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GROWTH, YIELD AND ECONOMIC ANALYSIS OF SUGARCANE UNDER DIFFERENT PLANTING METHODS

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ABSTRACT

A research trial was conducted during eksali, 2017, 2018 and 2020 at Agricultural Research Station, Basanthpur, Sangareddy, Telangana to assess the growth, yield attributes and economics of cultivation in relation to cane yield. The results unveiled a strong and positive relation of cane yield with tiller count at 75 and 120 DAP, cane height, number of millable canes, single cane weight, cane girth and gross returns with R^2 values of 0.8776, 0.9731, 0.9797, 0.988, 0.9932, 0.8408 and 0.8576 respectively, indicating the dependability on these parameters to enhance cane yield under different planting methods.

Keywords : Cane yield, Regression analysis, Sugarcane planting methods.

Introduction

Sugarcane (*Saccharum officinarum* L.) is a vital cash crop grown in over 90 countries worldwide, contributing significantly to global sugar production. Approximately 64.6% of the world's total sugar output comes from sugarcane. India ranks as one of the top sugar-producing nations, frequently competing with Brazil for the leading position in global sugar production. India accounts for about 13.25% of global sugar output and 41.11% of Asia's sugar production. The crop is cultivated on approximately 4.73 million hectares in India, with an annual production of 379.90 million tonnes and a productivity rate of 80.19 tonnes per hectare (Yadav *et al*., 2020).

One of the most critical and labor-intensive stages in sugarcane cultivation is planting (Kamini Singh and Lal Singh Gangwar, 2023). However, Indian agriculture faces significant challenges, particularly a persistent labor shortage. This shortage not only escalates the cost of cultivation but also jeopardizes the sustainability of farming as a livelihood. To address these challenges, it is essential to implement timely and appropriate technological advancements within existing agricultural practices (Yadav *et al*., 2020).

The most crucial and labour-intensive step in sugarcane cultivation is planting (Kamini Singh, Lal Singh Gangwar, 2023). Indian agriculture is still facing the problem of labour shortage and thereby it increases the cost of cultivation that leads to threatening the survival of farming community. In order to overcome such problems, we have to respond immediately by adopting appropriate technological interventions in existing agricultural practices (Yadav *et al*., 2020).

A substantial portion of the production cost in sugarcane cultivation is attributed to seed cane, the primary planting material, which is required in large quantities. The germination and yield of sugarcane are influenced by several factors, including the type and quality of planting material, field layout, plant population density, planting methods, and the placement of buds during planting (Nalawade *et al*., 2018).

Adopting advanced technologies, particularly innovative planting techniques, is crucial for maintaining the production and productivity of the sugarcane industry in an economically viable and sustainable manner (Lalita Rana *et al*., 2023). In this context, exploring cost-effective and remunerative planting methods becomes imperative to ensure the long-term viability of sugarcane cultivation. The present study was conducted with the objective of evaluating different planting methods to identify the most cost-effective and productive approach for sugarcane cultivation. As part of the study, an effort was made to correlate growth parameters, yield attributes, and the economics of cultivation with cane yield. The objective was to identify the most reliable factors whose improvement could significantly enhance cane yield under various planting methods.

Materials and Methods

The study was conducted during the *eksali* seasons of 2017, 2018, and 2020 at the Agricultural Research Station, Basanthpur, Sangareddy, Telangana, located at 17°47'52.55" N latitude and 77°32'37.77" E longitude, with an elevation of 626 meters above mean sea level (AMSL). The experimental site featured red laterite loam soil, which was characterized as low in available nitrogen (265 kg ha^{-1}), medium in organic carbon (0.6%), phosphorus (18 kg ha^{-1}), and potassium (134 kg ha^{-1}). The study evaluated seven planting methods: ridge and furrow method with three-budded setts (P_1), single-node planting using a seedling transplanter (P_2), direct planting of bud chips (P_3), manual planting of seedlings (P_4), transplanting seedlings with a transplanter (P_5), planting with a cutter planter (P_6), and farmer's practice using two-budded setts (P_7). The experiment followed a randomized block design with three replications, with the sugarcane variety Co 86032, also known as *Nayana*. This medium-thick, reddish-pink "wonder cane" is suitable for year-round planting. The spacing was maintained at 150 cm x 30 cm. Fertilizers were applied as per the recommended NPK dosage of 250-100-100 kg ha^{-1} in the form of urea, single super phosphate, and muriate of potash, respectively. The collected experimental data were subjected to statistical analysis using regression techniques to quantify the relationships between various growth parameters, yield attributes, and economic factors with the final cane yield.

Results and Discussion

Growth and yield attributes of sugarcane in terms of yield were assessed by linear quadratic function i.e. $y = a + bx$.

Where, y is a dependent variable, a is the intercept, b is the regression coefficient indicating the magnitude of variation per unit increase independent variable and x is an independent variable.

Tiller count at 75 DAP

Tiller count at 75 DAP is a critical determinant of cane yield, as reflected by the positive slope and high R^2 value. The slope of the linear regression model fitted for tiller count at 75 DAP and cane yield was 1.4684 (Fig. 1) indicating that for every additional tiller at 75 DAP, the cane yield increases by 1.4684 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope indicates a strong, direct relationship i.e., more tillers at 75 DAP result in higher cane yield. The intercept of −14.224 implies that if the tiller count at 75 DAP is zero, the model predicts the cane yield would be -14.224 units. This suggests the model is only valid for realistic ranges of tiller counts and should not be extrapolated to extreme values of x=0. The R^2 value of 0.8776 indicates that a variation of 87.76% in cane yield can be explained by the tiller count at 75 DAP. This points out a strong fit of the regression model to the data, implying that tiller count at 75 DAP is a key factor influencing cane yield. Hence, improving practices that increase tiller count at 75 DAP is likely to enhance cane yield.

Tiller count at 120 DAP

Similar to tiller count at 75 DAP, the tiller count at 120 DAP also is an important determinant of cane yield, as evidenced by the positive slope and high R^2 value. The slope of the linear regression model for tiller count at 120 DAP and cane yield is 1.1958 9(Fig 2), meaning that for every additional tiller at 120 DAP, the cane yield increases by 1.1958 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope highlights a strong, direct relationship, where a higher tiller count at 120 DAP leads to greater cane yield. The intercept of -89.81 suggests that if the tiller count at 120 DAP were zero, the model would predict a cane yield of -89.81 units, which is not realistic. This indicates that the model is applicable only within the range of observed tiller counts and should not be extrapolated to extreme values like x=0. The R^2 value of 0.9731 indicates that 97.31% of the variation in cane yield can be attributed to the tiller count at 120 DAP. This reflects an excellent fit of the regression model, confirming that tiller count at 120 DAP is a key factor influencing cane yield.

Cane height at harvest

Cane height at harvest demonstrated by the positive slope and exceptionally high R^2 value in the regression model. The slope of the regression equation, 0.9554 (Fig 3), indicates that for every additional unit increase in cane height (e.g., centimeters), the cane yield increases by 0.9554 units (e.g., t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope highlights a strong, direct relationship between cane height and cane yield, implying that taller cane at harvest results in higher yields. The regression model is valid only for realistic ranges of cane height and should not be extrapolated to extreme or biologically implausible values such as zero height considering the intercept of -155.78. The R^2 value of 0.9797 reveals that 97.97% of the variation in cane yield can be explained by variations in cane height at harvest. This exceptionally high value reflects a near-perfect fit of the regression model to the data, confirming that cane height at harvest is a key factor influencing yield. Thus, the findings emphasize the importance of managing agronomic practices to optimize cane height at harvest, as it has a significant and direct impact on yield. Practices such as proper irrigation, nutrient management, and timely pest control can promote taller cane growth, thereby enhancing overall productivity.

Number of millable canes per ha

In line with the cane height, the number of millable canes at harvest also showed a positive slope and the exceptionally high R^2 value of the regression model. The slope of the regression equation, 1.7161(Fig 4), indicates that for every additional millable cane at harvest, the cane yield increases by 1.7161 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope underscores a strong, direct relationship between the number of millable canes and cane yield, where a higher count of millable canes results in increased yield. The intercept of -49.969 suggests that if the number of millable canes at harvest were zero, the model would predict a cane yield of -49.969 units, which is biologically implausible. The R^2 value of 0.988 reveals that 98.8% of the variation in cane yield can be explained by the number of millable canes at harvest. This extremely high R^2 value signifies an excellent fit of the model, confirming that the number of millable canes at harvest is a major determinant of cane yield.

Single cane weight

Single cane weight is a vital determinant of cane yield, as evidenced by the positive slope and a high R^2 value of the regression model. The slope of the regression equation, 84.361(Fig 5), indicates that for every additional unit increase in single cane weight (kg), the cane yield increases by 84.361 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope highlights a strong, direct relationship between single cane weight and cane yield, signifying that heavier individual canes contribute significantly to higher overall yields. Based on the intercept of -1.0295 it cane be concluded that the model is applicable only within the observed range of single cane weights and should not be extrapolated to extreme or unrealistic values. The R^2 value of 0.9932 shows that 99.32% of the variation in cane yield can be explained by variations in single cane weight. This exceptionally high R^2 value reflects an almost perfect fit of the model to the data, underscoring the critical role of single cane weight in determining cane yield. Similar results were found with the findings of Saini and Chakor (1992).

Cane girth

Cane girth in relation to cane yield had a positive slope and moderately high R^2 value of the regression model. The slope of the regression equation, 129.86(Fig 6), indicates that for every additional unit increase in cane girth (cm), the cane yield increases by 129.86 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope demonstrates a strong, direct relationship, where thicker canes contribute significantly to higher overall yields. The intercept of -247.08 suggests that if cane girth were zero, the model would predict a cane yield of -247.08 units, which is not realistic. The R^2 value of 0.8408 indicates that 84.08% of the variation in cane yield can be explained by variations in cane girth. While this shows a strong fit, it also suggests that other factors, such as cane height, millable cane count, or single cane weight, may account for the remaining 15.92% of the variation in cane yield. Nonetheless, the high R^2 value underscores the significant role of cane girth in determining cane yield.

Gross returns

Gross returns in rupees had a positive slope and the moderately high R^2 value of the regression model. The slope of the regression equation, 0.0003(Fig 7), indicates that for every additional unit increase in gross returns (1), the cane yield increases by 0.0003 units (t ha^{-1}), assuming a linear relationship and all other factors remaining constant. This positive slope suggests a direct relationship between gross returns and cane yield, indicating that higher returns are generally associated with increased productivity.

Fig 1. Correlation of cane yield with tiller count at 75 DAP in different planting methods of Sugarcane

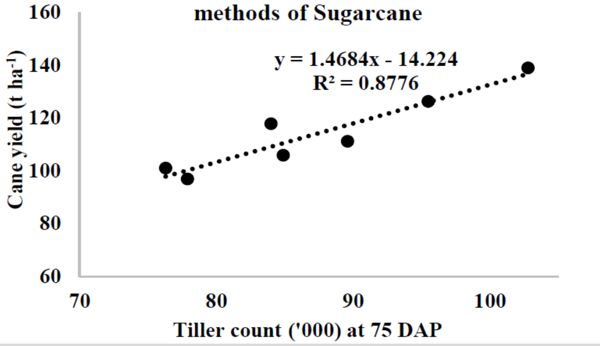


Fig 2. Correlation of cane yield with tiller count at 120 DAP in different planting methods of Sugarcane

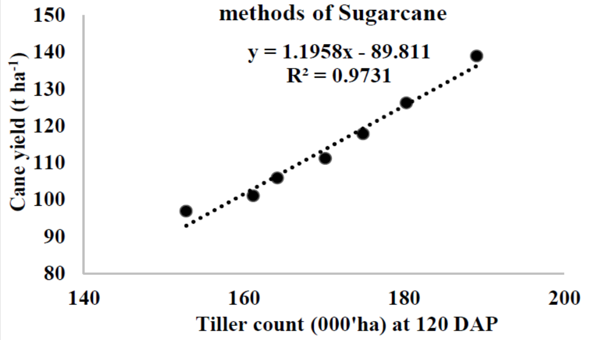


Fig 3. Correlation of cane yield with cane height at harvest in different planting methods of Sugarcane

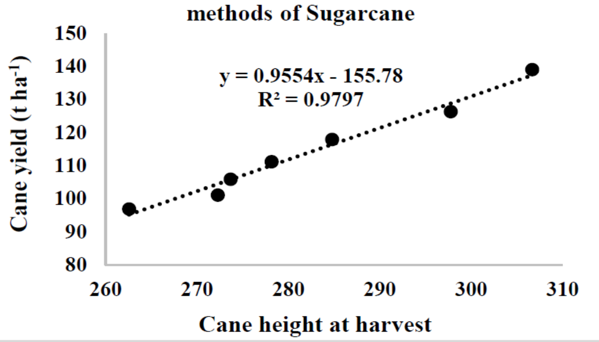


Fig 4. Correlation of cane yield with number of millable canes in different planting methods of Sugarcane

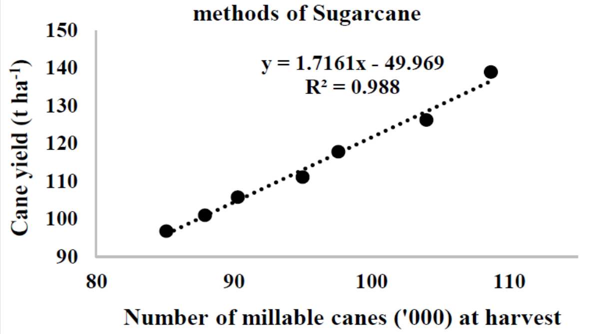


Fig 5. Correlation of cane yield with single cane weight (kg) in different planting methods of Sugarcane

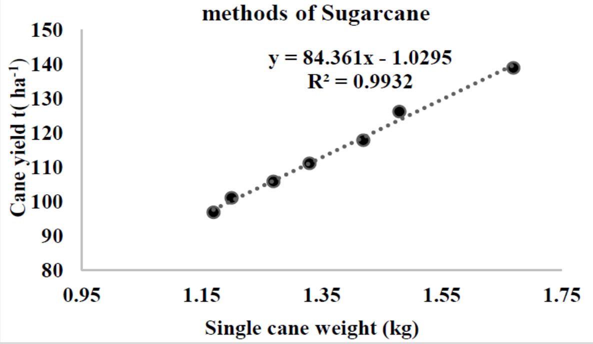


Fig 6. Correlation of cane yield with cane girth (cm) in different planting methods of Sugarcane

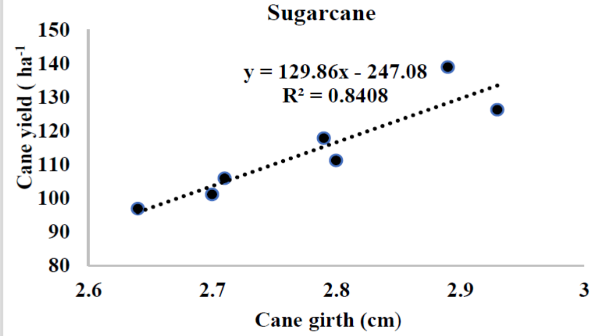
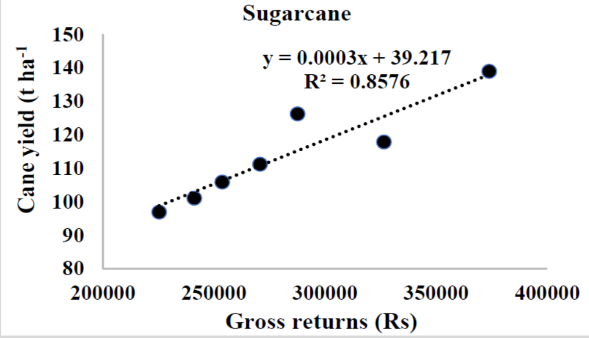


Fig 7. Correlation of cane yield with gross returns in different planting methods of Sugarcane



The intercept of 39.217 implies that if gross returns were zero, the model predicts a cane yield of 39.217 units (t ha^{-1}). While this may not be directly practical, it indicates the baseline yield that might occur independently of economic returns. The R^2 value of 0.8576 indicates that 85.76% of the variation in cane yield can be explained by variations in gross returns. This strong fit suggests that gross returns are a significant factor influencing cane yield, but other factors such as agronomic practices, environmental conditions, or input management may account for the remaining 14.24% of the variation. The above findings highlight a positive association between gross returns and cane yield, reinforcing the idea that investments in practices or resources that improve returns can lead to higher yields. This underscores the importance of optimizing economic inputs and returns to ensure enhanced productivity and profitability in cane cultivation.

In summary, the regression models presented above collectively highlight the significant role of various agronomic factors in determining cane yield. The consistent positive slopes across the models indicate that improvements in each respective factor viz., tiller count at 75 and 120 DAP, cane height at harvest, number of millable canes, single cane weight, cane girth and gross returns result in increased cane yield. These findings emphasize the direct relationship between these variables and cane yield, underscoring their importance in optimizing cane production.

The high R^2 values in most of the models, such as 0.988, 0.9932, and 0.9776, demonstrate that a substantial proportion of the variation in cane yield can be explained by these factors. Particularly, variables like single cane weight, cane height at harvest, and number of millable canes showed near-perfect correlations with cane yield, indicating that focusing on these elements could significantly boost productivity. On the other hand, variables like gross returns and cane girth, while also important, revealed slightly lower R^2 values, suggesting that other external factors may contribute to the remaining variation in yield.

Overall, these models provide valuable insights for agronomists, farmers, and researchers looking to optimize cane yield. Focusing on practices that enhance these key factors, such as improving plant density, enhancing cane growth conditions (through irrigation, fertilization, and pest management), and maximizing economic returns, can help drive higher cane yields and ultimately improve agricultural profitability. It is essential to take a holistic approach to cane cultivation, where multiple factors are simultaneously optimized to achieve the best possible outcomes in terms of yield and economic returns.

Conclusion

The evaluation of different planting methods in sugarcane should focus on optimizing key agronomic factors like tiller count, cane height, and millable cane number, as well as enhancing economic returns through effective resource management. The regression models suggest that a planting method that maximizes these factors will lead to higher cane yield, contributing to improved productivity and profitability

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