

Original Research Article

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Effect of Tillage, Sowing Time and Irrigation Levels on Nutrient Uptake and Yield of Maize (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2016-17 at Research farm of Bihar Agricultural College, Sabour, to evaluate the effect of tillage, sowing time and irrigation levels on nutrient uptake and yield of maize (*Zea mays* L.). The experiment comprised of two tillage methods *viz.* conventional tillage (CT) and zero tillage (ZT) in main plot, two sowing dates- 30th October and 10th November as sub-plot and three irrigation levels (I₂ - 2 irrigations at six-leaf stage and tasseling, I₄ - 4 irrigations at four-leaf stage, ten leaf stage, tasseling and milking and I₆ - 6 irrigations at four-leaf stage, eight leaf stage, ten leaf stage, tasseling, milking and dough stage) as sub-sub plot treatment. The results indicated that the nutrient dynamics and productivity of *rabi* maize is significantly influenced by management practices. The higher nutrient content was recorded in CT maize stover and ZT maize grain and with 4 irrigations. However, maximum nutrient uptake and grain yield (11.1 t ha⁻¹) was recorded in ZT system with six irrigation. Delay in sowing of *rabi* maize reduced the grain yield considerably at a rate of 121 kg/ha/day. With increasing resource as well as crop management constraints, adoption of ZT along with residue retention and optimum water use has the potential of improving the nutrient uptake, nutrient use efficiency and crop productivity.

Keywords

Zero tillage, Date of sowing, Maize nutrient content, Irrigation

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Introduction

In India, maize has been widely cultivated as a rainfed crop during *kharif* season but it can also be successfully grown during the *rabi* season as yield of *rabi* maize is considerably higher than that of *kharif* maize (Patel *et al.*, 2006). The *rabi* maize has been widely

accepted by farmers of Bihar with a cultivated area of 0.28 million ha with total production of 2.1 million tonnes (Directorate of Economics & Statistics, 2018-19). To augment the higher maize yield per unit area and sufficient nutrient uptake, proper crop agronomic management is necessary. Sowing of the crop at right time ensures better plant

growth, boosting the maize yield by increasing the resource use efficiency and also by inhibiting weed growth. Tillage system is an integral part of crop production and it has been confirmed by different scientists that conventional intensive tillage increases soil compaction, reduces soil aggregates stability, disrupts soil productivity, decreases retention and transportation of water and solutes and exacerbates losses due to run-off erosion (Goddard *et al.*, 2008). In contrast many beneficial effects of zero-till and minimum tillage have also been reported like increased porosity, organic carbon, water holding capacity and decreased bulk density. It is well documented that zero tillage and crop residues management improves soil health and quality by improving various soil properties like reduced penetration resistance as well as the apparent density of soil that checks the soil evaporation rate (Rivas *et al.*, 1998). Water infiltration and soil aeration that depend on bulk density are also modified (Rice *et al.*, 1987). Zero tillage affects water availability to plants, essentially through soil water capture and root uptake capacity (Gajri *et al.*, 1994; Ojeniyi, 1986). Zero tillage has also been reported to increase total nitrogen and microbial biomass in various soils (McCarty *et al.*, 1995). The crop residues in zero tillage become a mulch over the soil surface that protects the soil productive layer against run-off reducing the nutrient loss and erosion through runoff (Perret *et al.*, 1999, Smart and Bradford, 1999) and increases the percentage of organic matter in the superficial soil layer (Rivas *et al.*, 1998; Roldan *et al.*, 2003). Irrigation is another important management practice for higher crop production with better nutrient uptake which is mainly dependent on both irrigation frequency and total water application affecting root distribution and total root length (Robertson *et al.*, 1980). This determines the vital plant physiological processes like cell elongation, cell division,

cell wall synthesis, nitrate reductase activity and photosynthesis that are very sensitive to plant water status. Therefore, performance of a plant in terms of its growth, yield and nutrient content is mainly dependent on plant water status. Availability of optimum moisture in the soil enhances the efficiency of applied nutrients, and any reduction of soil moisture at these stages will considerably reduce the grain yield. The present investigation was carried out to evaluate the effect of tillage, sowing time and irrigation levels on nutrient concentration and uptake by maize and crop productivity.

Materials and Methods

A field experiment was conducted during the *rabi* season of 2016-17 at Bihar Agricultural University farm, Sabour (25°15'40" N, 87°2'42" E; 37 m above mean sea level), Bhagalpur, Bihar, India. The soil of the experimental field was sandy loam with neutral in reaction, medium in organic carbon (0.6%) and available phosphorus (35.2 kg P₂O₅ ha⁻¹), while low in available soil nitrogen (220.1 kg ha⁻¹), and rich in soil potassium (327 kg K₂O ha⁻¹). The experiment comprised of twelve treatment combinations laid out in split-split design with three replications. The two tillage methods *viz.* zero tillage (T₁ - ZT) and conventional tillage (T₂ - CT) were kept as main plots, while in sub-plot it was two sowing dates (D₁ - 30 October and D₂ - 10 November), and in sub-sub plot there were three irrigation levels *i.e.* I₂ (2 irrigations at six-leaf stage and tasseling), I₄ (4 irrigations at four-leaf stage, ten leaf stage, tasseling and milking) and I₆ (6 irrigations at four-leaf stage, eight leaf stage, ten leaf stage, tasseling, milking and dough stage). All the treatments received half nitrogen along with full dose of phosphorus and potassium as basal while the remaining N was top-dressed in two equal splits at knee-high and tasseling stage. The recommended dose of N:P₂O₅:K₂O

for maize crop was kept as 150:75:50 kg ha⁻¹. The maize crop was sown on 30 October and 10 November in the year 2016 with a spacing of 60×20 cm and harvested on 7 April and 20 April 2017, respectively. The plant samples for NPK analysis were collected at harvest stage. The Nitrogen content in dry matter was analysed by using micro-kjeldahl method (Tandon, 1993), phosphorus content by vanadomolybdate phosphoric acid yellow colour method (Jackson, 1973) and potassium content by flame photometer (Jackson, 1973). The N, P and K uptake were computed by multiplying nutrient content of grain and straw with respective dry weight (kg ha⁻¹) at harvest stage. Grain and stover yield in each net plot was weighed and expressed in kg ha⁻¹. The experimental data recorded were analyzed statistically in split-split plot design to test the significance of the overall differences among treatments by using the F test and conclusions were drawn at 5% probability level.

Results and Discussion

Nitrogen, phosphorus and potassium concentration in stover and grain of maize as influenced by different treatments

Results revealed that nitrogen content in both stover and grain was significantly affected by tillage practices and irrigation levels (table 1). Conventional tillage (CT) recorded significantly higher values of nitrogen (0.63%) and phosphorus content (0.28%) in stover respectively. Grain nitrogen content recorded higher value with zero tillage (ZT) (0.55%) whereas grain phosphorus content remained unaffected. On the contrary, date of sowing significantly affected only the phosphorus content in grain and the maximum phosphorus content for grain was recorded with D₂ sowing (0.31 %) which was significantly higher than D₁ sowing (0.29%). In sub-sub plot, due to irrigation levels,

nitrogen content of stover recorded higher value with I₄ (0.63%) which was found to be at par with I₆ (0.62 %) and significantly higher than I₂ (0.59%) whereas grain nitrogen content was significantly higher with I₆ (1.60%) followed by I₄ (1.54 %) and I₂ (1.44 %) irrigation levels respectively. The phosphorus content of stover was recorded higher with I₆ (0.28%) followed by I₄ (0.25 %) and I₂ (0.22%) whereas for grain phosphorus content was recorded higher with I₆ (0.33%) followed by I₄ (0.28 %) and I₂ (0.28 %). The data of the potassium content of stover and grain was influenced only by different irrigation levels in sub-sub plot treatment. For stover, it was recorded higher with I₆ (1.20%) which was at par with I₄ (1.19 %) and significantly higher over I₂ (1.13 %) respectively. In grain, the potassium content followed a similar trend with higher values being recorded under I₆ (0.69%) followed by I₄ (0.67 %) and I₂ (0.64 %) respectively. The N, P and K content of maize grain and stover was significantly influenced due to tillage and irrigation levels. The maximum value of N, P and K content was recorded under ZT with the highest level of irrigation applied with six irrigations. This could be attributed to the fact that ZT provided better soil environment for improved root development and also higher irrigation level ensured minimum water stress and also nutrient availability with increased forage area by the roots for nutrient extraction (Yadav *et al.*, 2016). A similar pattern of nutrient content in maize crop under zero-tillage based conservation agriculture practices have also been reported by other researchers (Alam *et al.*, 2014; Naresh *et al.*, 2014).

Total nitrogen, phosphorus and potassium uptake of maize as influenced by different treatments

The data recorded on the total uptake of nitrogen (N), phosphorus (P) and potassium

(K) has been presented in table 2. The data revealed that tillage practices significantly influenced the higher nitrogen uptake with zero tillage -T₂ (203.6 kg ha⁻¹) over conventional tillage - T₁(183.3 kg ha⁻¹) compared to the other nutrients like phosphorus and potassium. Unlike tillage, the difference in date of sowing only significantly influenced the nitrogen uptake by the crop. Due to tillage, the maximum total nitrogen uptake was recorded with D₁ sowing (202.1 kg ha⁻¹) which was significantly higher over D₂ sowing (184.9 kg ha⁻¹). However, difference in irrigation application led to significant variation in N, P and K uptake by the crop. In sub-subplot due to irrigation, maximum N, P and K uptake of 240, 69 and 146 kg ha⁻¹ was recorded with I₆ (six irrigations) which was significantly higher over I₄ and I₂ irrigation levels respectively. However, tillage and time of crop establishment influence the nature of water utilization by the crop and therefore water productivity. Parihar *et al.*, (2017) observed that the maize growth parameters were significantly ($p < 0.05$) superior under zero tillage and permanent bed compared to conventional tillage. Yadav *et al.*, (2016) reported that ZT provided better soil environment for improved root development and also higher irrigation level ensured minimum water stress and also nutrient availability with increased forage area by the roots for nutrient extraction.

Stover, grain and stone yield of maize as influenced by different tillage methods, date of sowing and irrigation levels

The data on the yield of maize crop has been presented in table 3. The data revealed that there was no significant difference in stover yield of maize due to individual effect of tillage, date of sowing and irrigation levels. However, grain yield differed significantly with tillage and recorded significantly higher

grain yield under ZT (9164.9 kg ha⁻¹) as compared to CT (8043.2 kg ha⁻¹) which was 14 per cent more over CT. In sub-plot due to date of sowing, grain yield was significantly higher when sown on D₁-30th October (9270.6 kg ha⁻¹) than D₂-10th November (7937.4 kg ha⁻¹) sowing. Due to the early sowing of maize the yield was higher by 17 per cent and the yield decreased at a rate of 121 kg/ha/day over early sown crop. In sub-sub plot significantly higher, grain yield was recorded with I₆ (11077.4 kg ha⁻¹) which was significantly higher over I₄ (9565.5 kg ha⁻¹) and I₂ (5169.1 kg ha⁻¹) irrigation levels. The significant yield increase with four irrigations (I₄) over I₂ was 85 per cent while a further increase of two irrigations under I₆, a 16 per cent increase in yield was recorded over I₄ irrigation level. From the results, it can be concluded that zero tillage had a significant influence in increasing the crop yield followed by sowing time and irrigation levels. ZT in combination with earlier sowing and six irrigations produced the maximum yield. However, ZT of the early sown crop with four irrigations could also produce equivalent yield to that of CT plots under D₁ sowing receiving six irrigations and also ZT with late sowing receiving six irrigations. The stone yield of maize did not vary significantly due to tillage methods or date of sowing. Due to irrigation application, the stone yield recorded higher values with I₆ (six irrigations) (2920 kg ha⁻¹) which was statistically at par with I₄ (four irrigations) (2635.2 kg ha⁻¹) and significantly higher over I₂ (two irrigations) (1580.8 kg ha⁻¹). The higher yield of maize in ZT plots could be attributed to the multiple effects of nutrients added (Blanco-Canqui *et al.*, 2009 and Kaschuk *et al.*, 2010), comparatively lower weed pressure due to maintenance of surface residue (Ozpinar, 2015 and Chauhan *et al.*, 2007), better water regimes promoting root growth and development (Govaerts *et al.*, 2009) compared to CT.

Table.1 Nitrogen, phosphorus and potassium concentration in stover and grain of maize as influenced by different tillage methods, date of sowing and irrigation levels

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Stover	Grain	Stover	Grain	Stover	Grain
Tillage						
T ₁	0.63	1.51	0.28	0.30	1.19	0.68
T ₂	0.60	1.55	0.22	0.29	1.16	0.66
SEm (±)	0.00	0.00	0.00	0.01	0.00	0.01
LSD (0.05)	0.02	0.03	0.03	NS	NS	NS
Date of sowing						
D ₁	0.61	1.52	0.25	0.29	1.17	0.66
D ₂	0.62	1.54	0.25	0.31	1.18	0.67
SEm (±)	0.01	0.02	0.00	0.00	0.00	0.01
LSD (0.05)	NS	NS	NS	0.01	NS	NS
Irrigation						
I ₂	0.59	1.44	0.22	0.28	1.13	0.64
I ₄	0.63	1.54	0.25	0.28	1.19	0.67
I ₆	0.62	1.60	0.28	0.33	1.20	0.69
SEm (±)	0.01	0.02	0.01	0.01	0.01	0.01
LSD (0.05)	0.02	0.07	0.03	0.02	0.03	0.02

T₁=Conventional Tillage; T₂-Zero Tillage; D₁=30th October; D₂=10th November; I₂=Irrigation at V₆ and tasseling; I₄-Irrigation at V₄, V₁₀, tasseling, milking; I₆-Irrigation at V₄, V₈, V₁₀, tasseling, milking, dough stage of the crop

Table.2 Total nitrogen, phosphorus and potassium uptake of maize as influenced by different tillage methods, date of sowing and irrigation levels

Treatment	Total N uptake (kg ha ⁻¹)	Total P uptake (kg ha ⁻¹)	Total K uptake (kg ha ⁻¹)
Tillage			
T ₁	183.3	52.9	119.3
T ₂	203.6	57.0	127.3
SEm (±)	1.1	1.8	3.0
LSD (0.05)	6.6	NS	NS
Date of sowing			
D ₁	202.1	55.0	125.9
D ₂	184.9	54.9	120.7
SEm (±)	1.3	1.0	2.0
LSD (0.05)	5.3	NS	NS
Irrigation			
I ₂	126.7	39.5	89.4
I ₄	213.7	56.6	134.8
I ₆	240.0	68.7	145.6
SEm (±)	3.1	1.3	1.7
LSD (0.05)	9.4	3.9	5.2

Table.3 Yield of maize as influenced by different tillage methods, date of sowing and irrigation levels

Treatment	Stover yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Stone yield (kg ha ⁻¹)
Tillage			
T ₁	7403.4	8043.2	2107.2
T ₂	7412.0	9164.9	2650.1
SEm (±)	398.2	55.4	105.6
LSD(0.05)	NS	336.9	NS
Date of sowing			
D ₁	7165.7	9270.6	2499.4
D ₂	7649.7	7937.4	2257.8
SEm (±)	394.2	154.9	65.5
LSD(0.05)	NS	608.3	NS
Irrigation			
I ₂	7183.4	5169.1	1580.8
I ₄	7820.7	9565.5	2635.2
I ₆	7218.9	11077.4	2919.9
SEm (±)	292.0	101.5	101.3
LSD(0.05)	NS	304.3	303.6

T₁=Conventional Tillage; T₂-Zero Tillage; D₁=30 October; D₂-10 November; I₂=Irrigation at V₆ and tasseling; I₄-Irrigation at V₄, V₁₀, tasseling, milking; I₆-Irrigation at V₄, V₈, V₁₀, tasseling, milking, dough stage of the crop

The findings of higher maize yield under ZT in close agreement with the findings of Yadav *et al.*, (2016), Gathala *et al.*, (2013), Parihar *et al.*, (2016). The higher yield of maize under zero tillage system could be attributed to the compound effect of early establishment of the crop due to favorable moisture conditions in soil, additional nutrients (Blanco-Canqui *et al.*, 2009 and Kaschuk *et al.*, 2010), reduced competition for resources and improved bio-physicochemical soil health as observed by previous researchers (Jat *et al.*, 2013 and Govaerts *et al.*, 2009) over conventional tillage system.

In conclusion, zero tillage was found to be an advantageous tillage practice in improving soil environment, facilitating maximum crop production while maintaining the soil health. In this experiment the zero tillage in combination with earlier sowing and six irrigations produced the maximum yield. Other interaction effect again confirmed that early sown maize with 4 irrigations under

zero tillage system also has the potential to produce similar or higher grain yield compared to early sown maize with six irrigations under conventional tillage. This higher yield and nutrient uptake in ZT plots could be attributed to the multiple effects of added nutrient and organic matter, comparatively lower weed pressure due to maintenance of surface residue, better water regimes promoting root growth and development compared to CT. Nutrient uptake was recorded highest with early sowing of maize with 6 irrigations under ZT system. Early sowing ensures better crop establishment and ZT with higher irrigation level provides better bio-physicochemical soil health for improved root development ensuring better nutrient extraction with increased forage area.

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