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Research Communication

Assessing productivity and profitability of maize (*Zea mays*) under conservation tillage and nutrient management

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ABSTRACT

The field experiment was conducted during the rainy (*kharif*) season of 2017 at New Delhi, to study the effect of tillage and nutrient management on productivity and profitability of maize (*Zea mays* L.). The results showed that zero-tilled flat bed (ZTFB) × 'nutrient expert' (NE)-based fertilization had the tallest plant, higher leaf-area index and accumulated the highest dry-matter irrespective of crop growth stages. Further, ZTFB-planted maize had higher yield by ~2% and ~25% than permanent beds (PNB) and conventional tillage (CT), respectively. Similarly, NE resulted in the maximum grain yield, but at par to recommended fertilization (RFA); which was ~17% higher than half the recommended fertilizer application (RFA) ½ + residue retention (CR). The maximum gross and net returns were recorded in permanent beds × NE planted maize which was similar to ZTFB × NE plots. Overall, our results indicated that adoption of conservation tillage coupled with NE-based nutrient management improved the productivity and profitability of maize.

Key words **:** Maize, Productivity, Profitability, Tillage, Nutrient-management, Conservation agriculture

Maize is an important cereal crop for food and nutritional security. It is considered as 'queen of cereals' because of its highest genetic yield potential among cereals and wider adaptability to different soil and climatic conditions (Parihar *et al.,* 2018). Despite of its higher genetic potential, the productivity of maize has not been intensified and considerable yield gaps are noticeable in different areas of India (Jat *et al.,* 2013). Thus, conventional system could be reoriented to conservation agriculture (CA)-based tillage practices, as it improves soil physico-chemical and biological properties (Parihar *et al.,* 2017), minimizes working expenditure (Sharma *et al.,* 2011) and hence assures higher crop yield and net returns. Prior studies indicated a little or no difference in yields of crops under zero-tilled systems as against conventional tillage. However, yield variability under zero-tillage remains a major concern among farmers and zero-tillage practices are more advantageous when residues are retained on the soil surface. Maize-based systems are nutrient exhaustive and extract more nutrients from different soil layer. Hence, proper nutrient-management is necessary to obtain higher yield and supply plant nutrients adequately. Therefore, different nutrient-management strategies, viz. nutrient expert (NE), recommended fertilizer application (RFA), and farmers fertilizer practices (FFP), along with maintaining ~30% residues of crops hold potential to enhance available nutrient status, fulfil the crop-nutrient demand and increase the soil organic matter content. 'Nutrient expert' is based on the principle of site-specific nutrient-management (SSNM), and thus provides fertilizer recommendations by considering yield responses and targeted agronomic efficiencies along with contribution of nutrients from indigenous sources (Pooniya *et al.,* 2015). Published data indicated that NE results in more yields and remunerative in terms of financial cost (Sapkota *et al.,* 2014). Therefore, aim of our study is to evaluate the influence of different tillage and nutrient management on productivity and profitability of maize.

The field experiment was conducted during the rainy season 2017 at ICAR-Indian Agricultural Research Institute, New Delhi. The area falls under 'Trans-Gangetic Plain' and experiences subtropical semi-arid climate. The total rainfall received during study period was ~565 mm and monthly variation in maximum, minimum temperatures and relative humidity (RH) ranged between ~32-35°C, 18 and 26°C and 75 and 90% respectively. The ex-

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perimental soil (0–15 cm) was sandy-loam in texture with *p*H 7.31 (1 : 2.5 soil and water ratio) and contained 0.414% Walkley-Black C (oxidizable SOC), 159.9 kg/ha alkaline $KMnO_4$-N, 15.6 kg/ha M-$NaHCO_3$-extractable-P and 161.3 kg/ha NH4OAc-K. The experiment was laid out in a split-plot design with 3 replications; consisting of 3 tillage practices (main-plots) [conventional tillage (CT), zero till flat beds (ZT–FB) and permanent beds (PNB),] and 4 nutrient-management (subplots) [farmers fertilizer practices (FFP), recommended fertilizer application (RFA), nutrient expert-assisted: site-specific nutrient-management (NE), half recommended fertilizer application + 2.5 t crop residue ha (½ RFA + CR). Maize hybrid 'PMH 1' was sown manually on 25 June using seed at 67 cm × 15–20 cm spacing in all respective plots and harvested in the second fortnight of October. All recommended package of practices except the treatments were followed uniformly. Growth parameters such as plant height, leaf-area index (LAI) and dry-matter accumulation were recorded at different growth stages, i.e. at 35 days after sowing (DAS), 70 DAS and physiological maturity. The leaf-area was measured using leaf-area meter (1/2–MDL–1,000, LICOR Ltd, USA).

For dry-matter accumulation, plants from sampling rows were uprooted, shade-dried and kept in oven at 65 ±5°C for 48 hr till constant weight was obtained. The dry weight of plants was expressed in g/plant. At maturity, maize was harvested manually from the net plot area leaving border rows and grain yield from each plot were reported. However, stover yield was determined after air drying and was expressed in t/ha. Total production cost and gross returns (maize grain price: ₹14,250/t, maize stover price: 1,000/t) were computed based on the prevailing market rates and minimum support price for the year 2017. Net income was calculated as the difference between gross income and total cost of production. Analysis of variance (ANOVA) was done to determine treatment effects (Gomez and Gomez, 1984). Fisher's least significant difference was used as a post hoc mean separation test (P<0.05) using Proc GLM in SAS 9.3 software.

Tillage and nutrient management had a significant (P=0.05) effect on plant height and leaf-area index at different growth stages except at 70 DAS (Table 1). However, tallest plant and maximum LAI were recorded under ZTFB, which was at par with PNB. Similarly, NE plots had the maximum plant height and LAI, irrespective of crop-growth stages compared to the other treatments. The tillage practices did not significantly affect the dry-matter accumulation at 35 DAS, while at 70 DAS and physiological maturity it showed significant differences. The maize planted on permanent beds had accumulated the highest dry-matter, followed by ZTFB plots. Similarly, NE resulted in the highest dry-matter accumulation and remained at par with RFA (Table. 1). The different tillage practices had significant impact on different yield attributes except weight/cob and 100-grain weight (Table 2). The maximum values for cob yields (5.52 Mg/ha), cob length (15.8 cm) and 100-grain weight (26.3 g) were recorded with ZTFB, while permanent beds resulted in higher weight/cob (130.5 g), grain weight/cob (106.8 g). Similarly, yield components were also significantly influenced by various fertilization practices. The application of nutrients based on NE–SSNM approach resulted in higher cob yields (5.49 Mg/ha), cob length (16.2 cm), weight/cob (137.1 g), grain weight/cob (110.8 g), and 100-grain weight (26.4 g), closely followed

Table 1. Effect of conservation tillage and nutrient-management on plant height, leaf-area index and dry-matter accumulation (DMA) of maize

Treatment	Plant height (cm)			Leaf-area index			DMA (g/plant)		
	35 DAS	70 DAS	PM	35 DAS	70 DAS	PM	35 DAS	70 DAS	PM
Tillage practices									
PNB	45.7	170.3	180.7	3.20	4.39	3.21	69.7	133.0	151.4
ZTFB	50.7	171.8	180.2	3.24	4.47	3.60	70.4	136.6	149.5
CT	45.4	168.4	175.8	2.74	4.25	3.00	65.8	122.3	139.7
SEm±	1.34	2.30	1.07	0.11	0.10	0.05	2.40	3.14	2.22
CD (P=0.05)	4.00	NS	NS	0.41	NS	NS	NS	12.33	8.70
Nutrient management									
FFP	37.5	165.0	177.2	2.72	3.96	3.00	61.5	120.6	125.5
RFA	48.8	173.6	179.3	3.11	4.48	3.05	70.3	135.0	160.8
NE–SSNM	55.3	175.3	183.2	3.41	4.91	3.58	76.9	142.4	164.2
½ RFA + CR	47.5	166.8	175.9	3.00	4.14	3.45	65.8	124.5	137.1
SEm±	0.49	2.48	2.21	0.08	0.10	0.09	2.32	3.08	2.93
CD (P=0.05)	1.92	7.37	6.57	0.25	0.29	0.26	6.91	9.14	8.71

PNB, permanent bed; ZTFB, zero-tilled flat bed; CT, conventional tillage; FFP, Farmers fertilizer practice;
RFA, Recommended fertilizer application; NE-SSNM, Nutrient Expert-Site Specific Nutrient Management; CR Crop Residue; DAS, Days after sowing; PM, Physiological maturity of the crops

by RFA.The NE–SSNM increased the grain weight/cob by ~10%, ~13 and ~20% compared to RFA, ½ RFA + CR and FFP respectively. The adoption of CA practices provides favourable microclimate due to improved aeration and adequate moisture supply to support healthy crop growth (Jat *et al*., 2013a). Another reason might be owing to improvement in different soil properties resulted from the balanced nutrient use and improvement in soil-nutrient status (Parihar *et al.,* 2016). The ZTFB resulted in significantly higher grain yield than CT, but statistically similar to PNB; which was ~25% more than CT (Fig. 1 a, b). The NE resulted in significantly higher grain yields being ~6% and ~17% more than RFA and ½ RFA + residue retention (CR) respectively. With regard to stover yield, PNB × NE recorded maximum values than the other treatment combinations. The higher yield of maize in ZTFB system could be the result of compound effects of residue retention and favourable soil properties (Blanco-Canqui *et al.,* 2006), lesser weed population (Ozpinar and Cay, 2006), better water regimes and improved nutrient-use efficiencies. The CT × RFA was the costliest treatment and PNB × NE fetched the maximum returns, which was very close with ZTFB × NE treatment combination (Fig. 2). This increment in net returns was mainly attributed to reduced cultivation cost, enhanced input-use efficiency and improved yield per hectare.

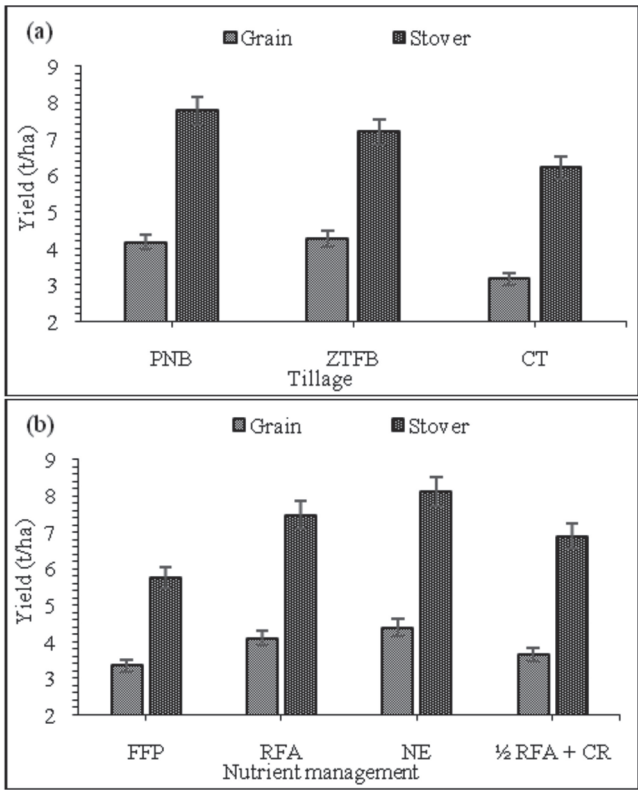

Fig. 1. Effect of conservation tillage (a) and nutrient management (b) on yield of maize. The vertical bar indicates CD at *P*=0.05.

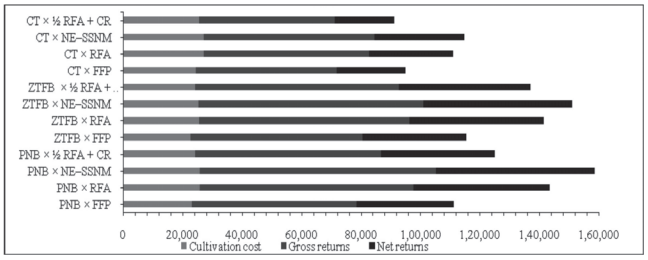

Fig. 2. Effect on cost of cultivation, gross and net returns of maize under conservation tillage and nutrient-management.

Table 2. Effect of different tillage and nutrient management on yield attributes of maize crop.

Treatment	Cob length (cm)	Weight/cob (g)	Cob yield (Mg/ha)	Grain Weight/cob (g)	100–grain Weight (g)
Tillage practices					
PNB	15.8	130.5	5.08	106.8	25.9
ZTFB	15.9	127.8	5.52	99.3	26.3
CT	14.8	118.0	4.07	93.5	25.5
SEm±	0.18	3.50	0.29	2.22	0.39
CD (*P*=0.05)	0.69	NS	1.13	8.71	NS
Nutrient-management					
FFP	14.5	115.7	4.18	91.0	24.7
RFA	15.7	122.1	5.18	100.2	26.2
NE–SSNM	16.2	137.1	5.49	110.8	26.4
½ RFA + CR	15.4	126.9	4.70	97.4	26.2
SEm±	0.17	3.29	0.15	2.83	0.26
CD (*P*=0.05)	0.49	9.78	0.42	8.42	0.78

PNB, permanent bed; ZTFB, zero-tilled flat bed; CT, conventional tillage; NE-SSNM, nutrient expert-site specific nutrient management; RFA, recommended fertilizer application

Thus, it is concluded that conservation tillage along with nutrient expert-based fertilization improved the crop productivity and profitability of maize.

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