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Research Communication

Effect of tillage and precision nutrient placement on growth and productivity of maize (*Zea mays*)

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ABSTRACT

The experiment was conducted at ICAR-Indian Agricultural Research Institute, New Delhi during rainy season of 2022 to asses the effect of tillage and precise nutrient placement on maize (*Zea mays* L.) growth. Employing a split-plot design with 3-tillage methods in main plots, viz. T_1, (conventional tillage); T_2, (once rotavator as minimum tillage) and T_3, (zero tillage) and 4, precision nutrient application options N_1, 50% RDF as point placement; N_2, 75% RDF as band placement; N_3, 100% RDF as band placement and N_4, 100% RDF as broadcasting were tested in subplots. Results indicated that tillage and precision nutrient placement practices improved the plant height and LAI of maize. Minimum tillage recorded significantly higher crop growth indices, viz. CGR (1.92 g/m^2/day), RGR (26.80 g/g/day) and dry matter accumulation (204.58 g/plant) over other tillage practices at 60 to 90 Days after sowing (DAS). Root attributes also improved under minimum tillage. The grain yield was significantly higher with minimum tillage (6.22 t/ha) over other tillage practices. Among the precision nutrient application options, 100% RDF as band placement recorded significantly higher grain yield (6.20 t/ha) over N_2 and N_4 but remained statistically at par with 50% RDF point placement (6.06 t/ha). The findings suggested that adopting minimum tillage and precise nutrient point placement could significantly enhance maize growth and yield in *kharif* seasons, offering 50% reduction in fertilizer consumption.

Key words: Band placement, Maize, Minimum tillage, Point placement and Productivity

Maize (*Zea mays* L.) stands as a pivotal cereal crop globally and ranks third in importance within India, earning its moniker as the 'queen of cereals' due to its remarkable yield potential. India contributes 2% of the world's maize production, totaling 33.6 million tonnes in the 2022-23 period from 10 million hectares with productivity of 3349 kg/ha (GOI, 2023). However, the inadequate crop management and imbalanced nutrient management practices contribute to diminished maize productivity in the country. Tillage, a fundamental practice in crop cultivation, enhances soil tilth, water retention, aeration, and moderates' soil hydraulic conditions (Karami *et al.,* 2012). While intensive tillage poses challenges, such as, soil compaction and reduced stability, minimum or reduced tillage aims to minimize soil disturbance, ensuring an optimal seed bed and conducive growing conditions. Optimal nutrient application directly at the crop's root zone improve root development, nutrient assimilation, and biomass accumulation, leading to increased yield (Dass *et al.*, 2014). Zero tillage further enhances soil properties, including aggregate stability and temperature regulation (Irizar *et al.,* 2013). The growth parameters and yield of maize increased with the increasing level of nitrogen from 0 to 240 kg/ha (Bamboriya *et al.*, 2023). Chen *et al*. (2016) reported that grain yield was 15% higher with banded N fertilizer treatment compared to broadcast application. Long-term conservation agriculture (CA) with point placement of N fertilizer has been identified as a strategy to enhance crop productivity, profitability, and nutrient uptake (Nayak *et al.*, 2022). Precision nutrient management with nutrient expert system under zero-tillage with crop residue (3.5 t/ha) increased the productivity and profitability of maize (Sepat *et al.,* 2023). In the light of these considerations, the study aimed to investigate the effect of tillage and precision nutrient placement on the growth and productivity of maize.

A field experiment conducted during the rainy (*kharif*) season of 2022 at the ICAR–Indian Agricultural Research Institute, New Delhi, aimed to assess the effect of tillage and precision nutrient placement on growth and productivity of maize (*Zea mays* L.). The soil characteristics of the

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experimental site showed a sandy loam composition with 58.6% sand, 22.8% silt, and 18.6% clay, along with electrical conductivity of 0.66 dS/m and a soil pH of 7.6. The bulk density of the 0–15 cm surface soil was 1.51 g/cm^3, featuring 0.41% oxidizable organic carbon, available N at 225 kg/ha, available P at 12.3 kg/ha, and available K at 230 kg/ha. The experiment was tested in a split-plot design with 3-tillage practices, viz. T_1, conventional tillage (field was ploughed 3-times with cultivator followed by rotavator); T_2, Minimum tillage (field was prepared with one rotavator and previous 30% crop residue incorporated in the soil and T_3, Zero tillage (field was not disturbed and 3 t/ha anchor wheat residues) in main plots and 4-methods of precise nutrients application options, viz. N_1 -50% RDF (1/3rd point placement as basal, 30 and 50 DAP); N_2 75% RDF (1/3rd band placement as basal, 30 and 50 DAP); N_3 100% RDF (1/3rd band placement as basal, 30 and 50 DAP) and N_4 100% RDF as conventional (1/3 basal + 2 Top dress broadcasting at 30 and 50 DAP). In point placement, fertilizers were placed between the plants in a row with the help of dibbler while in band placement, fertilizers applied in a continuous band between the rows. Maize Hybrid 'Kaveri 25K55' was sown on 16th of July 2022 in rows keeping row to row distance of 60 cm and plant to plant distance of 20 cm with seed rate of 20 kg/ha. The recommended dose of 150:60:50 kg/ha N, $P_2O_5K_2O$ was applied through urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) in maize. The amount of fertilizers applied for each subplot is mentioned in Table 1. The other agronomic practices like weed, water, insect-pests management etc. were kept common for all treatments. The root parameters such as fresh root weight (g/plant), dry root weight (g/plant), root volume (cm^3) and root mass density (g/cm^3) were analysed using WINRHIZO software by scanning and analysing (Pang *et al.,* 2011). The crop growth parameters, like plant height, dry-matter accumulation (DMA), leaf-area index (LAI) and yields were determined using standard procedures (Rana *et al.,* 2014). Crop growth indices, like CGR and RGR were calculated using standard equations (Watson 1952). The amount of available nitrogen, phosphorous and potassium were analysed as per standard procedures (Subbiah and Asija, 1956,

Table 1. Fertilizers applied to each treatment

Precision nutrient application method	N (kg/ha)	P (kg/ha)	K (kg/ha)
N_1, 50% RDF (Point placement)	75	30	25
N_2, 75% RDF (Band placement)	112.5	45	37.5
N_3, 100% RDF (Band placement)	150	60	50
N_4, 00% RDF (Broadcasting)	150	60	50

Table 2. Effect of tillage and precision nutrient placement on various growth parameters of maize

Treatment	Plant height (cm)		Leaf area index		Dry matter accumulation (g/plant)		CGR (g/m^2/day)		RGR (g/g/day)	
	30 DAP	60 DAP	30 DAP	60 DAP	60 DAP	60 DAP	30–60 days	60–90 days	30–60 days	60–90 days
Tillage										
T_1, Conventional tillage	56.9	148.4	1.90	3.80	22.48	76.87	0.90	1.70	41.05	27.71
T_2, Reduced tillage	64.1	157.5	2.15	4.23	24.14	89.06	1.08	1.92	43.44	26.80
T_3, Zero tillage	61.5	145.7	1.94	3.98	23.31	86.12	1.04	1.60	43.47	27.81
SEm±	2.47	2.73	0.04	0.07	0.20	1.50	0.02	0.16	0.63	0.56
CD (P=0.05)	5.14	8.07	0.18	0.31	0.83	6.0	0.10	NS	NS	NS
Precision nutrients application										
N_1, 50% RDF (Point placement)	62.9	153.2	2.05	4.12	23.39	84.91	1.02	1.81	42.91	27.75
N_2, 75% RDF (Band placement)	59.4	150.53	1.92	3.90	23.24	82.81	0.99	1.83	42.27	27.83
N_3, 100% RDF (Band placement)	64.1	159.48	2.34	4.37	24.38	88.75	1.07	1.85	42.87	26.66
N_4, 100% RDF (Broadcasting)	57.0	138.87	1.69	3.63	22.24	79.6	0.95	1.46	42.56	27.54
SEm±	1.59	3.16	0.10	0.08	0.31	1.66	0.02	0.16	0.51	0.56
CD (P=0.05)	2.90	9.32	0.30	0.23	0.94	4.97	0.07	NS	NS	NS
Interaction					NS					

DAP: Days after planting

Olsen, 1954 and Jackson, 1973). The significant of the recorded data was tested by analysis of variance (ANOVA) using OPSTAT software. Standard error of mean and least significant difference (LSD) at 5% level of significance were calculated for each treatment and treatment means were compared.

The maximum values for the growth parameters of maize were recorded with minimum tillage (T_2) and found in most of the cases significant over conventional tillage (T_2) but remained at par with zero tillage (T_3) at 30 and 60 DAP (Table 2). Notably, zero tillage showed comparable results to minimum tillage at at all growth stages. These results might be due to the minimum soil disturbance and crop residue incorporation and retention helped in maintaining congenial microclimate for plant growth (Nayaka *et al.,* 2021). Among precision nutrient application options, the maximum values for the growth parameters were recorded with the 100% RDF as band placement (N_3) while the lowest values for the same recorded with 100% RDF as conventional broadcasting (N_4) at all growth stages of maize. However, the growth parameters remained statistically at par with 50% RDF as point placement (N_1) and 100% RDF as band placement (N_3) in most cases. Point placement of fertilizer led to the highest concentration of nutrients around the crop's root zone. This facilitated easy nutrient uptake by the roots, resulting in enhanced crop growth indices due to improved dry matter accumulation throughout the crop growth period (Nayak *et al.,* 2022).

The root parameters viz., fresh root weight, dry root weight, root volume, and root mass density, revealed the highest values at the 0-30 cm soil depth with minimum tillage followed by zero tillage (Fig. 1). The enhanced root growth observed in minimum tillage and zero tillage was attributed to increased nutrient availability and soil aeration, fostering greater photosynthate production and subsequent root development compared to conventional tillage (CT). These findings align with prior research by Nayaka *et al.,* 2021 supporting the idea that reduced soil disturbance improve the microclimate which helped in increased maize growth parameters.

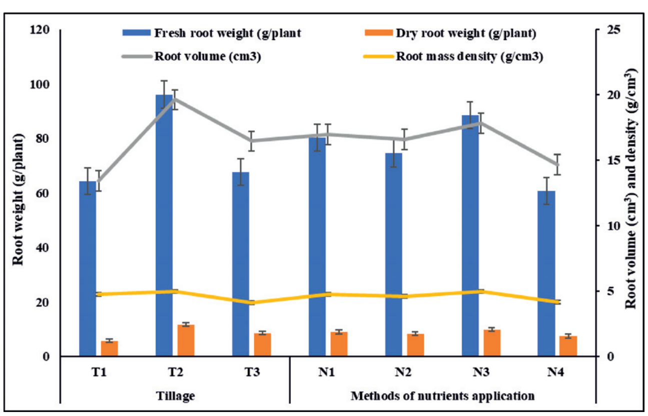

Fig. 1. Effect of tillage and precision nutrient placement on root parameters of maize

The precision nutrient application methods indicated that 100% RDF band placement resulted in the highest fresh root weight, dry root weight, root volume, and root mass density followed 50% RDF point placement (Fig. 1). This outcome suggests that applying nutrients directly close to the plant roots minimizes losses and enhances nutrient uptake, facilitating robust root growth. The findings corroborate with research conducted by Mashingaidze *et al.* (2010), emphasizing the effectiveness of targeted nutrient application methods in promoting optimal root development.

The productivity of maize was significantly influenced by tillage and precision nutrient application strategies (Fig. 2). Minimum tillage recorded 11.6% higher grain yield (6.22 t/ha) compared to conventional tillage (5.57 t/ha), but remained statistically at par with zero tillage (6.13 t/ha). The better performance of maize under minimum and zero tillage happened mainly due to improved soil structure, leading to enhanced water infiltration, root penetration, water retention and enhanced soil health (Choudhary *et al*., 2019). Notably, 100% RDF as band placement resulted in 4.91 and 8.39% higher grain yield (6.20 t/ha) compared to 75% RDF as band placement (5.91 t/ha) and 100% RDF broadcasting (5.72 t/ha), respectively. However, productivity of maize with 50% RDF point placement (6.06 t/ha) was statistically at par with 100% RDF as band placement. The lowest maize productivity was observed with 100% RDF broadcasting. The higher nutrient use efficiency under point placement over band placement, contributes to the superior performance in maize yield attributes (Nkebiwe *et al.,* 2016).

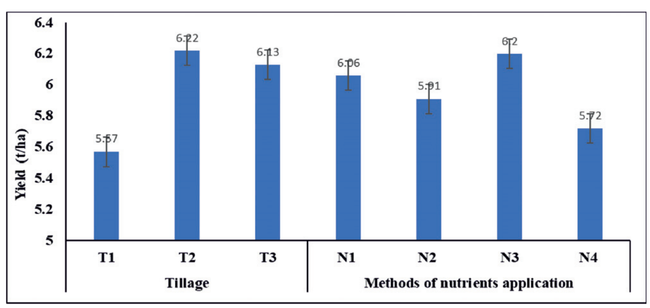

Fig. 2. Effect of tillage and precision nutrient placement on productivity of maize

There was non-significant effect on available NPK after the harvest of maize of tillage practices, while significant variations had been recorded with precision nutrient management practices (Table 3). The maximum values of available NPK were recorded with minimum tillage, which might be the result of partial incorporation of previous crop

Table 3. Effect of tillage and precision nutrient placement on soil fertility status after the harvest of crop

Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Tillage			
T_1, Conventional tillage	150.34	11.54	216.18
T_2, Minimum tillage	160.46	13.06	238.65
T_3, Zero tillage	153.26	12.96	222.81
SEm±	5.00	0.38	5.59
CD (P=0.05)	NS	NS	NS
Methods of nutrients application			
N_1, 50% RDF (Point placement)	133.93	11.30	203.95
N_2, 75% RDF (Band placement)	150.73	12.45	229.12
N_3, 100% RDF (Band placement)	169.93	14.11	239.74
N_4, 100% RDF (Broadcasting)	164.16	12.23	230.72
SEm±	6.30	0.49	5.82
CD (P=0.05)	18.89	1.48	17.43

residue. Among the precision nutrient application methods, both 100% RDF as band placement and 100% RDF as conventional broadcasting led to significantly higher available NPK over 50% RDF as point placement after maize harvest. The available NPK with 75% RDF as band placement was found statistically at par with 100% RDF as band placement and 100% RDF as conventional broadcasting. However, it remained statistically comparable to 100% RDF broadcasting. These differences in available NPK were due to the application of higher doses under 100% RDF treatments.

Minimum tillage produced higher growth and yield attributes which resulted in significantly higher grain and straw yields over CT, while remained statistically at par with ZT. Band placement of 100% RDF resulted in significantly higher values of growth, yield attributes and productivity of maize as compared to band placement of 75% RDF and conventional 100% RDF but it remained statistically at par with point placement of 50% RDF. However, available NPK was not affected by tillage practices. Thus, with the adoption of point placement of 50% RDF and 75% RDF band placement, 50 and 25% fertilizers can be saved over conventional 100% RDF broadcasting.

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