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Effect of Planting Method and Row Spacing on Nutrient Content and its Uptake in different Plant Parts of Bud Chip Planted Sugarcane (*Saccharum officinarum* L.) in Sub-tropical Region of India

Anupama Rawat[1]*, Naresh Malik[2], Subhash Chandra[3], Rohitasav Singh[2] and Rakesh Kumar[1]

[1]Ph.D. Scholar, Department of Agronomy, College of Agriculture,
GB Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand), India.
[2]Professor, Department of Agronomy, College of Agriculture,
GB Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand), India.
[3]Chief Scientist, Department of Agronomy, College of Agriculture,
GB Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand), India.

(Corresponding author: Anupama Rawat)*
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ABSTRACT: A field experiment was conducted on spring planted sugarcane during 2019-20 and 2020-21 at GB Pant University of Agriculture and Technology, Pantnagar. The objective of the study was to observe the effect of various planting methods and row spacing on cane yield, nutrient content and it's uptake by bud chip raised sugarcane settlings and conventionally planted sugarcane. Sugarcane is a long duration crop owing to which it requires careful management in terms of input application and utilization. Conventional planting restricts proper growth and development of sugarcane and also creates deleterious environment for crop resulting in poor yield and cane quality. The experiment comprised of 9 treatments each replicated thrice and total of 27 experimental units. The effect of planting method and row spacing was found to be significant on nutrient uptake by the crop. The results revealed that significantly highest cane yield was recorded under furrow planting (100.7 and 101.6 t/ha during 2019-20 and 2020-21, respectively) of bud chip raised settlings and among the various row spacing, 90 cm row spacing recorded significantly highest cane yield which was at par with 75 cm spaced rows but higher than 105 cm and 120 cm row spacing. Conventionally planted three budded sugarcane sets gave significantly low cane yield as against all the other bud chip treatments. The planting method and row spacing treatments gave non-significant impact on N, P and K content in cane, green top and trash of sugarcane during both the years. Whereas, the mean nutrient content in plant parts of bud chip planted treatments showed significantly higher nutrient content compared to conventionally planted sugarcane. N, P and K uptake by cane, green top and trash differed significantly due to variation in yield under different treatments.

Keywords: Bio-fuel, bud chip, byproducts, nutrients, settlings, sugarcane.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important commercial crop both globally and nationally. It supports livelihood of majority of rural population of India as it is labor intensive crop. Brazil holds the first position in sugarcane production followed by India. In India, Uttar Pradesh ranks first for sugarcane production. In 2020-21, India produced 370.50 Million Mt of sugarcane under the area 4.60 million hectares with the average productivity of 80.49 tons per hectare (DAC, 2020-21). The maximum percentage of the sugar demand is fulfilled by sugarcane followed by sugarbeet. Sugar industry is the second largest agro-industry after textiles in the country. India is the largest consumer of sugar and its requirement is expected to rise markedly in coming years due to population increase. Also the byproducts of sugarcane are gaining popularity majorly ethanol which is being consumed as a bio-fuel. Hence, overall demand of sugarcane is increasing for various purposes. However, area under the crop is shrinking and the enhanced demand can be achieved only by increasing crop productivity and sugar recovery. Sugarcane is a long duration crop producing huge biomass for which it requires optimum management practices. It faces various challenges during its growth cycle to attain its potential yield. Various constraints responsible for low productivity of sugarcane are low germination percentage, use of poor quality seed, inappropriate planting method and other management practices. Owing to poor germination percent of sugarcane, its seed requirement rate is high around 6-8 t ha^{-1} as reported by Loganandhan *et al.*, (2013). Use of high seed rate and with the present planting techniques i.e. use of three budded sett, cost of

cultivation of sugarcane is high as it contributes to 20 % of total cost of sugarcane production. Conventional planting of sugarcane is less time taking but is not suitable in terms of crop growth, productivity and profitability. In conventional planting closer row spacing and flat method of planting of setts impose serious problems like insect pest infestation, hampers mechanical and inter-culture operations and labor intensive etc. Adoption of suitable planting method and row spacing may help to solve the problem. Kumar (2019) reported that adoption of 90 cm row spacing resulted in enhanced productivity. With present sugarcane scenario in the country, sugarcane production need to be increased by enhancing its productivity as area under its cultivation is not likely to increase. There are various biotic and abiotic factors that limit sugarcane productivity. Under sub-tropical regions for sugarcane cultivation, climatic conditions are not favourable, crop growth period is short and continuous monocropping of sugarcane in the same field has created unhealthy soils which ultimately affect sugarcane productivity. Crop management techniques which allow minimal loss of seed and nutrient and better utilization of applied resources and nutrients need to be adopted. Bud chip technique is reported to provide scope to sustainably grow sugarcane with increased profitability. It has been reported by Narendranath, (1992) that adopting bud chip technique for growing sugarcane is three times more cost effective than conventional planting. It has been reported by Samant, (2017) that bud chip planting technique gave 37.9 % higher cane yield than conventionally planted sugarcane. It has been reported by Mishra, (2019) that bud chip planting of sugarcane recorded higher survival percentage of settlings. Conventional planting though easy to carry out but results in poor yield and yield attributing characters Research conducted by Tayade *et al.* (2021) revealed that planting bud chip grown settlings recorded the highest individual cane weight compared to the conventionally planted cane.

MATERIALS AND METHODS

A field experiment was conducted in Sugarcane Agronomy E7 Block at the Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, U. S. Nagar, Uttarakhand during 2019-20 and 2020-21. Pantnagar falls under sub-tropical region having humid condition with hot and dry summers. During summers, temperature may rise beyond 40°C and 0 °C during winters. The soil of the experimental site was silty clay loam with pH 7.6, 0.73 % organic carbon, 218.0 kg/ha available nitrogen, 29.6 kg/ha available P and 141.0 kg/ha available K. The experiment was laid out in factorial randomized block design with two planting methods (A1- flat planting and A2- furrow planting) and four different row spacing (B1- 75 cm, B2- 90 cm, B3- 105 cm and B4- 120 cm) with one additional treatment (conventional planting) having three replications. The Sugarcane variety 'Co Pant 3220' was used for planting. 30 days old bud chip raised settlings were transplanted to the main field under different treatments. In conventional planting three budded sets were planted in flat beds at a row spacing of 75 cm. A pre-sowing irrigation was given to all the experimental plots. After transplanting a shallow irrigation was applied to all the plots to favor settling establishment. Fertilizer was applied at a rate of 150: 60: 40 with urea (46 %), NPK (12:32:16) and MOP (60% P_2O_5) as a source. Half dose of nitrogen and full doses of phosphorus and potassium were applied as a basal and the remaining dose of nitrogen was split into two and applied at 60 DAT and 90 DAT. Band application of fertilizer was done in case of transplanted bud chip settling while in conventional planting fertilizer was broadcasted. Plant samples *viz.* cane, green top and trash were collected from sampling row in each plot at the time of harvest and was oven dried and its dry weight was recorded. It was grounded into fine powder for further analysis of N, P and K in different plant parts. Uptake of nutrients by different plant parts was calculated based on dry weight. Recorded data were analyzed using analysis of variance for factorial RBD (Gomez and Gomez, 1984) and the CD was calculated at 5% level of significance.

RESULTS AND DISCUSSION

Nutrient uptake by canes, green top and trash depends upon the nutrient content in the respective plant parts and their dry weight at harvest.

Cane yield. The study revealed that planting method significantly affected cane yield during both the years. Settlings planted in furrows gave significantly higher cane yield of 100.7 and 101.6 t/ha, respectively in 2019-20 and 2020-21 compared to flat planting method. Similar results are in comformity with Bhullar *et al*., (2002) as he recorded higher cane yield with furrow planting of setts than conventional planting. Maximum cane yield was recorded with sugarcane planted at a row spacing of 90 cm during both the years of experimentaion. It was statistically at par with 75 cm row spacing and significantly higher than 105 cm and 120 cm row spacing.This might be due to the fact that narrower the inter-row spacing higher the number of millable canes. El-Shafai and Ismail (2006) reported similar results and recorded higher cane yield under narrow row spacing than wide row spacing. Cane yield is a function of millable cane population at harvest and individual cane weight. In the present study both number of millable canes/ha and individual cane weight were higher at furrow planting and at a row spacing of 90 cm.

The interaction between planting method and row spacing was non-significant on cane yield of bud chip planted settlings during both the years of investigation.

Conventional planting of sugarcane recorded significantly lower cane yield of 88.1 and 91.5 t/ha during 2019-20 and 2020-21, respectively compared to mean cane yield of bud chip planted treatments.

Table 1: Effect of Planting method, row spacing and mean of bud chip planted treatments v/s conventional planting on cane yield of sugarcane.

Treatments	Cane yield (t/ha)	
	2019-20	2020-21
Planting methods		
Flat	92.1	96.0
Furrow	100.7	101.6
SEm±	1.8	1.6
CD (5%)	5.3	4.9
Row spacing		
75 cm	98.6	101.4
90 cm	102.8	105.5
105 cm	93.2	96.7
120 cm	90.9	91.7
SEm±	2.5	2.3
CD (5%)	7.5	6.9
Interaction (planting method × spacing)		
A×B	NS	NS
Conventional v/s others		
Conventional	88.1	91.5
Others	96.4	98.8
SEm±	2.7	2.4
CD (P=0.05)	8.0	7.3

Nitrogen content and uptake in Sugarcane. The results showed that influence of planting methods, row spacing and their interaction was not significant on nitrogen content in cane, green top and trash of sugarcane during both the years of the study. However, planting bud chip raised settlings recorded significantly higher nitrogen content in cane, green top and trash compared to planting of three budded setts. Similar trend was observed during both the years of the investigation. The effect of planting method on nitrogen uptake by different parts was significant except by trash where the difference in uptake was non-significant during both the years. Furrow planting method was superior over flat planting method. Influence of row spacing on nitrogen uptake was also found to be significant by all the plant parts except green top. It has been reported by Nimbalkar *et al.,* (2018) that planting methods significantly affected uptake of nitrogen, phosphorus and potassium by sugarcane. Nitrogen uptake by green top was observed to be non-significant under the influence of row spacing during both the years. The total nitrogen uptake differed significantly under the influence of various row spacing.

Table 2: Effect of Planting method, row spacing and mean of bud chip planted treatments v/s conventional planting on Nitrogen content and uptake by cane, green top and trash of sugarcane.

Treatments	Nitrogen Content (%)						Nitrogen uptake (kg/ha)							
	Cane		Green top		Trash		Cane		Green top		Trash		Total	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Planting methods														
Flat	0.414	0.415	0.618	0.621	0.388	0.390	125.6	131.6	33.3	37.2	22.6	25.1	181.5	193.9
Furrow	0.415	0.416	0.626	0.629	0.389	0.391	137.7	139.6	35.5	39.5	22.3	23.5	195.6	202.6
SEm±	0.004	0.002	0.008	0.008	0.004	0.005	2.4	2.2	0.6	0.6	0.5	0.6	2.5	2.4
CD (5%)	NS	NS	NS	NS	NS	NS	7.1	6.7	1.9	1.8	NS	NS	7.5	7.1
Row spacing (cm)														
75	0.412	0.415	0.619	0.623	0.387	0.388	134.1	138.9	34.3	38.3	24.2	26.1	192.6	203.3
90	0.414	0.415	0.621	0.624	0.388	0.390	140.1	144.5	36.5	40.4	23.5	25.3	200.2	210.2
105	0.415	0.416	0.623	0.626	0.390	0.391	127.4	152.6	33.7	37.4	21.4	23.1	182.5	193.0
120	0.417	0.418	0.626	0.628	0.391	0.393	125.0	126.4	32.0	37.3	20.5	22.8	178.9	186.5
SEm±	0.005	0.003	0.012	0.012	0.005	0.007	3.4	3.1	0.9	0.9	0.7	0.9	3.5	3.4
CD (P=0.05)	NS	NS	NS	NS	NS	NS	10.0	9.4	NS	NS	2.0	2.6	10.6	10.1
Interaction (planting method × spacing)														
A×B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Conventional v/s others														
Conventional	0.398	0.408	0.582	0.579	0.371	0.369	115.7	123.1	29.5	32.6	17.7	20.6	162.8	176.2
Others	0.414	0.416	0.622	0.621	0.389	0.391	131.67	135.6	34.4	38.3	22.5	24.3	188.5	198.2
SEm±	0.005	0.003	0.0012	0.014	0.005	0.007	3.55	3.33	1.0	0.9	0.7	0.9	3.8	3.6
CD (P=0.05)	0.016	0.008	0.037	0.041	0.016	0.021	10.64	9.98	2.9	2.7	2.2	2.8	11.3	10.7

The highest uptake was recorded for 90 cm row spacing and the minimum for 120 cm row spacing. Asokan *et al.,* (2005) reported the highest N uptake for 75 cm row spacing than 90 cm row spacing. On comparing conventionally planted sugarcane with the mean of bud chip planted treatments the difference was found to be significant. Conventionally planted sugarcane resulted in lower uptake of nitrogen compared to the bud chip planted treatments. The total uptake of nitrogen for bud chip planted was 188.5 kg/ha and 198.2 kg/ha, respectively during 2019 and 2020. Respective uptake of nitrogen under conventional planting was 162.8 kg/ha and 176.2 kg/ha.

Phosphorus content and uptake. The results showed that influence of planting methods and row spacing was not significant on phosphorus content in cane, green top and trash of sugarcane during both the years of the study. The interaction between planting method and row spacing also failed to show any significant effect on phosphorus content of sugarcane except in green top during 2020 where 120 cm row spacing recorded significantly lowest phosphorus content in green top. However, planting bud chip raised settlings recorded significantly higher phosphorus content in cane, green top and trash compared to planting of three budded setts. Similar trend was observed during both the years of the investigation. Total uptake of phosphorus and uptake by cane was significantly affected due to planting methods during 2019-20 but was non-significant in 2020-21. Uptake by green top differed significantly under the influence of planting methods whereas by trash it was non-significant during both the years of the study. Different row spacing failed to make a significant difference in phosphorus uptake by sugarcane crop except by green top during 2020-21. The difference in phosphorus uptake under conventional planting and the mean of bud chip planted treatments was found to be significant. Bud chip planted treatments resulted in significantly higher uptake of phosphorus compared to conventional planting.

Potassium content and uptake. Potassium uptake by different plant parts was found to be non-significant under the influence of different planting methods during both the years except by green top during 2020, where furrow planting method recorded significantly higher potassium uptake (58.1 kg/ha) than flat planting (55.3 kg/ha). Total potassium uptake was significantly affected due to planting methods. Furrow planting method recorded significantly higher potassium uptake during both the years. The magnitude of increase was 7.7 and 4.7 %, respectively in 2019 and 2020. Among different row spacing the effect on uptake of potassium was found to be significant for cane. Similar results were reported by Patel *et al.,* (2014) who has recorded the highest N, P and K uptake under 120 cm spaced rows as against 90 and 150 cm row spacing. The difference was non-significant for green top during 2019 and trash in 2020. The total uptake was found to be the highest under 90 cm row spacing (238.1 kg/ha) which was at par with 75 cm row spacing (229.1 kg/ha) but significantly higher over 105 cm and 120 cm row spacing during 2020. The difference between different row spacing for total uptake of potassium was found to be non-significant during 2019.

The mean of bud chip planted treatments recorded significantly higher potassium content and its uptake in sugarcane crop compared to conventionally planted sugarcane during both the years. The mean of bud chip planted treatments for total potassium uptake was significantly higher than conventional planting. The magnitude of increase was 23.5% in 2019-20 and 16.8 % in 2020-21.

Table 3: Effect of Planting method, row spacing and mean of bud chip planted treatments v/s conventional planting on phosphorus content and uptake by cane, green top and trash of sugarcane.

Treatments	Phosphorus Content (%)						Phosphorus uptake (kg/ha)							
	Cane		Green top		Trash		Cane		Green top		Trash		Total	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Planting methods														
Flat	0.051	0.055	0.0970	0.0978	0.0861	0.0868	15.4	17.3	5.23	5.86	5.04	5.61	25.7	28.8
Furrow	0.053	0.054	0.0986	0.0987	0.0867	0.0876	17.6	18.0	5.60	6.19	4.98	5.27	28.2	29.4
SEm±	0.002	0.002	0.0011	0.0004	0.0018	0.0010	0.6	0.8	0.12	0.08	0.18	0.17	0.7	0.8
CD (5%)	NS	NS	NS	NS	NS	NS	1.8	NS	0.37	0.23	NS	NS	1.9	NS
Row Spacing (cm)														
75	0.051	0.052	0.0968	0.0973	0.0850	0.0862	16.7	17.4	5.38	6.0	5.33	5.80	27.4	29.2
90	0.052	0.054	0.0975	0.0978	0.0863	0.0869	17.6	18.7	5.74	6.3	5.23	5.64	28.6	30.7
105	0.052	0.055	0.0982	0.0987	0.0868	0.0875	16.0	17.5	5.32	5.9	4.80	5.16	26.1	28.6
120	0.053	0.056	0.0987	0.0992	0.0875	0.0883	15.8	16.9	5.21	5.9	4.68	5.15	25.7	27.9
SEm±	0.002	0.002	0.0016	0.0006	0.0025	0.0015	0.9	1.1	0.17	0.11	0.25	0.23	0.9	1.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.33	NS	NS	NS	NS
Interaction (planting method × spacing)														
A×B	NS	NS	NS	S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Conventional v/s others														
Conventional	0.041	0.046	0.0917	0.0964	0.0780	0.0810	11.9	14.0	4.6	5.4	3.7	4.5	20.2	23.9
Others	0.052	0.054	0.0978	0.0983	0.0864	0.0872	16.5	17.6	5.1	6.2	5.0	5.4	26.9	29.1
SEm±	0.002	0.003	0.0017	0.0006	0.0027	0.0016	0.91	1.1	0.2	0.1	0.3	0.3	0.9	1.2
CD (P=0.05)	0.007	0.008	0.0050	0.0018	0.0080	0.0047	2.73	3.4	0.5	0.4	0.8	0.7	2.3	3.7

The results showed that during 2020, significantly higher phosphorus content was observed under 105 cm row spacing which was statistically similar to 90 cm row spacing under flat planting. Bud chip settlings planted at a row spacing of 120 cm in furrow attained significantly higher phosphorus content in green top compared to other row spacing.

Table 3a: Effect of interaction between planting method and row spacing on phosphorus content in green top of bud chip planted sugarcane.

	B1	B2	B3	B4
A1	0.097	0.099	0.100	0.096
A2	0.098	0.097	0.098	0.103
SEm±	0.001			
CD (P=0.05)	0.002			

Table 4: Effect of Planting method, row spacing and mean of bud chip planted treatments v/s conventional planting on potassium content and uptake by cane, green top and trash of sugarcane.

Treatments	Potassium Content (%)						Potassium uptake (kg/ha)							
	Cane		Green top		Trash		Cane		Green top		Trash		Total	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Planting methods														
Flat	0.427	0.428	0.923	0.924	0.432	0.438	129.6	135.45	49.7	55.3	25.22	28.21	204.6	219.0
Furrow	0.430	0.431	0.924	0.925	0.434	0.439	143.0	144.75	52.4	58.1	24.94	26.44	220.4	229.3
SEm±	0.012	0.008	0.009	0.008	0.005	0.006	5.1	3.21	1.0	0.7	0.67	0.82	5.0	3.3
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.0	NS	NS	15.0	9.8
Row Spacing (cm)														
75	0.426	0.427	0.921	0.923	0.432	0.437	138.4	143.0	51.1	56.7	27.09	29.42	216.6	229.1
90	0.428	0.430	0.922	0.923	0.433	0.439	145.2	149.9	54.2	59.8	26.25	28.42	225.7	238.1
105	0.429	0.430	0.925	0.925	0.433	0.438	132.2	136.78	50.1	55.3	23.82	25.85	206.1	217.9
120	0.431	0.432	0.926	0.927	0.434	0.441	129.6	130.80	48.8	55.0	23.15	25.62	201.5	211.4
SEm±	0.018	0.012	0.012	0.004	0.008	0.008	7.2	4.54	1.4	0.9	0.94	1.16	7.1	4.6
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	13.61	NS	2.8	2.82	NS	NS	13.9
Interaction (planting method × spacing)														
A×B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Conventional v/s others														
Conventional	0.370	0.392	0.883	0.897	0.409	0.412	107.8	118.50	44.7	50.5	19.46	22.94	172.0	191.9
Others	0.428	0.430	0.923	0.925	0.433	0.439	136.3	140.10	51.1	56.7	25.08	27.33	212.5	224.1
SEm±	0.019	0.012	0.013	0.004	0.008	0.008	7.6	4.82	1.5	1.0	1.00	1.23	7.5	4.9
CD (P=0.05)	0.056	0.037	0.039	0.012	0.024	0.025	22.9	14.44	4.5	2.9	2.99	3.70	22.6	14.7

CONCLUSION

From the results of the present study it can be concluded that among planting methods, furrow planting of bud chip raised settlings and among various row spacing, 90 cm recorded the highest cane yield and nutrient uptake by the crop. There is a need to further study the influence of planting methods and row spacing on cane yield, nutrient content and it's uptake by bud chip raised settlings. Also research should be done to optimize best suitable management practices for bud chip planting technique.

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