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AGRO-ECONOMIC EVALUATION OF SUGARCANE CROP GEOMETRY UNDER DRIP-IRRIGATION IN THE SUGAR BELT OF KAWARDHA

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ABSTRACT

Effect of planting geometry on growth, yield attributes, yield, quality and economics of sugarcane under drip irrigation was studied at SKCARS, Kawardha Chhattisgarh. The experiment was laid out in randomized block design which consist 8 treatments of plant geometry {T_1 :120 × 60 cm, T_2 :120 × 90 cm, T_3 : 120 × 120 cm, T_4 : 150 × 60 cm, T_5 : 150 × 90 cm, T_6 : 150 × 120 cm, T_7 : FP (2 eye bud), T_8 : FP (3 eye bud)} and replicated thrice. On the basis of pooled analysis results obtained were significant with different planting geometry. In growth parameters plant height (3.91 m), number of tillers (19.57), nodal length (15.08 cm) was significantly higher under 150 x 120 cm planting geometry but cane girth was numerically higher under 120 cm × 60 cm. The closer planting geometry of 120 cm × 60 cm (T_1) produced the highest sugarcane yield (161.94 t ha^{-1}) and sugarcane equivalent yield (192.06 q ha^{-1}). In contrast, T_4 recorded the maximum single cane weight (1.92 kg), indicating superior growth of individual canes under relatively wider spacing. The widest planting geometry, 150 cm × 120 cm (T_6), proved most suitable for onion intercropping by producing the highest intercrop yield (105.37 q ha^{-1}). Juice percentage was highest under T_6, indicating improved juice extraction under wider spacing. Sucrose percentage was highest under T_2 (14.04%) and statistically at par with T_5 and T_3. Recovery percentage was maximum under T_3 (13.01%), followed by T_6. The maximum net return (₹401,100 ha^{-1}) was obtained under T_1, which was analogous to T_4. The maximum B:C ratio (4.73) was recorded under T_1, closely followed by T_4.

KEYWORDS: Cane; Tillers Juice per cent; recovery per cent; Net return; Sugarcane Equivalent Yield

INTRODUCTION

Sugarcane is a member of the Poaceae family comes under Saccharum genus and officinarum species. It is said to have originated in New Guinea and spread throughout all of the world's tropical and subtropical regions. The two primary groups of sugarcane grown in India are Sacchaum barberi and Sacchaum sinense and Sacchaum officinarum. It contains 63-73% water, 11-16% fibre, 12-16% soluble sugars and 2-3% non-sugar carbohydrates. One of India's most significant cash crops is sugarcane. With an average yield of 82 to 86 tonnes per hectare, India produces between 450 and 475 million tonnes of sugarcane yearly on an area of about 5.0 to 5.5 million hectares. India is the second-largest producer in the world, behind Brazil, which produces more than 700 million tons (1). India is the second-largest producer of sugarcane after Brazil and a major user of sugar. Refined sugar is the primary product of sugarcane juice but during its processing, various other valuable products are also obtained in an unrefined form, such as brown sugar, molasses and jaggery. Sugarcane juice is widely used in India in the treatment of jaundice, hemorrhage, dysuria, anuria and other urinary diseases (2). Sugarcane has emerged as a popular crop for the generation of environmentally friendly and renewable energy in recent years. Also provides the industrial foundations for one of the world's greatest agro-industries. The scope of sugarcane production has expanded due to the anticipated increase in energy consumption.

The high photosynthetic efficiency of sugarcane and its long history in industrial agriculture have raised it to prominence as the world's most important energy crop (3). Increasing the row spacing of sugarcane from the present recommended spacing of 90 to 120 cm would greatly facilitate to provide enough space for intercepting the light to get higher productivity, especially under frequently irrigated tropical climatic regions.

The higher plant height, number of leaves might be due to proper orientation and establishment of plants in wider rows. The higher number of leaves could be attributed to the fact that more area of land per shoot was available for growth and development under pair row planting as compared to single row planting. The higher dry matter production due to higher number of leaves per shoot available for the purpose of photosynthesis production under paired row planting (4). Spaced area between rows of sugarcane also provides opportunity to adopt intercropping to obtain additional income to the farmer. Adoption of drip irrigation in sugarcane increases the water use efficiency upto 60-200%, saves water about 20-60%, reduces fertilization requirement rate @20-33% through fertigation and produces better quality crop and increases the yield upto 7-25% as compared with conventional irrigation (5). The objective of this research is to find out suitable planting patterns for sugarcane to minimize the cost of cultivation and therefore this study on Agro-economic evaluation of sugarcane crop geometry under drip-irrigation in the sugar belt of Kawardha was done.

MATERIALS AND METHODS

Site of experiment

This experiment was conducted on Sant Kabir College of Agriculture and Research Station, Kawardha. Site was situated above the mean sea level of 353 meter with 81.25º E longitude and 22.02° N latitude.

Treatment details

The experiment was conducted in randomized block design in which eight treatments was taken and replicated it thrice. The eight treatments are T1: 120 × 60 cm, T2: 120 × 90 cm, T3: 120 × 120 cm, T4: 150 × 60 cm, T5: 150 × 90 cm, T6: 150 × 120 cm, T7: FP (2 eye bud), T8: FP (3 eye bud).

Methods of observation

Plant Height: The plant height was measured above the ground to tip of the heighted leaf. The height was measured in meter.

Number of Tillers: The number of tillers per plant was physically counted from selected plants and recorded for the result.

Nodal Length: It's the space between two nodes measured in the scale in centimeter.

Girth: The girth was measured with the help of a thread which was surrounded from one point to end at the same point. Then it was measured with the help of scale in centimeter.

Sugarcane Yield: After harvest of matured canes, it was weighed and converted in ton per hectare for the result.

Single Cane Weight: The single cane was weighed and recorded for the data.

Intercrop (Onion) Yield: After digging of intercropped onions, it was weighed and recorded for the results in quintal per hectare.

Sugarcane Equivalent Yield: $SEY = Y_c + (Y_i \times P_i)/P_c$

Where,

Y_c - yield of sugarcane main crop

Y_i - yield of the intercrop

P_i- price of the intercrop

P_c- price of the sugarcane

Brix: It is measured by using brix refractometer on extracted cane juice. It represents total soluble salts in mature canes and data taken in percentage.

Purity: It measures the ratio of actual sucrose to total soluble solids (brix) in the sugarcane juice.

$$\text{Purity \%} = \frac{\text{Sucrose \%}}{\text{Brix \%}} \times 100$$

Juice: It is determined by crushing a weighed sample of cane and collecting the extracted juice. The ratio of the weight of the juice to the initial weight of the sugarcane stalk is known as juice percentage.

Sucrose percentage: It was analysed through chemical/ Titrimetric Method (Lane-Eynon Method). In which after Fehling test enzymatic hydrolysis was done then after titration the reading was multiplied by 0.95.

Recovery percentage: This was calculated through a formula:

$$\text{Recovery \%} = \frac{\text{Sucrose \%}}{\text{Brix \%}} \times 100$$

Economics: Prices (₹ ha-1) for the experimental year were taken for the inputs included under cost of cultivation and gross return was calculated by multiplying the FRP for sugarcane with its yield.

Net Return = Gross return- cost of cultivation

B-C Ratio = (Gross return)/(Cost of cultivation)

RESULT AND DISCUSSION

Growth Parameters

The pooled analysis clearly indicated that planting geometry significantly influenced important vegetative growth parameters of sugarcane. The planting geometry of 150 cm × 120 cm (T_6) consistently produced the highest number of tillers (19.57), tallest plants (3.91 m) and maximum nodal length (15.08 cm) during both years as well as in the pooled analysis. These improvements can be attributed to optimum utilization of growth resources, reduced inter-plant competition and efficient water use under drip irrigation. Although cane girth was numerically higher under 120 cm × 60 cm (T_1), the differences among improved planting geometries were statistically non-significant. Therefore, based on the overall performance, 150 cm × 120 cm planting geometry under drip irrigation proved to be the most suitable planting geometry for obtaining superior vegetative growth of sugarcane in the Kawardha region. This was the result of optimum plant population in the field under these treatments.

Yield Attributes and Yield

The pooled analysis clearly demonstrated that planting geometry significantly affected sugarcane yield and its associated yield attributes under drip irrigation. The planting geometry of 120 cm × 60 cm (T_1) produced the highest sugarcane yield (161.94 t ha-1) and sugarcane equivalent yield (192.06 q ha-1) owing to the greater plant population per unit area. In contrast, 150 cm × 60 cm (T_4) recorded the maximum single cane weight (1.92 kg), indicating superior growth of individual canes under relatively wider spacing. The result indicates the inverse relationship between planting density and weight of cane. The widest planting geometry, 150 cm × 120 cm (T_6), proved most suitable for onion intercropping by producing the highest intercrop yield (105.37 q ha-1) because of increased inter-row space and better utilization of environmental resources. Thus, while wider spacing favored intercrop performance and individual cane growth, the closer spacing of 120 cm × 60 cm was found to be the most productive in terms of overall sugarcane and sugarcane equivalent yield under drip irrigation conditions in the Kawardha region.

Quality Parameters

Brix (%) and Purity (%) remained statistically non-significant during both years and in the pooled analysis, indicating that planting geometry had little influence on these parameters. Juice percentage was highest under T_6 (150 × 120 cm) with a pooled value of 69.83%, indicating improved juice extraction under wider spacing. Sucrose percentage was highest under T_2 (14.04%), followed closely by T_5 (13.95%) and T_3 (13.94%). Recovery percentage was maximum under T_3 (13.01%), followed by T_6 (12.59%), indicating better sugar recovery under these planting geometries. Both farmer practice treatments (T_7 and T_8) consistently recorded the lowest values for juice quality parameters.

Economics

The highest pooled gross return (₹486,825 ha-1) was recorded under T_1 (120 × 60 cm), followed by T_4 (₹462,217 ha-1). Cost of cultivation was highest under T_1 due to higher plant population and management requirements, while the lowest pooled cost (₹71,475 ha-1) was recorded under T_8.

The maximum pooled net return (₹401,100 ha-1) was obtained with T_1, followed by T_4 (₹380,762 ha-1). The net return obtained under T_1, was higher by ₹ 60475, 87735, 104750, 121058, 134500, 139925 ha-1 over T2, T3, T5, T6, T7, T8. Higher net returns of sugarcane crop can be achieved with planting single eye bud settling either at 120 cm row spacing or 60-120-60 cm pair row spacing; intra row spacing should be kept 45 cm under south Gujarat condition (6).

The highest pooled B:C ratio (4.73) was recorded under T_1, closely followed by T_4 (4.65), indicating that these planting geometries were economically the most profitable under drip irrigation.

DISCUSSION

The pooled analysis clearly indicated that planting geometry significantly influenced important vegetative growth parameters of sugarcane. These improvements can be attributed to optimum utilization of growth resources, reduced inter-plant competition and efficient water use under drip irrigation. In contrast, 150 cm × 60 cm (T_4) recorded the maximum single cane weight (1.92 kg). The result indicates the inverse relationship between planting density and weight of cane. Less cane weight at higher seeding density under farmer's practice was due to the enhanced interplant competition (7).

The widest planting geometry, 150 cm × 120 cm (T_6), proved most suitable for onion intercropping by producing the highest intercrop yield (105.37 q ha-1) because of increased inter-row space and better utilization of environmental resources. Landscape ensures clean solar radiation and air penetration through the lower canopy levels by widening the spatial row configuration. This also eliminates micro-resource competition. The extra space accelerates secondary photosynthetic loops, expanding the diameter, thickness and singular commercial weight of individual stalks (8).

The non-significant impact of planting geometry on Brix (%) and Purity (%) across both experimental years and the pooled analysis indicates a strong genetic buffering capacity for primary sucrose synthesis and internal quality traits in sugarcane. Total soluble solids (Brix %) and sugar purity are fundamentally regulated by genetic traits, ambient solar accumulation and nutritional fertilizers. Because fertilizer distribution rates remain identical across all treatment plots, changing row distances does not affect internal juice concentrations (9). Conversely, juice extraction percentage exhibited a strong sensitivity to spatial configurations, peaking under the widest spacing geometry, T_6 (150 × 120 cm), with a pooled value of 69.83%. This phenomenon can be attributed to the edge effect and reduced intra-crop competition for subterranean and aerial resources. In wider spatial arrangements, individual sugarcane clumps experience enhanced interception of photo-synthetically active radiation (PAR), optimal air circulation, and expanded root volume for moisture and nutrient uptake. Similarly, at 100% PE, commercial cane sugar (12.42 t ha-1) and juice (38.98%) were found to be greater. Drip irrigation at 80% PE, however, produced commercial cane sugar (9.42%), brix (16.49%) and poll (13.93%). Due to water stress, drip irrigation with 60 % PE produced the maximum baggese (63.98%) and juice purity (10). These favorable micro-environmental conditions promote robust stalk development, increased cell elongation, and pith hydration, ultimately yielding thicker, juicier stalks that facilitate higher juice expression during milling. Interestingly, the highest sucrose percentage was recorded under T_2 (14.04%), closely rivaled by T_5 (13.95%) and T_3 (13.94%), while the maximum sugar recovery percentage was achieved under T_3 (13.01%), followed by T_6 (12.59%). These results demonstrate that intermediate-to-wide spatial geometries establish a critical metabolic equilibrium. By optimizing the plant canopy configuration, these treatments prevent excessive vegetative shading which typically triggers gibberellin-mediated inter-node elongation at the expense of sugar storage (11).

The maximum pooled net return (₹401,100 ha-1) was obtained with T_1, followed by T_4 (₹380,762 ha-1). Higher net returns of sugarcane crop can be achieved with planting single eye bud settling either at 120 cm row spacing or 60-120-60 cm pair row spacing; intra row spacing should be kept 45 cm under south Gujarat condition (6).

CONCLUSION

On the basis of above findings, it may be concluded that planting at the spacing of 120 x 60 cm with drip irrigation is most suitable and profitable planting geometry for sugarcane cultivation in Kawardha district of Chhattisgarh.

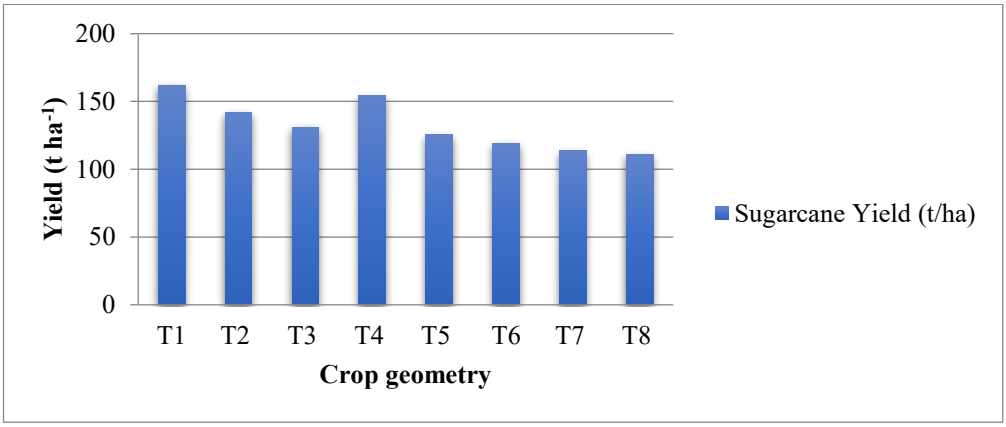


Fig. Effect of planting geometry on sugarcane yield attributes under drip irrigation

Table 1: Effect of planting geometry on growth parameters of sugarcane under drip irrigation in Kawardha Chhattisgarh (Year I, Year II and Pooled)

Treatments	Number of Tillers			Plant Height (m)			Nodal Length (cm)			Girth (cm)		
	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled
T_1 – 120 × 60 cm	16.33	16.80	16.57	3.60	3.65	3.63	14.53	14.70	14.62	9.17	9.05	9.11
T_2 – 120 × 90 cm	16.50	17.10	16.80	3.75	3.79	3.77	14.77	14.88	14.83	8.40	8.55	8.48
T_3 – 120 × 120 cm	18.50	18.90	18.70	3.81	3.87	3.84	14.90	15.02	14.96	8.54	8.68	8.61
T_4 – 150 × 60 cm	18.00	18.40	18.20	3.61	3.68	3.65	14.42	14.58	14.50	8.87	8.96	8.92
T_5 – 150 × 90 cm	18.67	19.05	18.86	3.59	3.66	3.63	14.80	14.92	14.86	8.56	8.70	8.63
T_6 – 150 × 120 cm	19.33	19.80	19.57	3.88	3.94	3.91	15.00	15.16	15.08	8.40	8.58	8.49
T_7 – FP (2 eye bud)	8.67	9.10	8.89	2.95	3.02	2.99	13.20	13.38	13.29	7.23	7.38	7.31
T_8 – FP (3 eye bud)	6.50	6.90	6.70	2.77	2.84	2.81	12.73	12.92	12.83	7.33	7.48	7.41
SEm±	1.02	0.98	0.71	0.18	0.17	0.12	0.47	0.44	0.32	0.54	0.50	0.37
CD (P=0.05)	2.06	1.99	1.45	0.37	0.35	0.25	0.95	0.89	0.65	1.10	1.02	0.76

Table 2: Effect of planting geometry on sugarcane yield attributes under drip irrigation in Kawardha Chhattisgarh

Treatments	Sugarcane Yield (t/ha)			Single Cane Weight (kg)			Intercrop (Onion) Yield (q/ha)			Sugarcane Equivalent Yield (q/ha)		
	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled
T_1 – 120 × 60 cm	160.67	163.20	161.94	1.86	1.89	1.88	88.89	90.56	89.73	190.30	193.82	192.06
T_2 – 120 × 90 cm	140.33	143.10	141.72	1.82	1.84	1.83	85.56	87.22	86.39	168.85	171.94	170.40
T_3 – 120 × 120 cm	129.67	132.40	131.04	1.77	1.80	1.79	87.78	89.10	88.44	158.93	162.15	160.54
T_4 – 150 × 60 cm	152.51	155.80	154.16	1.90	1.93	1.92	100.00	102.22	101.11	185.84	189.46	187.65
T_5 – 150 × 90 cm	123.67	126.90	125.29	1.73	1.76	1.75	102.22	104.10	103.16	157.74	161.48	159.61

T_6 – 150 × 120 cm	117.83	120.50	119.17	1.68	1.71	1.70	104.44	106.30	105.37	152.65	156.28	154.47
T_7 – FP (2 eye bud)	112.47	115.10	113.79	1.19	1.22	1.21	70.56	72.10	71.33	135.99	139.21	137.60
T_8 – FP (3 eye bud)	109.63	111.90	110.77	1.30	1.33	1.32	69.78	71.00	70.39	132.89	135.74	134.32
SEm ±	7.57	7.22	5.24	0.18	0.17	0.12	5.21	5.04	3.61	7.22	6.95	5.06
CD (p=0.05)	15.30	14.60	10.62	0.37	0.35	0.25	10.54	10.20	7.31	14.59	14.05	10.24

Table 3: Effect of planting geometry on chemical attributes of sugarcane under drip irrigation in Kawardha Chhattisgarh region (Year I, Year II and Pooled)

Treatments	Brix (%)			Purity (%)			Juice (%)			Sucrose (%)			Recovery (%)		
	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled
T_1 – 120 × 60 cm	20.46	20.58	20.52	83.60	83.74	83.67	67.48	67.92	67.70	13.56	13.70	13.63	12.17	12.31	12.24
T_2 – 120 × 90 cm	20.41	20.52	20.47	82.93	83.10	83.02	67.53	67.98	67.76	13.98	14.10	14.04	12.19	12.34	12.27
T_3 – 120 × 120 cm	20.94	21.08	21.01	83.54	83.72	83.63	68.47	68.86	68.67	13.86	14.02	13.94	12.93	13.08	13.01
T_4 – 150 × 60 cm	20.93	21.05	20.99	83.28	83.44	83.36	67.67	68.12	67.90	13.62	13.76	13.69	12.02	12.18	12.10
T_5 – 150 × 90 cm	20.60	20.74	20.67	83.81	83.96	83.89	67.78	68.24	68.01	13.88	14.01	13.95	12.11	12.26	12.19
T_6 – 150 × 120 cm	20.70	20.84	20.77	83.66	83.82	83.74	69.63	70.02	69.83	13.79	13.95	13.87	12.51	12.66	12.59
T_7 – FP (2 eye bud)	19.97	20.10	20.04	82.43	82.58	82.51	63.64	64.02	63.83	11.64	11.82	11.73	11.07	11.18	11.13
T_8 – FP (3 eye bud)	19.48	19.60	19.54	81.74	81.90	81.82	63.43	63.80	63.62	11.03	11.18	11.11	11.10	11.22	11.16
SEm ±	0.73	0.70	0.50	1.19	1.15	0.83	2.17	2.08	1.51	0.49	0.47	0.34	0.45	0.43	0.31
CD (p=0.05)	NS	NS	NS	NS	NS	NS	3.10	2.98	2.16	0.99	0.95	0.69	0.91	0.87	0.63

Table 4: Effect of planting geometry on economics of sugarcane under drip irrigation in Kawardha Chhattisgarh (Year I, Year II and Pooled)

Treatments	Gross Return (₹/ha)			Cost of Cultivation (₹/ha)			Net Return (₹/ha)			B:C Ratio		
	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled	Y-I	Y-II	Pooled
T_1 – 120 × 60 cm	482000	491650	486825	84150	85900	85025	396450	405750	401100	4.73	4.72	4.73
T_2 – 120 × 90 cm	421000	429250	425125	83200	84800	84000	336800	344450	340625	4.06	4.06	4.06
T_3 – 120 × 120 cm	389000	397600	393300	79670	81200	80435	310330	316400	313365	3.88	3.90	3.89

T_4 – 150 × 60 cm	457533	466900	462217	80980	82600	81790	377223	384300	380762	4.65	4.65	4.65
T_5 – 150 × 90 cm	371000	379400	375200	78600	80100	79350	293400	299300	296350	3.72	3.74	3.73
T_6 – 150 × 120 cm	353500	361800	357650	76866	78350	77608	276634	283450	280042	3.60	3.62	3.61
T_7 – FP (2 eye bud)	337400	345200	341300	74500	75900	75200	263900	269300	266600	3.53	3.55	3.54
T_8 – FP (3 eye bud)	328900	336400	332650	70800	72150	71475	258100	264250	261175	3.65	3.66	3.66
SEm ±	18240	18680	13020	1250	1280	895	17650	18050	12610	0.18	0.19	0.13
CD (p=0.05)	36890	37780	26340	2530	2590	1810	35720	36520	25520	0.36	0.38	0.26

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