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Physiological studies on tiller production and its senescence in sugarcane – response comparison between plant and ratoon crops

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ABSTRACT

Tiller production, growth and mortality were compared between plant and ratoon crops of sugarcane (*Saccharum officinarum* L.) varieties Co 7805, Co 91010, Co 97008 and Co 98013, raised under different row spacings (0.75m,0.90m and 1.50m). Tillers emerged early and in a synchronous fashion in ratoon crop which was lacking in plant crop. The entire tillering phase has been shortened in ratoon crop to sixty days from one hundred and twenty days of plant crop. This places the advantage of ratoon crop for better growth. However, the early tiller mortality with high intensity in ratoon crops results in poor performance due to heavy competition for nutrients among the tillers in the early stages of sprouting of tillers. Suitable management practices if followed can reduce the tiller mortality and improve ratoon performance.

Key words : Biomass, Leaf area index, Ratoon, Sucrose % juice, Tiller mortality

In India, sugarcane (*Saccharum officinarum* L.) plant crop is normally harvested in twelve month, while the ratoon crops matures early and can be harvested earlier. Tillering in ratoon starts early and more synchronous than in plant crop due to more buds available in stubble as compared to the two budded setts of plant crop. While the germination takes almost 6-8 weeks more in plant crop, the ratoon crop has the advantage of establishing early. More profuse tillering and quick production of tillers is the speciality of the ratoons (Verma 2009). Ratoon started under favourable temperature and moisture conditions results in the production of about 80 percent of the peak number of shoots within about a fortnight. Excessive tillering in the case of ratoon results in greater competition and consequently greater mortality than the plant canes.

Both tillering and tiller senescence are sensitive to light competition and can be expected to be partly driven by the state of the existing canopy. Inman-Bamber (1994) noted that severe tiller senescence could be expected once the canopy intercepts 70% of incoming radiation. As a consequence of early establishment of tillers the ratoon crop canopy develops faster resulting in early canopy coverage, subsequently the tiller senescence starts early and heavily in ratoon. The present study is intended to elucidate the physiological variation in tiller production and mortality as well as other growth characteristics in plant and ratoon crops of sugarcane grown in different row spacings.

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MATERIALS AND METHODS

A field experiment was conducted with four varieties in three row spacings (0.75,0.90 and 1.5m) during the crop seasons (2009-2011), to study the extent of variability for tiller production, and its mortality between plant and ratoon crop. The genotypes were Co 7805, Co 91010, Co 97008 and Co 98013 . Three replications were maintained in a completely randomized block design. Standard cultural operations were carried out as per recommended practice. Growth physiological and biochemical parameters were studied during and after peak tillering phase. Tillers produced at different days (45, 60, 90,120 and 150) were marked with different colour tags. Tiller count was recorded at fortnightly intervals. Tiller, stalk population and number of millable canes were worked out at grand growth and maturity phases and at harvest. Tiller mortality (%) was worked out from the data on tiller population at 120 days (being peak tiller population time) and NMC at harvest. Juice quality was analysed at 10^{th} and 12^{th} month in different groups of stalks. Cane yield and related parameters were recorded at harvest. After the harvest of the plant crop, stubble shaving was done to raise ratoon crop. The field was irrigated immediately and basal dose of super phosphate (175 kg/ha), urea 240 kg (120+120) and potash 80 kg (40 + 40) were applied. Tiller count was recorded from 30 days after ratooning. All observations were recorded for ratoon crop similar to plant crop.

Sucrose % juice: Juice quality was analysed at 10^{th} and

12th month in different groups of stalks. Five canes in each replication were cut and juice was extracted through a crusher (extraction efficiency ~ 65%). The clarified juice was used to determine the brix, sucrose and purity, utilizing Automatic Saccharimeter (Autopol 880, Rudolph, USA)

Data on physiological parameters, cane yield and juice quality were analysed for significance using OP-STAT programme.

RESULTS AND DISCUSSION

Tiller production

In the plant crop, the shoot population was highest at 120 days after planting (DAP) while in ratoon crop the peak population was at 60 days after ratooning (Fig 1). The tiller population was highest under narrow (0.75m) spacing and in variety Co 98013 (225 177/ha), while under wide row (1.5m) the same variety produced only 116900 tillers/ha. Among the genotypes Co 98013 produced more shoots followed by Co 91010 and Co 97008. The tiller population was highest at 60 days after ratooning (DAR) in most of the genotypes and spacings except Co 91010 wherein the peak tiller population was recorded at 100 DAR (Fig 1). At 210 DAR the stalk population stabilized. The peak of tiller production in ratoon crop showed earliness by about 60 days as compared to plant crop. Canopy development in ratoon crop is more rapid than in plant crop (Thompson 1988, Robertson *et al.* 1996) because more buds are available to produce primary shoots and the buds are closer to the surface than in a plant crop.

Tiller mortality

Tiller mortality was high in narrow spacing (38%) as compared to normal (33%) and wide row (28%). Variety Co 98013 recorded higher tiller mortality in all the spacings, while Co 91010 recorded least. In plant crop, the tiller mortality was very low during the peak tillering stage, i.e. 60-120 days after planting subsequently a steep increase in tiller

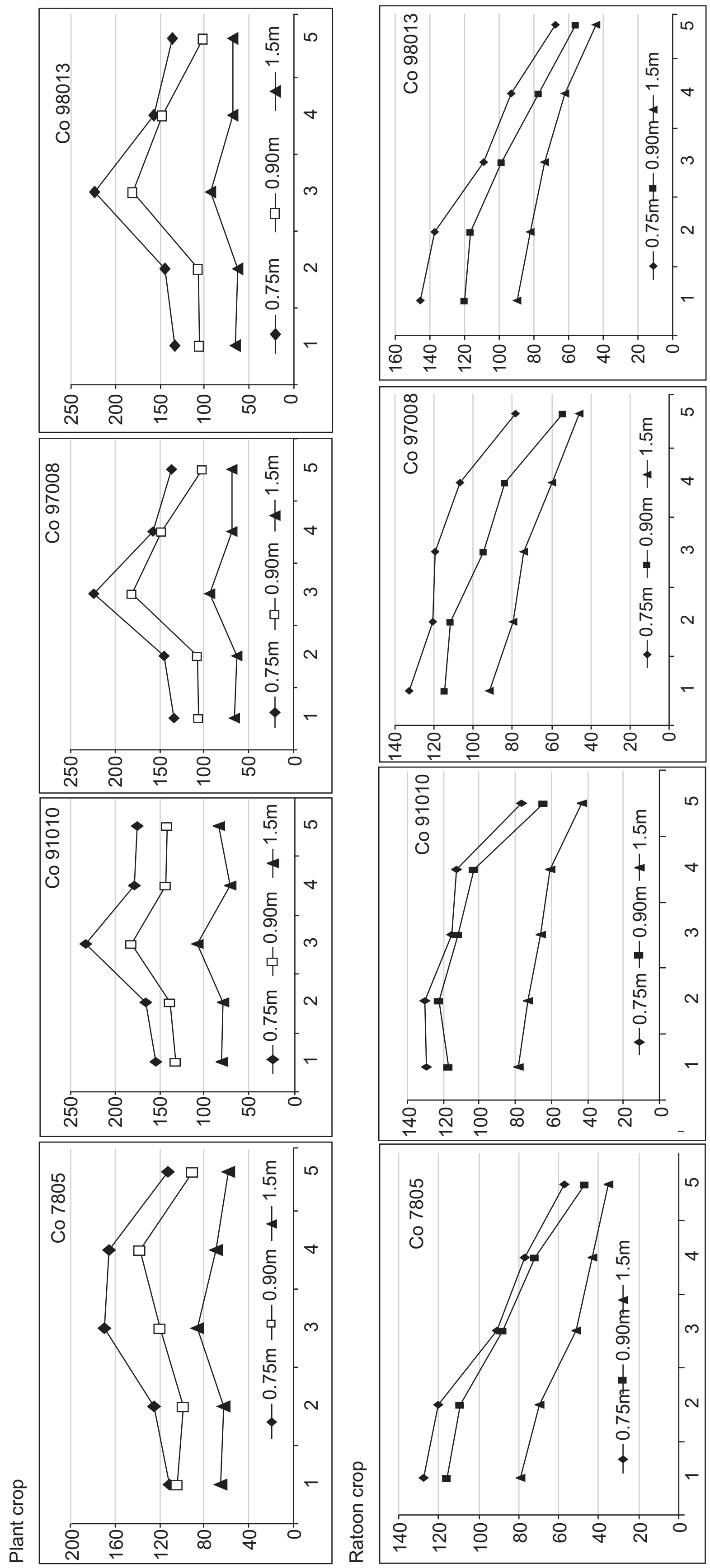

Fig.1 Tiller /stalk population in plant and ratoon crops (Plant crop:1-5 in the x -axis represents 60,90,120,210 and 360 days after planting; Ratoon crop 1-5 represents 60,90,150,210 and 360 days after ratooning. Y- Axis represent tiller/stalk population ('000/ha).

Table 1 Tiller mortality (%) in plant and ratoon crops

Genotype	Plant crop			Ratoon crop		
	Narrow	Normal	Wide	Narrow	Normal	Wide
Co 7805	33.8 (±2.5)	24.9 (±3.1)	31.4 (±6.3)	54.6 (±6.5)	59.6 (±3.7)	52.2 (±9.5)
Co 91010	22.1 (±4)	21.7 (±2.4)	20.7 (±6.6)	38.8 (±12.2)	44.7 (±6)	44.2 (±6.2)
Co 97008	36.6 (±8.4)	40.5 (±6.8)	22.9 (±2.9)	40.2 (±7.1)	52.4 (±3.5)	48.7 (±7.8)
Co 98013	50.1 (±10)	48.0 (±8)	38.7 (±7.2)	73.43 (±2.7)	53.5 (±2.1)	50.9 (±2.8)

mortality was recorded. The tiller mortality in ratoon was 45% as against plant crop of 36% in narrow spacing. In normal and wide row the tiller mortality of ratoon and plant crops are 51%/30% and 43%/24% respectively (Table 1). The ratoon crop tiller mortality occurred even at 40 days of crop age in all the row spacings. However, in the plant crop the peak tiller mortality was observed beyond 120 days of crop age. The earliness of peak tillering phase in ratoon is perhaps responsible for the higher mortality. The tillers formed from the stubbles are more synchronous resulting in tough competition for nutrients rendering more tillers to senesce. The earliness of tiller production as well as tiller mortality suggests that the critical nutrient as well as water requirement of the ratoon crop for sustaining the large tiller population at early stage, failing which, result in less number of millable canes, consequently lower cane yield. Planting season influenced tillering considerably. Tiller mortality was high in autumn planted sugarcane than spring and summer. Delayed ratooning increased the tiller production in the first fortnight and also their relative contribution to millable canes (Pandey and Shukla 1992).

Leaf Area Index and biomass

LAI varied from 3.35 to 4.28 under wide row, while under normal and narrow spacings it varied from 4.35-7.62 and 5.75-6.72 respectively. Co 98013 recorded higher LAI in all the spacings. In the ratoon crop, the leaf area index was comparatively less than plant crop, mainly due to less population (Table 2). The lower leaf area and number of millable cane together resulted in reduced cane weight in ratoon crop. However, better cane characteristics, viz. length, girth and weight compensated this reduction due to lower leaf area and stalk population, in plant crop.

Biomass at grand growth was high in narrow spacing in varieties Co 7805 (4.152 kg m^2), Co 91010 (4.06 kg m^2) and Co 97008 (4.5 kg m^2). Under wide row all the varieties produced lower biomass. In the ratoon crop, the total biomass production followed similar trend (Table 2).

Juice quality

Sucrose % juice varied from 16.98 (Co 98013) to 19.65 (Co 91010) in narrow spacing. In normal row spacing it varied from 16.31 (Co 98013) to 18.94 (Co 7805) and under wide row the sucrose % varied from 17.85 (Co 97008) to 19.63(Co 7805). In the ratoon crop, the juice quality at 270 days of crop age showed more or less comparable sucrose% in the juice with plant crop of 300 days crop age. The sucrose%juice in the plant crop of age 360 days much lower as compared to ratoon crop of age 330 days (Table 4). Ratoon crop performs on par/better than plant crop with respect to quality characters, viz. sucrose % juice, commercial cane sugar% and also ripens much earlier than plant crop.

Table 2 LAI (a) and biomass production (b, kg/m^2) at grand growth stage

Genotype		Plant crop			Ratoon crop		
		75cm	90cm	150cm	75cm	90cm	150cm
Co 7805	a.	5.7	4.3	3.3	3.9	3.2	2.6
	b	4.1	3.1	2.9	4.8	3.8	2.1
Co 91010	a	5.8	5.7	3.4	5.4	2.5	2.2
	b	4.0	3.2	2.8	3.0	2.6	2.3
Co 97008	a	6.4	5.4	3.3	5.4	3.1	2.4
	b	4.5	3.0	3.1	4.3	2.6	2.1
Co 98013	a	6.7	7.6	4.2	5.9	4.4	3.2
	b	4.7	4.9	3.7	4.8	3.5	2.8
(P=<0.5)		SEd	CD		SEd	CD	
G × Spacing	a	0.46	0.95		0.60	NS	
	b	0.65	NS		1.02	2.12	

Harvest data

In plant crop, cane yield ranged from 119.02 tonnes/ha

Table 3 Sucrose % juice during ripening in plant and ratoon crop

Genotype	300 DAP			360 DAP		
	0.75m	0.90m	1.5m	0.75m	0.90m	1.5m
Co 7805	18.38	18.94	16.87	18.84	19.92	19.63
Co 91010	18.70	18.62	17.82	19.65	19.98	18.23
Co 97008	17.37	17.81	16.61	18.44	18.04	17.85
Co 98013	14.52	16.31	15.89	16.98	17.78	18.43
	SED	*CD (0.05%)*		*SED*	*CD (0.05%)*	
Genotype	0.41	0.85		0.48	NS	
Spacing	047	0.98		0.56	1.17	
G × S	0.82	NS		0.97	NS	
Ratoon crop	*270 DAR*			*330 DAR*		
Co 7805	17.86	18.50	16.84	20.16	19.59	19.66
Co 91010	16.74	16.10	16.41	19.41	19.77	19.74
Co 97008	16.88	15.77	16.71	18.45	18.39	19.04
Co 98013	16.26	16.01	16.40	19.75	19.46	19.59
	SED	*CD (0.05%)*		*SED*	*CD (0.05%)*	
Genotype	0.39	NS		0.34	NS	
Spacing	0.45	0.93		0.39	0.81	
G × S	0.78	NS		0.68	NS	

Table 4 Number of millable canes and cane yield at harvest

Genotype plant crop	Number of millable canes ('000/ha)			Cane yield (tonnes/ha)		
	0.75m	0.90m	1.5m	0.75m	0.90m	1.5m
Co 7805	112.444	90.277	58.888	127.61	125.52	92.42
Co 91010	170.222	139.81	87.222	117.29	119.02	112.45
Co 97008	128.133	98.444	70.733	138.23	158.41	122.70
Co 98013	110.777	96.759	70.922	165.99	151.44	160.54
	SED	*CD (0.05%)*		*SED*	*CD (0.05%)*	
Genotype	4.31	8.95		8.99	18.65	
Spacing	3.74	7.75		7.78	NS	
G × S	7.48	15.51		15.57	NS	
Ratoon crop						
Co 7805	57.283	46.789	35.094	38.06	41.40	36.76
Co 91010	77.036	64.32	43.58	41.36	51.78	32.86
Co 97008	78.641	54.322	45.926	65.63	42.49	45.94
Co 98013	67.777	55.555	43.950	88.77	78.65	78.42
	SED	*CD (0.05%)*		*SED*	*CD (0.05%)*	
Genotype	3.57	7.40		3.83	7.95	
Spacing	3.09	6.41		3.32	6.88	
G × S	6.18	NS		6.64	NS	

(Co 91010) to 158.41 tonnes/ha (Co 97008) in 0.90 m spacing. In 0.75m spacing the yield varied from 117.29 tonnes/ha (Co 91010) to 165.99 tonnes/ha (Co 98013). Under wide row (1.5m) cane yield varied from 92.42 tonnes/ha (Co 7805) to 160.54 tonnes/ha (Co 98013). Cane yield significantly varied among the varieties, while spacing and variety × spacing interaction was not statistically significant suggesting wide row planting does not affect cane yield. Number of millable canes was least in wide row spacing (1.5m), as compared to conventional and narrow spacings (0.9 and 0.75m). Number of millable canes (NMC) was highest under narrow spacing (0.75m) in all the varieties. It ranged from 101.933('000/ha) in Co 7805 to 160.822 ('000/ha) in Co 91010. Under conventional row spacing (0.90m), the NMC varied from 85.481 to 135.481('000/ha). The data on NMC and cane yield indicated that with increase in NMC (under narrow spacing) the single cane weight decrease. Under wide row the single cane weight significantly improved in all the varieties. Perhaps this single factor compensates for reduction in cane yield and the cane yield did not vary significantly among treatments. Cane yield varied from 38 tonnes/ha (Co 7805) to 88.7 tonnes/ha (Co 98013) in narrow spacing, while in normal and wide row it ranged from 41 to 78.6 and 25 to 78.4 tonnes/ha, respectively. The varietal variation for cane yield was significant while spacing and interaction was not significant. Sucrose% juice varied significantly among spacings; however, the interaction between spacing and varieties was not significant (Table 4). The reduction of about 50 % in number of millable canes and cane yield suggest that the heavy tiller mortality is responsible for the poor ratoon performance. Following suitable cultural practices to improve tiller survival during initial stages of growth, i.e. up to 90 days after ratooning, perhaps would improve ratoon productivity.

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