Influence of Integrated Nutrient Management on Growth and Quality of Pre-seasonal Ratoon Sugarcane in Vertisol

Abstract

A study was conducted in an ongoing field experiment started during 2007-08 at Central Sugarcane Research Station, Padegaon, Maharashtra during 2012-13 and 2013-14 to study the effect of integrated nutrient management on yield and quality of pre-seasonal ratoon sugarcane (cv. CO-86032). The experiment consisted of eight integrated nutrient management (INM) treatments *viz.*, 100 % of RD through organics (T_1), 100 % NPK through inorganic (T_2), Fertilizer as per soil test, FYM and biofertilizers (T_3), 75 % of RD through organics + 25 % of RD through inorganics (T_4), 50 % of RD through organics and 50 % of RD through inorganics (T_5), 25 % of RD through organics + 75 % of RD through inorganics (T_6), rishi-krishi tantra (T_7) and jivamrut (T_8) were laid down in randomized block design with replicated thrice. The results indicated that the number of millable canes, cane, top and sugar yields were recorded maximum (91.64, 132.09, 14.90 and 18.81 t ha^{-1} during I^{st} ratoon 2012-13 and 83.82, 124.69, 13.98 and 18.41 t ha^{-1} during II^{nd} ratoon 2013-14, respectively) under the application of 25 % RD through organics and 75% RD through inorganic treatment (T_6) and remained statistically at par with T_3 (Fertilizer as per soil test, FYM @ 25 t ha^{-1} and biofertilizers as seed treatment @ 5 kg ha^{-1}). The maximum value of reducing sugar 0.565 and 0.552% during I^{st} ratoon (2012-13) and II^{nd} ratoon (2013-14), respectively was observed under treatment T_2 (100 % NPK through inorganic).

Keywords: - Integrated nutrient management, pre-seasonal, ratoon, treatments, cane and sugar.

1. Introduction

Sugarcane (*Saccharum officinarum* L.), crop is able to regenerate shoots more than one from a single planting due to its perennial nature. After the mature crop is removed at ground level for harvest, buds on the remaining subterranean section of the stem re-germinate and produce a new crop, known as a "ratoon crop." Typically, a crop's first harvest after planting is referred to as the plant crop, and each subsequent harvest is referred to as the "first ratoon," "second ratoon" and so on. Ratoons may be grown for around 25% to 30% less money [25] since they don't require new seed or special soil preparation, and they require less irrigation and crop upkeep due to shorter crop cycles. Ratoon crops in Maharashtra, India were 45% less expensive and had a net return that was twice as high as that of plant crops. Raising multiple ratoons, ranging in number from 4-6, is fairly prevalent in India, Cuba, Philippines and Egypt [15], [11]. Typically, Mauritius raises 5-8 ratoon harvests from a single planting [16]. In Taiwan, up to 6-8 consecutive ratoons are bred [21]. However, the average field output of the ratoons in different parts of the world only varies from 22 to 57% compared to the experimental maximum [18].

Next to cotton, sugarcane is one of the most important commercial crops for the industrial sector. With 35 million farmers farming 51.44 lakh acres of land and producing 3593.33 lakh tonnes of cane annually, India is the second-largest producer of sugarcane in the world. Sugarcane takes up 2.2% of the total planted area in India. The productivity is 69.90 t ha^{-1} with a recovery of 10.37% sugar and Maharashtra produces 915.38 lakh tonnes of sugarcane annually on an area of 9.87 lakh ha. The recovery of sugar is 11.30% and the productivity is 78.10 t ha^{-1} [3,4]. According to projections, the country would need 625 MT of sugar by the year 2025, hence sugarcane yield must be increased and maintained at that level [25]. In order to optimise input utilisation, enhance output, and sustain it without compromising crop quality or soil health, integrated nutrient management (INM) uses a combination of organic manures, mineral fertilisers and industrial agricultural wastes in a complementary manner. It makes it possible to profitably use trash or underutilised renewable resources.

In addition to promoting greater sugarcane growth, the use of organic fertiliser in conjunction with chemical fertilisers lowers cultivation costs, reliance on chemical fertilisers, environmental contamination, and deterioration of soil health. The usage of both chemical and organic fertilisers together has been found to be particularly advantageous for the sustainability of sugarcane and sugar production.

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Increased soil fertility and cane output were the results of integrating organic and inorganic fertiliser sources [5].

Soil quality encompasses all of the physical, chemical and biological characteristics of the soil and controls the dynamics of nutrient and moisture availability as well as rooting behaviour, soil quality is most significance for the production of long-duration, nutrient-exhaustive sugarcane. Since ancient times, several organic materials have been employed as nutrient sources, including farmyard manure, oil cakes, pressmud cake, vermicompost, green manure, legume as intercrops and sugarcane trash. Supplementing sugarcane's nutritional needs with organic sources of nutrients also helps to maintain a healthy soil's physical, chemical, and biological conditions. This will aid in the efficient disposal of locally accessible bio-resources as well as their utilisation as sources of fertilisers for crop production. Chemical fertilisers, organic manures or bio-fertilizers cannot supply all of the plant nutrients needed by a crop in intensive agriculture. Vermicompost is an organic fertiliser created by the microbial composting of organic wastes using earthworm activity. It has a greater amount of organic matter, organic carbon, total and readily accessible N, P and K, as well as micronutrients, microbial activity and enzyme activity [14].

Many people think of organic farming as a type of agriculture that uses exclusively organic inputs for nutrition delivery and disease and insect management. In actuality, it is a specialised type of diversified agriculture in which agricultural issues are only resolved with the aid of regional resources. The word "organic" alludes to the idea of a farm as an organism rather than the specific sort of inputs that are employed. Organic farming has frequently come under fire for the claim that using just organic inputs may not increase agricultural production and profitability due to the limitations of organic sources [2]. Organic farming reduces yield in intensive agricultural systems; the amount depends on the degree of external input utilised prior to conversion [24]. Organic sugarcane farmers in Maharashtra frequently apply the elements of the rishi-krishi tantra and jivamrut.

Vertisols make up a significant portion of India's geography, accounting for 22.2% of its total area. They are primarily found in the country's central region. A significant majority of the clays in these soils are swelling smectite clays [28]. They need to be managed carefully in order to maximise their potential and prevent soil quality loss. To create and execute farming strategies that will maintain these soils productive for the present and future generations, it is essential to understand the condition of these soils. Information on how integrated nutrient management strategies for sugarcane under heavy cropping in irrigated soils have changed the quality of the soil. Hence an investigation was planned to study the long-term use of integrated nutrient management on yield and quality of pre-seasonal sugarcane.

2. Materials and Methods

A field experiment was initiated during 2006-07 at Central Sugarcane Research Station, Padegaon, Maharashtra on pre-seasonal sugarcane (cv. CO-86032) as plant cane followed by succeeding four ratoons during the year 2007-08 to 2010-11 in the first cycle. The experiment was conducted on same site with same treatment randomization as plant cane during 2011-12 followed by succeeding two ratoons during 2012-13 and 2013-14. The Central Sugarcane Research Station, Padegaon is located in scarcity zone of Maharashtra, geographically at an elevation of 556 m above mean sea level on 18^{o} 12" N latitude and 74^{o} 10" E longitude. The soils of the experimental site classified as *Typic Haplustert* (Vertisol) belongs to bumne soil series. The experiment soil was low in available nitrogen (198 kg ha^{-1}), very high in phosphorus (32 kg ha^{-1}) and high in potassium (354 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 8.30) and high organic carbon content (0.72%). The experiment consisted of eight integrated nutrient management (INM) treatments *viz.*, 100 % of RD through organics (T_1), 100 % NPK through inorganic (T_2), Fertilizer as per soil test, FYM and biofertilizers (T_3), 75 % of RD through organics + 25 % of RD through inorganics (T_4), 50 % of RD through organics and 50 % of RD through inorganics (T_5), 25 % of RD through organics + 75 % of RD through inorganics (T_6), rishi-krishi tantra (T_7) and jivamrut (T_8) were laid down in randomized block design with replicated thrice. The organic materials included press mud, farmyard manure (FYM), vermicompost and green manure (GM) of Sunhemp (*Crotalaria juncea*); the fertilizers were Urea, single superphosphate, suphala, muriate of potash, ferrous sulphate and zinc sulphate. Composite culture of biofertilizers i.e., *Azotobactor, Acetobactor, Azospirillum* and *PSB* @

1.25 kg each were added in respective treatment. Cane samples were taken at the time of harvest and cane juice quality parameters were analysed on AUTO-POL analyser. Sugar yield [9] was calculated as-
sugar yield (t ha^{-1}) = [S – 0.4 (B-S) x 0.73] x cane yield (t/ha)/100
where S and B are sucrose and brix percent in cane juice, respectively.

Brix was analysed by brix hydrometer [22], pol analysed by poloriscope [10], reducing sugar calculated by volumetry method [10], sucrose and commercial cane sugar was determined using procedure outlined by [22].

The results were interpreted on the basis of F-test and critical difference at 5% was used for calculating the significant difference between the means of two treatments [13].

3. Results and discussions

3.1 Yield and yield attributes

The perusal of data (Table 1) revealed that the number of millable canes, cane, top and suger yields (t ha^{-1}) were significantly influenced by different nutrient management treatments in both the ratoons. The number of millable canes, cane, top and suger yield (t ha^{-1}) were recorded maximum 91.64, 132.09, 14.90 and 18.81 t ha^{-1}, respectively during I^{st} ratoon (2012-13) and 83.82, 124.69, 13.98 and 18.41 t ha^{-1}, respectively during II^{nd} ratoon (2013-14) under treatment T_6 (25 % of RD through organics + 75 % of RD through inorganics) and remained statistically at par with T_3 (Fertilizer as per soil test, FYM @ 25 t ha^{-1} and biofertilizers as seed treatment @ 5 kg ha^{-1}). Application of organic nutrient combination with inorganic sources accelerated yield attributing characters i.e., number of millable canes resulting higher cane yield. The application of organics released nutrient through decomposition and mineralization that would have increased the availability of plant nutrients at later stage and brought improvement in physical, chemical and biological properties of soil [27]. The immediate and quick supply of nutrients through inorganic fertilizer and steady supply of plant nutrients by organics throughout the growth period of the crop resulted in higher cane yield. Further, number of tillers were converted into NMC with significantly more cane weight which led to higher cane yield [26], [6]. The integrated use of organic and inorganic fertilizers with biofertilizers increased the availability of nutrients which resulted in higher number of millable canes, height and girth which ultimately reflected on increase in yield of cane. The similar results were also reported by [17], [20]. It was clearly indicated that nutrients applied through inorganic, organic, biofertilizers and green manuring showed balance nutrient supply improved, physical, chemical as well as biological properties of soil resulted in higher cane yield and sugar yield. Similar results are in conformity with [19], [12], [8].

3.2 Quality of sugarcane juice

Data presented in Table 2 revealed that the brix during II^{nd} ratoon (2013-14), pol, purity, commercial cane sugar and sucrose content in juice were not significantly affected by different integrated nutrient management treatments during both the ratoons. The highest value (22.24^0) of brix was recorded under treatment T_6 (25 % of RD through organics + 75 % of RD through inorganics) during I^{st} ratoon (2012-13) and remained statistically at par with T_3 (Fertilizer as per soil test, FYM @ 25 t ha^{-1} and biofertilizers as seed treatment @ 5 kg ha^{-1}) and T_2 (100 % NPK through inorganic). The maximum value of reducing sugar 0.565 and 0.552%, respectively during I^{st} ratoon (2012-13) and II^{nd} ratoon (2013-14) was observed under treatment T_2 (100 % NPK through inorganic) which was remained statistically at par with T_3 (Fertilizer as per soil test, FYM @ 25 t ha^{-1} and biofertilizers as seed treatment @ 5 kg ha^{-1}). Application of organic manure together with inorganic fertilizer, compared to addition of either organic manure or inorganic fertilizer alone had higher positive effect on quality of sugarcane [23], [5]. The combination of organic nutrient source was found beneficial in improving cane juice and sugar recovery. Sugar yield followed the similar trend of yield of sugarcane. Sugar yield is function of cane yield, juice quality and juice recovery. Higher cane yield and juice recovery due to application of nutrients from organic and inorganic sources resulted in high sugar yield. Similar findings were also reported by [26], [7]

4. Conclusion

Sugarcane yield increased significantly with integration of organic and inorganic nutrient sources and combinations of FYM and along with biofertilizers was more effective for sustainable sugarcane production and quality of juice. However, it may be concluded that integrated use of organic and

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inorganic fertilizer not only sustained sugarcane yield but also improve juice quality. Nutrient combination supplying through 25 % of RD through organics + 75 % of RD through inorganics meet the demand of N for obtaining higher cane and sugar yield besides improvement in quality of juice in Vertisol.

5. References

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Table 1. Effect of integrated nutrient management on number of millable canes, cane, top and sugar yields of pre-seasonal ratoon sugarcane at harvest

Treatments	I[st] ratoon (2012-13)				II[nd] ratoon (2013-14)			
	Number of millable canes (t ha^{-1})	Yield (t ha^{-1})			Number of millable canes (t ha^{-1})	Yield (t ha^{-1})		
		Cane	Top	Sugar		Cane	Top	Sugar
T_1	73.53	95.05	10.14	13.05	67.27	89.83	9.56	12.78
T_2	84.16	119.37	12.37	16.88	76.95	112.71	11.69	16.52
T_3	87.01	130.05	14.19	17.60	79.55	121.14	13.32	17.24
T_4	75.43	107.66	12.93	14.77	69.00	101.67	12.22	14.46
T_5	75.78	113.23	11.63	15.25	69.30	106.91	10.93	14.92
T_6	91.64	132.09	14.90	18.81	83.82	124.69	13.98	18.41
T_7	64.84	83.67	8.08	11.53	59.29	79.01	7.64	11.28
T_8	67.25	82.56	8.81	11.36	61.51	77.96	8.32	11.12
SEm$\pm$	3.89	3.78	1.00	0.637	3.55	3.89	0.90	0.623
CD (p=0.05)	11.79	11.47	3.02	1.93	10.78	11.81	2.73	1.89

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Table 2. Effect of integrated nutrient management on quality of pre-seasonal ratoon sugarcane juice at harvest

Treatments	Juice quality parameters											
	I[st] ratoon (2012-13)			II[nd] ratoon (2013-14)			I[st] ratoon (2012-13)			II[nd] ratoon (2013-14)		
	$Brix^0$	Pol (%)	Purity (%)	$Brix^0$	Pol (%)	Purity (%)	commercial cane sugar (%)	Sucrose (%)	Reducing Sugar (%)	commercial cane sugar (%)	Sucrose (%)	Reducing Sugar (%)
T_1	21.02	20.08	96.96	20.90	20.86	96.87	13.74	20.38	0.390	14.30	20.24	0.370
T_2	21.89	20.64	95.54	21.72	21.40	95.51	14.14	20.91	0.565	14.69	20.75	0.552
T_3	22.01	19.78	96.13	21.77	20.74	96.04	13.52	21.16	0.558	14.21	20.88	0.526
T_4	21.25	20.06	96.91	21.24	20.75	96.46	13.72	20.59	0.456	14.22	20.49	0.434
T_5	21.56	19.69	96.50	21.47	20.41	96.46	13.46	20.80	0.359	13.98	20.71	0.327
T_6	22.24	20.81	95.56	22.07	21.58	95.47	14.26	21.26	0.465	14.82	21.07	0.462
T_7	21.23	20.15	95.93	21.11	20.93	95.89	13.79	20.36	0.295	14.35	20.24	0.283
T_8	21.47	20.11	94.59	21.22	20.86	94.52	13.76	20.29	0.243	14.30	20.05	0.225
SEm$\pm$	0.24	0.574	0.765	0.349	1.014	1.12	3.89	0.168	0.004	0.73	0.236	0.006
CD (p=0.05)	0.74	NS	NS	NS	NS	NS	NS	NS	0.011	NS	NS	0.019

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