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Effect of different planting methods, planting techniques and row spacing pattern on germination/survival rate percent and growth of sugarcane (*Saccharum officinarum* L.)

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Abstract
Field experiment was conducted at GB Pant University of Agriculture and Technology, Uttarakhand, during spring season 2021-22 and 2022-23, respectively. To determine the effect of different planting methods, planting techniques and row spacing pattern on germination/survival rate and growth of sugarcane (*Saccharum officinarum* L.). The field study consisted of three replications, nine interventions, and a total of twenty-seven experimental units. The effect of establishment and row spacing on the germination/survival percentage of sugarcane was found to be significant. The results indicated that trench planting yielded the maximum germination percentage (103. and 105.8 t/ha in 2021-22 and 2022-23, respectively) without reaching statistical significance. In terms of planting techniques, bud chip planting achieves a substantially higher cane yield than single budded sett planting, and among the various row spacing patterns, 150 cm (30/120) row spacing registered the highest cane yield in comparison to 75 cm row spacing. The conventional planting of three budded sugarcane sets resulted in a substantially lower cane yield than any other bud chip treatment.

Keywords: Sugarcane, trench, bud chip, paired row spacing, bio feul

Introduction
Sugarcane (*Saccharum officinarum* L.) is a significant worldwide and national commercial crop. Because it is a labor-intensive crop, it provides a living for the bulk of India's rural people. Brazil is the world's biggest sugarcane grower, followed by India. Uttar Pradesh is the leading producer of sugarcane in India. In 2020-21, India produced 370.50 million Mt of sugarcane on 4.60 mt at an average productivity of 80.49 t/ha. (DAC, 2020-21). India is the second largest producer of sugar in the world after Brazil and 78% of sugarcane used for sugar production, 15% of the crop is used to produce various other sweets (gur or brown sugar) and remaining is used for the bio-fuel production. (Nandhini and Padmavathy, 2017) [13].After textiles, the sugar industry is the country's second major agricultural sector. Sugarcane occupies an important position among commercial crops grown in the world. This crop is efficient in utilizing solar energy for production of sugar and other renewable energy (Mohanty *et al*., 2015) [7].

According to Narendranath (1992) [18], the bud chip method of sugarcane cultivation is three times more economical than conventional sowing. Samant (2017) [14], reported that the bud chip planting method of sugarcane produce 37.9% more cane yield than conventional planting. Mishra (2019) [15] stated that the bud chip settlings planting of sugarcane resulted in a greater proportion of settling survival. Although conventional planting is simple, it produces low production and yield-attributing characteristics. Tayade *et al.* (2021) [12] Compared to conventional plating, it was discovered that planting bud chip grown settlings produced the heaviest individual cane weight. Principal benefit of single-bud setts (SBS) is substantial seed material savings and disease resistance. The seed requirement per hectare is reduced to less than one ton. Compared to the conventional multibudsett (MBS) sowing system, single-bud setts (SBS) require less planting material and allow for a greater multiplication rate of the source material. (Moraes *et al.* 2018) [16].

Among various planting methods adopted for sugarcane, trench is the prominent one. In trench method of sugarcane sowing, furrows of 20-25 cm depth are opened with tractor drawn ridger,

having row to row distance of 75 cm. The high cane yield was obtained in paired trench plantation than conventional planting (Singh *et al*., 2012) [8]. In trench method of sugarcane plating sugarcane gives about 30% higher cane yield as compared to conventional method (IISR, 2014) [3]. The higher (23.2%) production of cane yield in wide bed and trench paired planting than conventional is a function of more no. of millable cane, cane length, weight of individual cane and cane girth (Singh *et al*., 2018) [9].

Row spacing and seeding densities have a key role in maximizing sugarcane yield and improving its quality. (Navnit, 2019) [19] found significant variation among different planting geometries in bud chip method and found 150 cm row to row and 40 cm plant to plant as optimum spacing to achieve higher yield and economic returns. With the present challenges it is necessary to identify suitable land form and inter-row spacing that may improve sugarcane productivity and unitizes the resources more efficiently.

Materials and Methods

A field experiment was conducted in E7 Block at the Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, U. S. Nagar, Uttarakhand to successive years Pantnagar is located in a subtropical region with humid conditions and scorching, arid summers. The temperature may exceed 42°C during the summer and 0°C during the winter. The experimental site's soil was a silty clay loam with a pH of 7.3, 0.68% organic carbon, 203 kg/ha available nitrogen, 28.9 kg/ha available phosphorus, and 210.0 kg/ha available potassium. The experiment used a factorial randomized block design with two sowing methods (trench planting and broadcast planting) and flat planting), two planting materials (bud chip and single budded sett), and distinct row spacing (150 cm (30/120) paired row spacing and 75 cm conventional row spacing, with three replications for one additional treatment (conventional planting). For sowing, the sugarcane variety 'Co Pant 03220' was utilized. Under various conditions, 25-day-old bud chip-raised settlings were transplanted to the main field from a nursery. A scythe was used to cut single budded setts and three budded setts. All experimental sites were provided with a pre-sowing irrigation. After transplanting the bud fragment, a modest irrigation was administered to ensure proper settling. Under the flat method, a single budded sett and three budded setts were planted in 10-12 cm deep furrows, and the surface was then leveled. The single-budded setts were planted in a trench, covered with 2-3 centimetres of soil, and given sallow irrigation. As a source, urea (46%), NPK (12:32:16), and MOP (60% KCL) were administered at a ratio of 150: 80: 60 nutrient dose. As a base application, a half dose of nitrogen and full dosages of phosphorus and potassium were applied, while the remaining nitrogen dose was divided and applied at 60 DAP and 90 DAP. The data were analyzed using analysis of variance for factorial RBD TNAU analytical page, and the coefficient of determination (CD) was computed at a 5% level of significance.

Results and Discussion

Percent Emergence/Survival rate

During both the years of experiment, the germination/survival percent was not significantly affected by the establishment method and row spacing. In contrast, the germination/survival percent was significantly affected by the planting techniques in the 2021-22 and 2022-23 cropping seasons. The bud chip method recorded 11.8% more emergence/survival% which was significantly more as compared to single budded sett respectively. Among row spacing pattern did not significantly affect sugarcane percent emergence or survival rate in 2021-22 and 2022-23, respectively. The mean of germination/survival rate under different establishment method and row spacing pattern was significantly higher as compared to single budded sett. In year 2021 and 2022-23, the extent of increase was 61.6 and 43.8% with the mean of treatments compared to that in the conventional method. The sugarcane germination is influenced by various internal and external factors which include sufficient moisture, optimum temperature, proper aeration and good quality seed. The significantly higher germination 43.1% and 62.1% was observed in wide bed and furrow paired row planting at 30 and 45 DAP respectively over conventional method and was par with half ridge open furrow irrigation planting and wider planting which might be due to adequate soil moisture (Singh *et al*., 2018) [8]. Similar results were also reported by Prem *et al.* (2017) [17] and Prabhakar *et al.* (2014) [11].

Crop Growth Rate: It is evident from the data that different establishment method had a significant effect on growth period of sugarcane at all the successive crop growth interval during both years of investigation. The data revealed that the growth period 90-120 DAP, of sugarcane attained the significantly higher under trench method compared to flat method. But at 150-180 DAP, interval it was found non-significant during both the years. In case of planting techniques, the bud chip method had a significantly in growth period as compared to single bud at all the successive growth interval during both years but it was non-significant at 90-120 DAP. However, highest growth was found at 180 DAP and lowest at 90 DAP during both the years of research study in both the methods. Mangrio*et al.* (2022) [5] reported that the bud chip settlings observed significantly more crop growth rate (CGR) than direct placed setts. The row spacing pattern for growth period was found non-significantly at all the successive growth interval during both the years but higher growth was found in 150 (cm) 120+30) spacing as compared to 75 cm.In comparison between conventional and rest of the methods, the combined performance of planting method, planting techniques and row spacing methods was found significantly better compared to conventional method at all the successive growth interval during both the years. The extent of increase at 150-180 DAP was 42.4% and 34.3% during in 2021-22 and2022-23, respectively. The greater distance between sets of rows in the broad bed and furrow paired row system allows for more light interception and optimum aeration, which in turn promotes less lodging and more efficient nutrient absorption by the crop. (Katiyar *et al.*, 2013 & Gupta *et al.*, 2004) [4, 2].

Table 1: Effect of establishment methods and roe spacing pattern v/s conventional method on emergence/Survival rate per cent of sugarcane at 45 DAP

Treatments	% Emergence/Survival	
	2021-22	2022-23
Establishment method		
Flat	68.0	69.3
Trench	68.7	71.0
S.Em±	2.4	2.4
CD at 5%	NS	NS
Planting method		
Bud chip	72.2	74.1
Single bud	64.6	66.3
S.Em±	2.4	2.4
CD at 5%	7.2	7.3
Row spacing (cm)		
75	69.1	68.9
150 (120+30)	67.6	71.5
S.Em±	2.4	2.4
CD at 5%	NS	NS
Conventional v/s others		
Conventional	42.2	48.8
Others	68.4	70.2
S.Em±	3.8	3.9
CD at 5%	11.5	11.7

Relative Growth Rate: It is evident from the data that different establishment method had a significant effect on RGR by the crop at all the successive crop growth interval during both years of investigation. The data revealed that the RGR by crop attained the significantly higher under trench method compared to flat method at all the crop growth interval during both years. In case of planting methods, bud chip method reported a significant increase in RGR as compared to single bud at all the successive growth interval during both years.

Table 2: Crop growth rate (g/g/day) of sugarcane under different planting method and row spacing pattern v/s conventional planting method at different growth stages

Treatments	Growth period (Days after planting)					
	90-120 DAP		120-150 DAP		150-180 DAP	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Establishment method						
Flat	17.9	19.1	26.5	25.3	33.6	33.4
Trench	20.9	24.2	30.9	27.7	35.1	34.1
S.Em±	0.5	1.2	1.2	1.3	1.7	1.3
CD at 5%	1.5	3.6	3.5	NS	NS	NS
Planting method						
Bud chip	19.9	23.1	31.6	29.9	37.8	35.6
Single bud	19	20.3	25.9	23.1	31.9	31.8
S.Em±	0.5	1.2	1.2	1.3	1.6	1.3
CD at 5%	NS	NS	3.5	3.9	5.0	3.9
Row spacing (cm)						
75	18.9	20.6	28.1	23.2	34.1	32.2
150 (120+30)	20.02	22.7	29.4	29.1	35.7	35.3
S.Em±	0.5	1.2	1.2	1.3	1.7	1.3
CD at 5%	NS	NS	NS	NS	NS	NS
Conventional v/s others						
Conventional	13.8	18.1	25.3	20.9	24.5	25.1
Others	19.5	21.6	28.7	26.4	34.9	33.7
S.Em±	0.8	1.9	1.9	2.1	2.7	2.1
CD at 5%	2.4	5.7	5.6	6.2	7.9	6.1

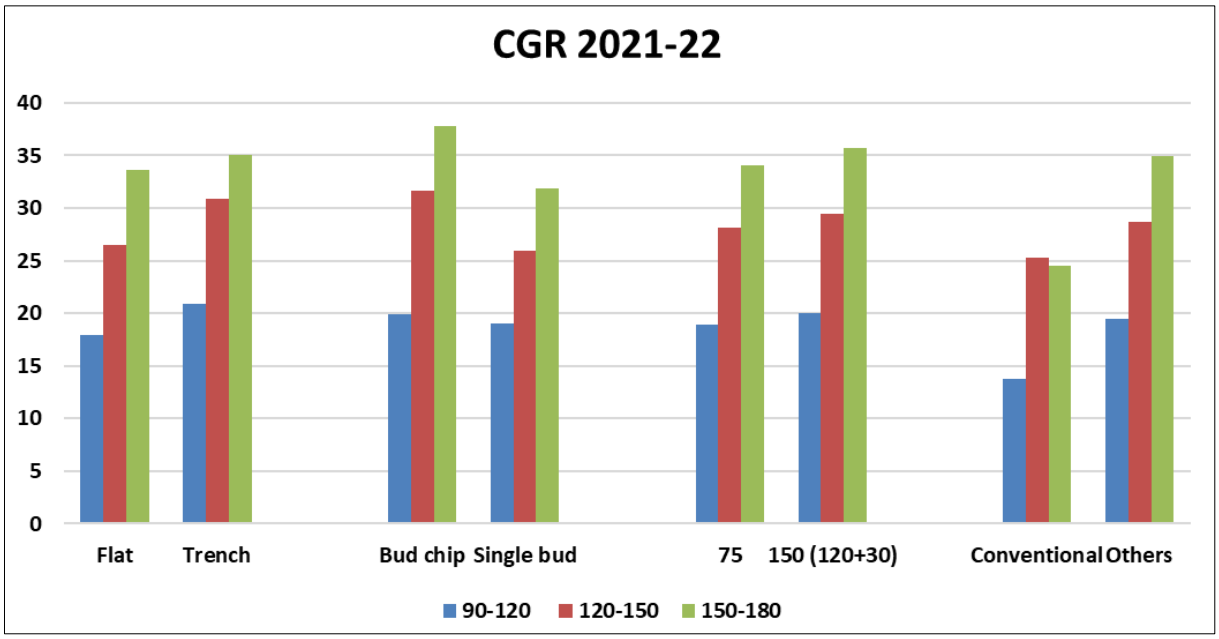

Fig1: Effect of planting methods, planting techniques and row spacing pattern vs. convention on Crop growth rate of sugarcane

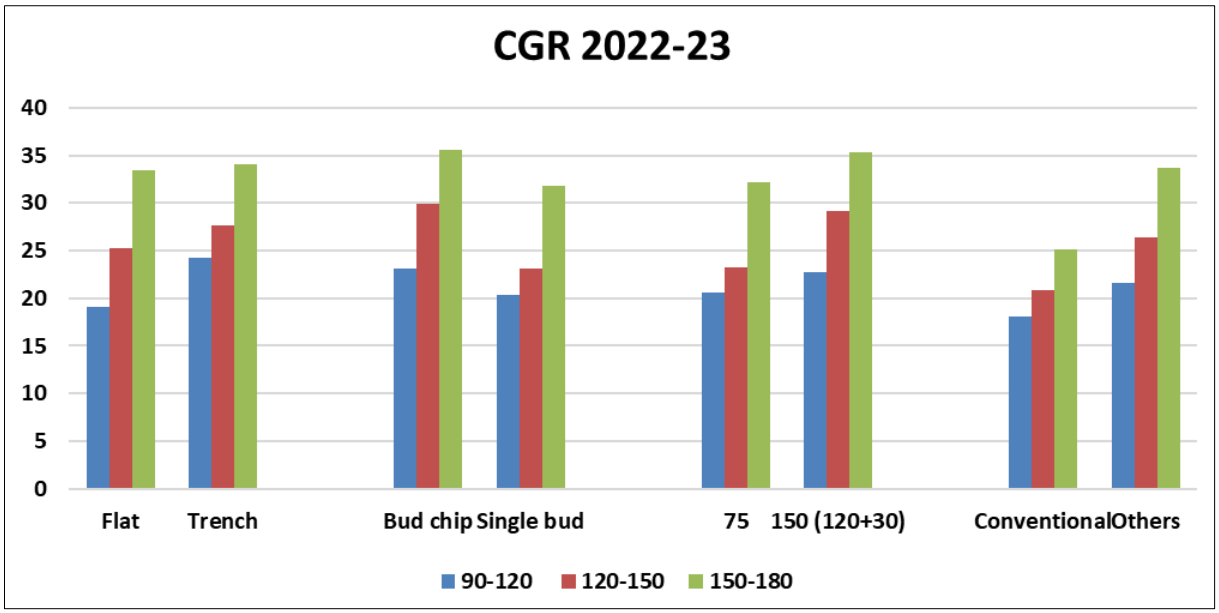

Fig 2: Effect of planting methods, planting techniques and row spacing pattern vs. convention on Crop growth rate of sugarcane

Table3: Relative growth rate of sugarcane under different planting methods, Planting techniques and row spacing pattern v/s conventional planting method at different growth stages

Treatments	RGR (Days after planting)					
	90-120 DAP/DAT		120-150 DAP/DAT		150-180 DAP/DAT	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Establishment method						
Flat	2.937	2.97	3.189	3.174	3.287	3.361
Trench	2.980	3.012	3.219	3.226	3.522	3.383
S.Em±	0.01	0.01	0.01	0.01	0.02	0.01
CD at 5%	0.02	0.03	0.03	0.02	0.05	0.02
Planting method						
Bud chip	2.977	3.028	3.221	3.234	3.444	3.391
Single bud	2.941	2.954	3.186	3.164	3.365	3.353
S.Em±	0.01	0.01	0.01	0.01	0.02	0.01
CD at 5%	0.02	0.03	0.03	0.02	0.05	0.02
Row spacing (cm)						
75	2.948	2.973	3.196	3.171	3.388	3.356
150 (120+30)	2.970	3.008	3.212	3.227	3.421	3.388

S.Em±	0.01	0.01	0.01	0.01	0.02	0.01
CD at 5%	0.02	0.03	0.03	0.02	NS	0.02
Conventional v/s others						
Conventional	2.870	2.932	3.125	3.125	3.324	3.278
Others	2.959	2.991	3.204	3.199	3.404	3.372
S.Em±	0.01	0.02	0.02	0.01	0.03	0.01
CD at 5%	0.03	0.05	0.05	0.03	0.07	0.03

However, highest dry matter was found at 180 DAP and lowest at 90 DAP during both the years. The row spacing at 150 cm significantly increased dry matter at 90, 120, 150 and 180 DAP as compared to 75 cm dunging both the years but at 180 DAP dry matter production was found non-significant during both the years. However, at 180 DAP, the RGR found to be non-significant during 2021-22. If compared between conventional and rest of the methods, the combined performance of planting, establishment and row spacing methods was found significantly higher with better RGR compared to conventional method at all the successive growth interval during both the years.

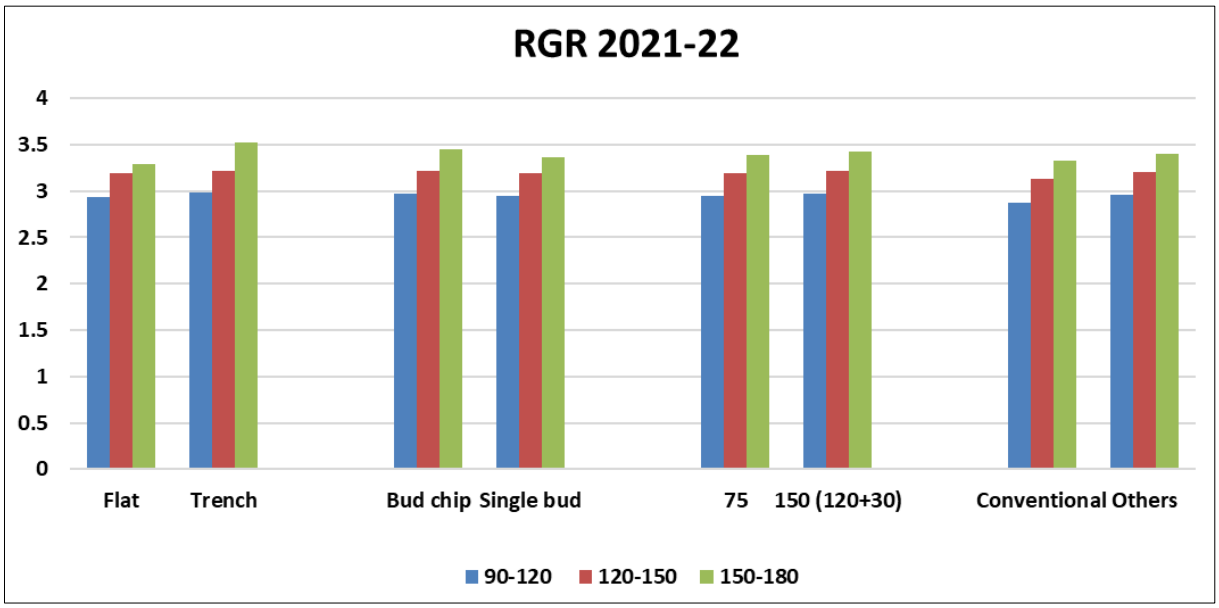

Fig 3: Effect of planting methods, planting techniques and row spacing pattern vs. conventional on Relative growth rate of sugarcane

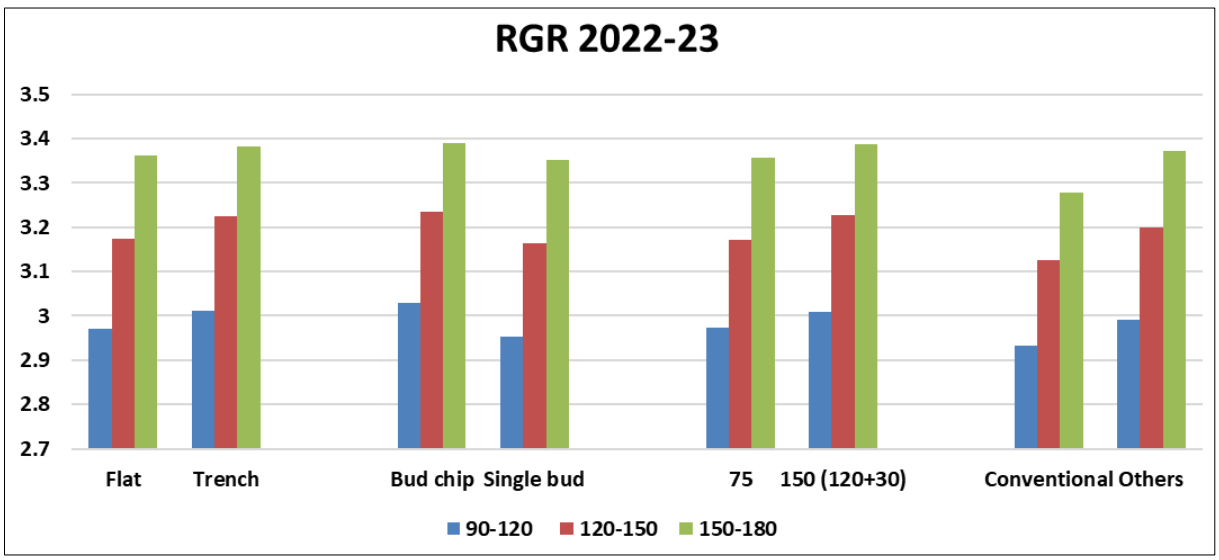

Fig 4: Effect of planting methods, planting techniques and row spacing pattern vs. conventional on Relative growth rate of sugarcane

Conclusion

Significantly higher percent emergence/survival rate was recorded in bud chip planting 8.94% than single budded sett of sugarcane planting in year 2021-22 and 2022-23 respectively. Crop growth rate (g/m^2/day) at 90-120 DAP period was significantly affected by planting method. In planting techniques, the CGR (g/m^2/day) under bud chip planting was significantly affected at 120-150 DAP and 150-180 DAP than single budded sett planting. The mean Crop growth rate in establishment method and row spacing pattern was significantly higher than conventional method during in 2021-22 and 2022-23, respectively. The Mean Relative

Growth Rate of establishment method and row spacing pattern was significantly higher as compared to conventional planting at all the growth stages during both the years of study. The mean cane yield of establishment method and row spacing pattern obtained higher cane yield than conventional planting and the magnitude of increase was 11.4% and 8.4%, in 2021-22 and 2022-23, respectively.

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