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RESEARCH PAPER

Studies on optimum plant geometry and nutrient management strategy on biomass and economics of sugarcane (*Saccharum species* Hybrid)

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Abstract : In a modern and sustainable agriculture, the use of biofertilizers, soil amendments and suitable plant geometry with mechanization are eligible to increase plant production and to meet economic criteria to enhance soil fertility and to minimize environmental damage. A field experiment for consecutive two years *i.e.* 2014-16 and 2015-17 was conducted at research farm of Genda Singh Sugarcane Breeding and Research Institute, Seorahi, Kushinagar in autumn season to find out optimum plant geometry and nutrients management for efficient use of machinery with economics. The soil of the experimental plot was medium in organic carbon, medium in available phosphorus and low in potash with pH 8.2. The experiment consisting of four plant geometry *i.e.* S_1 - 90 cm row spacing (conventional method), S_2 - Trench planting in paired row at 120 (90:30) cm. S_3 - Trench planting in paired row at 150 (120:30) cm. S_4 - Trench planting in paired row at 180 (150:30) cm and two nutrient management practices *i.e.* F_1 -100% recommended dose of fertilizers through inorganics F_2 - 100% recommended dose of fertilizers through inorganics and 25 % N through organic manures along with biofertilizers (*Azotobacter* + P.S.B. @ 10 kg/ha each) was laid out in Factorial Randomized Block Design with three replications. On the basis of pooled data of two years, S_2 treated plot produced significantly higher cane yield (104.72 t/ha) over other geometry operations. Gross income, net return (Rs. 175593/ha) and B: C ratios (1.50) were recorded significantly higher in S_2 plant geometry treatment compared with remaining geometry treatments. Effect of nutrient management on gross return, net return, B: C ratio (1.44) and cane productivity (100.72 t/ha) were calculated significantly higher in 100% recommended dose of fertilizers through inorganics and 25 % N through organic manures along with biofertilizers (*Azotobacter* + P.S.B. @ 10 kg/ha treated plots (F_2) but effects on plant height and cane length were non significant. Sucrose per cent was not affected significantly with different treatments of plant geometry and nutrient managements operations.

Key Words : Sugarcane, Fertility, Biofertilizer, Biomass, Trench planting, Geometry, Economics

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INTRODUCTION

Sugarcane is the most important agro-industrial crop next to cotton which is being cultivated in around 5.09 million hectares area with 70.3 t/ha productivity in India. Uttar Predesh state occupies an area of 22.99 lakh hectare with average yield is 72.40 t/ha. In present Era of energy crises, sugarcane is also coming up as biofuel crop, mixing of ethanol by 10-15 per cent has already been recommended. Hence, there is great need to enhance sugarcane productivity and net profit of farmers. In the present context of globalization, ways and means have to be further evolved to produce more sugar per unit area, time and input in order to keep pace with the population growth while preserving the soil and water resources. The challenges in the millennium can be met effectively by adopting the appropriate mechanical alternatives not only for increasing the productivity but inculcating cost efficiency in sugarcane production system. The farm mechanization in the context of sugarcane cultivation aims at introducing timeliness of operation, reducing human drudgery and improving overall production efficiency. Sugarcane remains in the field for almost a year and right from land preparation to harvesting of crop there is heavy demand of labor and machinery throughout its crop cycle. Sugarcane accounts for 60-70% of the cost of sugarcane production and thus has a vital role to make sugar industry a commercially valuable venture (Singh *et al*., 2011). Use of machinery helps in labor saving, ensures timeliness of operation, reduces drudgery, helps in improving quality of work, reduces cost of operation and ensures effective utilization of resources. Thus, there is a considerable mechanization gap, especially in the area of sugarcane planting, intercultural operations, harvesting and ratoon management. Therefore, it is necessary that concentrated efforts be made for adoption, development and popularization of sugarcane machinery for various cultural operations. Planting of sugarcane in paired rows compared with that in single row has proved beneficial in India (Yadav *et al*., 1997) and in Pakistan (Bajelan and Nazir, 1993). Bhullar *et al.* (2002) advocated that planting method should provide enough opportunity to conserve soil moisture to facilitate settling establishment. Hari and Srinivasan (2005) reported that cane yield improvement due to application of *Azotobacter*. Integrated nutrient supply system is the need of the hour, involving a judicious combination of organic, inorganic and biofertilizers for sustainable crop production. Biofertilizers play an important role in achieving this goal in an ecofriendly manner by fixing nitrogen, improving the crop growth by production of growth promoting chemicals and improving the nutrient uptake of the crops. Biofertilizers are ready to use live formulates of such beneficial micro-organisms which on application to seed, root or soil mobilize the availability of nutrients by their biological activity in particular and help build up the micro-flora and in turn the soil health in general. Use of such natural products like biofertilizers in crop cultivation will help in safeguarding the soil health and also the quality of crop products, restore natural soil fertility, provide protection against drought and some soil borne diseases, cost effective supplement to fertilizers. The use of biofertilizers and soil amendments is eligible to increase plant production and to meet economic criteria to enhance soil fertility and to minimize environmental damage (Elsayed *et al.,* 2008). Therefore, keeping above facts in view, the present investigation was conducted to studies on optimum plant geometry and nutrient management strategy on biomass and economics of sugarcane (*Saccharum species* hybrid).

MATERIAL AND METHODS

Field experiment was conducted at research farm of Genda Singh Sugarcane Breeding and Research Institute, Seorahi, Uttar Pradesh during 2014-16 and 2015-17. The experiment consisting of four plant geometry *i.e.* S_1 - 90 cm row spacing (conventional method, S_2 - Trench planting in paired row at 120 (90:30) cm. S_3 - Trench planting in paired row at 150 (120:30) cm. S_4 - Trench planting in paired row at 180 (150:30) cm and two nutrient management practices *i.e.* F_1 -100% recommended dose of fertilizers through inorganics. F_2-100% recommended dose of fertilizers through inorganics and 25 % N through organic manures along with biofertilizers (*Azotobacter* + P.S.B. @ 10 kg/ha each) was laid out in Factorial Randomized Block Design with three replications. The soil of experiment plot was medium in organic carbon, low in available phosphorus and medium in potash with nearby pH 8.02. Recommended dose of fertilizers was 200, 80, 60 (NPK) kg per ha for spring planted sugarcane crop. The nitrogen 1/3 and full dose of P and K were applied at the time of planting and remaining nitrogen was applied in two equal split doses as top dressing before the onset of monsoon season. Sources of nitrogen, phosphorus and potash were urea, single super phosphate and muriate of potash,

Table A : Metrological data

Months	Temperature		Humidity		Rainfall	No. of rainy day
	Min	Max	Forenoon	Afternoon		
Nov-14	12.19	29.08	84.46	56.9	00	00
Dec-14	7.87	18.54	91.67	64.35	53.0	03
Jan-15	8.78	19.38	90.58	62.03	66.0	06
Feb-15	9.85	23.9	88.07	58.75	13.8	02
March-15	12.91	27.19	82.87	59.58	100.2	05
April-15	18.3	31.39	80.44	58.34	64.8	07
May-15	23.13	34.39	74.12	50.45	53.0	02
June-15	25.96	36.06	69.2	50.13	59.8	06
July-15	25.89	32.43	86.09	61.96	258.4	13
August -15	24.75	32.03	88.06	59.93	192.4	14
Sept-15	25.15	33.66	80.46	50.7	5.6	01
Oct-15	19.22	32.01	84.71	57.29	60.8	04
Nov-15	13.51	28.91	82.36	56.06	00	00
Dec-15	9.31	24.83	90.54	58.35	00	00
Jan-16	7.36	20.12	91.80	57.26	5.6	01
Average	16.28	28.26	84.36	57.47	933.4	64
Nov-15	13.51	28.91	82.36	56.06	00	00
Dec-15	9.31	24.83	90.54	58.35	00	00
Jan-16	7.36	20.12	91.80	57.26	5.6	01
Feb-16	10.11	25.41	83.31	53.24	1.2	01
Mar-16	14.46	30.05	72.38	43.93	0.8	01
April-16	23.72	36.02	66.13	40.30	00	00
May-16	23.03	34.90	81.35	53.45	187.6	11
June-16	24.94	33.90	80.56	58.16	73.2	14
July-16	24.85	30.61	92.06	69.35	397.4	22
August -16	25.41	32.43	88.0	62.06	95.4	13
Sept-16	24.38	31.25	94.58	70.46	274.2	19
Oct-16	20.28	32.35	90.58	59.96	26	01
Nov-16	12.6	28.89	93.80	59.46	00	00
Dec-16	9.04	21.25	95.55	62.93	00	00
Jan-17	6.94	21.30	93.94	60.16	17.2	02
Average	16.66	28.81	86.46	57.68	1078.60	85

respectively. The improved crop management practices were followed during experimentation in the both years. Cane length of all ten canes was measured with the help of measuring tape and averaged. Plant height of all ten plants was measured from base of stem to the tip of the top most leaf with the help of meter tape at harvesting stage. The crop was harvested from ground level and green and dry leaves were stripped off. Net return of individual treatment was calculated by deduction of cost of cultivation from the gross return of particular treatment. In order to find out net benefit: cost ratio, the net return from individual treatments was divided by their respective cost of cultivation. Table A showed that total of 933.40 and 1078.60 mm rain were recorded during 2014-16 and 2015-17 crop periods in 64 and 84 days rainy days with highest 258.40 and 397.4 mm in July months. The average forenoon and afternoon relative humidity during crop period was recorded ranged between 40.30 to 95.55 per cent. The maximum temperature was ranged from 20.12 to 36.06^{0}C whereas minimum temperature ranged from 6.94 to 25.96^{0}C during crop periods.

RESULTS AND DISCUSSION

The results obtained from the present investigation

as well as relevant discussion have been summarized under following heads :

Effect of geometry :

In Table 1 pooled data of two years indicated that effect of plant geometry on plant height, cane length and cane productivity were recorded significant. S_4 plant geometry treatment noted significantly higher plant height and cane length as compared with remaining geometry treatments except of plant height in S_3 treatment. Cane productivity was obtained significantly higher in S_2 (104.72 t/ha) over remaining treatments. Total cost of cultivation was calculated maximum in S_2 treatments. 90:30 cm plant geometry obtained significantly higher gross income (Rs. 293213/ha), net return (Rs. 175593/ ha) and B : C ratio (1.50) over other plant geometry treatments. B: C ratio was increased 8.70, 11.11, and 19.04 per cent more in S_2 treatment as compared with S_3, S_1 and S_4 cultural operations, respectively. Sucrose per cent were not affected significantly with different plant geometry treatments but maximum value obtained (17.54) in S_2 treatment. Singh *et al.* (2007) also reported improvement in physical properties of soil by addition of organic manure like F.Y.M. etc. and resulting in better crop yield of sugarcane. The differences in commercial and sugar per cent in cane among difference planting geometry and fertility levels found to be also non-significant. Similar opinion was also expressed by Thakur and Sharma (2005); Yadav *et al*. (1997); Bajelan and Nazir (1993) and Singh *et al*. (2016).

Effect of nutrients management :

Cane productivity was produced significantly higher in F_2 between nutrients management treatment. Plant

Table 1 : Two years pooled data of economics and pant height, cane length, sucrose per cent and productivity

Treatments	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio	Plant height (cm)	Cane height (cm)	Sucrose per cent	Cane productivity (t/ha)
Plant geometry								
S_1- 90 cm row spacing (conventional method)	109788	259077	149289	1.35	407.79	273.27	17.34	92.53
S_2 -Trench planting in paired row at 120 (90:30) cm	117620	293213	175593	1.49	420.52	275.67	17.54	104.72
S_3 - Trench planting in paired row at 150 (120:30) cm	113899	270884	156985	1.38	449.13	285.69	16.97	96.74
S_4- Trench planting in paired row at 180 (150:30) cm	110178	248861	138683	1.26	450.21	299.33	17.28	88.88
S.E.±	-	3485	3485	0.03	4.76	2.75	0.15	1.24
C.D. (P=0.05)	-	10674	10674	0.09	14.58	8.43	NS	3.80
Nutrients Management								
F_1- 100% recommended dose of fertilizers through inorganics	110323	254557	144234	1.30	430.99	283.53	17.23	90.91
F_2- 100% recommended dose of fertilizers through inorganics and 25 % N through organic manures along with biofertilizers (*Azotobactor* + P.S.B @ 10 kg/ ha each)	115419	281460	166041	1.44	432.83	283.45	17.33	100.52
S.E.±	-	2464	2464	0.02	3.36	1.95	0.11	0.88
C.D. (P=0.05)	-	7547	7547	0.07	NS	NS	NS	2.69

NS=Non-significant

Table 2 : Economics of different treatments of sugarcane cultivation

Treatments	Common cost (Rs./ha^{-1})	Treatments cost (Rs./ha^{-1})	Total cost (Rs./ha^{-1})	Cane yield (q ha^{-1})	Gross return (Rs./ha^{-1})	Net return (Rs./ha^{-1})	B:C ratio
S_1F_1	76122	31868	107990	876.51	245423	137433	1.27
S_1F_2	76122	35464	111586	974.04	272731	161145	1.44
S_2F_1	76122	38700	114822	1014.20	283976	169154	1.47
S_2F_2	76122	44296	120418	1082.17	303009	182591	1.52
S_3F_1	76122	34979	111101	890.33	249292	138191	1.24
S_3F_2	76122	40575	116697	1040.55	291355	174658	1.50
S_4F_1	76122	31258	107380	855.48	239535	132155	1.23
S_4F_2	76122	36854	112976	922.09	258186	145210	1.29

Sale price 280/qtl, labor cost 174/labour,Urea 601/qtl, SSP=800/qtl, MOP=1100/qtl, FYM =30/qtl,Azoctobacter/PSB=50/kg (Rupees)

height, cane length and sucrose per cent were not affected significantly with different nutrient management treatments but maximum value obtained in F_2 treatment. Pooled data in Table 1 showed that F_1 treatment produced significantly lower gross return (Rs. 254557/ ha), net return (Rs. 144234/ha) and B: C ratio (1.30) between nutrient management treatments. F_2 treatment obtained 10.77 per cent more B: C ration over F_1. These results are in agreement with the earlier results of Bhullar *et al.* (2002); Hari and Srinivasan (2005) and Singh *et al*. (2016).

Effect of plant nutrients and plant geometry management on economics :

Table 2 showed that S_2F_2 treatment combination recorded maximum value of B: C ratio (1.52), gross return (Rs. 303009/ha) and net return (Rs. 182591/ha) followed by S_3F_2 combination (1.50, Rs. 291355 and Rs. 174658 per ha, respectively) and S_2F_1 (1.47, Rs. 283976 and Rs. 169154 per ha, respectively). Clearly indicated that S_2F_2 combination is best on economics point of view for cane grower. It might be due to trench and biofertilizer that results more explore for utilization of space and light mobilize the availability of nutrients by their biological activity and increase the nutrients uptake.

Conclusion :

Our results in the present study concluded that S_2 and F_2 treatment produced significantly higher cane productivity and benefit: cost ratio. S_2F_2 treatment combination is benefited to cane grower because B: C ratio (1.52) and cane productivity (108.21 t/ha). Sucrose per cent was not affected significantly with different treatments.

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