Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 1158-1161
Received: 10-05-2019
Accepted: 12-06-2019

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Organic nutrient management practices on the yield and quality of sugarcane

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Abstract
Field experiment was conducted to study the response of two sugarcane cultivars (SNK 09211 (C_1) and SNK 07680 (C_2) to different organic nutrient management practices [N_1: 100% organics through farmyard (FYM), vermicompost (VC), *in situ* green manuring of *Dhaincha* (IGM) equivalent to RDN, N_2: 100% organics through FYM, VC, biodigetser filtrate (BDF) 1/3rd each equivalent to RDN, N_3: 100% organics through FYM and BDF (50% each) equivalent to RDN, N_4: 100% organics through FYM and VC (50% each) equivalent to RDN, N_5: Farmers practice and N_6: Recommended package of practices (RPP)] with special reference to jaggery production and quality during 2017-18 at permanent organic site at ARS, Sankeshwar. The results revealed that, SNK 07680 recorded significantly higher cane weight, No. of millable cane and cane yield (128 t ha^{-1}) compared to C_1. Cultivar SNK 07680 also recorded significantly higher sugar yield over SNK 09211. Quality parameters of sugarcane did not differed significantly among cultivars, NMPs and their combined effects. Among the nutrient management practices (NMPs), RPP recorded higher number of millable cane and cane yield (131 t ha^{-1}) compared other NMPs. Among the organic treatments 100% organics through FYM, VC and IGM equivalent to RDN recorded significantly higher cane (126 t ha^{-1}) and sugar yield (17.30 t ha^{-1}) over organic treatments. N_1 recorded significantly higher gross and net returns (Rs.3,78,300, and 2,38,550 ha^{-1}) over rest of the treatments. While, BC ratio was higher (3.19) with N_3 than other treatments.

Keywords: Sugarcane yield, organic nutrient management practices, organic cane

Introduction
Sugarcane is the major cash crop in India, responsible for the overall socio-economic development of the farming community. It is cultivated on 5.0 million hectares providing an annual sugarcane production of 362 million tones and average productivity is thus relatively low, at 71.4 t/ha. Major cane producing states are Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka and Gujarat (Anon., 2017) [2]. Organics like farm yard, composts, sugar and biodigetser filterate, sugarcane trash composts etc., improves the growth and yield due to balanced supply of all essential nutrients in right proportion and slow release throughout the cropping season. Various organic sources like farm yard (FYM), vermicompost, green, legume as intercrops and sugarcane trash are used as sources of nutrients since ages, of late, from the green revolution era; fertilizers have come into picture from the point of view of sugarcane nutrition. Now they have attained a major proposition notwithstanding the importance of organics. The recent trend is over dependence on fertilizer nutrients in sugarcane. However, on a long run, proper blend of organic and inorganic sources is needed. Organic sources of nutrients not only help in supplementing the nutrients to sugarcane but also maintain favourable physical, chemical and biological soil environment. Long term fertilizer experiments have indicated the need for basal application of FYM for maintaining optimum fertility status. Many workers have studied the effect of organics as a source of plant nutrients. It also enriches the soil in terms of organic matter which improved the physical properties of the soil especially the water transmission characteristics of soil. Increase in the available nitrogen with application of bio-compost and farmyards may be attributed to the incorporation of organic matter which enhances the multiplication of microbes by incorporation of different organic sources for the conversion of organically bound N to inorganic form (Sinha *et al.*, 2014) [9]. Looking to the importance of organic nutrient management practices, a field investigation was carried out to study the effect of organic sources of nutrients on yield and quality of sugarcane.

Material and Methods
The experiment conducted at the Agricultural Research Station (ARS), Sankeshawar is situated at 16° 14' North latitude and 74° 29' East longitude with an altitude of 624 m above

the mean sea level which lies in northern transition zone of Karnataka (Zone-8) and Region-II of Agro climatic zones of India. The soil of the experimental site belongs to the order Vertisols. Texturally the soils are medium black soil. The soils are neutral in reaction; low in organic carbon, available nitrogen, medium in available phosphorus and high in available potassium.

The field trail was laid out in strip plot design during 2017-18 at permanent organic site with two newly released sugarcane cultivars (SNK 09211 and SNK 07680) as main plot treatments and six different nutrient management practices as sub plot treatments *viz.,* N_1: 100% organics through farmyard (FYM), vermicompost (VC), *in situ* green manuring of *Dhaincha* (IGM) equivalent to RDN, N_2: 100% organics through FYM, VC, biodigetser filtrate (BDF) 1/3rd each equivalent to RDN, N_3: 100% organics through FYM and BDF (50% each) equivalent to RDN, N_4: 100% organics through FYM and VC (50% each) equivalent to RDN, N_5: Farmers practice (documented based on survey) and N_6: Recommended package of practices (RPP) consisting of fertilizers 250: 75 : 190 kg N: P_2O_5: K_2 O ha^{-1} respectively, $ZnSO_4$ and $FeSO_4$ @ 25 kg ha-1 each, coupled with organic s (FYM @ 25 t ha-1), and Bio-fertilizers: *Azospirillum* and phosphorus solubilizing bacteria (PSB) @ 10 kg ha-1. All the organic sources were applied to plant crop in two splits @ 50 per cent as basal dose and remaining 50 per cent as top dress at 14th weeks after planting. The fertilizer nutrients were applied as per recommendation. *i.e.,* 10 per cent of nitrogen as basal and remaining 90 per cent in 3 splits @ 20, 30 and 40 per cent of N at 6, 10 and 14th weeks after planting as top dressing and entire phosphorus and potassium were applied as basal dose. The fertilizers were incorporated into the soil in the plough furrows by covering the soil.

Sugarcane sets were treated with *Gluconacetobacter* @ 4 l ha-1 (N1 to N_4). However, for RPP treatment chemical set treatment was done for 10 minutes with carbendazim 50 WP @ 1 g l-1 and chlorpyriphos 20 EC @ 1 ml l-1. The organic s *viz.,* biodigester filterate, farm yard, vermicompost and *Dhaincha* were analyzed for their nutrient content before application for making N equivalent nutrient application. The *in situ* green crop, *Sesbania acculeta* L. (*Dhaincha*) was sown in between the rows of sugarcane by dibbling the seeds at both side of the ridge and incorporated at 45 days after planting (DAP). *Azospirillum* and PSB @ 10 kg ha-1 were applied along with the organic s at the time of organic s application to fully organic treatments (N_1 to N_5) and for RPP. Liquid organic s like *Gluconacetobacter* was applied @ 5% at 30 DAP and Panchagavya was applied as foliar spray @ 3 per cent at 60 and 90 DAP to all the organic treatments (N1, to N4). The data on yield indices and yields were recorded at harvest (300 and 360 DAP). Quality parameters of cane were analyzed as per standard procedure and treatment wise economics were worked out. The data collected were statistically analyzed by using MSTATC programme according to Gomez and Gomez (1984) [3].

Results and Discussion

Effect on Cane Yield and Yield attributes (cf. Table 1)

The number of millable canes differed significantly among NMPs and combined effect of NMPs and cultivars. However, was no significant difference due to cultivars. Among NMPs, RPP (N_6) recorded significantly higher number of millable canes (88960 ha^{-1}) than other nutrient management practices, except N_1 and N_2. Both were at par with best treatment. Interaction among the cultivars and NMPs showed that, SNK 07680 and SNK 09211 recorded higher number of millable canes with RPP (N_6) and lowest was with farmer practice (N_5) than other NMPs.

Single cane weight differed significantly due to cultivars and NMPs. Among the cultivars, SNK 07680 recorded significantly higher single cane weight (1.24 kg $cane^{-1}$) as compared to SNK 09211 (1.16 kg $cane^{-1}$). In NMPs, N_1, N_2, N_3, N_4 and N_6 recorded significantly higher single cane weight than N_5 (Farmer practice).The combined effect of NMPs and cultivars on single cane weight did not differed significantly.

The cultivar SNK 07680 recorded higher cane yield (128.1 t ha^{-1}) than SNK 09211 (116 t ha^{-1}).Significantly higher cane yield was observed with RPP (131.3 t ha^{-1}) than other nutrient management practices. Lower cane yield was with farmer practice (112.8 t ha^{-1}).The combined effect of NMPs and cultivars showed that, both cultivars recorded significantly higher cane yield with RPP (N_6), N_1 and N_2 which were inturn at par with each other. Significantly lower cane yield was recorded with N_5 (Farmer practice).The results are in confirmity with the findings of Kuri and Chandrashekhara (2015) [5], who reported that CoSnk 05104 showed higher yield and yield attributing characters followed by CoSnk 07103 and Co 92005 and among NMPs, RPP recorded higher yield attributes and cane yield over organic NMPs.

Table 1: Number of millable canes, Single cane weight and Cane yield of planted sugarcane as influenced by organic, integrated nutrient management practices and cultivars

Nutrient management practice (NMP)		Number of millable canes (000 ha-1)			Single cane weight (kg)			Cane yield (t ha-1)		
		Cultivars			Cultivars			Cultivars		
		C1	C2	Mean	C1	C2	Mean	C1	C2	Mean
N1	100% organics equivalent to RDN through FYM (1/3rd) +IGM (1/4th) +VC (1/2th)	88.50ab	88.97ab	88.74a	1.18a	1.29a	1.24a	119.8cd	132.4ab	126.1b
N2	100% organics equivalent to RDN through FYM+ VC+BDF (1/3rd each)	86.95a-c	86.81a-c	86.88a	1.12a	1.24a	1.18a	117.8c-e	130.4ab	124.1b
N3	100% organics equivalent to RDN through FYM + BDF (50% each)	85.72a-c	85.47a-c	85.60b	1.16a	1.21a	1.19a	113.2de	126.5bc	119.8c
N4	100% organics equivalent to RDN through FYM + VC (50% each)	85.10a-c	84.90bc	85.00b	1.14a	1.24a	1.19a	111.9de	124.6bc	118.3c
N5	Farmers Practice	83.21c	83.40c	83.31b	1.10a	1.20a	1.15b	108.0e	117.5c-e	112.8d
N6	Recommended package of practices (RPP)	88.68ab	89.24a	88.96a	1.19a	1.29a	1.24a	125.4bc	137.1a	131.3a
Mean		86.36a	86.47a		1.16b	1.24a		116.0b	128.1a	
		S.Em±			S.Em±			S.Em±		

Cultivars (C)	0.12	0.02	0.91
Nutrient management practices (NMP)	0.86	0.03	1.03
Main plot at same level of sub plot	1.01	0.08	1.71

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)
FYM- Farm Yard, BDF-Biodigester filtrate, VC- Vermicompost, IGM-*Insitu* green manuring, C 1- SNK 09211 C2- SNK 07680, DAP- Days after planting

Effect on sugarcane juice quality parameters (cf. Table 2 and 3)

The data on sugarcane juice quality parameters like juice extraction, brix, pol, purity and CCS per cent indicated that the values were not significantly influenced by the application of different sources of nutrients, due to influence of cultivars and combined effect of NMPs and cultivars. Findings of the present study are in tune with Rakkiyappan *et al.* (2001) [8], Esther *et al.* (2012), Umesh *et al.* (2013) and Kuri (2014) [6] who analyzed that, juice quality mainly depends upon genetic nature of the variety although nutrient management practices cause less considerable variation in juice brix, sucrose, purity and CCS%.

The CCS yield significantly due to cultivars NMPs and their combined effect. Among cultivars, SNK 07680 recorded higher CCS yield (17.21 t ha^{-1}) than SNK 09211 (15.68 t ha^{-1}). In NMPs, significantly higher CCS yield with RPP (N_6). The next best treatment were N_1 to N_4 which were on par with each other with the best treatment lower CCS yield (14.86 tha^{-1}) was with farmer practice (N_5).The combined effect of NMPs and cultivars showed that, both cultivars recorded significantly higher CCS yield with RPP (N_6) which was on par with all the treatment combinations except SNK 09211 with farmer practice (N_5). The similar increased quality parameters in the cultivar Co 86032 were also reported by earlier workers Kadam *et al.* (2005) [4], Manimaran and Kalyanasundaram (2006) [7].

Table 2: Juice extraction, Brix, Pol and Purity of planted sugarcane as influenced by organic, integrated nutrient management practices and cultivars

Nutrient management practices (NMP)		Juice extraction (%)			Brix (%)			Pol (%)			Purity (%)		
		Cultivars			Cultivars			Cultivars			Cultivars		
		C1	C2	Mean	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean
N1	100% organics equivalent to RDN through FYM (1/3rd) +IGM (1/4th) +VC (1/2th)	62.12b	65.12a	63.62a	20.92a	22.42a	21.67a	19.65a	19.58a	19.62a	91.88a	91.58a	91.73a
N2	100% organics equivalent to RDN through FYM+ VC+BDF (1/3rd each)	62.10b	65.00a	3.55a	21.42a	20.41a	20.92a	19.30a	19.32a	9.31a	90.42a	90.50a	90.46a
N3	100% organics equivalent to RDN through FYM + BDF (50% each)	62.01b	65.10a	63.56a	21.42a	21.92a	21.67a	19.54a	19.21a	19.38a	91.42a	90.04a	90.73a
N4	100% organics equivalent to RDN through FYM + VC (50% each)	62.00b	65.12a	63.56a	21.92a	21.42a	21.67a	19.74a	19.15a	19.45a	92.25a	89.79a	91.02a
N5	Farmers Practice	62.10b	65.20a	63.65a	21.92a	21.88a	21.90a	18.98a	19.32a	19.15a	89.08a	90.50a	87.79a
N6	Recommended package of practices (RPP)	62.20b	65.40a	.80a	20.92a	19.56a	20.24a	18.86a	18.74a	18.80a	88.58a	88.08a	88.33a
Mean		62.09b	65.16a		21.42a	21.27a		19.35a	19.22a	19.28	90.60a	90.08a	
		S.Em+			S.Em+			S.Em+			S.Em+		
Cultivars (C)		0.75			0.31			0.09			0.64		
Nutrient management practices (NMP)		0.52			0.47			0.24			0.41		
Main plot at same level of sub plot		1.14			0.83			0.64			0.68		

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)
FYM- Farm Yard, BDF-Biodigester filtrate, VC- Vermicompost, IGM-*Insitu* green manuring, C 1- SNK 09211 C2- SNK 07680

Table 3: the mean sea level which lies in northern transition zone of Karnataka (Zone-8) and Region-II of Agro climatic zones of India. The soil of the experimental site belongs to the order cultivars

Nutrient management practices (NMP)		CCS (%)			CCS Yield (t ha-1)		
		Cultivars			Cultivars		
		C1	C2	Mean	C1	C2	Mean
N1	100% organics equivalent to RDN through FYM (1/3rd) +IGM (1/4th) +VC (1/2th)	13.97a	13.46a	13.72a	16.74ab	17.83ab	17.30a
N2	100% organics equivalent to RDN through FYM+ VC+BDF (1/3rd each)	13.47a	13.79a	13.63a	15.87ab	17.98ab	16.91a
N3	100% organics equivalent to RDN through FYM + BDF (50% each)	13.72a	13.23a	13.47a	15.52ab	16.74ab	16.15a
N4	100% organics equivalent to RDN through FYM + VC (50% each)	13.77a	13.32a	13.55a	15.42ab	16.59ab	6.02a
N5	Farmers Practice	13.00a	13.36a	13.18a	14.04b	15.69b	14.86b
N6	Recommended package of practices (RPP)	13.17a	13.44a	13.30a	16.51ab	18.43a	17.46a
Mean		13.52a	13.43a		15.68b	17.21a	
		S.Em+			S.Em+		
Cultivars (C)		0.26			0.49		
utrient management practices (NMP)		0.40			0.59		
Main plot at same level of sub plot		0.45			0.96		

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)
FYM- Farm Yard, BDF-Biodigester filtrate, VC- Vermicompost, IGM-*Insitu* green manuring, C 1- SNK 09211, C2- SNK 07680

Economics (cf. Table 4)

The gross and net return obtained was varied significantly due to different nutrient management practices and cultivars.

Growing of sugarcane cultivar SNK 07680 resulted in significantly higher gross and net return (Rs. 372.86 and Rs. 242.66 thousand ha^{-1}respectively) as compared to SNK 09211 (Rs. 337.62 and Rs. 207.42 thousand ha^{-1}

respectively).Among the different nutrient management practice, N_1 recorded significantly higher gross and net return (Rs. 378.30 and 238.55 thousand ha^{-1} respectively) than RPP and farmers practice. Whereas, N_2, N_3 and N_4 were on par with each other and with N_1. The interaction effect of different nutrient management practices and cultivars influence on gross return significantly. SNK 07680 and SNK 09211 cultivars supplemented with 100% organics through N_1 recorded significantly higher gross return than RPP and farmer practice. While, both cultivars with N_2, N_3 and N_4 were on par with each other and with N_1. The higher cost of cultivation of organic treatments as compare to 100 per cent inorganic is due to higher requirement of different organic s in bulk to meat out the N requirement (250 kg N ha^{-1}) of sugarcane.

Among the sugarcane cultivars, growing of SNK 07680 resulted in maximum benefit cost ratio (2.86) as compared to SNK 09211 (2.59).The 100 per cent organics through N_3 recorded significantly higher benefit cost ratio (3.19) than other nutrient management practices. The next best treatment was RPP (2.90). While, significantly lower benefit: cost ratio was obtained with application of 100% organics as per FYM + VC (50% each) (2.45) (N_4).The interaction effect of different nutrient management practices and cultivars did not influence on BC ratio significantly. The higher premium price (20-25%) for organic cane as compared to factory rate for normal cane. Therefore, organic sugarcane cultivation coupled with organic jaggery processing fetches good market price in view of health consciousness by consumers. Similar results confirmed by Aluri, (2013) [1] and Kuri (2014) [6].

Table 4: Economic parameters of planted cane as influenced by organic, integrated nutrient management practices and cultivars

Nutrient management practices (NMP)		Cost of Cultivation (Rs.000 ha^{-1})			Gross returns (Rs.000 ha^{-1})			Net returns (Rs.000 ha^{-1})			BC ratio		
		Cultivars			Cultivars			Cultivars			Cultivars		
		C1	C2	Mean	C1	C2	Mean	C1	C2	Mean	C1	C2	Mean
N1	100% organics equivalent to RDN through FYM (1/3rd) +IGM (1/4th) +VC (1/2th)	139.75	139.75	139.75	359.40b-d	397.20a	378.30a	219.65b	257.45ab	238.55a	2.57a	2.84a	2.71cd
N2	100% organics equivalent to RDN through FYM+ VC+BDF (1/3rd each)	140.45	140.45	140.45	353.40cd	391.30a	372.35a	212.95b	250.85ab	231.90ab	2.52a	2.79a	2.65d
N3	100% organics equivalent to RDN through FYM + BDF (50% each)	112.82	112.82	112.82	339.50e	379.50ab	359.50ab	226.68b	266.68a	246.68a	3.01a	3.36a	3.19a
N4	100% organics equivalent to RDN through FYM + VC (50% each)	145.06	145.06	145.06	335.80d-f	373.80a-c	354.80ab	190.74cd	228.74b	209.74c	2.31a	2.58a	2.45e
N5	Farmers Practice	130.12	130.12	130.12	324.10ef	352.50cd	338.30bc	193.98c	222.38b	208.18c	2.49a	2.71a	2.60d
N6	Recommended package of practices (RPP)	112.99	112.99	112.99	313.50f	342.83de	328.17c	200.51bc	229.85b	215.18bc	2.77a	3.03a	2.90b
	Mean	130.20	30.20		337.62b	372.86a		207.42b	42.66a		2.59b	2.86a	
					S.Em±			S.Em±			S.Em±		
Cultivars (C)					5.09			4.92			0.02		
Nutrient management practices (NMP)					6.22			6.41			0.05		
Main plot at same level of sub plot					8.23			9.01			0.35		

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)
FYM- Farm Yard, BDF-Biodigester filtrate, VC- Vermicompost, IGM-*Insitu* green manuring, C1- SNK 09211, C2- SNK 07680
Price: Rs. 3000 t-1 (Organic cane) Rs 2500t-1 (Sugar cane)

Conclusion

The sugarcane genotype SNK 07680 is significantly better for obtaining higher sugarcane yield (128 t ha^{-1}) and economics over SNK 09211.

For organic sugarcane cultivation,

1. Supplementation of nutrients equivalent to 100 per cent recommended dose of nitrogen through Farm Yard (33%), *in situ* green manuring with *Dhaincha* (25%) and Vermicompost (50%) or Farm Yard, Vermicompost and bio digester filtrate @ 33% each along with soil application of bio-fertilizers (*Azospirillum* and PSB @ 10 kg ha^{-1} each.
2. Sett treatment with *Glucan acetobacter* @ 4 l ha^{-1} along with foliar spray at 30 DAP of *Glucan acetobacter* (5%) and panchagavya (3%) at 60 and 90 DAP results in higher sugarcane yield with high monetary returns.

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