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Productivity and profitability of winter-initiated sugarcane (*Saccharum* spp. hybrid complex) ratoon through intercropping of forage legumes and nitrogen nutrition

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ABSTRACT

Field experiments were conducted during 2000-01 and 2001-02 at Lucknow to study the effect of berseem [*Trifolium alexandrinum* (L.) Juslen.] and *senji* (*Melilotus* sp.) intercropping on growth, yield and quality of winter-initiated ratoon of sugarcane (*Saccharum* spp. complex hybrid). Intercropping of berseem in winter-initiated sugarcane ratoon significantly increased the number of millable canes (117.8 thousand/ha), cane yield (72.4 t/ha), cane-equivalent yield (90.81 t/ha) and commercial cane sugar (8.81 t/ha) compared with sole cropping (7.66 t/ha). The cane yield, cane-equivalent yield and sugar yield increased significantly with increase in N level in sugarcane + berseem and sugarcane + *senji* intercropping systems. Early-maturing, high-sugar variety 'CoS 687' sugarcane yielded higher (63.1 t/ha) under berseem intercropping system than sole cropping (54.7 t/ha). Application of 125% of the recommended N fetched the highest net income (Rs 60,041/ha) and B:C ratio (2.76). Highest profit of Rs 71,570/ha and B:C ratio of 3.13 were recorded under sugarcane ratoon + berseem intercropping system along with 125% N of the recommended dose. Intercropping of berseem and *senji* improved the physical properties of the soil by increasing the infiltration rate (4.82 mm/hr) and reducing the bulk density (1.26 g/cm^3).

Key words: Cane-equivalent yield, Commercial cane sugar, Forage legume, Intercropping, Nitrogen nutrition, Winter-initiated ratoon

In India more than 50% of the sugarcane area is occupied by ratoon crop, which often yields poorly. In sub-tropical belt the availability of sugarcane varieties with higher sugar accumulation early in the crushing season with good ratoonability is an important strategy to fetch high sugar recovery in the mills and ensure higher margin of profit to cane growers. The high-sugar genotypes are, however, generally low yielder in plant crop and poor ratooner especially under winter-initiated conditons. The sugarcane harvested during winter fails to sprout to give good ratoon crop because of low-temperature conditions (Hunsigi, 2000). This is one of the major constraints to increase ratoon productivity and also adoption of autumn planting because their harvesting commences in December or January (Lal and Singh, 2006). Failure of sub-terranean bud sprouting in winter-harvested plant cane is the major constraint in ratooning faced under severe cold conditions. The problem is more acute in high-sugar, early-maturing cane varieties. Although growth-regulators like ethrel and CCC (cycocel) hold promise in increasing the sprouting (Bhale and Hunsigi, 1994), the management strategy lies in keeping the metabolic activities of stubble buds alive till the commencement of favourable growth environment. In this context high-density, early-bulking forage legumes may serve as live mulch, regulating rhizospheric thermal regime through root respiration, protecting stubble buds from severe cold or frost injury, counteracting the ill-effects of sugarcane monoculture autotoxicity and economizing fertilizer nitrogen besides generating mid-season income in the crop-livestock production system. The present investigation was undertaken to find out the effect of forage legume intercropping and nitrogen nutrition on the growth, yield and quality of sugarcane and sustainability of the system of winter-initiated ratoon.

MATERIALS AND METHODS

Field experiments were conducted during 2000-01 and 2001-02 at Indian Institute of Sugarcane Research, Lucknow (26°5′ N, 80°6′E and 111 m above mean sea-level). The soil was clay-loam (Inceptisol), low in available N (208.7 kg/ha) and medium in available P (20.1 kg/ha) and exchangeable K (193 kg/ha). The climate of the location is semi-arid subtropical with dry hot summers (April to June) and cold winters (November to January). The

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average annual rainfall is 1,000 mm and nearly 85% of the total rainfall is received through north-west monsoons during the second fortnight of June to September. The average monthly minimum and maximum temperatures fluctuate from 6.8 to 8.0°C and 19.6 to 21.5°C in winter and from 22.0 to 24.6°C and 38.5 to 41.5°C in summer respectively. The experiments were laid out in split-plot design with three replications. The main-plot treatments consisted of six combinations of sugarcane varieties, viz. 'CoLk 8102' (mid-late) and 'CoS 687' (early maturing), and cropping systems, viz. sugarcane ratoon sole, sugarcane ratoon + berseem (Egyptian clover) and sugarcane ratoon + *senji* (Indian clover); whereas subplot treatments included N levels, viz. no N (control), recommended N dose for ratoon (187.5 kg/ha), 125% RDN (recommended dose of N) and 75% RDN. Ratoon was initiated from sugarcane planted at 90 cm row spacing and intercrops were sown as per the recommended practice in the first week of December. In addition to N (as per the treatment), 60 kg P and 40 K/ha were applied as basal fertilizer dose to sugarcane at ratoon initiation. Nitrogen was applied in three equal splits at initiation, after final cut of the intercrop and at late-tillering stage. The nitrogen-use efficiency was calculated in terms of kg cane/kg N applied. The irrigation was given as per requirement of berseem and *senji*. Depending on the growth of the forages under different treatments, 3-4 cuttings were taken. Root residues were incorporated in the field after final cutting.

RESULTS AND DISCUSSION

Growth and yield

Intercropping of forage legumes in winter-initiated ratoon significantly increased the number of millable canes, cane yield and commercial cane sugar (CCS) (Table 1). Ratoon cane + berseem gave significantly highest cane yield (72.4 t/ha), cane-equivalent yield (90.8 t/ha) as well as CCS yield (8.81 t/ha), followed by ratoon cane + *senji*. This can be attributed to higher cane production under the systems because of quick-growing, high-density bulking berseem, functioning as live mulch in regulating the rhizospheric thermal regime, which helped in sprouting of stubble buds (76% sprouted stubbles). Verma and Yadav (1988) also reported that ratoon with potato intercropping produced higher number of millable canes and yield. The mid-late variety 'CoLk 8102' yielded significantly higher (80.4 t/ha) than early-maturing variety 'CoS 687' (58.6 t/ha).

The number of millable canes and cane yield increased with increase in nitrogen level. Significantly highest number of millable canes (120.2 thousand/ha), cane yield (77.3 t/ha) and cane-equivalent yield (86.3 t/ha) were recorded with 25% higher N than the control (no N). However, it was found comparable to the recommended dose of N. The commercial cane sugar percentage was not affected by different nitrogen levels, but the sugar yield was the highest (9.16 t/ha) at 25% higher N. This can be attributed mainly to increase in yield of sugarcane, which was also reflected in the sugar yield. Singh *et al.* (2004) also reported increase in yield of sugarcane at higher N levels.

Combined effect on cropping system and N level

Interaction effect of N levels and cropping systems was significant on cane yield, cane-equivalent yield and sugar yield (Table 2). Highest yield of sugarcane (82.7 t/ha) was recorded with ratoon cane + berseem intercropping system at 25% higher N, which was significant in comparison with sole sugarcane with recommended fertilizer N. A similar trend was observed in ratoon cane + *senji* inercropping system. The growth of forage legumes at higher N was accelerated, resulting in a dense coverage of the sprouting stubbles of sugarcane ratoon. Thick live mulch of the forage legume protected the buds from frost injury and provided congenial atmosphere for sprouting.

Cropping system × genotype interactions

Interactions between sugarcane genotypes and intercropping of forage legume showed significant effect on cane yield, cane-equivalent yield and commercial cane-sugar yield (Table 2). Maximum yield of sugarcane and cane-equivalent yield were recorded with 'CoLk 8102' grown in association with berseem. Significantly higher cane-equivalent yield of ratoon (79.2 t/ha) was recorded under 'CoS 687' + berseem intercropping system compared with that under sole ratoon cane. The magnitude of increase in cane yield and sugar yield was 15.4 and 14.5%. This increase in the system productivity was observed with the *senji* intercropping system under both the genotypes. However, 'CoLk 8102' had an edge over 'CoS 687'.

Profitability

Ratoon cane + berseem system fetched the highest net return (Rs 64,191 /ha), and B:C ratio (2.93), followed by ratoon cane + *senji* (Table 3). Application of 125% RDN proved more profitable (Rs 60,041/ha). The ratoon cane + berseem intercropping system supplied with 125% RDN gave the highest net returns (Rs 71,570/ha) and benefit : cost ratio (3.13).

The profitability of the ratoon cane + berseem intercropping system at recommended dose of fertilizer N was higher compared with ratoon cane + *senji* at 25% high N level. However, the ratoon cane + *senji* intercropping system fetched higher profit than sole ratoon cane. The prof-

Table 1. Effect of different treatments on yield and quality of sugarcane (pooled data of 2 years)

Treatment	Sprouting of stubbles (%)	No. of millable canes ('000/ha)	Cane yield (t/ha)	Intercrp yield (t/ha)	Cane-equivalent yield (t/ha)	Comercial cane sugar (t/ha)	N uptake by sugarcane (kg/ha)
Cropping system							
Ratoon cane sole	56.4	112.4	64.8		64.8	7.66	98.6
Ratoon cane + berseem	76.0	117.8	72.4	32.2	90.8	8.81	115.7
Ratoon cane+*senji*	71.2	116.5	71.5	17.1	79.9	8.26	111.2
SEm±	3.7	1.6	2.3		0.9	0.09	1.7
CD(P=0.05)	11.6	5.0	6.6		2.9	0.30	5.4
Variety							
'CoLk 8102'	71.3	129.4	80.4	25.0	89.3	9.51	128.5
'CoS 687'	64.5	100.7	58.6	24.3	67.1	7.10	87.2
SEm±	2.7	2.5	2.8		1.8	0.25	2.2
CD (P=0.05)	NS	7.9	8.7		5.8	0.80	6.8
N level							
No N (control)	62.8	108.5	57.3	23.0	66.1	6.88	83.7
RDN	68.3	118.1	73.0	26.1	81.8	7.74	114.9
125% RDN	70.8	120.2	77.3	24.8	86.3	9.16	132.4
75% RDN	69.6	116.1	69.7	24.6	78.4	8.18	102.9
SEm±	2.8	2.6	1.9		1.7	0.26	2.9
CD (P=0.05)	NS	7.5	5.7		4.9	0.75	8.3

Table 2. Productivity of sugarcane and sugar (t/ha) under different treatments (pooled data of 2 years)

Treatment	N level				Variety	
	Control	Recommended N	125% RDN	75% RDN	'CoLk 8102'	'CoS 687'
Cane yield						
Ratoon cane sole	51.4	67.9	72.0	67.8	75.1	54.7
Ratoon cane + berseem	62.9	76.9	82.7	73.3	84.8	63.1
Ratoon cane + *senji*	59.0	72.6	77.4	67.4	80.3	58.1
Forage yield						
Ratoon cane sole						
Ratoon cane + berseem	30.7	33.9	32.4	31.7	32.7	31.6
Ratoon cane + *senji*	15.4	18.3	17.2	17.5	17.4	16.8
Cane-equivalent yield						
Ratoon cane sole	51.4	67.9	72.0	67.8	75.1	54.7
Ratoon cane + berseem	78.9	94.6	99.6	90.0	102.4	79.2
Ratoon cane + *senji*	67.7	82.9	87.6	77.3	90.4	67.3
Sugar yield						
Ratoon cane sole	6.0	8.10	8.52	7.99	8.7	6.6
Ratoon cane + berseem	7.6	9.27	9.68	8.68	10.0	7.6
Ratoon cane + *senji*	7.0	8.85	9.28	7.88	9.41	7.11

	Cane yield		*Cane-equivalent Yield*		*Sugar yield*	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Cropping system × N	4.0	12.6	3.4	10.4	0.5	1.4
Cropping system × varieties	3.6	11.3	3.6	10.7	0.4	1.3

itability of winter-initiated ratoon-based intercropping system was also supported by Verma and Yadav (1988).

Soil physico-chemical properties

The highest infiltration rate (4.82 mm/ha) and lowest bulk density (1.26 g/cm^3) were recorded under the plot of sugarcane ratoon+berseem intercropping system (Table 4). This was closely followed by sugarcane ratoon + *senji* system. The data on available N recorded at 0-15 cm and 15-30 cm depths clearly indicate that the intercropping of berseem and *senji* improved the available N compared with the sole crops. The magnitude of increase was higher

Table 3. Net returns and benefit: cost ratio of winter-initiated ratoon-based cropping systems

Treatment	Net returns at N level				
	Control	Recommended N	125% RDN	75% RDN	Mean
Ratoon cane sole					
Cost of cultivation (Rs/ha)	17,911	19,901	20,379	19,423	19,404
Gross returns (Rs/ha)	48,642	64,112	67,992	64,588	61,333
Net returns (Rs/ha)	30,731	44,211	47,613	45,165	41,930
B:C ratio	1.72	2.22	2.34	2.33	2.16
Ratoon cane + berseem					
Cost of cultivation (Rs/ha)	20,500	22,412	22,890	21,934	21,934
Gross returns (Rs/ha)	74,924	89,748	94,460	85,367	86,125
Net returns (Rs/ha)	54,424	67,336	71,570	63,433	64,191
B:C ratio	2.65	3.00	3.13	2.89	2.93
Ratoon cane + senji					
Cost of cultivation (Rs/ha)	19,550	21,462	21,940	20,948	20,948
Gross returns (Rs/ha)	64,794	78,452	82,879	73,147	74,668
Net returns (Rs/ha)	44,644	56,990	60,939	52,163	53,684
B:C ratio	2.28	2.66	2.78	2.49	2.56
Mean					
Cost of cultivation (Rs/ha)	19,320	21,258	21,736	20,780	
Gross return (Rs/ha)	62,587	77,437	81,777	74,367	
Net return (Rs/ha)	42,266	56,179	60,041	53,587	
B:C ratio	2.24	2.64	2.76	2.58	

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

	Ratoon cane sale	Ratoon+ berseem	Ratoon+ *senji*
Physical property			
Infiltration rate (mm/hr)	3.63	4.82	4.31
Bulk density (g/cm^3)	1.42	1.26	1.31
Available soil N (kg/ha)			
0-15cm			
Initial	208.7	208.7	208.7
After harvest of forage	205.9	243.5	253.6
15-30 cm			
Initial	200.0	200.0	200.0
After harvest of forage	190.6	233.6	243.7

under sugarcane+*senji* intercropping system (253.6 and 243.7 kg/ha respectively).

It was concluded that intercropping of winter-initiated ratoon with berseem holds promise in realizing higher cane productivity, especially from early-maturing sugarcane varieties. Further, winter-initiated ratoon requires 25% higher N than recommended to maintain high level of productivity and profitability.

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