I J T A
© Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3.03

Effect of Nutrient Management Practices on Growth Indices and Yield of Sugarcane#

Keshavaiah K. V.*[1], Palled Y. B.* and Channal H. T.*

ABSTRACT: *An experiment was conducted during 2007-08 at Zonal Agricultural Research station, V.C.Farm, Mandya with the plant crop of sugarcane on the effect of organic and integrated nutrient management practices on LAI, LAD,CGR, dry matter production and subsequent yield of sugarcane. The treatments consisted of two varieties Co 62175 and Co 86032 as main plot and eight nutrient management practices. Among the nutrient management practices, The results revealed that the LAI, LAD, CGR and dry mater production were higher with recommended package of practices (N7) recorded significantly higher values of above growth indices in all the stages of crop growth. Among the varieties tested, CO 62175 variety of sugarcane recorded higher growth indices compared to Co 86032. This in turn had a positive influence on the yield of cane recorded as higher the growth indices, higher the cane yield manifested by these indices.*

Key words: *LAI, LAD, CGR, Dry mater production and Integrated nutrient management*

INTRODUCTION

Sugarcane, a complex hybrid of *Saccharum* spp., is one of the important commercial crops of industrial importance next only to cotton in India. Sugarcane occupies a pivotal position in the agricultural economy of India. As an instrument of agrarian reform and economic emancipation, sugarcane is second to none. This is so because, it is a labour intensive crop and provides livelihood to millions through an organized industry that it carries with it in the rural India. Sugarcane in agricultural sector shares seven per cent of total value of agricultural output and occupies only 2.5 per cent of Indian gross cropped area. In the country, there are 571 sugar industries in operation in rural areas.

It is estimated that about 35 million farmers and their dependents are engaged in cultivation of sugarcane and another 0.5 million skilled and unskilled workers including highly qualified technologists engaged in manufacturing sugar. The sugarcane growers and their dependents receive Rs 5000 crores annually for the cane they supply. The industry generates 50 million employments through 571 sugar factories across the country. India's domestic sugar market is estimated to be Rs. 6163 crores (Anon., 2013).

Globally sugarcane is cultivated on an area of 24.26 million hectares with a production of 1736.3 million tonnes and productivity of 71.58 tonnes/ha. India is next only to Brazil with respect to cane area and production as well of sugar production. In India, it is cultivated in an area of 5.06 million hectares in 2013 with a production of 338.9 million tonnes with an average productivity of 66.9 tonnes/ha. Though, there is a wide variation with productivity across different regions (Anon., 20113). Karnataka is a leading sugarcane growing state with high sugarcane production potentialities particularly in the sugarcane growing Cauvery command area. In the state, it is cultivated in four lakh hectares with a productivity of 90 tonnes /ha which is well above the national average. However, there is still a lot of scope for increasing the productivity as compared to neighboring Tamil Nadu state, where the productivity (109 tonnes /ha) is highest in the country.

Sugarcane is considered as one of the best converters of solar energy. The theoretical yield of cane is something in the order of 450 tonnes/ha,

* Zonal Agricultural Research station, V. C. Farm, Mandya, University of Agricultural Sciences, Bangalore, [1]*E-mail: kvkeshavaiah@gmail.com*
# Part of Ph.D. thesis of the first author
1. Plant scientist (Sugarcane) ZARS, University of Agricultural Sciences, Bangalore
2. Professor of Agronomy and Fodder Scheme head, University of Agricultural Sciences, Dharwad
3. Retired Associate Director of Research, ZARS, University of Agricultural Sciences, Bangalore
4. Chief Scientific Officer, Directorate of Research, University of Agricultural Sciences, Dharwad

though there is a yawning gap between this and practically realized yields in the field. There are biotic and environmental factors that limit the productivity of the crop in different regions. One of the notable characteristics of sugarcane agriculture in the country is inherent instability. Vagaries of rainfall, extreme weather conditions, biotic and abiotic factors are some of the impediments in cane cultivation.

Sugarcane yield is manifested in the early stage growth of the crop. The growth analysis technique helps in identifying which stage of growth in sugarcane is more critical as far as sugarcane yields are concerned. The growth analysis is the physiological probe on the development of the crop to elucidate and account for the causes for the yield through the events that have already occurred on the growth. Sugarcane yield ultimately depends on the vegetative growth of crop and growth analysis is more relevant to sugarcane crop for obtaining cane yields. Hence the physiological probe on the growth parameters like Leaf area index (LAI), leaf area duration (LAD) and CGR were made at different stages of crop growth and attempts were made to correlate the growth indices to yield of sugarcane.

This in view, the studies were undertaken to investigate the effect of nutrient management practices on crop growth and subsequent growth indices and their relation on yield of varieties in plant crop sugarcane.

MATERIAL AND METHODS

The experiment was laid out in the plot number 99 of D block of the Zonal Agricultural Research Station (ZARS), V.C.Farm, Mandya under the University of Agricultural Sciences, Bangalore. The station is situated between $12^0$18′ and $13^0$04′ north latitude and $76^0$79′ and $77^0$20′ east longitude and at an altitude of 695 metres above mean sea level in the Agro-climatic zone -6 (Southern dry zone) of region III of Karnataka. Before taking up the planting of sugarcane, cowpea was sown in the experimental area. The sugarcane plant crop was planted on 16th August, 2007 and harvested during 27th August, 2008. The experiment was laid out in split plot design with two varieties Co 62175 (V1) and Co 86032 (V2) as main plot treatments and the nutrient management practices (both organic and inorganic) as sub plot treatments. The sub plot treatments are as under. The data were subjected to statistical analysis using analysis of variance technique.

Sub-plot treatments

N_1	Pressmud (150 kg N equivalent/ha)	Sunnhemp (50 kg N equivalent/ha)	Biofertilizers (50 kg N equivalent/ha)	
N_2	Pressmud (100 kg N equivalent/ha)	Farmyard manure (100 kg N equivalent/ha)	Biofertilizers (50 kg N equivalent/ha)	
N_3	Pressmud (75 kg N equivalent/ha)	Farmyard manure (75 kg N equivalent/ha)	Frenchbean as intercrop (50 kg N equivalent/ha)	Biofertilizers (50 kg N equivalent/ha)
N_4	Pressmud (87.5 kg N equivalent/ha)	Farmyard manure (87.5 kg N equivalent/ha)	Neem cake (25 kg N equivalent/ha)	Biofertilizers (50 kg N equivalent/ha)
N_5	Pressmud (87.5 kg N equivalent/ha)	Farmyard manure (87.5 kg N equivalent/ha)	Vermicompost (25 kg N equivalent/ha)	Biofertilizers (50 kg N equivalent/ha)
N_6	50% N equivalent through organic and 50% NPK through chemical fertilizers			
	Pressmud (75 kg N equivalent/ha)	Chemical fertilizer (125 kg N, 50 kg P and 62.5 kg K_2O/ha)	Biofertilizers (50 kg N equivalent/ha)	
N_7	Recommended package of practices			
	Chemical fertilizers (250 kg N : 100 kg P_2O_5 : 125 kg K_2O/ha)	Farmyard manure (25 t/ha)		
N_8	Chemical fertilizers alone (250 kg N : 100 kg P_2O_5 : 125 kg K_2O/ha)			

Leaf area, leaf area index, leaf area duration and crop growth rate were enumerated for assessing their role in the manifestation of cane yield. The procedure for estimation of these parameters are given below.

Leaf area index (LAI)

It is the ratio of the leaf area to the land area covered and the values were computed as per the following formulae proposed by Watson (1952).

$$\text{Leaf area index} = \frac{\text{Leaf area (m}^2\text{)}}{\text{Land area (m}^2\text{)}}.$$

The leaf area was measured by leaf product method i.e., maximum length ´ maximum width ´ K where K is equal to 0.75.

The leaf area of five cane samples selected from the net plot area at 6th month, 9th month and harvest were computed to hectare basis on the plant population at the respective stages of growth. The values of LAI were recorded as the ratio of leaf area (m^2) to land area (m^2).

Leaf area duration (LAD)

It is the integral of leaf area index over a period of time and found out with the help of following formulae proposed by Power *et al.,* (1967).

$$LAD = \frac{LAI_1 + LAI_2}{2} \times (t_2 - t_1) \text{ days}$$

LAI_1 = Leaf area index at time t_1

LAI_2 = Leaf area index at time t_2

Crop growth rate (CGR)

It represents the total dry matter productivity of the community per unit land area over certain time lag. The values of CGR were worked out by using the following formulae

$$\text{CGR} = \frac{(\log_e L_2 - \log_e L_1)(W_2 - W_1)}{(L_2 - L_1)(t_2 - t_1)}$$

L_1 = leaf area at time t_1,

L_2 = leaf area at time t_2,

W_1 = dry weight at time t_1,

W_2 = dry weight at time t_2,

$CGR\,(g/m^2/day)$ = NAR × Mean LAI

RESULTS AND DISCUSSION

The data on leaf area index (LAI) at different stages of crop growth are presented in Table 1. The LAI was significantly higher at 6 months with Co 62175 variety of sugarcane (3.34) compared to Co 86032 (2.89). Recommended package of practices recorded significantly higher LAI compared to all the other treatments at 6 months stage but it was on par with N_6. Treatments N_6 and N_7 were significantly superior over organic management treatments. Among the organic management treatments, N_3 recorded significantly higher LAI over N_2 and was on par with rest of the treatments.

The interaction effect of varieties and nutrient management practices was significant. RPP with Co 62175 recorded significantly higher LAI (4.31) over all other combinations except V_1N_6 (4.19) with which it was on par. The LAI at 9 months and at harvest

Table 1
Leaf area index (LAI) at 6 months, 9 months and harvest as influenced by nutrient management practices in plant crop of sugarcane

		LAI at 6 months			*LAI at 9 months*			*LAI at harvest*		
		Varieties			*Varieties*			*Varieties*		
	Nutrient management practices (N)	V_1	V_2	*Mean*	V_1	V_2	*Mean*	V_1	V_2	*Mean*
N_1	Pressmud + sunnhemp + biofertilizers	3.02	2.65	2.83	3.93	3.45	3.69	2.49	2.19	2.34
N_2	Pressmud + FYM + biofertilizers	2.98	2.64	2.81	3.88	3.44	3.66	2.46	2.18	2.32
N_3	Pressmud + FYM + French beans + biofertilizers	3.06	2.83	2.94	3.98	3.67	3.83	2.53	2.33	2.43
N_4	Pressmud + FYM + neem cake + biofertilizers	3.04	2.70	2.87	3.95	3.51	3.73	2.50	2.23	2.37
N_5	Pressmud + FYM + vermicompost + biofertilizers	3.03	2.67	2.85	3.94	3.47	3.71	2.50	2.20	2.35
N_6	50% N through pressmud + 50% NPK through fertilizer + biofertilizer	4.19	3.41	3.80	5.45	4.43	4.94	3.46	2.81	3.14
N_7	Recommended package of practices	4.31	3.46	3.88	5.52	4.49	5.00	3.53	2.91	3.22
N_8	100% NPK through fertilizers only	3.06	2.78	2.92	3.97	3.61	3.79	2.52	2.29	2.41
	Mean	**3.34**	**2.89**	**-**	**4.34**	**3.76**	**-**	**2.75**	**2.39**	**-**
		S.E.m ±		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*
	Varieties (V)	0.02		0.06	0.03		0.08	0.02		0.05
	NMP (N)	0.04		0.11	0.05		0.15	0.03		0.09
	V × N	0.06		0.16	0.07		0.21	0.04		0.13
	N × V	0.06		0.16	0.07		0.21	0.05		0.13

V_1 = Co.62175; V_2 – Co.86032.

Table 2
Leaf area duration (LAD in days) at 6-9 months and 9 months -harvest as influenced by nutrient management practices in plant crop of sugarcane

		LAD at 6-9 months			*LAD at 9 months-Harvest*		
		Varieties (V)			*Varieties (V)*		
	Nutrient Management Practices (N)	V_1	V_2	*Mean*	V_1	V_2	*Mean*
N_1	Pressmud + sunnhemp + biofertilizers	315.92	277.40	296.66	275.92	242.23	259.08
N_2	Pressmud + FYM + biofertilizers	312.28	276.49	294.39	272.76	241.52	257.14
N_3	Pressmud + FYM + French beans + biofertilizers	320.32	295.75	308.04	279.79	258.14	268.97
N_4	Pressmud + FYM + neem cake + biofertilizers	317.75	282.86	300.30	277.35	247.11	262.23
N_5	Pressmud + FYM + vermicompost + biofertilizers	317.44	279.37	298.41	277.21	243.95	260.58
N_6	50% N through pressmud + 50% NPK through fertilizer + biofertilizer	438.62	356.42	397.52	383.13	311.18	347.15
N_7	Recommended package of practices	446.96	361.73	404.35	388.86	318.20	353.53
N_8	100% NPK through fertilizers only	319.87	290.90	305.39	279.36	253.99	266.67
	Mean	**348.65**	**302.62**	**–**	**304.30**	**264.54**	**–**
		S.E.m ±		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*
	Varieties (V)	2.13		6.17	1.85		5.36
	NMP (N)	4.13		11.97	3.54		10.26
	V × N	5.84		16.92	5.01		14.51
	N × V	5.86		16.99	5.04		14.59

V_1 = Co.62175; V_2 – Co.86032.

followed similar trend as at 6 months stage. The LAI was maximum at 9 months stage and declined towards harvest.

The data on leaf area duration between 6th and 9th month of crop growth (Table 2) was significantly higher with Co 62175 variety (348.65) compared to Co 86032. The recommended package of practices recorded significantly higher LAD (404.35) compared to all the other nutrient management practices except N_6 with which it was on par. Among the organic nutrient management practices, N_3 recorded significantly higher LAD over N_2 and the rest of the treatments were on par. The interaction effect was significant. Nutrient management practice of 50 per cent N through pressmud and 50 per cent through fertilizers recorded significantly higher LAD over all other practices except RPP with which it was on par. Interaction with all the organic nutrient management practices was on par with each other. Similar trend was observed with the interaction of Co 86032 variety also. The LAD values computed for the period between 9th month and harvest however followed similar trend of LAD as was observed in the preceding of crop growth.

PRODUCTION OF DRY MATTER AND CROP GROWTH RATE (CGR)

The data on dry matter production during different stages of crop growth are furnished in Table 3. Variety Co 62175 produced significantly higher dry matter (10.74 t/ha) compared to Co 86032.

Among the nutrient management practices, 50 per cent N through pressmud and 50 per cent NPK through fertilizer and biofertilizer recorded significantly higher dry matter (12.26 t/ha) over all the other practices except RPP with which it was on par. Among the organic nutrient management practices, the treatment with combination of pressmud, FYM, French beans and biofertilizers (N_3) recorded significantly higher dry matter production compared to N_2 and it was on par with rest of the treatments.

The interaction effect of varieties and nutrient management practices with respect to dry matter production was statistically significant. Variety Co 62175 with RPP recorded significantly higher dry matter production over all the treatments except V_1N_6 with which it was on par. Similar trend was observed with Co 86032 variety of sugarcane. The dry matter production at 9 months and harvest showed similar trend as that of 6th month stage. The dry matter production increased at 9th month and at harvest it was almost three fold. Sonawane and Sabale, (2000) reported that application of 250 kg nitrogen through urea and 50 kg N through pressmud showed positive response with respect to millable cane number, leaf area and dry matter production.

The data on Crop Growth Rate (CGR) between 6th and 9th month period are provided in Table 4. Co 62175 variety of sugarcane produced significantly higher CGR (7.21 g / m^2/ day) compared to Co 86032.

Among the nutrient management practices, 50 per cent N through pressmud and 50 per cent N through

Table 3
Dry weight (t ha^{-1}) at 6 months, 9 months and harvest as influenced by nutrient management practices in plant crop of sugarcane

		Dry weight at 6 months			*Dry weight at 9 months*			*Dry weight at harvest*		
		Varieties			*Varieties*			*Varieties*		
	Nutrient management practices (N)	V_1	V_2	*Mean*	V_1	V_2	*Mean*	V_1	V_2	*Mean*
N_1	Pressmud + sunnhemp + biofertilizers	9.74	8.57	9.16	15.69	13.80	14.75	39.24	34.49	36.87
N_2	Pressmud + FYM + biofertilizers	9.64	8.53	9.09	15.52	13.75	14.64	38.81	34.37	36.59
N_3	Pressmud + FYM + French beans + biofertilizers	9.89	9.12	9.51	15.93	14.70	15.31	39.83	36.74	38.29
N_4	Pressmud + FYM + neem cake + biofertilizers	9.80	8.73	9.27	15.79	14.06	14.93	39.47	35.16	37.32
N_5	Pressmud + FYM + vermicompost + biofertilizers	9.79	8.62	9.21	15.78	13.89	14.83	39.44	34.71	37.07
N_6	50% N through pressmud + 50% NPK through fertilizer + biofertilizer	13.53	10.99	12.26	21.80	17.72	19.76	44.44	44.29	44.36
N_7	Recommended package of practices	13.64	11.27	12.46	21.95	17.88	19.91	45.30	45.54	45.42
N_8	100% NPK through fertilizers only	9.87	8.97	9.42	15.90	14.46	15.18	39.74	36.14	37.94
	Mean	**10.74**	**9.35**	**–**	**17.30**	**15.03**	**–**	**40.78**	**37.68**	**–**
		S.E.m ±		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*
	Varieties (V)	0.06		0.17	0.11		0.31	0.24		0.68
	NMP (N)	0.13		0.36	0.20		0.58	0.50		1.44
	V × N	0.18		0.51	0.29		0.83	0.71		2.04
	N × V	0.18		0.51	0.29		0.83	0.70		2.03

V_1 = Co.62175; V_2 – Co.86032.

Table 4
Crop growth rate (g m^{-2} day $^{-1}$) at 6-9 months and 9 months to harvest as influenced by nutrient management practices in plant crop of sugarcane

		CGR @ 6-9 months			*CGR at 9 months to harvest*		
		Varieties (V)			*Varieties (V)*		
	Nutrient Management Practices (N)	V_1	V_2	*Mean*	V_1	V_2	*Mean*
N_1	Pressmud + sunnhemp + biofertilizers	6.54	5.75	6.15	27.38	24.06	25.72
N_2	Pressmud + FYM + biofertilizers	6.47	5.73	6.10	27.08	23.98	25.53
N_3	Pressmud + FYM + French beans + biofertilizers	6.64	6.13	6.39	27.79	25.64	26.72
N_4	Pressmud + FYM + neem cake + biofertilizers	6.58	5.86	6.22	27.54	24.54	26.04
N_5	Pressmud + FYM + vermicompost + biofertilizers	6.57	5.79	6.18	27.51	24.21	25.86
N_6	50% N through pressmud + 50% NPK through fertilizer + biofertilizer	9.09	7.39	8.24	26.32	30.90	28.61
N_7	Recommended package of practices	9.13	7.26	8.20	27.15	32.17	29.66
N_8	100% NPK through fertilizers only	6.63	6.03	6.33	27.73	25.21	26.47
	Mean	**7.21**	**6.24**	**–**	**27.31**	**26.34**	**–**
		S.E.m ±		*C.D. @ 5%*	*S.E.m ±*		*C.D. @ 5%*
	Varieties (V)	0.05		0.15	0.15		0.43
	NMP (N)	0.09		0.25	0.35		1.01
	V × N	0.12		0.35	0.49		1.43
	N × V	0.12		0.36	0.48		1.40

V_1 = Co.62175; V_2 – Co.86032.

fertilizer and biofertilizer recorded significantly higher CGR (8.24 g/m^2/day) over all the other practices except RPP with which it was on par. Among the organic management practices, N_3 recorded higher CGR over N_2 and on par with rest of the organic management practices and even the chemical fertilizers alone treatment. The interaction effect of varieties and nutrient management practices was statistically significant. Co 62175 variety with RPP recorded higher CGR (9.13 g/m^2/day) over rest of the treatments except N_6 with which it was on par. All the other interaction effects were on par with each other. The Crop Growth Rate (CGR) between 9th month and harvest period followed similar trend as

Table 5
Sugarcane yield (t ha^{-1}) as influenced by nutrient management practices in plant crop of sugarcane

	Varieties			
Nutrient Management Practices (N)		V_1	V_2	*Mean*
N_1	Pressmud + sunnhemp + biofertilizers	135.31	118.95	127.13
N_2	Pressmud + FYM + biofertilizers	133.83	118.52	126.17
N_3	Pressmud + FYM + French beans + biofertilizers	137.35	126.69	132.02
N_4	Pressmud + FYM + neem cake + biofertilizers	136.11	121.25	128.68
N_5	Pressmud + FYM + vermicompost + biofertilizers	135.99	119.69	127.84
N_6	50% N through pressmud + 50% NPK through fertilizer + biofertilizer	187.94	152.72	170.33
N_7	Recommended package of practices	191.65	157.99	174.82
N_8	100% NPK through fertilizers only	137.04	124.63	130.83
	Mean	**149.40**	**130.05**	**–**
		S.E.m ±	*C.D. @ 5%*	
	Varieties (V)	0.94	2.73	
	NMP (N)	1.73	5.02	
	V × N	2.45	7.10	
	N × V	2.48	7.18	

V_1 = Co.62175; V_2 – Co.86032.

was observed in previous stage. However, the CGR was in the increasing trend towards the harvest stage.

YIELD OF CANE

The yield of cane is directly dependent on the growth rate; dry matter accumulation which are resultant of higher leaf area and more greener leaves which is reflected in the leaf area duration. As it is seen, the higher leaf area, leaf area duration and dry matter accumulation results in higher yields of cane as evidenced from the Table 5.

The dry matter production recorded at 6th month (10.74 t/ha) and 9th month (17.30 t/ha) of crop growth was significantly higher with Co 62175 over Co 86032 which accounted for 15 per cent higher dry matter production over the latter. The dry matter production recorded at harvest stage with Co.62175 (40.78 t/ha) was significantly higher over Co 86032 (37.68 t/ha) variety of sugarcane. The higher dry matter production was due to higher LAI and LAD. The LAI recorded for Co 62175 at 6 months was significantly higher (3.34) over Co 86032 (2.89) accounting for 16 per cent higher LAI over latter. Similarly Co 62175 variety recorded significantly higher LAI at 9 months (4.34) and at harvest (2.75) over its counterpart. The peak LAI was at 9 months stage which coincided with grand growth period. The dry matter production was higher at harvest stage because of the accumulation of food material in cane during harvest.

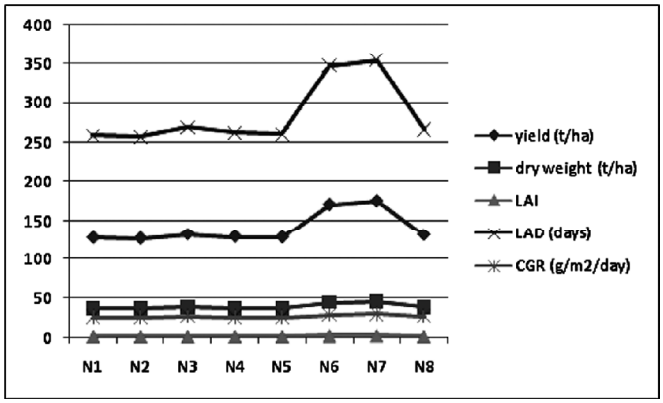

Figure 1: Mean yield of cane against dry weight, LAI, LAD and CGR

The higher growth attributing characters manifests in higher growth analysis parameters like LAI, LAD and dry matter accumulation and resulted in recording of higher yields of cane with Co 62175 variety over Co 86032. Shankaraiah and Kalyanamurthy (2005) and Venkatakrishnan and Ravichandra (2007) reported an enhancement of cane yield (187.89 t/ha) when enriched pressmud cake was applied at the rate of 10 t/ha and it was on par with yield obtained with 15 t/ha of raw pressmud. This indicates the beneficial effect of enrichment of pressmud. Saini *et al.* (2006a) from their experiments at Panthnagar, Uttaranchal reported that a combination of fly ash, PMC and PSB with fertilizers benefited the sugarcane crop by increasing the cane yield over chemical fertilizers alone. This can reduce the dosage of chemical fertilizers thereby reducing the dependence on fertilizers. A quantity of 10 tons of PMC along with fly ash (10 t/ha) and PSB and 75 per cent of recommended fertilizers was ideal for getting higher sugarcane yields.

Rakkiyappan *et al.*, (2001) reported similar observations of integration of PMC and fertilizers. Results indicated that 10 t/ha of PMC along with 75%

recommended fertilizers enhanced cane yields over chemical fertilizers alone. Pressmud was better than bio compost. Application of enriched pressmud along with 50 per cent NPK yielded on par with 75% NPK fertilizers alone. Similarly application of organics along with 75 per cent NPK fertilizers yielded on par with 100% NPK fertilizers. However, the yield improvement due to organics was more pronounced under low level of fertilizers (50% NPK) than higher level (75% NPK) Application of pressmud at the rate of 4 tonnes per hectare increased the cane yield by 12 per cent and further saving of 20 kg/ha phosphorus was possible (Sharma *et al*., 2003).

REFERENCES

Anonymous, (2013), Sugarcane Breeding institute Coimbatore, *www.sugarcane res.in SBI website*

Anonymous, (2014), Cooperative sugar, **45**(9): *www. sugarcane res.in SBI website*

Cochran W. G. R. and Cox G. M., (1965), *Experimental Design*, Asia Publishing House, Bombay (India).

Rakkiyappan P., Thangavelu S., Malathi R. and Radhamani R., (2001), Effect of biocompost and enriched press mud on sugarcane yield and quality, *Sugartech,* **3**(3): 92-96.

Saini S. K., Rajesh A., Vijendar Singh and Sinha S. K., (2006a), Effect of fly ash, press mud cake and phosphorus solubilising bacteria (PSB) on yield, growth and quality of sugarcane, *Indian Sugar,* July 2006, pp. 25-28.

Shankaraiah C. and Kalyanamurthy K. N., (2005), Effect of enriched press mud cake on growth, yield and quality of sugarcane, *Sugartech*, **7**(2&3), 1-4.

Sharma B. L., Singh R. R. and Singh S. B., (2003), Integrated response of phosphorus solubilising bacteria (PSB) with press mud cake on sugarcane in calcareous soils, *Cooperative Sugar,* **35(**1): 37-40.

Sonawane D. A. and Sabale R. N., (2000), Effect of different sources of organic nitrogen on growth, yield and quality of Suru sugarcane, *J. Maharashtra Agric. Univ.,* **25**(1): 15-17.

Venkatakrishnan D. and Ravichandran M, (2007), Effect of organic manures and fly ash on nutrient uptake of sugarcane, *Indian Sugar,* February 2007, pp. 41-46.