Effects of Stubble Shaving, Fertilisation and Gap Filling on the Performance of Sugarcane (*Saccharum officinarum* L.) Ratoon Crops in Sri Lanka

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ABSTRACT

In sugarcane, ratoon crop occupies larger fraction of the plantations worldwide but poor management is a major constraint to increase their productivity. A field experiment with plant (PC), first ratoon (ratoon I) and second ratoon crops (ratoon II) was conducted from 2005 to 2009 to determine the effects of stubble shaving, fertilisation and gap filling on the performance of ratoon crops at the research farm of the Sugarcane Research Institute of Sri Lanka (SRI), Uda Walawe.

The tested management practices and their different combinations had no significant effect on number of stools, total stalks per stool, live stalks per stool, percentage of dead stalks per stool and millable stalks number in ratoon I. However, the stool number in ratoon II increased by 24% with gap filling in fertilised plots under stubble shaving. In contrast, no gap filling enhanced total stalks and live stalks number per stool in ratoon II, but these increases did not increase final cane yield. However, in ratoon II, gap filling increased millable stalks number by 19%. Fertilised plots in ratoon I and ratoon II had 28% and 31% more cane yields, respectively than unfertilised plots. The mean cane yield of PC, ratoon I and ratoon II also increased by 23% in the fertilised plots. Sugarcane juice quality did not show significant difference among different treatment plots of ratoon I and ratoon II. The study indicated that all three cultural practices tested are important ratoon management practices, but fertilisation contributed to increase yield both in ratoon I and II. Gap filling contributed to enhance yield without fertilisation in ratoon II and stubble shaving contributed only to reduce stalk mortality in ratoon II.

Key words: *fertilisation, gap filling, ratoon, stubble shaving, sugarcane*

INTRODUCTION

After harvesting cane at ground level, the sugarcane stool, which remains rooted in the ground, has an ability to regenerate and produce shoots from the auxiliary buds present in the stubble. This natural sprouting of vegetative buds to produce new sets of aerial shoots from the stubbles is exploited commercially, and is known as multi-ratooning. The crop is thus, allowed to regenerate repeatedly, and a number of ratoon crops are raised, before replanting. Since there in no land preparation and fresh planting, ratooning reduces sugarcane production costs substantially and has become a common practice throughout the sugarcane-growing world.

Generally, the yields of sugarcane ratoon crops are not the same as those of plant crop, and a lower yield is more common (Sundara, 2004). However, as reported by Rozeff (1999), high yields may still be obtained even after 16 harvests. Also, some local farmers in Sevanagala and Hingurana areas of Sri Lanka have harvested good yields even after thirteen ratoons (Pers. Com., Agronomists Hingurana and Sevenagala Sugar Companies). Keerthipala and Dharmawardene (1996) reported an increase in rain-fed sugarcane yields from plant crop to first ratoon and reduction thereafter with subsequent ratoonings. Ratoon yield is an ultimate expression of interplay of several factors, such as, the ratooning ability of a given variety (Milligan *et al*., 1992), the influence of environment on its expression (Chapman, 1988) and the degree of ratoon management (Soopramanien, 1996). Therefore, a good ratooning variety, under favourable environmental conditions could give yield as good as plant crop, or even more, if it was managed properly (Sundara, 2004; Ng Kee Kwong, 2004). Stubble shaving, fertilisation and gap filling are the three important initial management practices, which have substantial impact on ratoon crop productivity.

Stubble shaving is the practice of shaving off the portion of stalks that are protuberant above the soil surface after harvest of sugarcane, so that underground buds are encouraged to sprout and produce new shoots. Stubble shaving, thus, helps to establish deep-rooted and vigorous ratoon crop (Sundara, 2004). Fertilising sugarcane, both plant and ratoon crops, is essential to replenish the nutrient removed with each harvest and maintain soil fertility and enhance crop yield (Schroeder *et al*., 2005). The gaps in ratoon fields may occur due to situations such as failure of some of the stubbles to sprout, dying out of sprouted buds in hot weather, damage due to pests and diseases, poor plant crop stand, ratoon decline and poor field conditions. These gaps have to be filled to obtain an optimum crop stand and maximum yield.

The above-mentioned management practices of ratoon crops are important to increase productivity and profitability of sugar cane farming. However, the contribution of each management practice on ratoon yield has not been studied under Sri Lankan conditions. Farmers, often, neglect or delay various management practices in their ratoon fields. This study was, therefore, planned to investigate the effects of stubble shaving, fertilisation, gap filling on the performance of sugarcane ratoon crops and to find out relative importance these management practices on increasing ratoon yield.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of the Sugarcane Research Institute (SRI), Uda Walawe (6^0 21' N, 80^0 48' E; altitude, 76 m), Sri Lanka. The area is located in the south-eastern boundary of the dry and intermediate zones of Sri Lanka. The soil is predominantly a well-drained, reddish brown earths (Alfisol to Ustalf), with a sandy-clay loam texture, pH 5.5 to 7.0, low organic matter content (1 – 2%), and moderate to low levels of N and K and cation exchange capacity (CEC) (DE Alwis and Panabokke, 1972). The area is characterised by a bi-modal pattern of rainfall with an approximately 1300 mm average annual precipitation. About two-thirds of the annual rainfall is received during

September to February (*Maha* season). There is a small peak of rainfall during March to May (*Yala* season), but the rainfall during these months is erratic. The rest of the months in a year are relatively dry, except occasional showers in between. Ambient air temperatures are relatively high, ranging from 28 – 32^{0}C throughout the year. Bright sun shine ranges from about 6 to 8 h d^{-1} and winds with a velocity of about 4 to 7 km h^{-1} are common, particularly during the dry period (Panabokke, 1966).

A uniform piece of land representing the general topography of the area selected for the experiment was ploughed as per recommendations for commercial sugarcane planting (SRI, 1991) and 15-18 cm deep furrows were made at a spacing of 1.37 m to plant sugarcane. The field was laid out to develop three blocks, each having eight treatment plots. Each treatment plot surrounded by a 1.5 m wide boundary consisted of six rows each 9 m long. The experiment was established on 4th April 2005 with the variety SL 83 06. After harvesting the plant crop (PC), the first and second ratoon crops (ratoon I and ratoon II) which were raised in March 2007 and September 2008 respectively were used for testing the treatments mentioned below:

Stubble shaving: with stubble shaving
without stubble shaving

Fertilisation: with fertilisation
without fertilisation

Gap filling: with gap filling
without gap filling

The effects of two levels of each of the above treatments and their possible combinations (Total eight treatment combinations) were tested in 2^3 factorial-structured RCBD statistical design with three replications. The ratoon II was harvested in September 2009.

Field plots to allocate different treatment combinations were identified randomly after establishing the plant crop. Fertilisation and gap filling treatments were introduced to the respective plots of the plant crop and these treatments were repeated in the same plots in ratoon I and ratoon II. The stubble shaving treatment was introduced to the respective plots of ratoon I. Number of stools and stalks per stool were recorded after harvesting PC, but before shaving the stubble, and the same procedure was carried out in the same plots in ratoon II.

The plots, which were identified to be fertilised, were supplied with Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) at the rates of 232 kg, 94 kg and 101 kg per hectare respectively. 38 kg of Urea and the total dose of TSP and 45 kg of MOP were applied at planting. The balance Urea was applied in two split doses; 116 kg/ha. at 45 days after planting (DAP) and 78 kg/ha. at 90 DAP. Likewise, the balance amount of MOP was applied in two equal doses at 45 and 90 DAP. For ratoon crops, Urea, TSP and MOP were applied at the rates of 255, 134 and 84 kg/ha., respectively. As for the plant crop, one third of Urea, full dose of TSP and one third of the amount of MOP were applied soon after ratooning. The balance Urea and MOP were applied in two equal doses at 45 and 90 days after rationing (DAR).

A distance of 45 cm or more along the cane rows without a plant at 30 DAP or DAR was considered as gaps, and such gaps only in the respective treatment plots were filled with one- month old plants raised in poly-bags. The crop was supplementary irrigated and other management practices were carried out as per recommendations (SRI, 1991). Each plot was irrigated separately to avoid movement of fertilisers from one plot to another.

Plants that emerged one month after ratooning (MAR) in the inner four rows were counted to measure germination in each treatment. Number of tillers in randomly-selected two inner rows were counted at three MAR to measure tillering. At harvest, all mature stalks in the inner four rows were counted and weighed to estimate millable stalks number per a metre row length and cane yield in tonnes per hectare. Twelve stalks from each plot were crushed and the extracted juice was analysed to estimate pure obtainable cane sugar content (POCS). After harvesting each crop, cane stools in two inner cane rows in each plot were counted to estimate stool density per metre row length. Also, number of total stalks and number of live stalks in ten randomly-selected stools in inner cane rows were counted and values were averaged for presentation. Number of stalks died out of total in a stool was converted to percentages. Analysis of variance (ANOVA) for each variable was done using SAS package to test the effects of treatments.

RESULTS AND DISCUSSION

Ratoon I crop

Performances of stools and stalks of ratoon I, in which the impact of stubble shaving treatment was not applicable were presented in a two-way table showing fertilisation and gap filling treatments and their two levels (Table 1) (Gomez and Gomez, 1984).

Fertilisation and gap filling had no significant effect ($P \leq 0.05$) on germination and tillering of ratoon I. The effects of either fertilisation or gap filling treatments and their interactions were also non-significant ($P \geq 0.05$) on numbers of stools per metre, number of total stalks per stool, number of live stalks per stool and dead stalks percentage per stool (Table 1). This may be due to better establishment of plant crop, as indicated by its germination (6 ± 0.76 shoots/m) and tillering (17 ± 1.4 shoots/m) coupled with an inherent ability of the variety to produce a good ratoon crop. Studies conducted at the SRI revealed that SL 83 06 was a good ratooning variety (SRI, 1990/92).

Table 1. Stool number per metre, total stalks per stool, live stalks number per stool and percentage dead stalks per stool in ratoon I crop with and without fertilisation and gap filling, showing differences between the two levels in each of two factors

	Number of stools per metre			**Number of total stalks per stool**		
	With fertiliser	**Without fertiliser**	**Difference†**	**With fertiliser**	**Without fertiliser**	**Difference†**
Gap fill	3.2	3.4	0.2 ns	7.3	7.1	0.2 ns
No gap fill	2.9	3.4	0.5 ns	8.7	9.1	0.4 ns
Difference†	0.3 ns	0.0 ns		1.4 ns	2.0 ns	
	Live stalks number per stool			Dead stalks percentage per stool		
	With fertiliser	Without fertiliser	Difference†	With fertiliser	Without fertiliser	Difference†
Gap fill	6.1	5.8	0.3 ns	15.9	19.3	3.4 ns
No gap fill	7.0	7.6	0.6 ns	20.1	16.8	3.3 ns
Difference†	0.9 ns	1.8 ns		4.2 ns	2.5 ns	

† Values are average of three replications. The differences are non-significant (ns) at $P \leq 0.05$ in DMRT separation

In ratoon I crop, stubble shaving did not show a significant ($P \leq 0.05$) effect on millable stalk number in the different treatments (Table 2). There were no significant interactions ($P \leq 0.05$) between different treatments and their two levels. This may be due to harvesting the plant crop at the base, as the stubble appeared above the soil surface after harvesting was measured and values ranged 3 to 18 cm.

There were also no significant effects of fertilisation and gap filling either alone or together on millable stalk number. As a consequence of better establishment of PC and ratoon I coupled with other crop management practices, the tested management practices would not have affected the millable stalks number significantly at this stage.

In contrast, cane yields showed different responses as there was interplay of different management practices and their two levels on their expression in different treatment plots. Stubble shaving alone did not contribute significantly ($P \leq 0.05$) to increase or decrease cane yield. However, in the stubble shaved plots, cane yields were significantly ($P \leq 0.05$) greater (45% more in fertilised plots than unfertilised plots) without gap filling. Similarly, in the stubble shaved plots, effect of fertilisation and gap filling together contributed to increase ($P \leq 0.05$) cane yield by 35% when compared to the plots in which none of these two treatments were adopted. In contrast, in the plots stubbles were not shaved, higher cane yields (29%) were recorded in fertilised plots than unfertilised plots both with gap filling. Unlike under stubble shaving and gap filling, there was a 28% increase of mean cane yield in fertilised plots (89.7 ± 3.5 t/ha.) than in unfertilised plots (70.3 ± 3.6 t/ha). The above results indicate that fertilisation is important in ratoon I crop to get higher cane yield.

Table 2. Millable stalks number and cane yields in ratoon I crop with and without stubble shaving, fertilisation and gap filling; showing differences between the two levels of fertilisation and gap filling

	With stubble shaving			Without stubble shaving		
	With fertiliser†	**Without fertiliser†**	**Difference‡**	**With fertiliser†**	**Without fertiliser†**	**Difference‡**
Millable stalks at harvesting (no./m)						
Gap fill	10.7	9.0	1.7 ns	9.3	9.0	0.3 ns
No gap fill	10.7	8.7	2.0 ns	9.7	9.3	0.4 ns
Difference‡	0.0 ns	0.3 ns		0.4 ns	0.3 ns	
Cane yield (t/ha)						
Gap fill	86.5 ab	70.7 bc	15.8 ns	92.1 a	71.2 bc	20.9*
No gap fill	93.1 a	64.1 c	29.0*	87.1 ab	75.1 abc	12.0 ns
Difference‡	6.6 ns	6.6 ns		5.0 ns	3.9 ns	

† Values are average of three replications. Mean separation by DMRT at $P \leq 0.05$. Values follow by common letters under each variable are not significantly different.

‡ ns - The differences are not-significant; * The differences are significant.

The study further indicates that in ratoon I, gap filling alone has not increased cane yields significantly ($P \leq 0.05$) with or without fertilisation both with and without stubble shaving. In this experiment, good-quality seed cane was used and a recommended density was planted. In the plots identified to fill the gaps, a distance of 45 cm. or more without a plant along the cane rows were filled. However, there were few gaps, which were more than 45cm along the cane rows without a plant in the other plots both in PC and ratoon I, but these gaps have not contributed to significant yield losses in no gap filled plots. Thus, intensity of gaps and their frequency of occurrence in no gap filled plots would not have adequately contributed to decrease ratoon I yield. As reported by Sundara (2004), significant yield losses could occur only if there are gaps of 60cm or more without a plant along the cane rows. Chauhan (1992) states that gaps exceeding 15% of the area caused significant yield losses in sugarcane.

Ratoon II crop

As in ratoon I, effects of either stubble shaving, fertilisation or gap filling or their interactions were non-significant ($P \geq 0.05$) on mean germination (16 ± 1.7 shoots/m) and tillering (16 ± 1.0 shoots/m). This may be due to better field establishment of PC and ratoon I coupled with inherent higher ability of the variety to regenerate from the stubble and produce more tillers. Similar germination and tillering pattern were recorded at 1 and 3 MAR respectively in ratoon II compared to germination (6 ± 0.76 shoots/m at 1 MAP) and tillering (17 ± 1.4 shoots/m at 3 MAP) of PC, indicating that ratoon crop had sprouted and produced tillers earlier than the PC. Therefore, relevant management practices of ratoon crops should be carried out at the correct time and any delay of their adoption would damage the crop and or would have no impact.

Similar to the ratoon I, stubble shaving alone did not show significant impact ($P \leq 0.05$) on number of stools per metre, number of total stalks per stool, live stalks number per stool and dead stalks percentage per stool (Table 3). However, there was an increase in mean percentages of stalks death without stubble shaving (17%) than the mean percentages of stalk death with stubble shaving (13%). The higher percentages of dead stalks per stool (more than 17%) occurs more often (three occasions out of four) without stubble shaving than with stubble shaving (one occasion out of four) (Table 3). The lowest figure (3.8%) was with stubble shaving. This indicates that there is an increasing trend of stalk death in the stools as a consequence of failure to shave stubbles. The stalks produced from the aerial buds of the stubble protruded above ground after harvesting sugarcane are weak and vulnerable to environmental hazards (Sundara, 1998). This could be attributed to the high rate of stalks death in the treatment plots where stubbles were not shaved. Thus, stubble shaving increases stalk survival and is an important ratoon management practice. This, however, has to be investigated further in later stages after consecutive ratooning.

Unlike in ratoon I, in the stubble shaved plots, gap filling contributed to increase ($P \leq 0.05$) stool number by 24% in fertilised plots (Table. 3). This indicates that gap filling increases stool density in ratoon II and is an important ratoon management practice. In contrast, in no gap filled situation, number of total stalks per stool was 57% more in stubble shaved plots with and without fertilisation than in the plots where cane had stubble shaving, gap filling and no fertilisation. Similarly, in the plots where stubbles were not shaved, total stalks per stool were more (68%) in no gap filling and without fertilisation than in the plots where cane had stubble shaving, gap filling and no fertilisation. In the stubble shaved plots, live stalks number per stool were more (66%) in no gap filling both with and without fertilisation than in the gap filled plots without fertilisation. However, in the plots where stubbles were not shaved, live stalk numbers per stool were more (62%) in no gap filled and unfertilised plots than gap filled and unfertilised plots in stubble shaving. These increases of total stalks and live stalks per stool in no gap filled plots may be due to production of more shoots and their higher survival rate as there was less interference from the neighbouring plants in the fields with gaps. However, increases of number of total stalks and live stalks per stool in no gap filled plots did not increase ratoon II yield (Table. 4).

Percentages of dead stalks per stool were highest (20%) in the plots treated with gap filling and fertilisation combination with stubble shaving, and the impact was significantly more ($P \leq 0.05$) than the least percentages of dead stalks per stool recorded in the plots treated with no fertilisation and no gap filling combined with stubble shaving (Table 3). The percentage values of dead stalks per stool in the stubble shaved plots did not indicate that the effects of fertilisation and gap filling alone had contributed to make any significant changes in stalk mortality. There are no significant differences in dead stalk percentage per stool between plots treated with different treatment combinations without stubble shaving (Table 3).

Table 3. Stool number per metre, total stalks, live stalk numbers and percentage dead stalks per stool in ratoon II crop with and without stubble shaving, fertilisation and gap filling; showing differences between the two levels of fertilisation and gap filling

	With stubble shaving			Without stubble shaving		
	With fertiliser†	Without fertiliser†	Difference‡	With fertiliser†	Without fertiliser†	Difference‡
Numbers of stools per meter						
Gap fill	2.31ᵃ	2.15ᵃᵇ	0.16 ns	2.13ᵃᵇ	2.00 ab	0.13 ns
No gap fill	1.87ᵇ	1.94ᵃᵇ	0.07ns	1.78ᵇ	2.00 ab	0.22ns
Difference‡	0.44*	0.21ns		0.35ns	0.00ns	
Numbers of total stalks per stool						
Gap fill	6.43ab	4.47b	1.96 ns	5.53ab	5.50 ab	0.03ns
No gap fill	7.47a	6.57ab	0.90ns	6.37 ab	7.50a	1.13ns
Difference‡	1.04ns	2.1 ns		0.84ns	2.0ns	
Live stalks number per stool						
Gap fill	5.23ab	3.83b	1.4ns	4.40 ab	5.03 ab	0.63ns
No gap fill	6.40a	6.30a	0.1 ns	5.17 ab	6.20a	1.03ns
Difference‡	1.17ns	2.47*		0.77ns	1.17ns	
Dead stalks percentage per stool						
Gap fill	19.5a	14.2ab	1.0ns	20.7a	8.7ab	1.7ns
No gap fill	14.0ab	3.8b	2.0ns	18.7a	19.2a	0.7ns
Difference‡	5.5ns	10.4ns		2.0ns	10.5ns	

† Values are average of three replications. Mean separation by DMRT at $P \leq 0.05$. Values follow by common letters under each variable are not significantly different.

‡ ns - The differences are not-significant; * The differences are significant.

Presence of gaps (Sundara, 2004), shaving stubble at ground level (Ferraris and Chapman, 1991) and limited supply of nutrition (Chapman, 1988) limit tiller density in ratoon crops and thus reduces mutual competition. These might have contributed for higher stalk survival in no gap filled, unfertilised and stubble shaved plots. However, this has not contributed to increase final cane yield.

As in ratoon I crop, stubble shaving did not have a significant effect ($P \leq 0.05$) on millable stalk number. This may be due to the harvesting of ratoon II close to ground level (Table 4). However, there is an increase ($P \leq 0.05$) of millable stalks number by (22%) in fertilised plots than in unfertilised plots without gap filling under stubble shaving. Further, there was an increase ($P \leq 0.05$) of millable stalks number in the plots treated with fertilisation and gap filling together than the plots treated with no fertilisation and no gap filling treatments in combination with and without stubble shaving. Plots treated with no gap filling and with fertilisation combination and with gap filling and no fertilisation combination showed similar millable stalks numbers to the plots treated with gap filling and fertilisation combination both with and without stubble shaving. This shows that fertilisation and gap filling are important ratoon management practices as both alone and together contribute to increase millable stalks, and any setback due to non-adoption of any practice could be compensated by the other. On average, there was a 12% increase of millable stalks number in fertilised plots (11.0 ± 0.29 stalks/m) than in unfertilised plots (9.8±0.37 stalks/m). Likewise, there was an 8% increase of millable stalks number in gap filled plots (10.8 ± 0.32 stalks/m) than in no gap filled plots (10.0 ± 0.41 stalks/m). Similar to millable stalk number, stubble shaving had no significant impact on ratoon II cane yield (Table 4). However, with stubble shaving, in gap filled plots, fertilisation increased ($P \leq 0.05$) cane yield by 31% and in no gap filled plots fertilisation increased cane yield by 45%. Fertilisation and gap filling together contributed to increase the ratoon yield by 52% than without adopting these two management practices in the stubble-shaved plots. However, without stubble shaving, a significant ($P \leq 0.05$) increase in cane yield (31%) due to fertilisation was observed only with gap filling. Moreover, without stubble shaving, there is an increase ($P \leq 0.05$) of cane yield by 40% due to the combined effect of fertilisation and gap filling than without fertilisation and no gap filling. The results show that in ratoon II, fertilisation alone increased cane yield in both gap filled and unfilled plots with stubble shaving. Also, fertilisation enhanced yield further in no gap filled plots with stubble shaving. However, without stubble shaving, an interplay of both fertilisation and gap filling was required to increased cane yield. Thus, both fertilisation and gap filling are important ratoon management practices. Moderate response to gap filling shown here may be due to low intensity of gaps and their low frequency of occurrence as a consequence of better establishment of PC and ratoon I together with inherent varietal performance. However, there was a 31% increase of mean cane yield in fertilised plots (76.5 ± 1.9 t/ha.) than in unfertilised plots (58.2 ± 3.4 t/ha.). This indicates that fertilisation and gap filling are important management practices of ratoon II crop as they have significant impacts on final cane yield.

The mean PC, ratoon I and ratoon II cane yield was 38% more ($P \leq 0.05$) in gap filled and fertilised plots than in no gap filled and unfertilised plots with stubble shaving (Table 4). In contrast, without stubble shaving, increase (P≤0.05) of mean cane yield (33%) with fertilisation was observed only in gap filled plots. This indicates that fertilisation is important for producing high ratoon yield. With stubble shaving, yields recorded in no gap filled and fertilised plots were similar to those with gap filled and unfertilised plots. This indicates that with stubble shaving, gap filling has enhanced cane yield in unfertilised plots. Similarly, fertilisation has enhanced cane yields in no gap filled plots. The average cane yield was significantly greater (27%) in gap filled and fertilised plots than in gap filled and unfertilised plots without stubble shaving. Overall means of average of PC, ratoon I and ratoon II cane yield was 23% higher in fertilised plots (71.7±2.2 t/ha) when compared to unfertilised plots (58.2±2.9 t/ha). This further confirms that fertilisation is important for obtaining higher yields from ratoon crops, and gap filling has enhanced yields both with and without fertilisation. Therefore, both these practices are important ratoon management practices and significant effects of fertilisation were seen both in ratoon I and II crops. A significant effect of gap filling on cane yield was found only in ratoon II. There was an apparent impact of stubble shaving on stalk mortality only in ratoon II.

Sugarcane juice quality (POCS) estimated from the cane samples collected after each harvesting did not show significant difference (P≤0.05) between different treatment plots.

Table 4. Millable stalks number and cane yields in ratoon II crop and mean cane yields of plant, ratoon I and ratoon II crops with and without stubble shaving, fertilisation and gap filling; showing differences between the two levels of fertilisation and gap filling

	With stubble shaving			Without stubble shaving		
	With fertiliser†	Without fertiliser†	Difference‡	With fertiliser†	Without fertiliser†	Difference‡
Millable stalks at harvesting (no./m)						
Gap fill	11.3ᵃ	10.3ᵃᵇ	1.0 ns	11.7ᵃ	10.0ᵃᵇ	1.7 ns
No gap fill	11.3ᵃ	9.3ᵇ	2.0*	10.0ᵃᵇ	9.3ᵇ	0.7 ns
Difference‡	0.0 ns	1.0 ns		1.7 ns	0.7 ns	
Cane yield (t/ha)						
Gap fill	79.5ᵃᵇ	60.6ᵈᶜ	18.9*	81.4ᵃ	62.0ᵇᶜᵈ	19.4*
No gap fill	75.6ᵃᵇᶜ	52.0ᵈ	22.7*	69.4ᵃᵇᶜᵈ	58.1ᶜᵈ	11.3 ns
Difference‡	3.9 ns	8.6 ns		12.0 ns	3.9 ns	
Mean cane yields of plant, ratoon I and ratoon II crops (t/ha)						
Gap fill	72.2ᵃᵇ	60.4ᵃᵇᶜ	11.8 ns	75.2ᵃ	59.3ᵇᶜ	15.9*
No gap fill	69.5ᵃᵇ	52.3ᶜ	17.2*	70.0ᵃᵇ	60.9ᵃᵇ	9.1 ns
Difference‡	2.7 ns	8.1 ns		5.2 ns	1.6 ns	

† Values are average of three replications. Mean separation by DMRT at P≤0.05. Values follow by common letters under each variable are not significantly different.

‡ ns - The differences are not-significant; * The differences are significant.

This indicates that the tested management practices had no significant impact on cane quality of ratoon crops.

CONCLUSIONS

Higher germination and tillering of PC, ratoon I and ratoon II crops observed in this study show that better plant crop establishment with a good ratooning variety is a prerequisite to maintain higher ratoon crop yields. Ratoon crops had sprouted faster and produced tillers earlier than the plant crop. This has to be taken into consideration in managing ratoon crops as ratoon crops start fast and give rapid ground cover than plant crop.

There was an apparent increase in stalks death in the plots where stubble was not shaved in ratoon II crop, even though these did not contribute to make a significant impact on final yield. Thus, neglect of this practice would lead to a reduction in yields in late ratoon crops. This has to be investigated further with long-term ratooning.

Vacancies in cane fields have to be filled to maintain higher stool density and cane yield, particularly, in late ratoon crops, and therefore, gap filling is an important management practice for ratoon crops. Fertilisation increased yield from the first ratoon crop itself. This practice was more significant as there was an increase in the parameters of ratoon I and ratoon II crops performance with fertilisation in several occasions, unlike in the other treatments.

There was a combined effect of two or more factors on various ratoon parameters. Enhancement of the effect of one treatment and compensation of setback due to absence of the other were found, particularly with fertilisation and gap filling treatments.

The above results indicate that all tested management practices, *i.e.*, stubble shaving, fertilisation and gap filling, directly or indirectly contribute to enhance ratoon crop performance and yield. Fertilisation appeared to be more important as its effect was significant both in ratoon I and II. Effect of gap filling was significant only in some situations in ratoon II. However, it appeared that gap filling has contributed to enhance growth and yield of unfertilised ratoon crops. This practice is, therefore, important for ratoon performance, particularly in late ratoon crops. Stubble shaving was important as there was an apparent reduction of stalk mortality, particularly in late ratoon crops.

This study, however, was conducted with ratoon I and II only. Effect of some of the treatments, for example stubble shaving and gap filling and their different combinations appears to be significant in late ratoon crops. Therefore, long-term studies of the effects of these ratoon management practices with several ratoons should be undertaken to confirm the results.

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