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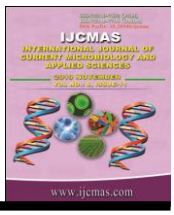

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Growth, Sugar Yield, Quality and Economics of Sugarcane under Different Establishment Techniques and Planting Geometries

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A B S T R A C T

A Field experiment was carried out in a black clay [the soil was slightly alkaline pH (8.23), low in EC (0.20 dSm^{-1}) and organic carbon (0.43%), low in available nitrogen (166.8 kg ha^{-1}), high in available phosphorus (55.0 kg ha^{-1}) and available potassium (300.5 kg ha^{-1})] soil to study the growth, sugar yield, quality and economics of sugarcane under different establishment techniques and planting geometries at Experimental block, Agricultural Research Station, Dhadesugur which falls under Northern Dry Zone of Karnataka (Zone-III) during 2016-17. Ten treatments were evaluated in different planting techniques and planting geometries in randomized block design with three replications. Among different treatments Two eye budded setts with dual row planting (30 cm-150 cm-30 cm) was recorded significantly highest sugar yield (15.2 t ha^{-1}), green biomass yield (16.2 t ha^{-1}), number of leaves (20.7 $plant^{-1}$), leaf, stem and total dry matter production (72.6, 342.1 and 414.6 g $plant^{-1}$, respectively) and which was on par with Two eye budded setts with paired row planting (60 cm-120 cm-60 cm) and Two eye budded setts with wide row planting (120 cm). The lowest sugar yield (10.4 t ha^{-1}), green biomass yield (11.9 t ha^{-1}), number of leaves (17.0 $plant^{-1}$), leaf, stem and total dry matter production (61.4, 320.6 and 382.0 g $plant^{-1}$, respectively) was recorded with Three eye budded setts with conventional planting (90 cm).While brix %, pol %,purity co-efficient % and commercial cane sugar % remained non-significant by different planting techniques and planting geometries. Two eye budded setts with dual row planting recorded higher gross returns (Rs. 411493 ha^{-1}) followed by two eye budded setts with paired row planting (Rs. 390780 ha^{-1}) and two eye budded setts with wide row planting (Rs. 385320 ha^{-1}).

Introduction

Globally, sugarcane is cultivated in an area of 24.5 m ha with a production of 1850 m t and a productivity of 75.5 t ha^{-1} (Anon, 2015). In India, sugarcane is grown in Maharashtra, Karnataka, Gujarat, Tamil Nadu, Uttar Pradesh, Punjab, Haryana and Bihar. India is the world's second largest producer of sugarcane in terms of area (5.3 m ha) of world's total sugar production (27.1 m t). In Karnataka, it is cultivated in an area of about 0.50 m ha with a production of 47 m t and a productivity of 94.0 t ha^{-1} (Anon., 2015a).Of the many variables involved in the production of higher cane and sugar yield from sugarcane plant, probably the most important factor is the millable canes per unit area of land at harvest, which can be achieved by manipulating planting geometry/density to greater extent by way of maximizing efficient interception of incident radiant energy. Since, closer spacing hinders the mechanized intercultural operation; adoption of wider spacing is increasing in many parts of India. In recent past wider row spacing is very popular as it helps mechanization of several field operations thereby results in minimization cost of production. However, as spacing increases, number of millable canes can become a limiting factor in sugarcane productivity (Singh *et al.*, 2006).

The primary components of cane yield arecane population and weight of individual cane. Cane population per unit area is directly affected by planting density which changes rapidly with the closer spacing or with the increase in seed rate. Thus, yield level can be increased substantially by manipulating certain cultural practices like spacing, planting material *etc*. The adaption of optimum spacing, suitable planting pattern/ crop geometry, sett size and sett rate will go a long way in increasing yield and quality of sugarcane. The information on testing of different planting material under various planting techniques is lacking and needs to be worked out. It is, therefore, necessary to standardize the suitable planting techniques with spacing/ plant geometry that may improve the quality, productivity and profitability of sugarcane.

Materials and Methods

A Field experiment was carried out in a black clay [the soil was slightly alkaline pH (8.23), low in EC (0.20 dSm^{-1}) and organic carbon (0.43%), low in available nitrogen (166.8 kg ha^{-1}), high in available phosphorus (55.0 kg ha^{-1}) and available potassium (300.5 kg ha^{-1})] study the growth, sugar yield, quality and economics of sugarcane under different establishment techniques and planting geometries at Experimental block, Agricultural Research Station, Dhadesugur which falls under Northern Dry Zone of Karnataka (Zone-III) during 2016-17. The station is situated between 15º41' N latitude, 76º 53' E longitude and at an altitude of 380 meters above mean sea level. The composite soil samples from 0 to 15 cm depth were collected before planting and at harvest. Soils were air dried in shade, powdered and passed through 2 mm sieve and analysed for pH, EC, OC, available N, P_2O_5 and K_2O_5 by following the methods described by Jackson (1973) and Lindsay and Norvel (1978). The experiment comprised of ten treatments *viz*. T_1-Single eye budded setts with wide row planting (120 cm furrow), T_2: Single eye budded setts with paired row planting (60 cm- 120 cm- 60 cm), T_3: Single eye budded setts with dual row planting (30 cm- 150 cm- 30 cm), T_4: Two eye budded setts with wide row planting (120 cm), T_5: Two eye budded setts with paired row planting (60 cm- 120 cm- 60 cm), T_6: Two eye budded setts with dual row planting (30 cm- 150 cm- 30 cm), T_7: Bud chip seedlings with wide row planting (120 cm furrow), T_8: Bud chip seedlings with paired row planting (60

cm- 120 cm- 60 cm), T_9: Bud chip seedlings with dual row planting (30 cm- 150 cm- 30 cm) and T_{10}: Three eye budded setts with conventional planting (90 cm). The experiment was laid out in randomized complete block design (RCBD) with three replications. The sugarcane variety 2003-V-46 was planted on 1st of February, 2016. Fertilizer was applied @ 250 kg N, 100 kgP_2O_5 and 125 kgK_2Oha^{-1} in the form of Urea, DAP, and SOP, respectively. The entire dose of P, K, and 1/3rd of N were applied as a basal dose at the time of planting, while remaining N was applied in two splits, 1/3rd at the start of tillering and 1/3rd before earthing up by side dressing. The crop was harvested manually after its maturity on 29th of February, 2017. Recommended packages of practices were adopted for crop production. Five randomly selected canes at harvest were weighed and crushed to extract the juice and used for analyzing the quality parameters using standard procedures. Sugar yield was calculated by using the formula as suggested by Sastry and Venkatachari (1960). It is the product of commercial cane sugar (%) and cane yield (t ha^{-1}). The cost of inputs, labour charges and prevailing market rates of farm produce were taken into consideration for working out cost of cultivation, gross returns and net returns per hectare. The net returns were calculated by deducting cost of cultivation from gross returns. The analysis and interpretation of data were done using the Fisher's method of analysis and variance technique as given by Gomez and Gomez (1984).

Results and Discussion

Growth parameters

Significantly higher number of leaves was observed in two eye budded setts with dual row planting (20.7). Whereas, lower number of leaves were recorded with three eye budded setts with normal row planting (17.0).The dry matter accumulations in leaf, cane and plant at different growth stages (Table 1) were higher under 30cm-150cm-30cm row spacing (T_6) and lower under 90 cm row spacing (T_{10}). At initial period to 90 DAP, dry matter accumulation was found lower there after it was increased drastically due to development number of leaves and leaf area.

This was attributed to better growth of plant in terms of plant height. Similarly, Shinde *et al.*, (2000) and Rehman *et al.*, (2013) observed higher dry matter accumulation in plant under dual row planting.

Sugar yield

Growing of sugarcane with two eye budded setts with dual row planting (30 cm-150 cm - 30 cm) recorded significantly higher sugar yield (15.2 t ha^{-1}) and it was on par with the two eye budded setts with paired row (60 cm-120 cm-60 cm) planting (14.2 t ha^{-1}) and two eye budded setts with wide row (120 cm) planting (13.9 t ha^{-1}).

However, the sugar yield was on par with planting of sugarcane with single eye budded setts and bud chip seedling with different planting geometries (Table 2). Whereas, planting of sugarcane with three budded setts (conventional planting) recorded significantly lower sugar yield (10.4). The increased cane and sugar yield might be due to better light interception, greater availability of moisture, more aeration to individual setts and increased plant population which led to better tillering tiller retention, taller canes and increased cane weight at harvest over the rest of plant geometries. Similarly, Patel and Patel(2014) reported that planting of sugarcane with two budded setts was found to be significantly superior in increasing number of millable canes, cane and sugar yield over three and single budded setts.

Quality parameters

The quality parameters of sugarcane *viz.*, brix, pol, purity co-efficient and commercial cane sugar did not differ significantly as influenced by the establishment techniques and planting geometries (Table 3) but higher values recorded in two eye budded setts with dual row planting (19.2, 16.8, 87.5 and 11.5 %, respectively). Non-significant results might be ascribed to stable genetic character of the variety as well as similar environmental conditions. The findings are similar to those of Ruk *et al.*, (2014), Maqsood *et al.*, (2005), Singh *et al.*, (1999) and Shinde *et al.*, (2001)who reported non-significant effect of row spacing on brix percentage.

Table.1 Number of leaves per plant, Dry matter accumulation in leaf, stem and total in sugarcane as influenced by different establishment techniques and planting geometries

Treatments	Number of leaves (plant^{-1})	Dry matter accumulation (g plant^{-1})at harvest		
		Leaf	Stem	Total
T_1: Single eye budded setts with wide row planting (120 cm furrow)	18.0	62.5	323.8	386.3
T_2: Single eye budded setts with paired row planting (60 cm-120 cm-60 cm)	18.3	62.7	324.8	387.5
T_3: Single eye budded setts with dual row planting (30 cm-150 cm-30 cm)	18.3	63.2	325.0	388.2
T_4: Two eye budded setts with wide row planting (120 cm)	19.7	68.1	333.8	401.9
T_5:Two eye budded setts with paired row planting (60 cm-120 cm-60 cm)	20.0	68.5	341.6	410.1
T_6: Two eye budded setts with dual row planting (30 cm-150 cm-30 cm)	20.7	72.6	342.1	414.6
T_7: Bud chip seedling with wide row planting (120 cm furrow)	17.0	62.0	322.5	384.5
T_8: Bud chip seedling with paired row planting (60 cm-120 cm-60 cm)	17.3	62.1	323.2	385.3
T_9: Bud chip seedling with dual row planting(30 cm-150 cm-30 cm)	17.7	62.6	323.5	386.1
T_{10}:Three eye budded setts with conventional planting (90 cm)	17.0	61.4	320.6	382.0
S.Em.±	**0.8**	**2.2**	**4.4**	**3.6**
C.D. (P=0.05)	**2.3**	**6.6**	**13.2**	**10.6**

Table.2 Yield parameters and sugar yield of sugarcane as influenced by different establishment techniques and planting geometries

Treatments	Inter nodal length (cm)	Cane diameter (cm)	Green biomass yield (t ha^{-1})	Sugar yield (t ha^{-1})
T_1: Single eye budded setts with wide row planting (120 cm furrow)	11.1	2.6	13.6	12.2
T_2: Single eye budded setts with paired row planting (60 cm-120 cm-60 cm)	11.2	2.7	13.9	12.7
T_3: Single eye budded setts with dual row planting (30 cm-150 cm-30 cm)	11.3	2.7	14.2	12.8
T_4: Two eye budded setts with wide row planting (120 cm)	11.5	2.7	14.4	13.9
T_5:Two eye budded setts with paired row planting (60 cm-120 cm-60 cm)	11.5	2.7	15.0	14.2
T_6: Two eye budded setts with dual row planting (30 cm-150 cm-30 cm)	11.7	2.8	16.2	15.2
T_7: Bud chip seedling with wide row planting (120 cm furrow)	11.0	2.6	12.8	10.9
T_8: Bud chip seedling with paired row planting (60 cm-120 cm-60 cm)	11.0	2.6	13.2	11.6
T_9: Bud chip seedling with dual row planting (30 cm-150 cm-30 cm)	11.0	2.6	13.4	12.1
T_{10}:Three eye budded setts with conventional planting (90 cm)	10.8	2.3	11.9	10.4
S.Em.±	**0.3**	**0.1**	**0.6**	**0.7**
C.D. (P=0.05)	**NS**	**NS**	**1.9**	**2.2**

NS- Not Significant

Table.3 Quality parameters and sugar yield of sugarcane as influenced by different establishment techniques and planting geometries at harvest

Treatments	Brix (%)	Sucrose (%)	Purity co-efficient (%)	CCS (%)
T_1: Single eye budded setts with wide row planting (120 cm furrow)	18.5	15.9	85.9	10.8
T_2: Single eye budded setts with paired row planting (60 cm-120 cm-60 cm)	18.5	16.1	87.0	11.0
T_3: Single eye budded setts with dual row planting (30 cm-150 cm-30 cm)	18.8	16.2	86.1	11.0
T_4: Two eye budded setts with wide row planting (120 cm)	18.9	16.5	87.3	11.3
T_5:Two eye budded setts with paired row planting (60 cm-120 cm-60 cm)	19.0	16.6	87.3	11.4
T_6: Two eye budded setts with dual row planting (30 cm-150 cm-30 cm)	19.2	16.8	87.5	11.5
T_7: Bud chip seedling with wide row planting (120 cm furrow)	18.2	15.2	83.5	10.2
T_8: Bud chip seedling with paired row planting (60 cm-120 cm-60 cm)	18.3	15.5	84.6	10.5
T_9: Bud chip seedling with dual row planting (30 cm-150 cm-30 cm)	18.4	15.8	85.8	10.7
T_{10}:Three eye budded setts with conventional planting (90 cm)	18.1	15.2	83.9	10.2
S.Em.±	**0.6**	**0.6**	**2.9**	**0.5**
C.D. (P=0.05)	**NS**	**NS**	**NS**	**NS**

CCS- commercial cane sugar **NS-** Not Significant

Table.4 Economics of sugarcane as influenced by different establishment techniques and planting geometries

Treatments	Cost of cultivation	Gross returns	Net returns	Benefit cost ratio (B:C)
	(Rs.ha^{-1})			
T_1: Single eye budded setts with wide row planting (120 cm furrow)	121633	359667	238900	3.0
T_2: Single eye budded setts with paired row planting (60 cm-120 cm-60 cm)	124733	367467	245200	3.0
T_3: Single eye budded setts with dual row planting (30 cm-150 cm-30 cm)	125700	368940	246390	3.0
T_4: Two eye budded setts with wide row planting (120 cm)	123183	385320	259620	3.1
T_5:Two eye budded setts with paired row planting (60 cm-120 cm-60 cm)	126750	390780	264030	3.1
T_6: Two eye budded setts with dual row planting (30 cm-150 cm-30 cm)	127683	411493	280760	3.2
T_7: Bud chip seedling with wide row planting (120 cm furrow)	117850	344500	226650	2.9
T_8: Bud chip seedling with paired row planting (60 cm-120 cm-60 cm)	119600	353600	234000	3.0
T_9: Bud chip seedling with dual row planting (30 cm-150 cm-30 cm)	120667	359147	238480	3.0
T_{10}:Three eye budded setts with conventional planting (90 cm)	112933	318933	206000	2.9
S.Em.±	**-**	**13444**	**10858**	**0.03**
C.D. (P=0.05)	**-**	**39944**	**32263**	**0.10**

Similarly, Ullah *et al.,* (2011), Ghaffar *et al.,* (2012) and Mahadevaswamy and Matrin (2002), observed that different planting techniques did not affect pol contents. Further, Ghaffar *et al.,* (2012), Hussain *et al.,* (2005) While Patel and Patel (2014) also witnessed that purity was non-significantly affected by different row spacings. CCS % is one of the aspects of cane quality, the final goal to achieve optimum sugar yield. The real cane quality is reflected by its commercial cane sugar (CCS) percentage. Commercial cane sugar was not significantly affected by different planting geometries. Under different planting configurations commercial cane sugar (CCS %) ranged from 14.03% to 14.18%. Results fall in line with those of Ullah *et al.,* (2011), Sajjad *et al.,* (2014) and Roodagi *et al.,* (2001) stated that establishment techniques failed to affect CCS %

Economics

Maximum cost of cultivation, gross returns, net returns and BC ratio (Rs.127683, Rs.411493, Rs.280760 ha^{-1} and 3.2, respectively) was recorded with two eye budded setts with dual row planting (30 cm-150 cm -30 cm)and it was on par with the two eye budded setts with paired row (60 cm-120 cm-60 cm) planting (Rs. 126750, Rs.390780, Rs.264030 ha^{-1} and 3.1, respectively) and two

eye budded setts with wide row (120 cm) planting (Rs.123183,Rs.385320,Rs. 259620 ha^{-1} and 3.1, respectively). Whereas, planting of sugarcane with three budded setts (conventional planting) recorded significantly least cost of cultivation, gross returns, net returns per hectare and BC ratio (Rs.112933, Rs.318933, Rs.206000 ha^{-1} and 2.8, respectively) (Table 4). This was due to the higher yield realized in these treatments which resulted in higher gross returns. Higher cane yield contributed to higher net returns and B:C ratio. These results are in line with Saxena *et al.,* (2012). Thus, the two budded setts with dual row planting was superior to the conventional planting in saving the resources

Results of this study indicated that, planting of sugarcane with two eye budded setts with dual rows (30 cm-150 cm -30 cm) recorded higher sugar yield in addition to net returns and B:C ratio followed by two eye budded setts with paired row (60 cm-120 cm-60 cm) planting and two eye budded setts with wide row (120 cm) planting. Further, this technique may help to reduce the cost of production and also suitable for mechanical harvesting.

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