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Combined effect of tillage and nutrient management practices on *kharif* maize (*Zea mays* L.) yield and chlorophyll content

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ABSTRACT

Our accustomed agricultural practices of tilling the soil continuously and excessive fertilizer applications caused not only decreased in organic carbon content and soil degradation but also disturbed environmental harmony. With this backdrop, current study was conducted at research farm, Dholi to determine the interactive effect of tillage and nutrient management practice under maize crop during kharif 2018 and 2019. The split-plot design was laid out with tillage as the main plot and nutrient management practice as sub-plot with 3 replications. The results showed significantly superior maize cob yield in PB (84.02 q ha^{-1}& 88.01 q ha^{-1}) and 60% RDN+GSGN (81.96 & 85.17 q ha^{-1}) over CT (64.48 & 72.71 q ha^{-1}) and RDF (71.94 & 77.25 q ha^{-1}) during 2018 and 2019. Similarly, higher chlorophyll content and nutrient content was also noticed with an interaction effect of PB and 60% RDN+GSGN. Based on the results, adoption of PB and 60% RDN+GSGN will help in the realization of better yield with maximum profit by way of reducing the input capital apart from improving soil health thereby sustaining natural resources for future generations.

***Keywords*:** Chlorophyll content, conservation tillage, permanent bed, precision nutrient management and yield enhancement

INTRODUCTION

In India after rice and wheat, maize (*Zea mays* L.) is the third most important cereal crop. Due to its high yield potential and versatile in nature, maize is popularly known as "Queen of cereals". Maize is staple food for humans and has high quality feed content, used as supplement for animals and becoming an emerging industrial crop especially in poultry industry. In addition to this, it can be used as basic raw materials in textile, cosmetic, oil industry and pharmaceuticals. Maize has a slow growth pattern during the initial stages leads to heavy infestations of weeds due to which loss of water and nutrients takes place (Kumar *et al.,* 2014). In accounting to this, limitation in crop management practices *viz.,* low fertilizer use efficiency, improper application of fertilizer and ignorance of nutrient balance leads to threat in maize production.

In a post green revolution, Indian agriculture was mainly focused on food security without considering soil health and ecosystem. In this era, the introduction of high yielding varieties and growing rice-wheat cropping system leads to application of high fertilizer doses and exploration of groundwater to meet out the requirement of crop demands and unconsciously deteriorate the soil health (Sharma *et al*., 2012 and Humphreys *et al*., 2010). In addition to this, trafficking of heavy implements to prepare seedbed preparations and intercultural operations leads to developments of hardpans, oxidation of organic matter, removal of topsoil through soil erosion. All these deteriorated resources to an extent of future production leads unsustainable. This indicates that our future production should be more sustainable along with advanced technologies and new management practices.

In recent years, climate change has a major effect on crop production, along with unsustainable practices leads to crop failures. With this problem, conservation agriculture based maize production technology was emerging in recent decades. It is resource conserving technology with high sustainable production and economic benefits. Conservation agriculture has three principles *viz*., maximum soil cover, crop diversification and minimum soil disturbance (FAO, 2001). The fourth principle was suggested and included by Vanlauwe *et al.* (2014) *viz*., appropriate use fertilizer. Based on the above considerations, present study was conducted on different tillage and nutrient management practices on maize to enhance production and profitability of farmers.

MATERIALS AND METHODS

The experiment was conducted in the year 2018 and 2019 during *kharif* season at research farm, TCA, Dholi, DRPCAU, Pusa, Bihar, situated at a latitude of 24^{0} 99' N and longitude of 84^{0} 60' E with an elevation of 51.18 m MSL. The experimental design was laid out in split plot with a set of tillage and nutrient management practices *viz.,*conventional tillage (CT), zero tillage (ZT) and permanent bed (PB) as the main plot and Recommended dose of fertilizer (RDF), Recommended

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dose of nitrogen 60% (RDN) + Green seeker guided N application (GSGN) and Site-specific nutrient management (SSNM) as sub plot and replicated thrice. The location selected for a field experiment was uniform in fertility, the gross area of the experimental site was about 450 m^2 and each unit size was 4.02 × 4.20 m with 6 interrow and 21 intrarow. The quality protein maize (QPM) hybrid variety (Shaktiman-5) was used in the experiment. The seed rate of 20 kg ha^{-1} was sown during the first fortnight of July. The spacing of the maize crop was 67 × 15 cm.

The climatic condition of the experimental site was sub- tropical with extreme weather condition and falls under 'middle Gangetic' Agro-climatic zone. The mean average annual rainfall receives in the location was 869.8mm. The experimental site was sandy loam in texture with 1.30 g/cm^3 BD, 29.84% water holding capacity (WHC), medium range in Organic carbon, available phosphorus, available potassium and low available nitrogen in soil.

The seeds were sown by opening the furrow with liner (locally made implement) under zero tillage and permanent bed practices, where tillage operations were restricted to an extent. The reshaping of beds was done before the start of an experiment. While in case of CT plots, operations were followed according to local farmer practices. Across nutrient management practices, 120:60:50 kg N: P_2O_5: K_2Oha^{-1} was applied in RDF treatments. However, under SSNM treatment90-40-50 kg N: P_2O_5: K_2O ha^{-1}and 103-38-52 kg N: P_2O_5: K_2O ha^{-1}was applied based on the recommendation of Nutrient Expert software application developed by international plant nutritional institution (IPNI). In case of nitrogen three split applications were given *viz.,* 50% as basal and remaining 50% as in two split doses one at knee height stage and another at flowering stage. However, in RDN 60% + GSGN treatment, maize crop was fertilized with 60% of recommended dose of nitrogen *viz.*, 72 kg ha^{-1}as a basal dose of application and thereafter based on NDVI values obtained by crop was measured with green seeker instrument and were converted into nitrogen doses., P_2O_5 and K_2O was applied in full doses as basal application.

Under ZB and PB, Roundup (Glyphosate @ 1.0 L a.i. ha^{-1}) was sprayed at 30 days before sowing of crop to kill perennial and grassy weeds. Later, 2 days after sowing pre-emergence application (Atrazine @ 2.0 kg ha^{-1}) of herbicide was applied in all the treatments. Thereafter, hand weeding was done at 35th day after planting with the hand hoe.

Yield and yield attributes were recorded after the harvest of the crop. The cobs were harvested, when it attains physiological maturity and measured in q ha^{-1}. To measure yield attributing characters, 10 cobs were selected randomly from each experimental unit. Based on ANOVA technique given by Gomez and Gomez (1984) for spilt- plot design was used to analyse the recorded data at % level of significance (p=0.05).

RESULTS AND DISCUSSION

The chlorophyll A content showed significant results under tillage practices during 30 DAS and 60 DAS (Table 1). In tillage practices, PB recorded maximum Chlorophyll A content in both years expect 2018 at 90 DAS followed by ZT and CT. Across nutrient management practices, RDN 60% + GSGN treatment observed higher values followed by SSNM and RDF (except Chlorophyll B 30 DAS was higher under RDN 60% + GSGN treatment followed by RDF and SSNM). Similarly, Chlorophyll B content also showed higher values under PB was maximum values during 60 DAS in both years and 90 DAS (2019). Whereas, CT was maximum at 30 DAS (2018). SSNM showed maximum Chlorophyll B during 30 DAS (2019) and 90 DAS (2018). The maximum Chlorophyll content under a conservation practice and SSNM was due to timely application of nutrients and addition of crop residue increased nutrient mineralization and enhancement of root growth which might help to better access for nutrient uptake especially nitrogen content. Whereas, increase in nitrogen content in plants helps to develop higher Chlorophyll content per unit area (Munyao *et al.,* 2019). Agamy *et al.* (2012) observed positive interaction between plant nutrients and chlorophyll content.

No significant results were observed under yield attributing characters [(except no. of grains of the cob (2019), girth of cob (2018) and 1000 grain weight (2019)] (Table 2).The highest values of yield attributing characters were observed under PB followed by ZT and CT among tillage practices (expect no. of cobs plant^{-1} and length of cob during 2019 were higher under ZT). However, RDN 60%+GSGN treatment showed maximum values among yield attributing characters followed by SSNM and RDF (except no. of cobs plant^{-1} during 2018 and 1000 grain weight during 2018-2019 were maximum with SSNM).

In both years of experimentation, the cob yield showed significant results under tillage and nutrient management practices (Table 3). The highest values were obtained under PB (84.02 q ha^{-1}& 88.01 q ha^{-1}) statistically at par with ZT (78.18 & 82.06 q ha^{-1}) compared with CT (64.48 & 72.71 q ha^{-1}). Among nutrient management practices, RDN 60% + GSGN (81.96 & 85.17 q ha^{-1}) treatment showed significantly superior cob yields followed by SSNM (76.79 & 80.35 q ha^{-1}) over RDF (71.94 & 77.25 q ha^{-1}). The higher cob yields of maize in permanent bed were due to the fact that improved soil physical properties by residue retention.

Table 1: Performance of tillage and nutrient management practices on chlorophyll content of maize during 2018 and 2019

Treatment	Chlorophyll A						Chlorophyll B					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Tillage treatments												
ZT	0.68	0.75	1.10	1.20	0.90	0.97	0.12	0.14	0.74	0.94	0.45	0.47
CT	0.61	0.72	0.97	1.07	0.92	0.97	0.15	0.11	0.66	0.90	0.46	0.47
PB	0.75	0.85	1.30	1.35	0.91	0.98	0.11	0.13	0.96	1.100	0.44	0.48
LSD (0.05)	**0.103**	**0.090**	**0.108**	**0.105**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Nutrient management treatments												
RDF	0.67	0.76	1.11	1.18	0.85	0.92	0.13	0.12	0.78	0.96	0.46	0.52
SSNM	0.65	0.74	1.13	1.21	0.90	0.97	0.12	0.13	0.84	1.05	0.45	0.45
RDN 60%+GSGN	0.72	0.82	1.13	1.23	0.97	1.04	0.13	0.13	0.74	0.92	0.44	0.46
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
p-value												
Tillage	0.04050*	0.02896*	0.00267*	0.00428*	0.94350 ns	0.98157 ns	0.26885 ns	0.81501 ns	0.10885ns	0.06531 ns	0.69444 ns	0.87103 ns
Nutrient management	0.08154ns	0.11531 ns	0.79880ns	0.56423 ns	0.16351 ns	0.07729ns	0.84838*	0.88362 ns	0.25696 ns	0.06568 ns	0.81017ns	0.31041 ns
Tillage X Nutrient management	0.16763ns	0.29230ns	0.05947ns	0.45686ns	0.63922ns	0.56394ns	0.62725ns	0.86416ns	0.06978ns	0.08822ns	0.15314ns	0.28723ns

Table 2 : Performance of tillage and nutrient management practices on yield attributes of maize during 2018 and 2019

Treatment	No of cobs plant^{-1}		No of grains cob^{-1}		Length of cob (cm)		Girth of cob (cm)		1000 grain weight (gm)	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Tillage treatments										
ZT	1.19	1.28	419.55	431.77	14.68	16.90	17.15	14.45	252.05	268.16
CT	1.17	1.19	411.66	419.11	14.17	15.67	15.97	13.83	237.48	228.18
PB	1.28	1.31	437.55	458.66	15.00	16.20	17.61	15.13	268.44	281.55
LSD(0.05)	**NS**	**NS**	**NS**	**15.18**	**NS**	**NS**	**1.26**	**NS**	**NS**	**29.67**
Nutrient management treatments										
RDF	1.17	1.21	419.11	421.33	14.46	15.24	15.65	14.26	239.70	241.92
SSNM	1.24	1.29	420.22	437.77	14.33	16.31	16.45	14.50	259.53	272.24
RDN 60%+GSGN	1.23	1.29	429.33	450.44	15.06	17.22	18.63	14.65	258.74	263.74
LSD(0.05)	**NS**	**NS**	**NS**	**17.46**	**NS**	**NS**	1.50	NS	NS	21.94
p-value										
Tillage	0.09719ns	0.05503 ns	0.07489 ns	0.00423*	0.07734 ns	0.22743 ns	0.04698*	0.24983 ns	0.14863 ns	0.01518*
Nutrient management	0.40712ns	0.07775 ns	0.64022ns	0.01073*	0.20671 ns	0.06160ns	0.00259*	0.70838 ns	0.16944 ns	0.02733*
Tillage X Nutrient management	0.05920ns	0.30253ns	0.05051ns	0.58336ns	0.93570ns	0.09836ns	0.27278ns	0.73085ns	0.05435ns	0.04091ns

Table 3: Performance of tillage and nutrient management practices on yield parameters of maize during 2018 and 2019

Treatment	Cob yield (q ha^{-1})		Stone yield (q ha^{-1})		Production Efficiency (kg day^{-1})	
	2018	2019	2018	2019	2018	2019
Tillage treatments						
ZT	78.18	82.06	22.15	23.59	0.21	0.22
CT	68.48	72.71	18.55	22.01	0.18	0.19
PB	84.02	88.01	22.75	25.07	0.22	0.24
LSD (0.05)	**6.48**	**9.42**	**2.98**	**NS**	**0.019**	**0.027**
Nutrient management treatments						
RDF	71.94	77.25	20.55	22.21	0.19	0.21
SSNM	76.79	80.35	21.31	23.66	0.21	0.22
RDN 60%+GSGN	81.96	85.17	21.60	24.80	0.22	0.23
LSD (0.05)	**5.32**	**5.57**	**NS**	**NS**	**0.014**	**0.016**
p-value						
Tillage	0.00601*	0.02409*	0.03083*	0.12133^{ns}	0.00918*	0.02176*
Nutrient management	0.00480*	0.02693*	0.90102^{ns}	0.07344^{ns}	0.00295*	0.03563*
Tillage X Nutrient management	0.84048^{ns}	0.90252^{ns}	0.15397^{ns}	0.58782^{ns}	0.75987^{ns}	0.91209^{ns}

Similar results were also reported by Jat *et al.* (2021). Moreover, as the study area was in a high rainfall zone, permanent bed technology was promising for maize crop (sensitive to soil moisture) by avoiding excess soil moisture and better aeration because of better infiltration. Similarly, it was noticed that a higher chlorophyll content in the plant might be attributed to higher production of photosynthates and better assimilation to sink. Shyam *et al.* (2021) also reported enhanced yield attributes under green seeker based nutrient management. The need-based fertilizer application decreases the loss of fertilizer and increases growth, yield attributes and cob yield of maize. However, no significant results were observed in stone yield (except under tillage practices during 2018). Maximum values were noticed in PB (22.75 & 25.07 q ha^{-1}) and ZT (22.15 & 23.59 q ha^{-1}) over CT (18.55 & 22.01 q ha^{-1}). The superior values under nutrient management were noticed in RDN 60% + GSGN (21.60 & 24.80 q ha^{-1}) followed by SSNM (21.31 & 23.66 q ha^{-1}) and RDF (20.55 & 22.21 q ha^{-1}). Production efficiency showed significant results during both the years. PB (0.22 & 0.24 kg day^{-1}) showed significantly superior values under tillage practices followed by ZT (0.21 & 0.22 kg day^{-1}) and CT (0.18 & 0.19 kg day^{-1}). Similarly, higher production efficiency under permanent bed system was reported by Jat *et al.*(2021) in maize crop. RDN 60% + GSGN (0.22 & 0.23 kg day^{-1}) treatment showed higher values compared with SSNM (0.21 & 0.22 kg day^{-1}) and RDF (0.19 & 0.21 kg day^{-1}). These higher values might be attributed due to greater availability of nutrients at the time of crop needs facilitating the translocation of produced photosynthate from source to sink. (Blanco-Canqui and Lal (2009); Kaschuk *et al.* (2010); Kumar *et al.* (2004) and Govaerts *et al.* (2005) also evidenced the same results of higher maize yields in PB.

The nutrient uptake of nitrogen, phosphorous and potassium under different tillage and nutrient management showed significant results (Fig. 1). Among tillage practices, PB (160.4 & 164.74 kg ha^{-1}) planting recorded significantly superior values on both the years of nitrogen uptake which was statistically at par with ZT (147.89 & 156.88 kg ha^{-1}) over CT (122.57 & 127.35 kg ha^{-1}). RDN 60% + GSGN (158.48 & 162.02 kg ha^{-1}) treatment showed maximum values followed by SSNM (140.04 & 147.37 kg ha^{-1}) and RDF (132.19 & 143.47 kgha^{-1}). Similarly, phosphorous and potassium uptake also followed similar results. Across phosphorous uptake, PB (43.62 & 50.16 kg ha^{-1}) recorded superior values compared with ZT (40.61 & 42.44 kg ha^{-1}) and CT (32.79 & 34.80 kg ha^{-1}). Nutrient management treatment RDN 60% + GSGN (41.90 & 45.92 kg ha^{-1}) observed higher values over SSNM (38.41 & 40.15 kg ha^{-1}) and RDF (36.71 & 41.33 kg ha^{-1}). PB (138.96 & 142.16 kg ha^{-1}) planting showed significantly superior values compared with ZT (127.94 & 129.85 kg ha^{-1}) and CT (110.59 &

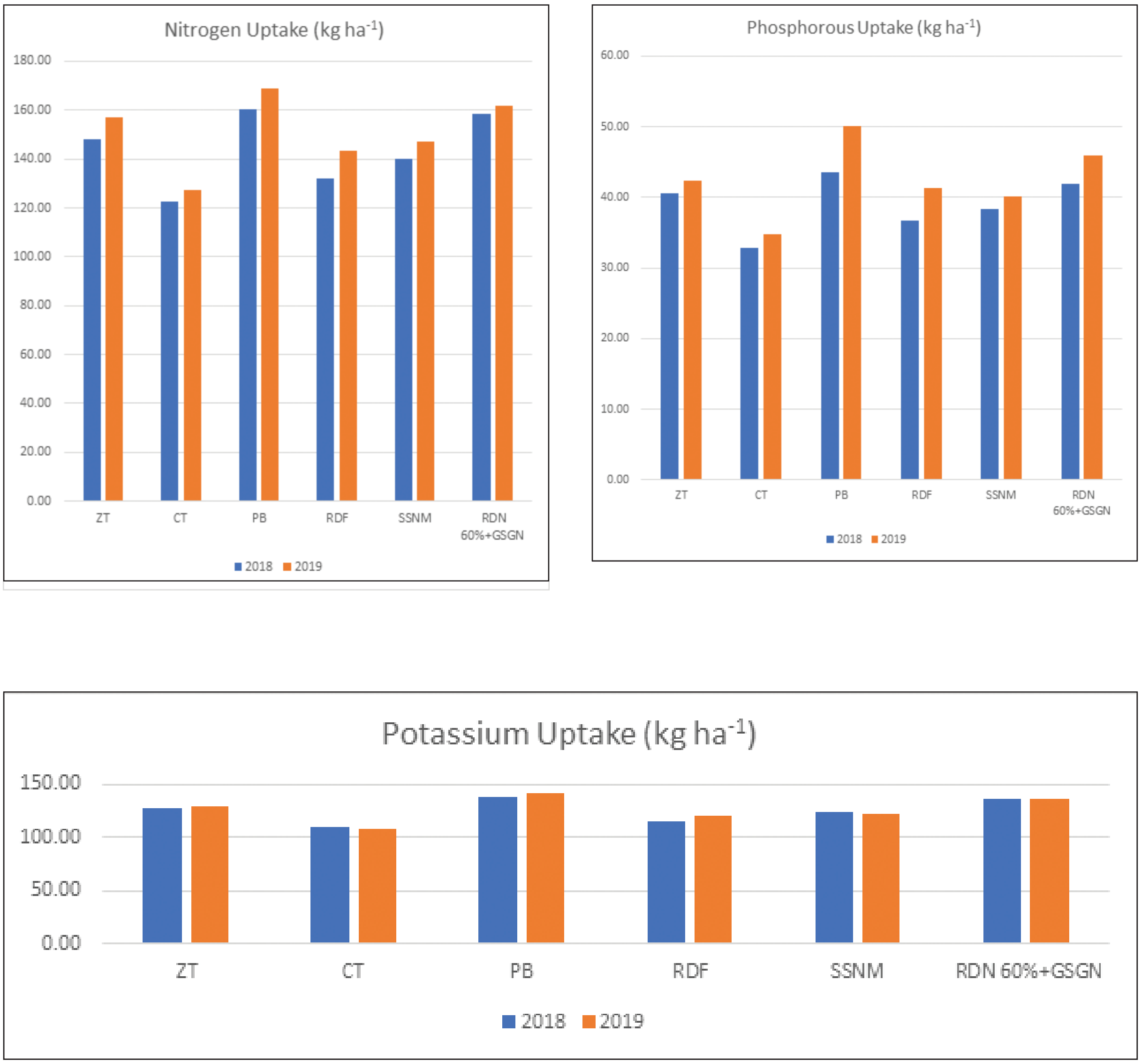

Fig. 1: Performance of tillage and nutrient management practices on nutrient uptake of maize during 2018 and 2019

108.71 kg ha^{-1}). Nutrient management treatment RDN 60% + GSGN (137.19 & 136.18 kg ha^{-1}) observed maximum values over SSNM (123.93 & 123.11 kg ha^{-1}) and RDF (116.37 & 121.44 kg ha^{-1}).The higher nutrient concentration in maize crop was due to better root biomass and root development which helps to uptake of more amount of nutrients from the soil. Due to increase in root growth, the forage area of root increased and there was maximum exposure of nutrients present in the rhizosphere which led to increase nutrient uptake by the crop. Beside this, in conservation agriculture practices (*viz.,* PB and ZT), tillage operations were restricted to minimum levels and hardpans were absent in sub-soil layers which helps to grow the root deep in to the soil and nutrient were extracted from the deeper layers. Apart from this, the preceding crop residue retention was done which helped to add more amount of organic matter to the soil and recycle nutrients in the soil and lead to increase in nutrient uptake. In addition to this, a higher amount of organic matter resulted in increase the chelation with the nutrients applied through fertilizers, which reduced the loss of nutrients and making it available to the crop. Yadav *et al.* (2016) also observed significantly higher nutrient uptake in PB and ZT as compared to CT.

We know that imbalance application of nutrients leads to decrease the plant uptake and cause adverse effects on plant growth and development. In addition to this, nitrogen plays a major role in dry matter production which helps to increase the yield of the crop. An imbalance application of nitrogen was toxic to plants and has adverse effects on ground water. Based on the results, the balanced application of nutrients was obtained through RDN 60% + GSGN and SSNM. The application of nutrient under SSNM and RDN 60% + GSGN was based on crop demand and soil status leads to higher nutrient uptake by a crop. Jyothsna *et al.* (2021) also reported higher nutrient uptake in maize under green seeker guided nitrogen management.

CONCLUSION

From this study it has been assessed the better tillage and precise nutrient management practices on maize crop in North Bihar. The research results showed that maize cob yield increased significantly over years under conservation tillage. Further interaction with nutrient management, RDN 60% + GSGN with Conservation tillage led to enhancement in chlorophyll content, yield attributes and nutrient uptake that sustained maize yield. Therefore, shift in paradigm has become the need of the hour in view of problems like resource degradation, population explosion *etc*., the conservation tillage with precision nutrient management will be a viable and sustainable option making agriculture more resource use efficient.

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