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Effect of planting rows and intercropping on physiological parameters of sugarcane under sustainable sugarcane initiative

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Abstract
A field experiment was conducted at Sugarcane Research Station, Sirugamani during the first plant crop 2016-17, effect of planting rows and intercropping on physiological parameters of sugarcane under SSI. The experiment was laid out in strip plot design with three replications. The main plot treatments comprised of crop geometry *viz.*, M_1- 150 x 60 cm Single row planting, M_2- 150 x 60 cm Double row planting, M_3- 180 x 60 cm Single row planting and M_4- 180 x 60 cm Double row planting. The sub plot treatments were S_1-Sole crop of Sugarcane, S_2-Sugarcane + Greengram (Co 8), S_3-Sugarcane + Blackgram (VBN 5) and S_4-Sugarcane + Sunnhemp (Co 1). The intercrops were raised in additive series *viz.*, 3 rows under a row spacing of 150 cm in sugarcane and 4 rows under 180 cm. The recommended schedule of drip fertigation for SSI was followed by using surface drip irrigation system. The physiological parameters of sugarcane like absolute growth rate, crop growth rate and chlorophyll index were observed under SSI. The results revealed that raising physiological parameters recorded higher absolute growth rate, crop growth rate and chlorophyll index, double row planting with sugarcane with sunnhemp (M_2S_4).

Keywords: sustainable sugarcane initiative (SSI), absolute growth rate (AGR) and crop growth rate (CGR)

Introduction
Sugarcane (*Saccharum officinarum*) is one of the most important industrial crops in our country and also emerging as a multi-product crop contributing to the production of sugar, jaggery, alcohol, electricity, paper and other allied products. Sugar which adds sweetness to food stuff is extracted from the juice of the sugarcane. The thick stalks of canes store energy as sucrose in the sap. The word 'sugar' is derived from the Sanskrit word *Sakkara/Sarkara*. The Sustainable Sugarcane Initiative (SSI) is a practical approach to sugarcane production which is based on the principles of 'more with less' in agriculture like System of Rice Intensification (SRI). The SSI improves the productivity of water, land and labour, while reducing the overall pressure on water resources. Technique is a method of sugarcane production which involves using fewer setts, less water, optimum utilization of fertilizers and land to achieve more yields (WWF-ICRISAT, 2009) [11]. In view of dwindling land resources, changing market scenario, consumers' preferences and global competitions, new income generating opportunities need to be created through intercropping in sugarcane. Success of a commercial cane variety in a given environment depends on the synchronized production and growth of tillers. Late formed tillers not only contributed to tonnage loss but also seriously draw upon the nutritional resources of the early tillers which in turn lead to decreased overall yield (Ramanujam, 1969) [6].
Methods of planting play an important role in sugarcane production. Normally, sugarcane crop is cultivated in ridges and furrows by adopting single row planting in our country. But, when double row planting is adopted in sugarcane, possibilities are there to increase the yield compared to single row planting due to availability of sufficient sunlight, better aeration coupled with effective utilization of space and nutrients through more millable cane production. Dhotre *et al.* (2008) [1] reported that drip irrigation with double side planting has recorded maximum yield (134.9 t ha^{-1}) compared to single side planting (103.8 t ha^{-1}). Hence, the present study was made to effect of planting rows and intercropping on physiological parameters of sugarcane under SSI.

Materials and Methods
Field experiment was laid out during *special* season of 2016 at Sugarcane Research Station, Sirugamani, located at Cauvery delta zone of Tamil Nadu. The geographical location of the experiment site is 10^0 56'N latitude and 78^0 26'E longitude with an altitude of 78.12 m above

the MSL. The farm receives an average rainfall of 730.30 mm. The soil of the experimental site was well drained clay loam in texture with low in available nitrogen, medium in available phosphorus and high in available potassium. The soil analyzed 234, 15.8 and 467 kg/ha, respectively of $KMno_4$-N, Olsen P and NH_4OAc-K, respectively with EC of 0.29 dsm^{-1}, pH of 8.58 and organic carbon of 0.58%. The experiments were laid out in split plot design (SPD) with four main treatment and four sub treatments replicated thrice. The net plot size adopted was 27.00m^2 (9.0 m X 3.0 m). Short duration pulses of greengram (ADT 3), blackgram (VBN5) and sunnhemp (CO1) maturing in 60-75 days were used for the study. The main plot treatments comprised of crop geometry *viz.*, M_1- 150 x 60 cm Single row planting, M_2- 150 x 60 cm Double row planting, M_3- 180 x 60 cm Single row planting and M_4- 180 x 60 cm Double row planting. The subplot treatments were S_1-Sole crop of Sugarcane, S_2-Sugarcane + Green gram, S_3-Sugarcane + Blackgram and S_4-Sugarcane + Sunnhemp. The intercrops were raised in additive series *viz*., 3 rows under a row spacing of 150 cm in sugarcane and 4 rows under 180 cm. The recommended schedule of drip fertigation for SSI was followed under surface drip irrigation system. The absolute growth rate, crop growth rate at 120-180 DAP, 180-240 DAP and 240-300 Days after planting, Chlorophyll index at 120 DAP, 180 DAP, 240 DAP and 300 DAP were observed.

Result

Absolute growth rate (g plant $^{-1}$ day $^{-1}$)

In 2016-17, among the row plantings, 180 cm single row planting (M_3) recorded higher growth rate (57.24, 31.20 and 13.49 at 120-180, 180-240 and 240-300 DAP, respectively) followed by 150 cm single row planting (M_1). Planting at 180 cm double row planting (M_4) has recorded the least absolute growth rate (Table, 1).

With regard to intercropping systems, sugarcane with sunnhemp (S_4) recorded higher absolute growth rate (41.45, 22.83 and 13.49 at 120-180, 180-240 and 240-300 DAP, respectively) followed by sugarcane with blackgram (S_3) and both were comparable with each other.

The interaction between row planting and intercropping systems under SSI practices was significant at 180-240 and 240-300 DAP. During these stages, the treatment combinations, sugarcane planted at 180 cm in single row plantig (M_3) with greengram (M_3S_2) recorded higher absolute growth rate while the treatment combination involving planting at 180 cm in double rows recorded lesser absolute growth rate (M_3S_4).

Table 1: Effect of spacing and row arrangement, and intercropping systems on absolute growth rate (g $plant^{-1}$ day^{-1}) of sugarcane under SSI

Treatment	120-180 DAP					180-240 DAP					240-300 DAP				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	47.00	27.17	54.45	27.00	38.90	25.50	12.92	31.95	14.62	21.25	11.33	11.49	13.20	7.06	10.77
S_2	45.41	27.68	55.20	28.01	39.07	24.50	13.59	32.42	14.62	21.28	12.80	10.49	12.44	8.10	10.96
S_3	43.65	28.24	58.71	26.92	39.38	22.54	12.59	29.94	14.03	19.78	15.90	10.44	12.00	8.37	11.68
S_4	48.52	29.13	60.60	27.55	41.45	25.97	22.12	30.51	12.74	22.83	12.14	13.87	18.23	9.70	13.49
Mean	46.14	28.05	57.24	27.37		24.63	15.31	31.20	14.00		13.04	11.57	13.97	8.31	
	M	S	M at S	S at M		M	S	M at S	S at M		M	S	M at S	S at M	
SEd	0.71	0.49	1.64	1.55		0.65	0.50	1.07	0.98		0.16	0.08	0.32	0.28	
CD (P=0.05)	1.74	1.19	NS	NS		1.60	1.22	2.38	2.15		0.40	0.20	0.69	0.60	

Main plot : Spacing and row arrangement

M_1 : 150 x 60 cm Single row planting
M_2 : 150 x 60 cm Double row planting
M_3 : 180 x 60 cm Single row planting
M_4 : 180 x 60 cm Double row planting

Sub plot : Intercropping systems

S_1 : Sole crop of sugarcane
S_2 : Sugarcane +Greengram
S_3 : Sugarcane + Blackgram
S_4 : Sugarcane + Sunnhemp

Crop growth rate (g m^{-2} day^{-1})

In 2016-17, among the row plantings, 180 cm single row (M_3) recorded higher crop growth rate (53.00 and 28.89 at 120-180 and 180-240 DAP, respectively) and (M_1) 150 cm in single row planting recorded higher crop growth rate (14.49 at 240-300 DAP) (Table, 2).

With regard to intercropping systems, sugarcane with sunnhemp (S_4) recorded higher crop growth rate (23.89 and 13.69 at 180-240 and 240-300 DAP, respectively) followed by sugarcane with blackgram (S_3) and sugarcane with greengram (S_2), and both were comparable with each other.

The interaction between row planting and intercropping under SSI practices was significant at 180-240 and 240-300 DAP. During these stages, the treatment combinations, sugarcane planted at 180 cm in single row (M_3) with greengram (M_3S_2) recorded higher crop growth rate at 180-240, while sugarcane planted in single row with blackgram (M_1S_3) recorded higher CGR at 240-300 DAP.

Table 2: Effect of spacing and row arrangement, and intercropping systems on crop growth rate (g m^{-2} day^{-1}) of sugarcane under SSI

Treatment	120-180 DAP					180-240 DAP					240-300 DAP				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	52.22	30.18	50.41	25.00	39.45	28.33	14.36	29.58	13.54	21.45	12.58	12.76	12.22	6.54	11.03
S_2	50.46	30.75	51.11	25.93	39.56	27.23	15.10	30.02	13.54	21.47	14.22	11.66	11.52	7.50	11.23
S_3	48.50	31.38	54.36	24.93	39.79	25.05	13.99	27.72	12.99	19.94	17.66	11.60	11.11	7.75	12.03
S_4	53.91	32.36	56.11	25.51	41.97	28.86	24.58	28.25	11.80	23.37	13.49	15.41	16.88	8.99	13.69
Mean	51.27	31.17	53.00	25.34		27.37	17.01	28.89	12.97		14.49	12.86	12.93	7.69	
	M	S	M at S	S at M		M	S	M at S	S at M		M	S	M at S	S at M	
SEd	1.12	0.88	1.85	1.71		0.39	0.26	0.84	0.79		0.15	0.20	0.39	0.42	
CD (P=0.05)	2.73	NS	NS	NS		0.96	0.64	1.83	1.69		0.37	0.49	0.85	0.91	

Main plot : Spacing and row arrangement

M_1 : 150 x 60 cm Single row planting
M_2 : 150 x 60 cm Double row planting

Sub plot : Intercropping systems

S_1 : Sole crop of sugarcane
S_2 : Sugarcane + Greengram

M_3	:	180 x 60 cm Single row planting	S_3	:	Sugarcane + Blackgram
M_4	:	180 x 60 cm Double row planting	S_4	:	Sugarcane + Sunnhemp

Chlorophyll index

In the 2016-17 plant crop I, higher chlorophyll index was observed under double row planting (M_2) at all the stages of observation followed by 150 cm single row planting (M_1). Invariably, 180 cm double row planting (M_3) registered lower chlorophyll index at 120, 180, 240, and 300 DAP (Table, 3).

With regard to intercropping systems, chlorophyll index was higher with sugarcane + sunnhemp (S_4) at all the stages *viz*., 120 DAP (49.64), 180 DAP (54.86), 240 (49.75) and 300 DAP (44.31) than sole crop of sugarcane.

During the 2016-17 Plant crop I, there was no significant interaction between the planting rows and intercropping systems under SSI practices at all the stages.

Table 3: Effect of planting rows and intercropping on Chlorophyll index (SPAD value) of sugarcane under SSI

Treatment	120 DAP						180 DAP				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	47.22	49.00	43.15	46.25	46.41	S_1	52.29	54.29	47.52	51.80	51.48
S_2	47.36	49.50	43.25	46.78	46.72	S_2	53.88	54.49	48.23	51.92	52.13
S_3	47.11	52.20	44.00	46.80	47.53	S_3	52.90	55.08	48.00	52.00	51.99
S_4	50.25	52.17	47.75	48.40	49.64	S_4	55.00	57.98	51.95	54.50	54.86
Mean	47.99	50.72	44.54	47.06			53.52	55.46	48.92	52.56	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	1.04	0.78	1.62	1.47			1.05	0.73	1.67	1.50	
CD (p=0.05)	2.55	1.91	NS	NS			2.56	1.78	NS	NS	

Treatment	240 DAP						300 DAP				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	47.12	49.29	42.80	46.21	46.36	S_1	41.80	43.58	37.98	41.85	41.30
S_2	47.28	49.28	42.91	46.35	46.46	S_2	41.92	44.23	38.38	41.99	41.63
S_3	47.00	50.00	43.20	47.58	46.95	S_3	41.00	44.33	39.21	42.00	41.64
S_4	50.00	53.78	45.00	50.21	49.75	S_4	43.90	46.33	42.00	45.00	44.31
Mean	47.85	50.59	43.48	47.59			42.16	44.62	39.39	42.71	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	1.10	0.75	2.25	2.11			0.75	0.71	1.46	1.44	
CD (p=0.05)	2.68	1.84	NS	NS			1.84	1.74	NS	NS	

Main plot	:	**Main plot–Spacing and row arrangement**	**Sub plot**	:	**Sub plot- Intercrops**
M_1	:	150 x 60 cm Single row planting	**S_1**	:	Sole crop of sugarcane
M_2	:	150 x 60 cm Double row planting	**S_2**	:	Sugarcane +Greengram
M_3	:	180 x 60 cm Single row planting	**S_3**	:	Sugarcane + Blackgram
M_4	:	180 x 60 cm Double row planting	**S_4**	:	Sugarcane + Sunnhemp

Discussion

Absolute growth rate and Crop growth rate (CGR)

The significant variation in absolute growth rate and crop growth rate were found due to row planting and intercropping systems in first plant crop. Higher absolute growth, crop growth rate (CGR), optimum LAI and an early shift in dry matter allocation to the stem were found to be desirable for higher biomass production (Ramesh, 2000) [7]. According to Gardner *et al.* (1998) [2], visibility in genetic potential and efficient utilization of applied inputs in a particular set of environment is reflected by crop growth rate.

Crop growth rate, a derivative of dry matter production was significantly influenced by 180 cm in single row planting (M_3) and 150 single row (M_1). The higher absolute growth rate and crop growth rate under fertigation with normal fertilizer was mainly due to adequate availability soil moisture and water soluble fertilizers by continuous supply of nitrogen, phosphorous and potassium through fertigation upto 210 days along with the supply of adequate quantity of water needed for biochemical activities of the sugarcane crop Matheswaran (2008) and Subramani (2008) [9].

Intercropping system practice significantly influence the crop growth rate in sugarcane. Higher absolute growth rate and crop growth rate were recorded with sugarcane + sunnhemp, during both the year of study due to 45th day incorporation of sunnhemp in dry matter, producing the NPK nutrients of sunnhemp and enhanced vegetative growth. Lower crop growth recorded under sole crop of sugarcane. This was in confirmation with the findings of Mahendran (1994) [4], Guru (1997) [3] and Udayakumar (2003) [10].

Chlorophyll index

Chlorophyll index is a function of chlorophyll content in plants. Decrease in chlorophyll index refers to less chlorophyll, which ultimately indicates deficiency of nutrients, particularly N. The present study showed the chlorophyll index was influenced due to different spacing and planting methods. Significant difference was observed in the chlorophyll index at all the stages. Higher chlorophyll index was recorded under 150 cm double row planting followed by 150 cm single row. Lower chlorophyll index was observed under 180 cm single row planting. Yoshida (1981) [12] opined that maintaining adequate leaf nitrogen throughout the growing period was crucial for achieving high yield because the leaf photosynthetic rate and leaf nitrogen concentration were closely related. Similar result was also reported by Sathiyaraj (2010) [8].

Among the intercropping systems, higher chlorophyll index was recorded under sugarcane with sunnhemp followed by sugarcane with blackgram.

Conclusion

The results revealed that the planting of sugarcane at 150 cm in double rows planting with intercropping of sunnhemp

(M_2S_4) produced higher absolute growth rate, crop growth rate and chlorophyll index.

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