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RESEARCH ARTICLE

Effect of Intercropping and Double Row Planting on Growth Attributes, Yield of Sugarcane under Sustainable Sugarcane Initiative

Saranraj Thirugnanasambandam[1]*, Chandrasekaran R[2], Nageswari R[3] and Veeramani P[4]

[1] Krishi Vigyan Kendra, Tamil Nadu Agricultural Univeristy, Vellore-632 104, India

[2] AC&RI, Tamil Nadu Agricultural Univeristy, Nagapattinam-611 104, India

[3,4] Tapioca and Castor Research Station, Tamil Nadu Agricultural Univeristy, Salem- 636 119, India

ABSTRACT

A field experiment was conducted at Sugarcane Research Station, Tamil Nadu Agricultural University, Sirugamani during (Plant crop) 2017-18 to find out the effect of intercropping and double row planting on growth attributes, the yield of sugarcane under the Sustainable sugarcane initiative. The experiments were laid out in a 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 S1- Sole crop of Sugarcane, S2-Sugarcane + Greengram (Aduthurai 3), S_3- Sugarcane + Blackgram (Vamban 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 the Sustainable sugarcane initiative was followed by using a surface drip irrigation system. Observations on growth attributes, and yield parameters were taken under the Sustainable sugarcane initiative. The results revealed that higher growth attributes and higher cane yield of sugarcane were also recorded under 150 cm double row planting of sugarcane with sunnhemp (M_2S_4).

Keywords: *Sustainable sugarcane initiative (SSI); Inter cropping; Growth; Yield*

INTRODUCTION

Sugarcane (*Saccharum officinarum*) is one of the most important industrial crops in our country and is emerging as a multi-product crop contributing to the production of sugar, jaggery, alcohol, electricity, paper, and other allied products. Sugar that adds sweetness to our food is extracted from the sugarcane juice. The thick stalks of canes store energy in the form of sucrose in the stem sap. India ranks second in global sugarcane production next to Brazil. Currently, sugarcane is cultivated in an area of 4.95 million ha with average productivity of 61.3 t ha^{-1} with a total production of 303.6 million tonnes of sugarcane. About 50 million farmers are directly dependent on sugarcane cultivation for their livelihood and an equal number of agricultural laborers to sustain livelihood by involving themselves in sugarcane cultivation (Anonymous, 2016).

Sustainable Sugarcane Initiative (SSI) is a vital and innovative technology to improve the productivity and quality of sugarcane when compared to the conventional production system. System of Rice Intensification (SRI), which turned out to be a major success in rice production, has inspired the evolution of SSI. The SSI method of sugarcane cultivation includes raising of portray seedlings, wider row spacing of 5 feet, water saving through micro irrigation, intercropping, and addition of organic inputs. Tillering potential in SSI is quite impressive and its full potential is yet to be harnessed (WWF-ICRISAT, 2009). Effective and efficient use of water and seed cane has made SSI, a viable technology among farmers for sustainable production.

Methods of planting play an important role in sugarcane production. Normally, the sugarcane crop is cultivated in ridges and furrows by adopting single-side planting in our country. But, when double side planting with wider row spacing is adopted in sugarcane, possibilities are there to increase the yield compared to single side planting due to the availability of sufficient sunlight, better aeration coupled with effective utilization of space and nutrients through more millable cane production. Dhotre *et al*. (2008) reported that drip irrigation with double side planting had recorded a maximum yield (134.9 t ha^{-1}) compared to single side planting (103.8 t ha^{-1}).

Corresponding author email. tsaranrajagronomy@gmail.com

Intercropping is one of the sure ways of increasing production without much increase in the application of inputs. Intercropping refers to the growing of two or more crops simultaneously on the same piece of land. This system gives crop intensification in both time and space. Apart from its advantages like diversification, labour distribution, soil fertility maintenance, and weeds suppression, two major advantages are higher productivity and greater stability through utilizing solar energy, moisture, and nutrients. Hence, the present study has been proposed to find out the effect of intercropping and double row planting on growth attributes, the yield of sugarcane under SSI

MATERIALS AND METHODS

The field experiment was laid out during the special seasons of 2017-18 at Sugarcane Research Station, Sirugamani, located in Cauvery delta zone of Tamil Nadu. The geographical location of the experiment site is 100 56'N latitude and 780 26'E longitude with an altitude of 78.12 m above the MSL. The farm receives an average rainfall of 730.3 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 was analyzed at 234, 15.8 and 467 kg/ha, respectively of $KMno_4$-N, Olsen P and NH_4OAc-K, respectively with EC 0.29 dsm^{-1}, pH 8.58, and organic carbon 0.58%. The experiments were laid out in strip plot design (SPD) with four treatments in the main plot and four treatments in sub plot replicated thrice. The net plot size adopted was 27.0 m^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 intercrops were raised in additive series viz., 3 rows under a row spacing of 150 cm in sugarcane and 4 rows under 180 cm Figure 1. The recommended schedule of surface drip fertigation for SSI was followed under the surface drip irrigation system. The recommended dose followed was 300:100:200 kg/NPK/ha^{-1}. No additional fertilizers were applied to the intercrops. The growth parameter of plant height (240 and harvest) and Dry Matter Production at 300 and harvest were recorded. The yield attributes of cane equivalent yield at harvest were recorded.

The plant population maintained under different treatments were as follows

Plant population	150 cm x 60 cm and 180 cm x 60 cm single row planting		150 cm x 60 cm and 180 cm x 60 cm double row planting	
	M1	M3	M2	M4
	11,111	9,260	22,222	18,520

Crop equivalent yield (CEY): It is the economic yield worked out by multiplying the intercrop's market price with its yield, dividing it by the sugarcane price, and then adding it to the sugarcane yield of that respective treatment.

$$CEY = \sum_{i=1}^{n} (yi \times ei)$$

Where,

n = 1,2, 3....n, total number of crop in association,

yi= the economic yield of the ith crop and

ei= the cane equivalent factor of the i^{th} crop

The ei was calculated using the following formula

$$ei = \frac{Pi}{Ps}$$

Where,

Pi = the price of unit weight of the i^{th} crop and Ps = the price of the unit weight of the cane

The above formula was based on the one evolved by Verma and Modgal (1983) for calculating crop equivalent yield (CEY).

RESULTS AND DISCUSSION

Plant height

In plant crops during 2017-18, planting at 150 cm in double rows (M_2) recorded distinctly taller plants (4.28 and 5.19 m 240 DAP and at harvest, respectively) and was comparable with 150 cm single row planting (M_1). But, discernibly shorter plants were recorded under 180 cm single row (3.27 and 3.73 m at 240 DAP and harvest, respectively) during all the stages of observation. Among the intercropping systems, sugarcane with sunnhemp (S_4) recorded conspicuously taller plants (4.19 and 4.90 m 240DAP and harvest, respectively) followed by sugarcane +blackgram (S_3). The sole crop of sugarcane (S_1) produced shorter plants at all the stages of observation.

The interaction between different spacing row arrangements, and intercropping systems under SSI practices was significant at all crop growth stages. The treatment combination of 150 cm double row planting with sunnhemp (M_2S_4) recorded taller plants (4.78 and 5.62 m 240 DAP and at harvest, respectively) followed by150 cm double row planting with black gram (M_2S_3) at all the stages. Significantly shorter plants were recorded under 180 cm single row planting with a sole crop of sugarcane (M_3S_1).

Enhanced plant height under double row planting with wider row spacing might be due to the presence of favorable microclimate to the plants and application of sufficient nutrients in readily available form would have accelerated the production of growth regulators such as auxins and cytokinins which in turn stimulated the action of cell elongation and cell division and resulted in increased plant height (Dhanalakshmi, 1999). Among the intercropping systems, sugarcane with sunnhemp (S_4) recorded conspicuously taller plants at 90, 150, 240 DAP and at harvest, followed by sugarcane with blackgram (S_3). The sole crop of sugarcane (S_1) produced shorter plants at all the stages of observation. This might be due to the addition of organic matter which improved the soil's physical and biological conditions which would have facilitated better availability and absorption of plant nutrients from the soil with water retaining and a favorable environment for root development, augmenting the absorption of nutrients by which it increased the plant height. Nambiar and Ghosh (1984) and Buragohain (2000) have also reported similar findings.

Dry matter production

With regard to spacing and row arrangement, 150 cm double row planting recorded significantly higher total dry matter production of 111.69 and 116.99 t ha^{-1} at 300 DAP and at harvest, respectively. However, it was comparable with 150 cm single row planting and 180 cm double row planting (M_1M_4) at all the stages of observation. Conversely, planting at 180 cm single row (M_3) recorded the least dry matter production. A significant difference in DMP of sugarcane crop was noticed at all the stages due to different intercropping systems, where in sugarcane with sunnhemp (S_4) registered higher dry matter production (92.75 and 96.30 t ha^{-1} at 300 DAP and at harvest, respectively) followed by sugarcane with blackgram (S_3) and sugarcane with greengram (S_3).

The interaction between the spacing row arrangement, and intercropping systems was significant at all crop growth stages. Sugarcane planted at 150 cm in double rows and intercropped with sunnhemp (M_2S_4) registered higher dry matter production of 131.78 and 137.02 at 300 DAP and at harvest, respectively. All the treatment combinations of planting at 180 cm in a single row (M_3S_1) recorded lesser dry matter production.

Double row planting at 150 cm (M_2) recorded higher DMP followed by 150 cm single row (M_1). Increased plant height, a higher number of tillers, and enlarged leaves increased the photosynthetic accumulation, which in turn enhanced higher biomass production under double row planting. Higher dry matter production might also have been due to the higher number of leaves per shoot available for photosynthate production under double row planting. The dry matter per plant was reduced significantly under double row planting. This finding is in conformity with Ombase *et al.* (2018).

Cane equivalent yield (t ha-1)

The cane equivalent yield was significantly influenced by plant geometry and intercropping in plant crops during 2017-18 (Table 4). Among the different planting rows higher cane equivalent yield was recorded under 150 cm double row planting (M_2) (152.56 t ha^{-1}) in the plant crop, followed by 150 cm single row planting (M_1)(128.70 t ha^{-1}). With regard to intercropping systems, sugarcane with sunnhemp (S_4) recorded higher cane equivalent yield (138.92 t ha^{-1}) and was on par with sugarcane with greengram (S_2) (132.55 t ha^{-1}). Lower cane equivalent yield was observed under sole crop of sugarcane (S_1) (101.04 t ha^{-1}).

The interaction between planting rows and intercropping systems was significant in cane equivalent yield. In the treatment combination, sugarcane was planted at 150 cm in double rows (M_2S_4) and intercropped with sunnhem precorded higher cane equivalent yield (170.46 t ha^{-1}) followed by sugarcane with blackgram (M_2S_3) (153.01 t ha^{-1}) and both were comparable. Lower cane equivalent yield was observed under 180 cm single row planting with sole crop of sugarcane (M_3S_1) (84.19 t ha^{-1}). The response of sugarcane to intercropping systems was much more substantial. Sugarcane with sunnhemp (S_4) resulted in a higher cane equivalent yield (139.04 t ha^{-1}) followed by sugarcane with blackgram (S_3),

greengram (S_2) and both were comparable with each other. The sole crop of sugarcane recorded lower cane yield compared to other intercropping systems under SSI practices. Increased productivity by intercropping of onion as reflected by CEY confirmed with a report by Venkataraman (1977). Since the yield was not affected due to increased density of onion planting in wide row spacing of 120 and 150 cm, it would be advisable to go for an increased intercrop population of onion (1:4 ratio) while at a normal row spacing of 90 cm, lower population (1:1 ratio) reported by Mahadevasamy (2001).

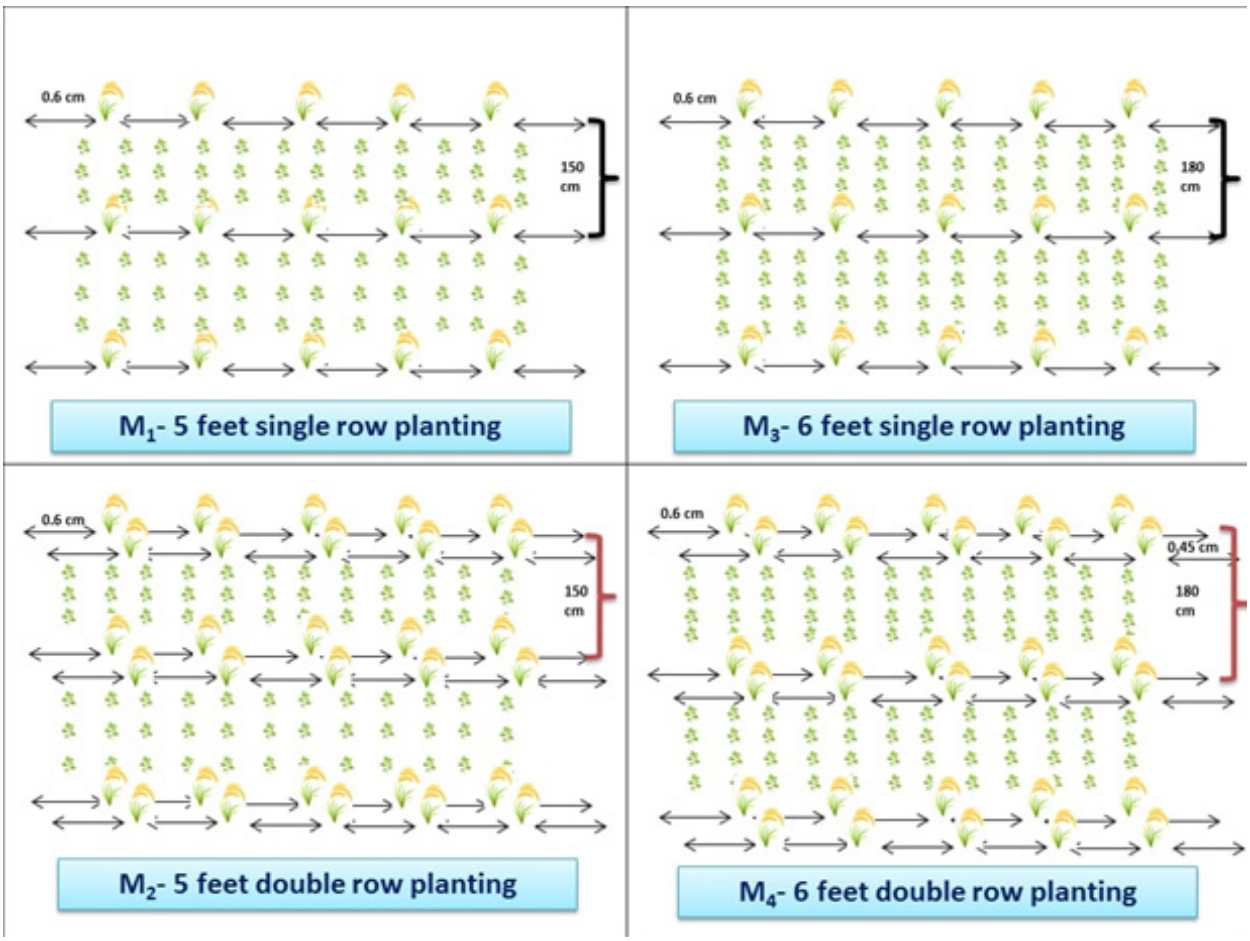

Figure 1.Schematic diagram showing different crop geometry for sugarcane based intercropping in SSI planting techniques:M_1-150 cm single row sugarcane planting; M_2-150 cm double row sugarcane planting; M_3-180 cm single row sugarcane planting; M_4-180 cm double row sugarcane planting.

Table 1. Details of fertigation schedule for RDF: 300:100:200 NPK kg ha^{-1}

Days after planting	Urea (kg ha^{-1})	Muriate of potash (K_2O kg ha^{-1})	Days after planting	Urea (kg ha^{-1})	Muriate of potash (K_2O kg ha^{-1})
10	32.50	0.00	120	50.00	20.00
20	32.50	0.00	130	22.50	16.75
30	32.50	0.00	140	22.50	16.75
40	32.50	7.75	150	22.50	16.75
50	35.00	8.00	160	22.50	16.75
60	35.00	8.00	170	22.50	16.75
70	47.50	19.25	180	22.50	16.75

80	47.50	19.25	190	7.50	30.50
90	47.50	19.25	200	7.50	30.50
100	50.00	20.00	210	7.50	30.00
110	50.00	20.00	TOTAL	650.0	334.00

Table 2. Influence of double row planting and intercropping systems on plant height (m) of sugarcane

Treatment	240 DAP					Harvest				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
S1	3.43	3.97	2.98	3.24	3.40	4.22	4.85	3.63	3.67	4.09
S2	3.26	4.28	2.81	3.42	3.44	4.12	5.10	3.14	3.82	4.05
S3	3.79	4.09	3.34	3.28	3.63	4.64	5.19	3.71	3.60	4.29
S4	4.11	4.78	3.96	3.93	4.19	4.91	5.62	4.45	4.63	4.90
Mean	3.65	4.28	3.27	3.47		4.47	5.19	3.73	3.93	
	M	S	M at S	S at M		M	S	M at S	S at M	
SEd	0.06	0.04	0.11	0.10		0.15	0.08	0.18	0.13	
CD (P=0.05)	0.16	0.10	0.25	0.22		0.38	0.19	0.43	0.28	

Table 3. Influence of double row planting and intercropping systems on dry matter production (t ha^{-1}) of sugarcane

Treatment	300 DAP					Harvest				
	M1	M2	M3	M4	Mean	M1	M2	M3	M4	Mean
S1	76.66	103.21	70.20	76.11	81.55	80.27	109.21	73.23	80.12	85.71
S2	76.77	105.24	70.16	77.29	82.37	80.52	110.42	74.10	80.85	86.47
S3	77.11	106.33	70.31	77.95	82.93	79.73	111.32	75.89	80.93	86.97
S4	83.60	131.78	74.12	81.48	92.75	86.50	137.02	79.25	82.45	96.30
Mean	78.54	111.64	71.20	78.21		81.76	116.99	75.62	81.09	
	M	S	M at S	S at M		M	S	M at S	S at M	
Sed	0.97	0.90	3.43	3.42		0.97	0.90	3.43	3.42	
CD (P=0.05)	2.36	2.20	7.31	7.26		2.36	2.20	7.31	7.26	

Table 4. Influence of double row planting spacing and intercropping systems on cane equivalent yield (t ha^{-1}) of sugarcane

Treatment	Plant crop				
	M_1	M_2	M_3	M_4	Mean
S_1	109.97	132.23	84.19	77.77	101.04
S_2	140.13	154.55	116.75	118.78	132.55
S_3	128.18	153.01	111.01	115.69	126.97
S_4	136.50	170.46	119.96	129.25	139.04
Mean	128.70	152.56	107.97	110.37	
	M	S	M at S	S at M	
SEd	1.64	1.01	3.06	2.77	
CD (P=0.05)	4.02	2.48	6.73	5.95	

CONCLUSION

From the experiment results, it concluded that double row planting of sugarcane at 150 cm spacing with in situ incorporation of sunnhemp on 45th DAP can enhance the growth, and yield attributes, and cane yield of sugarcane.

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Ethics statement

No specific permits were required for the described field experiment studies because no human or animal subjects were involved in this research.

Originality and plagiarism

This is original research work and any work and/or words of others, has been appropriately cited

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required.

Author contributions

Idea conceptualization- RC, RN, TS Experiments- TS, Guidance –RC, NR, Writing original draft - TS, Writing- reviewing &editing - TS, VP,

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