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Identification of integrated nutrient management for sustaining soil health and sugarcane yield in South Western Punjab

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Abstract

A field study was conducted from 2006-2010 for three plant - ratoon cycles of sugarcane at Punjab Agricultural University, Regional Station, Faridkot to explore the possibilities of incorporating organic components of nutrients in sugarcane cultivation. The recommended nitrogen (Rd N) for plant and ratoon crop of sugarcane was 150 kg ha^{-1} and 225 kg ha^{-1}, respectively. Nitrogen was applied as organic (FYM) and inorganic (urea) in various proportions. In addition to urea and FYM, biofertilizer (*Azotobacter and PSB*) and trash mulching was applied and green manuring of green gram (*Phaseolus radiata*) was done in various treatments. The pest control was also done by chemicals or by cultural practices. The pooled results for three years indicated that in plant crop, the cane yield of 80.4 t ha^{-1} was obtained when recommended dose of N was given as urea and pests were controlled chemically. This was significantly higher than all other treatments, except 76.9 t ha^{-1} yield obtained when 25% of Rd N was applied from FYM + Biofertilizer + 75% of Rd N from Urea + pest control by cultural mode. In ratoon crop, cane yield (72.6 t ha^{-1}) was recorded with 100% Rd N from urea + trash burning + chemical pest control, which was at par other combinations of N supply. Replacing 25% N by FYM showed good performance in plant-ratoon system indicating possibilities of saving 25% nitrogen fertilizers without affecting yield levels of sugarcane.

Key words

FYM, Green Manuring, Sugarcane, Trash mulching, Urea

Introduction

Sugarcane produces heavy tonnage of biomass and removes large quantity of plant nutrients from soil. For obtaining high productivity, high yielding crop varieties require more nutrients, especially nitrogen besides other critical inputs. Sugarcane has high nitrogen requirement that normally exceeds the inherent capacity of soils to supply it by mineralization of organic matter. To achieve optimum productivity in sugarcane, application of nitrogenous fertilizers will not only increase the cost of cultivation but will also increase the chances of nitrate pollution of the ecosystem and atmosphere. Moreover, increased use of high-analysis fertilizers leads to deficiency of several micronutrients (Pathak and Ghosh, 1996). Imbalanced and inadequate use of some nutrients results in poor cane yield, deterioration of soil health and multiple nutrient deficiencies. This calls for substituting a part of inorganic N fertilizers by locally available organic sources of nutrients viz. manures, green manures, crop residues, bio fertilizers. Combined application of organic manure along with inorganic fertilizers assure high productivity on sustainable basis in various cropping systems (Singh and Biswas, 2000; Mohammad, 2009). Organic sources can also ensure adequate supply of micronutrients to meet the crop need. This will lead to increased fertilizer-use-efficiency (Singh *et al.,* 1999). Application of organic and inorganic fertilizers can increase the activities of soil micro-organisms and enzymes and soil available nutrient contents (He and Li, 2004; Saha *et al.,* 2008). Organic manures not only replenish lost nutrients but also improve the physical, chemical and biological properties of such ecologies, which will enhance the performance of soil applied inputs (Vanlauwe *et al.,* 2001). Organic fertilizers have been a valuable source of nutrients for crop growth for many years and are usually applied based on the N crop requirement. Singh and Singh (2002) reported that application of organic manures along

with N fertilizer resulted in significant increase in yield of plant crop of sugarcane with a substantial residual effect on following ratoon crop (the new cane which grows from the stubble left behind after harvesting of sugarcane plant crop). Bokhtiar and Sakwai (2005) recorded 25 % saving in N fertilizer with the application of farmyard manure (FYM) at 15 t ha^{-1} used in plant and ratoon crop of sugarcane. Bhullar *et al.* (2005) reported 37.5 kg N ha^{-1} saving with green manuring of intercropped *Phaseolus radiata*, after picking pods, in plant crop of sugarcane. Now a days as more stress is on organic farming and also the World Trade Organization (WTO) regime demands only quality agro-products free from insecticide residues. In order to maintain the ecological balance as well as to meet the demands of the international market it will be of utmost importance to intensively incorporate non-chemical methods for pest control in IPM of sugarcane. The cultural methods are the most eco-friendly ways to achieve the dreams of organic sugarcane. In view of these points, the present study was conducted, from 2006-2010 for three plant - ratoon cycles of sugarcane, to evaluate the response of organic nitrogen in the form of FYM with combination of green manuring, intercropping of green gram (a legume crop), biofertilizer, trash mulching as an alternate source of nitrogen to replace organic fertilizers for developing an integrated nutrient management package in sugarcane.

Materials and Methods

A field experiment was conducted during 2006-2010 for three plant - ratoon crops of sugarcane at Punjab Agricultural University, Regional Station, Faridkot. A mid-maturing sugarcane variety (CoJ 88) was planted in March, 2006, 2007 and 2008, respectively for three seasons using 80 q ha^{-1} seed while ratoon of plant crops were maintained by harvesting the plant crop in the month of January 2007, 2008 and 2009, respectively. The ratoon crops were harvested in January of the respective year. The recommended nitrogen (Rd N) applied to plant and ratoon crop was 150 and 225 kg ha^{-1}, respectively. This nitrogen dose was applied from FYM as organic and urea as inorganic source. Organic manure, FYM and bio-fertilizer (BF) (*Azotobacter* and PSB) were applied at planting stage. The sugarcane trash mulch @ 6.25 t ha^{-1}, in alternate rows, was applied at the time of ratoon initiation. Green gram (*Phaseolus radiata*) was sown in between the rows of plant crop and alternate rows of ratoon crop in last week of March and was incorporated 45 days after sowing. The initial soil status of the experimental site is given in Table 1.

Table 1 : Initial soil status of experimental field during different years

Year	pH	EC (dS m^{-1})	OC (%)	P_2O_5 (kg ha^{-1})
2006-07	8.6	0.58	0.54	9.5
2007-08	8.1	0.45	0.52	4.5
2008-09	8.2	0.58	0.49	4.9

The data on shoot number was collected at maximum tillering stage, while the data on millable canes, cane length, cane weight, cane yield and Commercial Cane Sugar (CCS %) were recorded at the time of harvest.

Results and Discussion

Sugarcane supplied with recommended dose of N from Urea + chemical pest control (T1) recorded significantly more number of shoots (163.58) over T2 (Rd N from FYM + Biofertilizer (BF) + intercropping of *Phaseolus radiata* + chemical pest control). However, number of shoots in T1 was at par with T3, T4 and T5, respectively (Table 2). The maximum number of millable canes were produced under T1 (105.33) which was at par with T5 but significantly higher than T2, T3 and T4 treatments. In the present study only recommended fertilizers were applied but significantly high number of millable canes was reported by Kumar (2012) and Shukla (2007) by applying high level of fertilizers. Due to improvement in stalk girth, the cane weight was found to be higher under T4 and T5 treatments as compared to rest of the treatments. However, it was significantly more in T5 (953 g) than T2 and T3 treatments but at par with T1 as well as T4 treatments, respectively. The least cane weight was produced with organic manure treated plots (T3) which was 12.9 % less than T5 treatment. The treatments did not have any significant influence on the length as well as girth of sugarcane. The pooled values indicated that the recommended dose of N from Urea + chemical pest control (T1) recorded significantly higher cane yield (80.4 t ha^{-1}) as compared to T2 (66.6 t ha^{-1}), T3 (67.2 t ha^{-1}) and T4 (70.0 t ha^{-1}) treatments, however it was at par with T5 (76.9 t ha^{-1}). This increase in cane yield over T2, T3 and T4 treatments was 20.7, 19.6 and 14.8 % (Table 3). The sugar yield also showed similar trend corresponding to cane yield. Patil *et al.* (2012) also reported that recommended application of N, P and K fertilizers @ 25% through organic sources and 75% through chemical fertilizers recorded higher cane and sugar yield. According to Mahar *et al.* (2008), application of farm yard manure alone was not much effective nutrient source for crop growth and quality characters. Virdia *et al.* (2009) reported that integrated use of FYM @ 25% of recommended dose of N with 100% NPK and bio-fertilizer increased the cane yield and cane sugar. Higher cane and CCS yield with 150 t ha^{-1} FYM was also observed by Deshmukh *et al.* (2012). The increased absorption of nutrients in integrated treatments helped to improve the yield attributes and ultimately the cane yield in T5.

In ratoon crop, combination of inorganic and organic sources performed on par with recommended levels of inorganic fertilizer. Significantly more number of shoots (thousands ha^{-1}) was recorded under T1 (230.75), T2 (230.50), T4 (217.0) and T5 (221.58) as compared to T3 (211.5) (Table 2). The pooled data showed that the highest ratoon cane yield (72.6 t ha^{-1}) was recorded with T1, which was at par with T5 (72.1 t ha^{-1}), T3 (71.0 t ha^{-1}), T2 (69.5 t ha^{-1}) and T4 (67.1 t ha^{-1}) respectively (Table 3)

Table 2 : Yield attributing characters of plant and ratoon sugarcane under different treatments (Pooled mean of 3 years)

Treatments	No. of shoots (000 ha^{-1})	NMC (000 ha^{-1})	Stalk length (cm)	Stalk girth (cm)	Single cane weight (g)
Plant					
T1	163.58	105.33	209	2.33	898
T2	147.83	94.25	201	2.29	840
T3	155.00	97.00	199	2.25	829
T4	157.58	94.92	206	2.36	906
T5	158.66	104.58	209	2.32	953
CD (5%)	**10.14**	**5.84**	**NS**	**NS**	**72**
Ratoon					
T1	230.75	127.83	205	2.43	874
T2	230.50	125.83	203	2.41	865
T3	211.50	125.92	204	2.38	860
T4	217.00	126.58	198	2.47	885
T5	221.58	133.75	203	2.42	922
CD (5%)	**14.59**	**NS**	**NS**	**NS**	**NS**

Plant : T_1 : Rd N from Urea + chemical pest control ; T_2 : Rd N from FYM + Biofertilizer (BF) + intercropping of *Phaseolus radiata* in plant sugarcane + chemical pest control, T_3 : T_2 + pest control by cultural mode and detrashing of leaves in ratoon instead of chemical pest control, T_4 : 75% Rd N from FYM + Biofertilizer + 25% Rd N from Urea + pest control by cultural mode and T_5 : 25% Rd N from FYM + Biofertilizer + 75% Rd N from Urea + pest control by cultural mode; **Ratoon:** T_1 : Rd N from Urea + chemical pest control + Trash burning ; T_2 : Rd N from FYM + Biofertilizer (BF) + Trash mulching and green manuring in alternate rows in ratoon sugarcane + chemical pest control, T_3 : T_2 + pest control by cultural mode and detrashing of leaves in ratoon instead of chemical pest control; T_4 : 75% Rd N from FYM + Biofertilizer + 25% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode and T_5 : 25% Rd N from FYM + Biofertilizer + 75% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode

Table 3 : Cane and sugar yield of plant crop of sugarcane under different treatments

Treatments	Cane yield (t ha^{-1})			Pooled Mean	Sugar yield (t ha^{-1})			Pooled Mean
	2006-07	2007-08	2008-09		2006-07	2007-08	2008-09	
Plant								
T1	95.2	76.9	69.1	80.4	11.79	9.65	8.39	9.94
T2	74.2	65.0	60.6	66.6	9.28	8.12	7.65	8.35
T3	77.2	66.7	57.6	67.2	9.54	8.30	6.78	8.21
T4	80.0	68.1	61.9	70.0	9.84	8.49	7.67	8.67
T5	89.3	71.0	70.4	76.9	11.16	8.85	8.65	9.55
CD (5%)	**14.5**	**7.5**	**6.3**	**5.5**	**1.80**	**NS**	**0.88**	**0.72**
Ratoon								
Treatments	**2007-08**	**2008-09**	**2009-10**	**Pooled Mean**	**2007-08**	**2008-09**	**2009-10**	**Pooled Mean**
T1	63.0	78.1	76.7	72.6	7.73	10.58	10.93	9.75
T2	60.0	70.3	78.3	69.5	7.55	10.63	10.95	9.71
T3	61.3	75.8	75.9	71.0	7.78	10.20	10.68	9.55
T4	59.2	71.7	70.4	67.1	7.15	10.37	9.86	9.13
T5	64.8	76.0	75.6	72.1	8.05	10.88	10.44	9.79
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Plant: T_1 : Rd N from Urea + chemical pest control ; T_2 : Rd N from FYM + Biofertilizer (BF) + intercropping of *Phaseolus radiata* in plant sugarcane + chemical pest control; T_3 : T_2 + pest control by cultural mode and detrashing of leaves in ratoon instead of chemical pest control; T_4 : 75% Rd N from FYM + Biofertilizer + 25% Rd N from Urea + pest control by cultural mode and T_5 : 25% Rd N from FYM + Biofertilizer + 75% Rd N from Urea + pest control by cultural mode; **Ratoon:** T_1 : Rd N from Urea + chemical pest control + Trash burning; T_2 : Rd N from FYM + Biofertilizer (BF) + Trash mulching and green manuring in alternate rows in ratoon sugarcane + chemical pest control; T_3 : T_2 + pest control by cultural mode and detrashing of leaves in ratoon instead of chemical pest control; T_4 : 75% Rd N from FYM + Biofertilizer + 25% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode and T_5 : 25% Rd N from FYM + Biofertilizer + 75% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode

although the differences among the treatments were non-significant. High cane yield with FYM along with N fertilizer was also reported by Virdia *et al.* (2009). The maximum sugar yield was achieved with T5 (9.79 t ha^{-1}) followed by T1 (9.75 t ha^{-1}), T2 (9.71 t ha^{-1}), T3 (9.55 t ha^{-1}) and T4 (9.13 t ha^{-1}) treatments. The results indicated that GM or FYM or both could help in saving 25% N *i.e.,* 56.25 kg ha^{-1} in ratoon crop of sugarcane. The slow decomposition of organic material release the nutrients over a long time during the crop growth period and also improves the soil properties (Aruna and Mohammad, 2005). Bhullar *et al.* (2005) reported 37.5 kg N ha^{-1} saving with green manuring of intercropped *Phaseolus radiata* after picking pods in plant crop.

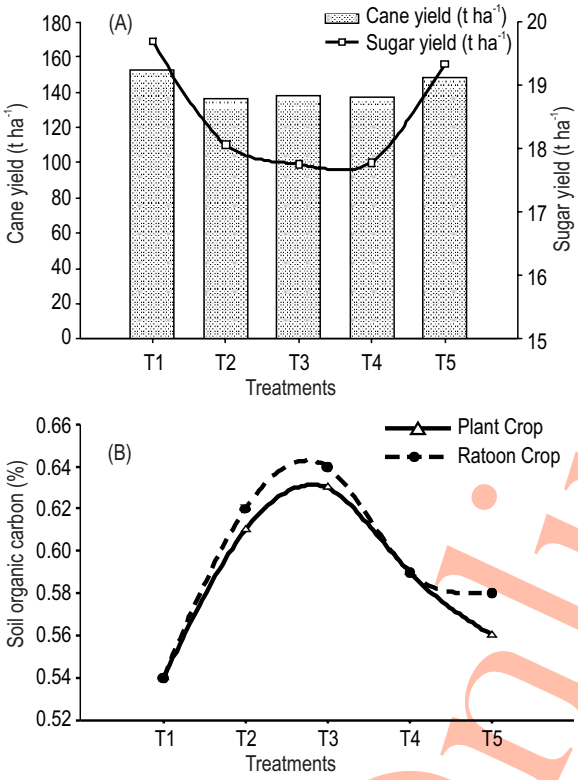

Fig.1 : (A) Cane and sugar yield of plant + ratoon sugarcane under different treatments; (B) Soil organic carbon (%) after harvest of plant and ratoon crop based on average of three years; T_1 : Rd N from Urea + chemical pest control + Trash burning; T_2 : Rd N from FYM + Biofertilizer (BF) + Trash mulching and green manuring in alternate rows in ratoon sugarcane + chemical pest control, T_3 : T_2 + pest control by cultural mode and detrashing of leaves in ratoon instead of chemical pest control, T_4 : 75% Rd N from FYM + Biofertilizer + 25% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode and T_5 : 25% Rd N from FYM + Biofertilizer + 75% Rd N from Urea + Trash mulching and green manuring in alternate rows in ratoon + pest control by cultural mode

The highest cane productivity of 153 t ha^{-1} for plant-ratoon system was achieved under T1 followed by T5 (149 t ha^{-1}), T3, T4 and T2 treatments and sugar productivity was also found to be highest in T1 followed by T5, T2, T4 and T3 treatments, respectively (Fig. 1A). Application of Rd N to plant and ratoon from FYM + Biofertilizer (BF) + intercropping of *Phaseolus radiata* (in plant sugarcane) followed by Trash mulching and green manuring in alternate rows (in ratoon sugarcane) and 75% Rd N from FYM + Biofertilizer + 25% Rd N from urea to both plant and ratoon crop, could not match system productivity of full recommended dose of N through fertilizers for both the crops. But replacing 25% N by FYM performed well in plant-ratoon system, indicating possibilities of saving 25% nitrogen fertilizer without affecting yield level of sugarcane.

The soil analysis done after the harvest of plant and ratoon crop of sugarcane revealed non-significant difference among different treatments with respect to soil organic carbon as both the crops utilized majority of the nutrients whether applied from organic and inorganic sources. However, a tendency of build up of organic carbon was observed. Compared to OC content of 0.54 % from inorganic N sources, 0.62 and 0.63 % were recorded in treatments involving Rd N to plant and ratoon from FYM + Biofertilizer (BF) + intercropping of *Phaseolus radiata* (in plant sugarcane) + Trash mulching and green manuring in alternate rows (in ratoon sugarcane) and detrashing of leaves for ratoon, respectively (Fig. 1B).

Difference in cane yield by inorganic and organic N sources were more in plant crop than ratoon crop, indicating the increased availability of organic N to sugarcane in ratoon crop. Mean cane yield among chemical and cultural methods of pest control was at par indicating that the cultural practices play a key role in pest management, especially in ratoon crop which is most vulnerable to pest attack. However in plant crop, the combination of cultural practices with chemicals will help to reduce the increasing pesticide load on this high export valued crop. In nutshell the organic sources if available will help farmers to fetch higher returns from organic produce.

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