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Performance of Sugarcane Bud Chip Planting Technique at Different Locations of Sindh, Pakistan

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ABSTRACT

This study assessed the effectiveness of the Bud Chip planting technique for sugarcane at three locations in Sindh province, Pakistan, during the 2020-2021 cropping season. Two sugarcane varieties, YtTh-55 (V1) and Th-2109 (V2), were evaluated at Abdul Rahim farm (L1), Sharif Bukhari farm (L2), and Ghulam Rasool Jatoi farm (L3) using a randomized complete block design. Parameters measured included plant height, tillers per plant, internodes per plant, stem girth, millable canes, and cane yield. The results indicated significant differences in plant height, internodes per plant, stem girth, millable canes, and cane yield across treatments. V1L3 exhibited the tallest plants (305.00 cm), whereas V2L1 had the shortest (171.00 cm). Tillers per plant showed no significant variation, with V1L3 having the highest (10.66) and V2L1 the lowest (7.53). V2L3 had the highest number of internodes (18.33), and V2L1 the lowest (10.00). Stem girth was greatest in V1L3 (32.00 mm) and smallest in V1L1 and V2L2 (27.33 mm). The highest number of millable canes was in V1L3 (76.187 thousand per acre), while V2L1 had the fewest (43.063 thousand per acre). Cane yield peaked in V1L3 (1577.2 mounds per acre) and was lowest in V2L1 (854.4 mounds per acre). The findings suggest that the Bud Chip planting technique combined with appropriate variety and location selection, significantly enhances sugarcane growth and yield. YtTh-55 performed exceptionally well at Ghulam Rasool Jatoi farm, emphasizing the importance of site-specific agronomic practices. Further research is recommended to validate these results across additional varieties and locations to optimize sugarcane production strategies.

INTRODUCTION:

Sugarcane (Saccharum officinarum L.) is a globally significant crop, providing not only sugar but also ethanol, bioenergy, and a range of by-products utilized in various industries (Raza et al., 2019; Ali et al., 2021). In Pakistan, sugarcane holds a vital position in the agricultural sector, contributing substantially to the economy (Afghan et al., 2023). The crop is primarily cultivated in the provinces of Punjab, Sindh, and Khyber Pakhtunkhwa, where it supports the livelihoods of millions of farmers and laborers. Pakistan ranks among the top ten sugarcane-producing countries in the world (Rehman et al., 2015). The crop covers approximately 1.1 million hectares, with an annual production of around 60-70 million tons of cane, resulting in 5-6 million tons of sugar (Qureshi and Afghan, 2020). Despite its significant contribution to the agricultural GDP, the average yield of sugarcane in Pakistan is relatively low compared to other leading sugarcane-producing countries such as Brazil, .India, and Thailand (Raza et al., 2023)

Several factors contribute to the suboptimal yield of sugarcane in Pakistan. Sugarcane is sensitive to extreme weather conditions. Drought, excessive rainfall, and temperature fluctuations can adversely affect growth and yield (Hussain et al., 2018; Msomba et al., 2021). Many sugarcane fields in Pakistan suffer from poor soil health due to continuous monocropping, inadequate use of organic matter, and imbalanced fertilization practices (Ahmed et al., 2019). Inefficient irrigation practices and water scarcity issues, especially in regions dependent on canal irrigation, lead to water stress and reduced crop performance (Levidow et al., 2014). Sugarcane is vulnerable to various pests and diseases, such as borers, red rot, and smut, which can significantly reduce yield if not managed effectively (Usman et al., 2020). Traditional planting methods and outdated agronomic practices limit the potential yield of sugarcane. There is a need for modernization and adoption of innovative .techniques to enhance productivity

Traditional sugarcane planting methods in Pakistan involve the use of whole cane stalks or setts (sections of cane with buds) planted in furrows. This approach has several drawbacks i.e., traditional methods require a substantial amount of seed cane, which constitutes a significant cost for farmers, the germination rate of buds on setts can be inconsistent, leading to uneven crop stands and reduced yields, and the use of untreated seed cane can facilitate the spread of diseases, affecting the health and productivity of the crop .(Singh and Gangwar, 2023)

To address these challenges, innovative planting techniques such as the Bud Chip method have been developed. The Bud Chip planting technique has emerged as a promising method to improve sugarcane cultivation. This technique involves the use of individual buds, scooped from healthy cane stalks, to raise seedlings in a controlled nursery environment before transplanting them into the field. The method has been shown to reduce seed cane requirements, enhance germination rates, and promote uniform plant growth, thereby potentially increasing overall cane yield and quality (Khaliq et al., 2020; Galal and .Yousif, 2022)

This study evaluates the Bud Chip planting technique across different locations in Sindh province, using two sugarcane varieties, YtTh-55 (V1) and Th-2109 (V2). The objective is to confirm the results of earlier trials, examine the interactions between location and variety on key growth parameters and yield, and provide practical recommendations for optimizing sugarcane production in Pakistan.

MATERIAL & METHODS

The study was carried out at PARC-NSTHRI, Thatta to introduce sugarcane cultivation through bud chip method and seedlings were transplanted in the field using locally manufactured modified sugarcane transplanter. During 2020 PARC-NSTHRI, Thatta with the help of PARC-NARC-FMI, Islamabad locally designed settling transplanter (Fig. 1)

Fig. 1: Local modified, designed and manufactured sugarcane transplanter. The implement in the figure is the front view of mechanical transplanter that supports bud chip sugarcane planting technology.

with some modification and hired the services of Janjua Agro-Industry Chiniot for manufacturing of seedling trans planter machine with capacity of 0.40 ha h-1. Successful mechanized transplanting of bud chip nursery seedlings was carried out in the field at constant distance (plant to plant distance 1.5 feet and row to row distance 4 feet) (Fig. 2)

Fig. 2: The implement in the figure is the rear view of mechanical transplanter that maintain constant row to row distance in the field and plant sugarcane seedlings 3 inches deep in the soil.

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To establish the technology on commercial scale, initially a research experiment was laid out with randomized complete block designby using two different sugarcane varieties V1 (YtTh-55) and V2 (Th-2109) at three different locations and placed as L1= (Abdul Rahim farm Badin), L2 = (Sharif Bukhari farm Badin) and L3= (Ghulam Rasool Jatoi, Moro) The treatment was arraigned as: 2x3x3, While; (Row length = 6.0 m Row to Row spacing = 1.25 m, No of rows for each variety = 6). The net plot size was 872.7 m2.

2.1 Bud Chip Method:

2.1.1 Raising Sugarcane Nursery: For sugarcane plantation through Bud Chip technique the sugarcane healthy nursery was developed from 15 tons of striped cane on 1st September 2020 forty days before planting in field. Buds were scooped through manual bud chip cutter/machine (Fig.3).

Fig. 3: Mechanical bud chip cutter having sharp U shape blade that cuts the bud with small chip from the sugarcane in the proper and simple manner, which allows individuals to use easily.

The scooped buds were treated with a fungicide (Fig.4)

Fig. 4: Bud chip technology encourages the farmers to treat the buds with fungicide and remove infected/diseased buds manually. The healthy buds treated with fungicide minimizing the chances of seed transmitted diseases in the farmer field thus increasing the yield.

and hot water treatment (53°C for few minutes) to avoid disease infestation in the resulting plants, the scooped buds were placed on gunny bag and then covered over with another bag. The bags were kept moist properly to facilitate pre-sprouting of the buds. After 3-4 days, the sprouted buds were shifted to nursery trays filled with peat moss and kept in the greenhouse (Fig. 5).

Fig. 5: Sprouted bud chips are ready to in-vitro transfer into the potting media in the trays and discard the dormant bud chips.

When seedlings reached the age of 40 days (Fig. 6)

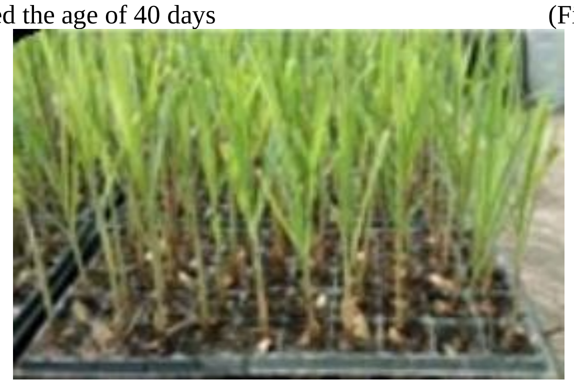

Fig. 6: The bud chips seedlings completed in-vitro life span of 40 days and ready for transplantation into the field.

the sugarcane seedlings were transplanted in leveled field on 15th October with the help of sugarcane seedling transplanter (Fig. 1) at the distance of 4 x 1.5 feet row to row and plant to plant respectively (Fig. 7).

Fig. 7: Constant row to row and plant to plant spacing were achieved by using the newly locally developed transplanter, minimizing time consuming human efforts in manageable way.

By using seedling trans planter 7260 settlings Ac^{-1} were planted.

2.2 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) to determine the significance of differences among the treatments. The statistical software used for the analysis was SPSS (version 25.0). The ANOVA was performed for each parameter to assess the effects of variety, location, and their interaction on sugarcane growth and yield. The F-test was used to test the significance of the main effects (variety and location) and their interaction at a significance level of 0.05. When significant differences were detected by ANOVA, the least significant difference (LSD) test was conducted to compare the means of the different treatments. The LSD value was calculated to determine the minimum difference required between treatment means for the difference to be considered statistically significant (Steel, 1997). The CV was calculated for each parameter to assess the relative variability in the data.

3 Results

3.1 Plant Height

The results for plant height revealed significant differences among the treatments (Table-1). The tallest plants were found in V1L3, which reached a height of 305.00 cm, followed by V2L3 at 265.00 cm, and V2L2 at 225.00 cm. On the lower end, V2L1 had the shortest plants with a height of 171.00 cm. The analysis indicated a significant effect of the treatments on plant height with an LSD value of 53.66 and a CV of 8.46%.

3.2 Tillers per Plant

The number of tillers per plant did not vary significantly among the treatments (Fig. 8). The highest number of tillers was observed in V1L3 with 10.66 tillers per plant, while V2L1 had the lowest at 7.53. Other treatments showed tiller numbers within this range. The statistical analysis revealed no significant differences among treatment combinations.

3.3 Internodes per Plant

There were significant variations in the number of internodes per plant across the treatments (Fig. 8).

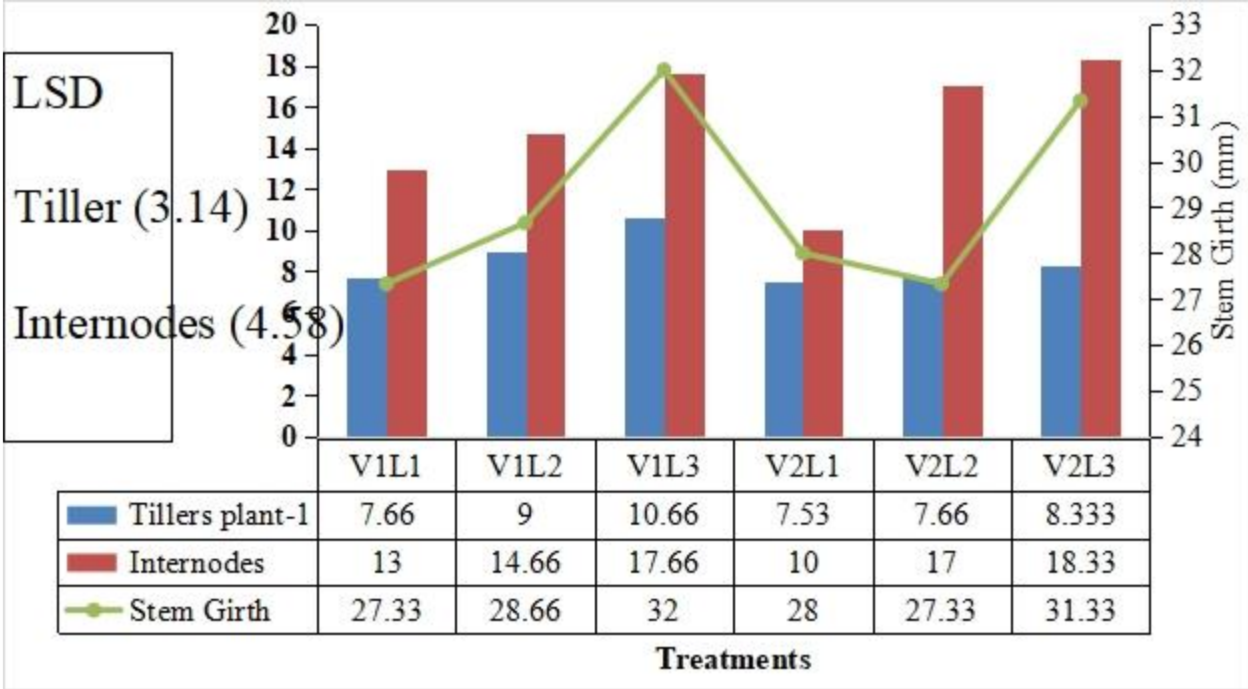

Fig. 8: The impact of sugarcane varieties planted through Bud Chip technique at different locations on tillers, internodes and stem girth of a plant.

V2L3 had the highest number of internodes with 18.33, closely followed by V1L3 at 17.66 and V2L2 at 17.00. The lowest number of internodes was recorded in V2L1 with 10.00. The differences were statistically significant.

3.4 Stem Girth

Stem girth showed significant differences among the treatments (Fig. 8). The thickest stems were found in V1L3 with a girth of 32.00 mm, followed by V2L3 at 31.33 mm and V1L2 at 28.66 mm. The thinnest stems were recorded in V1L1 and V2L2, both measuring 27.33 mm. These differences were statistically significant, with an LSD of 3.64.

3.5 Millable Canes

The number of millable canes per acre showed notable variation among the treatments (Table-1). V1L3 had the highest number of millable canes with 76.187 thousand per acre, followed by V1L2 with 66.783 thousand and V2L3 with 58.967 thousand. The lowest number was recorded in V2L1 with 43.063 thousand per acre. Statistical analysis confirmed significant differences, with an LSD value of 13.310 and a CV of 12.61% (Fig. 9).

Fig. 9: Sugarcane yield is directly proportional to the number of tillers arises from a single plant. This figure specifically focusing on the increased number of tillers produced by a single plant rose through bud chip technique.

3.6 Cane Yield

Cane yield exhibited significant differences across the treatments (Table-1). The highest yield was observed in V1L3 with 1577.2 moundsper acre, followed by V1L2 with 1419.0 mounds and V2L3 with 1289.6 mounds per acre. The lowest yield was recorded in V2L1 with 854.4 mounds per acre. These differences were statistically significant.

Table 1: Mean performance of sugarcane varieties planted through Bud Chip technique at different locations.

Treatments	Plant Height (cm)	Millable canes (000 kg Ac^{-1})	Cane Yield (Mounds Ac^{-1})
V1L1	177 cd	49.350 bc	893.7c
V1L2	201 cd	66.783 ab	1419.0 ab
V1L3	305 a	76.187 a	1577.2 a
V2L1	171 d	43.063 c	854.4c
V2L2	225 bc	53.840 bc	1145.4bc
V2L3	265 cd	58.967 abc	1289.6 ab
LSD (0.5%)	53.66	13.310	291.57
CV	8.46	12.61	13.40

3.7 Analysis of Variance

The analysis of variance (ANOVA) (Table-2) showed significant differences for most parameters across different sources of variation. The error variance for each parameter was low, indicating that the experimental design was robust, and the results are reliable.

Table 2: Mean squares and their significance from analysis of variance for sugarcane varieties planted through Bud Chip technique at different locations.

Source of Variation	DF	Height (cm)	Tillers $plant^{-1}$	Internodes $plant^{-1}$	Stem Girth (mm)	Millable canes (000 Ac^{-1})	Cane Yield (Mounds Ac^{-1})
Rep	2	64.7	2.40889	2.88889	5.0556	145.168	125596
Location	2	19026.0	5.50889	65.7222	29.5556	664.301	180210
Variety	1	242.0	7.22000	2.49631	0.8889	708.408	502322
Location*Variety	2	1538.0	1.82000	11.1667	1.5556	45.535	29192
Error	10	359.3	1.23556	2.62222	1.6556	53.522	25685
Total	17	--	--	--	--	--	--

4 Discussion

The present study aimed to evaluate the Bud Chip planting technique in different locations and its interaction with two sugarcane varieties, YtTh-55 (V1) and Th-2109 (V2), during the cropping season 2020-2021. The study revealed significant insights into plant height, tillers per plant, internodes per plant, stem girth, millable canes, and cane yield across different locations. The significant variation in plant height observed among the treatments indicates a strong influence of location and variety interaction. The tallest plants recorded in V1L3 (305.00 cm) suggest that the combination of YtTh-55 variety and Ghulam Rasool Jatoi, Moro location provides an optimal environment for plant growth. The shorter plants in V2L1 (171.00 cm) highlight that Th-2109 may not be well-suited to the conditions at Abdul Rahim farm, Badin. This underscores the importance of selecting appropriate variety-location combinations to maximize plant height as being reported by Tayade et al. (2021).

Although the number of tillers per plant did not vary significantly among the treatments, the highest number of tillers in V1L3 (10.66) suggests a positive response of YtTh-55 variety to the Bud Chip technique at Ghulam Rasool Jatoi, Moro. The consistency in tiller numbers across different treatments indicates that tillering may be less sensitive to location and more dependent on genetic factors of the varieties (Kumar, 2020). However, the slight variations observed could still influence overall yield and should be considered in future research.

The significant differences in the number of internodes per plant across the treatments demonstrate the impact of environmental factors and variety characteristics. The highest number of internodes in V2L3 (18.33) and V1L3 (17.66) suggests that both varieties perform well at Ghulam Rasool Jatoi, Moro. The lowest internode count in V2L1 (10.00) further indicates that Th-2109 may not thrive as well in the conditions at Abdul Rahim farm, Badin. This variation is critical as the number of internodes can directly affect the length and quality of the cane.

The significant differences in stem girth among the treatments highlight the effect of the Bud Chip technique and location on stem development. The thickest stems in V1L3 (32.00 mm) and V2L3 (31.33 mm) confirm that the Ghulam Rasool Jatoi, Moro location supports robust stem growth for both varieties. In contrast, the thinner stems in V1L1 and V2L2 (both 27.33 mm) suggest that these conditions are less favorable. Stem girth is a crucial parameter for cane quality and milling efficiency, emphasizing the need for optimal growing conditions.

The notable variation in the number of millable canes per acre among the treatments indicates that location and variety significantly influence cane production. The highest number of millable canes in V1L3 (76.187 thousand per acre) suggests that YtTh-55 variety excels at Ghulam Rasool Jatoi, Moro. The lowest count in V2L1 (43.063 thousand per acre) further supports the observation that Th-2109 is less suited to Abdul Rahim farm, Badin. These findings are essential for maximizing cane production through appropriate site and variety selection and are in conjunction with the findings of Khaliq et al. (2020).

The significant differences in cane yield across the treatments underscore the impact of the Bud Chip technique, location, and variety interaction on overall productivity. The highest yield in V1L3 (1577.2 tons per acre) highlights the potential of the YtTh-55 variety at Ghulam Rasool Jatoi, Moro to achieve superior production. The lowest yield in V2L1 (854.4 tons per acre) indicates that Th-2109 may not be optimal for conditions at Abdul Rahim farm, Badin. These results are supported by Mohanty and Nayak (2021) and reinforce the importance of selecting suitable variety-location combinations to maximize yield and enhance sugarcane production efficiency.

5 Conclusions and Recommendations

The study demonstrated that the Bud Chip planting technique, when combined with appropriate variety and location selection, can significantly enhance sugarcane growth and yield. The findings emphasize the need for continued research to fine-tune these interactions and expand the use of the Bud Chip technique across different regions. Future studies should explore additional varieties and locations to further validate these results and optimize sugarcane production strategies.

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The research was funded by PARC-NSTHRI, Thatta under PSDP- Productivity Enhancement of Sugarcane (PESC) Project has successfully introduced sugarcane cultivation through bud chip method. Under the same project during 2020 PARC-NSTHRI, Thatta with the help of PARC-NARC-FMI, Islamabad locally designed settling transplanter with some modification and hired the services of Janjua Agro-Industry Chiniot for manufacturing of seedling trans planter machine with capacity of 0.40 ha h^{-1}.

Novelty statement

This machine is the first ever addition in the agriculture sector of Pakistan, which helps in mechanized transplanting of bud chip nursery seedlings in the field at the fixed distance (plant to plant distance 1.5 feet and row to row distance 4 feet). This newly introduced machine reduces time and makes sugarcane cultivation very easy. One acre of land can be cultivated within one and half hours through transplanting machines.

This is an innovative and low-cost effective sugarcane planting technology that ensures up to 20% enhanced cane productivity followed by better economic returns to the farming community. Sugarcane varieties developed by this institute are being multiplied in speedy manner through sugarcane bud chip method on different farmer fields and sugar mills farms all over Pakistan. This planting technique saves 75% of seed cost as compared to conventional planting technique and supports the development of insect pest and disease free healthy as well as pure sugarcane seed for planting.

Success Story

After successful and encouraging results of the research trials on Sugarcane planting through Bud chip techniques conducted at PARC-National Sugar and Tropical Horticulture Research Institute, Makli, Thatta. This technique is getting popular in Sindh province of Pakistan.

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