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Evaluation of Zero Tillage Maize under Irrigated Conditions

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A field experiment was conducted at Krishna College of Agriculture and Technology during the period from June to August 2025 to assess the productivity and economic viability of zero tillage (ZT) maize cultivation in comparison with the conventional method of ridges and furrows. The study focused on evaluating different plant spacings ranging from 45×30 cm to 90×30 cm, along with the integration of black gram as an intercrop under a sustainable cropping system. The experimental design aimed to identify an optimal combination of spacing and intercropping that enhances yield, resource-use efficiency, and profitability.The results revealed that zero tillage maize planted at a spacing of 60×30 cm and intercropped with black gram in a 1:1 ratio significantly outperformed all other treatments. This combination recorded the highest grain yield of 7,400 kg/ha, indicating improved crop performance under reduced soil disturbance. Additionally, the Land Equivalent Ratio (LER) of 1.22 confirmed the advantage of intercropping over monocropping in terms of efficient land utilization. From an economic perspective, this treatment also generated the highest net income of ₹99,460 per hectare and achieved a Benefit-Cost (B:C) ratio of 3.9, which was notably higher than the conventional control treatment (3.3).The findings highlight that zero tillage combined with pulse-based intercropping not only enhances crop productivity but also improves soil health, reduces cultivation costs, and increases farm profitability. Therefore, the adoption of zero tillage maize intercropped with black gram can be considered a technically feasible, environmentally sustainable, and economically superior practice for conservation agriculture in Tamil Nadu. The study provides valuable insights for farmers, researchers, and policymakers aiming to promote sustainable intensification in maize-based cropping systems.

Keywords: zero tillage, maize cultivation, intercropping, land equivalent ratio, conservation agriculture

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1. Introduction

Maize (*Zea mays* L.), often referred to as the "Queen of Cereals," occupies a prominent position in global as well as Indian agriculture due to its high productivity, versatility, and wide range of applications in food, feed, and industrial sectors. In India, maize stands as the third most important cereal crop after rice and wheat, contributing significantly to food security, livestock nutrition, and agro-based industries. With the increasing demand driven by population growth, urbanization, and expanding poultry and starch industries, there is a pressing need to enhance maize production. However, this must be achieved within the constraints of limited arable land, declining soil fertility, and increasing input costs. Hence, the focus has shifted toward sustainable and resource-efficient production technologies.

In this context, conservation agriculture has emerged as a promising approach to ensure long-term agricultural sustainability. It is based on key principles such as minimal soil disturbance, permanent soil cover, and diversified crop rotations. Among these, zero tillage (ZT) is gaining considerable attention as an effective practice that reduces the need for repeated ploughing and land preparation. By minimizing soil disturbance, zero tillage helps in maintaining soil structure, conserving soil moisture, and enhancing biological activity. It also significantly reduces labor requirements, fuel consumption, and operational costs, making it economically attractive for farmers.

Zero tillage has been successfully adopted in several regions across the world, particularly in wheat-based systems in North India. However, its application in irrigated maize cultivation, especially in Tamil Nadu, is relatively new and still under exploration. The agro-climatic conditions of Tamil Nadu, characterized by diverse soil types and irrigation practices, offer potential opportunities for adapting zero tillage technology. Introducing this method in maize cultivation can help improve input use efficiency, reduce production costs, and sustain soil health over time.

Another important dimension of sustainable maize production is intercropping, particularly with pulse crops such as black gram (*Vigna mungo* L.). Pulses play a vital role in enhancing soil fertility through biological nitrogen fixation and improving soil structure.

Intercropping maize with black gram not only optimizes the use of available resources like light, water, and nutrients but also provides an additional source of income to farmers. This integrated approach contributes to system productivity and resilience by diversifying cropping patterns and reducing risks associated with monocropping.

The combination of zero tillage and pulse-based intercropping represents a holistic strategy for improving agricultural sustainability. It aligns with the goals of conservation agriculture by enhancing resource use efficiency, reducing environmental degradation, and increasing farm profitability. In the context of Tamil Nadu, where sustainable intensification of agriculture is essential, the adoption of zero tillage maize with black gram intercropping holds significant promise. This approach not only supports higher productivity but also contributes to ecological balance and long-term soil health, thereby ensuring the sustainability of maize-based cropping systems.

2. Materials and Methods

The present study was conducted to evaluate the performance of zero tillage maize under different plant spacings and intercropping systems using a well-structured experimental approach. The experiment was laid out in a Randomized Block Design (RBD) with three replications to ensure reliability and minimize experimental error. This design was chosen as it effectively accounts for field variability and allows for precise comparison among treatments.

A total of seven treatments were included in the study, each representing a combination of tillage practice, plant spacing, and intercropping system. Treatments T1 to T4 consisted of zero tillage maize cultivated at varying spacings of 45×30 cm, 60×30 cm, 75×30 cm, and 90×30 cm, respectively. These treatments were designed to identify the optimum plant density under zero tillage conditions. Treatments T5 and T6 incorporated an intercropping system, where maize was grown along with black gram in a 1:1 row ratio. Specifically, T5 consisted of maize at 60×30 cm spacing intercropped with black gram, while T6 involved maize at 75×30 cm spacing with black gram intercrop. The inclusion of pulse crops aimed to enhance system productivity and soil fertility through biological nitrogen fixation.

Treatment T7 served as the control and followed the conventional method of ridges and furrows with a spacing of 60×25 cm, representing the standard farmer practice in the region.

The experimental plots were prepared according to the respective treatment requirements. In zero tillage plots, sowing was carried out without prior ploughing, ensuring minimal soil disturbance. In contrast, conventional plots were prepared using standard tillage operations to form ridges and furrows. Recommended agronomic practices, including irrigation, fertilization, and weed management, were uniformly applied across all treatments to maintain consistency and eliminate bias.

Data collection focused on both growth parameters and yield attributes of maize. Key observations included cob weight, cob length, cob girth, and 1000-grain weight, which are critical indicators of crop performance and productivity. In addition, grain yield per hectare was recorded to assess the overall effectiveness of each treatment. To evaluate the efficiency of intercropping systems, the Land Equivalent Ratio (LER) was computed, providing insights into the comparative advantage of mixed cropping over sole cropping.

Economic analysis was also an integral part of the study. Parameters such as cost of cultivation, gross returns, net returns, and Benefit-Cost (B:C) ratio were calculated for each treatment. This analysis helped in determining the economic feasibility and profitability of zero tillage and intercropping practices compared to conventional methods.

Overall, the methodology was designed to comprehensively assess the agronomic and economic performance of zero tillage maize under varying spacings and intercropping systems. The use of a systematic experimental design and detailed data collection ensured that the findings would be reliable and applicable for promoting sustainable maize cultivation practices.

3. Results and Discussion

3.1 Growth and Yield Performance

The growth and yield performance of maize were significantly influenced by different spacing levels and intercropping systems under zero tillage conditions.

Among the treatments, T5 (Zero Tillage maize at 60×30 cm spacing intercropped with black gram in a 1:1 ratio) recorded the highest plant height, indicating better crop vigor and efficient utilization of available resources. The performance of T5 was found to be statistically comparable with the conventional cultivation method (T7) and sole zero tillage maize at 60×30 cm spacing (T2), suggesting that zero tillage practices can effectively match or even exceed the growth performance of traditional methods.

Leaf Area Index (LAI), an important indicator of photosynthetic efficiency, was observed to be higher under closer spacing (T1: 45×30 cm). This could be attributed to the increased plant population per unit area, which resulted in greater canopy coverage. However, despite higher LAI in closer spacing, it did not translate into superior yield performance, possibly due to increased competition among plants for nutrients, water, and light.

Yield attributes such as cob weight, cob length, cob girth, and 1000-grain weight showed significant variation across treatments. T5 consistently outperformed all other treatments, recording the highest cob weight (157.8 g) and 1000-grain weight (245 g). The improved yield attributes in T5 can be attributed to the synergistic effect of optimum plant spacing and intercropping with black gram, which enhanced nutrient availability, particularly nitrogen, and improved overall crop growth. The presence of the pulse intercrop likely contributed to better soil fertility and reduced competition, thereby supporting enhanced maize productivity.

3.2 Yield and Land Use Efficiency

Grain yield is a key determinant of the effectiveness of any cropping system. In the present study, zero tillage maize intercropped with black gram (T5) recorded a significantly higher grain yield of 7,400 kg/ha compared to the conventional control (T7), which yielded 4,700 kg/ha. This substantial increase in yield highlights the advantage of integrating conservation agriculture practices with intercropping systems. The enhanced yield in T5 can be attributed to improved soil moisture conservation, reduced soil disturbance, and efficient nutrient cycling facilitated by the leguminous intercrop.

The evaluation of land-use efficiency through the Land Equivalent Ratio (LER) further emphasized the benefits of intercropping.

The LER value of 1.22 recorded in T5 indicates that the intercropping system utilized land resources more efficiently than sole cropping. In practical terms, this means that 22 percent more land would be required under monocropping to achieve the same yield obtained from intercropping. This demonstrates the superiority of the maize–black gram intercropping system in maximizing productivity per unit area.

In addition to yield advantages, the intercropping system also contributes to risk reduction and income stability for farmers by diversifying outputs. The findings clearly indicate that zero tillage combined with pulse intercropping not only enhances crop yield but also improves land-use efficiency, making it a sustainable and economically viable option for maize cultivation in Tamil Nadu.

Table 1: Effect of Spacing and Intercropping on Yield and Economics

Treatment	Spacing/ System	Grain Yield (Kg/ha)	Total Cost (Rs/ha)	Net Income (Rs/ha)	B:C Ratio
T1	45×30 (ZT)	5,400	30,120	72,480	2.4
T2	60×30 (ZT)	6,100	32,990	96,210	3.4
T3	75×30 (ZT)	5,700	29,340	85,260	2.9
T4	90×30 (ZT)	4,200	28,920	50,280	1.7
T5	60×30 + BG (1:1)	7,400	34,720	99,460	3.9
T6	75×30 + BG (1:1)	6,800	29,560	87,410	2.9
T7	60×25 (Conventional)	4,700	30,690	95,810	3.3

Table 1 clearly shows the influence of spacing and intercropping systems on both yield and economic returns of maize cultivation. Among all treatments, T5 (Zero Tillage maize at 60×30 cm spacing intercropped with black gram in a 1:1 ratio) recorded the highest grain yield of 7,400 kg/ha, indicating the superior performance of integrated cropping systems under zero tillage conditions. This treatment also generated the highest net income of ₹99,460 per hectare along with the maximum Benefit-Cost (B:C) ratio of 3.9, demonstrating its strong economic viability.

Among the sole zero tillage treatments, T2 (60×30 cm spacing) performed better than other spacing levels, with a grain yield of 6,100 kg/ha and a B:C ratio of 3.4. This suggests that 60×30 cm is the optimum spacing for maize under zero tillage conditions when grown as a sole crop. Wider spacing (T4: 90×30 cm) resulted in the lowest yield (4,200 kg/ha) and the minimum B:C ratio (1.7), indicating underutilization of available resources. On the other hand, closer spacing (T1: 45×30 cm) showed moderate yield but lower economic returns due to increased competition among plants.

Intercropping treatments (T5 and T6) consistently outperformed their respective sole cropping counterparts in terms of yield and profitability. The inclusion of black gram not only enhanced grain yield but also improved economic returns, highlighting the benefits of crop diversification and efficient resource utilization. Although T6 also performed well, it was slightly inferior to T5, suggesting that 60×30 cm spacing is more suitable for intercropping than wider spacing.

The conventional method (T7) recorded a moderate yield of 4,700 kg/ha but showed relatively high net income (₹95,810) and a B:C ratio of 3.3, indicating its continued relevance. However, it was clearly outperformed by T5 in both productivity and profitability. Overall, the results indicate that zero tillage combined with optimum spacing and pulse intercropping significantly enhances both yield and economic returns, making it a sustainable and profitable alternative to conventional maize cultivation practices.

3.3 Economic Feasibility

The economic feasibility of different treatments was evaluated by analyzing cost of cultivation, net returns, and Benefit-Cost (B:C) ratio. The results clearly indicate that zero tillage practices significantly reduced the overall cost of cultivation compared to the conventional method. This reduction is primarily attributed to the elimination of preparatory tillage operations such as ploughing, harrowing, and leveling, which in turn minimized labor requirements, fuel consumption, and machinery usage. As a result, zero tillage treatments proved to be more cost-efficient and farmer-friendly.Among all treatments, T5 (Zero Tillage maize at 60×30 cm spacing intercropped with black gram in a 1:1 ratio) recorded the highest cost of cultivation (₹34,720/ha). This relatively higher cost can be attributed to additional inputs and management practices involved in intercropping, including seed cost, sowing operations, and intercrop maintenance. However, despite the increased cost, T5 delivered the highest economic returns, with a net income of ₹99,460 per hectare and a superior B:C ratio of 3.9. This clearly demonstrates that the additional investment in intercropping is justified by the substantial increase in productivity and profitability.

In comparison, the conventional method (T7) recorded a B:C ratio of 3.3, which, although economically viable, was lower than that of T5. The relatively higher cost in conventional cultivation is mainly due to intensive land preparation practices, which increase operational expenses without proportionate gains in yield. Similarly, other zero tillage treatments showed moderate economic performance, with T2 (60×30 cm spacing) emerging as the best among sole cropping systems.Overall, the findings indicate that zero tillage combined with intercropping not only reduces unnecessary input costs but also enhances economic returns through better resource utilization and increased productivity. This makes it a financially attractive option for farmers seeking sustainable agricultural practices.

4. Conclusion

The present study clearly establishes that the cultivation of maize under zero tillage conditions is both technically feasible and economically advantageous in the agro-climatic conditions of Tamil Nadu. The results highlight that zero tillage practices can effectively reduce production costs while maintaining or even improving crop productivity compared to conventional methods. Among the various treatments evaluated, maize grown at an optimized spacing of 60×30 cm under zero tillage, combined with black gram intercropping in a 1:1 ratio (T5), emerged as the most efficient and profitable system. This treatment not only recorded the highest grain yield but also demonstrated superior land-use efficiency and economic returns. The integration of pulse crops contributed to improved soil fertility, better nutrient availability, and enhanced system sustainability. Therefore, it can be recommended that farmers in Tamil Nadu adopt zero tillage maize cultivation with black gram intercropping at 60×30 cm spacing to achieve higher productivity, efficient resource utilization, and increased profitability. This approach aligns well with the principles of conservation agriculture and offers a sustainable pathway for improving maize-based cropping systems in the region.

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