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Research Communication

Tillage and nutrient management strategies for improving productivity and profitability of maize (*Zea mays*)

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ABSTRACT

The experiment was carried out during *Kharif* season of 2021 at Farm unit 5, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, U.P. (India) to evaluate the effect of tillage and nutrient management strategies on maize productivity. The experiment was laid out in a split plot design with 2 tillage options *i.e.,* Conventional tillage (CT) and Raised beds planting (RBP) as main plots and 5 nutrient management practices*, viz.* FP (Farmer practice), ST (State recommendation), STBR (soil test-based recommendation), NE (Nutrient expert™) 6t/ha and NE 7 t/ha were assigned in sub-plots with 3 replications. The RBP recorded significantly higher yield attributes, *viz.* cob girth (16.8 cm), grain row/cob (16.2), grain/row (40.6), no. of grain/cob (700.1), grain weight/cob (162.7 g) over CT. Similarly, significantly higher grain (7.22 t/ha), stover (11.01 t/ha), cob (9.72 t/ha), biological yield (20.70 t/ha), total uptake of N, P and K, gross return, net return and B: C ratio was noted in RBP than CT. The yield attributes, yield parameters nutrient uptake and economics in maize were significantly influenced by nutrient management techniques. The maximum yield attributes*, viz.* cob girth, grain row/cob, grain/row, no. of grain/cob, grain weight/cob and yield were recorded under NE @7 t/ha. Similarly, total uptake of N, P and K, gross return, net return and B: C ratio was noted NE @7 t/ha than remaining other treatment. Overall, results revealed that growing maize on permanent raised bed along with NE @ 7 t/ha is a promising option for sustaining the productivity of maize intensively grown in Upper Gangetic Plains of India.

***Key words*:** Conventional tillage, Nutrient Expert, Nutrient uptake, Nutrient Management, Raise Bed planting and Productivity

Maize (*Zea mays* L.) is a major grain crop in the world due to its high yield potential and adaptation to diverse climatic conditions than other cereals crops. It occupies an important place as food (13%), animal feed (13%), poultry feed (47%), processed food products (7%), starch (14%) and in other uses (6%) (FAOSTAT 2018). Maize is also grown for a variety of different reasons, including high protein maize, sweet corn, baby corn, popcorn, waxy corn, high oil, and high amylase corn. It is considered a good fodder crop because it is free from antinutritional factors, has high productivity, energy and soluble carbohydrates compared to other forage crops (Satyanarayana *et al.,* 2013). Under farmer's field condition, the imbalanced use of nutrients due to more application of N and P fertilizers and neglecting potassium fertilizers cause poor growth and productivity of maize crop. K is a major nutrient element involved in increasing resistance to drought as well as biotic stresses. The huge yield gap exists due to the mismatch between state recommendation and farmer's practice which not only decreases the yield but also causes nutrient mining in regions like Upper Gangetic Plains (UGP). To mitigate these adverse effects, resource conservation technologies (RCTs) like direct drilling, zero tillage, bed planting and laser land levelling etc. have saved substantial quantity of irrigation water, improving water and nutrient-use efficiency (Jat *et al.,* 2014). Under these circumstances, precision nutrient-management strategy as site-specific nutrient management (SSNM) approach may augment crop

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productivity and sustain the soil health through ensuring an adequate supply of the nutrients specific to the crop and soil (Singh *et al.,* 2016). The present study was under taken to assess the effect of precision nutrient-management prescription on growth, yield and yield attributes of CA-based maize-production system.

The field experiment was carried out during *Kharif* season of 2021 at Farm unit 5, IIAST, Integral University, Lucknow, U.P. (India). The soil of experimental site was sandy clay loam in texture with *p*H 7.2. The soil was low Walkley–Black carbon (0.46%), oxidizable N (262.00 kg/ha) and medium in available Olsen's, phosphorous (22 kg/ha) and potassium (220 kg/ha). The experiment consisted of 10 treatment combinations comprising of 2 tillage systems, viz. Conventional tillage (CT) and Raised Beds planting (RBP) in main plots while, five nutrient management practices, *viz.* FP (Farmer practice), ST (State recommendation), STBR (Soil test-based recommendation), NE (Nutrient expert™ 6t/ha), and NE 7t/ha. were assigned in sub-plots under split plot design with 3 replications. Maize variety "Shiv Ganga 25" was sown in monsoon season using seed drill in CT and a bed planter in RBP. Seed rate was kept at 20 kg/ha and row to row and plant to plant spacing was maintained at 60 cm × 20 cm. The dose of fertilizers was applied based on treatment. The 4–5 irrigation were used throughout the agricultural growing season to supplement rainfall during rainy periods. To provide an ideal weed free environment in maize crop a pre-plant application of glyphosate @ 1.00 kg *a.i.*/ha one week before sowing followed one hand weeding at 20 DAS in CT plots and spraying of tembotrione @ 120 ml *a.i.*/ha at 25 days after sowing in RBP was made, respectively. Granules of furadan (Carbofuron) were applied in a whorl pattern to provide protection against borer attack. All the data was statistically analyzed using the analysis of the variance (ANOVA) technique. The critical differences at 0.05% level of probability were calculated to assess the significance between treatments if significant (Gomez and Gomez 1984).

Different tillage practice and nutrient-management options significantly influenced the yield attributes except no. of cob/plant, cob length and 1,000 seed weight of maize (Table 1). The maximum cob girth (16.8 cm), grain row/cob (16.2) grain/row (40.6), no. of grain/cob (700.1) and grain weight/cob (162.7 g) were obtained with RBP, which was significantly higher than CT practice. Increased growth parameters (leaf area, dry matter accumulation, LAI and higher CGR) in RBP causing more photosynthesis production during vegetative phase and its efficient translocation towards sink led to higher yield attributes parameters. In fact, crop residue retention improves water and nutrient availability to crop and inhibit crop-weed

Table 1. Effect of tillage and nutrients management options on growth parameters and yield attributes of maize

Treatment	Cob/ plant	Cob length (cm)	Cob girth (cm)	Grain row/ cob	Grain/ row	Grain/ cob	Grain weight/ cob	1000 seed weight (g)	Grain yields (t/ha)	Stover yield (t/ha)	Cob yield (t/ha)	Biological yield (t/ha)	Shelling (%)	Harvest index (%)
Tillage practices														
CT	1.6	20.1	15.1	14.9	36.8	559.0	148.2	258.9	6.14	9.66	8.21	17.87	74.30	34.30
RBP	1.7	21.50	16.8	16.2	40.6	700.1	162.7	265.6	7.22	11.01	9.72	20.70	74.70	34.80
SEm±	0.03	0.04	0.10	0.3	1.1	4.2	2.4	2.0	0.10	0.21	0.24	0.25	1.2	0.9
CD (P=0.05)	NS	NS	0.5	1.2	2.7	16.3	8.5	NS	0.32	0.87	0.66	0.91	NS	NS
Nutrient management options														
FP	1.6	19.9	15.4	15.3	32.6	579.6	144.9	257.2	6.08	9.65	8.18	17.84	74.10	34.00
ST	1.6	20.4	15.9	15.6	35.8	584.6	155.9	259.7	6.51	9.82	8.69	18.49	74.20	34.30
STBR	1.7	20.6	16.1	16.0	36.0	631.3	156.0	263.2	6.80	10.23	9.17	19.87	74.30	34.60
NE @ 6 t/ha	1.8	20.8	16.2	16.6	40.5	668.8	157.7	265.2	7.00	10.74	9.34	20.05	74.50	35.00
NE @ 7 t/ha	1.8	20.9	16.4	16.6	40.8	683.8	163.0	266.1	7.02	10.76	9.45	20.19	75.10	35.10
SEm±	0.03	0.01	0.01	0.12	0.6	2.6	1.7	2.1	0.05	0.03	0.04	0.04	0.03	0.02
CD (P=0.05)	NS	NS	0.2	0.5	2.5	20.9	6.1	NS	0.16	0.13	0.25	0.19	NS	NS

Where, CT, Conventional tillage; RBP, raised bed planting; FP, farmer practices; ST, state recommendation; STBR, soil test based recommendation; NE, nutrient expert™

competition for nutrients and water, ultimately produced higher yield (Saad *et al.,* 2014). The higher cob girth (16.4 cm), grain row/cob (16.6) grain/row (40.8), no. of grain/cob (683.8) and grain weight/cob (163 g) were recorded under NE @ 7/ha followed by NE @ 6 t/ha and being significantly higher than other treatments. Banerjee *et al*., 2014 reported that STB fertilizer recommendations are based on a general fertility rating (Low, medium and high) which do not match with actual crop requirement especially for high yield cultivars, therefore lesser yield and yield attributes were noticed.

The tillage practices and nutrient management options had preformed effect on grain, stover, cob and biological yield however, selling and harvest index did not very significantly. The maximum grain (7.22 t/ha), stover (11.0 t/ha), cob (9.72 t/ha) and biological (20.70 t/ha) yields were recorded under RBP which were significantly higher than CT (6.14, 9.66, 8.21 and 17.87 t/ha, respectively). The higher yield on RBP may be visualized as lower soil bulk density in top (0–15 cm) soil depth which facilitated better initial crop establishment, more root proliferation leading to efficient soil-nutrient utilization (Hasanain *et al.,* 2021). The maximum grain (7.02 t/ha), stover (10.76 t/ha), cob (9.45 t/ha) and biological (20.19 t/ha) yield were recorded under NE @ 7/ha followed by NE @ 6 t/ha and being significantly higher than other treatments. The site-specific information captured by NE helps for assessing soil supply capacity and actual nutrient required to far targeted yield, therefore, productivity improves (Sapkota *et al*., 2014). In fact, science of synchronizing nutrients supplies from the soil with the plant demand a complex task, which is ensured through precision nutrient management (Banerjee *et al*., 2014).

Different tillage practice and nutrients management options significantly influenced the total N, P and K in maize (fig. 1&2). The maximum total uptake of N (160.0 kg/ha), P (54.0 kg/ha) and K (196.6 kg/ha) with RBP, which was significantly higher than CT practice. The higher amount of

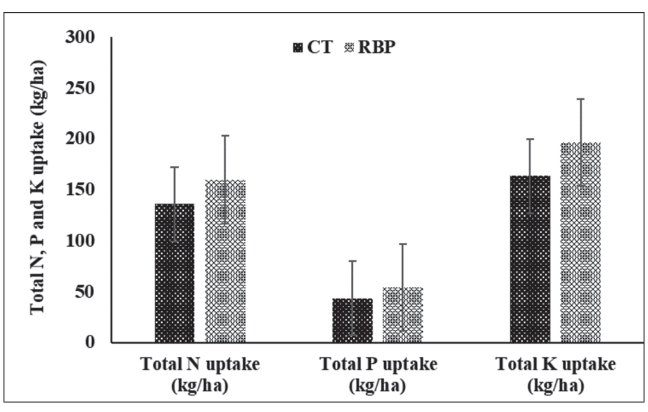

Fig. 1. Effect of tillage practices on nutrient uptake in maize

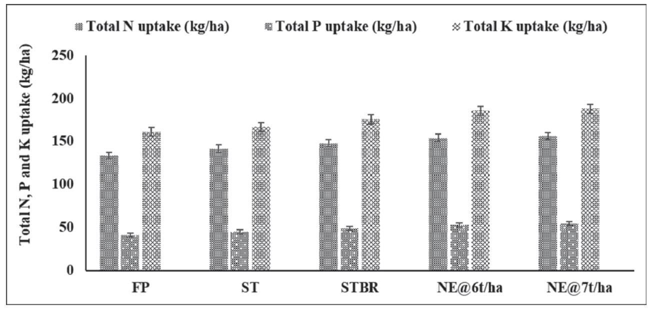

Fig. 2. Effect of nutrient management options on nutrient uptake in maize

uptake of nutrients under RBP was associated with higher biomass production which led to higher uptake of N, P and K (Naresh *et al.,* 2014). The higher nutrient uptake in RBP was mainly due to reduced nutrient loss, availability of sufficient soil moisture for mineralization of native as well as applied nutrients, and efficient utilization of available nutrients through better root growth and proliferation on ridge bed (Hasanain *et al.,* 2021). The maximum total uptake of N, P and K were recorded under NE @ 7/ha followed which was at par with NE @ 6 t/ha and being significantly higher than other treatments. Higher nutrient uptake might be attributed to more proliferation of root system and higher dry matter accumulation by individual plant which in turn yielded higher under NE @ 7/ha based nutrient recommendation in comparison to other treatments. The significant improvement in uptake of these nutrients coupled with increased grain and straw yields increased the total uptake of N, P and K substantially (Singh *et al.,* 2016).

The cost of cultivation varied depending on the tillage practices. CT (35,058 ₹/ha) has the highest cost of cultivation compared to RBP (28,058 ₹/ha). The maximum gross return (134,995 ₹/ha), net return (106,937 ₹/ha) and B: C ratio (3.81) was reported under RBP which was significantly greater than CT practices during experimentation. The higher gross return and net return of maize under RBP was accrued due to higher grain and straw yield obtained under RBP plots over CT. On the other hand, lower gross return under CT plots was due to lower yield and additional cost innovative on production of maize crop (Meena *et al.,* 2023). In general, the minimum cost of cultivation was observed under STBR (31,096 ₹/ha), whereas maximum cost of cultivation was observed under FP (32,096 ₹/ha). The gross return (131218 ₹/ha) and net return (99706 ₹/ha) was significantly maximum with NE @ 7 t/ha which was significantly higher than remaining other treatment. The highest B: C ratio (3.16) was noted with NE @ 7 t/ha, which was significantly higher over STBR, ST and FP but remained statistically at par with NE @ 6 t/ha. The NM approaches increased plant growth by promoting a higher

Table 2. Effect of tillage and nutrient management practices o yield and economics of maize crop

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Tillage Practices				
CT	35,058	114,818	79,760	2.28
RBP	28,058	134,995	106,937	3.81
SEm±	-	787	337	0.06
CD (P=0.05)	-	2,347	1,015	0.18
Nutrients management options				
FP	32,096	113,659	81,563	2.54
ST	31,546	121,644	90,098	2.86
STBR	31,096	123,495	92,399	2.97
NE @ 6 t/ha	31,238	128,937	97,699	3.12
NE @ 7 t/ha	31,512	131,218	99,706	3.16
SEm±	-	598	366	0.02
CD (P=0.05)	-	1,798	1,102	0.06

Where, CT, Conventional tillage; RBP, raised bed planting; FP, farmer practices; ST, state recommendation; STBR, soil test based recommendation; NE, nutrient expert™

photosynthetic leaf area of plant, which ultimately increased crop yield, besides this, it also aims to increase system nutrient use efficiency, leading to more returns per unit of fertilizer invested (Sepat *et al.,* 2023).

Thus, it can be concluded that raised bed planting and precision nutrient prescription using Nutrient Expert® 7 t/ha is better option for improving yield attributes, productivity and economics returns of maize crop in the Upper Gangetic Plains of India.

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