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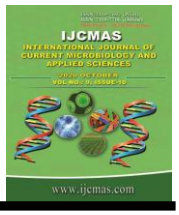

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Improving Sugarcane Productivity through Single Eye Bud Settling by Adopting Different Inter and Intra Row Spacing of Sugarcane

D. S. Thorave*, J. D. Thanki and K. B. Patil

Department of Agronomy, N.M. College of Agriculture, Navsari, Navsari Agricultural University, Navsari, Gujarat, India

**Corresponding author*

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A B S T R A C T

An experiment was conducted for two consecutive years at Main Sugarcane Research Station, Navsari, Navsari Agricultural University, Gujarat, India during 2017-18 to 2018-19 to study effect of inter and intra row spacing on growth, yield and quality of sugarcane by using single eye bud settling. It comprised total sixteen treatments of four inter row spacing *viz.*, planting of single eye bud settling at 105 cm row spacing (R_1), planting of single eye bud settling at 120 cm row spacing (R_2), planting of single eye bud settling at 135 cm row spacing (R_3) and planting of single eye bud settling at 150 cm row spacing (R_4) and four intra row spacing *viz.*, planting of single eye bud settling at 45 cm (S_1), planting of single eye bud settling at 60 cm intra row spacing (S_2), planting of single eye bud settling at 75 cm intra row spacing (S_3) and planting of single eye bud settling at 90 cm intra row spacing (S_4) were evaluated in split plot design with three replications. On the basis of pooled analysis, the growth attributes such as number of tillers at 90, 120, 180 days after planting and number of shoots at 240 days after planting and yield attributes such as millable cane height, cane girth, number of internodes per cane, average cane weight and number of millable canes were improved due to different inter and intra row spacing. Significantly higher cane yield at harvest was found under the treatment of planting of single eye bud settling at 120 cm row spacing and remained at par with planting of single eye bud settling at 135 cm row spacing.. The planting of single eye bud settling at 60 cm gave significantly superior cane yield at harvest than rest of treatments. On the basis of pooled results, it is concluded from the study that for getting higher yield of sugarcane crop can be achieved with 120 cm x 60 cm (R_2S_2) inter and intra row spacing, respectively through single eye bud settlings under south Gujarat condition.

Introduction

India is the second largest producer of sugarcane after Brazil cultivated sugarcane on 4.73 million hectares area with production of 376 million tonnes of sugarcane, 32.32 million tonnes of sugar and 10.73 % sugar recovery with an average productivity 79.60 t/ha during 2017-18 (Anonymous, 2019). Gujarat state cultivating sugarcane crop on area of 1.82 lakh hectares with production of 120.52 lakh tonnes of sugarcane and 10.67

lakh tonnes of sugar, 10.19 % sugar recovery with an average productivity 66.22 t/ha during 2017-18 (Anonymous, 2019).

Among different agronomic management practices, row spacing influences sugarcane productivity by maintaining adequate stalk population per unit area. Plant population in row crops is based on the spacing between two adjacent rows (inter row) and spacing between plants within row (intra row). Planting geometry plays an important role in water use efficiency, interception of solar radiation and evaporation. Row spacing is considered to be the most important planting geometry parameter in sugarcane. Row spacing determines tiller development and effective utilization of incident solar radiation and its conversion to biomass and stalk yield. Hence, it is imperative to identify such planting geometry, which maintains plant population, improves light interception, enhances nutrient availability, increases water use and facilitates intercropping and mechanization of sugarcane agriculture. Plant spacing is the critical one for providing proper nutrition, water and light to the crop plants. It is, therefore, essential that a suitable and effective area must be provided to a plant by growing it under suitable row to row and plant to plant distance or suitable planting technique (Babar *et al.,* 2011). Therefore this research serves to come up standard intra row plant spacing that can be adopted by sugarcane grower so as to attain high returns.

South Gujarat is the main sugarcane belt in a state. Favourable climatic condition and sugar factories enhanced farmers for growing sugarcane crop. It has been reported that sugarcane yields of 341 t/ha were achieved by adopting wide row spacing in Vapi (South Gujarat) conditions (MangalRai, 2002). Sugarcane planting is done by conventional methods like 2 or 3 budded setts. South Gujarat has good potential of expanding area under sugarcane by adopting alternative planting method like sugarcane settling. Progressive farmers are adopting settling planting material for sugarcane planting. However, no adequate information is so far available on inter and intra row spacing of sugarcane by using single eye bud settling in Gujarat. Keeping aforesaid all points in view, the present research work was planned to find out suitable inter and intra row spacing of sugarcane by using single eye bud settling for incresing sugarcane productivity.

Materials and Methods

An experiment was conducted during 2017-18 and 2018-19 at Main Sugarcane Research Station, Navsari, Navsari Agricultural University, Gujarat, India. It comprised total sixteen treatments of four inter row spacing *viz.,* planting of single eye bud settling at 105 cm row spacing (R_1), planting of single eye bud settling at 120 cm row spacing (R_2), planting of single eye bud settling at 135 cm row spacing (R_3) and planting of single eye bud settling at 150 cm row spacing (R_4) and four intra row spacing *viz.,* planting of single eye bud settling at 45 cm (S_1), planting of single eye bud settling at 60 cm intra row spacing (S_2), planting of single eye bud settling at 75 cm intra row spacing (S_3) and planting of single eye bud settling at 90 cm intra row spacing (S_4) were evaluated in split plot design with three replications. Single eye bud settlings were transplanted as per different treatments of inter and intra row spacing. Single eye bud settlings of sugarcane variety CoN 05071 were planted in first week of December, 2017 and 2018 and harvested in the first week of December, 2018 and 2019. Recommended doses of fertilizers were applied to sugarcane (N: P_2O_5: K_2O 250: 115: 115 kg/ha). N was applied in four splits (15 % at planting, 30 % at 6-8 weeks after planting, 20 % at 12-16 weeks after planting and 35 % at earthing up) and dose of P and K fertilizers

(50 % at the time of planting and 50 % at the time of earthing up). Data obtained from the experiment was statistically analyzed by standard statistical methods from Panse and Sukhatme (1967) and Gomez and Gomez (1984).

Results and Discussion

Effect on growth attributes

Effect of row spacing

The number of tillers per hectare at 90, 120, 180 days after planting and number of shoots at 240 days after planting (Table 1) were significantly influenced by different inter row spacing. On the basis of pooled results, the number of tillers per hectare at 90, 120, 180 days after planting (48698, 59317, 51145 thousand/ha, respectively) and number of shoots per hectare at 240 days after planting (50667 thousand/ha) were significantly higher with planting of single eye bud settling at 120 cm (R_2) and found at par with planting of single eye bud settling at 105 cm (R_1).

The reason for higher number of tillers and number of shoots might be due to efficient light interception, nutrients, water, adequate space, aeration and lesser inter row plant competition at 120 inter row spacing. As inter row spacing increased, the number of settlings per hectare is reduced which results into lower number of tillers and number of shoots. These results are in agreement with Bhatnagar (2003), Yadav *et al.*, (2014), Khalid *et al.*, (2015), Chandrasekaran *et al.*, (2017), Chaudhari *et al.*, (2018), Galal (2018) and Chandrakar *et al.*, (2019).

Effect of intra row spacing

The number of tillers at 90, 120, 180 days after planting and number of shoots at 240 days after planting (Table 1) were significantly influenced by different intra row spacing. On the basis of pooled findings, significantly higher number of tillers per hectare at 90, 120, 180 days after planting (52271, 63667, 55005 thousand/ha, respectively) and number of shoots per hectare at 240 days after planting (54471 thousand/ha) under planting of single eye bud settling at 60 cm (S_2) and remained at par with planting of single eye bud settling at 45 cm (S_1).

These results might be attributed to higher number of settlings and consequently higher tillers/ha. This might be due to adequate space within the plants compare to 75 cm and 90 cm intra row spacing facilitated the production of higher number of tillers. This is in agreement with the findings reported by Raskar (2002), Pawar *et al.*, (2005), Chaudhari *et al.*, (2018) and Galal (2018).

Interaction effect

The interaction effect between different inter and intra row spacing were significantly influenced on number of tillers at 90, 120 and 180 days after planting and number of shoots at 240 days after planting in pooled analysis. The treatment combination 120 cm x 60 cm inter and intra row spacing, respectively (R_2S_2) recorded significantly higher number of tillers at 90, 120, 180 (59449, 72421, 62620 thousand/ha, respectively) and number of shoots at 240 days after planting (62078 thousand/ha) (Table 1a) and remained at par with 120 cm x 45 cm (R_2S_1) during both the years and in pooled analysis.

This might be due to adequate number of settlings which gets sufficient space, water and sunlight for photosynthesis resulted in production of more tillers and shoots. Similar results were reported by Chaudhari *et al.*, (2018) and Galal (2018).

Effect on yield attributes and yield

Effect of inter row spacing

Among different parameters related to yield *viz.,* millable cane height, cane girth, number of internodes per cane, number of millable canes, average cane weight and cane yield (Table 2) were significantly influenced by various inter row spacing are described. On the basis of pooled data, millable cane height at harvest (276.67 cm) was significantly higher under planting of single eye bud settling at 150 cm row spacing (R_4) and found at par with planting of single eye bud settling at 135 cm row spacing (R_3). Significantly higher cane girth at harvest (6.37 cm) was produced under planting of single eye bud settling at 150 cm row spacing (R_4) being remained at par with planting of single eye bud settling at R_2 (120 cm) and R_3 (135 cm). The maximum number of internodes per cane at harvest (28.96) reported significantly under planting of single eye bud settling at 150 cm row spacing (R_4) over rest of inter row spacing. Higher average cane weight at harvest (2.12 kg) produced significantly under planting of single eye bud settling at 150 cm row spacing (R_4) being remained at par with planting of single eye bud settling at 120 cm row spacing (R_2). Higher yield attributes like millable cane height, cane girth, number of internodes per cane and average cane weight under wider row spacing might be due to the availability of optimum of nutrient, water and light utilization that does not create any sort of competition whereas in case of closer spacing might built some sort of competition. Similar results are reported by Bhatnagar (2003), Mokashi (2005) and Ullah *et al.,* (2016). Significantly higher number of millable canes at harvest (50113 thousand/ha) was recorded under the treatment of planting of single eye bud settling at 120 cm (R_2) and remained at par with planting of single eye bud settling at 105 cm (R_1). This was largely attributed to more efficient utilization of moisture, nutrients and solar energy which gave higher numbers of millable canes per hectare than closed row spacing. Above results are in line with findings of Devi *et al.,* (2014), Singh and Brar (2015), Singh *et al.,* (2016) and Chaudhari *et al.,* (2018).

Planting of single eye bud settling at 120 cm (R_2) resulted in significantly higher cane yield (94.48 t/ha) and remained at par with planting of single eye bud settling at 135 cm (R_3). This might be due to optimum plant population and availability of ample sunlight which results into higher number of millable canes per hectare with maximum millable cane height, cane girth, number of internodes and average cane weight. The present findings are in close agreement with the results obtained by Chattha *et al.* (2007), Khandagave (2011), Gouri *et al.,* (2014), Khalid *et al.,* (2015), Singh *et al.,* (2016). Chaudhari *et al.,* (2018) and Chandrakar *et al.,* (2019).

Effect of intra row spacing

Among different parameters related to yield *viz.,* millable cane height, cane girth, number of internodes per cane, number of millable canes, average cane weight and cane yield were significantly influenced by various intra row spacing.

Millable cane height (276.54 cm) and number of internodes per cane (26.96) at harvest resulted in significantly higher under planting of single eye bud settling at 90 cm (S_4) which was at par with planting of single eye bud settling at 75 cm (S_3). The cane girth at harvest (6.40 cm) reported significantly higher under planting of single eye bud settling at 90 cm (S_4) being remained at par with planting of single eye bud settling at 75 cm (S_3). Planting of single eye bud settling at 90 cm (S_4) registered significantly superior average cane weight (2.25 kg) over other intra

row spacing. Increase in intra row spacing from 45 to 90 cm improved millable cane height, cane girth, number of internodes per cane and average cane weight. This might be due to severe competition for space, sun light and other growth factors for closer spacing as compared to wider intra row spacing which enjoyed the benefit of proper space and light for development of plants. These results are in corroborate with Bhatnagar (2003), Raskar and Bhoi (2003), Pawar *et al.*, (2005) and Chaudhari *et al.*, (2018).

Number of millable canes per hectare at harvest (53897 thousand/ha) reported significantly higher under planting of single eye bud settling at 60 cm (S_2) which remained at par with planting of single eye bud settling at 45 cm (S_1).

Table.1 Number of tillers and number of shoots of sugarcane (thousand/ha) as influenced by different inter and intra row spacing (Pooled data)

Treatment	Number of tillers of sugarcane (thousand/ha)			Number of shoots (thousand/ha)
	90 days after planting	120 days after planting	180 days after planting	240 days after planting
(A) Main plot factors (Inter row spacing)				
R_1: Planting of single eye bud settling at 105 cm	47470	57632	49857	49269
R_2: Planting of single eye bud settling at 120 cm	48698	59317	51145	50667
R_3: Planting of single eye bud settling at 135 cm	41585	50736	43750	43306
R_4: Planting of single eye bud settling at 150 cm	37519	45794	39447	39061
SEm±	951.82	1304.03	1153.05	1055.71
CD (P=0.05)	2932.84	4018.13	3552.89	3252.96
CV (%)	10.64	11.97	12.27	11.35
(B) Sub plot factors (Intra row spacing)				
S_1: Planting of single eye bud settling at 45 cm	52249	63627	54920	54382
S_2: Planting of single eye bud settling at 60 cm	52271	63667	55005	54471
S_3: Planting of single eye bud settling at 75 cm	40978	49966	43073	42559
S_4: Planting of single eye bud settling at 90 cm	29774	36218	31201	30890
SEm±	600.06	717.04	602.74	607.70
CD (P=0.05)	1706.26	2038.87	1713.86	1727.96
CV (%)	6.71	6.58	6.41	6.53
Interaction (M x S)				
SEm±	1200.12	1434.07	1205.47	1215.39
CD (P=0.05)	3412.52	4077.73	3427.71	3455.93
CV (%)	6.71	6.58	6.41	6.53
General mean	43818	53370	46050	45576

Table.1a Interaction effect as influenced by different inter and intra row spacing on growth attributes of sugarcane

Intra row spacing (S)	Number of tillers at 90 days after planting				Number of tillers at 120 days after planting			
	Inter row spacing (R)							
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
S_1	51746	58611	50343	48296	62735	71435	61270	59068
S_2	54579	59449	50741	44315	66344	72421	61872	54030
S_3	47048	44648	38304	33911	57349	54411	46738	41367
S_4	36506	32083	26953	23556	44101	39001	33063	28708
SEm±	1200.12				1434.07			
CD (P=0.05)	3413				4078			
CV (%)	6.71				6.58			
Intra row spacing (S)	Number of tillers at 180 days after planting				Number of shoots at 240 days after planting			
S_1	54454	61591	52864	50769	53870	61047	52326	50287
S_2	57472	62620	53363	46567	56854	62078	52838	46117
S_3	49458	46904	40263	35668	48644	46430	39862	35301
S_4	38045	33465	28509	24783	37709	33113	28199	24540
SEm±	1205.47				1215.39			
CD (P=0.05)	3428				3456			
CV (%)	6.41				6.53			

Table.2 Effect of different inter and intra row spacing on yield attributes and yield of sugarcane at harvest

Treatment	Millable cane height (cm)	Cane girth (cm)	Number of internodes/cane	Number of millable cane (thousand/ha)	Average cane weight (kg)	Cane yield (t/ha)
(A) Main plot factors (Inter row spacing)						
R_1: Planting of single eye bud settling at 105 cm	255.04	6.13	20.17	48869	1.68	75.98
R_2: Planting of single eye bud settling at 120 cm	265.42	6.28	23.75	50113	2.03	94.48
R_3: Planting of single eye bud settling at 135 cm	272.75	6.30	26.25	42888	2.10	86.85
R_4: Planting of single eye bud settling at 150 cm	276.67	6.37	28.96	38670	2.12	78.22
SEm±	1.54	0.03	0.52	1092.81	0.04	2.67
CD (P=0.05)	4.73	0.09	1.59	3367	0.13	8.24
CV (%)	2.81	2.35	10.19	11.86	10.48	15.61
(B) Sub plot factors (Intra row spacing)						
S_1: Planting of single eye bud settling at 45 cm	254.50	6.11	21.75	53832	1.53	79.30
S_2: Planting of single eye bud settling at 60 cm	266.25	6.25	24.42	53897	2.06	105.10
S_3: Planting of single eye bud settling at 75 cm	272.58	6.32	26.00	42225	2.08	85.05
S_4: Planting of single eye bud settling at 90 cm	276.54	6.40	26.96	30586	2.25	66.09
SEm±	1.73	0.03	0.55	552.67	0.03	2.00
CD (P=0.05)	4.91	0.08	1.56	1572	0.09	5.69
CV (%)	3.16	2.13	10.88	6.00	7.59	11.70
Interaction (M x S)						
SEm±	3.45	0.05	1.10	1105.34	0.06	4.01
CD (P=0.05)	9.82	0.16	NS	3143	0.17	11.39
CV (%)	3.16	2.13	10.88	6.00	7.59	11.70
General mean	267.47	6.27	24.78	45135	1.98	83.88

Table.2a Interaction effect as influenced by different inter and intra row spacing on yield attributes of sugarcane

Intra row spacing (S)	Millable cane height (cm) at harvest				Cane girth (cm) at harvest				Number of millable cane (thousand/ha)			
	Inter row spacing (R)											
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	53359	60378	51822	49769
S_1	225.33	258.83	264.00	269.83	5.72	6.22	6.25	6.28	56339	61288	52311	45650
S_2	260.50	262.67	268.00	273.83	6.21	6.26	6.23	6.30	48484	45980	39470	34965
S_3	266.17	267.17	277.17	279.83	6.27	6.29	6.34	6.37	37295	32806	27948	24295
S_4	268.17	273.00	281.83	283.17	6.32	6.35	6.38	6.53	53359	60378	51822	49769
SEm±	3.45				0.05				1105.34			
CD (P=0.05)	9.82				0.16				3143			
CV (%)	3.16				2.13				6.00			

Intra row spacing (S)	Average cane weight (kg)				Cane yield (t/ha) at harvest			
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
S_1	1.44	1.48	1.58	1.64	71.46	86.02	80.26	79.44
S_2	1.55	2.18	2.25	2.26	80.94	120.66	117.12	101.68
S_3	1.58	2.22	2.26	2.28	73.87	99.98	88.32	78.01
S_4	2.16	2.26	2.29	2.30	77.64	71.27	61.70	53.77
SEm±	0.06				4.01			
CD (P=0.05)	0.17				11.39			
CV (%)	7.59				11.70			

The cane yield at harvest (105.10 t/ha) recorded significantly superior with planting of single eye bud settling at 60 cm (S_2) over rest of intra row spacing. The increased number of millable canes and cane yield might be due to better light interception, greater availability of moisture, more aeration and efficient utilization of nutrients to optimum plant population. These results are in line with Pawar *et al.,* (2005), Tayade *et al.,* (2017) and Kumar (2019).

Interaction effect

The interaction effect between various inter and intra row spacing on millable cane height, cane girth, number of millable canes, average cane weight and cane yield at harvest (Table 2a) were significantly influenced in pooled results. However the interaction effect on number of internodes per cane failed to express its significant effect in pooled results. On pooled analysis data, treatment combination 150 cm x 90 cm (R_4S_4) recorded significantly higher millable cane height at harvest (283.17 cm) and remained at par with 135 cm x 75 cm (R_3S_3), 135 cm x 90 cm (R_3S_4), 150 cm x 60 cm (R_4S_2) and 150 cm x 75 cm (R_4S_3). Treatment combination 150 cm x 90 cm (R_4S_4) recorded significantly higher cane girth at harvest (6.53 cm) and remained at par with 135 cm x 90 cm (R_3S_4) and 150 cm x 75 cm (R_4S_3). The average cane weight at harvest (2.30 kg) reported significantly higher under treatment combination 150 cm x 90 cm (R_4S_4) and remained at par with R_1S_4, R_2S_2, R_2S_3, R_2S_4, R_3S_2, R_3S_3, R_3S_4, R_4S_2 and R_4S_3. This might be due to wider row and intra row spacing resulted in higher millable cane height, average cane weight and cane girth because less competition for resources likes nutrient, water and sunlight.

Treatment combination 120 cm x 60 cm (R_2S_2) recorded significantly higher number of millable canes at harvest (61288 thousand/ha) which remained at par with 120 cm x 45 cm (R_2S_1). This might be due to proper utilization of resources like light, nutrients, water. Similar results are corroborate with Chaudhari *et al.,* (2018), Galal (2018), Chandrakar *et al.,* (2019) and Chaudhari (2019).

Treatment combination 120 cm x 60 cm (R_2S_2) produced significantly higher cane yield at harvest (120.66 t/ha) which was at par with 135 cm x 60 cm (R_3S_2). The marked increase in yield appears due to better light interception, greater availability of moisture, more aeration to growth contributing characters like number of tillers and shoots as well as yield attributes like millable cane height, cane girth, number of internodes per cane, average cane weight, number of millable cane and average cane weight as compared to rest of the treatment combinations. These results are in agreement with Chaudhari *et al.,* (2018), Galal (2018), Chandrakar *et al.,* (2019) and Chaudhari (2019).

It is concluded from the study that for getting higher yield of sugarcane crop can be achieved with planting of single eye bud settlings at 120 cm x 60 cm (R_2S_2) inter and intra row spacing, respectively under south Gujarat condition.

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