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Integration of soil applied fertilizer nitrogen with organics and foliar spray of urea for higher nitrogen use efficiency vis-a-vis crop productivity of sugarcane plant-ratoon system

CH S RAMA LAKSHMI[1], T SREELATHA, A SIREESHA, T USHA RANI, K PRASAD RAO and R ANKAIAH

Regional Agricultural Research Station, Anakapalle – 531001, Visakhapatnam district (A.P)

ABSTRACT

A field experiment was conducted from 2007 to 2010 at Regional Agricultural Research Station, Anakapalle of Andhra Pradesh in sugarcane cultivar '93A145' plant-ratoon system for three consecutive years. Main objective of the investigation was to economize soil applied fertilizer nitrogen through its integration with organic manures and foliar spray of urea in sugarcane. Three years pooled data revealed that significantly highest cane and sugar yields were recorded with 75% fertilizer N + 2% foliar spray of urea which was at par with 100% soil applied fertilizer N. The highest nitrogen use efficiency was however observed in the treatment which received 50% fertilizer N + 2% foliar spray of urea closely followed by 75% fertilizer N + 2% foliar spray of urea. Conclusively, an integrated use of fertilizer N through soil + foliar spray of urea resulted in higher nitrogen use efficiency and productivity besides enhancing soil fertility status than fertilizer N alone.

Key words: Foliar spray of urea, Nitrogen use efficiency, Cane yield, Soil fertility

Nitrogen is the most important nutrient element in influencing the level of crop yield in sugarcane. Sugarcane is an exhaustive crop with an exceedingly high turn-over of plant nutrients in sugarcane agro-ecosystem. Because of low nitrogen status in most of the Indian soils, fertilizer nitrogen must be applied to meet the crop demand. To produce one ton of cane from plant crop, 1.270 kg of nitrogen is required, whereas nearly double the quantity of N is required for the first ratoon crop of sugarcane . Moreover, soil applied nitrogen fertilizers are subjected to greater nitrogen losses resulting into less nitrogen use efficiency in under field conditions.

Since chemical fertilizers have become costly and are expected to be more costly in future, emphasis should be laid on reducing the quantum of applied fertilizers and increasing its use efficiency. On the other hand, farmers are applying huge amounts of nitrogen fertilizers by ignoring the use of organics. As a result, the soil is getting depleted of organic matter and decreasing yield response to applied fertilizer (urea) is often observed. Integrated use of chemical fertilizers and organic manures improves the overall availability of nutrients through synergistic effects. The present experiment was therefore, conducted with a view to economizing soil chemical fertilizers through organic manuring and enhancing N use efficiency by foliar application in sugarcane plant- ratoon system over a period of three years.

[1]Scientist (Soil Science), Email: sitaramalakshmi20@yahoo.com

MATERIALS AND METHODS

A field experiment was conducted on sugarcane Cv. '93A145' plant-ratoon system in clay loam soil at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh for three consecutive years of 2007 to 2010 with the objective of economizing on soil applied chemical nitrogen fertilizers through organic manuring and increasing nutrient use efficiency by its foliar application. The experimental soils were neutral in reaction (7.50) with normal conductivity (0.160 dS/m), medium in per cent organic carbon (0.59%) and low available nitrogen (238 $kgha^{-1}$). Experiment was laid out in a split plot design with three replications. The treatments consisted of S1 (without organic manuring) and S2 (Farm yard manure @ 10 t/ha + vermi compost @ 2.5 t/ha) in main plots and T1 - absolute control, T2 - 50% chemical fertilizer N (soil application), T3 - 75% chemical fertilizer N (soil application), T4 - 100% chemical fertilizer N (soil application), T5 - 50% chemical fertilizer N (soil application) + Spraying of 2% urea thrice at 45, 60 and 90 days after planting/ratooning and T6 - 75% chemical fertilizer N (soil application) + spraying of 2% urea thrice at 45, 60 and 90 days after planting/ratooning in subplots. Recommended dose of chemical fertilizers (RDF) consists of 112 kg N + 100 kg P_2O_5 + 120 kg K_2O/ha for plant crop and 224 kg N + 100 kg P_2O_5 + 120 kg K_2O/ha for ratoon crop. Doses of nitrogen (urea) as per the treatments were applied in two equal splits at 45 and 90 days after planting and full doses of phosphorus (single super phosphate) and

potassic fertilizers (muriate of potash) were applied uniformly to all the plots at the time of planting as basal dose for plant crop where as for ratoon crop half dose of N fertilizers and full dose of P and K fertilizers were applied at the time of stubble shaving itself. Soil samples were collected (30 cm depth) after harvest of plant and ratoon crops. Chemical analysis of soil samples was done as per the procedure described by Tandon (1973). Cane yield was recorded at harvesting. Sugar yield was computed by multiplying cane yield with% CCS. Per cent commercial cane sugar (CCS) was obtained from the formula% sucrose/corrected brix X 100. Nitrogen Use Efficiency was calculated as per nutrient uptake data. In order to compare the effect of various treatments on soil fertility and yield of sugarcane, Analysis of Variance (ANOVA) was performed using standard procedure for split plot design (Chandel 2002).

RESULTS AND DISCUSSION

Cane and Sugar Yield

Among different treatments integrated use of chemical fertilizer (urea) with organic sources registered higher cane and sugar yield than chemical fertilizer alone. Increasing the dose of fertilizer N increased the yields and the highest cane as well as sugar yield was recorded with the treatment receiving 75% chemical fertilizer N + 2% urea spray. So much as it was par with 100% chemical fertilizer N through soil application which might be due to better nitrogen use efficiency and increased dry matter production as a result of their integrated use. The variations in cane yields under S1 (Chemical fertilizers alone) were 43.12 to 81.45 against 51.45 to 87.64 t/ha under S2 (integrated use of chemical fertilizers + organic manures) (Table 1).

It is inferred that integrated use of inorganics and organics gives markedly higher productivity besides bringing out a general improvement in soil fertility status than that of chemical fertilizers alone.

Three years pooled data on cane and sugar yields of ratoon crop (Table 2) revealed that, almost 10 to 12% yields were reduced in ratoon crop compared to plant crop. The yield levels varied from 38.12 to 79.38 t/ha under S1 (chemical fertilizers alone) and 49.12 to 81.80 t/ha under S2 (chemical fertilizers + organic manures) treatments. Difference between plant and ratoon crop might be due to differences in physical conditions of soil as well as nutrient use efficiency between plant crop and ratoon crop. Highest yield attributes i.e stalk population counts at grand growth stage and millable canes at harvest

Table 1 Effect of soil and foliar application of fertilizer nitrogen and organic manures on Cane yield and Sugar yield (t/ha) of plant and ratoon crops (pooled data for 3 years)

Treatments		Cane yield (t/ha)		Sugar yield (t/ha)	
		Without OM	With OM	Without OM	With OM
T1: 0 % RDFN – Control		43.12	51.45	5.26	6.40
T2: 50 % RDFN (soil application)		65.38	70.22	8.19	8.86
T3: 75 % RDFN (soil application)		73.49	78.22	9.24	9.97
T4: 100 % RDFN (soil application)		80.22	86.26	9.79	10.89
T5: 50 % RDFN +2 % urea spray		75.12	79.11	9.17	9.91
T6: 75 % RDFN +2 % urea spray		81.45	87.64	9.95	10.93
Mean		69.8	75.5	8.60	9.49
C.D (0.05)	S	3.9		0.51	
	SxT	4.6		0.72	
C.V (%)		9.8		8.9	

RDFN : Recommended dose of fertilizer nitrogen

Table 2 Effect of soil and foliar application of fertilizer nitrogen and organic manures on Cane yield and Sugar yield (t/ha) of ratoon crop (pooled data for 3 years)

Treatments		Cane yield (t/ha)		Sugar yield (t/ha)	
		Without OM	With OM	Without OM	With OM
T1: 0 % RDFN - Control		38.12	49.12	4.64	6.11
T2: 50 % RDFN (soil application)		61.20	67.58	7.67	8.55
T3: 75 % RDFN (soil application)		67.22	73.40	8.47	9.35
T4: 100 % RDFN (soil application)		78.63	83.58	10.06	10.54
T5: 50 % RDFN +2 % urea spray		71.45	75.43	8.70	9.43
T6: 75 % RDFN +2 % urea spray		79.38	84.22	9.77	10.48
Mean		66.00	72.20	8.12	9.07
C.D (0.05)	S	3.3		0.49	
	S x T	4.2		0.68	
C.V (%)		7.6		8.1	

were recorded in plots with integrated nutrient use which led to the highest cane and sugar yields as compared to plots receiving chemical fertilizers alone (Yaduvanshi and Yadav 1993).

Nitrogen use efficiency in plant and ratoon crops

Three years pooled data on nitrogen use efficiency in plant and ratoon crops (Table 3) revealed that the highest nitrogen use efficiency was observed with the treatment which received 50% fertilizer N + 2% foliar spray of urea than other combinations. This was however closely followed by 75% chemical fertilizers N + 2% foliar spray of urea. Nitrogen use efficiency was less in the treatments which received entire fertilizer N through soil application than reduced levels of soil N + foliar spray of urea. This might be due to minimum losses of foliar applied nitrogen and higher accumulation of nitrogen content in plants. Mean nitrogen use efficiency in plant crop varied from 29.65 to 36.38%, whereas in ratoon crop it ranged between 27.35 to 31.49%. Higher nitrogen use efficiency in plant crop compared to ratoon crop might be due to good soil physical conditions associated with better root growth and nutrient uptake in plant crop.

Nitrogen use efficiency (NUE) was more in organic manures added plots compared to treatments of chemical fertilizers alone. This could be due to continuous supply of nitrogen through mineralization of organic matter and reduction in nitrogen loss on account of formation of organo-mineral complexes. Due to application of farm yard manure and vermin compost, the activity of beneficial microbes and colonization of mycorrhizal fungi increased, These play an important role in mobilization of nutrients and thereby leading to their better availability and uptake by plants resulting in high nitrogen use efficiency (Chakravorti and Samantaray 2006).

Soil fertility status

Three years pooled data on soil fertility status in post-harvest soils of plant and ratoon crops are presented in tables 4 and 5, respectively. Results revealed that the combined application of organic manures with fertilizer N resulted in the higher organic carbon content and available nitrogen in the soil compared to chemical fertilizer N alone. This might have been due to continuous addition of organic manures along with chemical fertilizers which stimulates mineralization and immobilization of plant nutrients thereby affecting their amounts in different organic and inorganic forms in soil (Sihag *et al.* 2005). Comparatively less nitrogen status with low organic carbon content was observed after the harvest of ratoon crop than after plant crop. This might be due to high nutrient demand for ratoon crop than plant crop, which led to greater depletion of nutrients in ratoon crop than that in plant crop. Continuous increase in soil organic carbon and available nitrogen status from first year to third year in all the integrated treatments over fertilizer N alone is attributed to residual and cumulative effects of added organic manures in succeeding crops (Vliet *et al.* 2000 and Singh & Singh 2002). Integrated use of organic and inorganic sources of nutrients were more pronounced in ratoon crop than in plant crop as was evidenced by more difference between main plot treatments. Combined application of organic manures with inorganic fertilizers significantly increased the soil organic carbon content than chemical fertilizer N alone. This corroborates the findings of Singh *et al.* (2001).

The highest organic carbon accumulation was observed in the plot where FYM was applied. The increase in organic carbon content without decline in yield with combined use of organic and inorganic N indicates the sustainability of the system. These findings were in accordance with Kumarjit Singh *et al*. (2005). The favourable soil conditions under the treatments receiving organic manures might have helped in the mineralization of soil nitrogen leading to increase in available nitrogen content. Though pH and EC tended to decrease in manured plots from initial value, the decrease was non significant. Decrease in pH in manured plots is attributed to increase in partial pressure of CO_2 and organic acids consequent upon organic matter decomposition.

Table 3 Effect of soil and foliar application of fertilizer nitrogen and organic manures on Nitrogen Use Efficiency in Plant and ratoon crops (pooled data for 3 years)

Treatments	Plant crop		Ratoon crop	
	Without OM	With OM	Without OM	With OM
T1: 0 % RDFN - Control	--	--	--	--
T2: 50 % RDFN (soil application)	27.50	31.80	25.50	29.20
T3: 75 % RDFN (soil application)	28.15	32.35	25.11	30.85
T4: 100 % RDFN (soil application)	29.50	34.25	26.10	30.75
T5: 50 % RDFN +2 % urea spray	33.50	39.25	28.45	34.52
T6: 75 % RDFN +2 % urea spray	32.45	36.75	28.90	33.55
Mean	30.22	34.88	26.81	31.77
C.D (0.05) S	2.5		2.2	
S x T	3.4		3.1	
C.V (%)	7.8		7.1	

Table 4 Effect of soil and foliar application of fertilizer nitrogen and organic manures on soil chemical properties after the harvest of plant crop

		pH		EC (dS/m)		OC (%)		Available N (kg/ha)	
		Without OM	With OM	Without OM	With OM	Without OM	With OM	Without OM	With OM
Initial		7.50		0.160		0.59		238	
T1: 0 % RDFN Control		7.61	7.60	0.106	0.057	0.52	0.60	239	255
T2: 50 % RDFN (soil appli)		7.70	7.47	0.087	0.091	0.55	0.63	248	259
T3: 75 % RDFN (soil appli)		7.64	7.57	0.078	0.106	0.54	0.60	251	265
T4: 100 % RDFN (soil appli)		7.58	7.43	0.074	0.066	0.57	0.62	257	272
T5: 50 % RDFN +2 % spray		7.57	7.47	0.111	0.068	0.56	0.61	252	272
T6: 75 % RDFN +2 % spray		7.67	7.21	0.089	0.176	0.58	0.63	255	271
Mean		7.63	7.46	0.091	0.094	0.57	0.62	250	266
C.D (0.05)	S	-		-		0.032		12.5	
	S x T					0.041		15.1	
	C.V (%)	11.3		10.8		9.7		8.9	

Table 5 Effect of soil and foliar application of fertilizer nitrogen and organic manures on soil chemical properties after the harvest soils of ratoon crop

		pH		EC (dS/m)		OC (%)		Available N (kg/ha)	
		Without OM	With OM	Without OM	With OM	Without OM	With OM	Without OM	With OM
Initial		7.50		0.160		0.59		238	
T1: 0 % RDFN Control		7.58	7.28	0.211	0.208	0.50	0.55	202	235
T2: 50 % RDFN (soil appli)		7.62	7.19	0.298	0.188	0.53	0.58	213	239
T3: 75 % RDFN (soil appli)		7.66	7.22	0.118	0.213	0.54	0.58	218	242
T4: 100 % RDFN (soil appli)		7.58	7.31	0.201	0.204	0.53	0.62	224	248
T5: 50 % RDFN +2 % spray		7.49	7.21	0.208	0.278	0.54	0.61	220	244
T6: 75 % RDFN +2 % spray		7.18	7.30	0.268	0.297	0.55	0.63	221	245
Mean		7.52	7.25	0.217	0.231	0.53	0.60	216	242
C.D (0.05)	S	--		--		0.028		11.6	
	S x T					0.037		22.4	
	C.V (%)	7.9		8.1		8.6		9.2	

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