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Effects of *Crotalaria* and *Sesbania aculeata* green manures and N fertilizer on soil fertility and the productivity of sugarcane

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SUMMARY

The effects of green manuring with dhaincha (*Sesbania aculeata*) and sunhemp (*Crotalaria juncea*) in combination with four levels of urea-N (0, 75, 150 and 225 kg N/ha) on the productivity of a subsequent sugarcane (*Saccharum officinarum*) crop and the fertility of the soil were examined. *C. juncea* contributed more nitrogen to the soils when ploughed down than *S. aculeata* (56·7 *v.* 40·0 kg N/ha). The green manures and the supplemented urea-N increased cane yield by 2 to 26% and 26 to 57%, respectively. The organic matter, total N, available P and S of the soil was only slightly increased by the incorporation of green manures.

INTRODUCTION

Most soils in Bangladesh are low in organic matter, generally containing less than 1–2%. Soil organic matter contents of 2·5–3·0% are considered necessary for sustainable crop production (Bhander *et al.* 1998). Because of its large biomass yield and long growth period, sugar cane removes considerable amounts of nutrients from the soil and as a consequence the organic matter (OM) status of sugarcane soils has decreased over time to below 1%. Legumes fix atmospheric nitrogen and mobilize less available nutrients from the soil; they also improve soil structure and decrease leaching losses of nutrients (Sharma *et al.* 1985). The organic matter content of soil can be increased by green manuring with *Sesbania rostrata*, which contains about 1·25% N (Hossain *et al.* 1990) and supplies 200 kg N/ha when incorporated 50 days after sowing (Rinaudo *et al.* 1983). Furthermore, green manuring together with nitrogen fertilizer helps release nutrients more slowly during the period of crop growth (Singh *et al.* 1990). Successive applications of green manures increase the total carbon, total nitrogen and exchangeable K contents of the soil and its porosity but decrease its bulk density (Goto & Nagata 2000). The present experiments were done to assess the effectiveness of two types of green manure crops as substitutes for fertilizer N for a subsequent cane crop and their implications for yield and soil fertility.

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MATERIALS AND METHODS

The field experiments were conducted in two consecutive cropping seasons of 1998–99 and 1999–2000 in Bangladesh Sugarcane Research Institute farm at Ishurdi on the High Ganges River floodplain soils of Bangladesh (Typic–Eutrocrept). The soil under experiment was calcareous with pH 7·7, low in organic matter and deficient in total N. Factorial combinations of four rates of urea-N (0, 75, 150 or 225 kg/ha) applied to the sugarcane with three preceding green manuring treatments (none, *C. juncea* or *S. aculeata*) were tested in a randomized complete block design with four replicate blocks.

The green manure crops were sown at the rate of 250 g seed/plot in the summer season (mid May) and ploughed down 50 days after sowing.

No fertilizers were applied to the green manure crops. Before transplanting the sugarcane, soil samples (0–15 cm) were collected from each plot for soil nutrient analysis, both initially and at 90 days after incorporation of green manures. Soil pH was measured in a 1:2·5 soil:distilled water suspension by glass electrode pH meter. Total N for soil and green manure crops was determined by macro Kjeldahl

Table 1. *Biomass production and N-content of the different green manures at the time of ploughing the crops*

Crop year	Green manure crops	Dry biomass (t/ha)	N in DM (%)	N contribution (kg/ha)
1998–99	*C. juncea*	3·1	1·7	50·7
	S. aculeata	1·4	2·5	40·0
	S.E. (21 D.F.)	0·14	0·04	2·3
1999–2000	*C. juncea*	3·5	1·6	56·7
	S. aculeata	1·5	2·5	37·6
	S.E. (21 D.F.)	0·10	0·02	2·1

Table 2. *Effect of green manuring and fertilizer N on the yield and yield parameters of a sugarcane crop in 1998–99 and 1999–2000 cropping season*

	Number of tillers ($\times 10^3$/ha)		Number of millable cane stalks ($\times 10^3$/ha)		Cane yield (t/ha)		Recoverable sucrose (%)	
Treatment	1998–99	1999–2000	1998–99	1999–2000	1998–99	1999–2000	1998–99	1999–2000
Green manures								
C. juncea	158·0	165·2	90·0	81·3	62·1	75·3	9·6	9·9
S. aculeata	165·3	155·2	90·1	82·6	59·6	80·6	9·5	10·0
Control	157·0	163·1	75·7	80·2	49·2	73·8	9·7	10·0
S.E. (33 D.F.)	4·80	4·90	1·83	1·27	1·13	1·26	0·16	0·11
N (kg/ha)								
0	138·5	138·2	74·5	74·2	44·7	56·0	9·8	10·2
75	163·8	161·7	85·6	79·7	56·2	76·2	9·6	10·0
150	166·0	166·5	89·2	82·7	63·8	85·9	9·7	10·1
225	172·2	178·2	91·9	88·9	63·1	88·2	9·3	9·6
S.E. (33 D.F.)	5·54	5·66	2·11	1·46	1·31	1·5	0·18	0·13

procedure and organic C by the Walkley and Black wet oxidation method (Black 1965). Available soil P was extracted with 0·5 M $NaHCO_3$ and measured by spectrophotometry. Exchangeable K (NH_4OAc-extractable) was determined by flame photometry and available S by turbidimetric method (Black 1965). The fresh weight and height of the green manure crops were measured at 45 days after seed sowing.

Thirty-day-old single-bud sugarcane sets (variety Isd 20) raised in small polythene bags were transplanted in December each year and harvested 13 months later. Each sugarcane plot was 8 m × 1·5 m and received a basal dressing of 50 kg P/ha, 80 kg K/ha, 20 kg S/ha and 3 kg Zn/ha in the form of triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. The N treatments were applied in two equal split doses, the first after establishment of sets at 20 days after plantation (DAP) and the second at tiller completion stage (140 DAP). Half of the potash was applied as a basal dose at planting and the rest was applied with the second top dressing of N fertilizer. Standard cultural practices of weeding, mulching, earthing-up, typing, disease and insect control were used. The data obtained were analysed by analysis of variance.

RESULTS

Biomass and N yield of green-manure crops

By the time it was ploughed in, *C. juncea* had produced twice as much biomass as *S. aculeata*, but the dry matter had a low N content. On average, *C. juncea* supplied 25% more N to the soil than *S. aculeata* (Table 1).

Effect of green manure and urea-N on the sugarcane crop

The incorporated green manure significantly affected the following sugarcane crops, increasing total number of tillers and number of millable cane stalks in both the years (Table 2). Cane yield was significantly increased in both the years without affecting the

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Table 3. *Interaction effect of fertilizer N and green manuring on millable cane stalks, cane yield and recoverable sucrose during 1998–99*

Fertilizer N (kg/ha)	Number of millable cane stalks ($\times 10^3$/ha)			Cane yield (t/ha)			Recoverable sucrose (%)		
	C. juncea	*S. aculeata*	Control	*C. juncea*	*S. aculeata*	Control	*C. juncea*	*S. aculeata*	Control
0	80·3	74·2	68·7	49·3	43·1	41·7	9·9	9·5	9·8
75	91·8	92·0	72·8	65·9	55·6	47·0	9·9	9·4	9·5
150	93·5	98·6	75·6	67·4	73·0	51·2	9·9	9·5	9·7
225	94·5	95·6	85·5	65·7	66·6	57·0	8·6	9·6	9·5
S.E. (33 D.F.)		3·67			2·26			0·32	

Table 4. *Soil nutrient status sampled 90 days after the green manure crops were incorporated and the sugarcane planted*

Green manure crop	pH	OM (%)	N (%)	Available P (μg/g)	Exchangeable K (meq/litre)	Available S (μg/g)
Crop year 1998–99						
Control	7·5	0·98	0·07	9·0	2·6	13·0
C. juncea	7·6	1·0	0·08	11·0	2·5	13·8
S. aculeata	7·6	1·1	0·08	10·6	2·6	14·0
Crop year 1999–2000						
Control	7·7	1·06	0·06	12·0	2·2	27·0
C. juncea	7·8	1·08	0·08	14·0	2·2	27·5
S. aculeata	7·9	1·11	0·08	14·0	2·3	29·3

percentage of recoverable sucrose in the cane. The responses of sugarcane to green manuring were much smaller in 1999–2000 than in 1998–99. Green manuring with *C. juncea* increased cane yield over the untreated control by 21% in 1998–99 and 2% in 1999–2000 and *S. aculeata* by 26% in 1998–99 and 9% in 1999–2000.

Nitrogen applied as urea-N only increased the number of tillers and millable cane stalks and cane yield in 1999–2000; it had no significant effects on the percentage of recoverable sucrose in the cane in either year (Table 2). However, yields were only increased by increasing fertilizer up to 150 kg/ha, there was no further yield response to higher rates of N.

Interaction effects of urea-N and green manuring

The interaction effect between nitrogen level and the green manure crops on number of millable cane stalks and per cent recovery was not significant. There were significant interactions between the inorganic N and the green manuring treatments in 1998–99. The response in cane yield to fertilizer N was greater in the sugarcane grown after the *C. juncea* green manure than *S. aculeata* for fertilizer N application rates of 0 and 75 kg/ha. But, the yield for *S. aculeata* was found to be higher for fertilizer N application rates of 150 and 225 kg/ha. The highest cane yield of 73·0 t/ha was obtained with 150 kg N/ha in combination with the *S. aculeata* green manure; the same treatment following *C. juncea* produced a cane yield of 5·6 t/ha less, i.e. 67·4 cane yield (Table 3).

Effect of green manuring on soil chemical properties

The experimental soil was a calcareous sandy loam with pH 7·7. The soil was low in organic matter and deficient in total nitrogen. After incorporation of green manures there was a slight improvement in organic matter, total N and available P and S content over the control. Little change was observed on soil pH in either year (Table 4).

DISCUSSION

Intercropping in sugarcane with pulse, oilseeds and vegetables has been practiced in sugarcane growing countries to increase productivity in subsistence farming situations. Paul *et al.* (1999) investigated an experiment with three intercrops, viz. *Indigofera tinctoria*, *S. rostrata* and *C. juncea* along with four levels of P and reported that *C. juncea* produced

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highest biomass yield. In the present study we found in both seasons that *C. juncea* also produced better biomass yields and subsequently added more N to soils. This was also observed by Alam *et al*. (1997).

Furthermore, it was observed that cane yield in untreated control plots was higher in the 1999–2000 crop season than in 1998–99 due to a higher initial nutrient status of the experimental soil especially in P, K and S content. Similarly, the responses of green manure and fertilizer N were more conspicuous in the less fertile soil of 1998–99. It is recognized that application of nutrients in deficient soils promotes root growth, stimulates tillering and influences growth favourably in terms of millable cane and thereby yields and juice quality of sugarcane. These results agree with those of Rahman *et al*. (1992).

It was observed that total tiller numbers, number of millable cane stalks and cane yield were increased by green manuring in both years as has been previously observed (Uddin *et al*. 1996). Such improvement due to the beneficial effect of green manuring addition has also been reported by Singh *et al*. (1990). Buragohain & Medhi (1999) reported that the recommended dose of N in combination with green manuring recorded the highest number of millable cane and cane yield of sugarcane. In the present study, *S. aculeata* coupled with 150 kg N/ha produced the highest yield of cane. Jayapal *et al*. (2000) also reported that two rows of *S. aculeata* with 75% of the recommended N level produced higher economic cane yield and juice quality. Green manuring alone produced 60–80 t/ha, which is about 2–13 t/ha more than the control from an addition of inorganic N equivalent of 37·6–56·7 kg/ha in the green manured plots. Supply of N due to mineralization of green manure might have led to such increases in yield.

The N concentration in *S. aculeata* (2·5%) is higher than *C. juncea* (1·7%). Responses in cane yield to inorganic N were comparatively higher in the sugarcane grown after *S. aculeata* than that of *C. juncea*. In the present study, the response of N use was highly increased to 69% and 36% in *S. aculeata* and *C. juncea*, respectively, over the control. Chatterjee *et al*. (1979) also reported that inorganic N source applied in combination with organic sources is better utilized than inorganic source alone.

Researchers have advocated that incorporation of green manure crops increases soil N, concentrates P, maintains and renews organic matter and enriches the physico-chemical condition of soil (Jiao 1983; Ledgard *et al*. 1985; Lizhi 1988). The results in the present study revealed that organic matter, total N, available N and S were built up in treatments where green manure was incorporated at 45 days after emergence. These findings were also in agreement with the results of Alam *et al*. (1997).

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