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Integrated application of organic, inorganic and biological fertilizers for enhancing sugarcane productivity and improving soil health in plant Ratoon cycle

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Abstract

A Field experiment that consisted with organic, inorganic fertilizers at different doses and biofertilizer was laid out in randomized block design with three replications. The soil of experimental site was deep black clay in texture, medium in available nitrogen and phosphorus and high in available potash. Application of FYM @ 10 t ha^{-1} with biofertilizer (*Acetobacter* + PSB) and inorganic fertilizer (NPK application) applied on soil test basis significantly improved growth parameters (germination and tiller population) and yield attributes (number of millable canes, cane length, single cane weight) over sole application of inorganic fertilizer applied at 50 % recommended dose of fertilizer in plant-ratoon cycle. The cane yield increased to the tune of 21.91 % over inorganic nutrients applied at 50 % recommended dose of fertilizer. The net return (Rs. 298938 ha^{-1}) and B/C ratio (3.50) was the highest in application of FYM @ 10 t ha^{-1} with biofertilizer (*Acetobacter* + PSB) and inorganic fertilizer (NPK application) applied on soil test basis over sole application of inorganic fertilizer applied at 50 % recommended dose of fertilizer. Furthermore, it was found most beneficial with slightly higher maintenance of available nitrogen and lower bulk density. Thus it may be concluded that integrated application of organic and inorganic sources of nutrition would help to sustain the sugarcane productivity and improved soil health under south Gujarat condition

Keywords: Growth, yield, soil health, b/c ratio, net return, sugarcane

Introduction

Sugarcane is known to be one of the oldest cultivated plants in the world and grown commercially in the tropics and subtropics. It is a long duration and heavy feeder of nutrients. Owing to increased cost of cultivation and declining factor productivity of monetary inputs such as fertilizers and plant protection chemicals, profitability of sugarcane cultivation has drastically declined. Imbalance use of fertilizers results in poor yields, deterioration of soil fertility and emergence of nutrients deficiencies. Continuous application of heavy doses of fertilizers and plant protection chemicals probably impair the soil microbial activity leading to poor soil health reported by Singh *et al*. (2007) [6]. Therefore there is need to adopt organic based resources which supply nutrients to plants and may enrich soil organic carbon. Therefore, maintenance of adequate soil organic carbon is of great importance. At present, sustainability of the crop and soil productivity is burning issue, the integrated use of organics and inorganics needs to be emphasized to use nutrients and energy more efficiently than conventional practice as reported by Mader *et al.* (2002) [5]. Integrated application of FYM, biofertilizers, trash incorporation with inorganic fertilizers gave better economic output; improve soil health and higher microbial activity in sugarcane plant-ratoon system Tyagi *et al*. (2011) [10]. Biofertilizers are fixing N or mobilizing P and others nutrients are becoming an integral component of integrated nutrient management. It has been also reported that biofertilizers application led to a saving of nearly 25 % chemical fertilizers for sugarcane crop Muthukumarasamy *et al.* (1994) [4]. Hence, the present investigation was carried to develop nutrient management strategy for sustaining soil health and sugarcane production in plant-ratoon cycle.

Materials and Methods

Field experiments were conducted at the Main Sugarcane Research Station, Navsari Agricultural University, Navsari Gujarat during the years 2014-15 to 2016-17. The soil of experimental field was deep black clayey with pH 7.86, organic carbon 0.55 %, medium in available nitrogen and available phosphorus and high in available potash.

The experiment was conducted in randomized block design with three replications and nine treatments to plant and ratoon crops of sugarcane. The treatment details for plant- ratoon system are given below:

Treatments	Sugarcane (plant crop)	Ratoon-I	Ratoon- II
T_1	No organic + 50% RDF	Application of trash at 10 t ha^{-1} + 50% RDF	Application of trash at 10 t ha^{-1} + 50% RDF
T_2	No organic + 100% RDF	Application of trash at 10 t ha^{-1} + 100% RDF	Application of trash at 10 t ha^{-1} + 100% RDF
T_3	No organic + soil test based recommendation	Application of trash at 10 t ha^{-1} + soil test basis (NPK application)	Application of trash at 10 t ha^{-1} + soil test basis (NPK application)
T_4	Application of FYM @ 20 t ha^{-1} + 50% RDF (inorganic source)	Application of FYM @ 20 t ha^{-1} + 50% RDF (inorganic source)	Application of FYM @ 20 t ha^{-1} + 50% RDF (inorganic source)
T_5	Application of FYM @ 20 t ha^{-1} + 100% RDF (inorganic source)	Application of FYM @ 20 t ha^{-1} + 100% RDF (inorganic source)	Application of FYM @ 20 t ha^{-1} + 100% RDF (inorganic source)
T_6	Application of FYM @ 20 t ha^{-1} + inorganic nutrient application based on soil test (rating chart)	Application of FYM @ 20 t ha^{-1} + inorganic nutrient application based on soil test (NPK application)	Application of FYM @ 20 t ha^{-1} + inorganic nutrient application based on soil test (NPK application)
T_7	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 50% RDF	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 50% RDF	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 50% RDF
T_8	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 100% RDF	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 100% RDF	Application of FYM@ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + 100% RDF
T_9	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis (NPK application)	Application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis (NPK application)

(Recommended dose of fertilizer for plant crop: 250-125-125 kg NPK ha^{-1} and for ratoon crop: 300-62.5-125 kg NPK ha^{-1}).

The required quantities of farm yard manure were applied as per treatment, biofertilizer applied @ 5 lit ha^{-1} to plant and ratoon crop. Recommended dose of fertilizers N(RDFN) as per the treatment were applied in four splits *viz.*, 15 as basal, 30 % at 1.5 to 2 month after planting, 20 % at 3 to 3.5 month after planting and 35 % at final earthing up. Full dose of P and K was applied as basal to plant and both ratoon crop. Sugarcane CoN 05071 was planted in autumn season every year at row spacing of 90 cm using 50,000 setts ha^{-1} (2 eye bud setts). The other cultural operation and irrigations were given as common practices as per the recommendation for the sugarcane. The plant crop was harvested in January/February and treatments for ratoon crop were imposed, second ratoon crop was harvested in February.

Results and Discussion

The data presented in table 1 indicated that numbers of tillers were significantly affected due to different treatments in plant ratoon system. Germination % was recorded significantly highest with treatment T_9 over T_1 at both the stages. Significantly highest numbers of tillers were recorded with application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis (T_9) over sole application of inorganic fertilizer applied at 50 % RDF however it remained at par with T_6. Bokhtiar and Sakurai (2005) also reported that application of organic manure with chemical fertilizer increased tillers population in plant ratoon crop. Further, application of 100% RDF (250: 75: 190 kg N: P_2O_5: K_2O) along with FYM @ 25 t ha^{-1}, micronutrients @ 25 kg each of ZnSO4 and FeSO4 and biofertilizers (*Azospirillium* and PSB @ 10 kg ha^{-1} each) recorded highest number of tillers reported by Shridevi *et al.* 2016 [9].

The pooled data revealed that in plant-ratoon cycle, the highest number of millable canes (NMC) (105.87 000 ha^{-1}) were obtained with treatment T_9 and remained at par with T_6. This might be due to immediate and quick supply of plant nutrient through chemicals and steady supply of plant nutrients by organics throughout the growth period. Tyagi *et al.* (2011) [10] also reported that integrated application of inorganic fertilizer along with FYM and biofertilizer in plant where as in subsequent ratoon inorganic along with trash incorporation and biofertilizer improved NMC. Virdia and Patel (2010) [11] and Singh and Srivastava (2011) [7] also reported almost similar results.

The pooled data on cane yield indicated that, application of FYM @ 10 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis NPK application (T_9) recorded significantly higher cane and commercial cane sugar (CCS) yields (125.00 and 16.60 t ha^{-1}); statistically similar cane and CCS yields (117.13 and 16.58 t ha^{-1}) were recorded under the nutrient supply system of application of FYM @ 20 t ha^{-1} + inorganic nutrient application based on soil test (T_6). This enhanced cane yield in above treatments were mainly attributed to increased yield attributes *viz*, NMC and single cane weight. Singh *et al.* (2011) [7, 8, 10] reported that integrated use of organic, inorganic biological sources increased cane yield over inorganic source alone. It clearly indicates the importance of supplementing organic sources with inorganic sources application and it thus proves it's worthy to apply in sugarcane growing for better results. Singh and Srivastava (2011) [7] revealed that integrated use of organics and fertilizers up to 75 % substitution, recorded the highest cane yield in plant ratoon crop. While, the lowest cane yield was observed in 50 % RDF with no organics. Similarly, Bhalerao *et al.* (2006) [2] reported that adoption of either organic or inorganic nutrients alone registered comparatively lesser yields. As evident integrated nutrient management (INM) involving organic resources and chemical fertilizers substantially enhanced the cane yield over the systems totally based on chemical fertilizer or organics. This may be attributed to the balanced availability of nutrients over a longer duration under integrated system as compared to that with solely chemical or organic based fertilizer systems. Yadav and Prasad (1992) [12] also reported almost similar results. Soil properties *viz.*, organic carbon and available N, P, K after harvest crop were not significantly influenced due to integrated application of organics and inorganic while with respect to soil BD T_9 showed superior physical health as compared to other treatments (Table 3).

In plant as well as ratoon sugarcane crop, various juice quality parameters were not significantly influenced due to application of organics and inorganics nutrients. Similar results reported by Babu *et al.* (2007) [3]. Looking to the economics, application of FYM @ 25 t ha^{-1} + biofertilizer (*Acetobacter* + PSB) + soil test basis fertilizer (T_9) obtained highest net return 298938/- with BCR 3.50 followed by treatment T_6 269501/- with BCR 3.20.

Conclusion

It may therefore concluded that supply of nutrients in sugarcane plant ratoon system through integrated use of organic manure along with bio fertilizers and inorganic fertilizer based on soil test were found beneficial for sugarcane plant and ratoon cycle and it would not only help us to minimize the expenditure on costly inorganic fertilizers but sustaining soil health and enhancing the productivity and profitability of sugarcane.

Table 1: Growth and yield parameters of sugarcane as influenced by different organic and inorganic treatments (pooled data)

Treatment	Germination % at DAP		No. of tillers (000 ha^{-1}) at DAP/DARI		Number of Millable cane at harvest (000 ha^{-1})	Single cane weight (kg)	Cane yield (t ha^{-1})	CCS yield (t ha^{-1})
	30	45	120	150				
T_1	44.39	47.92	127.00	131.83	84.25	1.10	97.61	13.20
T_2	48.81	51.48	129.80	134.81	93.34	1.29	106.36	14.44
T_3	48.62	50.90	152.35	154.36	94.54	1.28	101.53	13.77
T_4	46.66	55.30	138.91	144.42	93.65	1.30	107.50	14.28
T_5	47.19	52.28	128.84	133.83	93.18	1.42	109.14	14.82
T_6	47.84	60.15	156.33	161.03	101.11	1.47	117.13	16.58
T_7	47.69	49.68	138.11	143.28	95.53	1.36	109.47	14.92
T_8	48.58	53.58	131.69	137.05	93.94	1.28	112.31	14.78
T_9	54.34	63.99	169.13	176.80	105.87	1.66	125.00	16.60
SEm±	3.24	3.09	4.56	4.28	2.40	0.06	2.79	0.38
CD (0.05)	9.72	9.27	12.88	12.10	6.78	0.18	7.88	1.08

DAP-Days after planting, DARI- Days after ratoon initiation

Table 2: Juice quality parameters of sugarcane as influenced by different organic and inorganic treatments

Treatment	At 12 month					
	Brix	CCS %	Pol % juice	Purity %	Pol % cane	Fibre %
T_1	21.53	13.48	19.34	89.82	14.73	13.85
T_2	21.88	13.55	19.44	88.89	14.76	14.08
T_3	21.90	13.55	19.62	89.73	14.86	14.26
T_4	21.45	13.37	19.10	89.00	14.47	14.19
T_5	21.85	13.55	19.57	89.61	14.82	14.27
T_6	22.44	14.15	20.14	89.77	15.28	14.13
T_7	21.86	13.62	19.67	90.02	14.92	14.16
T_8	21.09	13.19	18.87	89.50	14.29	14.27
T_9	21.47	13.27	19.21	89.48	14.56	14.22
SEm±	0.37	0.27	0.33	0.47	0.25	0.12
CD (0.05)	NS	NS	NS	NS	NS	NS

Table 3: Soil properties after harvest of crop as influenced by different organic and inorganic treatments

Treatment	OC%	BD (g cc^{-1})	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1	0.69	1.68	272.67	156.67	643.56
T_2	0.66	1.68	291.78	162.22	612.22
T_3	0.67	1.67	198.89	141.89	616.44
T_4	0.78	1.67	244.11	149.33	660.56
T_5	0.81	1.65	224.22	135.33	652.33
T_6	0.82	1.63	295.11	117.78	553.67
T_7	0.71	1.63	246.56	131.44	577.89
T_8	0.78	1.63	221.33	142.44	612.89
T_9	0.70	1.62	217.44	151.33	595.78
SEm±	0.06	0.01	34.39	13.54	28.72
CD (0.05)	NS	0.03	NS	NS	NS
Initial	0.49	1.22	359	23.11	358

Table 4: Effect of different treatments on gross returns, variable cost, net returns and B: C ratio of sugarcane (pooled)

Treatments	Cane yield (t ha^{-1})	Gross returns (ha^{-1})	Cost of cultivation (ha^{-1})	Net returns (ha^{-1})	B: C ratio
T_1	97.61	326701	108619	218093	3.01
T_2	106.36	355987	121325	234662	2.93
T_3	101.53	339821	113661	226149	2.99
T_4	107.50	359803	117502	242301	3.06
T_5	109.14	365292	130175	235105	2.81
T_6	117.12	392001	122511	269501	3.20
T_7	109.47	366396	114383	252002	3.20
T_8	112.30	375868	127057	248822	2.96
T_9	124.99	418342	119392	298938	3.50

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