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Productivity and Profitability of Spring Sugarcane (*Saccharum officinarum* L.) under different Planting Patterns Designed for Mechanized Intercultivation

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A field experiment was conducted at Pantnagar during spring 2012 to study the performance of sugarcane (*Saccharum officinarum* L.) under different planting geometries tailored for mechanized intercultivation. The experiment consisted of eight planting geometry treatments *viz*; 60 cm single row (T_1), 75 cm single row (T_2), 45/105 cm pair (T_3), 45/150 cm pair (T_4), 45/225 cm pair (T_5), 60/90 cm pair (T_6), 60/150 cm pair (T_7) and 60/225 cm pair (T_8) was laid in randomized block design with three replications. Weeding and interculture operations were carried out both using cultivator and manually in T_1 and T_2, by power weeder in T_3 and T_6, by power tiller in T_4 and T_7 and by tractor drawn small harrow in T_5 and T_8. The results indicated that the planting geometries having pair row spacing of 60 cm (*i.e.* 60/90, 60/150 and 60/225 cm) recorded significantly more yield attributing characters *viz;* number of millable canes, cane length, cane girth, number of internodes per cane and individual cane weight than rest of the planting geometries. Paired row spacing of 60/90 cm being at par with 60/150 and 60/225 cm produced significantly higher cane yield (84.24 t ha^{-1}) than rest of the planting geometries. The maximum gross (Rs. 217,836 ha^{-1}) and net return (Rs. 152,769 ha^{-1}) were obtained from 60/90 cm and that B:C ratio from 60/225 cm paired spacing (2.96).

Key words: Planting geometry, Intercultivation, Sugarcane, Yield

There is little scope to increase the area under sugarcane crop and the only way to increase its production is through improving the productivity through crop management practices. Regular single row planting is the most common practice of planting sugarcane. However, by changing planting pattern the resource use efficiency can be increased, so is the crop productivity. Planting geometry is a key factor, which actually decides the plant population per unit area and thus the yield. Therefore, it is imperative to identify such planting geometry, which maintains plant population, improves light interception, enhances nutrient availability, increases water use and facilitates weeding operation through mechanized intercultivation. Sugarcane is a long duration crop and its initial phase is very crucial from weed management point of view. The use of herbicides takes care of weeds hardly for one month and subsequently the weeds are controlled manually. Usually 2-3 weedings are essential to offset the yield loss caused by the weeds. Saini and Chaker (1993) reported that yield losses in sugarcane varied from 15-75 per cent depending upon weed flora, their density and the degree of competition affected by them. Manual weeding increases the cost of cultivation considerably. Further, hike in wages and limited availability of labourers has aggravated this problem.

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In North India, sugarcane in spring season is conventionally planted at 60 or 75 cm spaced rows, which hinders various management practices for good crop husbandry and hence, restricting yield to a considerable extent. Ramesh (1997) reported higher cane yield at 60/90 cm paired as compared to the conventional single row planting at 90 cm spacing. This suggests that planting geometry can conveniently be modified to facilitate mechanized intercultural operations without sacrificing the productivity. Availability of the machines *viz*. power weeder, power tiller and small harrow has provided an opportunity to perform intercultural operations mechanically. These tools, being operated by machines can perform intercultural operations, a cumbersome task, in less time thereby economizing the cost of cultivation. However, planting geometry has to be suitably modified so that these machines can easily move in the available space. Through pairing of rows, space is created between two pairs to perform mechanized intercultural operations. Sugarcane being an annual and tillering crop has great flexibility to compensate yield loss even with lower populations. The inter space between the pairs, in the present study was tailored suiting to the machine requirement. Therefore, a field experiment was conducted to study the performance of sugarcane under different planting geometries subjected to different mechanized intercultivation.

Materials and Methods

A field experiment was conducted at of G. B. Pant University of Agriculture and Technology, Pantnagar in spring season 2012. The experiment consisting of eight treatments *viz.* 60 cm single row (T_1), 75 cm single row (T_2), 45/105 cm pair (T_3), 45/150 cm pair (T_4), 45/225 cm pair (T_5), 60/90 cm pair (T_6), 60/150 cm pair (T_7) and 60/225 cm pair (T_8) was laid out in Randomized Block Design with three replications. The variety (Co Pant 90223) was planted on March 17, 2011 and harvested on February 17, 2012. The soil was silty clay loam in texture, neutral in reaction (pH 7.3), rich in organic carbon (1.07%), low in available nitrogen (234.3 kgha$_{-1}$), high in available phosphorus (34.5 kgha$_{-1}$) and medium in available potassium (258.7 kgha$_{-1}$).The crop was fertilized at the rate of 150:60:40 kg N:P_2O_5:K_2O per ha through urea, single super phosphate and muriate of potash, respectively. The whole phosphorous, potash and one third of nitrogen were applied at the time of sowing while remaining two equal halves of nitrogen were applied in last week of May and June, respectively. Intercultural operations to remove weeds were carried out twice, respectively in the month of May and June in T_1 and T_2 both by using cultivator and manually by spade; T_3 and T_6 by power weeder; T_4 and T_7 by power tiller and in T_5 and T_8 by tractor operated small harrow. The left over weeds between paired rows and within the rows were removed manually. The cost of cultivation was worked out considering current prices of the inputs and local charges of the laboures. Gross return was calculated by multiplying the cane yield with procurement price and green top yield with market price. Net return was calculated by difference method using the cost of cultivation and gross return. The benefit cost ratio was calculated on the basis of net return obtained and cost of cultivation incurred.

Results and Discussion

Yield attributes

Crop geometry affected the yield attributes significantly (Table 1). Regular single row spacing of 60 and 75 cm did not differ significantly for all the yield attributes. Wider paired spacing i.e. 60 cm recorded significantly higher value of yield attributes than narrow paired row spacing of 45 cm. Paired row spacing 60/90 cm produced significantly higher number of millable canes (102.05 thousands ha$_{-1}$) than rest of the planting geometries, barring planting with 60 cm pair spacing. Increase in number of millable canes in 60 cm pair row treatments is attributed to higher shoot population owing to better tillering in wider spacing. This result is in conformity with the findings of Ramesh (1997) and Mahmood *et al.* (2007) who also noted more number of millable canes, heavier individual cane weight and over all good cane growth under wider spacing.

Table 1. Effect of planting geometry on yield attributes of sugarcane

Planting geometry		NMC (000 ha$_{-1}$)	Cane length (cm)	Cane girth (cm)	Number of internodes per cane	Average cane weight (g)
T_1:	60 cm	83.91	244	7.4	21.4	875
T_2:	75 cm	85.79	248	7.5	21.6	885
T_3:	45/105 cm	79.90	231	7.2	20.0	840
T_4:	45/150 cm	83.19	236	7.4	20.5	875
T_5:	45/225 cm	88.13	245	7.6	21.5	910
T_6:	60/90 cm	102.05	265	7.6	21.8	941
T_7:	60/150 cm	98.28	266	7.7	22.2	950
T_8:	60/225 cm	96.01	270	8.0	22.4	955
	S.Em.±	3.99	4	0.1	0.2	23
	CD at 5%	12.10	13	0.3	0.7	69

Paired row 60/225 cm treatment was on par with 60/90 and 60/150 cm planting pattern but attained significantly more cane length (270 cm) and number of internodes (22.4) than rest of the planting geometries. Higher cane girth (8.0 cm) was also noted in paired row planting of 60/225 cm. All the planting patterns with 45 cm pair row spacing recorded on par values of yield attributes with regular row spacing of 60 and 75 cm but remained inferior to 60 cm pair row spacing treatments. Longer and wider cane under 60 cm paired row planting geometry might be attributed to proper intra pair and inter pair space which favored plant growth by facilitating mechanized inter cultivation and utilization of growth factors *e.g*. nutrient, moisture and sunlight etc. This result is in conformity with the findings of Cheema *et al.* (2002) and Sarala *et al.* (2010).

Crop raised in 60/225 cm paired system produced significantly heavier cane (955 g) than rest of the treatments, however was significantly equal to 45/225, 60/90 and 60/150 cm spacing. Canes obtained in 45/105 cm paired row spacing were of significantly lower weight and failed to bring significant increase over 45/150 cm pair of 60 and 75 cm. Significant variation in cane weight may be ascribed to differences in cane length and girth. Singh *et al.* (2010**)** also reported heavier canes under paired row pattern than single row planting.

Table 2. Effect of planting geometry on cane yield, gross return, net return and B:C ratio

Planting geometry		Cane yield(t ha^{-1})	Gross return(Rs. ha^{-1})	Net return(Rs. ha^{-1})	B:C ratio
T_1:	60 cm	71.32	184,119	111,382	1.53
T_2:	75 cm	73.90	190,580	125,344	1.92
T_3:	45/105 cm	66.47	171,134	106,067	1.63
T:	45/150 cm	69.63	179,271	122,061	2.13
T_5:	45/225 cm	74.79	192,914	141,518	2.75
T_6:	60/90 cm	84.24	217,836	152,769	2.34
T_7:	60/150 cm	81.06	209,269	152,767	2.70
T_8:	60/225 cm	77.37	199,829	149,318	2.96
	S.Em.±	2.96	7403	0.1	0.2
	CD at 5%	8.98	22454	0.3	0.7

Cane yield

A notable increase in cane yield was found due to paired row geometry (Table 2) . The paired row spacing of 60/90 cm being at par with 60/150 and 60/225 cm produced significantly higher cane yield (84.24 t ha^{-1}) than rest of the spacing. The per cent increase in cane yield under 60/90 cm pairing over 60 cm, 75 cm, 45/105 cm, 45/150 cm and 45/225 cm spacing was 18.1, 14.0, 26.7 and 21, respectively. Crop planted under 45/105 cm geometry resulted in significantly lower cane yield (66.47 t ha^{-1}), that did not differ significantly from regular planting (60 and 75 cm row spacing) and all inter pair spacing of 45 cm. The higher cane yields under different 60 cm pair row patterns might be attributed to more number of millable canes, higher cane length, wider cane girth and heavier individual cane weight. The higher cane yield with 60 cm pairs indicates that under this geometry crop did not face stiff inter row competition. Though closer spacing of 45 cm accommodate more number of rows per unit area but did not result in higher yield owing to poor growth and inferior yield attributes. For better growth sugarcane needs reasonable space for proper expansion of roots and higher availability of light to leaves. Durai *et al.* (2005) and Ramanand *et al.* (2007) also observed that paired row system was the best planting geometry owing to its higher cane yield over single row planting.

Economic parameters

Sugarcane grown under 60 cm paired row combinations was more remunerative as paired row planting of 60/90 cm gave significantly more gross return (Rs. 217,836 ha^{-1}) and net return (Rs. 152,769 ha^{-1}) than 45/105 and 45/150 cm pair combinations and single row planting (Table 2). The corresponding values were the least in 45/105 cm paired row system. Benefit cost ratio was significantly higher (2.96) and lower (1.53) in 60/225 cm paired row and single row 60 cm spacing, respectively. Except 45/ 105, 45/150 cm pair and 75 cm spacing all other pair row pattern recorded significantly higher B:C ratio than 60 cm single row planting. The maximum gross and net return under 60/90 cm paired row spacing was due to higher cane yield. Under 60/ 225 cm paired row system less seed requirement owing to wider row spacing and weed management through harrow, brought down the production cost considerably which in turn increased the B:C ratio.

Conclusion

Results of the present study suggest that 60/90 cm paired row planting system was the most viable preposition to achieve the maximum yield and economic returns. It was feasible to perform intercultivation by power weeder, power tiller and tractor mounted harrow, respectively in 90, 150 and 225 cm inter pair spacing.

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