PERFORMANCE OF MAIZE (*Zea mays* L.) HYBRID UNDER DIFFERENT TILLAGE AND NUTRIENT MANAGEMENT PRACTICES

Thesis

Submitted to the

Banda University of Agriculture & Technology, Banda-210001, Uttar Pradesh, India

By

ABHINAV YADAV

(ID. No. 1686)

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FORTHE DEGREE OF

MASTER OF SCIENCE (AGRICULTURE)
IN
AGRONOMY

2022

Dedicated

To

My Beloved Grandfather

Late Shree D.N. Singh Yadav

***Abhinav Yadav*……….**

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Certificate - I

This is to certify that the thesis entitled **"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices"** submitted in partial fulfillment of the requirement for award of the degree of **Master of Science (Agriculture)** in **Agronomy,** Department of Agronomy, Banda University of Agriculture and Technology (Banda), is a genuine record of bonafide research work carried out by **Mr. Abhinav Yadav, Id. No. 1686** under my guidance and supervision. The results of the investigation in this thesis have not so far been submitted for any other degree or diploma.

It is further certified that the help or information received during the course of investigation and preparation of the thesis have been duly acknowledged.

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Abhinav yadav

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LIST OF SYMBOL AND ABVRIVIATION

@	Attherate	Fig.	Figure
&	And	G	Gram
:	Colon	Ha	Hectare
^{0}C	Degree Celsius	Hr	Hours
=	Is equal to	RDN	Recommended dose of nitrogen
-	Minus	RDF	Recommended dose of fertilizer
×	Multiply	SSNM	Site specific nutrient management
%	Percentage	Kg	Kilogram
+	Plus	K	Potassium
;	Semicolon	Kg ha^{-1}	Kilogram per hectare
B:C	Benefit cost ratio	LAI	Leaf area index
CV	Co-efficient of variation	M	Meter
CD	Critical difference	Mm	Millimeter
Cm	Centimeter	Ml	Milliliter
Rs.	Rupees	Mg	milligram
DAS	Days after sowing	Mt	MillionTonnes
dSm^{-1}	Decisiemens per meter	Max.	Maximum
DAP	Di-ammonium phosphate	Min.	Minimum
EC	Electrical conductivity	NS	Non-significant
N	Nitrogen	CHNS	Carbon, Hydrogen, Nitrogen, Sulphur
P	Phosphorus	q ha^{-1}	Quintal per hectare
RH	Relative humidity	ET	Evapotranspiration
S	Significant	SEm±	Standard error of mean
Viz.	Which is or as follows	OC	Organic Carbon
RDF	Recommended dose of fertilizer	ZT	Zero tillage
CT	Conventional tillage	PB	Permanent bed
G	Granule	EC	Emulsifiable concentrate
T	Tillage	F	Fertilizer

Abstract

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Thesis title	:	**"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices".**			

An investigation was carried out at Agricultural research farm of Banda university of Agriculture and Technology, Banda UP on the prescribed topic **"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices"** during the Kharif season 2021. The comprehensive aim of experiment was to explore the most appropriate tillage practices for the maize crop that could produce optimum yield more remunerative along with better profitability and also to find out effective nutrient management practices that suited well to the region. The experiment comprises of two factor treatments conducted in split plot design with three main plot factor and three sub-plot factor. The total combination of treatments was nine and each treatment replicate thrice. The main plot consisted of the tillage practices namely, zero tillage, conventional tillage and permanent bed. Further, each main plot had divided in to 3 sub-plots held three nutrient management practices viz. 33% recommended dose of nitrogen (40 kg N ha^{-1}), 100% recommended dose of fertilizer (N:P:K-120:60:50 kg ha^{-1}) and site specific nutrient management (N:P:K-160:50:60 kg ha^{-1}).

The soil in which experiment conducted was silty clay and their pH value 7.89, EC 0.55 dSm^{-1} and total organic carbon was 0.76%. The observation in growth parameter and quantitative and qualitative attributes of maize were recorded as per schedule. During the field study it was observed that the highest growth parameter viz. plant height, number of leaves $plant^{-1}$, dry matter accumulation and maximum yield attributes namely, cobs ha^{-1}, grains cob^{-1}, seed index and greater profitability in terms of economic return were recorded under the zero tillage practice employed to the maize. Among the nutrient management practices the site specific nutrient management (SSNM) practice produced maximum growth, yield (economic yield and biological yield) and yield attributes and also economic return (gross return, net return). Among all interaction of tillage and nutrient management practices, the zero tillage practice along with SSNM produced maximum output, more remunerative and this combination practically feasible and economically viable to production of maize.

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सारांश

नाम	:	अभिनव यादव	**आई.डी. क्रमांक**	:	1686
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शोध का शीर्षक : **"विभिन्न जुताई एवं पोषक तत्व प्रबंन्धन प्रणाली के तहत संकर मक्का (*जिया मेस* एल.) का प्रदर्शन"**

वर्ष 2021 खरीफ मौसम के दौरान बाँदा कृषि एवं प्रोद्यौगिक विश्वविद्यालय बांदा उ0प्र0 के कृषि अनुसंधान प्रक्षेत्र में निर्धारित विषय **"विभिन्न जुताई एवं पोषक तत्व प्रबन्धन प्रणाली के तहत संकर मक्का (जिया मेस एल.) का प्रदर्शन"** पर एक शोध किया गया था। प्रयोग का उद्देश्य मक्के की फसल के लिये उपयुक्त जुताई प्रणाली तथा पोषक तत्व प्रबन्धन था। जो कि इस क्षेत्र के लिये अधिक उपयुक्त, बेहतर और आर्थिक रूप से लाभप्रद हो।

यह प्रयोग स्प्लिट प्लॉट प्रारूप में तीन मुख्य भूखण्ड उपचार तथा तीन उपभूखण्ड उपचार के साथ किया गया था। उपचारों का कुल संयोजन नौ था और प्रत्येक उपचार तीन बार दोहराया गया था। मुख्य भूखण्ड में जुताई प्रणाली जैसे– शून्य जुताई, परम्परागत जुताई तथा स्थाई बेड शामिल था। जबकि मुख्य भूखण्डों को तीन उप भूखण्डों में विभाजित किया गया था जिसमें पोषक तत्व प्रबन्धन की तीन प्रणाली शामिल की गयी थी। पोषक तत्व प्रबन्धन प्रणाली में क्रमशः 33% नाइट्रोजन की अनुशंसित मात्रा (40 किग्रा0 / हे0), उर्वरक की 100% अनुशंसित मात्रा (एन0पी0के0– 120:60:50 किग्रा0 / हे0) तथा प्रक्षेत्र विशिष्ट पोषक तत्व का प्रबन्धन (एन0पी0के0– 60:50:60 किग्रा0 / हे0) शामिल किया गया था।

यह प्रयोग सिल्ट क्ले मिट्टी में किया गया जिसका पी0एच0 मान 7.89, इलैक्ट्रीकल कन्डक्टिविटी 0.55 डेसी साइमन प्रति मीटर तथा कुल कार्बनिक कार्बन 0.76% था। मक्के का वृद्धि मापदंड, मात्रात्मक तथा गुणात्मक विशेषताओं का अवलोकन समय–समय पर आवश्यकता अनुसार किया गया था। मक्के के लिये नियोजित जुताई प्रणालियों में से शुन्य जुताई के अन्तर्गत सर्वाधिक वृद्धि विशेषता (पौधों की ऊँचाई, पत्तियों की संख्या, शुष्क पदार्थ संचय), अधिकतम उपज विशेषता (भुट्टा / हे0, दाना / भुट्टा, बीज सूचकांक) तथा आर्थिक उपज और सर्वाधिक आर्थिक लाभ प्राप्त हुआ था।

पोषक तत्व प्रबन्धन प्रणाली में प्रक्षेत्र विशिष्ट पोषक तत्व प्रबन्धन पद्धति के तहत अधिकतम वृद्धि गुण, उपज (आर्थिक उपज, जैविक उपज) और सर्वाधिक अर्थिक लाभ (सकल आय, शुद्ध आय) प्राप्त हुआ था। जुताई और पोषक तत्व प्रबन्धन प्रणाली के पारस्परिक प्रभाव के अध्ययन में शुन्य जुताई के साथ प्रक्षेत्र विशिष्ट पोषक तत्व प्रबन्धन मक्के के उत्पादन के लिये अधिक व्यवहारिक तथा आर्थिक रूप से लाभप्रद पाया गया।

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CHAPTER-1

INTRODUCTION

Chapter - 1

Introduction

Maize (*Zea mays* L.) is one of the most versatile and miracle crop grown throughout the world because of its production potential, industrial use and adoptability to wide range of environments. Maize is photo insensitive crop that helps to grown irrespective of the season. It is grown from 60 degree N in temperate countries like Canada and Russia to 40 degree S latitude in tropical countries such as Argentina, Brazil, Nigeria from the sea level to an altitude of >4000 m in Peruvian Andes, in region with <25 cm rainfall in semi-arid plains of Russia to >1000 cm rainfall in north east India (Prasad, 2002). It seems that, there is no cereal on the earth which has immense potentiality and that is why it is called ‘queen of cereals’.

Several workers say Maize is originated in Mexico. Cultivated maize originated from pod corn, a form in which the individual kernels are enclosing in floral bract. Maize is originated from its closest relative, teosinte, by direct selection, by mutation, or by hybridization of teosinte with an unknown grass now extinct.

Maize grows in almost all the state of India. In India, maize covers 9.18 mha acreage and produces 27.23 mt with an average productivity 29.73 q ha^{-1} (DAC&FW 2018-19). In UP, it covered 0.73 mha area and produce grain 1.53 mt along with 20.90 q ha^{-1} of average productivity (DAC&FW 2018-19).

India is the fifth largest producer of maize after USA, China, Brazil and Mexico in the world contributing 3% of the global production. In India, nearly 75% of maize production is from kharif season and remaining 25% during rabi and spring/summer season. Since the maize is primarily grown under rainfed conditions during kharif season but in rabi it is grown under assured irrigation. Among different maize based cropping systems, maize-wheat ranks 1st and it is the 3rd most important cropping system after rice-wheat and rice-rice having 1.8 m ha area that contributes about 3% in the food grain production of India (Jat *et al*, 2011).

Maize crop is utilized in many ways like other grain crops. Over 85% maize produced in the country is consumed as human food. Maize grains is also a good feed for poultry, piggery and other animals and however it ranks below wheat and sorghum but considerably above rice in nutrition. Maize grains contain about 10% protein, 4% oil, 70% carbohydrate, 2.3% crude fiber, 10.4% albuminoides, 1.4% ash. However Maize protein 'zein' is deficient in tryptophan and lysine, the two essential amino acids (Prasad, 2002). Maize grain has significant quantities of vitamin A. It is low in calcium, fairly higher in phosphorus and however maize crop furnishes huge quantity of green fodder for cattle too. In develop country maize is widely used in fermentation industries. By fermentation it produced various alcoholic beverages and industrial products. Making the ethanol (ethyl alcohol) by fermentation of maize starches, which is being used as a bio-fuel; a mixture of 10% ethanol and 90% gasoline is called gasohol.

Food security is major concerned of India. At present, it is difficult to increase acreage as well as irrigation because of stiff competition among different sectors; therefore, to enhance the crop productivity is the only option to increase food and nutritional security of the country (Kumar and Kumar, 2018).

For improving maize productivity, suitable hybrid along side of tillage and nutrient practices are key resource therefore these aspects have taken in to consideration of research problem proposed. Tillage is one of the basic agro-technical operations in agriculture because of its influence on soil properties, environment and crop growth. Since, continuous soil tillage strongly influences the soil physico-chemical and biological environment. Therefore, tillage has been an integrated component of all crops includes maize also mainly because it provides good soil tilth, improves water holding capacity, increase aeration, enhances microbial activity of soil to enhance nutrients uptake and also moderates soil hydraulic conditions (Karami *et al*, 2012). Farmer should adopted appropriate tillage practices according to their situation because role of tillage in production of all crops includes maize also very important.

Inappropriate tillage practices may reduce crop growth and yield. Whereas, selection of an appropriate tillage practice for crop production is very important for optimum growth and yield. A good, soil management program protects the soil from water and wind erosion, provides a good weed free seedbed for sowing, breaks hardpans that allow root development and even an increase of organic matter. Tillage management with chemical and manure applications are among the important factors affecting soil physical properties.

Permanent Bed planting helped in increased aeration of the root zone and assured plant stand by the increasing emergence, particularly in crusting type soils, which resulted in higher growth, and yield attributes of maize as compared to conventional tillage (Yadav *et al* 2016). The increasing demand of agricultural production including food, feed and fodder has changed our traditional agriculture to intensive agriculture that includes intensive tillage, heavy application of chemicals, water, labor, reduced the soil fertility and productivity. The research findings also confirmed that 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.

Bed planting of maize helps in proper plant establishment, increases input efficiency which enhances plant development and increases yields, also opens up avenues for double no-till system. Permanent beds conserve moisture during prolong dry spell in water scarcity areas for longer availability of moisture to sustain plant life and act as a drainage channel in high rain fall/waterlogged areas and provides better microclimate for plant growth and root development. (Jat *et al* 2011).

In contrast many beneficial effects of no-till/zero-till and minimum tillage have also been reported like increased porosity, aggregation, organic carbon, water holding capacity and decreases bulk density better infilltration. Adoption of no-till practice helps in timely seeding either of the crops in sequence, hence leads to increase in productivity (Jat *et al* 2011). Similarly, the ridge bed planting system have also been reported very beneficial for improving soil environment for better plant and growth development with minimum requirement of irrigation water. The grain yield, protein content and protein yield of maize were significantly influenced by different tillage, residue and nutrient-management options (Hasanain *et al* 2021).

The productivity of maize is largely dependent on its nutrient management. Existing nutrient management practices are not able to capture the momentum change in the scenario of soil nutrient supply capacity and plant nutrient demand for achieving higher yield target. Maize grown in a wide range of climatic conditions in India, proper assessment of the limiting conditions for maize production and productivity is difficult but inappropriate nutrient management is one of the most important factors limiting maize production (Dass *et al*. 2012). It is a general practice in our country to provide blanket recommendation of fertilizer for production of various crops. The general recommendation may not be equally effective across diverse agro-ecological regions, and soil types as nutrient uptake and crop yield are affected by the soil type and climatic condition. The blanket fertilizer recommendations do not account the change in ecology and the genetic potential of the genotype (Kumar *et al*. 2014). Different field surveys have also revealed that the farmers of Indo-Gangetic plains of India often apply very high dose of nitrogen in the form of urea and very low phosphorus and potassium and almost nil secondary and micronutrients leading to imbalance, toxicity as well as inadequate use of nutrients with reduce nutrient use efficiency and profitability (Singh *et al*, 2014). Ample supply of phosphorus is increase root/shoot ratio and strength of stalk. Potassium is a vital nutrient element involved in increasing resistance to drought as well as biotic stresses. Attention should also be given to reduce the yield gap between potential yield and average farmers yield.

Among the essential plant nutrients, nitrogen (N) is the most limiting one. However, both excess and deprived application could be detrimental to plants. Nitrogen shortage during the vegetative growth period directly affects root development, stem elongation, cell division and uptake of other nutrients, while impairs pollen shedding, fertilization, grain filling, and premature senescence of leaves, if it extends to flowering and later stages. In contrast, excess supply of N with a low potassium dose promotes vigorous vegetative growth, taller plant stature, and higher risk to lodging (Dhakal *et al* 2021)

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 addition, it increases environment risk associated with loss of unutilized nutrient through emission or leaching. Therefore, the intervention on plant nutrition’s like Site-Specific Nutrient Management (SSNM) and Recommended Dose of Fertilizer (RDF) based on proper field experimentations and crop response, covering special variability in indigenous nutrient supplying capacity of soil are urgently required.

Site-specific nutrient management follows 4R principle namely, right time, right source, right dose and right method. It increases nutrient supply capacity consistently up to peak reproductive phase therefore improve better nutritional supply to crop, increase nutrient-use efficiency and nutrient uptake leading to increase economic yield, biological yield, protein content and protein yield of maize. SSNM is increase the nitrogen use efficiency by reducing losses of nitrogen. It has been hypothesized that application efficiency of N fertilizer can be enhanced by synchronizing fertilizer application with plant demands. Fertilizer applied during peak plant N demand ensure maximum N use efficiency due to limiting losses from the soil-plant system by leaching, denitrification and volatilization. The balanced application of the nutrients in the SSNM lead to enhanced growth that increased the plant growth and yield attributes and ultimately had a better source-sink relationship. This might have led to increased yield of the maize under SSNM (Singh *et al* 2015).

Keeping all above view, a field experiment will be conducted at the Agriculture college research farm, Banda University of Agriculture and Technology, Banda during kharif 2021 entitled **"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices"** with following objectives:

1. To assess the best tillage practice for growth and yield of maize.
2. To find out the effective nutrient management system for maize crop.
3. To study the interaction effect of nutrient management and tillage practices on the performance of maize.
4. To compute the economics of treatment variables.

CHAPTER-2

REVIEW OF LITERATURE

Chapter - 2

Review of Literature

The aim of chapter "Review of literature" is to provide an overview of the important works done in the past because it provide a base for carrying out as well as understanding the outcome of present work. The review has been presented in following parameters.

2.1 Effect of Tillage on the Performance of Maize

2.1.1 Growth attributes

2.1.2 Yield and yield attributes

2.1.3 Nutrient content and uptake

2.1.4 Physio-chemical parameter of soil

2.1.5 Economics

2.2 Effect of Nutrient Management on the Performance of Maize

2.2.1 Growth attributes

2.2.2 Yield and yield attributes

2.2.3 Nutrient content and uptake

2.2.4 Physio-chemical parameter of soil

2.2.5 Economics

2.3 Interaction effect of tillage and nutrient management on the performance of maize

2.1 Effect of Tillage on the Performance of Maize

2.1.1 Growth Attributes

Akbarnia *et al*. (2010) observed that reduced tillage attained highest dry mass compared to conventional and no-tillage practice.

Hakim *et al*. (2011) reported that both maize and cotton crops produced highest leaf area index under permanent bed tillage practice than conventional tillage practice.

Singh *et al*. (2012) revealed that dry matter and leaf area index were minimum in sub soiling.

Wasaya *et al*. (2012) studied the effect of the three tillage practices (conventional tillage (2-cultivation), tillage with mouldboard plough + 2-cultivation and tillage with chisel plough + 2-cultivation). Conventional tillage practice was resulted the high plant height, leaf area index (LAI) and dry matter accumulation.

Memon *et al*. (2013) reported that 3 tillage practices (Deep tillage, conventional tillage and zero tillage) in which deep tillage give high seedling emergence percentage, tallest plants with more leaves over conventional and zero tillage.

Javeed *et al.* (2014) observed that significantly more number of days to tasseling, silking and more days to maturity and greater tassel length were measured in the zero tillage sown crops than the conventional and deep tillage.

Khan *et al.* (2014) revealed that highest dry matter accumulation with conventional tillage over other and after anthesis accumulation of dry matter for minimum tillage 4% higher than deep tillage.

Agber *et al*. (2017) noticed that significantly highest plant height (cm) and leaf area (cm^2) under ridged tillage then no tillage, minimum tillage and flat bed tillage of maize.

You *et al*. (2017) reported that short-term reduced tillage (no-tillage and rotary tillage) promoted root biomass (RB), shoot biomass (SB) and root-shoot ratio (R:S) over plough tillage.

2.1.2 Yield and Yield Attributes

Sharma and Gautam. (2010) reported that higher grain yield under zero tillage practice due to reduced population and dry weight of weeds when compared with no tillage.

Videnovic *et al.* (2011) was studied the effect of tillage practices (no tillage, conventional tillage and reduce tillage) on yield of maize. He observed that conventional tillage give significantly higher yield over reduce and no tillage practices.

Majumdar *et al*. (2012) observed that spring and winter maize in eastern India showed that maize yields under zero-till (ZT) were higher than those under conventional till (CT) for both seasons.

Jat *et al*. (2013) noticed that economic yield of maize was highest with permanent raised bad followed by no-tillage flat bed and conventional flat tillage.

Ramesh *et al.* (2016) revealed that green cob, green fodder, biological yield and harvest index was not significantly influenced by tillage practices in kharif as well as rabi season. The lower population under zero tillage practice did not significantly influenced cob yield of maize.

Parihar *et al*. (2016) reported that yield attributes of the crops (except wheat) grown in sequence with maize was maximum with zero tillage, however in initial years wheat outperformed on permanent bed over zero tillage and conventional tillage.

Kumar *et al.* (2018) observed that the highest yield attributes and yield viz., cobs plant^{-1}, length of cobs, grains cob^{-1}, girth of cobs, test weight and grain yield were noticed under bed planting tillage practices which was significantly superior over zero tillage and conventional tillage.

Aditi *et al*. (2019) noticed that maize yield did not differ significantly in response to tillage practices (zero tillage and conventional tillage).

Rashid *et al*. (2019) revealed that maize yields were significantly higher under permanent bed (PB) and strip tillage (ST) than conventional tillage.

Omara *et al.* (2019) reported that yield of wheat high under no tillage practice over the conventional tillage practice.

Ramdhan. (2020) reported that deep tillage and conventional tillage have been associated with greater plant height, yield components, grain and biomass yield than reduced tillage treatment.

Hasnain *et al.* (2021) observed that maize under permanent raised bed showed significantly higher grain yield, protein content and protein yield over conventional tillage.

2.1.3 Nutrient content and uptake

Zougmore *et al*. (2006) observed that maize crop was uptake significantly higher quantity of nitrogen and phosphorus under cover crop with zero tillage over natural fallow with conventional tillage.

Al-Kaisi and Mensah. (2007) reported that effect of tillage practices on grain N uptake at different N rates with organic and inorganic nitrogen sources was generally insignificant, except with fertilizer source, where strip tillage had improved nitrogen uptake compared with no-tillage and chisel plough for the 0 and 85 kg N ha^{-1} rates.

Chopra *et al*. (2008) reported that when compared with zero tillage, the conventional tillage and raised seed-bed method being statistically at par, resulted in significantly higher N, P and K uptake by maize crop.

Tolessa *et al*. (2009) reported that significantly higher grain N content was recorded with minimum tillage with residue retention than with minimum tillage without residue retention and conventional tillage. The stover N content was not significantly affected by the tillage practices. However, grain, stover and total biomass N uptake were consistently superior with minimum tillage with residue retention compared other tillage practices.

Vogeler *et al*. (2009) noticed that tillage system (conventional tillage and conservation tillage) did not significantly affect nitrogen and phosphorus uptake.

Naresh *et al*. (2014) found that nitrogen and phosphorus uptake was significantly higher in permanent bed tillage than conventional tillage practice but there was no significant difference for potassium uptake among the tillage practices.

Alam *et al*. (2014) observed that the total nitrogen content was 73.68, and 13.79% higher in zero tillage than the conventional tillage and minimum tillage, respectively. It was also observed that the total N (%) content gradually increased in ZT and MT with progressing time in respect to CT.

Yadav *et al*. (2016) observed that the maximum total nitrogen, phosphorus and potassium uptake (134.7, 40.9 and 156.6 kg ha^{-1}) as well as the protein content (8.7%) in maize grain were recorded with zero tillage compared to conventional tillage practice.

Majhi *et al*. (2019) reported that highest uptake of nitrogen, phosphorus and potassium recorded with glyphosate treated zero tillage followed by zero tillage, reduced tillage and conventional tillage.

Modak *et al*. (2019) observed that in tillage practices (zero tillage, minimum tillage and conventional tillage) zero tillage recorded the maximum uptake of nitrogen, phosphorus and potassium by the crop and improved physico-chemical and biological properties of soil after harvest.

Aditi *et al*. (2019) reported that no significant difference was observed in the nitrogen content of maize stover in response to tillage practices (zero tillage and conventional tillage).

2.1.4 Physical chemical parameter of soil

Kolodziej *et al*. (2004) revealed that soil organic carbon, soil microbial biomass and mineralizable carbon were 33, 58, and 79 % greater in the top 5 cm of reduced tillage treatment over conventional tillage practice.

Al-Kaisi *et al*. (2005) revealed that significant increase in soil organic carbon and soil organic nitrogen under no-tillage and strip-tillage practices then moldboard plow practice.

Dolan *et al*. (2006) reported that significantly higher soil organic carbon and nitrogen in surface (0-20 cm) soil with no-tillage then moldboard and chisel plough tillage treatment.

Monneveux *et al*. (2006) noticed that zero tillage was found to be related with increased soil bulk density, nitrogen concentration and microbial biomass organic carbon.

Zotarelli *et al*. (2007) concluded that aggregate size fractionation showed that no-tillage practice promotes conditions for aggregate formation, mainly in the 0–5 cm depth layer, and this effect was related to greater soil organic carbon accumulation under no-tillage than conventional tillage. Especially the combination of no-tillage and the inclusion of green manures enhance the stabilization of aggregate-associated carbon.

Thomas *et al.* (2007) noticed that in the top 0–10 cm depth, the quantity of soil organic carbon and total nitrogen were significantly greater under no-tillage than under reduced or conventional tillage practices. While up to top 30 cm depth, the average amount of soil organic carbon increased slightly, although it was similar under all tillage practices, while the quantity of total nitrogen decreased under conventional tillage and reduced tillage practices, but not under no-tillage practice.

Jacobs *et al*. (2009) revealed that significantly higher amount of soil organic carbon and soil organic nitrogen stored with minimum tillage practice over conventional tillage practice.

Saha *et a.l* (2010) found that the bulk density of the surface (0–0.15 m) soil layer was significantly reduced (P.05) after residue incorporation. Soil organic carbon and microbial biomass carbon, as well as mean weight diameter and geometric mean diameter of soil aggregates, were significantly greater in zero tillage with residue retention.

Mathew *et al.* (2012) found that long-term no-tillage treatment resulted in higher soil organic carbon and nitrogen contents, viable microbial biomass, and phosphatase activities at the 0–5 cm depth over the conventional tillage.

Ji *et al*. (2013) observed that deep tillage had significantly lower penetration resistance and lower soil bulk density and higher soil water content over conventional tillage.

Alam *et al.* (2014) studied that tillage management showed positive effects on soil properties, the highest OM accumulation, maximum root mass density and the improved physical and chemical properties were recorded in the conservational tillage practices(zero and minimum tillage). Bulk density and particle reduce and increase porosity due to tillage. The highest total N, P, K, and S in their available forms were found in zero tillage.

Islam *et al*. (2015) revealed that strip tillage increased soil organic matter over the bed and zero tillage at 0– 7.5 cm soil depth. Neither tillage nor residue management had any significant effect on soil pH, total nitrogen, available phosphorus and exchangeable potassium.

Parihar *et al*. (2016) noticed that significantly higher soil organic carbon, decreasing bulk density and penetration resistant under zero tillage and permanent raised bed then conventional tillage.

Naab *et al*. (2017) noticed that the conservation agriculture practices of no-tillage, residue retention and crop rotation/intercropping maintained higher soil organic carbon, and total soil nitrogen then conventional tillage practices.

Asenso *et al.* (2018) reported that zero tillage practice had significantly higher soil organic carbon and available nitrogen, phosphorus and potassium than sub-soiling and rotary tillage treatment.

Paliwal *et al.* (2018) reported that higher amount of soil organic carbon was recorded with zero tillage over conventional tillage and zero tillage with residue retention also shows the high soil organic carbon.

Nandan *et al*. (2019) reported that zero tillage crop establishment treatments had higher total soil organic carbon over conventional tillage treatment.

Ramadhan. (2020) experimented to access the effect of component of maize. The results showed that compared with reduced tillage, deep tillage and conventional tillage decreased soil bulk density, as well as led to increase soil water content.

Mamta *et al*. (2022) concluded that significantly positive effect of CA practices (zero tillage and permanent raised bed) on soil organic carbon (SOC) content, soil compaction, bulk density, root length density (RLD) of maize over the conventional tillage.

2.1.5 Economics

Ram *et al.* (2010) revealed that highest net returns B:C ratio were observed in no-tillage practice over conventional tillage and other tillage practices.

Jat *et al*. (2013) observed that permanent raised bed and no-tillage flat bed systems provided similar net returns in maize, which were higher compared to conventional tillage flat bed system.

Kumar and Angadin. (2014) reported that minimum tillage recorded significantly higher net returns as compared to zero tillage and conventional tillage practice in maize.

Yadav *et al.* (2016) noticed that net return and B:C ratio of maize was recorded highest with zero tillage and permanent bed tillage practices compared to conventional tillage practice.

Parihar *et al*. (2017) revealed that significant highest net return was occur in maize with zero tillage and permanent bed tillage then conventional tillage.

2.2 Effect of Nutrient Management on the Performance of Maize

2.2.1 Growth Attributes

Abbas *et al.* (2005) observed that increasing rate of nitrogen dose up to 300 kg N/ha^{-1} increased crop growth rate in maize.

Nadeem *et al*. (2009) reported that 150 kg N ha^{-1} produced significantly more number of leaves per plant than the other nitrogen levels (0, 50, and 100 kg N ha^{-1}).

Singh *et al*. (2012) reported that each successive increase in nitrogen level from 0 to 120 kg ha^{-1} significantly increase plant height but remained at par with 150 kg ha^{-1}.

Kumar *et al.* (2014) observed that significantly higher dry-matter accumulation, leaf-area index, crop growth rate (CGR) and relative growth rate (RGR) under site-specific nutrient management (SSNM) then the recommended dose of fertilizer (RDF) under conservation agriculture.

Iqbal *et al*. (2015) use five nitrogen levels (100, 120, 140, 160, 180 kg ha^{-1}) on maize. In which higher plant height, number of leaves per plant and stem diameter were recorded with 180 kg N ha^{-1} over other treatment.

Noonari *et al.* (2016) revealed that highest tillers, spike length and plant height was recorded with 90 kg phosphorus ha^{-1}+ recommended dose of nitrogen over 0, 30 and 60 kg P ha^{-1}+ recommended dose of nitrogen.

C.U Arubalueze. (2016) reported that nitrogen application up to 80Kg N ha^{-1} significantly increased plant height, number of leaves per plant, leaf area, leaf area index, cob length with exception of grain yield which increased with further application up to 120Kg N ha^{-1}. Phosphorus application of 30 Kg P ha^{-1} significantly increased growth parameter of plant.

Raj *et al*. (2018) reported that growth of maize revealed that site specific nutrient management manifested significantly higher plant height, leaf area index, dry matter accumulation, crop growth rate and relative growth rate over the recommended dose of fertilizer and farmer fertilizer practices.

Acharya *et al*. (2020) observed that significantly higher leaf area index and accumulation of dry matter under site specific nutrient management followed by recommended dose of fertilizer and 75% SSNM compare to farmer fertilizer practice.

Stesi *et al*. (2020) studied that growth characters viz., plant height, dry matter production, leaf area index and were significantly influenced by application of nitrogen at enhanced dose (125% RDN) when compared to the recommended dose (100% RDN). Enhanced N dose (125% RDN).

2.2.2 Yield and Yield Attributes

Bakht *et al.* (2006) reported that maximum number of leaves $plant^{1}$, number of cobs $plant^{-1}$, number of grains $cobs^{-1}$, grain and biological yield was recorded in ridge planting and application of 200kg N ha^{-1} over treatments.

Biradar *et al*. (2006) revealed that grain yield of rice, wheat and chickpea recorded highest with site specific nutrient management over recommended dose of fertilizer and farmer fertilizer practices.

Amanullah *et al.* (2009) studied effect of nitrogen rate and time of application on the leaf area, plant height and biomass yield of maize (*Zea mays* L.) planted at low density (60000) plants and high plant density (100000) and three nitrogen rate (60, 120, 180 kg ha^{-1}) while application of nitrogen in six split at different stage of maize at sowing and with 1^{st}, 2nd, 3^{rd} and 4^{th} irrigation at two week interval. It is concluded that growing of maize at higher density with 50% increase N dose (180 kg ha^{-1}) than recommended dose (120 kg ha^{-1}) in four to five split give high leaf area, taller plant so production of biomass defiantly maximum.

Ahmad *et al.* (2009) reported that Conventional tillage in interaction with 120 kg N ha^{-1} and two equally split application i.e. at sowing and pre tasseling of N showed higher yield as compared with their associated levels.

Onasanya *et al*. (2009) noticed that yield of maize was significantly higher with 120 kg N ha^{-1} + 40 kg P ha^{-1} over other N and P dose combination.

Arif *et al.* (2010) reported that the ears m^{-2}, grain yield and biological yield consistently increased with increase in plant density from 4 to 8 plants m^{-2}. However, grains per ear and thousand grain weight lessened with increase in plant density. It was concluded that the highest plant population of 8 plants m^{-2} and the highest N level of 160 kg ha^{-1} resulted in higher yield of maize.

Ghaffari *et al*. (2011) observed that number of grain rows per cob, number of grains cob^{-1}, 100-grain weight and grain yield was significantly higher with recommended dose of fertilizer (NPK) in addition with single spray of Multi-nutrients over recommended dose of NPK applied alone.

Sapkota *et al.* (2017) revealed that increasing level of N significantly increased grain yield up to 240 kg N ha^{-1} over 120, 160 and 200 kg N ha^{-1}. The results also revealed that split application of P failed to bring about any significant difference in the grain yield and yield attributing character of maize.

Khanal *et al*. (2017) noticed that nutrient expert based nutrient management practices was produced higher grain yield (9.22 t ha^{-1}), higher average cob number m^{-2}, average kernel rows cob^{-1} (14.2), average kernels number row^{-1} and test weight over farmer fertilizer practice.

Kumar *et al.* (2018) reported that highest yield attributes and yield viz., cobs plant^{-1}, length of cobs, grains cob^{-1}, girth of cobs, test weight and grain yield were observed under farmer fertilizer practices (150% of RDF + 10 ton FYM) which was significantly superior over recommended dose of fertilizer (120, 60 and 50 kg ha^{-1} N, P_2O_5 and K_2O) but statistically at par with site specific nutrient management practices.

Singh *et al.* (2018) reported that 3 nutrient management practices (recommended dose of fertilizer, site specific nutrient management and farmer fertilizer practice) in subplot replicated thrice. Site specific nutrient management exhibited significantly higher cob yield, grain yield and stover yield.

Phillippi *et al.* (2018) studied that significant increase in yield of maize with increasing amount of nitrogen based on nutrient expert tool.

Sharma *et al.* (2019) noticed that significantly higher grain yield of maize with 150 kg N ha^{-1} over the 120, 180, 210 and 240 kg N ha^{-1} treatments.

Singh *et al.* (2020) reported that grain yield of maize was significantly higher with nutrient expert based site specific nutrient management over the recommended dose of fertilizer and farmer fertilizer practices.

Verma *et al.* (2020) revealed that among the mulching and integrated nutrient management treatments, dust mulch and 100% RDF +25% N through poultry manure significantly recorded number of leafs, plant height (cm), leaf area index at 75 DAS, chlorophyll content at 75 DAS (spad value), grain yield (q ha^{-1}) and stover yield (q ha^{-1}) of maize over control and other mulching and integrated nutrients treatments.

Shahi *et al*. (2020) concluded that kernel yield of maize significantly higher with site specific nutrient management over different level of recommended dose of fertilizer.

Bana *et al.* (2020) said that nutrient application as per site specific nutrient management resulted in significantly high grain yields of maize, rice, wheat and other important crop over recommended dose of fertilizers (RDF) and farmer's fertilizer practices.

Hasnain *et al.* (2021) observed that nutrient management as par nutrient expert + green seeker resulted high grain yield, protein content and protein yield over nutrient expert alone and soil test - based recommendation.

2.2.3 Nutrient content and uptake

Ziadi *et al*. (2007) revealed that concentration of nitrogen and phosphorus in maize increase with increasing rate of fertilizer application. It is also noticed that linear relationship between nitrogen and phosphorus concentration in shoot and grain of maize.

Mahesh *et al*. (2010) reported that lower nitrogen, phosphorus and potassium uptake were observed in the treatment receiving 100 per cent recommended dose of NPK through commercial fertilizer i.e. 150:75:40 kg ha^{-1}.

Paramasivan *et al*. (2012) studied that higher amount of Nitrogen uptake by maize with 250 kg N ha^{-1} over other level of N. In case of P and K it was also found that highest uptake of P and K with 95 kg ha^{-1} and 110 kg^{-ha} respectively, over other treatment.

Kwadzo *et al.* (2017) noticed that uptake of nitrogen, phosphorus and nutrient status of post harvest of maize was higher with 150 kg N ha^{-1} and 75 kg P ha^{-1} over at par with 125 kg N ha^{-1} and 75 kg P ha^{-1}.

Shah and Wani. (2017) revealed that significantly highest nitrogen, phosphorus and potash uptake was recorded in maize with 100% N:P:K (60:60:30 kg ha^{-1}) + 3 tonne ha^{-1} vermicompost then 100%, 50% N, P and K alone and other treatments.

Hargilas *et al.* (2017) reported that the uptake of nitrogen, phosphorus and potassium by grain and stover and biomass was significantly higher with site specific nutrient management over recommended dose of fertilizer and farmer fertilizer practices.

Shreenivas *et al*. (2017) reported that significantly higher total uptake (grain + stover) of nitrogen, phosphorus and potash was recorded with the application of nutrients through site specific nutrient management for targeted yield of 8.0 t ha^{-1} (310.96, 52.65 and 243.12 kg ha^{-1}, respectively) followed by soil test based crop recommendation approach targeted yield of 8.0 t ha^{-1} (299.44, 50.44 and 230.74 kg ha^{-1}, respectively) as compared to recommended dose of fertilizer and state fertilizer recommendation.

Singh *et al.* (2018) reported that maize plant uptake significantly higher amount of Nitrogen, Phosphorus and Potash under site specific nutrient management over recommended dose of fertilizer and farmer fertilizer practice.

Priyanka *et al*. (2019) revealed that significantly higher quantity of nitrogen, phosphorus and potash was uptake in maize with 100% NPK + FYM 10 t ha^{-1} then other treatment.

Shahi *et al.* (2020) observed that Maximum N, P, K, S, Zn and B uptake was recorded with site specific nutrient management fallowed by 150% recommended dose of fertilizer.

Seth *et al*. (2020) observed that nitrogen content and uptake in straw was significantly higher with nitrogen rich plot treatment (150 % of recommendation) and was statistically at par with recommended NPK (120:60:30 kg ha^{-1})with top dressing of nitrogen both after and before irrigation and site specific nutrient management based on Nutrient Expert.

Dhakal *et al*. (2021) revealed that nitrogen application at 120 kg ha^{-1} was found to be optimum with highest nitrogen uptake and increasing the nitrogen dose beyond that had no significant effect on any of the response variables.

2.2.4 Physical chemical parameter of soil

Janwal *et al*. (2006) observed that application of Farmyard manure (FYM) increased significantly the available nitrogen, phosphorus and potassium status of the soil after maize harvest. The available P status increased significantly due to residual effect of FYM and fertility levels

Govaerts *et al*. (2007) reported that potassium concentration was 1.65 times and 1.43 times more in the 0–5 cm and 5–20 cm soil profiles, respectively, for permanent raised beds relatively conventionally tilled raised beds.

Das *et al*. (2010) revealed that highest soil organic carbon was recorded in maize soil after harvest with 50% nitrogen, phosphorus and potash (30. 30, 10 kg ha^{-1}) + Azolla compost 5 tonnes ha^{-1} over other treatment.

Kalhapure *et al*. (2013) found that improves soil physico-chemical properties with application of 25% recommended dose of fertilizers (RDF) in combination with biofertilizers and green manuring over other treatment.

Pooniya *et al*. (2015) observed that highest available nitrogen, potassium and soil organic carbon content were recorded with site specific nutrient management (SSNM)–nutrient expert (NE) + farm yard manure, although, this remained statistically at par with SSNM–NE and 125% recommended dose of fertilizer (RDF). 125% RDF exhibited highest available–P being statistically at par with SSNM-NE + FYM.

Kumar *et al.* (2015) reported that initially before crop sowing, significantly highest organic carbon in soil was in 100% RDF plots. However, significantly higher organic carbon build up was obtained with SSNM which remained at par with 100% RDF, after crop harvest.

Singh *et al.* (2015) revealed that soil available N, Olsen-P and available K content were either maintained or improved over its initial values under site specific nutrient management whereas these parameters declined or marginally increased over the initial contents with farmer fertilizer practices and state recommendation in 0-15 cm soil profile depth.

2.2.5 Economics:-

Biradar *et al*. (2006) noticed that highest net return was occur with site specific nutrient management practice over recommended dose of fertilizer and farmer practices.

Pasuquin *et al*. (2010) revealed that significantly higher gross return was recorded for maize with site specific nutrient management then farmer fertilizer practice.

Satyanarayana *et al*. (2013) reported that highest gross return above fertilizer cost with nutrient expert based fertilizer recommendation over state recommendation and farmer practice.

Nsanzabaganwa *et al.* (2014) found that combination of 240 kg N ha^{-1} and 26.4 kg P ha^{-1}, providing higher gross returns, net returns and net B:C ratio over 196 kg N ha^{-1} and 23.4 kg P ha^{-1}.

Kumar *et al.* (2015) reported that significantly higher gross return, net return and B: C ratio was obtained with SSNM over RDF.

Keteku *et al.* (2017) observed that significantly higher gross return, net return and B:C ratio was recorded with increasing Nitrogen dose (125 kg ha^{-1} and 150 kg ha^{-1}) over 100 kg N ha^{-1} and also this trend follow with Phosphorus except in B:C ratio where 75 kg P ha^{-1} recorded maximum value.

Prakasha *et al.* (2018) observed that higher gross returns and net returns were noticed in application of NPK fertilizers through soil test based crop recommendation (STCR) method over site specific nutrient management (SSNM) but higher B: C ratio was registered in nitrogen management through Green Seeker as compared to STCR and SSNM.

Otieno *et al*. (2018) reported that highest total production cost, gross return and net return due to application of nitrogen, phosphorus and potash + zinc, boron, magnesium, calcium and sulphur fertilizer than other treatments.

Khanal *et al.* (2018) revealed that significantly high gross return, net return and B:C ratio with site specific nutrient management over farmer fertilizer practices.

Mevada *et al*. (2018) reported that site specific nutrient management is a set of nutrient management principles which when combined with efficient crop management practices will help farmers to attain high yield and profitability.

Singh *et al*. (2020) reported that nutrient expert based site specific nutrient management significantly higher return over recommended dose of fertilizer and farmer fertilizer practices.

2.3 Interaction effect of tillage and nutrient management on the performance of maize:-

Mensah and Al-Kaisi. (2006) revealed that interaction effects of tillage, nitrogen rate, and nitrogen source on biomass yield were generally inconsistent with commercial fertilizer N. It appears that the combind effects of tillage and N rate were more frequent with commercial fertilizer N treatment, where most growth stages showed a favorable response to tillage and N rates, especially with N rates between 85 and 170 kg ha^{-1} with chisel plow and strip tillage tillage systems. It is also to be noted that the increase in N rate beyond 170 kg ha^{-1} did not show significant advantages in biomass yield or grain yield regardless of tillage system, N rate, or N source.

Sangoi *et al.* (2007) concluded that response of maize to the time and form of splitting nitrogen was not affected by the soil tillage practices (conventional tillage and no-tillage).

Wasaya *et al.* (2012) noticed that tillage practices improved the plant height, biomass yield, harvest index and shelling percentage while nitrogen application had no effect on plant height and harvest index but had significant effect on shelling percentage and biomass yield of maize.

Parihar *et al*. (2017) reported that combinations of zero tillage/permanent bed practices + site specific nutrient management/recommended dose of fertilizer nutrient management strategies registered significantly ($P < 0.05$) higher system water use efficiency, grain and biomass yield compared to conventional tillage + unfertilized/farmer fertilizer practice.

Buah *et al*. (2017) revealed that results of studies showed that no-tillage with N, P and K fertilizer (64:38:38 kg ha^{-1}) for maize generally resulted in the highest grain yields. No-tillage also gave the highest economic returns over conventional tillage.

Parihar *et al*. (2017) observed that conservation agriculture based zero tillage and permanent bed tillage practices and site specific nutrient management based balanced use of inorganic fertilizers guided by the Nutrient Expert® fertilizer decision support tool, caused a significant improvement in the WUE, net energy outputs, energy productivity and efficiency, system biomass productivity and economics of the maize-wheat-moongbean cropping system.

Kumar *et al*. (2018) reported that combination of zero tillage with crop residue retention along with application of 34.40 kg ha^{-1} resulted significantly higher grain yield (6.40 and 6.49 t ha^{-1}), gross returns and net returns compare to conventional tillage with no residue but B:C ratio was maximum under combination of zero tillage with no residue with application of 34.40 kg ha^{-1}.

Biswakarma *et al*. (2019) reported that significant tillage and nutrient management interactions were observed for maize grain and stover yield. However permanent bed and nutrient expert (NE) based nutrient management plot resulted in higher grain yield over zero tillage flat bed × NE and conventional tillage × NE plot, respectively.

Simic *et al*. (2020) reported that higher grain yield was recorded in conventional tillage with 280 N ha^{-1} over reduce and no-tillage with 0 and 180 kg N^{-1}.

Tigga *et al.* (2020) observed that crops residue retention as well as balanced fertilization (RDF and SSNM) under conservation agriculture helped in improving soil organic carbon, mineral N and soil aggregate stability which can lead to increased sustainability under cereal-based intensive cropping systems.

Njue *et al*. (2020) reported that highest yield and B:C ratio under combination of conservation tillage with nitrogen, phosphorus and potash (120, 60, 60 kg ha^{-1}) over conventional tillage with same amount of nitrogen, phosphorus and poyash.

Jat *et al.* (2021) concluded that nutrient expert tool, nutrient expert tool + green seeker and recommended dose of fertilizer based nutrient management tactics with seed drilling improved crop yields, nutrient-use efficiency, and economic profitability then NE-broadcasting, RDF broadcasting, and farmer fertilizer practices broadcasting methods. Maize-wheat system productivity and net returns under NE+GS-drilling on permanent bed were significantly higher compared to FFP-broadcasting.

CHAPTER-3

MATERIALS AND METHODS

Chapter - 3

Materials and Methods

The proposed research study entitled "**Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices** " was carried out during kharif season of 2021 at university research farm, Banda university of Agriculture and Technology Banda-210001 (Uttar Pradesh). A detailed account of the materials used, experimental procedure and methods adopted during the course of field investigation are described in this chapter.

3.1 Climatic and Edaphic Conditions

3.1.1 Experimental site

The experiment was conducted at university research farm 'Banda university of Agriculture and Technology Banda-210001 (Uttar Pradesh) during the kharif season 2021, is situated between latitudes 24º 53′ and 25º 55′ N and longitudes 80º 07′ and 81º 34′ E and having an altitude of 168m above sea level. This region falls under agro climatic zone VIII (Central Plateaus & Hills Region) of India. All required facilities to conduct the experiment are available on this farm.

3.1.2 Climate and weather

Bundelkhand is situated in the hot and semi-arid climatic zone, and is characterized by temperature extremes that reach peak 49°C in the summer and 1°C in the winter. Hot waves, a powerful dusty and hot wind in dry summer that blows across the entire region during the summer months, especially in May and June, sometimes causes fatal heat strokes. This zone's rainfall distribution pattern is erratic, with the part of rain falling during the monsoon months of June to September. The average annual precipitation is 850 mm, but due to undulated topography and a lack of infrastructure for water harvesting for future use, the majority of the rain is lost to runoff. In the winter months from November to March, occasional precipitation, which supplies adequate moisture to the crops of rabi season. The region is characterized by droughts and drought-like conditions in summer and flood situations in the monsoon. The details of climate and weather given below.

Soil types in Bundelkhand are black and a mix of black and red; the latter being formed recently. The black soils are deep, having medium organic carbon content with high moisture holding capacity while mixed soils are gravelly and shallow in depth, and thus unable to retain enough moisture. The weekly distribution of weather parameter recorded during crop period collected from meteorological observatory situated at same experimental farm is presented in **Table 3.1, fig 3.1 & 3.2.**

3.1.2.1 Rainfall (mm)

Total rainfall was received in 28th week before sowing and 29th sowing week was 18.25 mm and 118 mm respectively. Vegetative growth period 30th to 35th week recorded total rainfall during this period was 393.5 mm. Reproductive phase of crop started from 36th and complete in 38th week during which received rainfall was 128 mm. the rainfall received during grain filling to harvesting was 41 mm. Total rainfall received during experiment was 750 mm and out of total rainfall 391.5 mm was received between 28th to 31th week which revealed that erratic rainfall distribution. Pattern of rainfall presented in table 3.1 and fig. 3.1.

3.1.2.2 Evapotranspiration (mm)

Pattern of evapotranspiration (ET) standard week wise presented in table 3.1 and fig. 3.1showed that increasing rainfall decreases the ET during period. Minimum ET (2.8 mm) was recorded in 31st week while maximum ET (6.5 mm) was noticed in 28th standard week.

3.1.2.3 Temperature (^{0}C)

The weekly mean maximum and minimum temperature was recorded during the crop period 42 ^{0}C and 24 ^{0}C in 29th and 36th week, respectively. The range of temperature was recorded during the crop growth period minimum 24 ^{0}C to maximum 42 ^{0}C.

3.1.2.4 Sun shine (hr.)

Table 3.1 and fig. 3.2 showed pattern of sun shine (hr.) recorded during experimentation. Sun shine is affected by cloudy day so, in mansoon season recurrent occurrence of that type of day that’s why fluctuation seen in the sun shine (hr.). Minimum sun shine (3.65 hr.) was recorded in 34th week however; highest sun shine (8.01 hr) was recorded in 29th week.

3.1.2.5 Relative humidity (%)

The weekly average maximum and minimum relative humidity was recorded during the crop period 92.6% and 73.1 % in 30th and 28th week, respectively. The range of relative humidity was recorded during the crop growth period minimum 73.1 % to maximum 92.6%. This is presented in table 3.1.

3.1.2.6 Wind speed (km hr^{-1})

The weekly average maximum and minimum wind speed was recorded during the crop period 6 km hr^{-1} and 2.2 km hr^{-1} in 31th and 40th week respectively. The range of wind speed was recorded during the crop growth period minimum 2.2 km hr^{-1}to maximum 6 km hr^{-1}. The observation was presented in table 3.1 and fig 3.2

Table 3.1 Standard week wise meteorological data observed during experiment

Week No.	Period	Rainfall (mm)	Evapotrans-piration (mm)	Temperature (^0C)			Sunshine (hr)	Relative humidity (%)	Wind speed (km hr^{-1})
				Minimum	Maximum	Average			
28	9-15 July 2021	18.2	6.5	27	40	33.5	5.50	73.1	3.9
29	16-22 July 2021	118	4.5	26	42	34	8.01	79.2	2.6
30	23-29 July 2021	170	3.7	25	37	31	4.08	92.6	5.1
31	30 July -05 Aug. 2021	103.5	2.8	26	34	30	4.30	91.0	6.0
32	6-12 Aug. 2021	58.2	4.4	26	36	31	3.75	89.2	4.1
33	13-19 Aug. 2021	29	4.8	27	38	32.5	5.37	80.3	3.5
34	20-26 Aug. 2021	15	4.3	26	36	31	3.65	87.7	4.4
35	27 Aug. to 02 Sept. 2021	17.7	3.8	26	38	32	3.85	83.1	4.3
36	03-09 Sept. 2021	42	3.4	24	37	30.5	5.64	86.0	3.9
37	10-16 Sept. 2021	83.5	2.3	25	36	30.5	6.24	92.1	5.5
38	17-23 Sept. 2021	2.5	3.4	24	38	31	7.01	84.6	2.8
39	24-30 Sept. 2021	5	4.1	25	36	30.5	6.50	87.3	3.8
40	01-07 Oct. 2021	36	5.9	25	38	31.5	7.60	82.4	2.2
41	08-14 Oct. 2021	0	5.3	21	38	29.5	7.30	60.4	4.0
42	15-21Oct.2021	51.7	3.2	22	38	30	7.91	75.7	4.4

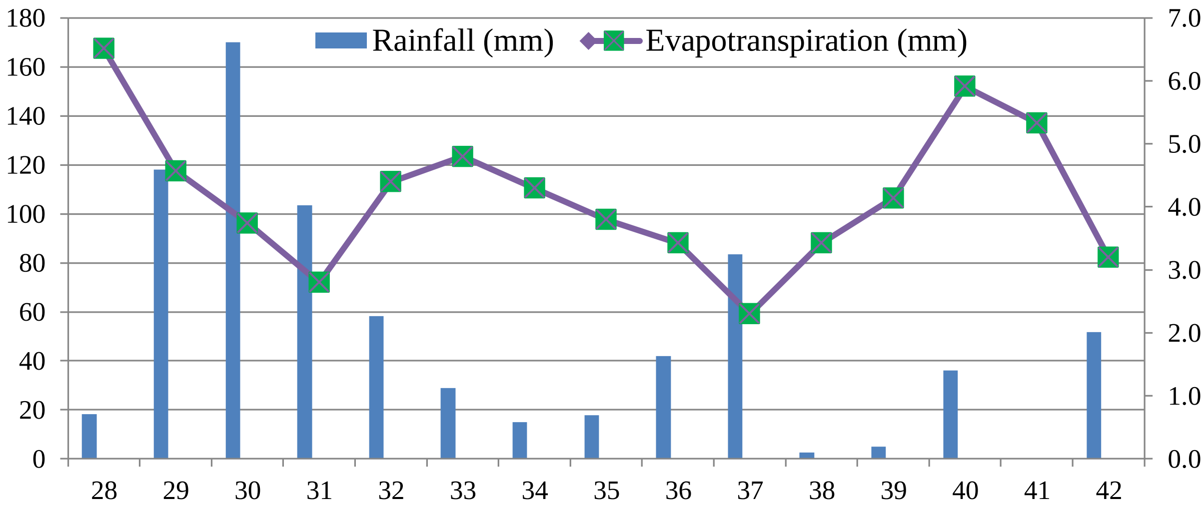


Fig 3.1: Pattern of rainfall (mm) and evapotranspiration (mm) against standard week

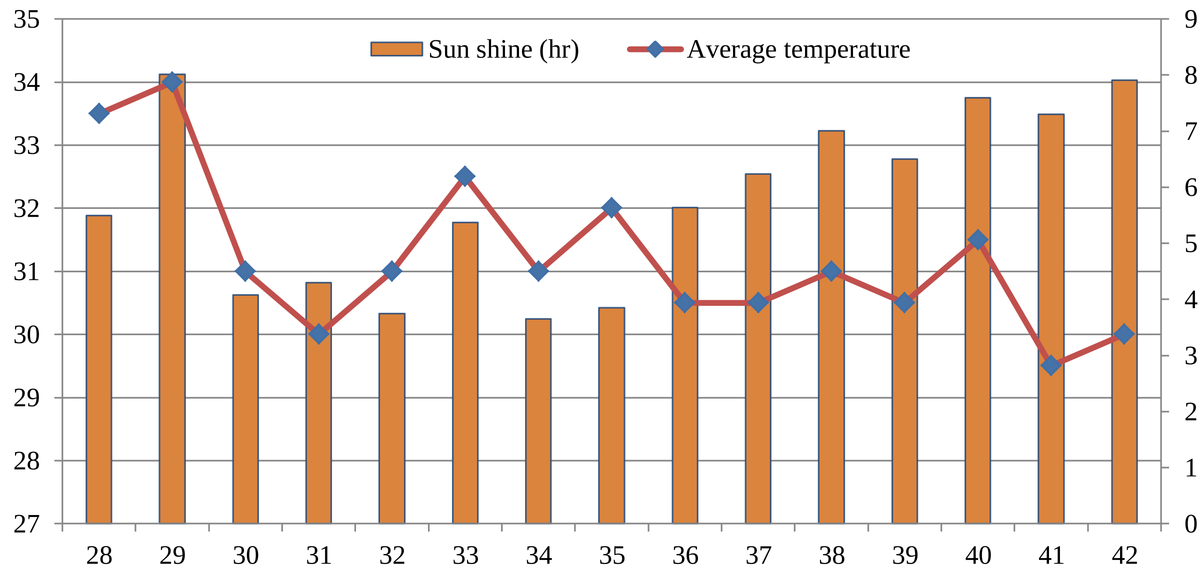


Fig 3.2: Pattern of sun shine (hr.) and average temperature (^{0}C) against standard week

3.2 Soil of the experimental field

To determine the physical and chemical properties of the soil, collected representative soil samples from zero tillage, conventional tillage and permanent bed plot separately to each other. Soil samples was taken from different places of experimental field 0-15 cm depth and mixed to form composite sample of each tillage plot separately A fraction of this composite sample was used for the textural class of soil by feel and appearance method. Another part of the composite sample taken from the main field was air dried at room temperature, powdered to pass through (2.0 mm) sieve and was used for chemical analysis.

The detail of physiochemical properties of soil is given in table 3.2 while, the result obtained from the chemical analysis of soil was compared with rating chart given by DAC, Ministry of Agriculture Government of India 2011 in Table 3.3.

Table 3.2 Physco-chemical properties of the soil

S.No	Particulars	Tillage employed (ZT, CT, PB)	Method adopted	References
A.	Mechanical analysis			
1.	Textural class	Silt clay	Feel and appearance	
B.	Chemical analysis			
1.	Soil pH	7.89	Glass electrode pH meter	Jackson (1973)
2.	Soil EC (dSm^{-1})	0.55	Conductivity bridge	Jackson (1973)
3.	Total OC (%)	0.76	CHNS analyzer	Antoine Lavoisier
4.	Total N (kg ha^{-1})	2352	CHNS analyzer	Antoine Lavoisier
5.	Available P (kg ha^{-1})	15.51	Olsen's mathod	(Olsen and Watanable, 1954)
6.	Available K (kg ha^{-1})	325	Flame photometer method	(Jackson, 1973)

* Carbon hydrogen nitrogen sulphur analyzer (CHNS)

Table 3.3 Rating chart for evaluating the fertility status of soil

No	Nutrient	Low	Medium	High
1.	Available P (kg ha^{-1})	<10 (kg ha^{-1})	10-24.6 (kg ha^{-1})	>24.6 (kg ha^{-1})
2.	Available K (kg ha^{-1})	<108 (kg ha^{-1})	108-280 (kg ha^{-1})	>280 (kg ha^{-1})

Source: - Methods manual soil testing in India, DAC, Ministry of Agriculture Government of India 2011.

3.3 Cropping history of experimental field

The details of the cropping history of experimental field since last three years of experimentation are given in Table 3.4.

Table 3.4 Cropping history of experimental field

Year	Kharif	Rabi
2018 – 2019	Maize	Mustard
2019 – 2020	Maize	Mustard
2020 – 2021	Maize	Mustard
2021 - 2022	Current experiment	---

3.4 Experimental details

The present investigation entitled "**Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices**" was conducted during the Kharif season of 2021. The experiment was taken in a split plot design with three replications. The treatments were split plot as per procedure given by Gomez and Gomez (1984). The details given in table 3.5.

Table 3.5 Technical program of work

1.	Site of experiment		College research farm BUAT, Banda.
2.	Crop		Maize (*Zea mays* L.).
3.	Season		Kharif (2021)
4.	Design		Split plot design
5.	Treatment	A. Main plot treatment B. Sub plot treatment	3 3
6.	Replication		3
7.	Total number of plot		27
8.	Net plot size		7.5 x 4 = 30 m^2
9.	Total field size		1375 m^2
10.	Spacing (cm)		60 x 25
11.	Seed rate		20 kg ha^{-1}
12.	Variety		NMH 8399 (hybrid)
13.	Date of sowing		18/07/2021

3.5 Treatments details of the experimental plot

Table 3.6 Factor A (Main plot): Tillage Practices

Symbol	Treatment
T_1	Zero tillage
T_2	Conventional tillage
T_3	Permanent bed tillage

Table 3.7 Factor B (sub plot): Nutrient management

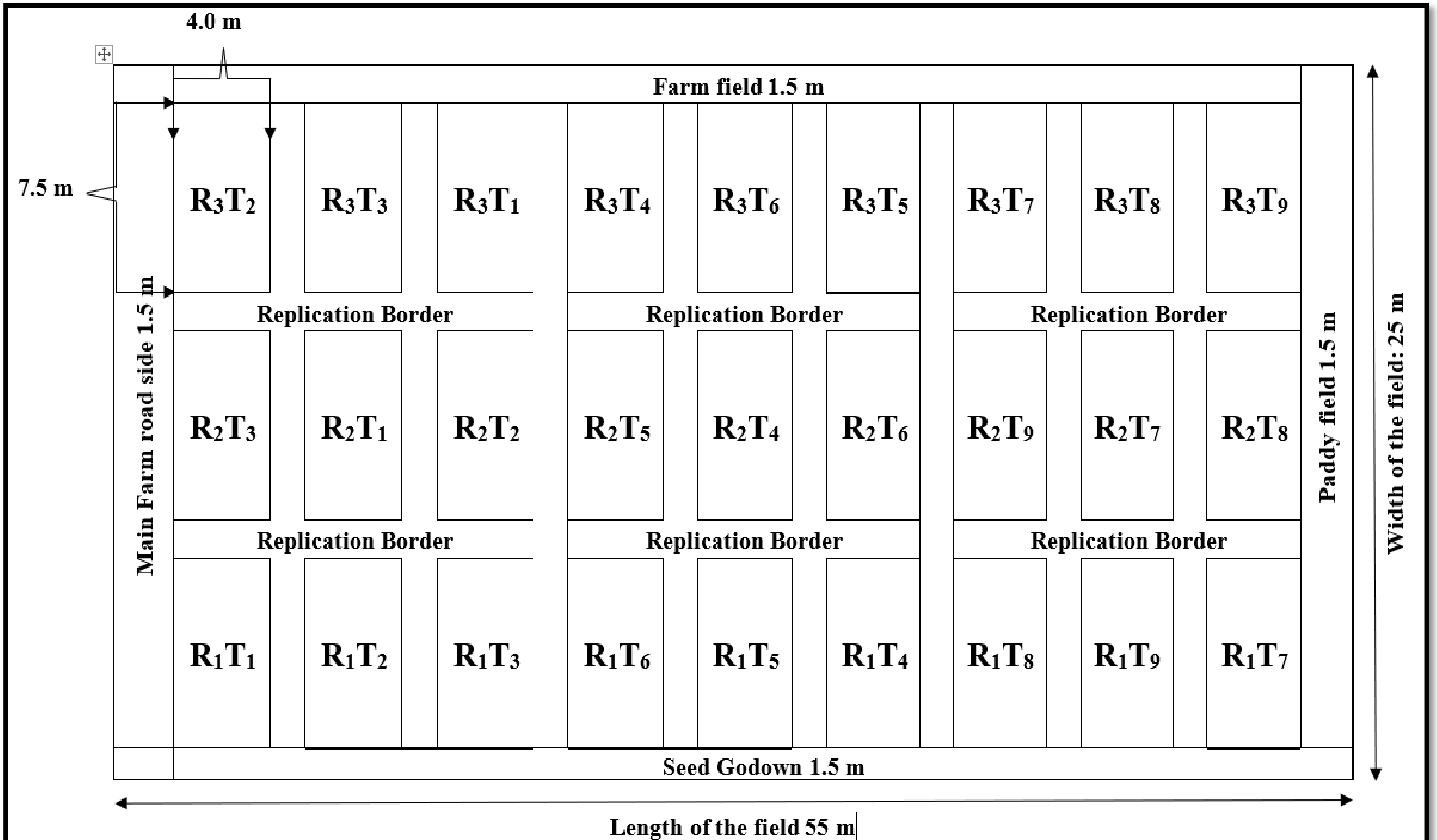
Symbol	Treatment
F_1	33% recommended dose of nitrogen (N 40 kg ha^{-1}).
F_2	Recommended dose of fertilizer ($N:P_2O_5:K_2O$ - 120:60:50 kg ha^{-1}).
F_3	Site specific nutrient management ($N:P_2O_5:K_2O$ - 160:50:60 kg ha^{-1}).

3.6 Treatment symbol

The details of experimental treatments and their symbols are given below:

Table 3.8 Description of treatments combination:-

T_1F_1	Zero tillage + 33% recommended dose of nitrogen (RDN)
T_1F_2	Zero tillage + recommended dose of fertilizer (RDF)
T_1F_3	Zero tillage + site specific nutrient management (SSNM)
T_2F_1	Conventional tillage + 33% recommended dose of nitrogen (RDN)
T_2F_2	Conventional tillage + recommended dose of fertilizer (RDF)
T_2F_3	Conventional tillage + site specific nutrient management (SSNM)
T_3F_1	Permanent bed tillage + 33% recommended dose of nitrogen (RDN)
T_3F_2	Permanent bed tillage + recommended dose of fertilizer (RDF)
T_3F_3	Permanent bed tillage + site specific nutrient management (SSNM)



Layout of experimental field.

3.7 Details of variety

Chancellor NMH 8399 is a hybrid maize variety. It is mature in 105 to 110 days. It require medium management, suitable for rainfed condition and orange colour grain. Special character of this variety is that highly tolerant to all leafy disease including wilt of maize. It is highly stable, rough and tough hybrid. It has unique character high productivity along with high disease resistance.

Cob of variety hybrid NMH 8399

Grain of variety hybrid NMH 8399

3.8 Cultivation details

3.8.1 Preparation of field

The experimental area was prepared as per treatment detail, however in conventional tillage two deep ploughing followed by two cultivator and planking employed, similarly same practices were employed in permanent bed tillage and later permanent bed were marked with the help of bed maker. Nevertheless in zero tillage no tillage was applied.

3.8.2 Seed and sowing

A good quality seed 20 kg ha^{-1} was used for sowing of maize. Seed was treated with thiamethoxam and thiram. Sowing of seed was done by seed-cum fertilizer drill in 3-4 cm depth on 18 July, 2021. Spacing between row to row 60 cm and spacing between seed to seed 25 cm.

Table 3.9 Details of crop calendar

A. Pre planting			
S.No	**Operation**	**Date**	**Remark**
1.	Spray Glyphosate 41% SL in zero tillage plot.	28/06/2021	2.5 l ha^{-1} spray by knapsack sprayer.
2.	Ploughing and harrowing of field then broad bed making.	13/07/2021	Tractor drawn cultivator and rotavator except zero tillage and BBF making by bed maker.
3.	Layout	16/07/2021	Manually
4.	Basal fertilizer application	18/07/2021	Seed-cum fertilizer drill.
5.	Sowing	18/07/2021	Seed-cum fertilizer drill.
B. Post planting			
1.	Herbicide spray	18/07/2021	Atrazine 50% WP @ 3 kg ha^{-1}.
2.	Bunding- creation of replication and field border	19/07/2021	By tractor drawn bund maker and manually where required
3.	Thinning and gap filling	5/08/2021	Manually
4.	Insecticide carbofuran 3% G	10/08/2021	Manually
5.	Sub-surface bending at knee height	17/08/2021	Mechanically
6.	Surface bending at tasseling stage	9/09/2021	Manually
7.	Irrigation	---	Not applied
8.	Insecticide emamectin benzoate 5% SG	3/09/2021 & 18/09/2021	By tractor drawn sprayer
9.	Harvesting	13/10/2021 (cob) 16/10/2021 (total crop)	Manually Manually

3.8.3 Thinning and gap filling

Sowing was done relatively at high seed rate to ensure adequate plant population within a row. Plant spacing was maintained by thinning and gap filling 18 days after sowing where ever it required.

3.8.4 Fertilizer application

Application of fertilizer was scheduled as basal of 1/3rd of nitrogen and total amount of phosphorus and potassium of recommended dose as per treatment by seed-cum fertilizer drill. Remaining 2/3rd part of nitrogen were applied in two equal doses. First top dressing (sub-surface bending) of nitrogen was done at knee height (30 DAS) stage and second top dressing (surface bending) at tasseling (52 DAS) stage.

Method of fertilizer application: Subsurface applications of 1/3rd of urea were applied in to the soil at a depth of 4-5 cm apart through ferti drill in sub surface of soil profile. This operation was done at 30 DAS and source of fertilizer were use neem coated urea prills. Surface bending in this method Neem coated urea prills applied near the row zone and subsequently cover with the slight soil this practice was adopted by surface bender by manually drawn surface bender. This stage was coincided at 52nd day of crop and crop reached tasseling stage.

Plate 1 A. Sub Surface bending of urea B. Surface Bending of Urea

3.8.5 Irrigation

Maize crop was growing in kharif season so recurrent rainfall occurs during the cropping period and no long dry period. Due to this no irrigation water was required of to the crop. Moisture was adequately available through the season.

3.8.6 Weed management

In zero tillage practice glyphosate 41% SL herbicide was applied @ 2.5 l ha^{-1} 15 days before sowing. One pre emergence spray of Atrazine @ 3.0 kg ha^{-1} was done after sowing in all tillage practices.

3.8.7 Plant protection measures

The maize crop was grown in kharif season there were two insect (stem borer and fall army worm) attacks on the crop. Stem borer attack on the crop 20-25 days after sowing. which was control by the soil application of Carbofuron 3% G @ 20 kg ha^{-1}. On other hand fall army worm was attack on the crop at cob formation stage. The insecticide Emamectine benzoate 5% SG @ 800 g ha^{-1} was applied two times at 15 day interval. First application was done at cob formation then second spray at dough stage of the crop.

3.8.8 Harvesting

The crop was harvested when the colour of silk radish brown, cobs become nearly dry and plants attained physiological maturity (yellowing). Formally, the cobs were removed from the standing crop later stover was harvested. The harvested cobs were kept in separate gunny bags for each plot and dried in the sun before shelling. After shelling, moisture percentage in grain and yield kg/plot were recorded and then converted into q ha^{-1} at 15 per cent moisture level.

3.9 Observations recorded

Five plants were taken and tagged from net plot at initial stage and tagged plants remain kept available for the recording observation at different stages of growth to till maturity of crop. The different growth stages when observations were recorded knee height stage (30DAS), tasseling stage (55 DAS) and physiological maturity (85 DAS). Yield attributes were recorded after harvesting.

3.9.1 Crop growth parameter

3.9.1.1 Plant population at harvest

Total plant population count at harvesting time was done randomly at three selected rows in each plot. The average plant population per row was converted into per plot and then computed it into per hectare basis.

3.9.1.2 Plant height (cm)

Height measurement was done with the help of meter scale. The height was measured of five randomly selected plants in each plot in centimeter and then average values were taken. Height was measured at knee height stage (30 DAS) and tasseling stage (55 DAS). The plant height was measured from the base of the plant to the tip of the upper most leaf.

3.9.1.3 Number of leaves plant^{-1}

Number of leaves counts were recorded from five randomly selected plant and then average values were taken. It was recorded at knee height stage (30 DAS) and tasseling stage (55 DAS).

Plate 2 Observation recorded during investigation (A) Plant height (B) Count number of leaves

3.9.1.4 Leaf area index

Five plants were selected randomly from each plot at knee height stage (30 DAS) and tasseling stage (55 DAS). All the leaves were removed from these plants, counted and categorized into three group of large, medium and small sized. A representative leaf from each category was chosen and measures the length and width and multiplied to get area of each category. The leaf area of plant was obtained by leaf area of each category multiplied by number of leaves in the respective category and then summed to get leaf area of 5 selected plants. Average leaf area plant^{-1} calculated by dividing the value obtained by five. The total value was multiplied by correction factor 0.75 (Montgomery, 1911) and (Pandey, 2019).

$$\text{Leaf area per plant (cm}^2\text{)} = \frac{\text{Leaf area}}{\text{Number of Plant}} \times 0.75$$

$$\text{Leaf area Index} = \frac{\text{Leaf area Plant}^{-1}}{\text{Ground area Plant}^{-1}}$$

3.9.1.5 Days to tassel emergence

For counting days to tasseling randomly 10 plants was selected than count the tassel. If these plants are bear tassel then date was noted. The days taken for tasseling emergence were calculated by taking difference in days between the date of sowing and date at which tasseling emergence count.

3.9.1.6 Days to silk emergence

For count days to silking randomly 10 plants were selected for count the tassel were used. If these plants are bear silk then date was noted. The days taken for silking emergence were calculated by taking difference in days between the date of sowing and date at which silking emergence count.

3.9.1.7 Dry matter accumulation (g plant^{-1}) at 30, 55 and 85 DAS

Randomly three plants were selected from observation rows of each plot and cut simply over the ground level with the help of a sickle. These plants were kept 48 hours in sun light for moisture loss. After moisture loss in the presence of sun light, these plants dried in the oven at 65±5^{O}C temperature for 48-72 hours till the sampled attained a constant weight and weighed. The dry matter was recorded in gram plant^{-1}.

3.9.2 Yield attributes

The following observations on yield attributes and yield studies were recorded during the experiment.

3.9.2.1 Number of cobs ha^{-1}

It was calculated by select the three rows and count the total number of plant and cobs in these rows then the average values of cob plant^{-1} were multiplied by total plant population.

3.9.2.2 Cob girth (cm)

The cob girth of five cobs was measured with the help of vernier caliper. It was measure the diameter of corn then diameter was changed in girth by multiplying with 3.14 (value of π) and the average value was expressed in cm.

3.9.2.3 Number of rows cob^{-1}

Five cobs were selected for count number of rows and average values were taken. Cob rows per cob were obtained always in even number.

3.9.2.4 Cob length (cm)

Five cobs were randomly selected from each plot at the time of harvesting. The husk was removed and length was measured with the help of scale and average value expressed in cm.

3.9.2.5 Number of grain row^{-1}

Five cobs were randomly selected from each plot at the time of harvesting. Count the number of grain in five rows and then average value was taken.

3.9.2.6 Number of grain cob^{-1}

Five cobs were randomly selected from each plot at the time of harvesting. Count the number of grain in five rows and the average value of these rows were multiplied by number of rows and then get number of grain cob^{-1}

Plate 3 Count Number of grain

3.9.2.7 Seed index (g)

From each plot 100-grains were counted and their weight was recorded to obtain the seed index in gram.

3.9.3 Crop yield

3.9.3.1 Economic yield (q ha^{-1})

The cobs were dehusked and moisture taken from the sample of each plot. Grain weight was taken from each plot in kg plot^{-1} converted into q ha^{-1} by using following formula.

$$\text{Economic yield (q ha}^{-1}\text{): Grain weight (kg plot}^{-1}\text{) x } \frac{100\text{- moisture \% in grains}}{100} \text{ x } \frac{1.176\text{x}0.8\text{x}10000}{\text{Plot size (m}^2\text{)x } 100}$$

Where,

1.176 = Constant used for 15 % moisture level

0.8 = shelling per cent

3.9.3.2 Biological yield (q ha^{-1})

Biological yield was obtained by plants of each plot cut from ground level with the assistance of sickle after removal of cobs. Plants and cobs were kept for sundry to obtain a constant weight which gave the biological yield in kg plot^{-1} and then converted into q ha^{-1} after summing the gross cob weight which was harvest before cutting of stover and stover weight.

Biological yield = Gross cobs weight + stover yield.

3.9.3.3 Harvest index (%)

The harvest index was calculated by dividing the economic (grain) yield to the total biological yield (gross cob weight + stover weight) and multiplying the factor by 100.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10 Insect-pest scaling

The incidence of the stem borer and fall army worm was recorded by counting the total number of the infested plants including leaves. The incidence can be explained as the percentage of plant showing the infestation or symptoms on total plants selected for observation in the plot (Girmay *et al*, 2015).

$$\text{Incidence \%} = \frac{Number\ of\ infected\ plant}{Total\ number\ of\ plants\ in\ sample} \times 100$$

3.11 Chemical analysis of soil

Initial soil sample was taken randomly from whole experimental field and composite them and prepare three sample for study while after cropping samples was collected separately treatment wise for studies of pH, EC, OC, N, P and K.

3.11.1 Soil reaction and electrical conductivity

pH and EC of the soil was determined in 1: 2 soil water ratio by pH meter and EC by Conductivity Bridge.

For pH measurement soil-water suspension was prepared in 1:2 ratio. Firstly calibrate the pH meter with the help of buffer solution (4.0, 7.0 and 9.0 pH) than take 20g soil and 40 ml distilled water in a 100 ml beaker, stir well for about five minute and keep for 30 minutes. Again suspension was stir just before immersing the electrodes and takes the pH reading.

Electrical conductivity was measured by EC meter. Firstly EC meter was calibrate by 0.1 N potassium chloride solution and this solution was gives an electrical conductivity of 1.41 dS m^{-1} at 25 ^{0}C. Soil sample was used in measurement of pH again used in measurement of soil EC. This suspension kept until clear supernatant liquid was obtained. Determine the conductivity of supernatant liquid with the help of conductivity meter.

3.11.2 Total organic carbon in soil and total nitrogen in soil, stover and grain (kg ha^{-1})

It was analyzed by CHNS automated analyzer. Elemental analysis is an experiment that determines the amount of an element in a compound. A CHNS analyzer is a scientific instrument which can determine the elemental composition of a sample. The name derives from the three primary elements measured by the device: carbon (C), hydrogen (H) and nitrogen (N) and oxygen (O) and Sulfur (S) can also be measured from the soil and plant sample.

3.11.2.1 Sample preparation

The different samples were dried at a temperature of about 25–30 ◦C (to avoid N loss) for a week. The samples were ground in a pestle and mortar so as to pass through a 2-mm sieve and obtain a homogenous sample. These samples were immediately dried at 60 ◦C in an oven. The samples were separated into different size groups (<0.25 mm, <0.50mm, <1.0 mm, <2 mm) using sieves of varying mesh sizes. 2 mg soil or plant sample was weighing with assistance of microbalance (sensitivity ±0.0001 mg) To avoid moisture adsorption samples were kept in screw-capped a vial which was made up of tin foil and were redried before analysis. (Dhaliwal *et al* 2014).

3.11.2.2 Basic Principle

The capsule is injected into a high temperature (1150°C) furnace and combusted in pure oxygen under static conditions. At the end of the combustion period, a dynamic burst of oxygen is added to ensure total combustion of all inorganic and organic substances. The resulting combustion products pass through specialized reagents to produce carbon dioxide (CO_2), water (H_2O) and Nitrogen (N_2) and oxides of nitrogen. These reagents also remove other interferences including halogens, sulfur and phosphorus. The gases are then passed over copper to scrub excess oxygen and reduce oxides of nitrogen to elemental nitrogen. After scrubbing, the gases enter a mixing volume chamber to ensure a homogeneous mixture at constant temperature and pressure. The mixture then passes through a series of high-precision thermal conductivity detectors, each containing a pair of thermal conductivity cells. Between the first two cells is a water trap. The differential signal between the cells is proportional to the water concentration, which is a function of the amount of hydrogen in the original sample. Between the next two cells is a carbon dioxide trap for measuring carbon. Finally, nitrogen is measured against helium. CHNS give reading in percentage (%) of sample analysis. (www.iitk.ac.in).

$$\text{Total nitrogen (kg } ha^{-1}) = Nitrogen\,\% \times 2.24 \times 10000$$

3.11.3 Available phosphorus

Available phosphorus was determined by method as described by Olsen and Watanable, (1954). 2.5 g of air dry soil was taken into a 100 ml conical flask. Add a pinch of Darco G-60 or equivalent grade P- free activated charcoal was added. Subsequently 50 ml of Olsen's reagent ($NaHCO_3$, pH 8.5) was added and the contents were shaken for half an hour. Filter through Whatman No.1 filter paper. Transfer 5ml of clear and colourless filtrate in to 25 ml volumetric flask and blue colour was developed using reagent (ammonium molybdate and potassium antimony tartrate) and ascorbic acid as reducing agent. The intensity of colour developed was measured at 660 nm on a spectrophotometer and the values are converted in kg ha^{-1}. (Olsen and Watanable, 1954).

3.11.4 Available potassium

Available potassium in the soil was determined by extracting the soil with neutral 1normality ammonium acetate solution (pH- 7.0) in soil. With soil to extracted ratio 1: 5 and then potassium was estimated in the extract with the help of flame photometer as described by (Hanway and Heidel, 1952) and the values are converted in kg ha^{-1}.

3.12 Chemical Studies of plant samples

3.12.1 Nutrient content (P and K)

The plant samples of maize crop was collected from each plot separately at the time of harvesting and dried for 48 hours in hot air oven at 65±5 ^{O}C temperature. These dried samples were grind to fine powder separately and filtered through 0.5 mm mesh sieve. These plant samples were examined for nitrogen, phosphorus, potassium.

3.12.1.1 Phosphorus content

Five ml. aliquot was taken in 50 ml. volumetric flask and 5 ml. molybdovanadate solution was included. The volume was made up to the imprint with refined water and blended altogether. Following 25 minutes when yellow shading had completely grown, then the rate transmittance was persued on UVobvious spectrophotometer at 440 nm (Jackson, 1973)

3.12.1.2 Potassium content

The concentration of K in plant sample was determined by flamephotometer in digested material after standardizing the flame photometer with concentration of K (Jackson, 1973).

3.13 Nutrient uptake (P&K) by plant

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{percent\ nutrient\ in\ sample\ \times yield\ (kg\ ha^{-1})}{100}$$

3.14 Economics

Economic indices of economic yield and stover yield were worked-out based on the minimum support prices (MSP) which is decided by GOI and market price respectively. Cost of cultivation was worked-out by taking into consideration all the expenses incurred in raising the crop.

3.14.1 Cost of production (Rs. ha^{-1})

Cost of production under different treatments was worked out separately. Labour and requirement of mechanical power and manual power for different operations such as land preparation; seed implements, fertilizers application, irrigation, weeding, and harvesting, maize shelling etc were calculated as per the local rates.

3.14.2 Gross return (Rs. ha^{-1})

Total gross return was worked out by multiplying the yield (grain, stover) separately/hectare under various treatments with prevailing MSP and market rate.

3.14.3 Net return (Rs. ha^{-1})

Net return was obtained by subtracting the cost of production from gross return of the individual treatments.

3.14.4 Benefit: Cost ratio

Benefit: Cost ratio was calculated by the following formula.

$$\text{B:C ratio} = \frac{Net\ return(Rs.\ ha^{-1})}{Cost\ of\ production(Rs.\ ha^{-1})}$$

3.15 Statistical analysis

The data obtained from different perception on growth, yield and yield attributes net return, gross return and B:C ratio were subjected to statistical analysis by utilizing Split Plot Design as described by Gomez and Gomez (1984) with the help of standard procedures of Analysis of Variance (ANOVA) given in table 3.11.

Table 3.10 The Skelton of Analysis of Variance

Source of variance	Degree of freedom	Sum of square	Mean sum of squire	F tabulated 5%
Replication	(r-1) = 2			
Tillage practice (t)	(t-1) = 2			
Error (a)	(r-1) (t-1) = 4			
Nutrient management (f)	(f-1) = 2			
Interaction (t×f)	(t-1) (f-1) = 4			
Error (b)	a(r-1) (f-1) = 12			
Total	(rtf-1) = 26			

If "F" test was found significant at 5% level of significance, the critical different (C.D.) was calculated to test the significance to test of differences between two treatments.

C.V. = √EMS/GM×100

S.Em ± = √EMS/r

S.Ed = √2EMS/r

CD at 5% prob. Level = S.E diff × $t_{5\%}$ table value

Where,

C.V = Coefficient of variance

S.Em ± = Standard of means

S.E diff = Standard error of difference

GM = Grand mean

C.D = Critical difference

$T_{5\%}$ = t, table value 5% probability level at error d.f.

Plate 4 Glimpses of my experimental Field.

A. General view of maize at 35 DAS (B) General view of maize at 65 DAS (C) Maize under best treatment (zero tillage × SSNM) (D) Close view of cob in field

Plate 5 Glimpses of Chemical Analysis of Soil and plant sample.

(A) Measurement soil pH. **(B)** Potassium measurement by flame photometer **(C)** Weighing of Soil for CHNS analysis **(D)** CHNS analysis **(E)**. Preparation of sample for estimation of P **(F)** Phosphorus measurement in spectrophotometer

CHAPTER-4

EXPERIMENTAL FINDINGS

Chapter - 4

Experimental Findings

The present investigation entitled **"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices"** was conducted during kharif 2021 at the collage research farm of Banda University of Agriculture and Technology, Banda UP. The data was recorded on the various parameters in all treatments during the course of experiment, and it was subjected to statistical analysis and results obtained along with appropriate interpretations have been presented and elaborated in this chapter with required tables.

4.1 Growth attributes
4.2 Yield attributes
4.3 Nutrient content, uptake and left in soil
4.4 Economics
4.5 Insect-pest scaling

4.1 Growth attributes

4.1.1 Plant height (cm)

The data on plant height are summarized in table 4.1 and fig. 4.1. Further scrutiny of data on plant height at knee height stage (30 DAS) of maize did not influence by treatment variable particularly tillage and nutrient management practices applied but on other hand the plant height at tasseling stage (55 DAS) was noted marked improvement.

A perusal of data showed plant height at tessaling stage under various tillage operations significantly varied. The maximum plant height (236.67 cm) was noted under zero tillage proved significantly taller over permanent bed (215.11 cm) though remained statistically comparable with conventional tillage (232.93 cm).

Among the nutrient management practices, increased application of nutrients correspondingly enhanced the plant height at 55 DAS. However, site specific nutrient management (SSNM) recorded remarkably tallest plant height (234.30 cm) over 33% recommended dose of nitrogen (RDN) while it was at par (230.96) with 100% recommended dose of fertilizer (RDF). However, the differences could touch the level of significance in terms of plant height only between SSNM and 33% RDN during field studies.

Scrutiny of data reported that none of the treatment combination showed significant interaction for plant height irrespective of the growth stage.

Table 4.1 Effect of tillage and nutrient management practices on plant height (cm)

Treatment	Plant height (cm) 30 DAS	Plant height (cm) 55 DAS
Tillage practices		
Zero tillage	70.44	236.67
Conventional tillage	64.56	232.93
Permanent bed	62.33	215.11
SEm±	7.89	3.76
C.D (P=0.05)	NS	**14.76**
CV (%)	**36.00**	4.90
Nutrients management		
RDN 33%	62.11	219.44
RDF 100%	66.78	230.96
SSNM	68.44	234.30
SEm±	3.27	3.86
C.D (P=0.05)	NS	**11.88**
CV (%)	**14.90**	5.10
Interaction tillage × nutrient management	NS	NS
***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**		

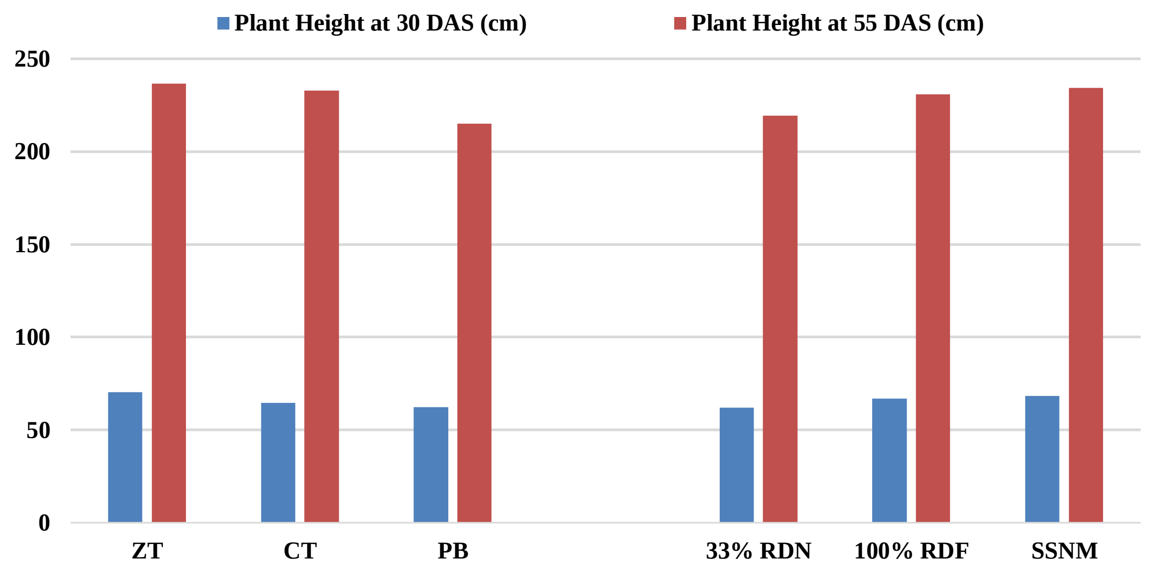


Fig 4.1 Effect of tillage and nutrient management practices on plant height (cm)

4.1.2 Number of leaves plant^{-1}

The data on number of leaves plant^{-1}recorded at 30 DAS and 55 DAS was summarized in table 4.2 and fig. 4.2. Further scrutiny of data on leaves plant^{-1}at knee height stage showed that none of the treatment variables demonstrated the marked improvement however lucid improvement in leaves plant^{-1} was noticed at tasselling stage of the crop.

Among the tillage practices studied, the zero tillage produced significantly more number of leaves (16.00) at tasseling stage over permanent bed (15.04) and it remained statistically close (15.52) to the conventional tillage practice.

Application of increasing doses of fertilizer to maize correspondingly enhanced the number of leaves at tasseling stage however variation in number of leaves could not touch the level of significance among the nutrient management practices at 30 DAS. It was significant only between SSNM and 33% RDN (15.04) though at par with 100% RDF (15.52) at 55 DAS.

It is evident from the data expressed by interaction of treatment variables failed to exert remarkable difference for number of leaves at both growth stages (knee height and tasseling stage).

Table 4.2 Effect of tillage and nutrient management practices on number of leaves plant^{-1}

Treatment	Number of leaves 30 DAS	Number of leaves 55 DAS
Tillage practices		
Zero tillage	6.56	16.00
Conventional tillage	6.50	15.52
Permanent bed	6.36	15.04
SEm±	0.05	0.18
C.D (P=0.05)	NS	**0.72**
CV (%)	**2.09**	3.52
Nutrients management		
RDN 33%	6.40	15.04
RDF 100%	6.55	15.52
SSNM	6.48	16.00
SEm±	0.07	0.22
C.D (P=0.05)	NS	**0.67**
CV (%)	**3.38**	4.19
Interaction tillage × nutrient management	NS	NS
***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**		

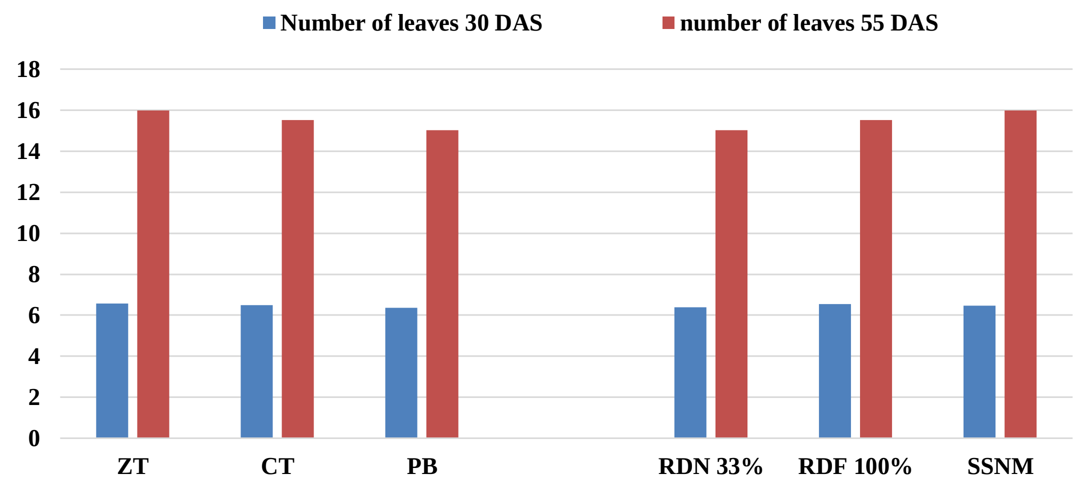


Fig 4.2 Effect of tillage and nutrient management practices on number of leaves plant^{-1}

4.1.3 Leaf area index plant^{-1}

The data on leaf area index presented in table 4.3 and fig. 4.3 at 30 DAS revealed that none of treatments strived significant difference however; at 55 DAS tillage and nutrient management practices exerted lucid differences in terms of LAI.

After analysis of data about leaf area index at knee height (30 DAS) reported no marked influence of different treatments and treatments combinations of tillage and nutrient management practices.

The data pertaining to leaf area index at tessaling stage (55 DAS) was expressed remarkable variation observed. Similarly zero tillage attained significantly more LAI (4.87) over the permanent bed (4.57) which was remained statistically comparable with conventional tillage (4.69).

Study of data at 55 DAS revealed that distinct variation in LAI of maize was observed due to different nutrient management system tested. The maximum LAI (4.89) was associated with site specific nutrient management (SSNM) applied however, it proved significantly superior over 33% recommended dose of nitrogen (4.41) but remained equal (4.83) with the 100% recommended dose of fertilizer (RDF).

It is further evident from data that none of the treatment combination of tillage and nutrient management practice was exerted significant variation for LAI at tasseling stage (55 DAS).

Table 4.3 Effect of tillage and nutrient management practices on leaf area index plant^{-1}

Treatment	Leaf area index (30 DAS)	Leaf area index (55 DAS)
Tillage practices		
Zero tillage	1.57	4.87
Conventional tillage	1.38	4.69
Permanent bed	1.46	4.57
SEm±	0.05	0.06
C.D (P=0.05)	NS	**0.22**
CV (%)	**10.41**	3.62
Nutrients management		
RDN 33%	1.44	4.41
RDF 100%	1.47	4.83
SSNM	1.51	4.89
SEm±	0.02	0.08
C.D (P=0.05)	NS	**0.24**
CV (%)	**4.88**	4.88
Interaction tillage × nutrient management	NS	NS

***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**

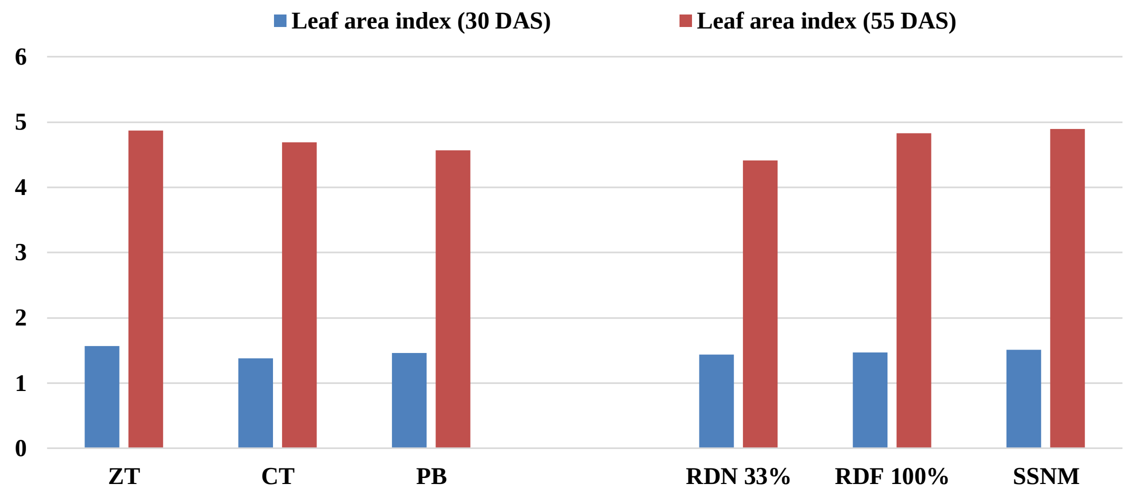


Fig 4.3 Effect of tillage and nutrient management practices on leaf area index plant^{-1}

4.1.4 Dry matter (g) plant^{-1}

The data regarding dry matter production plant^{-1} is summarized in table 4.4 and fig. 4.4. An evaluation of data clearly indicated dry matter production increased with advancement of time from sowing to till the harvest of maize crop.

A perusal of data confirmed that not significant variation was recorded in dry matter production at 30 DAS due to due to treatment variables tested either alone or in combination to the maize crop.

As regard to data, the zero tillage produced marked effect on dry matter production at tasseling stage (162.37 g) and at harvest (334.28 g) by maize crop during field experimentation. Similarly at tasseling stage, though it proved significantly superior over permanent bed (138.33 g) but remained close to the conventional tillage (150.70 g). On other hand, dry weight at harvest showed that permanent bed (240.85 g) and conventional tillage (264.66 g) remarkably inferior against zero tillage practice.

The study of data indicated that increasing fertilizer doses from 33% RDN to SSNM applied to maize correspondingly increased the dry matter accumulation plant^{-1} at both tessaling and harvest stage. However SSNM recorded significantly the maximum dry matter weight (160.93 g, 301.05g) at both growth stages, tasseling and at harvest, which distinct proved over 33% RDN and it remained statistically at par with 100% RDF.

Scrutiny of data further indicated that none of the tillage and nutrient management combinations endeavored significant in terms dry matter weight at tasseling and at harvest.

Table 4.4 Effect of tillage and nutrient management practices on dry weight (g) plant^{-1}

Treatment	Dry weight (g) 30 DAS	Dry weight (g) 55 DAS	Dry weight (g) 85 DAS
Tillage practices			
Zero tillage	7.30	162.37	334.28
Conventional tillage	7.21	150.70	264.66
Permanent bed	7.19	138.33	240.85
SEm±	0.08	4.21	10.48
C.D (P=0.05)	NS	**16.54**	**41.16**
CV (%)	**3.12**	8.39	11.23
Nutrients management			
RDN 33%	7.14	135.59	245.31
RDF 100%	7.24	154.89	293.44
SSNM	7.31	160.93	301.05
SEm±	0.07	4.24	13.22
C.D (P=0.05)	NS	**13.06**	**40.75**
CV (%)	**3.01**	8.45	14.17
Interaction tillage × nutrient management	NS	NS	NS
***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**			

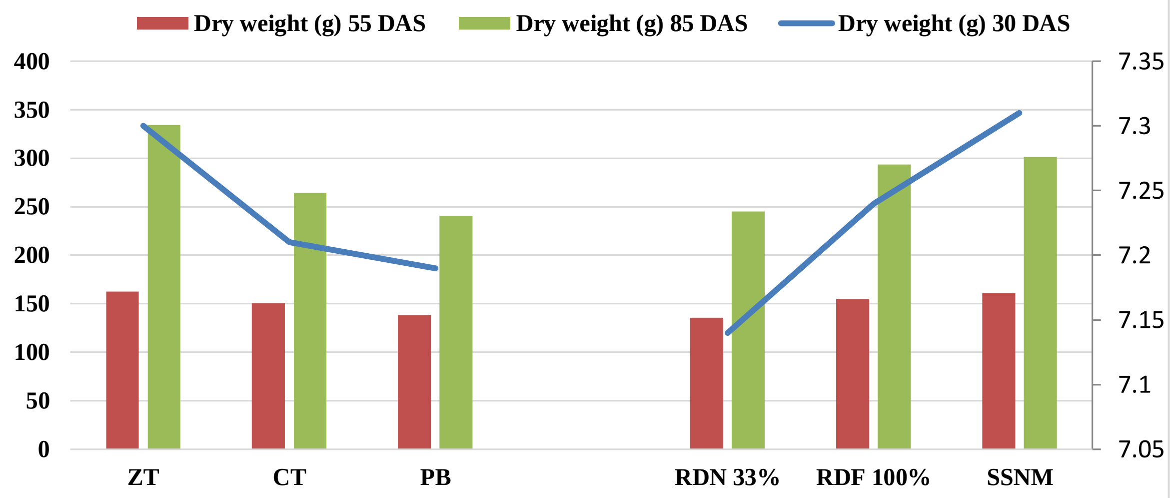


Fig. 4.4 Effect of tillage and nutrient management practices on dry weight (g) plant^{-1}

4.1.5 Days to tasseling

The data on days taken to tasseling emergence by maize presented in table 4.5 and fig. 4.5. Nonetheless distinct variation was noticed in terms of number of days taken to attain tasseling due to variation in treatment tested to the hybrid maize.

Data showed that zero tillage took 2-3 days lesser to attain tasseling then permanent bed however differences observed between both could touch the level of significance. Zero tillage and conventional tillage took similar days to attain tasseling and differences between each remain on par.

The 33% recommended dose of nitrogen took significantly lesser number of days (52.2) to tasseling than site specific nutrient management (53.4 days) and 100% recommended dose of fertilizer (53.0 days). However, differences among the nutrient management practices differed significant in terms of number of days taken to attain tasseling.

The different tillage and nutrient management combination significantly affected the days to tasseling emergence. Among the various combinations permanent bed with site specific nutrient management took remarkably more days (56.3) to tasseling however, it proved to be significant over other treatment combinations.

Table 4.5 Effect of tillage and nutrient management practices on days to Tasseling emergence (days)

Days to Tasseling (Days)				
Nutrient management/ Tillage	**ZT**	**CT**	**PB**	**Mean for SPT**
RDN (33%)	52.00	52.33	52.33	**52.22**
RDF (100%)	52.00	52.00	55.00	**53.00**
SSNM	52.00	52.00	56.33	**53.44**
Mean for MPT	**52.00**	**52.11**	**54.66**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	0.83	0.20	1.17	
Nutrient Management	0.61	0.19	1.12	
Int. of Tillage x Nut. management	1.18	0.35		
***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int. = Interaction, Nut.= Nutrient.**				

4.1.6 Days to silking

Data on days to silking was affected by different tillage and nutrient management practices presented in table 4.6 and fig. 4.5. Tillage and nutrient management exerted marked variation on maize for silking emergence.

As regard to data on tillage practices, zero tillage produced early silk as compared to the conventional tillage and permanent bed. However the differences between zero tillage and permanent bed in terms of days to attain silking remained significant and zero tillage & conventional tillage remained statistically equal and took similar days to attain silking.

An examination of data revealed that increasing doses of fertilizer correspondingly took more number of days to silk however, consecutive level of nutrient management failed to exert remarkable variation in terms of days to taken silking. 33% recommended dose of nitrogen bear significantly early (53.77) silk however, it was lucid superior on the 100% recommended dose of fertilizer (55.00) and site specific nutrient management (55.22) practice.

The scrutiny of data further reported that interaction of treatment combinations exerted marked variation in days to silking emergence of hybrid maize. Combination of permanent bed with site specific nutrient management took remarkably more time (58.00) to bearing silk over all other treatment combinations.

Table 4.6 Effect of tillage and nutrient management practices on days to silking emergence (days)

Days to Silking (Days)				
Nutrient management/ Tillage	**ZT**	**CT**	**PB**	**Mean for SPT**
RDN (33%)	53.33	54.33	53.67	**53.78**
RDF (100%)	54.00	54.33	56.67	**55.00**
SSNM	53.66	54.00	58.00	**55.22**
Mean for MPT	**53.66**	**54.22**	**56.11**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	1.87	0.47	2.55	
Nutrient Management	1.21	0.39	2.13	
Int. of Tillage x Nut. Management	2.43	0.76		
***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int.= Interaction, Nut.= Nutrient.**				

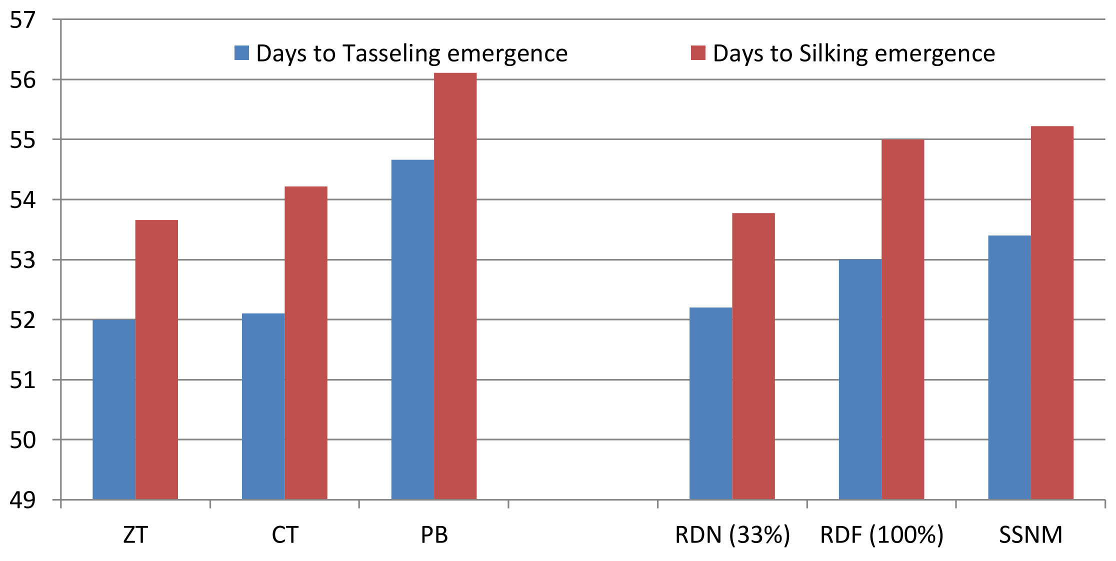


Fig 4.5 Effect of tillage and nutrient management practices on days to tasseling and silking (days)

4.2 Yield attributes

4.2.1 Plant population ha^{-1}

The data on plant population ha^{-1}recorded at harvest presented in table 4.7 and fig. 4.6 revealed that plant population ha^{-1} of maize did significantly not influence by the different tillage and nutrient management practices either by alone application or used in combinations.

4.2.2 Number of cobs ha^{-1}

The data regarding number of cobs ha^{-1}at harvest (table 4.7 and fig. 4.6) showed that none of the treatments and treatment combinations lucidly affects the total number of cobs produced irrespective of treatments (tillage practices and nutrient management practices).

Table 4.7 Effect of tillage and nutrient management practices on plant population and number of cobs ha^{-1}

Treatment	Plant population ha^{-1}	Number of cobs ha^{-1}
Tillage practices		
Zero tillage	66074	63852
Conventional tillage	65185	62704
Permanent bed	64556	63481
SEm±	1760	1514
C.D (P=0.05)	NS	NS
CV (%)	**8.10**	**7.20**
Nutrients management		
RDN 33%	64519	61815
RDF 100%	65222	63556
SSNM	66074	64667
SEm±	1350	914
C.D (P=0.05)	NS	NS
CV (%)	**6.20**	**4.30**
Interaction tillage × nutrient management	NS	NS
***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**		

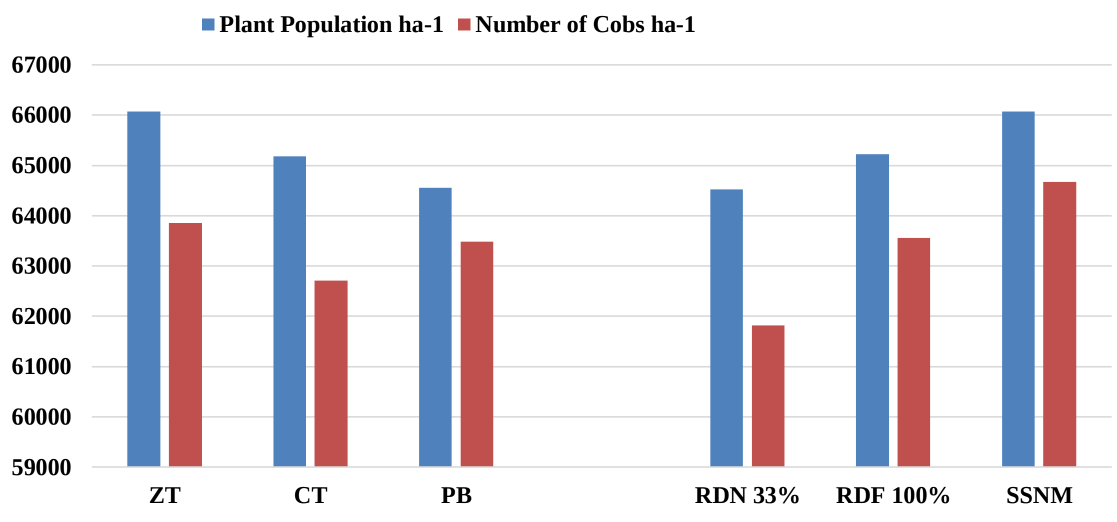


Fig. 4.6 Effect of tillage and nutrient management practices on plant population and number of cobs ha^{-1}

4.2.3 Number of rows cob^{-1}

The data regarding number of rows cob^{-1} are summarized in table 4.8 and fig. 4.7. It is clearly showed that none of the treatment and treatment combinations caused marked differences in producing more. In general maximum and minimum number of rows cob^{-1} was recorded with zero tillage and permanent bed while, increasing rate of fertilizer increases number of rows.

4.2.4 Number of grains cob row^{-1}

Data pertaining to number of grains cob row^{-1} presented in table 4.8 and fig 4.7. Number of grain cob row $^{-1}$ distinctly influenced by various tillage and nutrient management practices.

A close study of data revealed that zero tillage recorded remarkable number of grain cob row^{-1} (32.52) over permanent bed (29.38) while it was remained statistically comparable with conventional tillage practice (30.72).

Scrutiny of data once again imposed marked variation under various nutrient management practices for the number of grain cob row^{-1}. Under Site specific nutrient management noted lucidly maximum (31.75) number of grains cob row^{-1} over 33% recommended dose of nitrogen (29.29) while, it was similar to 100% recommended dose of fertilizer (31.59).

As evident from data none of the treatment combination imposed significantly marked variation on number of grains row^{-1} produced by maize.

4.2.5 Number of grain cob^{-1}

A perusal of data presented in 4.8 and fig. 4.7, various treatment exerted lucid effect on number of grain cob^{-1} during field experimentation on maize.

It could be seen that number of grain cob^{-1} was significantly affected by different tillage operations. However, it could be noted that zero tillage recorded remarkably maximum (473) number of grain cob^{-1} hence forth significantly minimum value was recorded with permanent bed (417) while, statistically close to the conventional tillage (446) practice.

Data regarding to number of grain cob^{-1} was lucidly affected by different nutrient management practices. Among the nutrient management practices site specific nutrient management exerted marked variation and it recorded maximum number of grain cob^{-1} (462). However 100% recommended dose of fertilizer (453) and 33% recommended dose of nitrogen (419) failed to cause distinct differences between each other during field experiment.

A critical analysis of data further revealed that none of the treatment combination exerted marked differences on number of grain cob^{-1}during field study.

Table 4.8 Effect of tillage and nutrient management practices on number of rows cob^{-1}, number of grain row^{-1} and number of grain cob^{-1} of maize.

Treatment	Number of rows cob^{-1}	Number of grain row^{-1}	Number of grain cob^{-1}
Tillage practices			
Zero tillage	14.53	32.52	473.00
Conventional tillage	14.51	30.73	446.00
Permanent bed	14.20	29.38	417.00
SEm±	0.11	0.47	7.68
C.D (P=0.05)	NS	**1.84**	**30.14**
CV (%)	**2.30**	4.54	5.04
Nutrients management			
RDN 33%	14.33	29.29	419.00
RDF 100%	14.36	31.59	453.00
SSNM	14.56	31.75	462.00
SEm±	0.10	0.70	11.37
C.D (P=0.05)	NS	**2.15**	**35.03**
CV (%)	**1.98**	6.78	7.91
Interaction tillage × nutrient management	NS	NS	NS
***RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.**			

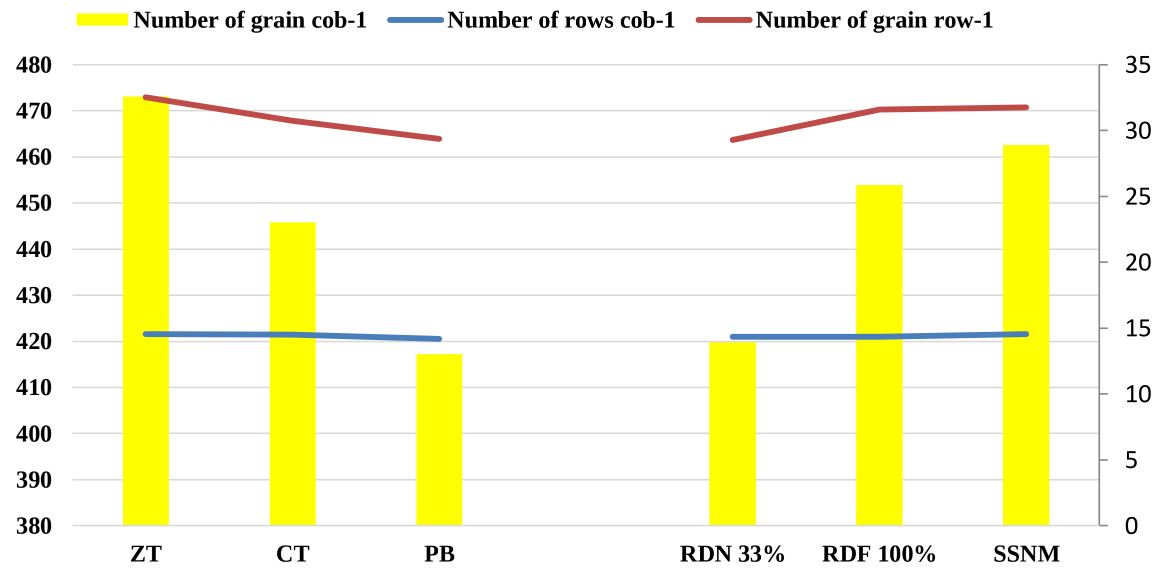


Fig. 4.7 Effect of tillage and nutrient management practices on number of rows cob^{-1}, number of grain row^{-1} and number of grain cob^{-1} of maize.

4.2.6 Cob length (cm)

The scrutiny of data on cob length presented in table 4.9 and fig. 4.8 illustrates that none of the tillage practices expressed marked variation. However, different nutrient management practices and their combinations with tillage caused remarkable variation.

Scanning of data revealed that none of the tillage operation imposed significant variation on cob length. But in general zero tillage recorded slightly long cob as compare to other tillage operations.

Study of data again exhibited that site specific nutrient management produced lucidly longer cob (17.83 cm) however, it proved significantly superior over 33% recommended dose of nitrogen (16.94 cm) but it again remained non-significant to the 100% recommended dose of fertilizer (17.37 cm).

As regard to data on interaction effect of different tillage and nutrient management practices on cob length. Amongst the various combinations, permanent bed with site specific nutrient management attained significantly the longest cob length which was exerted lucid differences over zero tillage × 33% RDN, conventional tillage × 33% RDN, 100% RDF &SSNM and permanent bed × 100% RDF. Although it was remained comparable under zero tillage × 100% RDF, SSNM & permanent bed × 33% RDN combinations.

Table 4.9 Effect of tillage and nutrient management practices on cob length (cm)

Cob length (cm)				
NM/ Tillage	**ZT**	**CT**	**PB**	**Mean for SPT**
RDN (33%)	15.93	17.13	17.76	**16.94**
RDF (100%)	18.00	16.80	17.33	**17.37**
SSNM	18.00	17.43	18.06	**17.83**
Mean for MPT	**17.31**	**17.12**	**17.72**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	NS	0.33	5.85	
Nutrient Management	0.66	0.21	3.68	
Int. of Tillage x NM	1.49	0.37		

***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int.= Interaction, Nut.= Nutrient**

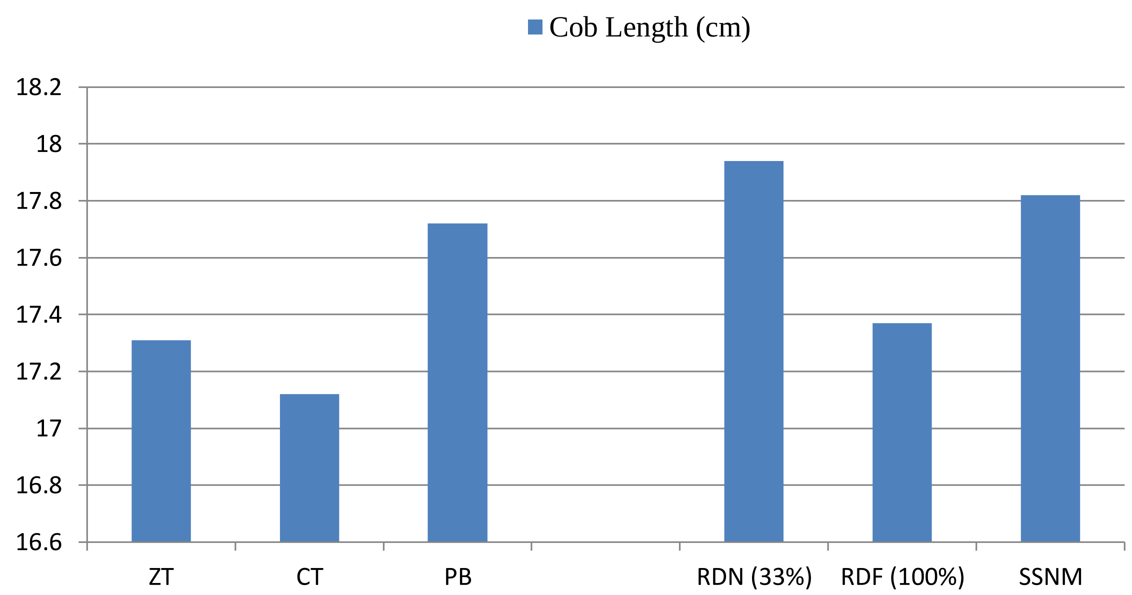


Fig. 4.8 Effect of tillage and nutrient management practices on cob length (cm)

4.2.7 Cob girth (cm)

A close study of data presented in table 4.10 and fig 4.9 revealed that none of the tillage and nutrient management practices expressed either alone or in combinations lucid variation on the cob girth during field experimentation. In general the maximum and minimum cob girth were observed with zero tillage and permanent bed among tillage practices applied. Likewise SSNM recorded the maximum cob girth and minimum was associated with 33% RDN when compare among nutrient management practices

4.2.8 Seed index (g)

The data on seed index in table 4.10 and fig. 4.9 illustrated that no lucid variation was reported among the tillage practices employed however, among the nutrient management practices exerted distinct differences for the seed index of hybrid maize.

A close examination of data revealed that the lightest and heaviest seed index of hybrid maize was noticed in zero tillage and conventional tillage respectively, and the differences between both could failed to touch the level of significance during field study conducted.

A critical analysis of data exhibited that various nutrient management practices *viz.* 33% RDN, 100% RDF and SSNM influenced significantly on seed index of hybrid maize. Seed index increases successfully with increasing amount of fertilizer application. Likewise Site specific nutrient management practice produced the heaviest seed index (19.97 g) and expected it lucid superiority over the 33% recommended dose of nitrogen that produced the lightest seed index (18.56 g) among the nutrient management practices during kharif 2021. Both the heaviest and lightest seed index remained statistically on par with the medium seed index that could achieve by the 100% recommended dose of fertilizer applied to the crop.

None of the treatment variables showed any significant response among the interaction of different tillage and nutrient management practice on seed index.

Table 4.10 Effect of tillage and nutrient management practices on cob girth (cm) and seed index (g)

Treatment	Cob girth (cm)	Seed index (g)
Tillage practices		
Zero tillage	12.65	18.86
Conventional tillage	12. 50	19.83
Permanent bed	12.45	19.16
SEm±	0.15	0.32
C.D (P=0.05)	NS	NS
CV (%)	**8.1**	**5.03**
Nutrients management		
RDN 33%	12.33	18.56
RDF 100%	12.55	19.32
SSNM	12.71	19.97
SEm±	0.18	0.3
C.D (P=0.05)	NS	**0.93**
CV (%)	**6.2**	4.71
Interaction tillage × nutrient management	NS	NS
RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.		

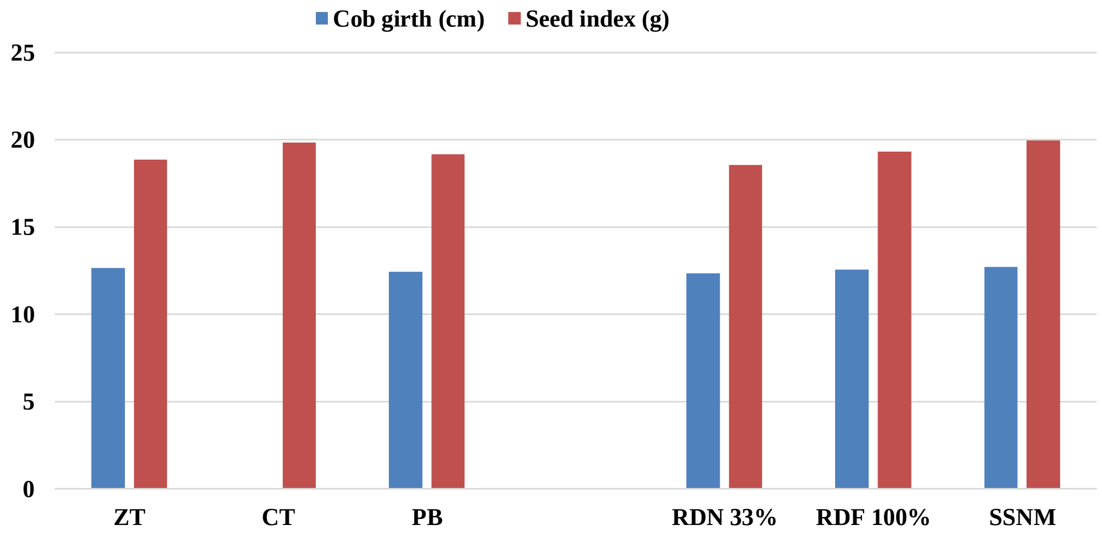


Fig. 4.9 Effect of tillage and nutrient management practices on cob girth (cm) and seed index (g)

4.2.9 Economic yield (q ha^{-1})

As evident from the data reported in table 4.11 and fig. 4.10 expressed that, marked improvement was noted in grain yield of hybrid maize by the treatments applied either of nutrient management practices or of tillage practices.

A close examination of data revealed that the maximum yield grain yield was achieved under zero tillage and it showed its remarkable advantage over the tillage practices followed. However, the minimum grain yield was associated with conventional tillage practice and it stood statistically comparable with permanent bed practice applied to maize crop. Similarly, zero tillage had on advantage of 8.08% and 6.95% over conventional tillage and permanent bed respectively, during field study conducted.

Among the nutrient management practices, increasing application of nutrients correspondingly increased the grain yield of maize. However, site specific nutrient management produced noteworthy more yield (56.52 q ha^{-1}) over 33% recommended dose of nitrogen (52.13 q ha^{-1}) though remained statistically similar with 100% recommended dose of fertilizer (56.29 q ha^{-1}) during the course of field study. Similarly the SSNM proved batter over, 100% RDF and 33% RDN and gave yield advantage of 0.40% and 7.76% respectively.

Perusal of relevant data indicated that none of the tillage and nutrient management combinations exerted significantly noticeable effect on economic yield of maize during course of field study in kharif 2021.

4.2.10 Biological yield (q ha^{-1})

The data pertaining to biological yield presented in table 4.11and fig. 4.10 showed marked variation was observed in the production of biological yield under different tillage and nutrient management practices.

The data regarding biological yield of maize produced significantly varied amount with different tillage operations fallowed. Zero tillage produced remarkably the highest biological yield (168.52 q ha^{-1}) which stood superior over both tillage practices permanent bed and conventional tillage. The conventional tillage (155.17 q ha^{-1}) and permanent bed (147.12 q ha^{-1}) exerted non-significant variation to the biological yield of maize during course of field investigation.

A close study of data exhibited that biological yield increases due to progressive increase in fertilizer doses however, under site specific nutrient management applied to maize produced remarkably the highest biological yield (162.08 q ha^{-1}) than 33%

recommended dose of nitrogen (151.30 q ha^{-1}) while it again remained statistically similar to the 100% recommended dose of fertilizer (157.43 q ha^{-1}) during course of field experimentation.

The scrutiny of data further indicated that interaction effect of different tillage and nutrient management on biological yield was found non-significant during field study.

4.2.11 Harvest index (%)

The scanning of data in table 4.11 and fig. 4.10 revealed that harvest index did not influence to the level of significance among various tillage and nutrient management practices applied to the maize. Similarly none of the treatment combination exerted marked variation on harvest index of maize.

Table 4.11 Effect of tillage and nutrient management practices on economic yield, biological yield and harvest index.

Treatment	Economic yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Tillage practices			
Zero tillage	57.88	168.52	34.45
Conventional tillage	53.21	155.17	34.34
Permanent bed	53.86	147.12	36.63
SEm±	0.93	2.20	0.70
C.D (P=0.05)	**3.64**	**8.63**	NS
CV (%)	5.05	4.20	**5.98**
Nutrients management			
RDN 33%	52.13	151.30	34.62
RDF 100%	56.29	157.43	36.03
SSNM	56.52	162.08	34.77
SEm±	0.89	2.67	0.88
C.D (P=0.05)	**2.74**	**8.24**	NS
CV (%)	4.84	5.11	**7.48**
Interaction tillage × nutrient management	NS	NS	NS

RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.

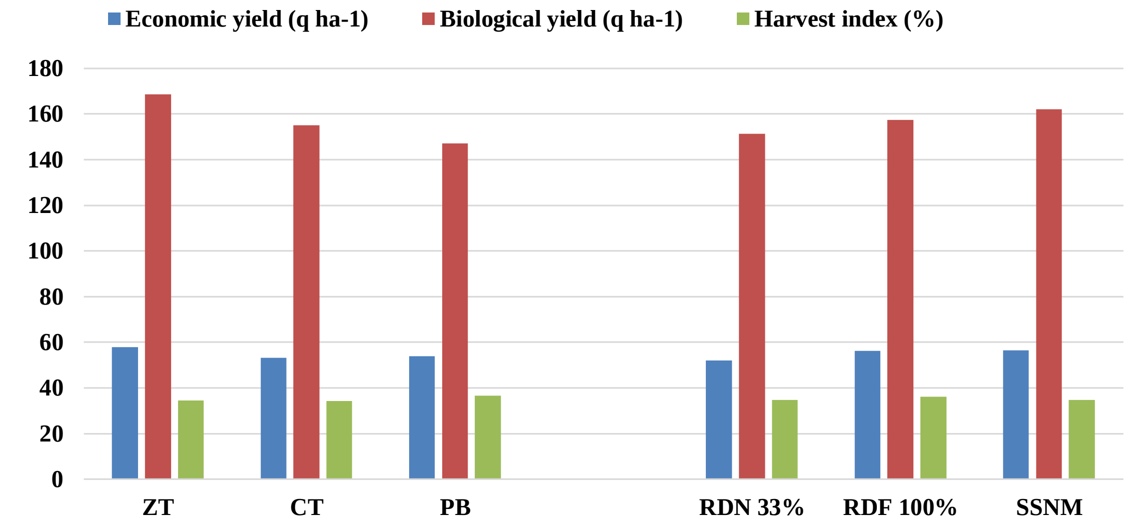


Fig. 4.10 Effect of tillage and nutrient management practices on economic yield, biological yield and harvest index.

4.3 Nutrient content, uptake and left in soil

4.3.1 Effect of tillage and nutrient management practices on nitrogen content in stover, grain, total uptake and left in soil.

4.3.1.1 Total nitrogen content in stover (kg ha^{-1})

The data regarding nitrogen content in stover (kg ha^{-1}) presented in table 4.12 and fig. 4.11 revealed that it was significantly influence by tillage & nutrient management practices and their interaction.

It is evident from data that the nitrogen content in stover was significantly affected by various tillage practices. Among the tillage practices noteworthy distinct nitrogen content (184.7 kg ha^{-1}) was observed with zero tillage than 33% RDN (144.2 kg ha^{-1}) but it remains comparable with 100% RDF (171.1 kg ha^{-1}).

A close examination of data illustrate that site specific nutrient management exert lucid impact on 33% recommended dose of nitrogen and 100% recommended dose of fertilizer. However, site specific nutrient management (SSNM) was recorded remarkably maximum (185.2 kg ha^{-1}) nitrogen content in stover over 33% RDN and 100% RDF. While nitrogen content under 33% RDN (167.4 kg ha^{-1}) significantly varied from 100% RDF (147.4 kg ha^{-1}).

Scanning of data further reported that combination of various tillage and nutrient management practices significantly influenced nitrogen content in stover of maize. The best combination for nitrogen content was zero tillage × SSNM which was recorded lucidly highest nitrogen content (204.3 kg ha^{-1}) over all combinations except conventional tillage × 33% RDN and SSNM observed (188.6 and 197.4 kg ha^{-1}), respectively.

Table 4.12 Effect of tillage and nutrient management practices on total nitrogen content in stover (kg ha^{-1})

Total nitrogen content in stover (kg ha^{-1})				
Nutrient management/ Tillage	**ZT**	**CT**	**PB**	**Mean for STP**
RDN (33%)	15.93	17.13	17.76	16.94
RDF (100%)	18.00	16.80	17.33	17.37
SSNM	18.00	17.43	18.06	17.83
Mean for MPT	**17.31**	**17.12**	**17.72**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	21.85	5.56	10.01	
Nutrient Management	15.39	4.99	8.99	
Int. of Tillage x Nut. management	26.66	8.65		
***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int.= Interaction, Nut.= Nutrient.**				

4.3.1.2 Nitrogen content in grain (kg ha^{-1})

The data with respect to nitrogen content of grain influenced by different tillage and nutrient management practices presented in table 4.13 and fig 4.11.

As expected, the nitrogen content in grain lucidly affected by different tillage practices. In comparison with various tillage practices zero tillage was strived significantly more nitrogen content (99.37 kg ha^{-1}) in grain over both tillage practices though, it again conventional tillage (89.21 kg ha^{-1}) and permanent bed (92.27 kg ha^{-1}) remained statistically at par among themselves.

Nevertheless, significant impact of different nutrient management on the nitrogen content of grain. The maximum nitrogen content in grain (99.99 kg ha^{-1}) under site specific nutrient management which was remarkably varied from both nutrient management practices whereas 33% RDN (87.82 kg ha^{-1}) and 100% RDF (93.04 kg ha^{-1}) did not produced significant variation.

The critical analysis of data revealed that various tillage and nutrient management practices combination was noticed lucid variation regarding nitrogen content in grain. The zero tillage × SSNM combination noted remarkably highest nitrogen content (105.80 kg ha^{-1}) over other except zero tillage × 100% RDF, conventional tillage × SSNM and permanent bed ×SSNM which was remain comparable to each other.

Table 4.13 Effect of tillage and nutrient management practices on total nitrogen content in grain (kg ha^{-1})

Nitrogen uptake in grain (kg ha^{-1})				
Nutrient management/ Tillage	**ZT**	**CT**	**PB**	**Mean for STP**
RDN (33%)	87.58	88.79	87.08	**87.82**
RDF (100%)	104.71	81.71	92.68	**93.03**
SSNM	105.79	97.14	97.05	**99.99**
Mean for MPT	**99.36**	**89.21**	**92.27**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	7.08	1.80	5.78	
Nutrient Management	5.52	1.79	5.74	
Int. of Tillage x Nut. management	9.57	3.10		

***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int.= Interaction, Nut.= Nutrient.**

4.3.1.3 Total nitrogen uptake (kg ha^{-1})

The data pertaining to nitrogen uptake summarized in table 4.14 and fig. 4.11 showed significant effect of tillage and nutrient management practices.

The scrutiny of data indicated zero tillage exerted marked variation in respect of nitrogen uptake (284.11 kg ha^{-1}). There was zero tillage support to lucidly maximum nitrogen uptake over permanent bed and then remained at par with conventional tillage practice during experimentation.

The maximum nitrogen uptake (285.19 kg ha^{-1}) was associated with treatment where site specific nutrient management supplied however, it prove to be remarkable superiority over both 33% RDN (255.23) and 100% RDF (240.46 kg ha^{-1}) but it again both remain non-significant among them.

A close study of data further indicated significant interaction effect of combination of different tillage and nutrient management practices on the nitrogen uptake. The combined effect of zero tillage × SSNM was proved to be noteworthy superior (310.13 kg ha^{-1}) over all treatment combination except zero tillage × 100% RDF (280.72 kg ha^{-1}) and conventional tillage × SSNM (294.56 kg ha^{-1}) which was remained comparable.

Table 4.14 Effect of tillage and nutrient management practices on total nitrogen uptake (kg ha^{-1})

Total nitrogen uptake (kg ha^{-1})				
Nutrient management/ Tillage	**ZT**	**CT**	**PB**	**Mean for STP**
RDN (33%)	261.48	277.40	226.81	**255.23**
RDF (100%)	280.72	208.83	231.80	**240.45**
SSNM	310.13	294.56	250.88	**285.19**
Mean for MPT	**284.11**	**260.26**	**236.50**	
Treatments	**CD (P=0.05)**	**SEm±**	**CV (%)**	
Tillage	26.56	6.76	7.79	
Nutrient Management	18.27	5.92	6.83	
Int. of Tillage x Nut. management	31.64	10.27		
***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management *Int.= Interaction, Nut.= Nutrient.**				

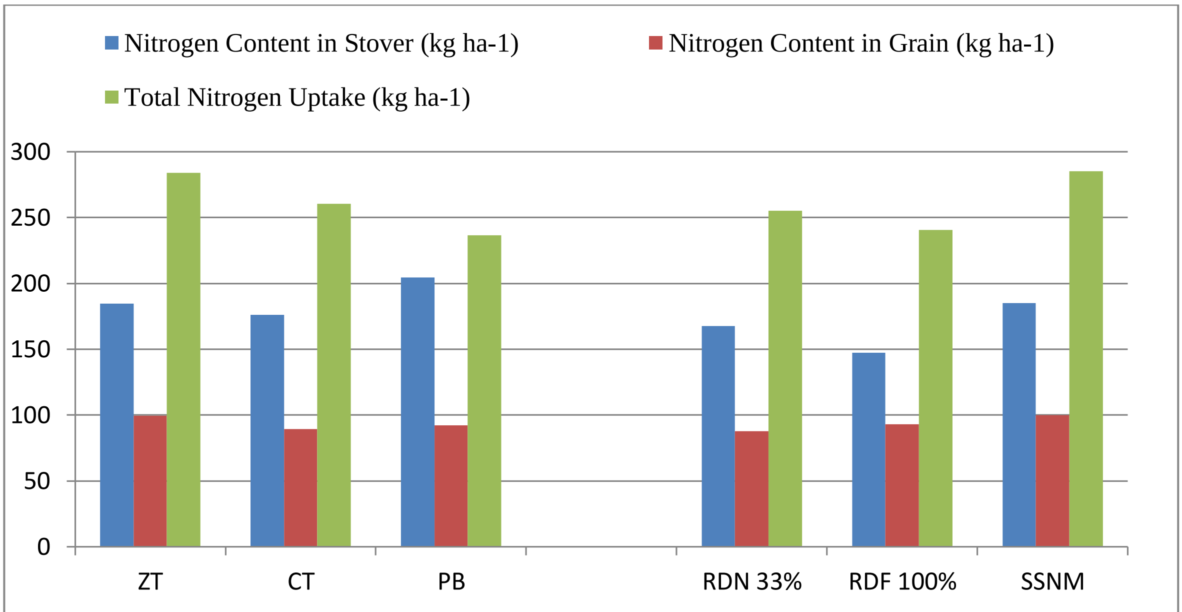


Fig. 4.11 Effect of tillage and nutrient management practices on nitrogen content in stover, grain, total uptake (kg ha^{-1})

4.3.1.4 Total initial soil nitrogen and left nitrogen in soil after harvest (kg ha^{-1})

The data regarding total initial soil nitrogen and left nitrogen in soil after harvest presented in table 4.15 and fig. 4.12. It revealed that non-significant effect of various tillage practices but significant effect of different nutrient management practices on left nitrogen in soil.

As regard to the data same amount (2485.3 kg ha^{-1}) of total initial soil nitrogen (initial soil N + applied N) under different tillage practices. However, continuous increment in nitrogen doses accordingly increases total initial soil nitrogen. Where maximum (2552 kg ha^{-1}) total initial N was noticed under site specific nutrient management practice while it was minimum (2392 kg ha^{-1}) with 33% recommended dose of nitrogen.

The perusal of data illustrated none of the any tillage practices exerted marked variation on the total nitrogen left in soil after harvesting of the crop. In general more nitrogen left in soil under permanent bed (2240 kg ha^{-1}) and minimum (2190 kg ha^{-1}) with conventional tillage.

A close study of data revealed that site specific nutrient management exerted lucidly noticeable effect it was left maximum total nitrogen (2513 kg ha^{-1}) in soil after harvest than 100% recommended dose of fertilizer (1941 kg ha^{-1}) and 33% recommended dose of nitrogen (2190 kg ha^{-1}) while remained close both to each other.

The scanning of data further showed that not significantly affected interaction of different combination of tillage and nutrient management practices on total nitrogen left in soil after harvest.

Table 4.15 Effect of tillage and nutrient management practices on total initial soil nitrogen and total nitrogen left in soil after harvest (kg ha^{-1})

Treatment	Total initial soil N+applied N (kg ha^{-1})	Total left N after harvest (kg ha^{-1})
Tillage practices		
Zero tillage	2485.00	2215.00
Conventional tillage	2485.00	2190.00
Permanent bed	2485.00	2240.00
SEm±		78.70
C.D (P=0.05)		NS
CV (%)		**10.70**
Nutrients management		
RDN 33%	2392.00	2190.00
RDF 100%	2512.00	1941.00
SSNM	2552.00	2513.00
SEm±		98.50
C.D (P=0.05)		**303.50**
CV (%)		13.30
Interaction tillage × nutrient management		NS

RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.

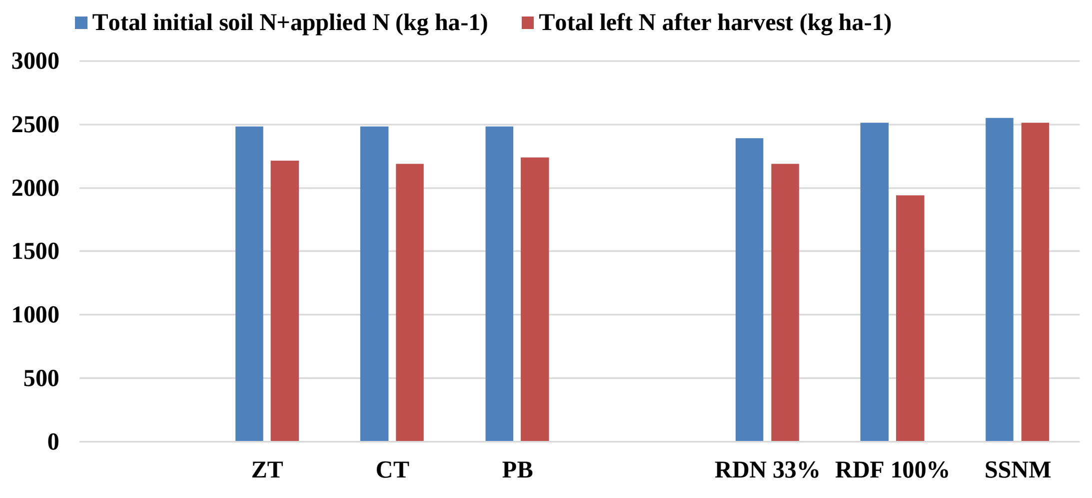


Fig. 4.12 Effect of tillage and nutrient management practices on total initial soil nitrogen and total nitrogen left in soil after harvest (kg ha^{-1})

4.3.2 Effect of tillage and nutrient management on phosphorus content in stover & grain and its uptake in maize plant (kg ha^{-1})

4.3.2.1 Phosphorus content in stover ((kg ha^{-1})

The data on phosphorus content in stover of maize are presented in table 4.16 and fig. 4.13 revealed that lucid variation was noticed due to the different experimental variable tested to the crop.

It is obvious from the data further illustrated that phosphorus content in stover significantly influenced by different tillage practices. Likewise, zero tillage was recorded highest P content (31.73 kg ha^{-1}) and it exerted significant differences regarding P content in stover over both tillage practices conventional tillage and permanent bed practice. However, both conventional tillage and permanent bed failed to cause marked variation in terms of P content in stover.

The data on phosphorus content of maize stover as affected by various nutrient management practices expressed significant variation. However, the minimum P content (23.38 kg ha^{-1}) in stover was associated in 33% recommended dose of nitrogen and highest P content (35.41 kg ha^{-1}) was associated with SSNM and differences between each other remain significant. Similarly, the SSNM also exerted its significant advantage over 100% recommended dose of fertilizer on the P content.

The perusal of data revealed that none of the tillage and nutrient management practices exerted marked effect on phosphorus content in stover during field study.

4.3.2.2 Phosphorus content in grain (kg ha^{-1})

As regard to data of phosphorus content in grain was presented in table 4.16 and fig. 4.13 reported that different treatment variables exerted marked differences on P content in grain.

Scanning of data revealed that the minimum (34.14 kg ha^{-1}) and maximum (36.37 kg ha^{-1}) P content in grain were recorded with permanent bed practice and zero tillage, respectively and difference between each other could not touch the level of significance. However, permanent bed and conventional tillage remained identical in containing P content in hybrid maize.

The data pertaining to P content in grain expressed that every increase in fertilizer nutrient doses applied to hybrid maize successfully enhanced the P content in grain. However, the site specific nutrient management (38.45 kg ha^{-1}) and 100% recommended dose of fertilizer (37.51 kg ha^{-1}) both showed their remarkable superiority in terms of P content in grain over 33% recommended dose of nitrogen (29.57 kg ha^{-1}) but they failed to cause marked variation between each other.

A critical analysis of data further exhibited that none of the different tillage and nutrient management combination exerted marked differences on phosphorus content in grain at physiological maturity during field study.

4.3.2.3 Phosphorus uptake (kg ha^{-1})

A close study of data summarized in table 4.16 and fig. 4.13 revealed that various tillage and nutrient management practices noteworthy affected phosphorus uptake.

The maximum phosphorus uptake was associated with treatment where zero tillage (68.11 kg ha^{-1}) operation employed however; it proved to be remarkable over conventional tillage (64.26 kg ha^{-1}) and permanent bed (63.34 kg ha^{-1}). Similarly, conventional tillage and permanent bed remained statistically comparable with each other.

An examination of data exposed remarkably highest amount of phosphorus uptake by maize crop under various nutrient management practices. The site specific nutrient management imposed to the crop gave lucid superiority (73.86 kg ha^{-1}) over 33% recommended dose of nitrogen (52.94 kg ha^{-1}) and it remained similar to the 100% recommended dose of fertilizer (68.90 kg ha^{-1}).

A critical analysis of data further illustrated interaction effect different tillage and nutrient management practices on phosphorus uptake did not find any distinct variation in terms of phosphorus uptake.

A critical study of data indicated none of the treatment either various tillage practices or nutrient management practices exerted lucid impact on the available phosphorus left in soil after harvest of the crop.

Table 4.16 Effect of tillage and nutrient management practices on phosphorus content in stover & grain its uptake, initial P and left P in soil after harvest (kg ha^{-1})

Treatment	P content (kg ha^{-1})		P uptake (kg ha^{-1})	Initial P + fertlizer P (kg ha^{-1})	P left in soil (kg ha^{-1})
	stover	grain			
Tillage practices					
Zero tillage	31.73	36.37	68.11	72.18	23.55
Conventional tillage	29.24	35.01	64.26	72.18	21.03
Permanent bed	29.20	34.14	63.34	72.18	20.84
SEm±	0.52	0.59	0.65		1.07
C.D (P=0.05)	2.05	2.30	2.56		NS
CV (%)	5.22	4.99	2.99		14.70
Nutrients management					
RDN 33%	23.38	29.57	52.94	75.51	22.13
RDF 100%	31.39	37.51	68.90	75.51	20.56
SSNM	35.41	38.45	73.86	65.51	22.74
SEm±	1.08	0.95	1.94		1.45
C.D (P=0.05)	3.32	2.93	5.98		NS
CV (%)	10.76	8.11	8.92		19.94
Interaction tillage × nutrient management	NS	NS	NS		NS

RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management, *P= Phosphorus

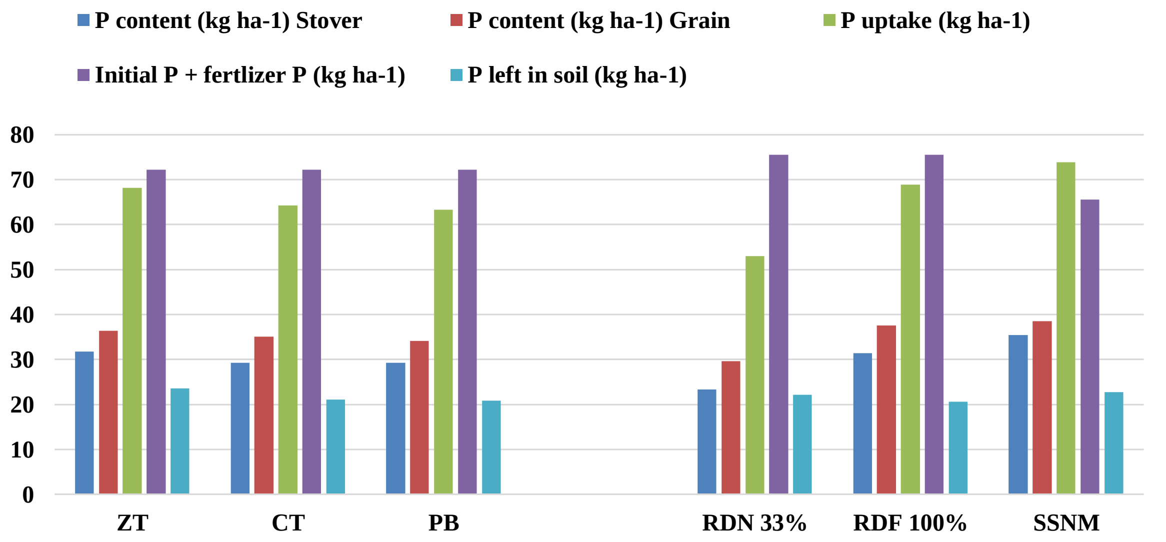


Fig. 4.13 Effect of tillage and nutrient management practices on phosphorus content in stover & grain its uptake, initial P and left P in soil after harvest (kg ha^{-1})

4.3.3 Effect of tillage and nutrient management practices on potassium content in stover & grain and its uptake in maize plant (kg ha^{-1})

4.3.3.1 Potassium content in stover and grain (kg ha^{-1})

The data regarding potassium content presented in table 4.17 and fig. 4.14 revealed that different tillage and nutrient management practices noted significant differences.

The scrutiny of data indicated zero tillage contains significantly highest potassium in both stover and grains (94.47 & 35.27 kg ha^{-1}) respectively over both tillage practices however, both remained significant to each other. Among the remaining tillage practices conventional tillage exerted lucid superiority regarding potassium content in stover and grain (90.82 & 32.92 kg ha^{-1}) respectively over permanent bed (86.91 & 30.39 kg ha^{-1}).

A close examination of data revealed that lucid differences were observed with different nutrient management practices to the potassium content in stover and grains. The data indicated potassium content under site specific nutrient management was highest in both stover and grain (99.67 & 35.66 kg ha^{-1}) respectively over 33% RDN (80.28 kg ha^{-1}) & 100% RDF (92.26 kg ha^{-1}) for stover and 33% RDN (29.13 kg ha^{-1}) for grains but remain close to the 100% RDF (33.79 kg ha^{-1}).

A critical examination of data further illustrates none of the any treatment combination exerted significant differences to the potassium content in stover and grain.

4.3.3.2 Potassium uptake (kg ha^{-1})

The data pertaining to potassium uptake summarized in table 4.17 and fig. 4.14 showed significant results was observed with various tillage and nutrient management practices to the potassium uptake by hybrid maize.

The scrutiny of data revealed that potassium uptake was remarkably differed due to different tillage practice. Zero tillage affect significantly to the potassium uptake under this maize uptake highest potassium (129.73 kg ha^{-1}) than conventional tillage (123.74 kg ha^{-1}) and permanent bed (117.30 kg ha^{-1}). However, again conventional tillage and permanent bed significantly varied to each other.

As evident from data the maximum potassium uptake (135.32 kg ha^{-1}) was related with treatment when site specific nutrient management applied though, it prove to be lucid superiority over 100% recommended dose of fertilizer (RDF) and 33% recommended dose of nitrogen (RDN) however, 100% RDF (126.04 kg ha^{-1}) exerted again remarkable superiority over 33% RDN (109.41 kg ha^{-1}).

The perusal of data further illustrates no marked differences were observed with any treatment combination to the potassium uptake by hybrid maize during the course of field study.

4.3.3.3 Available initial soil potassium and left potassium in soil after harvest (kg ha^{-1})

The data regarding total initial soil available potassium (initial K+applied K) and left potassium in soil after harvest presented in table 4.17 and fig. 4.14. It revealed that non-significant effect of various tillage practices but significant effect of different nutrient management practices on left available potassium in soil.

As regard to the data same amount (378.93 kg ha^{-1}) of available initial soil potassium (initial soil K+ applied K) was occur under different tillage practices.

The close study of data indicated different nutrient management practices exerted noteworthy variation for the potassium left in soil after harvest. However, significantly maximum (375.89 kg ha^{-1}) available potassium was noticed under 33% recommended dose of nitrogen its prove lucid superiority over site specific nutrient management (339.69 kg ha^{-1}) while it was remain similar to the 100% recommended dose of fertilizer (362.91 kg ha^{-1}).

The perusal of data illustrated none of the any tillage practices exerted marked variation on the available potassium left in soil after harvesting of the crop. In general maximum potassium left in soil under conventional tillage (370.42 kg ha^{-1}) and minimum with zero tillage (348.00).

The scanning of data further showed that not significant interaction of different combination of tillage and nutrient management practices on available potassium left in soil after harvest.

Table 4.17 Effect of tillage and nutrient management practices on potassium content in stover & grain its uptake, initial K and left K in soil after harvest (kg ha^{-1})

Treatment	K content (kg ha^{-1})		K uptake (kg ha^{-1})	Initial soil K+applied K (kg ha^{-1})	K left in soil (kg ha^{-1})
	Stover	Grain			
Tillage practices					
Zero tillage	94.47	35.27	129.73	378.93	348.00
Conventional tillage	90.82	32.92	123.74	378.93	370.42
Permanent bed	86.91	30.39	117.30	378.93	360.07
SEm±	0.48	0.47	0.40		8.63
C.D (P=0.05)	1.88	1.83	1.58		NS
CV (%)	1.58	4.24	0.98		7.20
Nutrients management					
RDN 33%	80.28	29.13	109.41	375.60	375.89
RDF 100%	92.26	33.79	126.04	375.60	362.91
SSNM	99.67	35.66	135.32	385.60	339.69
SEm±	0.59	0.70	0.60		7.70
C.D (P=0.05)	1.83	2.17	1.85		23.74
CV (%)	1.96	6.43	1.45		6.43
Interaction tillage × nutrient management	NS	NS	NS		NS

RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.

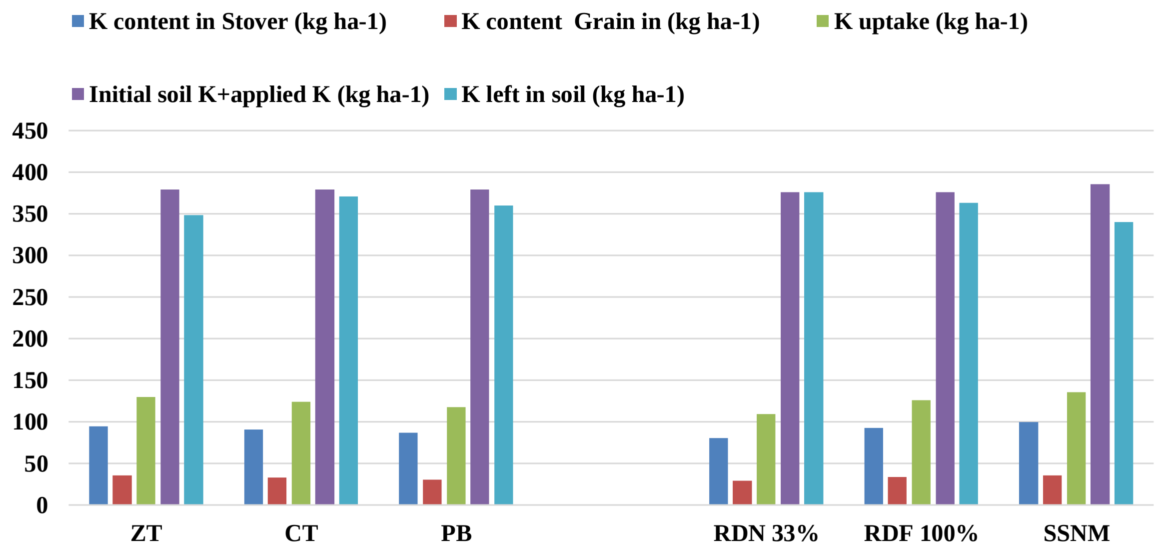


Fig 4.14 Effect of tillage and nutrient management practices on potassium content in stover & grain its uptake, initial K and left K in soil after harvest (kg ha^{-1})

4.4 Economics

Comparative economics of maize crop based on yield are presented in table 4.18.

4.4.1 Cost of cultivation (Rs.ha^{-1})

A perusal of data showed that minimum cost of cultivation (28726 Rs. ha^{-1}) was obtained with zero tillage practice while highest cost of cultivation was observed with permanent bed (33472 Rs. ha^{-1}) however under conventional tillage (31632 Rs. ha^{-1}) cost of cultivation slightly lower than permanent bed and more than zero tillage.

A close study of data reported increasing fertilizer doses resulted continuous increases cost of cultivation. Accordingly application of fertilizer based on site specific nutrient management consequences maximum cost of cultivation (33272 Rs. ha^{-1}). At the same time employed 33% recommended dose of nitrogen recorded minimum (27617 Rs. ha^{-1}) cost of cultivation while 100% recommended dose of fertilizer noted somewhat lower value (32977 Rs. ha^{-1}) than site specific nutrient management.

4.4.2 Gross return, net return (Rs.ha^{-1}) and B:C ratio

An introspection to data showed that among the different tillage practices zero tillage strived remarkably noticeable differences which was reported lucidly maximum gross return (130370 Rs. ha^{-1}), net return (101608 Rs. ha^{-1}) and B:C ratio (3.55) against both tillage conventional tillage and permanent bed practices. But on the contrary conventional tillage and permanent bed non-significant among themselves whereas, conventional tillage noted little bit more gross return (119890 Rs.ha^{-1}), net return (88257 Rs. ha^{-1}) and B:C ratio (2.80) than permanent bed. However permanent bed recorded lowest gross return (119368 Rs. ha^{-1}), net return (85896 Rs. ha^{-1}) and B:C ratio (2.57).

The scrutiny of data reported that grass return and B:C ratio lucidly influenced by different nutrient management practices but none of the treatment exerted significant impact on net return . Continuous increment in fertilizer doses consequently rise the gross return on other hand decline B:C ratio. The site specific nutrient management and 100% recommended dose of fertilizer was obtained remarkably noticeable gross return (126427 and 125880) respectively over 33% recommended dose of nitrogen however, SSNM and 100% RDF lucidly close among themselves during the course of experiment. As regard data 33% recommended dose of nitrogen noted noteworthy more B:C ratio (3.28) than both

100% recommended dose of fertilizer (2.83) and site specific nutrient management (2.82) practice. While 100% RDF and SSNM again remained comparable among them. Scanning of data further exposed that not any tillage and nutrient management combinations exerted remarkable variation in respect to the gross return, net return and B:C ratio of the maize crop.

Table 4.18 Effect of tillage and nutrient management practices on cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and B:C ratio

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Tillage practices				
Zero tillage	28762	130370	101608	3.55
Conventional tillage	31632	119890	88257	2.80
Permanent bed	33472	119368	85896	2.57
SEm±	-	1692	1692	0.053
C.D (P=0.05)	-	**6647**	6647	0.21
CV (%)	-	4.12	5.52	5.35
Nutrients management				
RDN 33%	27617	117321	89704	3.28
RDF 100%	32977	125880	92902	2.83
SSNM	33272	126427	93155	2.82
SEm±	-	1446	1446	0.047
C.D (P=0.05)	-	4457	NS	0.14
CV (%)	-	3.52	**4.72**	4.72
Interaction tillage × nutrient management	-	NS	NS	NS
RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.				

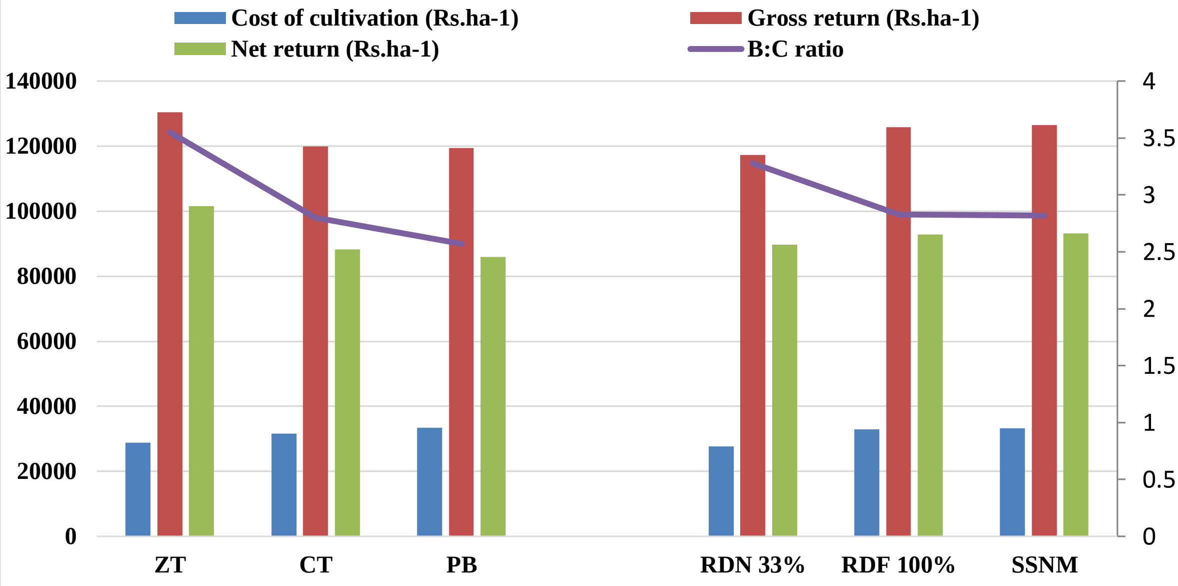


Fig. 4.15 Effect of tillage and nutrient management practices on cost of cultivation (Rs.ha^{-1}), gross return (Rs.ha^{-1}), net return (Rs.ha^{-1}) and B:C ratio

4.5 Effect of tillage and nutrient management practices on insect – pest scaling

4.5.1 Stem borer and fall army worm

A close examination of data regarding stem borer and fall army worm presented in table 4.19 and fig. 4.16 showed that none of the treatment and their combination exerted remarkable marked variation on insect infestation to hybrid maize. Maximum stem borer attack in conventional tillage it damage 3.2 plant out of 10 or 32% and under different nutrient management practices 100% RDF recorded more damage plant 2.9 plants out of 10 or 29%.

The data regarding fall army worm permanent bed showed more infestation 3 plant out of 10 or 30% and under various nutrient management site specific nutrient management was noticed more damage 2.6 plant out of 10 or 26% plants.

Table 4.19 Effect of tillage and nutrient management practices on stem borer and fall army worm

Treatment	Stem borrer scaling (%)	Fall army worm scaling (%)
Tillage practices		
Zero tillage	2.4 (24%)	1.5 (15%)
Conventional tillage	3.2 (32%)	2.5 (24%)
Permanent bed	2.3 (23%)	3.0 (24%)
SEm±	0.2 (2.0)	0.37 (3.7)
C.D (P=0.05)	NS	NS
CV (%)	**25.8**	**47.4**
Nutrients management		
RDN 33%	2.5 (25%)	2.2 (22%)
RDF 100%	2.9 (29%)	2.2 (22%)
SSNM	2.5 (25%)	2.6 (26%)
SEm±	0.21(2.1)	0.28 (2.8)
C.D (P=0.05)	NS	NS
CV (%)	**23.63**	**34.9**
Interaction tillage × nutrient management	NS	NS
RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management		

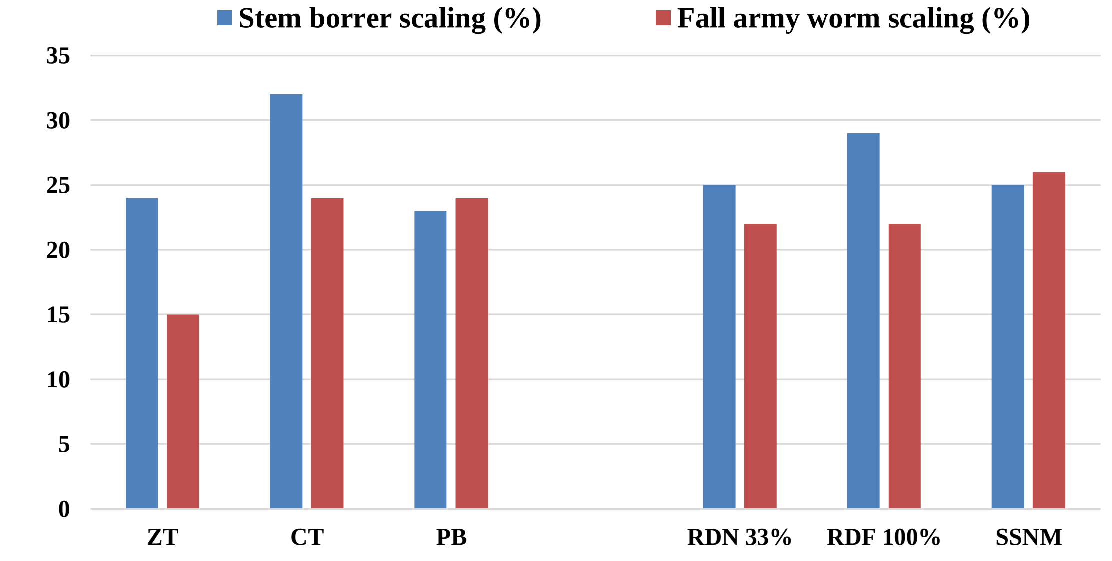


Fig. 4.16 Effect of tillage and nutrient management practices on stem borer and fall army worm

CHAPTER-5

DISCUSSION

Chapter - 5

Discussion

The crop plants growth and development both are directly related to their genetic constitution, though environment factors and cultural practices do influence on it directly / indirectly (Gardner *et al*., 1988). Scrutiny of the experimental findings discloses various computed outcomes under the title of my study "**Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices**". In this chapter, an attempt has been made to discuss and explain the salient findings in light of established theories and principles.

5.1 Effect of weather on crop growth and yield

Climate determines suitability of a crop to a particular region while weather plays a major role in the crop productivity in the region (Reddy, 2019). For proper growth and development, each crop needs a certain combination of favorable environmental conditions. Exploiting the genetic yield potential of crops requires matching crop phenology to the climate that prevails during the growing season. If weather conditions go beyond the cardinal bounds, either higher or lower, plants might fail to keep up their growth rhythm and hence perform poorly. During the investigation, the crop growth stages were affected by various abiotic factors such as temperature, rainfall, humidity, and evapotranspiration. A comparable high amount of variance in rainfall to typical days is seen in the weather. Similarly, the total amount of rainfall received throughout the cropping period was 750 mm however, the distribution of rainfall was unequal. Maize is highly sensitive to water stagnation. The heavy rainfall (118 mm) was coincided by 2 DAS which was adversely affected the germination and emergence of crop. Rainfall subsequently continued to receive by 273.5 mm in next 15 days. The 52.2% rainfall of total rainfall was recorded within 20 DAS which were responsible for the poor germination, emergence, establishment and crop stand. Permanent bed was more affected by water stagnation this might had happened due to more water stagnated in furrows for longer period of time and drainage facility was choked. Therefore the plants adjoining to the furrows affected severely. Under zero tillage no obstruction so, water was easily runoff and infiltrated well due to natural soil aggregation which helpful in avoiding anaerobic conditions due to water lodging (Jat *et al,* 2014). Temperature is known to have a remarkable impact on the different growth stages of the crop. The germination of maize is easily affected by temperature variations during the sowing period. The table and graphs showed that the average minimum and maximum temperature was recorded 30^0C and 34^0C respectively during the course of investigation. The minimum sun shine hours were recorded during vegetative growth period which was negatively influenced crop. Because maize develops its roots in the vegetative growth stage, and the growth of maize roots is very sensitive to the external environment during this period when less photosynthesis leads to a decrease in root biomass. Decreased root mass in the vegetative growth stage greatly hinders the development of shoot biomass during the later growth period due to weaker water and nutrient absorption. The vigorous shoot intercept high amount of light which direct related to the photosynthesis and dry matter accumulation ultimately it affect the quantity of yield. The declining sun shine hour reduces crop yield by weakening photosynthesis Song and Jin (2020). The remaining weather observation such as relative humidity, wind speed was satisfactory and it does not influence distinctly on the crop during experiment. Changes in environmental conditions have a considerable impact on crop growth, development, and yield potential of maize crop.

5.2 Effect of tillage and nutrient management on growth attributes

5.2.1 Plant height (cm)

In general, plant height increased as the crop advanced in age and attained its tallest height at the harvest. Initially, differences in plant height under different tillage and nutrient management practices did not influence but at the later stages it differed significantly.

Data on plant height recorded at 30 and 55 DAS have been presented in table no. 4.1. It showed that the plant height ranged from 62.33 to 70.44 cm and 215.11 cm to 236.67 cm at 30 DAS and 55 DAS respectively, under different tillage practices which were non- significant at 30 DAS and remarkable differences at 55 DAS. At 30 DAS non-significantly differed plant height was observed might be due to initially uniform physiochemical condition of soil, microbial activity resulted equal availability of readily available nutrients. Plants follow sigmoid growth curve in which initially arithmetic growth that is why uniform height observed and after that start exponential growth against the more availability of nutrients towards time. The similar result was found by Amrendra Kumar (2016). The increase in plant height at 55 DAS under zero tillage might be due to good physical condition, high aggregation, more microbial activity, optimum plant density and adequate availability of moisture attributed to better nutritional environment for plant growth at active vegetative stages as a result of enhancement in cell multiplications (geometric cell division), cell elongation and cell expression in the plant body which ultimately increased the height. Similar result was found by (Kumar *at el*, 2018). At high density interplant competition for light among maize plants increased which might have increased inter node length and thus increased plant height. By 10 cm taller plants than at low plant density (Ammanulah *et al*, 2009).

Among the nutrient management practices plant height varied from 62.11 cm to 68.44 cm and 219.44 cm to 234.30 cm at 30 DAS and 55DAS, respectively. The plant height significantly varied only at 55 DAS. At 30 DAS not remarkable differences in height might be due to similar condition of soil at early growth stage consequently equal mineralization of external inorganic NPK source, root development and more or less uniform activity of microorganism. Likewise, the site specific nutrient management practices (enhanced N dose) recorded lucidly tallest plant height and it expressed its remarkable variation over 33% RDN (40 kg), and this increase in plant height was recorded by 6.35% at 55 DAS. The increase in plant height was attributed to increase in N application that led to more vegetative growth and development triggered as compared to other treatments. Nitrogen is an integral part of chlorophyll and responsible for more vegetative biomass resulted the more light energy in to chemical energy needed for photosynthesis. These results are in conformity with the results obtained by Iqbal *et al* (2015) and Stesi *et al* (2019).

5.2.2 Number of leaves

The number of leaves increased with an advancement of crop till reproductive stage initiated and thereafter it decreased towards maturity. The number of leaves not remarkably varied at 30 DAS might be ascribe to similar plant height and biomass was recorded while at 55 DAS, it was varied significantly and attained more leaves ranging between 15.04 to 16.00 leaves plant^{-1} from permanent bed to zero tillage, correspondingly. Similarly, the zero tillage recorded significantly the highest number of leaves (16.00) over permanent bed (15.04) though it remained at par with conventional tillage (15.52). It was might be due to low bulk density, penetration resistance, high aggregation, moisture regime, early emergence resulted better nutritional environment produce taller plant under zero tillage with higher number of leaves. (Parihar *et al*, 2016) who reported highest number of leaves attain under zero tillage.

The number of leaves increases with correspondingly increase in nutrient dose. It was not remarkably varied at 30 DAS might be ascribe to similar plant height observed but significantly influenced by different nutrient management practices at 55 DAS however; the value was varied from (15.04 to 16.00) with 33% RDN and SSNM which was remain comparable with 100% RDF (15.52). Best plant nutrient supplementation improved plant growth and development leading to highest plant height and more number of leaves. Similar results were also reported by (Bakht*et et al,* 2006) and (Nadeem *et al,* 2009).

5.2.3 Leaf area index

The non-significant variation was observed in leaf area index at 30 DAS for the different tillage and nutrient management practices. while lucid variation were recorded at 55 DAS among tillage and nutrient management practices. The zero tillage and permanent bed was reach the level of significance and both recorded 4.87 and 4.57 LAI, respectively though, conventional tillage statistically at par with them and produced by 4.69 LAI. The higher leaf area index might be due to result of higher accumulation rate and conversion of energy with more number of leaves under zero tillage.

The LAI value are differed significantly at 55 DAS under different nutrient management practices SSNM (4.89) recorded the highest LAI followed by 100% RDF (4.83) remarkably lowest value with 33% RDN (4.41). Significantly highest LAI under SSNM might be due to more supply of nitrogen responsible for better growth of maize shoots. Nitrogen being vital part of protoplasm helped in cell-division, elongation and thus favored more production of leaves. Nitrogen assimilated in to amino acids that are subsequently combined in to proteins and nucleic acids then proteins provide framework for chloroplasts, mitochondrion and other structures in which most biochemical reaction occur consequently increase the production of food material. The higher value of leaf area was again proving to be more number of leaves and its expansion (Acharya *et al,* 2020). SSNM-based balanced dose provided nutrient as per the crop requirement, hence better plant growth was observed (Kumar *et al*, 2014). Increasing in LAI may be due to the fact that high amount of nitrogen increased number of leaves and total leaf area per plant and their effect on multiplication and enlargement of leaves cell (Amin 2010).

5.2.4 Dry matter (g)

The non-significant dry matter produced at 30 DAS may be due to similar plant height, number of leaves, leaf area index which directly related to the dry matter accumulation. The zero tillage produced significantly higher amount of dry matter at 55 DAS and 85 DAS as it also recorded high plant density, plant height and more number of leaves that is why their cumulative effect on plant increase dry matter accumulation. Zero tillage provided better physical condition for growth and development consequently vigorous plant growth which intercept more light leading to more dry matter accumulation (Memon *et al,* 2013).

Dry matter accumulation under various nutrient management practices was non-significant at 30 DAS may be due to less mineralization and initially similar availability of NPK to the plants. At 55 DAS to 85DAS dry matter accumulated significantly in increasing manner because more microbial activity towards maturity resulted in enhancing the mineralization of fixed and externally supplied nutrients which was converted in to easily available form to the plant. The dry matter production is the total effect of overall growth (Acharya *et al,* 2020). SSNM produced remarkably more dry matter might be due to higher leaf area index indicating higher chlorophilic area thus improving photosynthetic efficiency of plant which in turn resulted in higher dry matter accumulation (Raj *et al,* 2018).

5.2.5 Tasseling and silking

The scrutiny of data indicated that zero tillage took significantly 2-3 lesser days to emergence of tassel and silk. It was might be due to early seedlings emergence because thin soil cover on seed. Low bulk density, less root penetration resistance so more development of root efficiently uptake the nutrients from soil and aggregated soil conditions resulted it attained early reproductive stage in zero tillage treatments (Javeed *et al*, 2014).

The data regarding tasseling and silking reported that SSNM recorded significantly late emergence of tassel and silk may be due to high nitrogen dose which increase the succulency consequently increase vegetative phase and late entry in reproductive phase. High density plant population might be responsible for the late tassel and silk emergence. Similar results were found by Imran *et al*, (2015), Assefa and Mekonnen, (2019) and Amin, (2020). Phenology of plant is regulated by phytochromes responsible for the regulation of seed germination, synthesis of chlorophyll, elongation of seedling and timing of flowering which are affected by nutrients (Jan *et al,* 2018).

5.3 Yield attributes

5.3.1 Plant population (ha^{-1})

The plant population under various tillage and nutrient management practices did not significantly varied. It was might be ascribe to plant population depend on planting density and seed rate. Since planting density of maize was kept same in all treatments hence, plant population remained statistically same (Kumar, 2016).

5.3.2 Number of cob (ha^{-1})

The number of cob ha^{-1} among different tillage and nutrient management could not touch the level of significance because it was determined by plant population. Non-remarkable variation in plant population was the reason for at par differences on number of cobs among different treatments.

5.3.3 Number of rows cob^{-1}

None of the treatment exerted marked variation on the number of rows cob^{-1}. However, cob girth and rows are highly stable character of a distinct variety hybrid. The cob girth and number of rows cob^{-1} are basically representing the genetic behavior of variety. Therefore, cob girth under investigation indicated non-significantly varied among tillage and nutrient management practices.

5.3.4 Number of grain row^{-1}

The significant effect of different tillage and nutrient management practices on the number of grain row^{-1}. Among the tillage practices, zero tillage recorded more number of grains row^{-1} might be ascribe to the longest cob observed under zero tillage. The cob length directly influence the number of grains row^{-1} as it directly dependent on the cob length. The SSNM produced more grain in a single row may be due to it meet out the nutrient demand of crop and application of fertilizer according to 4R principle which fulfill the nutrient demand at critical growth stage attributed to better growth, sink-source ratio and partitioning of photosynthates. This line was earlier confirmed by Biradar *et al* (2006) and Bana *et al* (2020).

5.3.5 Number of grain cob^{-1}

The significantly maximum number of grains cob^{-1} was counted under zero tillage and SSNM. Similarly number of row cob $^{-1}$ and number grain in single row were recorded higher values when SSNM supplied to the crop and it directly affected the number of grain cob^{-1} and indirectly influenced by cob girth and cob length. Zero tillage recorded the higher number of grains cob^{-1} might be due to lower bulk density, more aggregation might have facilitated the root proliferation in the soil and increased the rate of water, air and nutrient uptake and movement. The last plays an important role in tissue development, cell division, enhance plant growth, and thereby increased number of grains per cob (Ramadhan, 2021). SSNM produced more number of grains cob^{-1} might be ascribe to it provided adequate amount of N, P and K in balance dose at appropriate time and place which enhance, the synthesis and translocation of phtosynthates efficiently to the cob resulted better grain filling (Khanal *et al*, 2017).

5.3.6 Cob length (cm)

Cob length significantly influenced by various tillage and nutrient management practices. The highest cob length was consequent of good plant growth under zero tillage because maximum number of leaves, leaf area index and taller plant increased the green surface area for light interception resulted more formation of photosynthates and their efficiently translocation from source to sink. Among the nutrient management practices, SSNM produced the highest cob length due to balanced application of the nutrients lead to enhanced growth attributes that increased the plant growth by more cell division and cell elongation resulted cob gain maximum length (Singh *et al*, 2018). Increased nitrogen dose resulted in more availability of N which helped in crop growth as evident by leaf area and dry matter accumulation per plant due to this it caused longer cobs in SSNM (Pandey, 2019).

5.3.7 Cob girth (cm)

Cob girth of maize cob was recorded numerically higher under zero tillage and SSNM as compared to other treatment but failed to reach the level of significance. In general zero tillage produced high cob girth might be due to more number of leaves, leaf area index which increase the total leaf surface area for photosynthesis resulted more production of photosynthates and efficiently translocated from sink to source helped better development of cob. Pandey (2016) confirmed the above result has studies earlear. The SSNM recorded higher cob girth may be due to application of balance nutrition resulted enhancement in growth attributes lead to good photosynthate partitioning and better source–sink relationship, which ultimately resulted in the form of enhanced cob girth. This line was also confirmed by Kumar *et al,* (2014).

5.3.8 Seed index (g)

The seed index significantly varied among different tillage and nutrient management practices. The grain weight mainly depends on dry matter accumulation in source and its translocation to sink. The significantly heavy seed weight recorded under zero tillage might be due to good physical condition of soil and moisture holding capacity and microbial activity supported more availability of essential nutrients and better plant growth attributes consequently produced heavy seed. These factors positively reflected on higher photosynthesis rate and accumulation of more assimilates during the reproductive phase which in turn increased the sink size i.e. produced bold grains in the cob. This line confirmed by Parihar *et al* (2016) and Kumar *et al* (2018). The SSNM produced bold and heavy seed may be due to meet out the nutrient requirement which increased the availability of nutrients at critical physiological phases resulted better translocation of photosynthates from source to sink, consequently better growth and yield attributing characters, and finally increasing the boldness of grain. Boldness of grain also might be due to efficient adjustments in applying nutrients to accommodate field specific needs of the crops for supplementing plant nutrients (Pooniya *et al,* 2015).

5.3.9 Economic yield (q ha^{-1})

The economic yield significantly varied among different tillage and nutrient management practices. The maximum grain yield (57.88 q ha^{-1}) achieved under zero tillage due to cumulative effect of greater value of growth and growth attributes like plant height, LAI and dry matter accumulation resulted it recorded the highest yield attributes such as cob ha^{-1}, grains cob^{-1}, cob girth, cob length and seed index on the economic yield. These lines were confirmed by Sharma and Gautam (2010), Majumdar *et al,* (2012) and Parihar *et al,* (2016). Under nutrient management practices SSNM produced highest economic yield due to cumulative effect of growth and yield attributes. Similar trends under SSNM produced maximum yield confirmed by Biradar *et al,* (2006), Khanal *et al,* (2017), Singh *et al,* (2018), Singh *et al,* (2020), Shahi *et al* (2020) and Hasnain *et al,* (2021).

5.3.10 Biological yield (q ha^{-1})

Biological yield significantly affected by different tillage and nutrient management practices. Biological yield is a output of seed and stover yield representing reproductive and vegetative growth of the crop. Zero tillage recorded significantly the highest biological yield. Sharma and Gautam (2020) confirmed that zero tillage produced higher biological yield. The SSNM produced a higher biological yield and it might be due to balance dose of nutrition at appropriate stage which ultimately resulted in higher value of growth and yield attributes. This line was also confirmed by Singh *et al* (2018) and Hasnain *et al*, (2021).

5.3.11 Harvest index (%)

The none of treatments was exerted marked variation on the harvest index but the highest HI obtained with permanent bed because it produced the lowest stover yield consequent lower biological yield. Regarding different nutrition aspect the 100% RDF was recorded the highest HI because not remarkable difference among 100% RDF and SSNM for the economic yield and biological yield but it was produced lower stover yield resulted low biological yield and ultimately a high harvest index.

5.4 Nutrients uptake (kg ha^{-1})

5.4.1 Nitrogen uptake

The significantly varied amount of nitrogen uptake was noted in experiment under the various tillage and nutrient management practices by maize crop. The nitrogen uptake by maize crop under zero tillage was recorded maximum might be due to it substantially suppressed weed development at initial stage resulted better root development responsible for more water and nutrient uptake from the soil. The developed roots increased the rhizospheric zone in which more microbial activity enhances mineralization and solubilization of nutrients consequently more availability of N, P, K and other essential nutrients to the plants. The zero tillage improved the soil micro environmental conditions, and leads the availability of water and nutrients which are key components for substantial nutrient uptake by maize plants (Zougmore *et al*, 2006). Chopra *et al*, (2008) reported that zero tillage recorded significantly higher amount of nitrogen uptake. The maize was uptake more nitrogen under SSNM may be ascribe to N uptake increased with increasing levels of N application (Tolessa *et al*, 2009). Sufficient quantity of nitrogen applied under SSNM might have assisted in higher amount of nitrogen uptake by the maize crop in accordance with the potential of the crop and genotype (Singh *et al*, 2018).

5.4.2 Phosphorus uptake

The phosphorus uptake was remarkably influenced by different tillage and nutrient management practices. The maize was uptake more phosphorus in zero tillage may be ascribed to the highest yield of grain and stover simultaneously resulted more in uptake of phosphorus. The highest phosphorus uptake by maize under SSNM might be due to enough quantity of phosphorus applied which helped in higher amount of P uptake by the maize crop. The greater mobilization of phosphorus in the presence of nitrogen may be another reason for higher uptake of phosphorus by crop (Kwadzo *et al*, 2017).

5.4.3 Potassium uptake

The significantly higher potassium uptake by crop was noticed under zero tillage may be due to better physiochemical condition of soil like low bulk density, high infiltration, aggregation, microbial activity and high moisture holding capacity resulted better root development increase the water and potassium uptake. The SSNM was recorded significantly maximum potassium uptake might be due to balanced application of N, P and K consequently synergistic effect of N and P to uptake of potassium.

5.5 Insect-pest scaling

The data regarding stem borer and fall army worm (FAW) scaling revealed that none of the treatment exerted marked variation on the insect scaling. The conventional tillage was recorded the maximum stem borer might be due to vigorous shoot growth. The 100% RDF recorded more stem borer may be due to high dose of nitrogen increase the leaf succulancy which attracted the incidence of stem borer. The FAW was highly infected in permanent bed might be due to weak plant which easily infected. The FAW was high in SSNM might be due to vigorous and succulent shoot growth. The non-significant yield loss due to insect because timely application of insecticides. The stem borer was control by soil application of Carbofuron 3G @ 20 kg ha^{-1}. On other hand fall army worm was attack on the crop at cob formation stage. The insecticide Emamectine benzoate in 800 liter of water was applied twice at an interval of 15 days at cob formation stage and subsequently at dough (milking) stage of the crop. First application was done at cob formation then second spray at dough stage of the crop.

5.6 Economics

Economics is the ultimate scale on which success or failure of a treatment in getting recommendation is finalized. A treatment is judge not only on the basis of its influence on its yield but more on its ability to influence economics favorably. Higher return is an important determination of tillage practices and nutrient management for particular agro-climatic situation because farmers are more concerned with higher net return per unit investment. Gross return is the directive of total biological and economical yield of any crop (Kumar, 2018). The perusal of data under different element of economics showed that gross return increased with increasing grain and stover yield of maize obtained under various treatments. The Maximum gross return was recorded under zero tillage practices. This might be ascribe to higher production of grain and stover yield and higher increase in output in comparison to input. The difference was recorded in cost of cultivation due to variations in different tillage and nutrient management practices. Among the tillage practices the highest cost of cultivation was recorded with permanent bed due to expend extra charge for bed making and ploughing compare to zero tillage. Net return with zero tillage was found to be the highest which was lucidly superior over both of the treatments (conventional tillage and permanent bed). Jat *et al*, (2013), Parihar *et al*, (2016) and Yadav *et al*, (2016) was found the highest net return with zero tillage and permanent bed. The reason of obtained maximum net return due to higher grain and stover yield in zero tillage while highest B:C ratio also observed with zero tillage followed by conventional tillage and permanent bed. This might be ascribe to low cost of cultivation in zero tillage as compare to the remaining tillage practices. Ram *et al*, (2010) was found that maximum net return and B:C ratio obtained under no tillage.

Among different nutrient management practices, higher cost of cultivation obtained under SSNM was due to the fact that increased dose of nutrient fertilizer applied to the crop. The 33% RDN was recorded the lowest cost of cultivation due to least amount of nitrogen were applied. The maximum gross return was obtained under SSNM which remarkable superior over 33% RDN but at par with 100% RDF. The SSNM produced the highest grain and stover yield. The similar result was found by Pasuquin *et al*. (2010), Satyanarayana *et al*. (2013) and Khanal *et al*. (2018) The data of net return revealed that none of the nutrient management practices exerted marked variation but SSNM was obtained a little bit more net return. These lines were also confirmed by Biradar *et al*. (2006), Kumar *et al* (2015) and Singh *et al* (2020). The highest B:C ratio was obtained with 33% RDN which was significantly superior over 100% RDF and SSNM might be due to low cost of cultivation and obtaining similar net returns.

CHAPTER-6

SUMMARY AND CONCLUSION

Chapter - 6

Summery and Conclusion

The present investigation entitled **"Performance of maize (*Zea mays* L.) hybrid under different tillage and nutrient management practices"** was conducted during kharif 2021 at the collage research farm of Banda University of Agriculture and Technology, Banda UP with broader aim to determine the best tillage and nutrient management practices for maize crop.

The weather condition during initial period of experiment was not congenial due to excess amount of rain fall during this period. The total amount of rainfall received throughout the cropping period was 750 mm while 52.2 % of total rainfall recorded within 20 DAS indicated unequal distribution of rainfall. The average minimum and maximum temperature was recorded 30^0C and 34^0C respectively during the course of investigation. The minimum sun shine hour during vegetative phase negatively affected the crop. The other weather observation such as relative humidity, wind speed was satisfactory and it does not influence distinctly on the crop during experiment. The soil texture of the experimental field was silty clay having pH 7.89 and EC 0.55 dSm^{-1} indicated slightly basic in nature. The overall nutrient status of soil was 0.76% total carbon, total nitrogen (2392 kg ha^{-1}), available phosphorus (15.51 kg ha^{-1}) and available potassium (325 kg ha^{-1}).

The field experiment was carried out in a split plot design in 3 replication with two treatment factor and both the treatment factors had 3 levels of it and treatment factor which took place in main plot namely tillage practices (zero tillage, conventional tillage and permanent bed) and sub plot such as 33% recommended dose of nitrogen (40 kg N ha^{-1}), 100% recommended dose of fertilizer (N:P:K- 120:60:50 kg ha^{-1}) and site specific nutrient management (N:P:K- 160:50:60 kg ha^{-1}). The all treatment was allocated to the experimental unit according to principle of randomization.

The crop response to the treatments was measured in terms of various growth components, viz, plant height (cm), number of leaves, leaf area index, dry matter accumulation (g) and days to tasseling and silking emergence; yield attributing character viz, plant population ha^{-1}, number of cobs ha^{-1}, grain rows cob^{-1}, number of grain in single row, grain cob^{-1}, cob girth (cm), cob length (cm), seed index (g) and economic yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%). The economic feasibility of treatments was computed as CoC, gross returns (Rs. ha^{-1}), net returns (Rs. ha^{-1}) and benefit: cost ratio. The experimental soil was analyzed for pH, EC, total organic carbon, total nitrogen, available phosphorus and available potassium before experimentation. However, after harvest chemical analysis of soil for estimation of nitrogen, phosphorus and potassium (kg ha^{-1}) to compute left amount of N, P and K. The plant sample (stover and grain) was analyze after harvest for computation of total uptake of N, P and K. The insect pest incidence was also observed during investigation. The results were drawn finely after the statistical analysis of the data collected throughout the experiment. The salient findings of the field study are summarized below with a specific conclusion against the objectives studied.

6.1 Effect of different tillage management practices on the growth, yield attributes, nutrients uptake and left and economics of maize crop

6.1.1 Effect of different tillage management practices on the growth attributes of maize crop

The different tillage practices did not touch the level of significance among them at 30 DAS for growth parameter viz. plant height (cm), number of leaves, LAI and dry matter accumulation. In general maximum value of above growth parameter recorded under zero tillage practice. These growth parameter values were differed significantly at latter stage of crop (55 DAS) among tillage practices. The growth component mentioned above obtained remarkably higher values under zero tillage over permanent bed and remained at par with conventional tillage at 55 DAS. Similarly, significantly highest dry matter was produced under zero tillage at 85 DAS.

6.1.2 Effect of different tillage practices on days to tasseling and silking emergence

The days to tasseling and silking indicated distinct variation was noticed in terms of number of days taken to emergence due to variation in tillage practices tested to the hybrid maize. The zero tillage practice took 2-3 days lesser to attain tasseling and silking then permanent bed however differences observed between both could touch the level of significance. Zero tillage and conventional tillage took similar days to attain tasseling and differences between each remain on par.

6.1.3 Effect of different tillage practices on yield attributes

The yield attributes viz. plant population, cob ha^{-1}, rows cob^{-1}, cob girth, cob length and seed index did not significantly influenced by various tillage practices. Generally these yield attributes has maximum values under zero tillage except cob length it was maximum under permanent bed.

The zero tillage and permanent bed practices could reach the level of significance while conventional tillage close to the zero tillage. The zero tillage recorded remarkably highest number of grains row^{-1} and grains cob^{-1} over permanent bed.

6.1.4 Effect of different tillage practices on economic yield, biological yield and harvest index

The economic and biological yield significantly affected by different tillage practices. The zero tillage produced significantly maximum economic and biological yield over permanent bed but it again close to the conventional tillage. Harvest index did not lucidly influenced by tillage practices.

6.1.5 Effect of different tillage practices on content and uptake of N, P and K and left in soil

The nitrogen, phosphorus and potassium content in stover, grain and their uptake was remarkably affected by different tillage practices. The maximum N, P and K content in plant (stover and grain) and uptake was recorded under zero tillage over permanent bed practices. The maximum amount of nitrogen left in soil under permanent bed while highest phosphorus left in soil with zero tillage and maximum potassium left associated with conventional tillage.

6.1.6 Effect of different tillage practices on economics

The minimum cost of cultivation was associated with zero tillage practice. The highest gross return, net return and B:C ratio obtained with zero tillage and it was prove to be significant superiority over both tillage practices namely conventional tillage and permanent bed.

6.2 Effect of different nutrient management practices on the growth, yield attributes, nutrients uptake and left and economics of maize crop

6.2.1 Effect of different nutrient management practices on growth attributes

The various nutrient management practices failed to reach the level of significance among them at 30 DAS for growth parameter viz. plant height (cm), number of leaves, LAI and dry matter accumulation. In general maximum values of above growth parameter were associated with SSNM. These growth parameters were differed significantly at latter stage of crop (55 DAS) among nutrient management practices. The growth component mentioned above obtained remarkably higher values under SSNM over 33% RDN and remained at par with 100% RDF at 55 DAS. Similarly, significantly highest dry matter was produced under SSNM.

6.2.2 Effect of different nutrient management practices on days to tasseling and silking emergence

The days to tasseling and silking indicated significant variation was noticed in terms of number of days taken to emergence due to variation nutrient management practices. Among different nutrient management practices SSNM took 2-3 days more for tasseling and silking which was significant over 33% RDN while it failed to reach the level of significance with 100% RDF.

6.2.3 Effect of different nutrient management practices on yield attributes

The yield attributes viz. plant population, cob ha^{-1}, rows cob^{-1}, cob girth failed to reach the level of significance among the different nutrient management practices. Generally these yield attributes has maximum values under SSNM followed by conventional tillage and permanent bed practice.

The application of increasing dose of nutrient correspondingly increases values of yield attributes. The yield attributes namely number of grains row^{-1}, grains cob^{-1}, cob length and seed index recorded significantly maximum under SSNM and it was again prove to be remarkable superiority over 33% RDN and at par with 100% RDF.

6.2.3 Effect of different nutrient management practices on economic yield, biological yield and harvest index

The economic and biological yield remarkably influenced by different nutrient management practices. The SSNM was produced significantly maximum economic and biological yield over 33% RDN but it again comparable to the 100% RDF. Harvest index fail to reach the level of significance among nutrient management practices but generally it recorded maximum with 100% RDF.

6.2.4 Effect of different nutrient management practices on content and uptake of N, P and K and left in soil

The nitrogen, phosphorus and potassium content in stover, grain and their uptake was remarkably affected by different nutrient management practices. The maximum N, P and K content in plant (stover and grain) and uptake was recorded under SSNM over 33% RDN and remained comparable with 100% RDF. The maximum amount of nitrogen and phosphorus was left in soil under SSNM while highest potassium left under associated with 33% RDN.

6.2.5 Effect of different nutrient management practices on economics

The minimum cost of cultivation was associated with 33% RDN and maximum with SSNM practice. The highest gross return and net return obtained with SSNM followed by 100% RDF and 33% RDN while significantly highest B:C ratio was obtained with 33% RDN and it exerted remarkable superiority over both nutrient management practices.

6.3 Effect of different tillage and nutrient management practices on insect pest incidence

The none of the treatment exerted marked variation in stem borer and fall army worm attack. The minimum incidence of stem borer on maize under permanent bed and SSNM while fall army worm was minimum attack on the zero tillage and equal attack in 33% RDN and 100% RDF.

Conclusion

Keeping in view of objectives of the present field study, it can conclude that:

1. The zero tillage is the best option among tillage practices that facilitate to achieve good plant with greater canopy and has better cumulative effect on yield attributes and yield of maize.
2. Among the nutrient management practices, tested the site specific nutrient management practices is found the most effective and it produced the enhanced growth and yield parameters resulted in increasing in the crop productivity.
3. The lowest cost of cultivation and maximum profit obtained by the zero tillage however, the site specific nutrient management fetched a high profit.
4. Among the tillage and nutrient management practices, the zero tillage coupled with site specific nutrient management is recommended for significantly maximum yield and economic return of maize crop during kharif season.

For generating a holistic recommendation on the experiment, subsequent execution of treatment has to be studied in coming year.

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APPENDICES

Appendix -1

General cost of cultivation

S.No		Particulars	Quantity	Rate (Rs.)	Total amount (Rs.)
1		**Layout**	5 Labour	245 manday^{-1}	1225
2		**seed and sowing**			
	A	Seed rate	20kg ha^{-1}	160 kg^{-1}	3200
	B	seed sowing by machine	2.45 hr ha^{-1}	750 hr^{-1}	1837
3		**Gap filling and thining**	5 labour	245 manday^{-1}	1225
4		**Irrigation and drainage**			
	A	Irrigation	1	500 irrigation^{-1}	500
	B	Labour	2	245 manday^{-1}	490
5		**weed management**			
	A	Atrazine herbicide	3.0 kg ha^{-1}	280 l^{-1}	840
	B	Labour for spray	2	245 manday^{-1}	490
6		**Pest management**			
	A	Isecticide Carbofuron	20kg ha^{-1}	90 kg^{-1}	1800
	B	Labour	1	245 manday^{-1}	245
	C	Insecticide Emamectine	800 g ha^{-1}	3.4 g^{-1}	2720
	D	Labour for spray	2	245 manday^{-1}	490
7		**Harvesting**			
	A	Lbour for harvesting	10	245 manday^{-1}	2450
8		**Shelling**			
	A	Shelling machine	1.5 hr	1200/hr^{-1}	1800
	B	Labour	2	245 manday^{-1}	490
9		**Cleaning, drying & storage**	6	245 manday^{-1}	1470
				Total	21272
10		**Intrest on working capital**	4 month	12% annum^{-1}	850.88
11		**Land revenue**		200 ha^{-1}	200
				Total	**22325**

Appendix-2

Cost of different tillage practices

Zero tillage					
S.No		**Operation**	**Input**	**Rate (Rs.)**	**cost (Rs.)**
1		**Field prepration**			
	A	**Ploughing**	0	0	0
	B	**Herbicide spray before sowing**	2.5 l ha^{-1}	500 l^{-1}	1250
	C	**Labour for spray**	2	245 $manday^{-1}$	490
				Total	**1740**
conventional tillage					
1		**Field prepration**			
	A	**Two Ploughing cultivator**	4 hr	750 hr^{-1}	3000
	B	**One harrowing by rotavator**	2.15 hr	750 hr^{-1}	1612
				total	**4612**
Permanent bed					
1		**Field prepration**			
	A	**Two Ploughing cultivator**	4 hr	750 hr^{-1}	3000
	B	**One harrowing by rotavator**	2.15 hr	750 hr^{-1}	1612
	C	**Bed maker charge**	2.45 hr	750 hr^{-1}	1837
				total	**6449**

Appendix-3

Cost of different nutrient management practices

33% recommended dose of nitrogen					
1		**Fertilizer**	**Input**	**Rate (Rs.kg^{-1})**	**Cost (Rs.)**
	A	**Urea**	86.8 kg	6.13 kg^{-1}	532
2		**Labour for top dressing**			
	A	**Labour for SSB at KH**	1	245 manday^{-1}	245
	B	**Labour for SB at TS**	1	245 manday^{-1}	245
				Total	**1022**
100% recommended dose of fertilizer					
1		**Fertilizer**	Input	Rate (Rs. kg^{-1})	Cost (Rs.)
	A	**Urea**	210 kg	5.92 kg^{-1}	1243
	B	**DAP**	130 kg	24.00 kg^{-1}	3120
	C	**MOP**	85 kg	18.00 kg^{-1}	1530
2		**Labour for top dressing**			
	A	**Labour for SSB at KH**	1	245 manday^{-1}	245
	B	**Labour for SB at TS**	1	245 manday^{-1}	245
				Total	**6383**
Site specific nutrient management					
1		**Fertilizer**	Input	Rate (Rs. kg^{-1})	Cost (Rs.)
	A	**Urea**	304 kg	5.92 kg^{-1}	1799
	B	**DAP**	108 kg	24.00 kg^{-1}	2592
	C	**MOP**	100 kg	18.00 kg^{-1}	1800
2		**Labour for top dressing**			
	A	**Labour for SSB at KH**	1	245 manday^{-1}	245
	B	**Labour for SB at TS**	1	245 manday^{-1}	245
				Total	**6681**

***18 % GST Include in labour charge**

Appendix-4

Treatment wise total cost of cultivation

S.No	Treatment name	General cost	Tillage cost	Nutrient cost	Total cost
1.	**ZT×RDN 33%**	22325	1740	1022	25087
2.	**ZT×RDF 100%**	22325	1740	6383	30448
3.	**ZT×SSNM**	22325	1740	6681	30746
4.	**CT×RDN 33%**	22325	4612	1022	27959
5.	**CT×RDF 100%**	22325	4612	6383	33320
6.	**CT×SSNM**	22325	4612	6681	33618
7.	**PB×RDN 33%**	22325	6449	1022	29796
8.	**PB×RDF 100%**	22325	6449	6383	35157
9.	**PB×SSNM**	22325	6449	6681	35455

***ZT= Zero tillage, *CT= Conventional tillage, *PB= Permanent bed, *RDN= Recommended dose of nitrogen, *RDF= Recommended dose of fertilizer, *SSNM= Site specific nutrient management.**

Appendix-5

Economics

Treatment	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	B:C ratio
Tillage practices				
Zero tillage	28762	119306	90545	3.17
Conventional tillage	31632	109693	78061	2.48
Permanent bed	33472	110043	76571	2.30
Nutrients management				
RDN 33%	27617	107404	79788	2.92
RDF 100%	32977	115788	82812	2.53
SSNM	33272	115849	82577	2.50

RDN 33%= 33% of recommended dose of nitrogen, *100% RDF= 100% of recommended dose of fertilizer, *SSNM= Site specific nutrient management.

Appendix-6

Analysis of variance

Appendix 6.1-ANOVA for plant height (cm) at 30 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	99.56	49.78	0.089	6.94	NS
Tillage Practices (T)	2	316.22	158.11	0.282	6.94	NS
Error (a)	4	2241.56	560.39			
Nutrient management (F)	2	194.00	97.00	1.011	3.89	NS
Interaction of TxF	4	649.78	162.44	1.693	3.26	NS
Error (b)	12	1151.56	95.96			
Total	26	4652.67				

Appendix 6.2-ANOVA for plant height (cm) at 55 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	24.92	12.46	0.098	6.94	NS
Tillage Practices (T)	2	2388.01	1194.00	9.389	6.94	SIG
Error (a)	4	508.66	127.16			
Nutrient management (F)	2	1093.09	546.55	4.082	3.89	SIG
Interaction of TxF	4	376.93	94.23	0.704	3.26	NS
Error (b)	12	1606.57	133.88			
Total	26	5998.18				

Appendix 6.3-ANOVA for number of leaves plant^{-1} at 30 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.026	0.013	0.695	6.94	NS
Tillage Practices (T)	2	0.198	0.099	5.382	6.94	NS
Error (a)	4	0.073	0.018			
Nutrient management (F)	2	0.100	0.050	1.044	3.89	NS
Interaction of TxF	4	0.014	0.003	0.071	3.26	NS
Error (b)	12	0.575	0.048			
Total	26	0.986				

Appendix 6.4-ANOVA for number of leaves plant^{-1} at 55DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.75	0.37	1.25	6.94	NS
Tillage Practices (T)	2	4.17	2.09	6.98	6.94	SIG
Error (a)	4	1.20	0.30			
Nutrient management (F)	2	4.20	2.10	4.96	3.89	SIG
Interaction of TxF	4	3.31	0.83	1.95	3.26	NS
Error (b)	12	5.09	0.42			
Total	26	18.71				

Appendix 6.5-ANOVA for leaf area index plant^{-1} at 30 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.048	0.024	1.02	6.94	NS
Tillage Practices (T)	2	0.167	0.083	3.54	6.94	NS
Error (a)	4	0.094	0.024			
Nutrient management (F)	2	0.027	0.013	2.56	3.89	NS
Interaction of TxF	4	0.051	0.013	2.46	3.26	NS
Error (b)	12	0.062	0.005			
Total	26	0.448				

Appendix 6.6-ANOVA for leaf area index plant^{-1} at 55 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.217	0.109	3.73	6.94	NS
Tillage Practices (T)	2	0.420	0.210	7.20	6.94	SIG
Error (a)	4	0.117	0.029			
Nutrient management (F)	2	1.245	0.623	11.76	3.89	SIG
Interaction of TxF	4	0.121	0.030	0.57	3.26	NS
Error (b)	12	0.635	0.053			
Total	26	2.755				

Appendix 6.7-ANOVA for days to Tasseling emergence

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.22	0.11	0.29	6.94	NS
Tillage Practices (T)	2	37.56	18.78	48.29	6.94	SIG
Error (a)	4	1.56	0.39			
Nutrient management (F)	2	6.89	3.44	9.79	3.89	SIG
Interaction of TxF	4	18.22	4.56	12.95	3.26	SIG
Error (b)	12	4.22	0.35			
Total	26	68.67				

Appendix 6.8-ANOVA for days to silking emergence

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	2	1	0.51	6.94	NS
Tillage Practices (T)	2	29.56	14.78	7.60	6.94	SIG
Error (a)	4	7.78	1.94			
Nutrient management (F)	2	10.89	5.44	4.03	3.89	SIG
Interaction of TxF	4	19.56	4.89	3.62	3.26	SIG
Error (b)	12	16.22	1.35			
Total	26	86				

Appendix 6.9-ANOVA for dry matter weight (g) at 30 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.027	0.013	0.264	6.94	NS
Tillage Practices (T)	2	0.065	0.032	0.634	6.94	NS
Error (a)	4	0.205	0.051			
Nutrient management (F)	2	0.126	0.063	1.331	3.89	NS
Interaction of TxF	4	0.165	0.041	0.869	3.26	NS
Error (b)	12	0.570	0.047			
Total	26	1.158				

Appendix 6.10-ANOVA for dry matter weight (g) at 55 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	315.69	157.84	0.99	6.94	NS
Tillage Practices (T)	2	2600.75	1300.37	8.14	6.94	SIG
Error (a)	4	638.81	159.70			
Nutrient management (F)	2	3151.71	1575.86	9.74	3.89	SIG
Interaction of TxF	4	240.71	60.18	0.37	3.26	NS
Error (b)	12	1940.84	161.74			
Total	26	8888.50				

Appendix 6.11-ANOVA for dry matter weight (g) at 85 DAS

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	2839.17	1419.58	1.44	6.94	NS
Tillage Practices (T)	2	42433.44	21216.72	21.45	6.94	SIG
Error (a)	4	3955.66	988.92			
Nutrient management (F)	2	16442.76	8221.38	5.22	3.89	SIG
Interaction of TxF	4	3156.02	789.01	0.50	3.26	NS
Error (b)	12	18888.58	1574.05			
Total	26	87715.64				

Appendix 6.12-ANOVA for plant population ha^{-1}

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	6526748.97	3263374.49	0.12	6.94	NS
Tillage Practices (M)	2	10477366.26	5238683.13	0.19	6.94	NS
Error (a)	4	111522633.74	27880658.44			
Nutrient management (F)	2	10921810.70	5460905.35	0.33	3.89	NS
Interaction of MxF	4	9053497.94	2263374.49	0.14	3.26	NS
Error (b)	12	196839506.17	16403292.18			
Total	26	345341563.79				

Appendix 6.13-ANOVA for number of cobs ha^{-1}

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	45687243	22843621.4	1.11	6.94	NS
Tillage Practices (T)	2	6181070	3090534.98	0.15	6.94	NS
Error (a)	4	82534979	20633744.9			
Nutrient management (F)	2	37193416	18596707.8	2.47	3.89	NS
Interaction of TxF	4	13547325	3386831.28	0.45	3.26	NS
Error (b)	12	90296296	7524691.36			
Total	26	275440329				

Appendix 6.14-ANOVA for number of rows cob^{-1}

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.581	0.290	2.63	6.94	NS
Tillage Practices (T)	2	0.625	0.313	2.83	6.94	NS
Error (a)	4	0.441	0.110			
Nutrient management (F)	2	0.270	0.135	1.65	3.89	NS
Interaction of TxF	4	0.539	0.135	1.65	3.26	NS
Error (b)	12	0.978	0.081			
Total	26	3.43				

Appendix 6.15-ANOVA for number of grain cob row^{-1}

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.19	0.09	0.05	6.94	NS
Tillage Practices (T)	2	44.43	22.22	11.30	6.94	SIG
Error (a)	4	7.86	1.97			
Nutrient management (F)	2	34.17	17.08	3.90	3.89	SIG
Interaction of TxF	4	16.38	4.10	0.93	3.26	NS
Error (b)	12	52.61	4.38			
Total	26	155.64				

Appendix 6.16-ANOVA for number of grain cob^{-1}

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	312.7	156.3	0.29	6.94	NS
Tillage Practices (T)	2	14071.3	7035.6	13.26	6.94	SIG
Error (a)	4	2121.7	530.4			
Nutrient management (F)	2	9221.3	4610.7	3.96	3.89	SIG
Interaction of TxF	4	3719.3	929.8	0.80	3.26	NS
Error (b)	12	13960.5	1163.4			
Total	26	43406.7				

Appendix 6.17-ANOVA for cob girth (cm)

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.33	0.16	0.78	6.94	NS
Tillage Practices (T)	2	0.20	0.10	0.48	6.94	NS
Error (a)	4	0.84	0.21			
Nutrient management (F)	2	0.67	0.33	1.16	3.89	NS
Interaction of TxF	4	0.48	0.12	0.41	3.26	NS
Error (b)	12	3.46	0.29			
Total	26	5.97				

Appendix 6.18-ANOVA for cob length (cm)

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	1.38	0.69	0.67	6.94	NS
Tillage Practices (T)	2	1.69	0.85	0.82	6.94	NS
Error (a)	4	4.14	1.04			
Nutrient management (F)	2	3.56	1.78	4.34	3.89	SIG
Interaction of TxF	4	6.40	1.60	3.90	3.26	SIG
Error (b)	12	4.92	0.41			
Total	26	22.09				

Appendix 6.19-ANOVA for seed index (g)

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.28	0.14	0.15	6.94	NS
Tillage Practices (T)	2	4.52	2.26	2.40	6.94	NS
Error (a)	4	3.77	0.94			
Nutrient management (F)	2	8.98	4.49	5.44	3.89	SIG
Interaction of TxF	4	8.99	2.25	2.73	3.26	NS
Error (b)	12	9.90	0.83			
Total	26	36.44				

Appendix 6.20-ANOVA for economic yield (q ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.57	0.29	0.04	6.94	NS
Tillage Practices (T)	2	115.51	57.76	7.48	6.94	SIG
Error (a)	4	30.90	7.72			
Nutrient management (F)	2	109.93	54.96	7.74	3.89	SIG
Interaction of TxF	4	5.89	1.47	0.21	3.26	NS
Error (b)	12	85.22	7.10			
Total	26	348.02				

Appendix 6.21-ANOVA for biological yield (q ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	89.14	44.57	1.02	6.94	NS
Tillage Practices (T)	2	2102.78	1051.39	24.16	6.94	SIG
Error (a)	4	174.10	43.52			
Nutrient management (F)	2	526.77	263.38	4.09	3.89	SIG
Interaction of TxF	4	55.07	13.77	0.21	3.26	NS
Error (b)	12	772.03	64.34			
Total	26	3719.87				

Appendix 6.22-ANOVA for harvest index (%)

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	6.47	3.23	0.72	6.94	NS
Tillage Practices (T)	2	29.98	14.99	3.36	6.94	NS
Error (a)	4	17.84	4.46			
Nutrient management (F)	2	7.15	3.58	0.48	3.89	NS
Interaction of TxF	4	2.54	0.64	0.09	3.26	NS
Error (b)	12	88.97	7.41			
Total	26	152.95				

Appendix 6.23-ANOVA for nitrogen content in stover (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	323.49	161.75	0.58	6.94	NS
Tillage Practices (T)	2	7646.23	3823.11	13.72	6.94	SIG
Error (a)	4	1114.83	278.71			
Nutrient management (F)	2	6430.76	3215.38	14.31	3.89	SIG
Interaction of TxF	4	4519.73	1129.93	5.03	3.26	SIG
Error (b)	12	2695.59	224.63			
Total	26	22730.62				

Appendix 6.24-ANOVA for nitrogen content in grain (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	295.05	147.53	5.03	6.94	NS
Tillage Practices (T)	2	488.03	244.02	8.32	6.94	SIG
Error (a)	4	117.33	29.33			
Nutrient management (F)	2	671.59	335.80	11.60	3.89	SIG
Interaction of TxF	4	462.50	115.62	3.99	3.26	SIG
Error (b)	12	347.31	28.94			
Total	26	2381.82				

Appendix 6.25-ANOVA for nitrogen uptake (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	104.05	52.03	0.13	6.94	NS
Tillage Practices (T)	2	10200.26	5100.13	12.38	6.94	SIG
Error (a)	4	1647.53	411.88			
Nutrient management (F)	2	9353.76	4676.88	14.78	3.89	SIG
Interaction of TxF	4	7563.81	1890.95	5.98	3.26	SIG
Error (b)	12	3797.04	316.42			
Total	26	32666.45				

Appendix 6.26-ANOVA for nitrogen left in soil after harvest (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0	0	0	6.94	NS
Tillage Practices (T)	2	11150.22	5575.11	0.10	6.94	NS
Error (a)	4	223004.44	55751.11			
Nutrient management (F)	2	1482979.56	741489.78	8.49	3.89	SIG
Interaction of TxF	4	780515.56	195128.89	2.23	3.26	NS
Error (b)	12	1048120.89	87343.41			
Total	26	3545770.67				

Appendix 6.27-ANOVA for phosphorus content in stover (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.62	0.31	0.13	6.94	NS
Tillage Practices (T)	2	37.84	18.92	7.68	6.94	SIG
Error (a)	4	9.86	2.46			
Nutrient management (F)	2	675.47	337.74	32.24	3.89	SIG
Interaction of TxF	4	13.93	3.48	0.33	3.26	NS
Error (b)	12	125.70	10.48			
Total	26	863.43				

Appendix 6.28-ANOVA for phosphorus content in grain (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	8.94	4.47	1.45	6.94	NS
Tillage Practices (T)	2	22.72	11.36	3.67	6.94	NS
Error (a)	4	12.37	3.09			
Nutrient management (F)	2	428.79	214.40	26.35	3.89	SIG
Interaction of TxF	4	49.17	12.29	1.51	3.26	NS
Error (b)	12	97.65	8.14			
Total	26	619.64				

Appendix 6.29-ANOVA for phosphorus uptake (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	13.26	6.63	1.73	6.94	NS
Tillage Practices (T)	2	115.02	57.51	15.02	6.94	SIG
Error (a)	4	15.31	3.83			
Nutrient management (F)	2	2150.27	1075.14	31.73	3.89	SIG
Interaction of TxF	4	96.92	24.23	0.72	3.26	NS
Error (b)	12	406.62	33.89			
Total	26	2797.41				

Appendix 6.30-ANOVA for phosphorus left in soil after harvest (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	131.86	65.93	6.41	6.94	NS
Tillage Practices (T)	2	41.21	20.61	2.00	6.94	NS
Error (a)	4	41.16	10.29			
Nutrient management (F)	2	22.75	11.37	0.60	3.89	NS
Interaction of TxF	4	50.28	12.57	0.66	3.26	NS
Error (b)	12	226.99	18.92			
Total	26	514.24				

Appendix 6.31-ANOVA for potassium content in stover (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	6.12	3.06	1.49	6.94	NS
Tillage Practices (T)	2	257.00	128.50	62.51	6.94	SIG
Error (a)	4	8.22	2.06			
Nutrient management (F)	2	1722.96	861.48	272.08	3.89	SIG
Interaction of TxF	4	4.17	1.04	0.33	3.26	NS
Error (b)	12	38.00	3.17			
Total	26	2036.46				

Appendix 6.32-ANOVA for potassium content in grain (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	18.67	9.34	4.79	6.94	NS
Tillage Practices (T)	2	107.12	53.56	27.49	6.94	SIG
Error (a)	4	7.79	1.95			
Nutrient management (F)	2	203.09	101.55	22.73	3.89	SIG
Interaction of TxF	4	4.14	1.04	0.23	3.26	NS
Error (b)	12	53.60	4.47			
Total	26	394.43				

Appendix 6.33-ANOVA for potassium uptake (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	12.79	6.39	4.40	6.94	NS
Tillage Practices (T)	2	695.96	347.98	239.37	6.94	SIG
Error (a)	4	5.81	1.45			
Nutrient management (F)	2	3102.39	1551.20	479.28	3.89	SIG
Interaction of TxF	4	15.55	3.89	1.20	3.26	NS
Error (b)	12	38.84	3.24			
Total	26	3871.34				

Appendix 6.34-ANOVA for potassium left in soil after harvest (kg ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	2442.29	1221.14	1.82	6.94	NS
Tillage Practices (T)	2	2266.79	1133.40	1.69	6.94	NS
Error (a)	4	2684.22	671.05			
Nutrient management (F)	2	6054.40	3027.20	5.67	3.89	SIG
Interaction of TxF	4	5394.75	1348.69	2.52	3.26	NS
Error (b)	12	6411.51	534.29			
Total	26	25253.97				

Appendix 6.35-ANOVA for gross return (Rs. ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	971437.12	485718.56	0.02	6.94	NS
Tillage Practices (T)	2	693409192.22	346704596.11	13.44	6.94	SIG
Error (a)	4	103184344.68	25796086.17			
Nutrient management (F)	2	469448320.47	234724160.23	12.46	3.89	SIG
Interaction of TxF	4	27982420.37	6995605.09	0.37	3.26	NS
Error (b)	12	226061824.2	18838485.35			
Total	26	1521057539				

Appendix 6.36-ANOVA for net return (Rs. ha^{-1})

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	971437.12	485718.56	0.02	6.94	NS
Tillage Practices (T)	2	1291944803.42	645972401.71	25.04	6.94	SIG
Error (a)	4	103184344.68	25796086.17			
Nutrient management (F)	2	66628773.80	33314386.90	1.77	3.89	NS
Interaction of TxF	4	27982420.37	6995605.09	0.37	3.26	NS
Error (b)	12	226061824.22	18838485.35			
Total	26	1716773603.62				

Appendix 6.37-ANOVA for B:C ratio

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.00	0.00	0.09	6.94	NS
Tillage Practices (T)	2	4.70	2.35	92.21	6.94	SIG
Error (a)	4	0.10	0.03			
Nutrient management (F)	2	1.22	0.61	30.78	3.89	SIG
Interaction of TxF	4	0.07	0.02	0.85	3.26	NS
Error (b)	12	0.24	0.02			
Total	26	6.33				

Appendix 6.38-ANOVA for stem borer scaling

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.907	0.454	0.942	6.944	NS
Tillage Practices (T)	2	3.907	1.954	4.058	6.944	NS
Error (a)	4	1.926	0.481			
Nutrient management (F)	2	0.907	0.454	1.126	3.885	NS
Interaction of TxF	4	4.093	1.023	2.540	3.259	NS
Error (b)	12	4.833	0.403			
Total	26	16.574				

Appendix 6.39-ANOVA for fall army worm scaling

Sources of Var.	D.F.	S.S.	MSS	F-Cal.	F-Tab. (0.05)	S/SIG
Replication	2	0.074	0.037	0.029	6.94	NS
Tillage Practices (T)	2	9.85	4.93	3.91	6.94	NS
Error (a)	4	5.04	1.26			
Nutrient management (F)	2	1.19	0.593	0.865	3.89	NS
Interaction of TxF	4	7.93	1.98	2.89	3.26	NS
Error (b)	12	8.22	0.685			
Total	26	32.30				

VITAE

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Academic Qualification

Examination	Passing Year	Institute/School	Board/University	Percentage/ OGPA
High School (Science)	2014	M D Inter College Harikaranpur Bijaura Ghazipur	U P Board	81.66%
Intermediate (Agriculture)	2016	P N Inter College Mardah Ghazipur	U P Board	72.50%
B.Sc. (Agriculture)	2020	P G College Ghazipur	V B S P U Jaunpur Uttar Pradesh	71.60%
M.Sc.(Ag.) Agronomy	2022	College of Agriculture BUAT Banda	BUAT Banda Uttar Pradesh	8.599

Place : Banda

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