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Effect of intercropping in sugarcane (*Saccharum* complex hybrid) on productivity of plant cane - ratoon system

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ABSTRACT

A field experiment was conducted at Lucknow during 2002-03 and 2003-04 to assess the production potential and economic viability of autumn-planted sugarcane–based intercropping systems, *viz.* sugarcane sole and sugarcane intercropped with lentil (*Lens esculentus*), rajmash (*Phaseolus vulgaris* L.), Indian mustard (*Brassica compestris*), rapeseed (*Brassica* sp.) and maize (*Zea mays* L.) for cobs at 2 row spacings of 90 and 75 cm. The intercropping with rajmash had no adverse effect on the number of millable canes (117.6 thousand/ha), cane length (213 cm) and cane yield (83.4 t/ha) compared with sole cane. Intercropping of rajmash and maize for green cobs resulted in highest net profit (Rs 89,883 and 83,815/ha) and benefit : cost ratio (B : C) (2.53 and 2.34) compared with sole sugarcane (Rs 50,199 /ha). Ratoon sugarcane intercropped with lentil gave higher cane yield (64.2 t/ha) than that from sugarcane sole. Besides, there was improvement in the physico-chemical properties of the soil under sugarcane + lentil intercropping system with lower bulk density (1.26 g/cm^3) and higher infiltration rate (4.75 mm/hr) compared with sole sugarcane. Inclusion of short-duration intercrops like rajmash, and maize for green cobs in autumn-planted sugarcane improved the productivity and profitability, and lentil intercropping improved the soil health under plant–ratoon system.

Key words: Autumn sugarcane, B : C ratio, Bulk density, Cane-equivalent yield, Commercial cane sugar, Infiltration rate, Net returns, Ratoon

Sugarcane (*Saccharum* complex hybrid), an important agro-industrial crop in the country, plays a pivotal role in national economy by contributing 1.9% to gross domestic product. However, plateauing yield level, declining factor productivity, increasing production cost, slashing sugar prices in international market and decreasing profitability in recent years indeed pose the real concerns before cane growers and mill owners. These necessitated the intensification of sugarcane-based production system through diversification in space and time to meet the multiple needs of cane farmers and maintain long-term soil health. Sugarcane - characteristically widely spaced, initially slow growing, of long duration and one-time income generating crop - lends ample scope for intercropping with short-duration, high-value and mid-season income generating crops for household nutrition and economic security, especially of small and marginal cane growers. Moreover, intercropping in sugarcane helps promote its autumn planting of sugarcane, gives 15-20% higher cane yield and 0.5 unit more sugar recovery than spring planting. Several crops are recommended as intercropping in autumn sugarcane (Lal and Singh, 2004). On an average intercropping of maize and cabbage reduced the yield of sugarcane in multi-location trial (Parsons, 2004). However, information on the compatibility of diverse group of intercrops, viz. pulses, oilseeds and cereals, with sugarcane in the system at different planting densities of sugarcane is not available. Hence, the present investigation was undertaken.

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MATERIALS AND METHODS

A field experiment was conducted on two plant- ratoon cycles for 3 years (2002-03 and 2003-04) at Indian Institute of Sugarcane Research, Lucknow. The climate of the region is characterized by hot dry summer and cold winter. The average annual rainfall is 1000 mm, of which 90% was received in rainy season (July to September) with occasional showers during the winter (November to March). The distribution of rainfall was erratic during both the years, and wet months (July-August) received 70-75% of total rainfall. In this semi-arid region, May and June are the hottest months (43-45°C). The soil of the experimental sites for both the years was sandy clay loam in texture and neutral in reaction (pH 7.7), low in organic C (0.32%) and available N (199.7 kg/ha), and medium in P (12.7 kg/ha and K (251.2 kg/ha). The experiment was laid out in

randomized block design keeping combinations of 6 cropping systems, viz. sugarcane sole, sugarcane + lentil (*Lens esculentus*), sugarcane + rajmash (*Phaseolus vulgaris*), sugarcane + mustard (*Brassica compestris*), sugarcane + *toria* (*Brassica* sp.) and sugarcane + maize (*Zea mays*) for green cobs and two planting densities, *viz.* 90 and 75 cm row spacings. It was replicated thrice.

Sugarcane cv 'CoPt 90223' was planted during the third week of October. About 37,000 and 47,000 three-budded setts were planted at 90 and 75 cm spacings, respectively. Two rows of each intercrop, viz. lentil ('DPL-15'), rajmash ('PDR-1'), Indian mustard ('Pusa Jaikisan'), rapeseed ('PT-303') and maize ('Azad Uttam') for green cobs) were sown between the rows of sugarcane at 30:30:30 crop geometry for 90 cm spacing and 25-25-25 for 75 cm spacing. Sugarcane was fertilized with 150 kg N, 26.2 kg P and 50 kg K/ha. Nitrogen was applied in 3 equal splits in plant cane, viz. at planting, just after harvest of intercrops and at late tillering phase. Ratoon crop was fertilized as per the recommendation (190 kg N, 26.2 kg P and 50 kg K/ha). Five pre-monsoon irrigations were applied to the ratoon-crop, starting from February onwards. Trash mulching was done uniformly in ratoon to conserve soil moisture and control weed growth. All the recommended plant protection measures were undertaken during the experimentation. The biometric observations on plant as well as ratoon crop were recorded at harvest, based on 5 randomly selected millable canes. The quality parameters for sugarcane were determined as per the method of Meade and Chen (1977). Cane and intercrop yields were recorded on the basis of net plot size. Soil physico-chemical properties were determined as per the standard procedures.

RESULTS AND DISCUSSION

Tillering pattern

Tillering in sugarcane was affected by different intercropping systems and row spacings. The number of tillers was high at narrow spacing throughout the growing period. Intercropping in sugarcane with different crops significantly affected tillering. Amongst the intercrops lentil had the highest adverse effect and rajmash the least during early stages. Number of tillers was significantly reduced during early growth stages under lentil, Indian mustard and rapeseed intercropping systems. The tiller population at late tillering phase (after harvest of intercrops) in sugarcane + lentil and sugarcane + rajmash intercropping systems was statistically similar to that in sole sugar-

Table 1. Effect of cropping system and sugarcane spacing on yield attributes, yield of sugarcane and net returns

Treatment	NMC ($\times 10^3$/ha)		Cane length (cm)		Cane girth (cm)		Weight/ cane (kg)		Cane yield (t/ha)		Intercrop yield (t/ha)		Cane equivalent yield (t/ha)		Net returns ($\times 10^3$ Rs/ha)		B:C ratio	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Cropping system																		
Sugarcane (sole)	119.9	124.3	228.3	199.8	2.17	2.81	0.77	0.86	84.3	86.3			84.3	86.3	49.3	51.1	1.60	1.66
Sugarcane + lentil	114.5	120.1	190.3	157.8	2.38	2.23	0.70	0.80	76.6	77.4	1.11	1.22	97.5	100.4	55.8	59.3	1.69	1.77
Sugarcane + rajmash	117.1	118.1	228.3	198.2	2.90	2.72	0.82	0.71	84.9	81.8	1.98	1.85	130.2	133.9	88.1	91.7	2.47	2.57
Sugarcane + Indian mustard	118.1	115.5	199.7	169.1	2.57	2.49	0.77	0.86	74.9	75.7	1.29	1.24	94.9	97.5	55.3	57.8	1.59	1.62
Sugarcane + rapeseed	109.1	110.8	193.5	161.8	2.70	2.31	0.75	0.78	73.9	74.8	1.11	1.08	89.3	91.2	50.2	51.9	1.45	1.49
Sugarcane + maize	115.1	108.6	192.3	158.2	2.58	2.27	0.75	0.79	78.5	78.7	80.4*	81.4*	124.8	121.1	82.7	84.9	2.31	2.37
SEm ±	2.1	1.9	6.4	5.9	0.07	0.06	0.06	0.07	3.0	2.7			2.5	2.6				
CD (P=0.05)	6.2	5.4	18.8	17.1	0.21	0.18	NS	NS	8.9	7.9			7.5	7.6				
Row spacing																		
90 cm	111.8	114.3	206.9	175.8	2.72	2.48	0.82	0.96	76.9	77.5			103.1	105.9	62.7	65.8	1.32	1.91
75 cm	117.3	118.1	203.9	171.2	2.59	2.26	0.70	0.82	80.7	80.6			103.9	104.1	64.4	66.5	1.86	1.92
SEm ±	1.4	1.1	1.4	1.6	0.04	0.04	0.03	0.03	1.4	1.2			0.68	0.8				
CD (P=0.05)	4.1	3.2	NS	NS	0.12	0.13	0.10	0.08	NS	NS			NS	NS				

*No. of green maize cobs/ha
Cost of the produce (Rs/t): Sugarcane, 950; lentil, 18,000; rajmash, 25,000; Indian mustard, 16,000; rapeseed,14,000; maize, Rs 0.50/greencob

cane. The observations show the compatibility of lentil and rajmash with sugarcane.

Yield of plant cane

Effect of intercropping systems on yield attributes, viz. number of millable canes (NMC), cane length and cane girth showed tangible difference during both the years (Table 1). The number of millable canes, average cane length, cane girth and cane yield under sole sugarcane were on a par with those recorded in sugarcane + rajmash intercropping system. The compatibility of lentil with sugarcane was observed next to rajmash in terms of NMC. The compatibility of legumes in sugarcane can be recognized in terms of higher microbial biomass and increased N availability (Suman *et al.*, 2006). The oilseed crops (Indian mustard and rapeseed) were found equally compatible for intercropping in sugarcane, as the NMC, cane length, cane girth and yield recorded under their intercropping with sugarcane were similar to that recorded in sole sugarcane. However, sugarcane yield decreased (11.8-12.8%) under these systems. The intercrop yield of rajmash was 1.98 and 1.85 t/ha, of lentil 1.11 and 1.22 t/ha, of mustard 1.29 and 1.24 t/ha and of rapeseed 1.11 and 1.08 t/ha during 2002-03 and 2003-04. The data on cane-equivalent yield calculated on the basis of existing market prices indicate that the sugarcane + rajmash intercropping system recorded the highest equivalent yield, closely followed by sugarcane + maize intercropping system This might be due to higher market prices of the produce, which resulted in high cane-equivalent yields. All the intercropping systems gave significantly higher cane-equivalent yield than sole sugarcane.

Sugarcane planted at closer row spacing (75 cm) recorded higher number of millable canes than that at normal spacing (90 cm). However, the other yield attributes like cane girth and single-cane weight were significantly reduced under closer spacing. Although the cane yield at 75 cm spacing was 5.8% more than at 90 cm spacing, it could not reach the level of significance, probably due to thin canes and reduced single-cane weight in narrow spaced crop. The juice-quality parameters, viz. brix, pol purity and commercial cane sugar (CCS) were not affected by different treatments. However, the value of commercial cane-sugar yield remained primarily a function of cane yield and was the maximum under sugarcane + rajmash intercropping system (Table 2).

Economics

The highest net returns and B : C ratio were observed under sugarcane + rajmash intercropping system, followed by sugarcane + maize (Table 1). Intercropping of sugarcane with lentil and Indian mustard also recorded almost equal net returns. The margin of profit by intercropping rapeseed was not tangible compared with that of Indian mustard. The effect of spacing was not tangible in terms of economic gains.

Growth and yield of ratoon

Ratoon crop after sugarcane plots intercropped with lentil resulted in taller cane than that with other systems (Table 3). The number of millable canes and cane yield was also significantly highest in this system during both the years. Singh *et al.* (2005) also reported better performance of ratoon under legume-intercropping systems. The yield and yield attributes of ratoon cane were adversely affected when plant crop was intercropped with oilseed crops (Indian mustard and rapeseed) and cereal (maize). The yield of sugarcane under these systems decreased perhaps because of high competition for the natural and applied resources in plant crop affected the viability of

Table 2. Effect of cropping system and planting density on juice quality parameters of sugarcane

Treatment	Brix		Pol (%)		Purity coefficient		CCS (%)		CCS (t/ha)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Cropping system										
Sugarcane (sole)	18.1	21.2	17.4	18.6	95.8	88.4	11.1	11.3	9.31	9.77
Sugarcane + lentil	18.8	20.4	17.6	18.7	92.2	89.5	10.8	11.9	8.24	9.27
Sugarcane + rajmash	19.0	20.7	17.1	18.6	94.5	90.3	11.1	11.8	9.40	9.71
Sugarcane + Indian mustard	18.8	20.7	17.5	18.7	94.1	89.2	10.9	10.8	8.23	8.18
Sugarcane + rapeseed	18.9	21.0	17.4	18.8	92.6	88.9	11.1	10.6	8.17	7.94
Sugarcane + maize	18.6	20.5	17.4	18.6	92.3	89.7	10.9	10.5	8.51	8.61
SEm±	0.3	0.1	0.3	0.4	1.2	0.9	0.8	0.4	0.2	0.3
CD (P=0.05)	0.8	0.4	NS	NS	NS	NS	NS	NS	0.6	0.7
Row spacing										
90 cm	18.7	20.8	17.4	18.8	98.1	89.5	10.9	11.4	8.42	8.83
75 cm	18.6	20.8	17.1	18.5	98.2	89.1	10.9	11.1	8.86	9.00
SEm±	0.6	0.5	0.5	0.5	0.4	0.5	0.2	0.3	0.4	0.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Performance of ratoon cane initiated from different treatments

Treatment	Cane length (cm)		Cane girth (cm)		Weight/cane (kg)		NMC (x 10^3/ha)		Cane yield (t/ha)		CCS (%)		CCS (t/ha)	
	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05
Cropping system														
Sugarcane (sole)	170.3	170.8	2.32	2.35	0.82	0.81	102.1	109.4	65.5	60.7	12.1	12.3	7.88	7.31
Sugarcane + lentil	174.8	172.4	2.50	2.48	0.87	0.85	104.1	113.2	66.2	62.2	11.9	11.9	7.81	7.38
Sugarcane + rajmash	170.6	168.8	2.25	2.15	0.76	0.75	98.9	105.2	63.2	58.6	11,9	11.9	7.49	6.97
Sugarcane + Indian mustard	158.4	160.1	2.12	2.12	0.74	0.74	91.0	97.4	59.7	54.5	11.9	12.0	7.14	6.48
Sugarcane + rapeseed	153.5	154.2	2.07	2.05	0.71	0.70	93.7	101.5	56.6	52.1	11.8	11.8	6.66	6.14
Sugarcane + maize	154.7	154.5	2.03	2.04	0.70	0.70	85.6	93.6	55.5	52.7	11.7	11.7	8.19	6.10
SEm±	0.9	1.1	0.07	0.14	0.02	0.70	1.6	1.6	0.9	1.1	0.4	0.3	0.09	0.20
CD (P=0.05)	2.7	3.1	0.20	NS	0.08	NS	4.7	4.8	2.7	3.1	NS	NS	0.28	0.60
Row spacing														
90 cm	168.7	170.2	2.29	2.28	0.81	0.83	92.7	99.5	60.1	55.7	11.8	11.8	7.16	6.87
75 cm	158.6	160.3	2.14	2.12	0.72	0.75	99.4	107.4	62.1	57.7	11.9	11.9	7.39	7.13
SEm±	4.3	4.6	0.42	0.44	0.20	0.22	1.2	0.8	0.7	0.6	0.1	0.2	0.04	0.11
CD (P=0.05)	NS	NS	NS	NS	NS	NS	3.6	2.5	2.0	1.7	NS	NS	0.14	0.31

stubbles in the successive ratoon. The productivity of sugar in terms of CCS was tangible and varied according to the cane yield.

The effect of spacing was not evident under plant crop but was clear in the subsequent ratoon, as significantly higher number of millable cane and cane yield was recorded at 75 cm row spacing. It was because higher plant stand per unit area nullified the gaps in ratoon at high-planting density (IISR, 2007). Although the CCS per cent was not affected by row spacing of plant crop, significantly higher sugar yield was recorded under 75 cm row spacing. This increase in sugar productivity is again a function of higher cane yield from the system. Singh *et al.* (2006) also reported higher tonnage of sugar at closer spacings.

Soil physico-chemical properties

The physico-chemical properties of the soil observed initially and after harvest of plant and ratoon crop (Table 4) decreased slightly in bulk density of furrow-slice soil (0-15 cm) under sugarcane + lentil intercropping system. The highest rate of infiltration after plant-crop harvest (4.75 mm/hr) and after ratoon harvest (4.25 mm/hr) was also recorded under this system. Bulk density was not affected by intercropping of Indian mustard, rapeseed and maize. The highest amount of available N (0-15 cm) was determined under lentil intercropping, which was 25.8 and 13.7% higher in plant and ratoon cane respectively over their initial values. After sugarcane + lentil, the next sustainable system was sugarcane + rajmash. The observed physico-chemical properties of soil under this system were very close to those of the lentil intercropping. The positive build-up of the soil-physical and chemical properties might be due to inclusion of grain legumes in the system, which contributed much to the soil organic matter and its fibrous root system rendered the soil porous, resulting in increased infiltration rate and reduced bulk density. Sultani *et al.* (2007) also reported improvement in the physical properties of soil by inclusion of legumes in the system.

Thus, the inclusion of short-duration intercrops like rajmash, lentil and maize for green cobs in autumn-planted sugarcane may improve the socio-economic status of small and marginal cane growers by generating mid-season income. Besides providing higher system profitability, intercropping of legumes also improves soil health and makes the plant–ratoon system sustainable.

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Table 4. Effect of cropping system on physico-chemical properties of soils

Cropping system	After harvest of plant crop (2002-03)			After harvest of ratoon cane (2003-04)		
	Bulk density (g/cm^3)	Infiltration rate (mm/hr)	Available N (kg/ha)	Bulk density (g/cm^3)	Infiltration rate (mm/hr)	Available N (kg/ha)
Sugarcane (sole)	1.36	4.00	209.8	1.30	4.10	225.6
Sugarcane + lentil	1.26	4.75	246.9	1.28	4.25	238.4
Sugarcane + rajmash	1.28	4.50	231.9	1.30	4.15	232.2
Sugarcane + Indian mustard	1.34	3.75	190.5	1.34	3.75	220.2
Sugarcane + rapeseed	1.39	3.75	142.5	1.34	3.80	212.8
Sugarcane + maize	1.36	4.25	204.4	1.36	3.75	220.4
Initial value	1.35	4.00	196.3	1.36	4.00	209.8

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