Indian Journal of Agronomy **48** (4) : 271–273 (December 2003)

Soil behaviour and growth and productivity of sugarcane ratoon as influenced by trash management and preceding intercrops

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Received : January 2003

ABSTRACT

A field experiment conducted during 1998–2000 at the Indian Institute of Sugarcane Research, Lucknow, revealed that intercropping blackgram (*Phaseolus mungo* L.) though adversely affected the growth and yield of plant crop, it had no adverse effect on the productivity of subsequent ratoon compared to that after sole sugarcane. Trash management practices, however brought about significant effects on ratoon growth, soil and plant nutrient status, cane yield and the juice quality. Trash mulching just after ratoon initiation resulted in greater availability and uptake of nutrients and enhancement in soil microbial population over trash burning. Further, there was an apparent increase in relative growth rate, net assimilation rate, leaf area and dry-matter partitioning to cane stalk with trash mulching. However, ratoon raised after trash burning suffered moisture stress during grand growth phase as indicated by drastic reduction in relative water content of leaves as well as cell membrane permeability and palpable increase in proline and epicuticular wax content.

Key words : Sugarcane, Intercrop, Trash mulching, Trash burning

In India more than 50% of sugarcane acreage is occupied by ratoons, which are often poor yielder than the plant cane. Keeping in view the targeted sugar production of 31 million tonnes by 2020 AD, raising of ratoon productivity from present 45 tonnes/ha to the plant crop productivity (79 tonnes/ha) level is imperative. This could be achieved only by adopting a system approach involving efficient management of natural resources as well as market purchased inputs. Sugarcane, a widely spaced row crop offers ample opportunity for additive series intercropping. Spring being main season of sugarcane planting in sub-tropical India, blackgram a commonly cherished pulse crop is the main intercrop taken by the farmers with sugarcane even by sacrificing the cane productivity, which often gets carried to the succeeding ratoon. Management of trash by mulching or burning has been reported to hold promise for improving ratoon productivity by modulating the nutrient status and its availability in the soil and conditioning the crop micro climate. The present investigation was conducted to assess the effect of trash mulching or burning in conjunction with the effect of the preceding cropping system on plant and soil health and finally the productivity and juice quality of sugarcane ratoon.

MATERIALS AND METHODS

The field experiment was carried out during 1998–2000 at Researh Farm of the Indian Institute of Sugarcane Research, Lucknow, (26°5' N, 80°6' E and 111 m above mean sea-level). The plant crop was planted in randomized block design with 4 replications, and trash management practices in ratoon, viz. mulching and burning, were superimposed on plant crop treatments. Soil was fine loam in texture having 7.2 pH. The soil contained 0.67% organic carbon, 200 kg/ha available N and 10.5 kg/ha available P. Trash mulching and burning treatments were applied at the time of ratoon initiation.

Growth parameters were studied on 10 plants uprooted for each sampling. Different plant components were separated and oven-dried at 80°C for 24 hr before weighing. The data were computed for the relative growth rate (RGR), net assimilation rate (NAR), dry-matter partitioning, leaf area, epicuticular wax content, relative leaf water contents (RWC%) and proline.

Nutrient contents in plant samples were determined by using an atomic absorption spectrophotometer. For soil chemical and microbial studies composite soil samples from treatment plots were collected from 0–15 cm depth and were dried at 60°C. For microbiota analyses, 10 g soil samples were used and the standard plate dilution technique was followed utilizing specific media.

RESULTS AND DISCUSSION

Trash management

Trash management practices significantly affected the

growth and yield of ratoon. Mulching with sugarcane trash at the time of ratoon initiation significantly increased number of millable cane (NMC), cane length, girth and yield of ratoon over burning of trash. There was a significant spurt in tillering just after burning which, leveled off 45 days after ratoon initiation and culminated into significantly less NMC in trash burnt plots than in trash mulched plots (Table 1).

As observed during the grand growth phase of the crop, partitioning of dry matter to cane stalk was higher (22.4%) with mulching over trash burning (18.3%) treatment. Similarly, the leaf area (343.4 cm^2), relative growth rate (0.026 g/g/day) and net assimilation rate (9.3 mg/cm^2/day) were conspicuously higher under trash mulching condition than that under trash burning, values for these parameters being 272.5 cm^2, 0.015 g/g/day and 3.2 mg/cm^2/day respectively. These findings indicated that mulching in sugarcane ratoon enhanced the growth of the crop over trash burning.

Burning of trash resulted in initially higher chlorophyll a (3.34 mg/g fresh weight) and b (1.04) contents over trash mulching (23.2 and 0.92). This was, however, reversed by 60 days after ratoon initiation, and plants with mulching treatment contained a higher amount of Chl a (3.34) and Chl b (1.98) over that of trash burning treatment (3.21 and 1.85). Initially, higher chlorophyll content with trash burning might be responsible for initial profuse tillering under the treatment.

Relative water content in the third leaf lamina of sugarcane ratoon reduced drastically (by 26.7%) due to trash burning compared to that under trash mulching practice. Furthermore, proline content (43.2 mol/g dry weight), epicuticular wax content (12.34 mg/dm^2) and the loss of cell membrane permeability under trash burning clearly indicate moisture stress faced by the crop as the proline content under mulching was 20.2 mol/g dry weight, and epicuticular wax content was 8.92 mg/dm^2. Decrease in relative water content and increase in proline accumulation indicated that plants in trash burnt plots suffered due to water stress which led to prominent epi-cuticular wax deposition, a characteristics of water-stressed plants (Larcher, 1980). On the other hand, trash mulching produced no such effects during the grand growth stage of the crop. This could be attributed to the moisture conserving effect of trash mulching. Trash mulching drastically cuts the evaporational loss of water from soi surface and also provides favourable microclimate for growth of sugarcane crop.

Acquisition of nutrients (both macro and micro) was higher under trash mulching than that under trash burning. Potassium concentration in sugarcane leaves was much higher (3.12%) with mulching over burning (1.23%). Since K is essential for stomata turgidity and its opening as well as closing, it enhances CO_2 assimilation and finally ratoon's productivity. Other elements, viz. N (1.83%), P (0.07%), Ca (0.05%), S (0.056%) and Mg (0.004%) were found higher in concentration under mulching compared with their respective concentrations (1.43, 0.003, 0.02, 0.022, 0.001%) under trash burning treatment. The decrease in uptake of these nutrients may be due to the loss of cell membrane's permeability in trash-burnt plots. Similar results were found for micro-nutrients, viz. Fe, Zn, Mn and Cu. Higher uptake and assimilation of all these nutrient elements under mulching conditions is supported by the data on the status of nutrients in soil at different stages of the crop growth (Table 2). Uptake of Zn in trash-mulched treatment (22.3 ppm against 12.4 ppm in trash burning treatment) may improve the auxin synthesis (Tsui, 1948) and the protein synthesis (Rhodes and Klung 1993), which may improve the cane growth in the mulched treatment. Moreover the C: N ratio and the N : P ratio under trash mulching remained narrower than those under trash burning all through the crop season. This indicates that the availability of nitrogen to crop was higher throughout the season under mulching and the 2 nutrient elements N and P were available to the crop in good balance.

Table 1. Effect of preceding cropping system and trash management practices on growth, yield and juice quality of sugarcane ratoon

Treatment	Shoot number (120 DAI) ('000/ha)	NMC ('000/ha)	Cane length (cm)	Cane girth (cm)	Yield (tonnes/ha)	Pol (%)
Cropping system						
Sugarcane sole	236.3	115.7	232.1	2.31	63.4	17.3
Sugarcane + blackgram	242.3	134.2	230.5	2.26	57.1	16.8
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Trash management						
Trash mulching	223.9	126.0	240.8	2.36	68.3	16.9
Trash burning	255.0	119.7	226.3	2.21	58.2	16.3
CD (P=0.05)	26.9	4.2	5.1	0.05	3.7	NS

DAI, Days after ratoon initiation; NMC, number of millable canes

Table 2. Effect of trash mulching and trash burning on soil fertility indicators

Fertility indicator	Growth stage of ratoon											
	Initial			Tillering			Grand growth			Harvest		
	TM	TB	CD (P=0.05)	TM	TB	CD (P=0.05)	TM	TB	CD (P=0.05)	TM	TB	CD (P=0.05)
Organic carbon (%)	1.43	1.51	NS	1.37	1.25	NS	1.27	1.19	NS	1.02	0.97	NS
Available N (kg/ha)	298	304	NS	340	350	5.8	392	345	12.3	220	196	9.5
Phosphorus (kg/ha)	37.7	38.7	NS	36.7	30.0	NS	39.7	38.6	NS	24.5	21.9	1.9
Potassium (kg/ha)	136	118	3.7	149	156	NS	152	156	NS	205	210	NS
Zinc (ppm)	3.7	2.1	0.3	2.6	2.4	NS	3.0	2.5	NS	1.9	2.3	NS
Copper (ppm)	5.1	4.9	NS	4.4	3.6	0.4	5.6	3.2	NS	8.5	7.2	NS
Manganese (ppm)	14.1	15.4	NS	18.0	19.2	NS	20.0	20.4	NS	4.5	4.8	NS
Iron (ppm)	139.7	157.5	6.2	119.8	111.8	6.3	132.0	120.4	7.5	45.0	51.0	NS

TM, Trash mulching; TB, trash burning

Biological parameters along with chemical aspects are significant indicators of change in soil quality (Parr *et al.*, 1992; Turco *et al.*, 1994). Recycling of crop residues to the soil, in contrast to their removal from field or burning *in situ* improves soil physico-chemical and biological properties. The measurement of organic carbon and nitrogen in present study has shown that there was only a marginal increase in organic carbon and nitrogen content due to trash mulching. Such a trend is indicative of the fact that any significant change in organic C is a time taking process (Staben *et al.*, 1997). Bauer and Black (1981) recorded that organic C and total N content in soil increased significantly after 25 years of stubble mulch over the conventional tillage system.

Due to trash mulching, initially the available N content decreased over trash burning, however a gradual and substantial increase up to harvest was observed. Overall the availability of N was 4.6% more under trash mulching than trash burning. Yadav (1987) also reported that due to trash incorporation in the field the available N content decreased initially up to 30 days from the control, followed by an increase in N availability. Although there was no change in available K, available P was more in trash-mulching plots. This has reflected in plant nutrition where C:N and C: P ratio of the plant under trash mulching has narrowed down.

Trash mulching also increased the availability of Zn and Cu, however, no effect was seen on Mn and Fe content. With respect to growth stages, interestingly, the Mn and Fe content reduced significantly at the harvest stage whereas the Cu content which was almost static up to grand growth stage, increased substantially at harvest stage under both trash mulching and burning (Table 2).

Preceding cropping system

The effect of preceding cropping systems on growth, yield and juice quality of subsequent ratoon was not significant; however, ratoon of a sole plant crop had higher yield than that of the ratoon of intercropped cane. The effect of preceding intercrop on physiological parameters and soil fertility indicators was not noticeable which may be attributed to the time gap (8 months) between harvest of intercrop and the time of ratoon initiation.

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