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Influence of conservation tillage and weed management practices on growth and yield attributes of maize (*Zea mays* L.) in Sandy Loam soil of Odisha

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Abstract

The field experiment was performed during the *rabi* season of 2020-21 at the AICRP on Weed Management Block, Central Farm, Odisha University of Agriculture & Technology, Bhubaneswar, Odisha. This experiment was conducted with tillage and weed management systems in maize (*Zea mays* L.) using a split plot design having three replications. The three different tillage practices included in the experiment were CT, ZT+M with paddy straw mulch 5 t ha⁻¹ and zero tillage by dibbling (ZT). Four different weed management practices were applied in the subplots which include pendimethalin 1 kg ha⁻¹ pre-emergence treatment, tembotrione 120 g ha⁻¹ post-emergence treatment, manual weeding and weedy check. Conventional tillage gave the highest values of green leaves plant⁻¹, leaf area index, dry matter accumulation and most yield attributes. At harvest, conventional tillage recorded 15.10 green leaves plant⁻¹, LAI of 3.41 and dry matter accumulation of 256.09 g plant⁻¹. Among weed-management methods, pendimethalin gave the highest values of green leaves, LAI, dry matter accumulation and various yield attributes such as cob length (21.36 cm), cob girth (15.17 cm), rows cob⁻¹ (14.72) and 1000-grain weight (352.64 g). The harvest index was 38.22% in case of conventional tillage and 38.22% for pendimethalin. Overall, the study indicates that conventional tillage combined with effective weed control provided the strongest crop-growth and yield-attribute performance under the tested *rabi* maize conditions. However, the available manuscript does not report grain yield or the tillage × weed-management interaction, so productivity advantages of individual treatment combinations should not be inferred beyond the reported traits.

Keywords: Conservation agriculture, conventional tillage, zero tillage, paddy straw mulch, maize, pendimethalin, tembotrione, weed management, leaf area index, yield attributes

Introduction

Maize (*Zea mays* L.) is one of the major cereal crops grown worldwide because of its high productivity, wide adaptability and diverse uses as food, animal feed and industrial raw material. Its growth and productivity are greatly influenced by soil conditions, moisture availability, nutrient supply and weed competition. Therefore, the choice of tillage system is important for proper crop establishment and growth, as well as for maintaining soil moisture, managing crop residues and controlling weeds.

Continuous intensive tillage can gradually deteriorate soil structure, reduce soil organic matter and increase the risk of soil erosion. Conservation agriculture offers a more sustainable alternative by minimizing soil disturbance, retaining crop residues on the soil surface and improving resource-use efficiency. However, conservation tillage may not always result in higher maize yields, particularly during the initial years of adoption. Studies have shown that its effectiveness depends largely on climatic conditions, soil characteristics, residue management and other crop-management practices. Poor weed management, in particular, can reduce the potential benefits of reduced tillage [1-4]. Residue mulching can further improve the effectiveness of zero tillage by conserving soil moisture, reducing evaporation, moderating soil temperature and suppressing weed emergence. Studies on tropical maize production systems have reported improvements in grain yield and biomass with mulching, although the response varies with rainfall, soil fertility, mulch quality and management practices [5].

Conservation agriculture may also alter weed populations and species composition over time, making integrated and location-specific weed management essential [3, 6].

In Odisha, maize is cultivated under diverse soil and climatic conditions, including sandy loam soils where moisture conservation and timely weed control are particularly important. Therefore, the present experiment was conducted during the *rabi* season of 2020-21 to evaluate conventional and zero-tillage systems, with and without paddy-straw mulch, combined with different weed-management practices for their effects on maize growth and yield attributes.

2. Materials and Methods

2.1 Experimental site and season

The experiment was conducted during *rabi* 2020-21 at the AICRP on Weed Management Block, Central Farm, Department of Agronomy, Odisha University of Agriculture & Technology (OUAT), Bhubaneswar, Odisha, India. The experimental soil was sandy loam, with pH 5.6, bulk density 1.5 Mg m^{-3} , organic carbon 6.3 g kg^{-1} , available nitrogen $218.28 \text{ kg ha}^{-1}$, available phosphorus 21.36 kg ha^{-1} and available potassium $127.28 \text{ kg ha}^{-1}$. The maize hybrid used was 'Nilesh hybrid'.

2.2 Experimental design and treatments

The experiment was arranged in a split-plot design with three replications. Tillage practices were assigned to main plots and weed-management practices to subplots.

Factor	Code	Treatment
Tillage	T ₁	Conventional tillage (CT)
Tillage	T ₂	Zero tillage + paddy-straw mulch @ 5 t ha ⁻¹ (ZT+M)
Tillage	T ₃	Zero tillage by dibbling (ZT)
Weed management	W ₁	Pendimethalin @ 1 kg ha ⁻¹ , pre-emergence
Weed management	W ₂	Tembotrione @ 120 g ha ⁻¹ , post-emergence
Weed management	W ₃	Manual weeding
Weed management	W ₄	Weedy check

2.3 Tillage operations

Under zero tillage, soil disturbance was minimized and sowing was carried out by opening narrow furrows with a power-tiller-operated zero-till drill. The same sowing method was followed under ZT+M, along with the application of paddy straw mulch at 5 t ha⁻¹. About 5-10% of the residue from the previous rice crop was also retained in the field. Under conventional tillage, the field was prepared by disc ploughing, followed by 2-3 harrowings and planking to obtain a suitable seedbed for sowing.

2.4 Observations and calculations

Ten plants were selected randomly to record the number of fully opened, green and photosynthetically active leaves. The area of the third leaf from the top was measured using a leaf-area meter and leaf area index (LAI) was calculated following Watson (1947). For dry matter accumulation, five plants were sampled; the shoot portion was collected intact, sun-dried for 24 h and subsequently oven-dried at 80 °C to constant weight. At harvest, yield attributes such as cob length, cob girth, number of rows cob⁻¹, number of grains row⁻¹ and 1000-grain weight were recorded. Harvest index

was determined as the percentage of grain yield to total biological yield, following Donald (1962).

2.5 Statistical analysis

The experiment was conducted in a split-plot design with three replications. The manuscript presents the standard error of mean (SEM) and critical difference (CD) at $P = 0.05$ for the main treatment effects. However, the source file does not include the complete analysis of variance (ANOVA) table or statistical information on the tillage $\times$ weed-management interaction. Therefore, no additional conclusions regarding interaction effects were drawn or interpreted in the present revision.

3. Results and Discussion

3.1 Number of green leaves plant⁻¹

Tillage significantly influenced leaf number at 60 and 90 DAS (Table 1), whereas the effect at 30 DAS was non-significant. Conventional tillage recorded 5.37, 9.32 and 15.10 green leaves plant⁻¹ at 30, 60 and 90 DAS, respectively. At 60 DAS, the CT treatment recorded a significantly higher number of leaves than ZT (8.85) and remained statistically at par with ZT+M (8.98). Weed-management treatments significantly influenced leaf number at all three stages of crop growth. Among the treatments, pendimethalin produced the highest values (5.78, 9.53 and 15.47), followed by tembotrione (5.60, 9.27 and 15.27), while the lowest values were observed in the weedy check (4.58, 8.64 and 14.53). The improvement in leaf development under effective weed control may be attributed to reduced crop-weed competition for light, moisture and nutrients. Since conservation-agriculture practices can influence weed populations, suitable weed-management strategies are essential to achieve better crop growth rather than depending on tillage alone [3, 6].

Table 1: Effect of tillage and weed management practices on number of green leaves/plant

Treatments	30 DAS	60 DAS	90 DAS
Tillage			
T ₁ -Conventional Tillage (CT)	5.37	9.32	15.10
T ₂ -Zero tillage+Mulching (ZT+M) (Paddy straw @5t/ha)	5.25	8.98	15.05
T ₃ -Zero Tillage (ZT) (dibbling)	5.18	8.85	14.75
SEM $\pm$	0.09	0.09	0.09
CD ($p=0.05$)	NS	0.35	0.30
Weed Management			
W ₁ - Pendimethalin (Pre-emergence@ 1 kg/ha)	5.78	9.53	15.47
W ₂ - Tembotrione (Post-emergence@ 120 g/ha)	5.60	9.27	15.27
W ₃ - Manual weeding	5.11	8.73	14.73
W ₄ - Weedy check	4.58	8.64	14.53
SEM $\pm$	0.10	0.11	0.09
CD ($p=0.05$)	0.31	0.33	0.27

3.2 Leaf area index

LAI increased up to 60 DAS and declined thereafter (Table 2). Conventional tillage recorded the highest LAI at 30, 60 and 90 DAS (2.68, 4.87 and 3.41), with significant differences among the tillage practices. ZT+M showed intermediate values (2.44, 4.69 and 3.06), while ZT recorded the lowest LAI (2.12, 4.38 and 2.84). Weed-management practices did not significantly influence LAI,

although pendimethalin recorded numerically higher values at all stages (2.55, 4.85 and 3.37). The better canopy development under conventional tillage may be due to more favourable seedbed and root-zone conditions, which

supported early crop growth. In comparison, the performance of conservation tillage may vary depending on local climatic conditions, soil properties and effective management of crop residues ^[1, 2].

Table 3: Effect of tillage and weed management practices on dry matter (g plant⁻¹) production

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Tillage				
T ₁ -Conventional Tillage (CT)	27.48	117.66	170.48	256.09
T ₂ -Zerotillage+Mulching (ZT+M) (Paddy straw @5t/ha)	23.65	110.24	167.84	236.07
T ₃ -Zero Tillage (ZT) (dibbling)	15.68	92.26	165.41	220.64
SEm±	1.028	2.094	0.547	1.185
CD (p=0.05)	4.035	8.221	2.148	4.653
Weed Management				
W ₁ - Pendimethalin (Pre-emergence@ 1 kg/ha)	25.42	122.46	177.99	261.60
W ₂ - Tembotrione (Post-emergence@ 120 g/ha)	23.12	115.03	173.82	243.95
W ₃ - Manual weeding	21.84	100.34	164.29	234.70
W ₄ - Weedy check	18.69	89.05	155.54	210.15
SEm±	0.85	1.69	0.52	4.65
CD (p=0.05)	2.53	5.01	1.56	2.28

3.3 Dry matter accumulation

Dry matter accumulation increased rapidly up to 60 DAS (Table 3) and continued to rise until harvest. Conventional tillage recorded significantly higher dry matter at reported stages, reaching 256.09 g plant⁻¹ at harvest, compared with 236.07 g plant⁻¹ under ZT+M and 220.64 g plant⁻¹ under ZT. Among weed-management treatments, pendimethalin produced the highest dry matter at 30, 60, 90 DAS and

harvest (25.42, 122.46, 177.99 and 261.60 g plant⁻¹), whereas the lowest values were observed in the weedy check. Better dry matter accumulation under effective weed control may be attributed to reduced competition for available resources, resulting in greater assimilate production. However, the lower performance of zero tillage observed in this experiment may vary with site, climatic conditions and management practices ^[1, 2, 4].

Table 3: Effect of tillage and weed management practices on dry matter (g plant⁻¹) production

Treatments	30 DAS	60 DAS	90 DAS	At harvest
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SEm±	0.85	1.69	0.52	4.65
CD (p=0.05)	2.53	5.01	1.56	2.28

3.4 Yield attributes

Conventional tillage recorded the highest cob length (21.52 cm), cob girth (15.10 cm), number of rows cob⁻¹ (14.91), grains row⁻¹ (36.38) and 1000-grain weight (354.08 g). The corresponding values under ZT+M were 20.81 cm, 15.05 cm, 14.63, 36.18 and 338.87 g, while ZT recorded 20.58 cm, 14.81 cm, 14.39, 35.63 and 333.65 g, respectively. For weed management, pendimethalin recorded the highest cob length

(21.36 cm), cob girth (15.17 cm), rows cob⁻¹ (14.72) and 1000-grain weight (352.64 g). Number of grains row⁻¹ was numerically highest under manual weeding (36.41), although the reported CD indicated a non-significant treatment effect for this trait (Table 4). Better weed suppression likely improved resource availability during the critical reproductive stages, resulting in improved yield attributes ^[6, 7].

Table 4: Effect of tillage and weed management practices on yield attributes

Treatment	Cob length (cm)	Cob girth (cm)	Rows cob ⁻¹	Grains row ⁻¹	1000-grain weight (g)
T ₁ - CT	21.52	15.10	14.91	36.38	354.08
T ₂ - ZT+M	20.81	15.05	14.63	36.18	338.87
T ₃ - ZT	20.58	14.81	14.39	35.63	333.65
W ₁ - Pendimethalin	21.36	15.17	14.72	36.05	352.64
W ₂ - Tembotrione	20.97	15.05	14.69	36.04	345.47
W ₃ - Manual weeding	21.04	15.02	14.69	36.41	336.92
W ₄ - Weedy check	20.50	14.69	14.48	35.75	333.77

3.5 Harvest index

Tillage treatments did not significantly affect harvest index (Fig 1). However, conventional tillage recorded the highest numerical value (38.22%), followed by ZT+M (37.84%) and ZT (37.05%). Among the weed-management practices, pendimethalin recorded the highest harvest index (38.22%),

followed by tembotrione and manual weeding, whereas the lowest value was observed in the weedy check (37.14%). Since only the main-effect means were reported, the response of individual tillage $\times$ weed-management combinations could not be assessed from the available data.

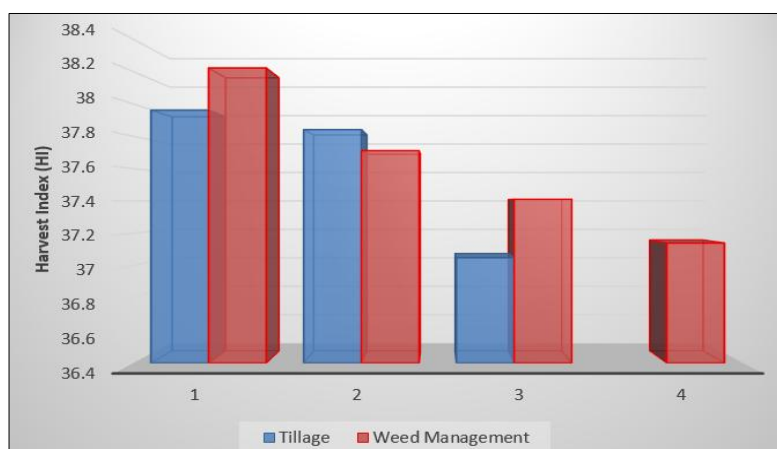


Fig 1: Effect of tillage and weed management practices on harvest index

4. Overall interpretation

The experiment showed that there is a significant main-effect superiority of the conventionally ploughed treatment in terms of the studied crop-growth characteristics and several yield-related attributes for the tested *rabi* maize environment. Efficient weed control was additionally found to contribute significantly to increased crop growth, where pendimethalin always provided the maximum values among the four weed control measures. The treatment combination ZT+M outperformed ZT in almost all measured growth and yield attribute factors, which could indicate that the residue retention strategy could have a complementary role in addition to decreased soil disturbance. However, the current dataset does not include the grain yield factor, treatment interaction means, weed density/biomass, or economic benefit. Consequently, conclusions should be restricted to the reported growth and yield attributes and harvest index.

5. Conclusion

Under the *rabi* 2020-21 conditions of the experimental site at OUAT, Bhubaneswar, conventional tillage resulted in better crop growth and recorded the highest values for most of the measured yield attributes of maize. Among the weed-management practices, pre-emergence application of pendimethalin at 1 kg ha⁻¹ generally recorded higher leaf number, LAI, dry matter accumulation and several yield attributes, followed by tembotrione. Zero tillage with paddy-straw mulch also performed better than zero tillage with dibbling alone. These results highlight the importance of combining suitable tillage and weed-management practices. However, multi-season studies covering grain yield, weed dynamics, economics and tillage $\times$ weed-management interactions are required before recommending a suitable combination for sandy loam soils of Odisha.

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