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Integrated nutrient management for sustainable cane production

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ABSTRACT

A field experiment was conducted during the crop season of 1998–99 and 1999–2000, to study the influence of integrated use of organic sources with different levels of mineral nutrients. Integrated use of pressmud at 5 tonnes/ha with NPK application @ 100% of the recommended dose influenced the yield attributes, nutrient uptake and remarkably increased the cane yield. It was comparable with conjuctive use of pressmud @5 tonnes/ha with NPK @ 100% of the recommended dose. But the magnitude of variation in cane yield was only marginal. Hence, it was possible to save 25% of the recommended dose of NPK when pressmud was applied @5 tonnes/ha. There was a drastic decrease in cane growth and cane yield when resorted to mineral nutrition alone. The juice quality also improved when organic sources were integrated with mineral nutrients.

Key words : Organic sources, Mineral nutrition, Yield attributes, Cane yield, Nutrient uptake, Juice quality

In Kerala, the scenario of sugarcane cultivation is confined to the deltaic belts of rivers, viz. Pampa, Manimala and Achenkovil, coming under Alleppey, Pathanamthitta and Kottayam districts, semi-arid tracts of Palghat and in the high ranges of Idukki district. There exists a gap between the genetic potential yield and actual yield achieved. This yield gap has to be narrowed and bridged. The major constraints for achieving potential yield is the problems associated with soil fertility. The long-term experiments conducted on manures and fertilizers in sugarcane proved that neither the chemical fertilizer alone nor the organic sources exclusively can achieve production sustainability of soil and crop (Singh and Biswas, 2000). However, the integrated use of organics with inorganic can restore and sustain soil fertility and productivity. The present study was undertaken to economize the use of mineral fertilizer through integrated nutrient management and to formulate a sustainable production technology by integrating organic, inorganic and biological sources of nutrients for maximum cane yield.

MATERIALS AND METHODS

The experiment was laid out in a strip-plot design during the crop season of 1998–99 and 1999–2000 at Sugarcane Research Station, Thiruvalla, with 6 organic sources in strip 1 and 3 fertilizer levels in strip II constituting 18 treatments combinations with 4 replications. The organic sources consisted of control (T_1), application of pressmud @ 5 tonnes/ha (T_2), application of trash @ 10 tonnes/ha (T_3), green manuring with intercropped cowpea (T_4), application of *Acetobacter diazotrophicus* at 10 kg/ha (T_5) and application of *Azospirillum brasilense* 10 kg/ha (T_6). Under mineral nutrition, the treatments were NPK application at 50% (F_1), 75% (F_2) and 100% (F_3) of the recommended dose. Green manuring was taken up with cowpea 'C-152' in the interspaces of sugarcane and incorporated @ 45 days after planting (DAP). *Azospirillum brasiliense* was applied as soil inoculation. While in the case of *Acetobacter diazotrophicus*, prior to planting the setts were treated with 50% of the biofertilizer and the remaining was applied as pocket application at 45 DAP.

The soil was entisol, acidic reaction, medium in available N and available K and low in available P. The test variety used for the study was 'Madhuri'. The trash, green tops and stem obtained at harvest through destructive sampling were used for finding out the dry-matter production and chemical analysis of N, P, K, Fe, Mn, Zn and Cu (Jackson, 1973). The crop was raised as per package of practices recommendations with exception to the manurial schedule.

RESULTS AND DISCUSSION

Effect of organic sources

Organic sources had significant impact on yield attributes, cane yield, nutrient uptake and juice quality (Tables 1, 2 and 3). Among the organic sources, pressmud application (T_2) appreciably increased the cane

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Table 1. Effect of organic sources and mineral nutrition on yield attributes and cane yield

Treatment	Cane girth (cm)		Cane length (cm)		Single cane weight (g)		Millable cane count ('000)		Cane yield (tonnes/ha)	
	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop
T_1	8.7	7.5	236	228	1,025	1,023	90.34	91.42	91.02	90.16
T_2	10.0	8.8	278	261	1,278	1,264	101.48	99.22	127.56	121.37
T_3	9.1	8.4	252	242	1,142	1,082	94.35	93.23	104.63	100.15
T_4	9.5	8.6	264	252	1,200	1,193	97.77	96.41	115.68	111.47
T_5	9.4	8.5	261	248	1,188	1,178	96.63	95.61	112.90	109.23
T_6	9.7	8.7	270	257	1,234	1,218	99.75	98.05	120.40	115.53
CD (P=0.05)	0.14**	0.10**	5.38**	3.78**	9.99**	23.90**	1.23**	0.56**	2.09**	2.49**
F_1	9.2	8.3	253	243	1,147	1,125	95.12	94.46	106.42	103.48
F_2	9.4	8.4	260	246	1,179	1,162	96.82	95.88	112.56	108.34
F_3	9.6	8.6	267	254	1,210	1,192	98.22	96.88	117.11	112.13
CD (P=0.05)	0.07**	0.10**	4.01**	3.83**	3.26**	8.78**	0.54**	0.39**	0.43**	0.6**
T_1F_1	8.4	7.0	220	216	961	979	87.50	88.98	82.22	83.74
T_1F_2	8.8	7.4	237	221	1,004	1,018	90.09	91.76	89.90	89.91
T_1F_3	9.0	8.4	251	230	1,109	1,072	93.42	93.52	100.92	96.85
T_2F_1	9.7	8.6	272	256	1,240	1,227	99.35	97.86	120.28	115.09
T_2F_2	10.0	8.8	275	264	1,280	1,270	101.67	99.25	128.24	121.83
T_2F_3	10.3	9.0	287	279	1,314	1,296	103.42	100.55	134.17	127.20
T_3F_1	8.9	8.4	247	238	1,106	1,046	92.87	92.59	97.88	94.35
T_3F_2	9.1	8.4	253	242	1,151	1,086	94.72	93.87	16.48	101.66
T_3F_3	9.2	8.5	257	246	1,169	1,113	95.46	94.72	109.54	104.44
T_4F_1	9.4	8.5	259	270	1,181	1,168	96.6	95.46	112.13	108.79
T_4F_2	9.5	8.6	265	251	1,207	1,191	98.05	96.47	116.49	111.76
T_4F_3	9.6	8.7	269	256	1,213	1,219	98.60	97.31	118.43	113.86
T_5F_1	9.3	8.5	256	248	1,175	1,145	96.20	94.91	110.55	105.92
T_5F_2	9.4	8.5	261	245	1,191	1,183	96.48	95.63	113.15	109.54
T_5F_3	9.5	8.6	266	250	1,199	1,205	97.22	96.29	114.99	112.22
T_6F_1	9.5	8.6	267	251	1,205	1,184	98.14	96.94	115.46	112.99
T_6F_2	9.7	8.7	270	255	1,213	1,226	99.90	98.33	121.11	115.37
T_6F_3	9.8	8.7	273	263	1,255	1,244	101.20	98.88	124.63	118.22
CD (P=0.05)	0.21**	0.20**	5.98**	5.47**	15.44**	NS	0.82**	0.82**	1.87**	1.93**

Details of treatments are given under Materials and Methods

Table 2. Effect of organic sources and mineral nutrition on juice quality

Treatment	Juice recovery (%)		Sucrose (%)		CCS (%)		SMT brix (%)		Reducing sugar (%)		Titrable acidity (ml of 0.1 NaOH 100/m)	
	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop
T_1	53.6	54.9	15.4	15.7	10.9	11.0	16.1	17.4	1.0	1.0	12.9	13.1
T_2	55.9	58.8	15.6	16.8	11.2	11.9	16.3	17.9	0.9	0.8	10.7	11.3
T_3	55.0	57.9	15.1	15.7	11.0	11.1	16.06	17.4	1.1	1.0	12.3	12.1
T_4	56.0	58.6	15.9	16.6	11.3	11.6	16.8	18.5	1.0	0.8	12.1	11.9
T_5	55.3	57.2	15.9	16.6	11.1	11.5	17.4	18.4	0.9	0.8	10.7	11.1
T_6	56.7	59.9	16.1	16.7	11.6	12.0	16.7	17.7	0.9	0.8	9.3	10.6
CD (P = 0.05)	1.62*	1.06**	0.61*	0.61*	NS	0.37**	0.83**	NS	0.06**	0.06**	1.01**	0.92**
F_1	54.8	56.9	15.6	16.2	11.1	11.4	17.0	17.9	1.0	0.9	11.0	11.1
F_2	55.5	58.2	15.6	16.5	11.1	11.6	16.5	18.1	1.0	0.9	11.7	11.9
F_3	56	58.5	15.8	16.3	11.3	11.6	16.8	17.6	0.9	0.9	11.3	12.0
CD (P=0.05)	0.86	0.93*	NS	NS	NS	0.37**	NS	NS	NS	0.04**	NS	0.68**

Details of treatments are given under Materials and Methods

girth, cane length, canesweight, millable cane count and resulted in the highest cane yield. It was superior to all other organic sources and it was closely followed by *Azospirillum* inoculation (T_6). The treatment without organic sources (T_1) recorded the lowest values for yield attributes as well as cane yield. The total uptake of N, P and K was highest in treatments with pressmud application (T_6). While *Azospirillum* inoculation remarkably increased the uptake of Fe, Mn, Zn and Cu.

Application of pressmud results in the release of major and minor nutrients when it undergoes mineralization. This would have increased the availability of plant nutrients and addition of organic matter to the soil.sAs a result of this, the fertility status of the soil increased and the absorption of plant nutrients might have also increased. The above factors might have favourbaly influenced the cane growth and attributed to the production of lengthier, thicker and heavier canes. The increased rate of cane growth coupled with better expression of yield attributes might have attributed for enhancing the cane yield in pressmud-applied and *Azospirillum*-inoculated plots. The results are in agreement with the findings of Sharma *et al.* (1999), Rao and Veeranna (1999) and Nagaraju *et al.* (2000).

While with juice quality, *Azospirillum* inoculation (T_6) invariably increased the value of juice recovery, sucrose content and CCS per cent. But recorded lower values for titrable acidity and reducing sugar. Bio-fertilizers are capable of synthesizing growth hormones and growth regulators in addition to the fixation of N. The phytohormones and other growth-regulators liberated in the treatment under *Azospirillum* inoculation (T_6) might have produced favourable effects in the soil for cane growth and nutrient uptake. This might have contributed for improving the quality parameters of cane juice (Perumal, 1999; Sharma *et al.*, 1999).

Effect of mineral nutrition

Application of NPK at 100% (F_3) of the recommended dose influenced the yield attributes, cane yield, nutrient uptake and recorded the highest value. It was statistically superior to NPK application at 75% (F_2) and 50% (F_1). But in the case of juice quality, the treatment effects due to mineral nutrition was significant only for juice recovery in both plant crops. While CCS per cent, reducing sugar and titrable acidity were significant only in second plant crop.

There is no second opinion that chemical fertilizers contribute a major share for enhancing the productivity of cane. The steady supply of plant nutrients in adequate quantities increased the availability of plant nutrients in the soil and mediates favourable environment for the absorption of nutrients. This again exerts positive effects on growth and development of cane. The results are in conformity with the findings of Bangar *et al.* (2000).

Interaction

The interaction effect between organic sources and mineral nutrition was significant for yield attributes, cane yield and nutrient uptake of F, K, Fe, Mn, Zn and Cu (Tables 1, 3). However, the interaction effect was non-significant for any of the juice parameters studied. Integrated use of pressmud with mineral nutrition at 100% of the recommended dose of NPK (T_2F_3) recorded maximum values for yield attributes, total uptake of NPK and resulted in the highest cane yield. It was closely followed by pressmud application with mineral nutrition at 75% (T_2F_2) and *Azospirillum* inoculation with mineral nutrition

Table 3. Effect of organic sources and mineral nutrition on the uptake of major and micronutrients

Treatment	Total uptake of N (kg/ha)		Total uptake of P (kg/ha)		Total uptake of K (kg/ha)		Total uptake of Fe (kg/ha)		Total uptake of Mn (kg/ha)		Total uptake of Zn (kg/ha)		Total uptake of Cu (kg/ha)	
	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop	First plant crop	Second plant crop
T_1	120.7	108.0	34.7	32.5	64.1	57.7	15.7	15.2	2.2	3.4	0.4	0.4	1.4	1.3
T_2	218.3	190.0	82.9	74.7	139.3	127.7	18.2	20.3	4.3	5.6	0.8	0.7	2.3	2.1
T_3	152.7	133.5	45.6	39.7	55.8	75.1	27.8	26.1	4.1	6.5	0.5	0.5	1.7	1.6
T_4	185.4	158.5	65.8	56.8	107.6	94.2	21.9	20.7	3.8	5.2	0.6	0.6	1.8	1.6
T_5	173.4	149.4	60.9	53.0	102.7	88.6	22.2	15.5	5.2	5.7	0.6	0.5	1.8	1.6
T_6	201.8	174.9	78.3	68.6	122.2	109.4	133.0	31.2	6.3	8.7	0.8	0.0	1.9	1.8
CD (P=0.05)	8.61**	15.13**	2.92**	3.12*	4.30**	3.81**	3.14**	3.09**	0.13**	0.80**	0.03**	0.02**	0.04**	0.04**
F_1	162.8	141.3	55.0	48.3	92.9	81.9	19.8	19.8	4.0	5.4	0.6	0.5	1.7	1.6
F_2	176.2	154.3	60.9	54.4	104.2	91.9	23.1	21.5	4.8	5.9	0.6	0.6	1.8	1.7
F_3	187.1	162.5	68.2	59.5	113.7	101.2	26.5	23.2	4.7	6.4	0.7	0.6	1.9	1.8
CD (P=0.05)	4.76**	10.22**	1.14**	1.15**	1.18**	1.71**	1.28**	0.81**	0.15**	0.17**	0.01**	0.01**	0.04**	0.02**
T_1F_1	99.8	90.9	28.8	27.3	50.7	47.6	13.2	12.6	4.8	2.7	0.3	0.3	1.2	1.2
T_1F_2	119.0	112.1	33.9	32.4	60.4	55.1	15.2	14.6	2.0	3.3	0.4	0.4	1.4	1.3
T_1F_3	143.2	120.9	41.3	37.7	81.3	70.5	18.8	18.5	2.7	4.2	0.4	0.4	1.8	1.5
T_2F_1	201.6	125.6	74.5	65.1	119.7	106.2	14.8	19.1	4.0	5.2	0.8	0.7	2.2	1.9
T_2F_2	221.7	194.7	80.6	75.2	144.9	122.3	16.8	20.2	4.3	5.6	0.9	0.7	2.3	2.1
T_2F_3	231.5	205.6	93.5	83.9	153.2	140.6	23.0	21.6	4.6	6.0	0.9	0.8	2.4	2.2
T_3F_1	140.9	122.1	39.3	35.3	76.8	66.8	26.2	24.8	3.7	6.1	0.5	0.4	1.5	1.4
T_3F_2	155.5	136.2	48.6	40.7	88.0	77.5	27.9	26.1	4.2	6.6	0.5	0.5	1.8	1.6
T_3F_3	161.7	142.0	49.3	48.1	92.7	80.9	29.2	27.3	4.2	6.9	0.6	0.5	1.9	1.7
T_4F_1	176.0	150.8	52.9	51.5	99.7	87.3	18.2	19.7	3.6	4.8	0.6	0.5	1.7	1.6
T_4F_2	183.8	152.0	64.4	55.7	107.6	94.7	22.7	20.6	3.9	5.2	0.6	0.6	1.8	1.6
T_4F_3	196.2	167.8	75.1	63.1	115.5	100.7	23.8	21.8	4.0	5.5	0.7	0.6	1.9	1.7
T_5F_1	164.2	146.2	56.1	47.9	98.2	83.2	14.1	13.0	4.9	5.1	0.6	0.5	1.7	1.6
T_5F_2	175.8	150.7	59.1	52.9	101.2	88.0	23.0	16.2	5.2	5.7	0.6	0.5	1.8	1.6
T_5F_3	180.4	156.3	67.6	58.1	108.7	94.7	25.6	17.4	5.5	6.2	0.6	0.6	1.8	1.6
T_6F_1	194.5	167.2	73.4	62.8	112.6	100.1	34.4	29.6	6.0	8.2	0.7	0.6	1.9	1.7
T_6F_2	201.6	174.9	79.0	69.8	123.0	108.5	32.8	31.1	6.3	8.6	0.8	0.7	1.9	1.8
T_6F_3	209.3	182.5	82.5	73.2	131.0	119.7	34.7	32.8	6.7	9.2	0.8	0.7	2.0	1.8
CD (P=0.05)	NS	NS	NS	NS	6.52**	3.81**	1.45**	0.94**	NS	0.19**	0.01**	0.01**	0.08**	0.05**

Details of treatments are given under Materials and Methods

at 100% of the recommended dose of NPK (T_6F_3). The total uptake of Fe, Mn, Zn and Cu increased with soil inoculation of *Azospirillum* at 10 kg/ha in combination with NPK at 100% of the recommended dose (T_6F_3).

It was observed that integration of pressmud with NPK application at 100% of the recommended dose had increased the cane yield to the tune of 4.51% compared to pressmud application at 5 tonnes/ha with mineral nutrition at 75%. But the magnitude of variation was only marginal. Hence it is possible to save 25% of the recommended dose of NPK.

Intensive cultivation without the addition of organic sources affects the productivity of soil. It is well realized that substantial qantities of chemical fertilizers applied to the soil are not amenable to the plants. A sizeable portion is lost by various mechanisms operating in soil. Integrated use of organic sources with chemical fertilizer enables to conserve the nutrients, release of nutrients at slower rate and improves the physico-chemical and biological condition of soil. This could be the reason for the treatments with chemical fertilizer application alone to record reduced levels of cane production.

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