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Influence of INM on sugarcane productivity and soil fertility under Indo-Gangetic plain

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ABSTRACT

A field experiment was conducted during 2016-17 at Punjab Agricultural University, Regional Research Station, Kapurthala, Punjab, India with nine treatments comprising various combinations of farmyard manure (FYM), bio-fertilizers and different levels of chemical fertilizers in a randomized block design (RBD). Our results demonstrated that application of FYM @ 20 t/ha with soil test based application of nutrients recorded significantly highest number of millable canes of 134.3 thousand/ha and number of shoots (142.2 thousand/ha) at 150 DAS. However, cane length, cane diameter, single cane weight, cane yield and sugar yield were statistically at par with either application of 100% RDF plus FYM @ 20 t/ha or with the soil test based application of nutrients along with biofertilizers and 10 t/ha of FYM. With 20 t/ha of FYM and chemical fertilizer, the build-up of organic carbon content, N, P, K, Zn, Fe, Cu and Mn were significantly higher than the treatments containing either 10 t of FYM/ha or no manure. Application of FYM or biofertilizers or both along with RDF or STB nutrient application resulted in 12.8 to 17.9% higher cane yield, resulting in additional net returns of ₹ 20592 to 45230/ha as compared to recommended dose of inorganic fertilizers alone. Our study showed that higher cane and sugar productivity and economic returns can be achieved by applying either 20 t of FYM or 10 t of FYM along with bio-fertilizers.

Keywords: Cane and sugar productivity, Integrated nutrient management, Nutrient status, Sugarcane

In India sugarcane is cultivated in over 4.5 million ha with annual production of 347.0 million tonnes in the year 2016-17 (Anonymous 2017). It is estimated that a crop of 100 tonnes cane yield removes 208, 52, 280, 30, 3.4, 1.2, 0.6 and 0.2 kg N, P, K, S, Fe, Mn, Zn and Cu respectively (Bhaskaran and Palanisami 2016) and therefore soil alone cannot sustain the heavy nutrients requirement of this crop during different crop growth stages. Indiscriminate use of inorganic fertilizers to supplement the crop nutrients need makes the soil more and more deficient in most of the plant nutrients along with declining soil microbial activity resulting in poor soil health (Singh *et al*. 2007). Organic manures have the potential to supply both macro and micro nutrients on sustainable basis for healthy crop growth and higher productivity. Balanced use of organic, inorganic and bio-fertilizers not only help to keep the soil in good soil physical and chemical conditions but also it serves as a source of energy for useful soil microbes. Integrated use of organic manures and chemical fertilizers is highly beneficial (Bangar and Sharma 1997 and Chaudhary and Sinha 2001), improves soil fertility for sustained crop productivity (Yadav 2000). Significantly higher cane yield was obtained from sugarcane inoculated with *Azotobactor* along with recommended nitrogen application. The cane yield obtained with recommended nitrogen application was statistically similar to that with 75% of recommended nitrogen along with seed inoculation with *Acetobactor* (Gosal *et al*. 2012). Application of 25% of the total nitrogen through press-mud or FYM could be used to prevent soil nutrient depletion and sustain the crop productivity as well (Banerjee *et al*. 2018).

The present study aimed to develop INM strategies for conjunctive use of organic and inorganic source of nutrients along with bio-fertilizers in such a way to sustain soil health and sugarcane productivity on long term basis under subtropical conditions of Punjab.

MATERIALS AND METHODS

Experimental site and soil characteristics: Field experiment on sugarcane was conducted (during spring 2016 and 2017) at Research Farms of Punjab Agricultural University, Regional Research Stations, Kapurthala located (31º 22'N latitude, 75º 22' E longitude and at an elevation of 229 m AMSL), Punjab located in Trans-Gangetic alluvial plains of India. The soil (0–15 cm layer) of the experimental field is a sandy loam in texture, with *p*H 8.05, low in Walkley-Black organic C 3.70 g/kg, electrical conductivity

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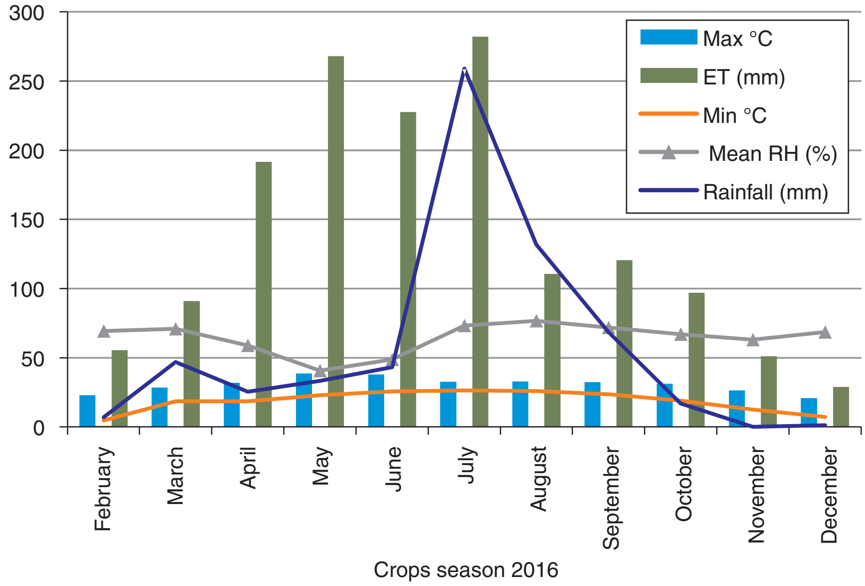

Fig 1 Mean temperature, evaporation and rainfall during 2016 at Punjab Agricultural University, Regional Research Stations, Kapurthala, Punjab, India.

0.231 dS/m, low in $KMnO_4$ oxidizable N content 65.3 mg/kg, medium in 0.5 M $NaHCO_3$ extractable P 6.15 mg/kg (Olsen *et al*. 1954) and in 1N NH_4OAc extractable K 60.3 mg/kg. It was sufficient in supply of micronutrients like Zn (2.32 mg/kg), Cu (0.35 mg/kg), Fe (8.40 mg/kg) and Mn (3.87 mg/kg).

Climate characteristics: Mean monthly maximum temperature during both the years was similar in all months except February, July and November (Fig 1 and 2). In year 2017 February and March months were comparatively warmer by 2.2°C and November was relatively cooler by 4.9°C as compared to 2016. The mean monthly minimum temperature of February 2017 was 3.6°C higher than in February 2016.Total rainfall of 647.5 mm was received in year 2016 (Fig 1) that was comparatively lesser than the total rainfall of 806 mm received during 2017 (Fig 2). Highest rainfall (241mm) was received in July 2016, whereas during 2017 it was highest (395mm) in the month of June. There was no rainfall in November and December 2016 (Fig 1). Rain fall of 21.5 mm and 18 mm was received in November and December during 2017, respectively (Fig 2).

Treatments and experimental design: The experiment was conducted in randomized block design (RBD) with nine treatment combinations and was replicated thrice (Table 1).

Crop management: The crop was planted on 13th and 27th of February during 2016 and 2017, respectively and harvested at full maturity in end February during 2017 and 2018.After seed bed preparation, farmyard manure (FYM) was applied as per the treatments 15 days prior to crop sowing and was mixed well in the soil. On an average, per cent content of C, N, P and K in FYM was 20.0, 0.67, 0.82 and 0.88, respectively. It also contained 10100, 523, 462 and 129 mg/kg of Fe, Mn, Zn and Cu, respectively. Bio-fertilizers were applied in band along the rows after covering the setts with soil as per the treatments. The seed setts of variety CoJ 88 were treated with 0.25% solution of Tilt 25 EC (Propiconazole) and then planted at a row spacing of 75 cm using recommended seed rate, i.e. 50 thousand (three budded setts) per ha. The crop was raised following recommended practices as given in the package of practices for crops of Punjab–*rabi* crops (Bhatti and Kaur 2018). The size of each sub-plot was 27 m^2 (6.0 m long and 4.5 m wide).

Soil sampling and analysis: The composite soil samples were taken from each treatment plots from 0-15 cm soil depth after harvesting of the crop. These samples were air dried under shade, crushed and sieved through 2.0 mm sieve. The samples were then used to determine chemical properties of soil.

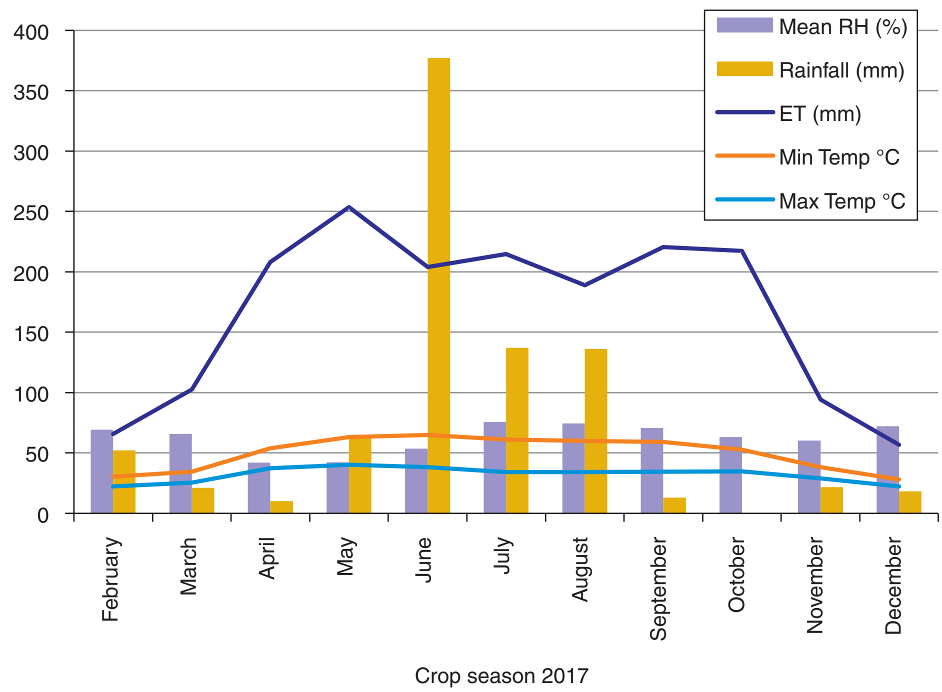

Fig 2 Mean temperature, evaporation and rainfall during 2017 at Punjab Agricultural University, Regional Research Stations, Kapurthala Punjab, India.

Table 1 Effect of integrated use of FYM, inorganic sources of plant nutrients and bio-fertilizers on yield attributes, cane and sugar yield, net returns and benefit-cost ratio of spring sugarcane

Treatment	Abbreviation	Number of shoots at 150 DAS (thousand/ha)	Cane length (cm)	Cane diameter (cm)	Single cane wt. (g)	Millable canes (thousand/ha)	Cane yield (t/ha)	CCS (%)	CCS (t/ha)	Net returns (₹/ha)	Benefit-cost ratio
No FYM + 50% of RDF	FYM_0 + RDF_{50}	113.7	182	2.32	961	84.1	71.0	2.32	9.3	63,973	1.49
No FYM+ 100% RDF (150 kg N/ha+ P_0 K_0 as soil is medium in available P and available K)	FYM_0 + RDF_{100}	120.4	184	2.24	1020	98.7	81.9	2.24	11.1	91,603	1.56
No FYM + STB (187.5 kg N/ha + P_0 K_0 as soil is medium in available P and available K)	FYM_0 + STB	125.6	190	2.31	1045	102.3	88.4	2.31	11.9	1,11,707	1.75
FYM @ 20 t/ ha + 50% RDF	FYM_{20} + RDF_{50}	121.1	187	2.28	1000	101.2	80.1	2.28	10.8	86,683	1.53
FYM @ 20 t/ha + 100% RDF	FYM_{20} + RDF_{100}	133.4	197	2.28	1095	111.4	91.7	2.28	12.8	1,22,195	1.75
FYM @ 20 t/ ha + STB	FYM_{20} + STB	142.2	198	2.25	1127	134.3	96.6	2.25	13.3	1,36,833	1.84
FYM @ 10 t/ ha + Bio-fertilizer (*Azotobacter* + *PSB*) + 50% RDF	FYM_{10} + BF + RDF_{50}	121.7	185	2.27	1005	94.1	77.8	2.27	10.6	81,950	1.51
FYM @ 10 t /ha + Bio-fertilizer (*Azotobacter* + *PSB*) +100% RDF	FYM_{10} + BF + RDF_{100}	133.5	192	2.30	1038	105.5	85.4	2.30	11.3	1,05,113	1.65
FYM @ 10 t/ ha + Bio-fertilizer (*Azotobacter* + *PSB*) + STB	FYM_{10} + BF + STB	135.9	194	2.31	1068	107.5	92.4	2.31	12.3	1,27,210	1.80
CD (P=0.05)		5.2	NS	NS	64.1	10.7	6.8	NS	4.0	19,758	0.13

FYM-Farmyard manure; RDF-Recommended dose of fertilizers; STB- Soil test based nutrient application and BF- Biofertilizer

Cane yield and components: Cane yield was measured by manual harvesting of an area of 15 m^2 from the centre of each plot to avoid the border effect. Total number of millable canes (NMC) and number of shoots at 150 days after crop planting were manually counted from net plots of each subplot and converted into thousands per ha. Other yield contributing characteristics like cane length, cane diameter and single cane weight was measured from 10 randomly selected canes from each plot and their respective values are presented as mean of 10 canes. The cane diameter was measured from top, middle and basal part of the cane with the help of verniercalliper and mean of three values was considered as cane diameter (cm).

Estimation of sugarcane quality parameters: The cane juice quality parameters were estimated from the three randomly selected canes from each treatment plot. Juice was extracted from the canes of each respective treatment by using sugarcane crusher. Sucrose and purity was estimated by using sucromat (automatic saccharimeter). Total soluble soilds/brix was estimated with hydrometry using brix spindle (0-20 and 21-30) as per the method described by Meade and Chen (1977). Commercial cane sugar % was computed using winter crop equation (Shukla 1991) from which sugar productivity was calculated by multiplying CCS% and cane yield.

$$CCS\% = \{sucrose\ \% - (Brix\%\text{-}Sucrose\ \%) \times 0.04\} \times 0.74$$

where, 0.4= multiplication factor; 0.74=crusher factor.

Statistical analysis: The data on various aspects were statistically analysed as prescribed by Cochran and Cox (1967) and adapted by Cheema and Singh (1990) in statistical package CPCS-1. The treatments were compared at 5% level of significance.

RESULTS AND DISCUSSION

The relative effect of different treatments on growth, cane yield and yield contributing attributes are presented in (Table 1). Highest cane yield of 96.6 t/ha was obtained in treatment FYM_{20}+ STB as compared to the yield obtained from all other treatments but was statistically similar to the cane yield obtained from treatment FYM_{20} + RDF_{100} or treatment FYM_{10} + BF + STB. Cane yield obtained from treatment FYM_0 + STB was statistically similar to cane yield obtained either from treatment FYM_0 + RDF_{100} or FYM_{10} + BF + RDF_{100}. On an average, application of FYM @ 20 t/ha along with STB nutrient application (187.5 kg N/ha) produced 35% and 17.9% higher cane yield over treatment FYM_0 + RDF_{50} and FYM_0 + RDF_{100}, respectively (Table 1). Higher cane yield in plots receiving FYM may be attributed to the improved soil conditions and balanced nutrients application encouraging root growth for efficient utilization of soil plants nutrients and water from the soil (Banerjee *et al.* 2018). Application of FYM along with recommended dose of fertilizer produced significantly higher cane and sugar yield in comparison to nitrogen application through inorganic fertilizers alone (Lakshami *et al.* 2011). Integrated use of organics sources and in-organics sources of plant nutrients markedly improves the soil physico-chemical status and impart more conducive environment for plant growth and development and hence enhance the crop yield (Ranjan *et al*. 2020). Statistically similar single cane weight was observed in treatments FYM_{20} + STB, FYM_{20} + RDF_{100} and FYM_{10} + BF + STB but these were significantly higher over all other treatments during the year 2017 and mean of pooled data over two years (Table 1). Commercial cane sugar (CCS) yields of treatments FYM_{20} + RDF_{100}, FYM_{20} + STB and FYM_{10} + BF + STB were statistically similar but were significantly higher over rest of the treatments in pooled mean data of two years (Table 1).

On an average FYM application @ 10 t/ha and 20 t/ha along with chemical fertilizers enhanced the commercial cane sugar by 5.88% and 14.2% over the treatments without addition of FYM (FYM_0 + RDF_{50}, FYM_0 + RDF_{100} and FYM_0 + STB). These results are corroborated with the findings of (Soomro *et al.* 2013) who also reported significantly higher commercial cane sugar yield of sugarcane with the application FYM @ 10 or 20 t/ha in combination with chemical fertilizer.

Soil properties at the harvest of crop: It was observed that the *p*H values ranged from 8.01 to 8.04 in treatments receiving FYM and was marginally lower from the treatments without FYM (Table 2). It might be due to the application of FYM resulting in the production of organic acids upon microbial decomposition of organic manures (Gawai 2003). The average organic carbon content increased by 34% and 21% with the application of FYM @ 20 and 10 t/ha, respectively in comparison to treatments without FYM application (Table 2). The per cent increase in $KMnO_4$ oxidizable N content in the treatments receiving 10 and 20 t/ha of FYM over the treatments with no manure was found to be 8.53 and 15.2%, respectively. The per cent increase in Olsen P content in the treatments receiving 10 and 20 t/ha of FYM over the treatments with no manure was found to be 26.0 and 36.7 %, respectively. Similar trend was observed in the ammonium acetate extractable K content and the respective values of per cent increase were found to be 20.2 and 39.6 (Table 2). Significant improvement in soil organic carbon, available N, P and K with the application of FYM and bio-fertilizers was also reported by Kumar (2012).

Application of 10 and 20 t/ha of FYM enhanced the DTPA extractable Zn by 30.8 and 62%, Fe by 27.6 and 61.4%, Mn by 24 and 51.6% and Cu by 6.4 and 9.2% over no application of manure. However, the content of DTPA extractable Fe, Mn, Zn and Cu were at par with application of either 20 or 10 t/ha of FYM. But the per cent increase of the respective micronutrients with the application of 20 t/ha of FYM over 10 t/ha FYM was found to be 26.5, 22.2 and 23%, respectively (Table 2). The significant increase in the availability of Fe with application of FYM might be due to very high concentration of Fe in the FYM. The chelation of Mn by organic matter is the major cause of its higher availability of Mn in the treatments with organic manures. The Zn complex with Fulvic acid (Zn-FA) increased the available Zn than that of $ZnSO_4$ (Kumar and Prasad 1989).

Economics analysis: Maximum net return was observed in the treatment FYM_{20} + STB followed by treatment FYM_{10} + BF + STB and FYM_{20} + RDF_{100}. However, the net returns as well as benefit cost ratio were statistically similar in these three treatments, i.e. (FYM_{20} + STB, FYM_{10} + BF + STB and FYM_{20} + RDF_{100} (Table 2). Application of FYM or biofertilizers or both resulted in 12.8 to 17.9% higher cane yield in these three treatments (FYM_{20} + STB, FYM_{10} + BF + STB and FYM_{20} + RDF_{100}) over the treatment FYM_0 + RDF_{100} thereby enhanced additional net returns to the tune of ₹ 20592–45230/ha as compared with the cultivation of sugarcane with recommended dose of fertilizers. It is suggested that even in the absence of FYM, soil test based application of nutrients can help to increase the net returns significantly over the application of recommended doses of fertilizers (Table 1).

In our study, cane weight highly affected the cane yield followed by cane length and NMC. The application of 20 t of FYM along with 100% RDF or by reducing the application of FYM by one half along with biofertilizers and 100% RDF produced similar grain yield as in conventional

Table 2 Effect of INM and biofertilizers on chemical properties of the soil at harvest of sugarcane after 2 years

Treatment	*p*H	EC (dS/m)	OC (%)	$KMNO_4$ -available N	P	K	Zn	Fe	Mn	Cu
				mg/kg						
FYM_0 + RDF_{50}	8.10	0.233	0.38	62.6	6.20	61.5	2.35	8.44	3.90	0.35
FYM_0 + RDF_{100}	8.10	0.233	0.40	66.8	6.30	63.0	2.40	8.48	3.92	0.36
FYM_0 + STB	8.10	0.235	0.41	67.3	6.30	64.0	2.45	8.48	3.92	0.36
FYM_{20} + RDF_{50}	8.01	0.238	0.52	73.5	9.80	85.1	3.85	13.70	5.91	0.39
FYM_{20} + RDF_{100}	8.01	0.245	0.54	76.3	9.90	88.1	3.90	13.60	5.95	0.39
FYM_{20} + STB	8.01	0.245	0.54	77.0	10.0	90.1	3.92	13.70	5.93	0.39
FYM_{10} + BF + RDF_{50}	8.04	0.242	0.48	70.2	8.40	79.9	3.12	10.80	4.86	0.38
FYM_{10} + BF + RDF_{100}	8.04	0.242	0.48	71.3	8.51	79.8	3.15	10.80	4.85	0.38
FYM_{10} + BF + STB	8.04	0.242	0.48	72.0	8.51	79.5	3.15	10.80	4.85	0.38
Initial value	8.05	0.231	0.37	65.3	6.15	60.3	2.32	8.40	3.87	0.35
CD (P=0.05)	NS	NS	0.06	4.32	2.08	17.9	0.66	2.31	0.91	0.021

practices and provided greater economic returns where there is a scarcity of FYM. Thus the application of 10 t FYM+ biofertilizers along with 100% RDF provided maximum net returns and resulted in gradual improvement in soil fertility with minimum ill effects of chemical fertilizer on soil and environment.

REFERENCES

Annonymous. 2017. India, Sugar annual. Global agriculture information network. USDA Foreign Agril Services, pp. 3.

Banerjee K, Puste A M, Gunri S K, Jana K and Barman M. 2018. Effect of integrated nutrient management on growth, yield, quality and soil health of spring planted sugarcane (*Saccharum officinarum*) in West Bengal. *Indian Journal of Agronomy* **63**(4): 41-47.

Bangar K S and Sharma S R. 1997. Role of organic manuring in improving sugarcane and sugar productivity. *Indian Journal of Sugar Technology* **12**: 59-66.

Bhaskaran A and Palanisami C. 2016. *Hand Book of Sugarcane*. Sugarcane Breeding Institute, Coimbatore, India.

Bhatti D S and Kaur S. 2018. *Package of practices for crops of Punjab–Rabi crops*. Punjab Agricultural University, Ludhiana, India.

Chaudhary C N and Sinha U P. 2001. Effect of concentrated organic manure, nitrogen and sulphur on the productivity and economics of sugarcane (*Saccharum officinarum*). *Indian Journal of Agronomy* **46**: 354-60.

Cheema H S and Singh B. 1990. *A user's manual to CPCS 1*. Punjab Agricultural University, Ludhiana. India.

Cochran W G and Cox G M. 1967. *Experimental Designs*. John Wiley Publishers. New York.

Gawai P P. 2003. 'Effect of integrated nutrient management system in sorghum-chickpea cropping sequence'. Ph D thesis, MPKV, Rahuri, Maharashtra, India.

Gosal S K, Kalia A, Uppal S K, Kumar R, Walia S S, Singh K and Singh H. 2012. Assessing the benefits of *Azotobacter* bacterization in sugarcane: A field appraisal. *Sugar Technology* **14**: 61–67.

Kumar N. 2012. Productivity, quality and nutrient balance in spring sugarcane (*Saccharum* spp. Hybrid complex) under organic and inorganic nutrition. *Indian Journal of Agronomy* **57**(1): 68–73.

Kumar M and Prasad B. 1989.The relative contribution of natural zinc complexing agents and $ZnSO_4$ to growth and zinc nutrition of maize. *Journal of Nuclear Agricultural Biology* **18**: 29–35.

Lakshmi S R, Sreelatha T, Usha T R, Rao S R K and Naidu N V. 2011. Effect of organic manures on soil fertility and productivity of sugarcane in north coastal zone of Andhra Pradesh. *Indian Journal Agricultural Research* **45**: 307-13.

Meade G P and Chen J C P. 1977. *Cane Sugar Handbook*. Willey-Science, Publication, New York.

Olsen S R, Coleman C W, Watnabe F S and Dean L A. 1954. Estimation of available phosphorus with sodium bicarbonate. *United States Department of Agriculture Circular* **939**: 19.

Ranjan A, Jha C K and Kumar N. 2020. A review on effect of INM on sugarcane growth, yield and quality. *International Journal of Current Microbiology and Applied Sciences* **9**(1): 2597-2605.

Shukla B S. 1991. Review of absolute sugar recovery and sugar recovery performance. (In) *Proceedings 53rd Annual Convention STAI,* New Delhi. December 24-25*,* pp 57-58.

Singh H, Jalota S K and Singh Y. 2007. Manuring and residue management effects on physical properties of soil under rice-wheat system in Punjab, India. *Soil and Tillage Research* **94**: 229-38.

Soomro A F, Shamasuddin T, Fateh C O and Inaitullah R. 2013. Integrated effect of inorganic and organic fertilizers on the yield and quality of sugarcane (S*accharum officinarm* L.). *Pakistan Journal of Botany* **45**: 1339-48.

Yadav D V. 2000. Organic manuring in sugarcane prospects and retrospects. *Indian Sugar* **49**: 979-88.