio-fertilizer treatments during all years and pooled analysis. Total N, P, and K uptake in sugarcane was also found to be non-significant in various INM treatments on a pooled basis. (Table no. 1)

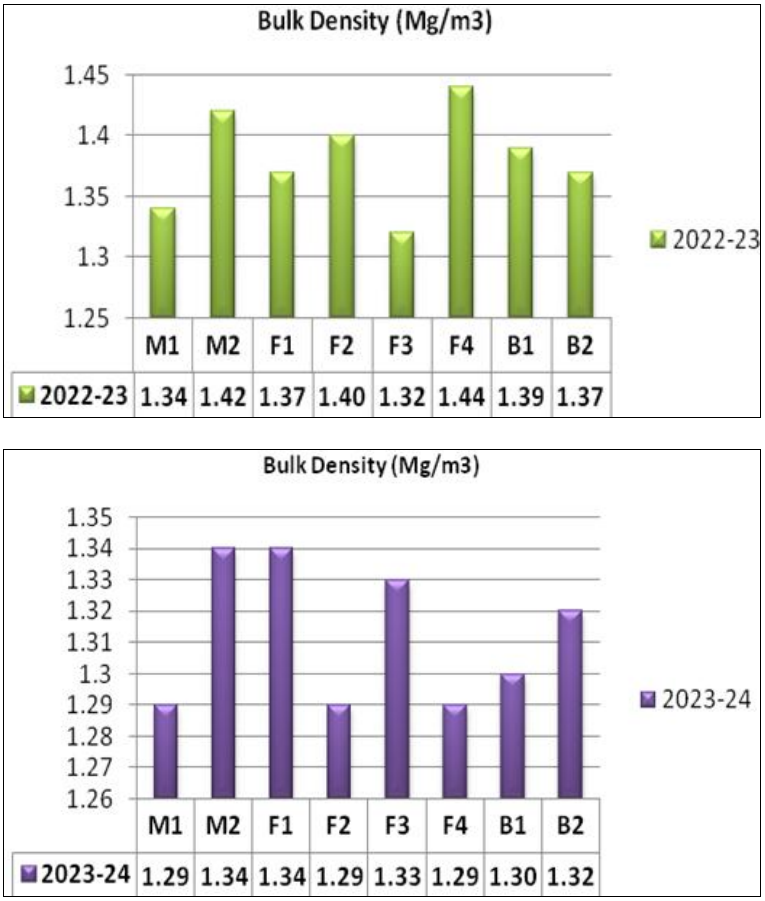
Table 1: Cane yield of sugarcane as influenced by different INM treatments (Pooled over three years)

Treatment	Cane Yield (t/ha)		Total N uptake (kg/ha)		Total P uptake (kg/ha)		Total K uptake (kg/ha)	
Manure (M)								
M_1: 25 t FYM/ha	105.50		159.41		79.20		228.81	
M_2: 15 t Bio compost/ha	102.07		154.53		80.19		2220.17	
S.Em.±	1.39		2.87		1.46		4.66	
CD at 5%	NS		NS		NS		NS	
Fertilizers (F)								
F_1: 75% RDF	100.62		150.90		76.40		222.09	
F_2: 100% RDF	104.04		155.99		78.28		223.00	
F_3: 125% RDF	104.07		157.82		81.34		219.32	
F_4: 150% RDF	106.40		163.17		82.76		233.55	
S.Em.±	1.96		6.06		2.06		6.59	
CD at 5%	NS		NS		NS		NS	
Bio-Fertilizers (B)								
B_1: Without	102.25		156.27		79.11		224.97	
B_2: With Bio-fertilizer	105.32		157.67		80.28		224.01	
S.Em.±	1.39		2.87		1.46		4.66	
CD at 5%	NS		NS		NS		NS	
	S.Em.±	**CD at 5%**	**S.Em.±**	**CD at 5%**	**S.Em.±**	**CD at 5%**	**S.Em.±**	**CD at 5%**
M x F	2.78	NS	5.742	NS	4.429	NS	13.854	NS
M x B	1.96	NS	4.060	NS	2.067	NS	6.599	NS
F x B	2.78	NS	5.742	16.16	2.923	NS	9.332	NS
M x F x B	3.93	NS	8.120	NS	4.134	NS	13.198	NS
CV (%)	11.35		15.52		15.66		17.64	

Table 2: Organic Carbon (%) in soil after harvest of sugarcane as influenced by different INM treatments

Treatments	Year					
	2021-22		**2022-23**		**2023-24**	
Manure (M)						
M1- 25 t FYM/ha	0.56		**0.77**		0.54	
M2- 15 t Bio C/ha	0.54		0.72		0.50	
S.Em±	0.015		0.015		0.016	
CD at 5%	NS		0.043		NS	
Fertilizers (F)						
F1- 75% RDF	0.55		0.73		0.54	
F2- 100% RDF	0.60		0.76		0.55	
F3- 125% RDF	0.52		0.75		0.50	
F4- 150% RDF	0.53		0.73		0.50	
S.Em.±	0.021		0.021		0.022	
CD at 5%	NS		NS		NS	
Bio-Fertilizers (B)						
B1- Without	0.57		0.73		0.54	
B2- With Bio-Fert	0.53		0.71		0.51	
S.Em.±	0.015		0.015		0.016	
CD at 5%	NS		NS		NS	
	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
M*F	0.030	0.08	0.030	NS	0.032	NS
M*B	0.021	NS	0.021	NS	0.022	NS
F*B	0.030	NS	0.030	NS	0.032	NS
M*F*B	0.043	NS	0.042	NS	0.045	NS
CV%	13.43		9.88		14.92	
Initial	0.60		0.72		0.60	





Graph 1: Bulk Density (Mg/m^3) in soil after harvest of sugarcane as influenced by different INM treatments

4. Conclusion

Based on pooled results of three year of experiment on "Effect of nutrient management on sugarcane planted through single eye budded settling" indicate that application of manure, fertilizer and bio fertilizer did not produce any significant effect in cane yield, available N, P and K status of soil and soil properties and uptake of major nutrients of sugarcane were not showed any significant effect due to different nutrient management practices. Application of FYM @ 25 t/ha or bio compost 15 t/ha and application of fertilizer @188-94-94 kg N-P_2O_5-K_2O/ha with bio fertilizer (*Acetobacter* +PSB+KMB applied two times as basal and before final earthing up @ 2.5 l/ha each both time) were found superior for saving of 25% fertilizer dose.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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