EVALUATION OF MECHANIZED SUGARCANE BUD CHIP PLANTATION IN CONTRAST WITH CONVENTIONAL METHOD

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ABSTRACT: A study conducted at Pakistan Agriculture Research Council-National Sugar and Tropical Horticulture Research Institute, Makli, Thatta during the 2020-2021 cropping season compared Bud chip planting with conventional methods in sugarcane cultivation. Using randomized complete block design, sugarcane varieties (CPF-251, Th-326, and SPSG-26) and planting methods (Bud Chip and sett planting) were evaluated. Results showed Bud chip planting outperformed conventional methods, with T1V2 (Th-326) displaying the highest performance in terms of tillers per plant (10.66), millable canes (73.418 thousand per acre), and cane yield (1311 mounds per acre). Conversely, T2V3 (SPSG-26) displayed the lowest performance. A non-significant interaction between varieties and planting methods was observed, indicating consistent results across experimental parameters. The findings suggest the potential of Bud chip planting technique for enhancing sugarcane yield and productivity, with implications for improving crop management practices and reducing production costs.

Keywords: Sugarcane, Bud Chip Plantation, Conventional Plantation, Mechanization.

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INTRODUCTION

Sugarcane (*Saccharum officinarum*) stands as one of the most significant cash crops globally, trailing only behind cotton in importance (Majumder et al., 2017). Within Pakistan, sugarcane holds a prominent position, boasting the fifth-largest cultivation area worldwide (Ali et al., 2015; Iqbal and Iqbal, 2014). Despite its substantial acreage, Pakistan ranks 15th in sugar production and disappointingly occupies the 48th position in terms of sugarcane yield per hectare on a global scale (Tunio et al., 2016). According to data from the Pakistan Sugar Mills Association (PSMA 2023), the country's sugarcane cultivation area spans approximately 1,101,000 hectares, yielding an annual production of 5.69 million tons. However, this output reflects the lowest yield per hectare when compared to other leading sugarcane-producing nations. Pakistan is categorized within the low-yield bracket, defined as producing less than 6 tons per hectare, as per the International Sugar Organization (ISO 2021). This categorization places Pakistan in a unique position, as it lacks counterparts among the top sugar-producing countries. Despite sharing identical environmental conditions, soil compositions, and other agroecological factors with neighboring India, Pakistan's average sugarcane yield remains notably lower at 60 tons per hectare (Afghan et al., 2023). In stark contrast, India boasts an average yield of 79.7 tons per hectare, showcasing a substantial productivity gap between the two nations (Chohan, 2019). The productivity contrast extends globally, with countries such as China, Thailand, Australia, Egypt, and Colombia consistently achieving higher averagesof 76.8, 76.5, 75.6, 118 and 88.75 tons per hectare sugarcane yields respectively (Kumar et al., 2015; Abrham et al., 2021). Sugar recovery rates further highlight Pakistan's challenges within the sugarcane industry. The country's sugar recovery rate remains disappointingly low at 9.8%, as reported in the Pakistan Economy (Hussain, 2023).

Amidst various factors contributing to low sugarcane and sugar yields, the inadequacy of pure, healthy seeds and reliance on traditional planting methods emerge as significant concerns (Rehman et al., 2015, Chohan, 2019). Farmers currently employ a considerable quantity of cane seed, ranging from 100 to 120 mounds per acre, which accounts for approximately 20-25% of the total input cost (Ali and Iqbal., 2023). However, they encounter challenges such as poor germination and bud damage during handling and transportation in the field. In response to these challenges, an innovative sugarcane planting technique known as "Bud chip" has emerged as a viable alternative (Ahmad et al., 2020). This method offers the potential to reduce seed rates and production costs while simultaneously enhancing seed quality through fungicide treatment, thereby facilitating improved yield returns (Sarala, 2017). Additionally, the adoption of this new planting technique has the ancillary benefits of reducing seasonal gaps, promoting mechanization of plantation processes, and facilitating practices such as intercropping and drip irrigation (Singh and Gangwar, 2023). The Bud chip technique requires a significantly lower quantity of seed, with only 0.75 tons of single-budded sugarcane seed needed for the plantation of one acre (Gujja and Natrajan, 2018). This substantial reduction in seed requirement underscores the efficiency and cost-effectiveness of the Bud chip method, offering promising prospects for enhancing sugarcane yield and overall agricultural productivity (Sanghera et al., 2020).

The significant bulk of planting material poses logistical hurdles in both the transportation and storage of seed cane. Remarkably, despite technological advancements, hand planting remains prevalent, accounting for approximately half of sugarcane planting in countries such as the United States, Brazil, and Australia, and surpassing 80% in India and other regions worldwide (Nalawade et al., 2018). However, these labor-intensive methods contribute to considerable losses in crop production, as highlighted by Gulati et al. (2015). To tackle these challenges, the bud chip technology emerges as a promising alternative, offering reduced mass and facilitating rapid seed multiplication. This innovative method proves to be more economically viable and convenient compared to the traditional approach of planting two to three bud setts. Notably, the adoption of bud chip technology yields relatively better returns, with significant savings on seed material utilized for planting (Galal, 2016).

Given Pakistan's significant reliance on sugarcane as a cash crop, addressing the existing yield and recovery rate differentials is imperative for bolstering agricultural productivity, ensuring food security, and nurturing economic stability. Therefore, this study seeks to explore various planting methods influencing sugarcane yield and sugar recovery rates, with the ultimate goal of proposing strategies to enhance productivity.

MATERIALS AND METHODS

An experiment was conducted to assess the efficacy of the Bud chip planting technique compared to the conventional planting method at the Pakistan Agriculture Research Council-National Sugar and Tropical Horticulture Research Institute, Makli, Thatta, during the cropping season of 2020-2021. The research trial employed a randomized complete block design, with factorial arrangement, incorporating three distinct sugarcane varieties: V_1 (CPF-251), V_2 (Th-326), and V_3 (SPSG-26), each subjected to two planting methods: T_1 the novel Bud chip method and T_2 the conventional sett planting method.

The experimental design followed a 2x3x3 factorial arrangement, where two planting methods were evaluated across three sugarcane varieties, with each combination replicated three times. Each treatment plot consisted of six rows, with a row length of 6.0 meters and a row-to-row spacing of 1.25 meters. Furthermore, six rows were dedicated to each variety and planting method within the experimental layout. The net plot size for each treatment was standardized at 872.7 square meters, ensuring consistency and comparability across all experimental units.

Bud Chip Method:

Raising Sugarcane Nursery: For the implementation of the Bud Chip technique in a sugarcane plantation, a healthy sugarcane nursery was established using 15 mounds of the striped cane on September 1, 2020, forty days before field planting. Buds were carefully scooped using manual bud chip cutters or machines (Figure 1a). Subsequently, the scooped buds underwent treatment with fungicide and hot water (at 53°C for a few minutes) to mitigate the risk of disease infestation in the resulting plants. These treated buds were then placed on gunny bags, covered with another layer of bags, and kept adequately moist to facilitate pre-sprouting.After 3-4 days, the sprouted buds (Figure 1b) were transferred to nursery trays filled with peat moss and maintained within a greenhouse environment (Figure 1c, d).

Sugarcane Nursery Transplantation: Upon reaching 40 days of age, the sugarcane seedlings (Figure 2a) were transplanted into levelled fields on October 15 using a sugarcane seedling Trans-planter (Figure 2b), designed in collaboration between PARC-NSTHRI Thatta and NARC-FMI, underwent modifications and was manufactured by Chinote Agro-Industry. The machine featured a capacity of 0.40 hectares per hour and a platform in the front for seedling placement, thereby streamlining the process and reducing labor requirements for sett placement into funnels at a faster rate. Utilizing the seedling transplanter, a total of 7260 setts per acre were successfully planted, demonstrating the efficiency and effectiveness of mechanized planting techniques in sugarcane cultivation.

Conventional Method: Following the conventional planting method, ridges were prepared with a spacing of 1.25 meters wide. The planting technique involved the overlapping placement of three-budded sets, following the methodology established by Soomro et al. (2009), which utilized a rate of 29,150 sets per acre.

The recommended fertilizer dosage of 275-112-175 kg NPK per hectare was applied, with all phosphorus (P) and potassium (K) and one-third of nitrogen (N) administered at the time of sowing. The remaining two-thirds of nitrogen was divided into two equal splits, with the first split applied upon germination completion and the second split applied during the initial earthing up stage. Additionally, all necessary cultural and agronomic practices were executed as per requirement throughout the cultivation period.

Figure 1. The process of bud scooping (a), sprouting on gunny bags (b), growth in nursery trays (c&d).

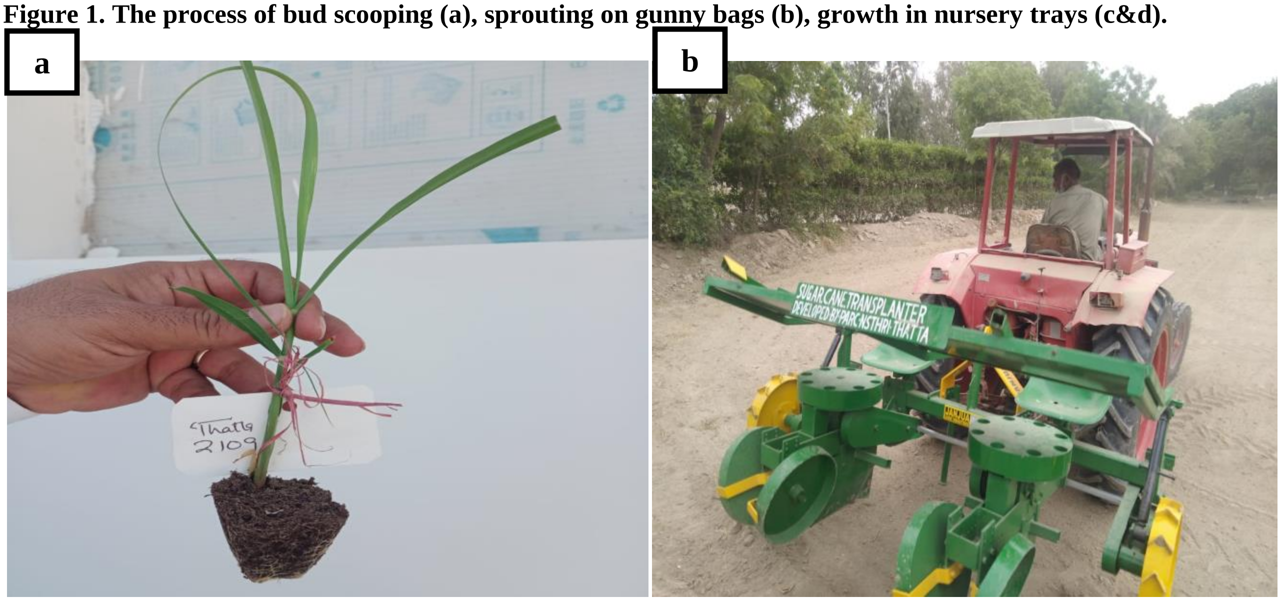

Figure 2. Sugarcane seedling (a) sprouted in trays and tractor mounted seedling transplanter (b)

During harvesting, data about cane thickness, tillers per plant, number of internodes per cane, and plant height were recorded from five randomly selected stools within each plot. Millable canes data were collected from canes within a five-meter row length, selected randomly from three rows within each plot. The weight of these millable canes was then utilized to calculate cane yield in tons per acre, excluding tops.

Subsequently, the collected data were subjected to statistical analysis using the American software Statistix 8.1 to ascertain any significant differences or trends among treatments and varieties. This rigorous statistical analysis ensures a robust interpretation of the experimental results and facilitates informed decision-making regarding sugarcane cultivation practices.

RESULTS

The statistical analysis of variance for the agronomic traits of sugarcane crop, comparing the Bud chip planting method with the conventional planting method, revealed significant differences at the 5% probability level in all quantitative traits except for plant height (ANOVA Table-01). This suggests that the choice of planting method significantly influenced various agronomic characteristics of the sugarcane crop, highlighting the potential advantages or limitations associated with each planting technique.

Table 01: Analysis of Variance for Different Parameters Affected by Sugarcane Planting Methods.

SOV	D.F	Height (cm)	Tillers plant^{-1}	Internodes plant^{-1}	Stem Girth (mm)	Millable canes (000 Ac$^{-1)}$	Cane Yield (moundsAc^{1})
Replication	2	293.39	2.389	0.5000	1.5556	194.12	60186
Planting Methods	1	256.89	117.556	84.5000	14.2222	3989.06	1092242
Variety	2	2251.06	0.722	16.1667	3.7222	155.36	39197
P x V	2	1269.39	7.389	4.5000	9.3889	71.51	36086
Error	10	94.39	2.922	3.7667	2.6222	87.63	21204
Total	17	--	--	--	--	--	--

Table 02 summarizes the mean values of various yield and yield-contributing characteristics observed in the study. Treatment combination (T_1V_2) emerged as the most promising, exhibiting the highest values for Tillers per plant (10.66), millable canes (73.418 thousand per acre), and cane yield (1311 mounds per acre). This was closely followed by Treatment-1 (T1V3), which recorded 9.33 Tillers per plant, 61.213 thousand millable canes per acre, and a cane yield of 1137 mounds per acre. Notably, while these differences were notable, statistical analysis indicated non-significance at the 5% probability level within both treatments.

Conversely, the Treatment combination (T_2V_3), employing the conventional planting method, demonstrated comparatively lower performance, with 3.66 Tillers per plant, 31.290 thousand millable canes per acre, and a cane yield of 625.6 mounds per acre. Despite this disparity, statistical analysis revealed no significant difference at the 5% probability level for variety x sowing methods.

Table-02:Performance of Sugarcane Varieties Affected by Different Planting Methods.

Treatments	Plant Height (cm)	Tillers plant^{-1}	Internodes plant^{-1}	Stem Girth (mm)	Millable canes (000 Ac^{-1})	Cane Yield (t Ac^{-1})
T_1V_1	161.67 c	8.33 ab	28.33 ab	25.33 ab	57.755 a	1203 a
T_1V_2	158.33 cd	10.66 a	29.00 a	24.33 abc	73.418 a	1311 a
T_1V_3	200.0 a	9.33 a	30.66 a	26.00 a	61.213 a	1137 ab
T_2V_1	192.67 ab	5.66 bc	25.00 bc	25.33 ab	34.959 b	874.3 bc
T_2V_2	158.33 cd	3.66 c	22.66 c	24.33 abc	36.817 b	674.3 c
T_2V_3	175.00 bc	3.66 c	27.33 ab	21.66 c	31.290 b	625.6 c
LSD (0.05)	17.67	3.10	3.53	2.94	17.030	264.91

DISCUSSION

The observed increase in cane yield associated with the Bud chip planting method can be attributed to several factors, particularly the enhanced tillers per plant and millable canes per acre (Ahmad et al., 2020). This phenomenon is consistent with findings in other crops cultivated through seedling transplantation, reflecting the concept of "Healthy nursery–Healthy crop". The establishment of vigorous seedlings in a nutrient-rich medium, such as peat moss, provides a strong foundation for root development and overall plant vigor. Root vigor plays a crucial role in nutrient uptake efficiency and soil interaction, ultimately influencing biomass production and yield potential (Sun et al., 2017).

The findings of this study align with previous research highlighting the importance of healthy nursery practices and mechanized plantation techniques in optimizing sugarcane cultivation. Root vigor emerges as a critical determinant of sugarcane performance, with research demonstrating a strong correlation between root mass fraction and key agronomic parameters such as tiller numbers and biomass accumulation. Research conducted by Pierre et al. (2019) and Pissolato et al. (2021) supports these observations, demonstrating a significant correlation between root mass fraction and plant performance. Increased root length and mass have been associated with higher tiller numbers, earlier assimilate production, and ultimately, greater biomass accumulation. This underscores the importance of a well-developed root system in optimizing sugarcane yield potential.

Moreover, the adoption of mechanical transplanting techniques offers additional benefits beyond yield enhancement. By reducing labor costs and increasing planting efficiency, mechanization facilitates timely plantation and minimizes seasonal gaps between crops. Research by Rossetto et al. (2022) highlights the potential of mechanized plantations in sugarcane cultivation, demonstrating a notable increase in stalk numbers and seed multiplication ratios without compromising yield.

The findings from this study underscore the importance of innovative planting techniques and mechanization in optimizing sugarcane cultivation practices (Kishore et al., 2017). By focusing on establishing healthy seedlings with robust root systems and embracing mechanized plantation methods, farmers can effectively enhance cane yield, reduce labor costs, and improve overall productivity (Filip et al., 2020). These insights have significant implications for sugarcane cultivation, particularly in regions with labor constraints and seasonal cropping patterns. Further research and extension efforts are warranted to promote the adoption of these practices and unlock their full potential in sugarcane production systems.

Conclusion: The research study underscores the efficacy of the Bud chip planting method in enhancing sugarcane yield compared to conventional planting techniques. The observed increase in cane yield can be attributed to factors such as improved tillers per plant and millable canes per acre, facilitated by the establishment of vigorous seedlings with robust root systems. Root vigor emerges as a critical determinant of sugarcane performance, with research demonstrating a strong correlation between root mass fraction and key agronomic parameters such as tiller numbers and biomass accumulation. The adoption of mechanical transplanting offers additional benefits, including labor cost reduction and increased planting efficiency, thereby minimizing seasonal gaps between crops and improving overall productivity. These insights emphasize the significance of innovative planting methods and mechanization in sugarcane cultivation, particularly in regions with labor constraints and fluctuating cropping patterns. By prioritizing the establishment of healthy seedlings and embracing mechanized plantation techniques, farmers can enhance cane yield, reduce production costs, and promote sustainable agricultural practices.

Moving forward, further research and extension efforts are warranted to promote the widespread adoption of these practices and unlock their full potential in enhancing sugarcane productivity and profitability on a broader scale.

REFERENCES

Abrhám, J., M. Vošta, P. Čajka and F. Rubáček (2021). The specifics of selected agricultural commodities in international trade. Agric. Res. Econ. Int. Sci. E-J.7(2): 5-19.

Afghan, S., M.E. Khan, W.R. Arshad, K.B. Malik and A. Nikpay (2023). Economic importance and yield potential of sugarcane in Pakistan. In Sugarcane-its products and sustainability. IntechOpen.

Ahmad, M.I., M.O. Galal, M.A. Osman and E.M. Yousif (2020). Prototype of sugarcane bud chips cutting machine for nursery planting. Egyp. J. Agric. Res.98(3): 473-487.

Ali, H. and M.A. Iqbal (2023). Economics and Marketing of Sugarcane Production in District Mandi Bahaudin. Int. J. Adv. Soc. Stud.3(1): 29-41.

Ali, S., N. Badar and H. Fatima (2015). Forecasting production and yield of sugar cane and cotton crops of Pakistan for 2013-2030. Sarh. J. Agric.31(1): 1-10.

Chohan, M. (2019). Impact of climate change on sugarcane crop and remedial measures-a review. Pak. Sug. J.34(1): 15-22.

Filip, M., T. Zoubek, R. Bumbalek, P. Cerny, C.E. Batista, P. Olsan, P. Bartos, P. Kriz, M. Xiao, A. Dolan and P. Findura (2020). Advanced computational methods for agriculture machinery movement optimization with applications in sugarcane production. Agric.10(10): 434.

Galal, M.O.A. (2016). A new technique for planting sugarcane in Egypt. Inst. Integ. Omic. App. Biotech. J.7(4): 15-21.

Gujja, B. and U.S. Natarajan (2018). The sustainable sugarcane initiative. In *Achieving sustainable cultivation of sugarcane Volume 1* (pp. 65-96). Burleigh Dodds Science Publishing.

Gulati, J.M.L., C.S. Kar, J. Behra, S.N. Jena and S. Lenka (2015). Effect of planting methods on growth pattern and productivity of sugarcane varieties. *Ind. J. Agric. Res.49*(3): 222-228.

Hussain, S. (2023). Pakistan Economy. *Crop.3*: 3-006.

Iqbal, M.A. and A. Iqbal (2014). Sugarcane production, economics and industry in Pakistan. *Am. J. Agric. Environ. Sci.14*(12): 1470-1477.

ISO Sugar Year Book 2022 data 2021. Year Book, International Sugar Organization, 2021.

Kishore, N., D. Gayathrid, J. Venkatesh, V. Rajeswari, B. Sangeeta and A. Chandrika (2017). Present mechanization status in sugarcane–a review. *Int. J. Agric. Sci.* 9(22): 4247-4253.

Kumar, R., Bajpaiand S. Hasan (2015). Map based analysis of sugarcane and sugar production in different countries with special reference to India–a new approach. *Ind.J. Sug. Technol.30*(02): 89-97.

Majumder, A., M. Kumar, D. Nishad, H. Das and A. Kumar (2017). Composite index for cash crop production. *RASHI.2*(1): 98-100.

Nalawade, S.M., A.K. Mehta and A.K. Sharma (2018). Sugarcane planting techniques: a review. In *Contemporary research in India: National Seminar Recent Trends in Plant Sciences and Agricultural Research (PSAR-2018)* (pp. 98-104).

Pierre, J.S., J.M. Perroux and A.L. Rae (2019). Screening for sugarcane root phenes reveals that reducing tillering does not lead to an increased root mass fraction. *Fron. Plant Sci.10*: 399009.

Pissolato, M.D., L.P.D. Cruz, N.M. Silveira, C.E. Machado and R.V. Ribeiro (2021). Sugarcane regrowth is dependent on root system size: an approach using young plants grown in nutrient solution. *Bragantia.80*: e4321.

PSMA. "Statistics National: Pakistan Sugar Mills Association." Pakistan Sugar Mills Association. http://www.psmacentre.com/ (accessed June 2, 2023).

Rehman, A., L. Jingdong, B. Shahzad, A.A. Chandio, I. Hussain, G. Nabiand M.S. Iqbal (2015). Economic perspectives of major field crops of Pakistan: An empirical study. *Pac.Sci.Rev. b: Human.Soc.Sci.1*(3): 145-158.

Rossetto, R., N.P. Ramos, R.C. de Matos Pires, M.A. Xavier, H. Cantarella and M. Guimarães de Andrade Landell (2022). Sustainability in sugarcane supply chain in Brazil: Issues and way forward. *Sug. Tech.24*(3): 941-966.

Sanghera, G.S., A. Kumar and R. Bhatt (2020). Prospects of precision farming in sugarcane agriculture to harness the potential benefits. *Cur. J. App. Sci. Technol.39*(2): 112-125.

Sarala, N.V. (2017). Influence of Planting Methods, Age of the Seedlings and Nutrient Management on Yield and Quality of Sugarcane raised from Bud Chip Seedlings in Sandy Loam Soils of Andhra Pradesh. *Int. J. Clin. Biol. Sci.2*(1): 44-49.

Singh, K. and L.S. Gangwar (2023). Planting Techniques in Sugarcane Cultivation: A Review. *Int. J. Agric. Sci.8*.

Sun, B., G.L. Liu, T.T. Phan, L.T. Yang, Y.R. Li and Y.X. Xing (2017). Effects of cold stress on root growth and physiological metabolisms in seedlings of different sugarcane varieties. *Sug. Tech.19*: 165-175.

Tunio, A., H. Magsi and M.A. Solangi (2016). Analyses of growth trends and production forecast of cash crops in Pakistan. *Int. J. Agron. Agric. Res.9*(1): 158-164.