



Integrated nutrient management for sugarcane (*Saccharum* spp. hybrid complex) plant-ratoon system

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Received: July, 2008

ABSTRACT

A field experiment was conducted at Navsari during 2002-2006 to study the influence of integrated nutrient management (INM) for sustained sugarcane plant-ratoon production system. Integrated use of various organics (FYM, pressmud, vermicompost and biofertilizers) with recommended dose of NPK fertilizers (RDF) to sugarcane plant crop followed by trash incorporation and green manuring with NPK and bio-fertilizers to ratoon sugarcane was studied. The results revealed that integrated use of FYM @25% of recommended dose of N (RDN) with RDF (250-125-125 kg N-P-K/ha) and biofertilizer (*Azotobacter* and phosphate solubilizing bacteria (PSB) to plant crop followed by 10 t/ha trash incorporation with bio-fertilizer inoculation + RDF (300-6.25-125 kg N-P-K/ha) application increased cane (13.3 to 30.6 t/ha) and commercial cane sugar (0.5 to 1.6 tonne/ha) yield. However, the magnitude of variation in cane yield was marginal when total N was applied through fertilizer alone. Hence, it was possible to save 25% N when organics was applied along with bio-fertilizers *Azotobacter* + PSB.

Key words: Commercial farming, Organics, Sugarcane

Sugarcane (*Saccharum* sp.) is an important commercial crop in semitropical India and contributes about 22% to 21% to cane area and production at global level. In Gujarat, intensive sugarcane cultivation is confined to the South Gujarat, covering 85% of total area of sugarcane in the state (i.e. about 0.2 m. ha). Lack of proper soil management decreased the average yield of sugarcane from 90 tonne/ha in 1990-91 to 71.99 tonne/ha in 2007-08. The productivity of sugarcane in the state has been badly affected during the last decade due to insufficient use of soil organic matter and imbalance in use of chemical fertilizer. Soil health seems to be deteriorated on physical, chemical and biological fronts. The formations of hardpan and soil salinity are indicators of soil deterioration.

The use of only either of organic manure or chemical fertilizers is not only un-feasible due to their limited availability and higher input cost but also not advantageous for sustainable crop production. The long-term experiments conducted on manures and fertilizers in sugarcane proved that neither the chemical fertilizer alone nor the organic source exclusively can achieve production sustainability of soil and crop (Singh and Biswas, 2000). Further, the price of inputs mainly inorganic fertilizers is increasing day by day, therefore emphasis is needed to maximize the nutrient use efficiency while minimizing the cost of production.

The efficiency of nutrient use may be raised by the conjunctive use of bio manures and inorganic fertilizers. Integration of organic resources such as vermicompost, farmyard manure and biofertilizers like *Azotobacter* and phosphate solubilizing bacteria (PSB) may also help in the restoration of soil health (Gaur and Singh, 1982). It was in this context that the effect of integration of organic, inorganic and biological sources of nutrients on sugarcane was studied.

MATERIALS AND METHODS

Field experiments were conducted at Regional Sugarcane Research Station, Navsari Agricultural University, Navsari, Gujarat during the year 2002 to 2006. The soil of the experimental field was deep black clayey with 1.66 g/cc bulk density, medium in organic carbon (0.50%), available N (248 kg/ha) and P(38.6 kg/ha) and high in available K (302 kg/ha), with 7.42 pH and 0.28 dS/m EC.

The experiment was conducted in randomized block design with three replications and ten treatments to plant and ratoon crops of sugarcane. The treatments to sugarcane plant crop viz., T₁, 250-125-125 kg N-P-K/ha (recommended dose of NPK fertilizer, RDF); T₂, 75% RDF + 25% RDN i.e. 62.5 kg/ha through farmyard manure (FYM); T₃, 75% RDF + 25% RDN through pressmud; T₄, RDF; T₅, 75% RDF + 25% RDN through FYM + biofertilizers (*Azotobacter* and phosphorus solubilizing

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bacteria, PSB); T₆, 75% RDF + 25% RDN through pressmud + biofertilizers; T₇, 50% RDF + 25% RDN through farmyard manure + biofertilizers; T₈, 50% RDF + 25% RDN through pressmud + biofertilizers; T₉, 50% RDF + 25% RDN through vermicompost + biofertilizers; T₁₀, RDF + 25% RDN through farmyard manure + biofertilizers. After harvest of the sugarcane plant crop sugarcane ratoon was taken without disturbing the plots of plant crop and treatments given as sequence. The treatment to sugarcane ratoon crop viz., T₁, 300-62.5-125 kg N-P-K/ha (recommended dose of N P K i.e. RDF); T₂, RDF + trash incorporation with cellulolytic culture; T₃, RDF + trash incorporation with cellulolytic culture; T₄, 75% RDF + green manuring (sunhemp); T₅, RDF + trash incorporation with cellulolytic culture + Biofertilizer (*Azotobacter* + PSB); T₆, RDF + trash incorporation with cellulolytic culture + Biofertilizers; T₇, 50% RDF + green manuring + Biofertilizer; T₈, 50% RDF + green manuring + Biofertilizer; T₉, 75% RDF + 25% RDN i.e. 75 kg N/ha through vermicompost + Biofertilizers; T₁₀, RDF + trash in corporation with cellulolytic culture + Biofertilizer. The required quantities of farmyard manure, pressmud and vermicompost were applied before planting as per the treatment and mixed well in the soil in sugarcane plant crop. The bio-fertilizers were applied @ 4 kg/ha to plant and ratoon crop as soil inoculation. Sugarcane trash was incorporated to soil after cutting into small pieces and treating with decomposing culture (1 kg *Trichoderma* decomposing culture + 8 kg urea + 10 kg single super phosphate + 100 kg cow dung/tonne of trash) @ 100 kg /ha was broad cast in inter row spaces of sugarcane after the harvest of plant crop and was incorporated *in situ* at 60 days in 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 both plant and ratoon crop. Sugarcane 'CON 95132' was planted in December every year at a row spacing of 100 cm using 50,000 sets/ha (2 eye bud set). The other operations and irrigations were given as common as per the recommendations for the sugarcane. The plant crop was harvested in next year January and immediately treatments for ratoon crop were imposed, ratoon crop was harvested in next year January/February. Nutrient content in organic manure before application were analyzed on dry weight basis. (FYM: 0.69-0.39-0.69; Pressmud: 0.59-0.74-0.18; Vermicompost: 0.49-0.35-0.55; Sugarcane trash 0.50-0.07-0.46% N-P-K). Soil and plant nutrient concentration after harvest of each plant and ratoon crop analyzed as per standard procedure. Quantity of each organic matter as per treatment were calculated by considering nitrogen per cent of the organic material on dry weight basis. The economics was worked out based on pooled yield data and considering price of input and output of the last year of study.

RESULTS AND DISCUSSION

Yield

Integrated nutrient application had significant impact on number of millable cane (Table 1), cane yield and commercial cane sugar (CCS) yield (Table 2). Among the treatments tested, RDF along with 25% additional dose of N through FYM + bio-fertilizer application to sugarcane plant crop followed by RDF along with trash incorporation and bio-fertilizer application in ratoon crop (T₁₀) produced significantly higher NMC (92.8 x 10³), cane yield

Table 1. Effect of different nutrient management treatments on number of millable cane (x 10³/ha) of plant and ratoon sugarcane crop

Nutrient management treatment		Plant crop			Ratoon crop		
Plant cane	Ratoon cane	2002-03	2003-04	2004-05	2003-04	2004-05	2005-06
T ₁ , RDF	RDF	131.5	83.4	100.2	78.6	73.3	80.4
T ₂ , 75% RDF + 25% N as FYM	RDF + TCCC	116.8	91.9	91.3	88.1	72.6	81.9
T ₃ , 75% RDF + 25% N as Pressmud (PM)	RDF + TCCC	126.2	75.9	92.8	74.6	73.1	77.8
T ₄ , RDF	75% RDF + GM	134.5	95.2	98.6	90.1	69.4	72.1
T ₅ , 75% RDF + 25% N as FYM + Bio-fertilizer (BF)	RDF + TCCC + BF	130.8	85.2	96.0	84.6	77.9	84.9
T ₆ , 75% RDF + 25% N as PM + BF	RDF + TCCC + BF	133.7	86.6	102.3	76.8	75.8	82.2
T ₇ , 50% RDF + 25% N as FYM + BF	50% RDF + GM + BF	123.6	78.7	85.8	70.7	65.6	66.1
T ₈ , 50% RDF + 25% N as PM + BF	50% RDF + GM + BF	124.3	86.0	89.0	67.2	65.4	61.9
T ₉ , 50% RDF + 25% N as Vermicompost (VC) + BF	75% RDF + 25% N as VC + BF	116.8	84.7	87.9	80.1	68.8	77.2
T ₁₀ , 100% RDF + 25% N as FYM + BF	RDF + TCCC + BF	138.1	99.4	105.5	98.6	80.7	99.2
SEm±		8.8	4.4	4.5	5.4	3.7	2.8
CD (P=0.05)		NS	13.0	NS	16.0	NS	8.3

RDF, Recommended dose of NPK fertilizers; FYM, Farmyard manure; TICC, Trash incorporation with cellulolytic culture; GM, Green manure

(92.46 + 69.8 t/ha) and CCS (12.07 + 9.35 t/ha). This might be due to immediate and quick supply of plant nutrient through chemicals for tillers and steady supply of plant nutrients by organics throughout the growth period. The organics released nutrients following 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. As a result of this, the fertility status of the soil might have increased and thus increasing the absorption of plant nutrients. More tillering which converted in to NMC lead to more yield. The results are in agreement with findings of Sharma *et al.* (1999), Rao and Veeranna (1999), Bangar *et al.* (2000) and Nagraju *et al.* (2000). However result of first two individual years were non significant but numerically higher value of growth and yield attributes were reported with INM treatments. In general, considering plant and ratoon crop, treatments receiving RDF with organics and bio-fertilizers (treatment T₁, T₅, T₆ and T₁₀) were reckoned as equally effective for sugarcane growth and yield. Shukla (2007) also opined that optimum nutrient management for sugarcane plant crop plays a key role, as it establishes vigorous stubble, which affects the ratoon yield.

It was also found that when 25% RDN was replaced through organics along with bio-fertilizers (Treatments T₅, T₆ and T₉) produced similar cane yield as that of 100% N either through recommended dose of fertilizer or in combination through organics. This observation indicates 25% saving of chemical fertilizer by using biofertilizers. Sharma *et al.* (1999) also reported that application of bio-fertilizers also effect on growth and yield of cane, as bio-fertilizer are capable of synthesizing growth hormones and/or regulators in addition to the fixation of N. The phytohormones and other growth regulators liberated in the treatment under biofertilizer along with organic manure or green manuring or incorporation of trash might have produced favorable effect on nutrient uptake and resulted in higher cane growth and yield.

Higher CCS yield with INM was due to more cane yield and good quality of juice under this treatment. Thomas and Kuruvilla (2005) also found that more N application reduces juice quality but integration of other micronutrients through organics and bio-fertilizer nullified the ill effect of higher N on quality of juice.

Nutrient uptake and soil fertility

Total nutrient uptake in the cycle (plant+ratoon) presented in Table 2 revealed that Treatment T₁₀ (RDF + 25% RDN through FYM + bio-fertilizer in plant crop and 100% RDF + trash incorporation + bio-fertilizer in ratoon crop) was better than other treatment. The data further

Table 2. Effect of different nutrients integration on cane, commercial cane sugar (CCS) yield (t/ha) and nutrient uptake (kg/ha)

Treatment	Cane yield						Plant + ratoon			CCS yield		Nutrient uptake		
	Plant crop			Ratoon crop			Plant + ratoon			Plant		Ratoon		
	2002-03	2003-04	2004-05	2003-04	2004-05	2005-06	1 st cycle	2 nd cycle	3 rd cycle	Crop	Crop	N	P	K
T ₁	98.4	76.1	87.2	61.9	64.8	63.8	160.4	140.9	151.5	11.5	8.4	194	56	218
T ₂	89.1	73.6	81.2	63.4	64.3	64.4	152.6	137.9	146.8	10.8	8.6	185	54	205
T ₃	89.4	72.5	79.0	63.3	62.3	62.6	152.7	134.8	141.2	10.7	8.4	163	47	180
T ₄	97.5	79.0	87.0	58.6	60.0	57.2	156.1	139.0	144.7	11.2	7.7	185	53	203
T ₅	90.0	75.9	84.5	63.4	67.6	65.1	153.4	143.6	152.5	10.9	8.7	187	56	210
T ₆	91.8	77.2	89.0	62.7	67.9	64.0	154.1	145.1	154.8	11.2	8.1	185	54	208
T ₇	81.9	75.6	76.2	58.4	55.6	52.0	140.4	131.3	129.1	10.0	7.8	138	39	157
T ₈	90.1	76.8	73.3	60.2	55.0	49.4	150.4	133.8	122.9	10.1	7.8	130	38	143
T ₉	83.9	73.6	78.8	62.6	60.5	63.4	146.5	134.1	140.6	10.2	8.3	171	47	183
T ₁₀	102.9	81.8	92.3	66.5	79.8	72.9	169.4	151.6	171.6	12.0	9.3	235	68	253
SEM±	4.5	4.1	3.2	3.6	3.7	2.6	7.2	6.1	4.4	0.3	0.3			
CD (P=0.05)	NS	NS	9.4	NS	NS	7.8	NS	NS	13.3	0.9	0.9			

* Treatment details are given in Table 1.

Table 3. Effect of different treatments on nutrient uptake (kg/ha) of sugarcane (plant+ratoon) soil properties and economics (x 10³ Rs/ha)

Treatment	pH (1:2.5)	Organic carbon (%)	Available Nutrients (kg/ha)			Bulk density (g/cc)	Cost of cultivation (Rs)	Net income	Net B:C ratio
			N	P	K				
T ₁	7.44	0.47	212	22.0	191.7	1.66	66.42	160.04	2.41
T ₂	7.19	0.92	248	45.7	230.0	1.57	71.58	147.11	2.06
T ₃	7.31	0.78	238	41.0	221.7	1.58	66.61	147.83	2.22
T ₄	7.39	0.55	222	33.5	202.5	1.65	66.13	153.80	2.33
T ₅	7.32	0.81	262	34.5	221.7	1.58	72.10	152.69	2.12
T ₆	7.33	0.77	251	29.4	214.2	1.58	67.13	159.96	2.38
T ₇	7.31	0.80	251	29.9	191.7	1.58	69.01	131.46	1.90
T ₈	7.27	0.72	230	29.3	188.3	1.58	64.04	139.57	2.18
T ₉	7.33	0.73	235	28.3	195.0	1.57	56.89	153.80	2.70
T ₁₀	7.28	0.99	282	46.9	237.5	1.57	73.58	172.81	2.35
SEm±	0.09	0.05	4	1.6	5.8	0.02			
CD (P=0.05)	NS	0.14	12	4.7	17.5	0.05			
Initial		0.50	248	38.6	302.0				

* Treatment details given in Table 1.

Price (Rs/ha) N = 10.90; P₂O₅ = 19.88; K₂O = 7.73; Labour = Rs. 50/day; Sugarcane seed: Rs 1,600/t and Sugarcane: Rs 1,400/t

revealed that among the major nutrients relatively higher total uptake of K (253 kg/ha) was recorded which was followed by N (235 kg/ha) and P (68 kg/ha) under this treatment (T₁₀). In present experiment irrespective of treatments on an average production of one tonne of sugarcane require 1.20–0.35–1.33 kg N-P-K. The better nutrient availability, higher yield and ultimately more nutrient uptake was recorded with T₁₀ as it received 25% additional N through FYM. Another reason that may be attributed to higher nutrient uptake may be the indirect effect of improved soil physical condition as a result of FYM/trash incorporation which works as soil conditioner. Apart from this, application of bio-fertilizer in presence of FYM/trash incorporation could also have further improved the availability of N and P in soil and fast conversion of soil nutrients in to available form to the plant. All these factors collectively might have resulted in higher total uptake of all the nutrients by sugarcane in treatment T₁₀ as compared to the rest of the treatments. The result of the present study are in close agreement with those reported earlier by Tiwari and Nema (1999), Yadav (1995), Bangar *et al.* (2000) and Rana *et al.* (2002).

Soil samples analyzed after ratoon crop (Table 3) indicated that pH of the soil did not differ significantly under different treatments. There were significant effects of treatments receiving organics along with inorganics, that gave higher values of organic carbon over treatments receiving only inorganics (T₁ and T₄ in plant crop and T₁ in ratoon crop). Available nutrients (N, P and K) also increased due to applied integrated use of fertilizers and manures (INM). Generally, higher availability of N, P and

K were observed in treatments receiving farmyard manure/Pressmud with inorganics over other INM treatments. Further significant influence of INM treatments was also observed on bulk density of soil. The lower bulk density was observed in the plots receiving organics with inorganics. The role of organic matter in maintaining physico-chemical as well as biological properties of soil were also reported by Sharma *et al.* (2006).

Economics

Treatment receiving RDF + 25% N through FYM + biofertilizers (*Azotobactor* + PSB each @ 2 kg/ha) to plant and RDF to ratoon crop+ trash incorporation @ 10 t/ha + bio-fertilizers gave the highest net income and B:C ratio. This was followed by the treatment of recommended dose of fertilizer in both plant and ratoon crop (Table 3).

It is concluded that sugarcane-plant-ratoon sequence in high clay containing soils of South Gujarat, application of recommended dose of fertilizer (250-125-125 kg N-P-K/ha) along with either FYM or pressmud (supplying 25% *i.e.* 62.5 kg N) + biofertilizers in plant cane and recommended dose of fertilizer (325-62.5-125 kg N-P-K/ha) + trash incorporation + Biofertilizers in ratoon crop is imperative for sustaining soil health and enhancing productivity.

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