Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)

THESIS

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BY

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April, 2017

CERTIFICATE-I

This is to certify that thesis titled **"Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)"** submitted in partial fulfilment of the requirement for the award of degree of **Master of Science** in the discipline of **Agronomy** is a bonafide research work carried out by **Mr. Sukhjinder Singh Bajwa (Registration number 11510632)** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

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CERTIFICATE-II

This is to certify that the thesis titled **"Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)"** submitted by **Sukhjinder Singh Bajwa** to the Lovely Professional University, Phagwara in partial fulfilment of the requirement for the degree of **Master of Science** in the discipline of **Agronomy** has been approved by the advisory committee after an oral examination of the student in collaboration with an External Examiner.

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DECLARATION

I hereby declare that the thesis entitled **"Effect of Integrated Nutrient Management (INM) in Kharif Maize (Zea mays.L)"** is an authentic record of my work carried out at Lovely Professional University as requirement for the degree of **Master of Science** in the discipline of **Agronomy,** under the guidance of Dr. Nitin Baban Misal, Assistant Professor, School of Agriculture and no part of this thesis has been submitted for any other degree and diploma.

_____

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Place: LPU, Phagwara

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LIST OF SYMBOLS AND ABBREVIATIONS

Abbreviated Form	Full Form
%	Percent
t	tonne
ha	hectare
MT	Metric tonne
mg	milligram
g	gram
Kg	Kilogram
et al	et alia and others
$^{-}1$	per
RDF	Recommended Dose of Fertilizer
RCBD	Randomized Complete Block Design
INM	Integrated Nutrient Management
q	Quintal
^{o}	Degree
cm	centimetre
m	metre
m^2	metre square
Km	Kilometre
EC	Electrical Conductivity
ml	milliliter
M	Mole
^{o}C	Degree Celsius
N	North
S	South
CO_2	Carbon Dioxide
µm	micrometer
ppm	Parts per million
FYM	Farm Yard Manure
DAP	Diammonium Phosphate
V.C	Vermicompost
MOP	Murate of Potash
SSP	Single Super Phosphate
a.i.	Active ingredient
B: C	Benefit Cost Ratio
DAS	Days after Sowing
i.e.	that is

resp.	respectively
±	Plus-minus sign
Fig.	Figure
Temp.	Temperature
N	Nitrogen
P_2O_5	Phosphorus
K_2O	Potassium
Ca	Calcium
Mg	Magnesium
Cu	Copper
PSB	Phosphate solubilizing bacteria
LAD	liquid anaerobic digestate
Mg	Megagram
pH	Power of Hydrogen atom
ANOVA	Analysis of variance
ICAR	Indian Council of Agricultural Research
IAU	Islamic Azad University
UMA	University of Maine at Augusta
SKUAST	Sher-e-Kashmir University of Sc. And Tech.
UJLoG	Université Jean Lorougnon Guédé
UIA	Universidad Adolfo Ibáñez
NAU	Northern Arizona University
NaoH	Sodium Hydroxide
$ZnSo_4$	Zinc Sulphate
$K_2Cr_2O_7$	Potassium Dichromate
KCl	Potassium Chloride
DMRTC	Duncun’s multiple range test comparison

ABSTRACT

A field experiment is designed in randomized block design, which consists of 7 treatments with three replications performed at the Agricultural Research Farm of Lovely Professional University, Jalandhar, Punjab during *kharif* season of year 2016. Aim was set to check the "Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)". Different sources of nutrients were selected. Organic source comprises of vermicompost and FYM. Inorganic sources of NPK were used. Organic and inorganic sources were also used in combination.

It was found that application of combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was found the most suitable dose of fertilizer to be adopted as it gives significantly higher performance in growth parameters (plant height 238.47 cm, stem girth 12.3 cm, number of green leaves 15.33 and number of internodes 18.10), yield attributes (1.33 cobs per plant, cob length 15.72 cm and 459 grains per cob) and yield aspect (test weight 219 g and grain yield 5400 kg ha^{-1}). Least observations were recorded from control where no fertilizers were used. In view of above, it is concluded that cultivation of maize under agro-climatic condition of Punjab, apply combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) to achieve higher productivity and best choice of sources for integrated nutrient management.

Keywords: Vermicompost, FYM and NPK

Chapter 1

INTRODUCTION

Corn or maize (*Zea mays*) is a crop which belongs to the family *Poaceae.* "*Zea*" (zela) was an old name in Greek, mainly known for food grass. There are mainly four species consist in genus *Zea* among which economically important species is *Zea mays* L. The other *Zea* sp., mainly teosinte is the wild grass which is native to Central America and Mexico (Doeblay, 1990). Cultivation of maize is believe to be originated in Mexico, Central America, from where it is believe that it spreads to Argentina in south and to Canada in north. Archaeologists found 7000 years old corn in Teotihuacan valley in Mexico, but there are chances that secondary centre of maize origin could be in America. In Mayan and Aztec civilizations, maize played a crucial role in their festivities, nutrition and religious beliefs. But today, it is cultivated throughout the world making it an important cereal worldwide. Maize is not only used for consumption of human but it is also used for the feed and fodder of cattle and raw material for industries. The products prepared from maize are corn cooking oil, corn starch, corn syrup, products needed for distilleries and fermentation. Now a days, biofuel can also be made from maize. Maize is an adaptable crop that can be cultivated over a range of agro-climatic zones. Maize can be grown below the sea level and high to an altitude of 3000 m, from 40°S to 58°N, and in areas with 250 mm to 5000 mm of rainfall per annum (Shaw, 1988; Dowswell *et al.,* 1996) and a range of 3 to 13 months of growing cycle (CIMMYT, 2000). Maize is becoming very popular in India as well as Punjab due to its higher market price and higher yield under irrigated conditions of Punjab state. Punjab agricultural university has an important role in the research field related to introducing new hybrid cultivars. For crop diversification maize is good alternate.

In the scenario of India, cultivation of maize comes under more than four percent of net area sown in the country. In India, among the total production of maize, about 48% is used for poultry feed, about 28% is used for human food purpose, about 11% as cattle feed, about 12% is used in milling industry for the production of oil and starch and about 1% for the seed production (Anon., 2007). After Independence, India has shown increase in production of maize as in 1950-51 it was 1.7 million tonnes, in 1960-61 it was 4.1 million tonnes and in 1970-71 it was 7.5 million tonnes. In year 2003-04, from 7.4 million hectares of land, India produce 14.7 MT of maize with an average grain yield of 1963 kg per hectare. In 2014-2015, the production of maize rises to 24.35 MT. (Anon., 2014).

In the Scenario of Punjab state, 129 thousand hectares of land comes under cultivation of corn, with a grain yield production of 475 thousand tonnes. 36.8 q ha^{-1} was the average yield during year of 2012-13. (Puja *et al*., 2004).

Soil is the major requirement or growing media for crop production, which is main source of nutrients and water. A limited amount of organic nutrients and minerals are supplied by soil. Often, external applications of fertilisers are given for better plant growth. These external fertilisers result into faster vegetative growth and improves crop grain yield. This results in agricultural intensification.

Fertilisers are of two types: organic and mineral. Mineral fertilisers are mainly source of NPK such as urea, DAP, MOP, SSP and etc. Organic fertilisers are those which are made from substances of animal and plant origin, such as compost, seaweed, manure and crop residue. To meet the demand of food for growing population a balance use of mineral fertilisers should be used (Anon.,1995). Increase in use of inorganic mineral fertilizers has been increase by five folds since 1960. Inorganic fertilizers had significantly supported food requirement of world population by increasing yield. (Smil., 2002) estimates that in past 50 years nitrogen based fertilisers had increased per capita food production by approximately 40 percent. Over reliance on mineral nutrients result into soil degradation by deteriorate the chemical and physical properties of soil (Hepperly *et al.,* 2009). Inorganic fertilizers cause significant land problems as well as soil pollution (Singh, 2000). Such environmental concern and economic constraints has warned that nutrient requirement should not be fulfil by solely through inorganic fertilisers. So, the solution to this problem is Integrated Nutrient Management (INM).

The efficient use of all available nutrient sources such as, organic sources, mineral sources, bio-fertilisers, and recyclable waste for the sustainable farming is called Integrated Nutrient Management (Royal *et al*., 2006). The aim of INM is to increase crop yield per unit area and to preserve soil productivity for next generation by integrated use of organic and chemical sources of nutrients (FAO., 1995). INM aims at ideal use of nutrient sources on a cropping system. It also aims on basis of crop rotation rather than on concentrating on one crop. This results in encouraging farmers to look on long term planning and have positive impact on environment for long term. Highest productivity of crops in sustainable manner could be achieved only by applying appropriate combination of different organic sources and inorganic sources of nutrients without deteriorating the condition of soil and other natural resources (Chandrashekara *et al*., 2000). Now a days, INM include new techniques such as urea coating to slow the denitrification *i.e.,* neem coating and deep placement of fertilisers

under the soil. It is the fact that optimum yield level of maize production can't be achieved by using only organic manures because of their low nutrient content. The jointly using chemical fertilizers along with various organic sources results in improving quality of soil and higher crop productivity on long- term basis.

Objective:

Present study was planned with the following objectives.

1. To study the effect of organic and inorganic fertilizers (INM) on yield and yield attributes of maize.
2. To compare the effect of FYM and vermicompost on crop plant in combination or without combination of inorganic fertilizers.
3. To identify the best combination of organic and inorganic fertilizers

CHAPTER 2

REVIEW OF LITERATURE

The brief summary on research work done in the past under varying agro climatic situations has been reviewed under following broad heads.

2.1 Effect of vermicompost (solely or in combination) on growth and yield parameters of maize:

Kannan *et al.*, (2013) carried out an experiment at VIA, Manakkadavu, during *rabi* season of 2012-13, to study the effect of integrated nutrient management on fertility of soil and productivity on maize. The application of recommended dose of inorganic fertilizer + vermicompost has significant results on growth and yield (4112 kg ha^{-1}) of maize as compared to rest of the treatment combinations.

Kalhapure *et al.*, (2013) conducted an experiment on Integrated Nutrient Management in maize for increasing production with sustainability at the Mahatma Phule Krishi Vidyapeeth at Rahuri during two *kharif* season of year 2010 and 2011. The treatment with 25% RDF + Biofertilizer (PSB and *Azotobacter chroococcum*) + green manuring through sunhemp + compost @10 ton ha^{-1} shows highest results. The grain yield was increased by 252.38% over control and it has about 147.62% increased over application of 100% RDF.

Abawari et al., (2016) designed a field experiment in Ethiopia at kersa wereda during *kharif* season of year 2014, to study the effect of vermicompost on dry matter and grain yield of maize. The treatment with application of vermicompost 13.75 ton ha^{-1} shows better dry matter yield as well as grain yield as compared to other treatments.

Zaremanesh *et al.*, (2016) designed a research in Iran. RCBD layout with split plot were designed with three replications. Research was conducted during 2013 on corn. There were four levels nitrogen fertilizer of 0, 25, 50 and 75 percent of recommended and sub plots have vermicompost control, 5, 7 and 9 tons per hectare. Treatment with 9 ton per hectare vermicompost has significantly higher yield (11.700 ton/ha). The lowest grain yield (6.400 ton/ha) was recorded in control treatment.

Baharvand *et al.*, (2014) conducted a field experiment on effect of INM on growth of corn at agricultural research centre in Iran. The integrated application of 50% RDF + 50% VC shows significant results on yield and yield attributes of corn.

Kmetova M. and Kovacik P., (2014) studied the effect of vermicompost on the yield parameters of corn. It was found that treatment with vermicompost dose 8.26 ton/hectare applied during autumn and application of LAD (ammonium nitrate with dolomite) @ 60 kg/ha N during spring has positive results on P and K content of phytomass, height, total chlorophyll content and stalk thickness. N content was highest when vermicompost was applied during spring season.

Nasab *et al.*, (2015) studied the effect of different doses of vermicompost on quality and yield parameters of maize. The research was conducted at IAU, Zahedan in Iran. They applied different levels of VC (0, 4, 8 and 12 ton ha^{-1}). The treatment with 12 ton vermicompost ha^{-1} has significantly influenced on grain yield (5444.44 kg ha^{-1}) of maize.

Azarmi *et al.*, (2009) designed an experiment at UMA, Ardabili in Iran, to study the effect of different levels of vermicompost on cucumber. The different doses of vermicompost 0, 10, 20 and 30 ton ha^{-1} were given. It was found that treatment with 30 ton ha^{-1} of vermicompost was significant in growth and yield parameters. This treatment also shows 26% increase in yield as compared to the treatment with no application of vermicompost (0 ton ha^{-1}).

Abafita *et al.*, (2014) studied the effect of vermicompost with different levels on yield and growth parameters of tomato. Different treatments were given with an increase in concentration of vermicompost (p_0=control, p_1=10%, p_2=20%, p_3=30% and p_4=40%w/w. Treatment with 20% increase in vermicompost shows the significant result on growth parameters such as plant height 59.67 cm, stem diameter 1.113 cm and 29.167 fruits per plant.

Kalantari *et al.*, (2009) conducted a field experiment on the effect of vermicompost and compost on growth of maize. Vermicompost and compost with different doses of 0,1,3,6 and 9% of pot weight were given to the maize plant in a pot. It was found that shoot and root dry matter were significant in treatments of vermicompost with 1% and 3% of pot weight.

Concentration of Ca, Mg, K, P, and N in aerial parts of corn were higher in all treatments except control. Cu was not affected in any treatment.

Kannan *et al.*, (2013) designed an experiment at Vanavarayar Institute of Agriculture, Manakkadavu, during 2012-13, to find effect of INM on soil fertility and productivity on maize. It was found that treatment with recommended dose of inorganic fertilizer + vermicompost has significant results with respect to growth and yield of maize.

2.2 Effect of FYM (solely or in combination) on growth and yield parameters of maize:

Panwar., ***(2008)*** conducted an experiment at ICAR, Umiam, Meghalaya to find the efficient combination of organic and inorganic sources on maize. It shows that the treatment with substitution of 50% of recommended dose of NPK through FYM has significant results.

Bunker *et al.*, (2013) carried a field experiment at Sardarkrushinagar Dantiwada Agricultural University, Bhiloda, Dist. Sabarkantha (Gujarat) to study the impact of integrated nutrient management on productivity and quality of single cross hybrid maize, during *kharif* season of year 2011. Among the different treatments of nutrient management, treatment 100 % NPK + farmyard manure @ 5 ton per hectare was recorded significantly higher in plant height at harvest (228.65 cm), dry matter accumulation at harvest (183.10 g plant-1), weight cob-1 (135.56 g), cob length (18.47 cm), weight of grains cob-1 (99.90 g), shelling percentage (78.60), 1000- grains weight (211.81 g), grain yield (4292 kg per hectare) and stover yield (5647 kg per hectare).

Kumara *et al.*, (2013) conducted a field experiment at University of Agricultural Sciences, Bangalore to know the influence of INM on yield of maize- rice cropping system. The study reveals that maize yield was significantly better observed in treatment T_6 which received 50 % N from FYM and 50 % NPK from inorganic fertilizers and the significantly higher rice grain yields were obtained in *kharif* season in treatment T_9 which receives 25% N from paddy straw and 75 % NPK from inorganic fertilizers.

Shah *et al.*, (2009) designed an experiment in which they found that application of nitrogen through FYM @ 15000 kg per hectare and urea @260 kg per hectare has highest grain yield (6.13 tons ha^{-1}) with in comparison to rest of the treatments.

Mahesh *et al.*, (2010) studied the effect of integrated nutrient management on economics and nutrient uptake of maize at Agricultural College, Mandya in Karnataka during *rabi* season of 2007-08 on sandy soil. Total twelve treatments were given consisting of four sources of organics combined with 100, 75 and 50 percent RDF. The study revealed that treatment with NPK (150:75:40 kg ha^{-1}) + FYM 10 t ha^{-1} has higher results with grain yield (65.9 q ha^{-1}), B:C ratio (2.62) and NPK uptake (160.8, 41.9 and 77.8 kg ha^{-1}, respectively). The lowest results were observed in the treatment with 100 percent RDF through chemical fertilizer (150:75:40 kg ha^{-1}) with grain yield of 47.3 q ha^{-1}, B:C ratio of 1.99 and NPK uptake of 86.1, 22.1 and 77.8 kg ha^{-1}, respectively).

Gautam *et al.*, (2013) conducted a field experiment to find out the effect of spacing and integrated nutrient management on economics and productivity of rice. The experiment was conducted at Palampur, Himachal Pradesh during 2009-10 in *kharif* season. All possible combination of treatments was given of three FYM levels (0, 10 and 20 t ha^{-1}) with three levels of fertilizers NPK (0, 50 and 100%). The application of 20 t ha^{-1} FYM + 100% RDF was significantly influenced on yield of rice. It was followed by the treatment combination of 20 t FYM ha^{-1} + 50% NPK.

Negassa *et al.*, (2005) conducted a research in western Oromia, Ethiopia. Different doses of nitrogen and phosphorus through inorganic fertilizer and different doses of FYM were applied solely and in combination. It was found that interaction of FYM and NP has significant results. Significant result of grain yield (7.68 t/ha) was achieved when both sources were used in combination (60/30 N/P + 12 ton/ha FYM). The application of alone FYM at 4,8,12 t/ha has average yield of 5.76, 5.61, 5.93 t/ha as compare to control.

Verma Neeraj Kumar (2011) studied the effect of INM on winter maize crop sown during different dates at Brahmanand Mahavidyalaya, Hamirpur during the 2006-07 and 2007-08 *rabi* season. They found that treatment having application of 7.50 t FYM + 100 kg inorganic N ha^{-1} sown at 25 Oct has significantly influence on grain yield of maize than other rest of the treatment combinations.

Sharma *et al.*, (2016) a field experiment was conducted on Arba Minch University research site having alluvial soil to know the response of maize crop to combined levels of N, P and K with or without farm yard manure (N0 P0 K0, N100 P0 K0, N100 P50 K0, N100 P50 K50, N50 P25 K25, N50 P25 K25 + FYM @10 t ha^{-1}, N100 P50 K50 + FYM @10 t ha^{-1}, N150 P75 K75, N150 P75 K75 + FYM @10t ha^{-1}, FYM @10 t ha^{-1}) under irrigated conditions. The grain yield without fertilization (93.4 q ha^{-1}) was at par with yield in treatment with higher level of nutrients like N150 P75 K75 (109.5 q ha^{-1}).

Nasim *et al.*, (2012) designed a field experiment at University of Agriculture, Faislabad in Pakistan to study the effect of inorganic and organic fertilizers on maize. It was found that treatment with 100 kg N ha^{-1} from urea + 100 kg N from poultry manure has higher maize yield and growth components as compared to other treatment combinations.

Kumara *et al.*, (2015) designed an experiment at Agricultural Research Station of University of Agricultural Sciences, Bangalore, to study effect of combination of inorganic and organic fertilizers on yield, uptake pattern of nutrients and fertility status in maize-rice cropping system. It was found that treatment with 25% N through paddy straw and 75% N through mineral source has higher rice grain yield. In maize treatment with 50 % N through FYM + 50 % N through inorganic has significant result.

Rasool S. *et al.*, (2016) conducted an experiment at SKUAST, Srinagar during *kharif* season of year 2011 and 2012. Their aim was to study the effect of INM on yield and yield attributes of sweet corn. The result shows that yield attributes like grains per row, weight of cob, rows per cob, number of cobs per plant were significantly higher in treatment with 75% NPK + FYM @ 4.5ton ha^{-1} + biofertilizer (Azotobacter + PSB) over other treatments and control.

Zerihun *et al.*, (2013) designed a field experiment at Bako, Western Ethiopia to know the best compatible soybean variety in intercropping system and economically best integrated fertilizers rate. The significant results were found in plant height, leaf area index and grain yield of maize by using integrated fertilizer sources. The treatments with 12 ton FYM ha^{-1} in combination with NP @ 28:12 ha^{-1} saved up to 75 % of cost of commercial fertilizer.

Soro *et al.*, (2015) conducted the experiment at the research fields of UJLoG to know the impact of two different ages (6 days and 6 month) of chicken manure on yield and growth parameters of corn. Two varieties GMRP-18 and Bon-mais of corn were used. It was found that manure of age six days with dose of 7 ton ha^{-1} with 46% urea @70 kg per hectare has significant result over control.

Abera *et al.*, (2005) conducted experiment at OARI, Ethiopia during year 2005. They study the effect of organic and inorganic fertilizers on yield in intercropping of climbing bean – maize. It was found that treatment in which climbing beans were grown as intercropping with maize at 10 cm distance with Urea and DAP @ 150 and 50 kg/ha, respectively + 4 ton of FYM ha^{-1} has significant results in grain yield with respect to control.

Brar *et al.*, (2015) designed an experiment at PAU, Ludhiana on effect of organic and inorganic sources of nutrient on organic carbon of soil and other physical properties in wheat maize rotation. Physical properties like infiltration rate, aggregate mean weight diameter were greater in treatment with 100% NPK in combine with FYM. Organic carbon of soil was 11.6 mg per hectare in this treatment as compare to 7.3 mg per hectare in control. This treatment gives significant grain yield of 7.22 t/ha and straw yield of 15.055 t/ha.

Mgbeze G.C. and Abu Y., (2010) set a field experiment in Nigeria to check the effect of NPK and FYM on growth of African yam bean. Treatments with 100%, 50%, 25%, 12.5% of FYM and 100% river sand were given. Treatment with 12.5% FYM at soil pH 8.32 was significant ($P<0.01$) with higher leaf area (23 cm^2) and number of leaves (10.7). They recommended FYM as alternate to inorganic sources for yam bean in Nigeria.

Verma *et al.*, (2006) conducted an experiment in research fields on maize. Different doses of FYM and NPK were applied. It was found that treatment in which they applied 20 t ha^{-1} of FYM and get significant results were received with magnitude of increase in weight per cob (22.0%), number of cobs/plant (10.0%), grain weight /cob (43.6%), test weight-1000 (9.3%), grain yield (34.4%) and stover yield (25.7%).

Dilshad *et al.*, (2010) conducted an experiment and found that treatment with either RDF (120:90:60) or 50% RDF+ FYM (10 ton ha^{-1}) + bio powder have significantly higher growth attributes as well as yield over other rest of the treatments.

Singh *et al.*, (2015) carried out a research at agricultural field at Khalsa College, Amritsar. They studied about the increasing growth of baby corn with sustainability through integrated nutrient management. The significant increase in all growth parameters was recorded by application of 5 ton of FYM + 100 kg N through inorganic sources.

2.3 Effect of Inorganic fertilizers (solely or in combination) on growth and yield parameters of maize:

Ghaffari *et al.*, (2011) conducted an experiment at University of Agriculture, Faisalabad to study the effect of INM on growth, yield and quality of maize. It was found that treatment with recommended dose of NPK + single spray of multinutrient @ 1.25 L ha^{-1} has significant result on growth and yield parameters of maize.

Jinjala *et al.*, (2016) conducted the field experiment at NAU in Gujarat to study the effect of INM on baby corn. They applied different levels of nitrogen through chemical and vermicompost with and without bio-fertilizers. The treatment with 100% RDF through inorganic source in combination with bio-fertilizer shows significantly higher growth attributes and yield of baby corn as compared to rest of the treatments combinations. The net return was higher in 100% RDN from inorganic source rather than vermicompost.

Gupta *et al.*, (2015) carried a field experiment on effects of integrated nutrient management on growth and yield of maize (*zea mays* l.) - gobhi sarson (*brassica napus* l.) cropping system in sub-tropical region under foothills of north-west himalayas. The highest growth, yield and yield components of maize crop were recorded with 100% recommended fertilizer dose-RFD + $ZnSO_4$ 20 kg/ha and the grain yield (2409 kg/ha) was about 101% higher over the control. In case of gobhi sarson, the highest seed yield (1081 kg/ha) was observed as a pronounced residual effect of 10 t/ha FYM in preceding maize crop; which was about 81% higher over the control.

Madane *et al.*, (2016) conducted an experiment during *kharif* season of 2013 at Kolhapur, to study the effect of INM on growth and yield parameters of maize. The application of 100% RDF (120:60:40 kg ha^{-1}) shows significantly better results with respect to grain yield (59.11 q ha^{-1}) as compared to other treatments.

Muna *et al.*, (2006) set an experiment in Meru district of Kenya in 2000 to find the effect of soil incorporated organic and mineral fertilizer inputs on maize. Different sources were given like, manure, manure + 30 kg N per hectare, tithonia, calliandra, leucaena, tithonia + 30 kg N per hectare, calliandra + 30 kg N per hectare, leucaena + 30 kg N per hectare, 60 kg N per hectare and control. It was found that on average, treatments with tithonia (with or without half RDF by mineral fertilizers) gave highest maize grain yields *i.e*, 5.5 and 5.4 Mg per ha respectively.

Lingaraju *et al*., (2010) conducted a study on effect of different levels of nutrient on maize- bengal gram cropping system. It was found that when NPK was given in 100 % recommended dose has 13.0 % higher maize yield over 50 % RDF and 5.4 % higher yield over 75 % RDF. Research was performed on maize - bengal gram cropping system.

Amanullah *et al*., (2011) designed a research on maize. Result obtain revealed that when NPK was applied in amount of 200:100:100 kg per hectare, it gave significantly higher dry matter at 30, 60 and 90 days after sowing (1265, 7528 and 17337 kg/ha^{-1}, respectively) on crop maize. The result obtain was of two years.

Waseem *et al*., (2011) conducted a study to check the effect of INM on maize crop. Different treatments consist of different sources of nutrient were given to maize crop. Result obtain revealed that when nitrogen @ 250 kg per hectare, was supplied through urea, results of grain yield and physiological traits were significantly higher in maize over other sources like FYM, sugarcane compost and poultry manure.

CHAPTER 3

MATERIALS AND METHODS

A field experiment is conducted in randomized block design, which consists of seven treatments with three replications performed at the Agricultural Research Farm of Lovely Professional University, Jalandhar, Punjab during *kharif* season of year 2016. Aim was set to check the "Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)". The details of experimental procedure adopted, materials used and techniques followed during the course of present investigation are described as under.

3.1 Description of experimental site:

3.1.1 Location:

The experiment was conducted in the research field of Lovely Professional University located at 31°14'43.8"N &75°41'44.1"E. The experimental field is present in Kapurthala district of Punjab state in India. Site is situated above 252m mean sea level with an average elevation. This region comes under central plain zone of climatic zone of the state.

3.1.2 Climatic and weather conditions:

3.1.2.1 Climate:

The research site has warm and temperate climate. In winter, it receives low precipitation than summer. According to Koppen and Geiger, this type of climatic condition is classified as Cwa. This site has an average annual temperature of 23.9°C. In summer, maximum temperature could reach 44°C. In winter, temperature could falls to precipitation received in this site is 769 mm. The maximum precipitation is obtained in month of July, August and September.

3.1.2.2 Weather report during research period:

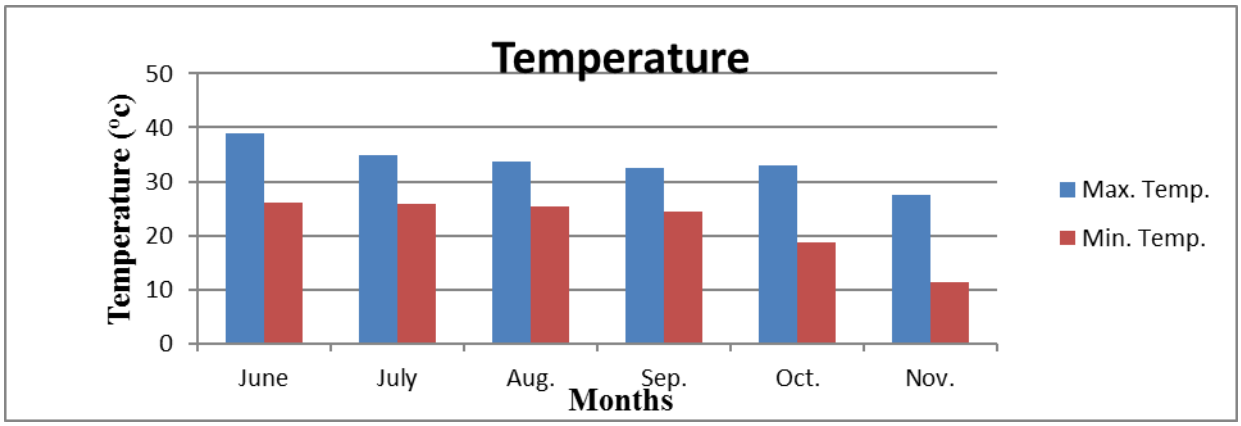


Figure 3.1 Temperature recorded during *kharif* season 2016:

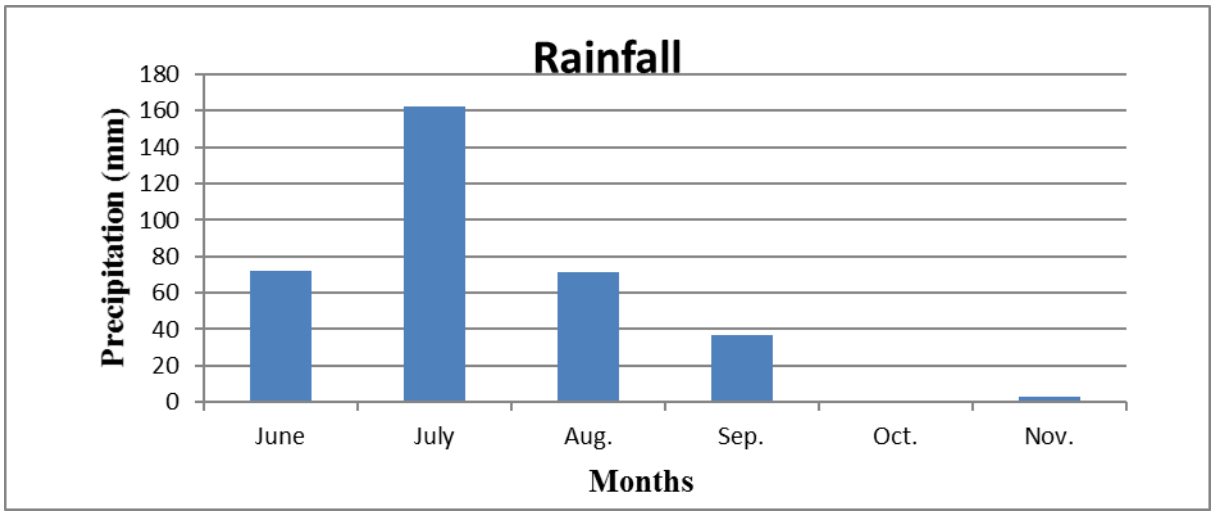


Figure 3.2 Rainfall obtain during *kharif* season 2016:

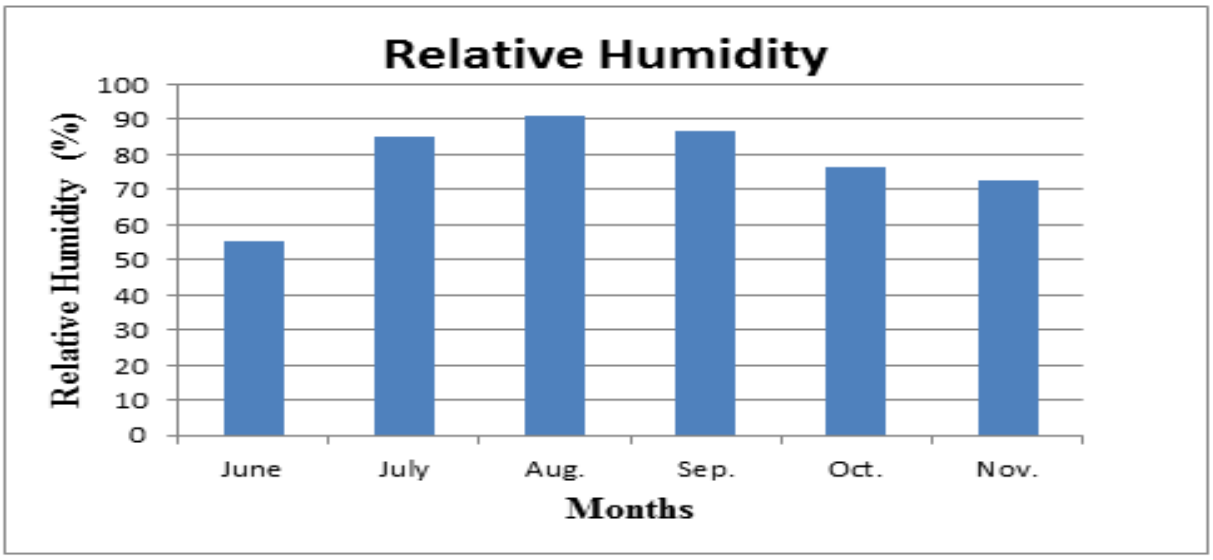


Figure 3.3 Relative humidity recorded during *kharif* season 2016:

3.1.3 Soil characteristics:

The experimental field is present in agricultural research fields of university. Soil samples were collected randomly from field for knowing the pre fertility status. They were further taken to soil laboratory for analysis of physiochemical properties. Soil parameters like soil pH, soil EC, organic carbon (%), organic matter (%), available nitrogen, phosphorus and potassium (kg/ha) were analysed. It was found that this field has sandy clay loam soil tract. Procedure of analysing the physiochemical properties of soil are given below.

1) Determination of soil pH:

Soil pH was measured by pH meter. First of all, 10 g of soil was taken in 150 ml beaker. Then, 25 ml of distilled water was added. Solution was stir for 6 times within an hour. After an hour, sample was again stir and pH was measured by pH meter. Readings were taken from pH meter. Reading are given in table no 3.1.

2) Determination of Soil Electrical Conductivity (EC):

Electrical conductivity was measured through EC meter. First of all, 10 g soil was weighed and then it was added with 25 ml of distilled water in 150 ml beaker. It was stir for 5-6 times. EC meter was calibrated with KCl to obtain cell constant. Readings taken are given in table no 3.1

3) Determination of soil organic carbon (%):

Walkley and Black method was used to determine the soil organic carbon. First of all, take 250 ml conical flask and add 2g soil and 10 ml of 1 N $K_2Cr_2O_7$. Mix it well and add concentrated H_2SO_4. Now leave the conical flask to cool down. Now, add 2 g sodium fluoride and 100 ml of distilled water. Shake it vigorously. Add few drops of diphenyl amine indicator. Colour of solution will be violet in colour. Titrate the solution with ferrous ammonium sulphate till the light green colour is attained.

4) Determination of available nitrogen (Kg/ha):

Alkaline potassium permanganate method was used to determine the available nitrogen. This method was given by Subbaih and Asija (1956). Soil was distillate by a solution of alkaline potassium permanganate (0.32%) and NaoH (2.5%) by which ammonium is liberated. Liberated ammonium is further absorbed in boric acid solution which contains indicator. It is determined volumetrically and gives index of available nitrogen. Readings are given in table no 3.1.

5) Determination of available phosphorus (Kg/ha)

Olsen calorimetric method (1954) was used to determine the available phosphorus. At first, phosphorus was extracted from soil through sodium bicarbonate. Then, phosphate was reacted with ammonium molybedate to form molybdophosphoric acid in an acid medium. Then colour of molybdophosphoric acid was reduced to blue colour by ascorbic acid. Then reading was taken by spectrophotometer at wavelength of 660 nm.

6) Determination of available potassium (Kg/ha)

Toth and Price method (1949) was used to estimate the available potassium from soil samples. Ammonium acetate was used to extract available potassium from soil and was estimated with the help of a flame photometer. When a salt solution is sprayed in flame, due to high temperature, solid gets separated to component atoms. Then a radiation of particular wavelength was emitted through exited atoms due to energy of flame. These radiations are proportional to compactness of particular element. Readings obtained are given in table no 3.1

Table 3.1 Physiochemical properties of soil of experimental field

Physiochemical properties	Content
Sand content (%)	75
Silt content (%)	10.3
Clay content (%)	14.7
Soil texture	Sandy loam
Soil pH	7.8
Soil Electrical Conductivity (ds/m)	3.9
Soil Organic carbon (%)	0.58
Available Nitrogen (Kg/ha)	220
Available Phosphorus (Kg/ha)	16.2
Available Potassium (Kg/ha)	240

3.2 Sources of nutrients:

This research contains five different source of nutrients provide to plant. Among which, three are inorganic sources and another two are organic sources. Inorganic source of NPK are urea, DAP, MOP and organic sources are FYM and vermicompost. Following table describes the nutrient composition of these sources.

Table 3.2 Nutrient composition of different fertilizers

Source	N (%)	P (%)	K (%)
Urea	46	-	-
DAP	18	46	-
MOP	-	-	60
FYM	0.5	0.2	0.5
Vermicompost	2.5	0.3	0.56

3.3 Cropping history:

This field is situated at Agricultural Research Centre of University. Before conducting this research, this field was used for cultivation of wheat crop. Previous wheat crop was harvested in late April, 2016. The time in between of last crop harvesting and sowing of research crop maize was about 50 days. Maize crop for study was sown in *kharif* season *i.e*, mid-June of 2016.

3.4 Details of treatments and experimental field:

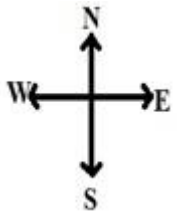
3.4.1 Treatments:

T_1	Control
T_2	100% Recommended Dose of NPK
T_3	50% Recommended Dose of NPK + 50% Vermicompost
T_4	100% Vermicompost
T_5	100% Farm Yard Manure
T_6	50% Recommended Dose of NPK + 50% Farm Yard Manure
T_7	50% Recommended Dose of NPK + 25% FYM + 25% Vermicompost

3.4.2 Experimental details:

- Crop : Maize
- Variety : P3396
- Total no. of treatments : 7
- Replications : 3
- Total no. of plots : 21
- Plot Area : 2 X 3 = 6 m^2
- Total Area : 21 X 6 =126 + margin = 150 m^2 (approx)
- Design of Experiment : Randomized Complete Block Design(RCBD)
- Period of Work : 2016-17
- Seed Rate : 20 kg/hectare
- Row to Row Distance : 60 cm
- Plant to Plant Distance : 22.5 cm
- Row Direction : North to South
- Topic Under Discussion : Effect of Integrated Nutrient Management on yield and growth parameters of maize.

3.4.3 Layout of experimental field:



R1	R2	R3
Water Channel 0.5m		
T1	T2	T6 (2m × 3m)
T3	T7	T2
Water Channel 0.5m		
T5	T1	T3
T7	T4	T1
Water Channel 0.5m		
T2	T3	T5
T4	T6	T4
Water Channel 0.5m		
T6	T5	T7

8m

3.4.4 Recommendation of fertilizers:

Table 3.3. Dose of fertilizers per plot:

Serial No.	Fertilizers	Dose per hectare
1.	N:P:K	125:60:60 kg
2.	FYM	15 ton
3.	Vermicompost	5 ton

3.5 Field preparation and planting:

3.5.1 Field preparation:

Maize crop is sown on ridges to avoid impact of water logging. So, to make ridges field must be cultivated finely and loosen up to 25 – 30 cm in depth. Dual harrow, thrice planking is enough for sandy clay loam soil. Ridges are made with the help of ridge maker. Finely cultivated field also uproots weeds from field which cultural method to eradicate weeds. Before sowing, uprooted weeds were remove from field to avoid germination of same weeds. Bunds were made to differentiate different bunds and water channels were made. Mixing of FYM and vermicompost as per doses was applied in concerned plots before 12 days of sowing.

3.5.2 Variety:

P3396 high yielding variety of maize was used for research. The seed was produced by Dupont with trademark Pioneer P3396. It has very unique plant structure. It has good standability, tolerant to water stress, high yield and disease resistance. It matures in 90 - 100 days after sowing. Ideal to be grown in agro climatic conditions of north India. It has dark green colour and broader leaves.

3.5.3 Sowing and seed rate:

Best sowing time to sown *kharif* season maize is Mid June to Mid July. Maize crop should be sown before onset of monsoon. Water stagnation effects the maize yield. To reduce impact of water stagnation, maize should be sown on ridges. So, crop was sown on June 18, 2016 with seed rate of 20 kg per hectare. Spacing was 60 cm row to row and 22.5 cm plant to plant. Seed was placed at depth of 3 cm.

3.5.4 Seed treatment:

Pioneer P3396 seed were treated with fungicide captan @ 3 g/kg and insecticide Imidacloprid to protect seed from insects. Seed can be sown just after few minutes after treatment.

3.6 Intercultural operations:

Intercultural operation are cultural practices perform during cultivation of crop. To raise the maize crop in this research, different kinds of intercultural practices were performed. Missing of any intercultural operation can impact yield parameter or growth parameters significantly. Intercultural operations those were performed during this research are given below.

3.6.1 Gap filling:

Due to conditions such as improper moisture, prey and pest attack, or low germination rate of few seeds results in inability of seed to germinate. To overcome such problem, gap filling is done. Seeds were sown in gaps. It was done after 10-12 days after sowing.

3.6.2 Thinning:

Due to error in sowing of seeds, in some place two or more number of seeds were sown. This results in two seedlings grown alongside. They would compete with each other. To maintain spacing and reducing competition thinning was done. Thinning is a process in which excessive or unwanted crop seedlings are uprooted. Thinning was performed after 20 days after sowing.

3.6.3 Irrigation:

Irrigation is a process of providing moisture to plant through artificially means. Normally, maize crops requires 4-5 irrigation. It may varies in different soil and different climatic conditions. First irrigation was given just after sowing of seeds to provide sufficient moisture for germination. Rest of irrigations were given as per requirement in addition of rainfall. Silking stage and tasseling to dough stage is critical stage of irrigation in maize crop.

3.6.4 Weed management:

Weeds are major reason for lowering the yield of maize. Koch *et al*., (1990) and Chikoye *et al*., (2001) describes that interference of spear grass in sweetcorn could loss yield as high as 80% yield. Major weeds found maize are *Cyperus esculentus, Cyperus rotundus, Amaranthus viridis, Euphorbia prostrate, Brachiaria reptans, Chloris barbata and Cyanodon dactylon*.

Atrazine is the one of the major pre emergence weedicide used widely in maize crop. Atrazine @ 0.25 kg/ha in 500 litres/ha rate was sprayed after the 2 days of sowing. Afterward, manual hand weeding was done after 30 days and onward were done whenever required.

3.6.5 Insect management:

Insects are one of major cause for reducing the crop yield. They may feed directly or work as carrier of diseases. To avoid loss from insect, plant protection important. During sowing, Imidacloprid was treated on seeds to avoid seeds from insects. Chlorpyrifos 20 % EC was

sprayed on crop on June 25, 2016 to protect crop from termites. Endosulfan 35 % EC was sprayed in 1000 Litre of water per hectare in the first week of august 2016.

3.6.6 Harvesting and threshing:

Harvesting in maize is an action to remove cob from its growing medium. Optimum time to separate cob from stalk is when moisture content of grains varies from 17-20 %. On September 25, 2016 crop was harvested from main field. Each plot was harvested separately and packed in labelled polythene bags. It was further left for dry. Grains were separated from cobs and readings of yield parameters were taken.

3.7 Treatment evaluation:

Different growth and yield parameters were taken throughout research to know the effect of integrated nutrient management on *kharif* maize. Growth parameters were recorded on 30, 60 and 90 days after sowing. Yield parameters were recorded after harvesting the crop. Growth and yield parameters recorded enlisted as below.

3.7.1 Growth parameters:

1) Plant height (cm):

Plant height of maize crop was recorded on 30, 60 and 90 days after sowing. Three plants were selected randomly and tagged for recording of parameters. Plant height was recorded with help of measuring tape from bottom to the flag leaf. Mean height of three plants was taken in cm and recorded for further statistical analysis.

2) Stem girth (cm):

Stem girth was measured with the help of measuring tape from the centre of plant stem. Data was taken on 30, 60 and 90 days after sowing from the tagged plants. Data was collected from all treatments. Mean stem girth (cm) was calculated and taken for further analysis.

3) Number of green leaves per plant:

Green leaves were counted from the labelled plants from all the plots. Values were obtained and mean number of green leaves was calculated. These readings were taken on 30. 60 and 90 days after the sowing. Number of green leaves are important with respect to forage yield.

4) Number of internodes per plant:

Number of internodes were counted from bottom to above. Data was taken on 30, 60 and 90 days after sowing. Mean value was calculated of selected labelled plants.

3.8.2 Yield parameters:

1) Number of cob/s per plant:

Number of cob/s on single plant were counted from randomly selected plants. Mean value was calculated for statistical analysis.

2) Cob length (cm):

Cob length was measured from the randomly selected plants. Mean value was calculated and recorded as well. Bigger the length more will be the yield.

3) Number of grains per cob:

It is one of important parameter to record. Number of grains were counted from the cobs selected from the tagged plants. Mean value was calculated.

4) Test weight (g):

This yield parameter is one major factor affecting yield of crop. Heavier the grain weight will result in higher yield. Weigh was done of 1000 grains in weighing machine in laboratory. Value was recorded for statistical analysis.

5) Grain yield per plot (kg/ha):

After drying in shade, grains were separated from cobs. Weigh was done of grains of all the plots to check yield. Value was recorded in kg unit for statistical analysis.

3.7.3 Percentage decrease and increase over the control:

$$\text{Percentage Decrease} = \frac{\text{Treatment value} - \text{Control value}}{\text{Control value}} \times 100$$

$$\text{Percentage Increase} = \frac{\text{Treatment value} - \text{Control value}}{\text{Treatment value}} \times 100$$

3.8 Economic analysis:

Net profit per hectare was calculated to determine the economics of treatments. To calculate the net profit, net return per hectare was calculated by subtracting the cost of cultivation from gross return. Further, benefit cost ratio was calculated by dividing the net profit by cost of cultivation.

Net Profit (₹/ha) = Gross return (₹/ha) – Cost of cultivation (₹/ha)

$$\text{B: C ratio} = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

3.9 Statistical analysis:

To check the significance difference between different treatments, statistical analysis was done. Statistical analysis was performed by SPSS™ 16 software. SPSS™ 16 was used to know significant level at 95 %. The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means. Critical difference between different variables was calculated to estimate significance treatment mean under the F-test of one way ANOVA.

3.10 Demonstration:

Figure 3.4 Field Preparation

Figure 3.5 Application of FYM

Figure 3.6 Spraying of Atrazine

Figure 3.7 Germination and Gap Filling

Figure 3.8 Plants at 30 DAS

Figure 3.9 Plants at 60 DAS

Figure 3.10 Harvesting

Figure 3.11 Sun Drying of Cobs

Figure 3.12 Data Collecting

CHAPTER-4

RESULTS AND DISCUSSION

For achieving the objectives envisaged in present study, a field experiment with maize crop was conducted during *Kharif* season of 2016-17 at fixed site on Agricultural Research Farm of Lovely Professional University, Jalandhar, Punjab. In all 7 treatment combinations comprising (T1: Control, T2: 100% recommended dose of NPK, T3: 50% recommended dose of NPK + 50% Vermicompost, T4: 100% Vermicompost, T5: 100% Farm Yard Manure, T6: 50% recommended dose of NPK + 50% Farm Yard Manure, T7: 50% recommended dose of NPK + 25% FYM + 25% Vermicompost were tested in FCRD with three repitations. The results pertaining to growth parameters, yield and yield attributes and soil fertility obtained during the course of present study are interpreted here with the help of statistical yard stick. The data was statistically analysed through SPSS™ software to check the significance results at level 95%. The discussion part includes analysis of hypothesis and expected objectives set for research. Brief discussion is written on result and the causes for such result.

4.1 GROWTH PARAMETERS

4.1.1 Plant height

Plant height is one of the main parameter to be observed. Fodder production is effected by the height of maize plant. Measurements were taken on 30, 60 and 90 days after sowing. Plant height was measured with the help of measuring tape in centimetres. The measurement was taken from surface to the flag leaf.

4.1.1.1 Effect of different level of organic and mineral fertilizers on plant height (cm) at 30 days after sowing:

The plant height under treatment T_7 (50% recommended dose of NPK + 25% FYM + 25% Vermicompost) was 80.99 cm followed by treatment T_6 (50% recommended dose of NPK + 50% Farm Yard Manure) with a plant height of 73.10 cm. The treatment T_1 (control) recorded lowest plant height (24.60 cm) as compared to rest of the treatment combinations.

The results shows that treatment T_7 (50% recommended dose of NPK + 25% FYM + 25% Vermicompost) has significantly 69.62% higher plant height than T_1 (control). The treatment T_6 (50% recommended dose of NPK + 50% Farm Yard Manure) has significantly 59.88% higher plant height than control.

The treatment T_3 (50% recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost) and T_5 (100% Farm Yard Manure) are similar to each other and significantly higher than control (table 4.1 and graph 4.1).

4.1.1.2 Effect of different level of organic and mineral fertilizers on plant height (cm) at 60 days after sowing:

The plant height was measured after 60 days after sowing, it was found that treatment T_7 (50% recommended dose of NPK + 25% FYM + 25% Vermicompost) has significantly higher plant height (233.92 cm) than other treatments. It has 47.23% higher plants than control. Second higher plants were of treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_2 (100% Recommended dose of NPK), which were similar to each other with plant height of 194.12 cm and 188.51, respectively.

Third highest plant height were in treatments T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost) and T_5 (100% Farm Yard Manure) with significantly similar to each other. Recorded data is given in table 4.1 and figure 4.1.

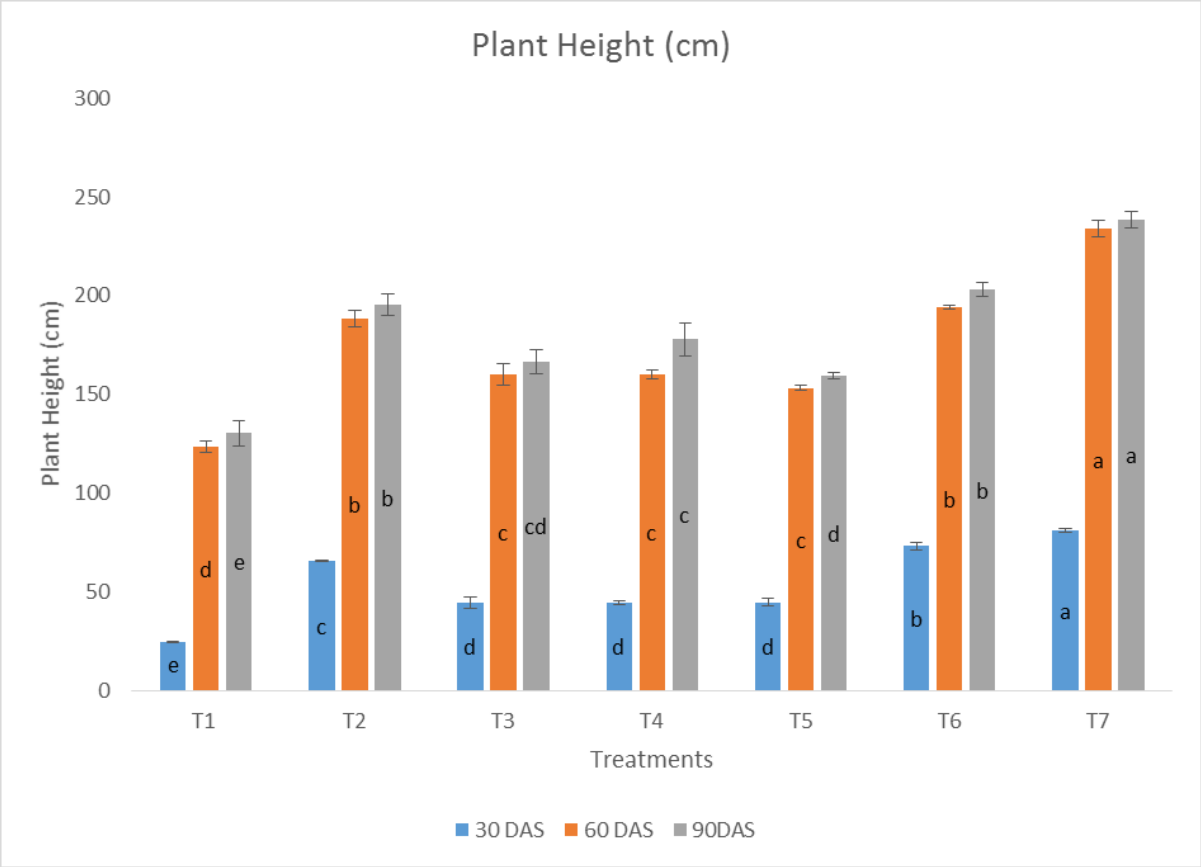
4.1.1.3 Effect of different level of organic and mineral fertilizers on plant height (cm) at 90 days after sowing:

The variety P3396 obtains maximum plant height within 60 days from sowing. After 60 days of sowing plant height increases few centimetres only. During data recorded at 90 days after sowing, it was found that T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was higher in plant height of 238.47 cm. It was followed by treatment T_2 (100% Recommended dose of NPK) and T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) with plant height of 195.51 cm and 203.34 cm, respectively.

The treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was 45.38 % higher plant height over control. It was followed by T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_2 (100% Recommended dose of NPK) with increase in height over control by 35.94% and 33.37%, respectively. Recorded data is given in table 4.1 and figure 4.1.

Table 4.1 Effect of different level of organic and mineral fertilizers on plant height (cm) of maize at 30, 60 and 90 days after sowing:

Treatments	30 DAS	60 DAS	90 DAS
T_1 (control)	24.60e±0.33	123.42d±2.76	130.25e±6.53
T_2 (100% Recommended dose of NPK)	65.72c±0.58	188.51b±4.36	195.51b±5.66
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	44.39d±2.65	160.15c±5.3	166.52cd±5.96
T_4 (100% Vermicompost)	44.36d±0.76	160.06c±2.25	177.79c±8.61
T_5 (100% Farm Yard Manure)	44.66d±2.04	153.16c±1.33	159.2d±1.61
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	73.10b±1.74	194.12b±1.11	203.34b±3.61
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	80.99a±0.82	233.92a±4.36	238.47a±4.25



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.1 Effect of different level of organic and mineral fertilizers on plant height (cm) of maize at 30, 60 and 90 days after sowing

4.1.2 Stem girth:

Stem girth is the measurement around the stem and perpendicular to the stem. It was measured with the help of measuring tape. The three plants were randomly selected and measurements were taken from those selected plants. Measurements were taken few centimetres above the ground. Measurements were taken on 30, 60 and 90 days after sowing. Treatments have different stem girth and few were significant. Different sources of nutrients shows different size of stem girth. Combination of different sources also give significant results.

4.1.2.1 Effect of different level of organic and mineral fertilizers on stem girth (cm) of maize at 30 days after sowing:

When reading was taken at 30 days after sowing it was found that treatment T_2 (100% Recommended dose of NPK) and treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has thicker stem girth of 10.45 cm and 9.9 cm, respectively. These treatments were followed by T_5 (100% Farm Yard Manure) with stem girth of 9.21 cm. It was found that stem girth of treatment T_1 (control) was least, about 7.09 cm only. Treatment T_2 (100% Recommended dose of NPK) and treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) were 32.15 % and 28.38 %, respectively thicker over control.

4.1.2.2 Effect of different level of organic and mineral fertilizers on stem girth (cm) of maize at 60 days after sowing:

Readings were taken on 60 days after sowing. It was found that treatments T_3 (50% Recommended dose of NPK + 50% Vermicompost) and T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) were significant to control. While T_2 (100% Recommended dose of NPK) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) were almost similar and lies near to T_2 and T_7.

Treatment T_2 (Recommended dose of NPK) shows significant results with stem girth of 11.03 cm, which is 10.51% thicker than control. Treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was also significant with girth of 11.17 cm, which is 11.63% thicker than control.

Treatment T_1 (control) had least stem girth of 9.87 cm among all other treatments.

4.1.2.3 Effect of different level of organic and mineral fertilizers on stem girth (cm) of maize at 90 days after sowing:

Next data was taken on 90 days after sowing. There was not much difference in data recorded than previous observation. It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was significantly thicker than all other treatments with stem girth of 12.3 cm. It was followed by T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure) and T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure). These treatments were significantly thicker than control but almost

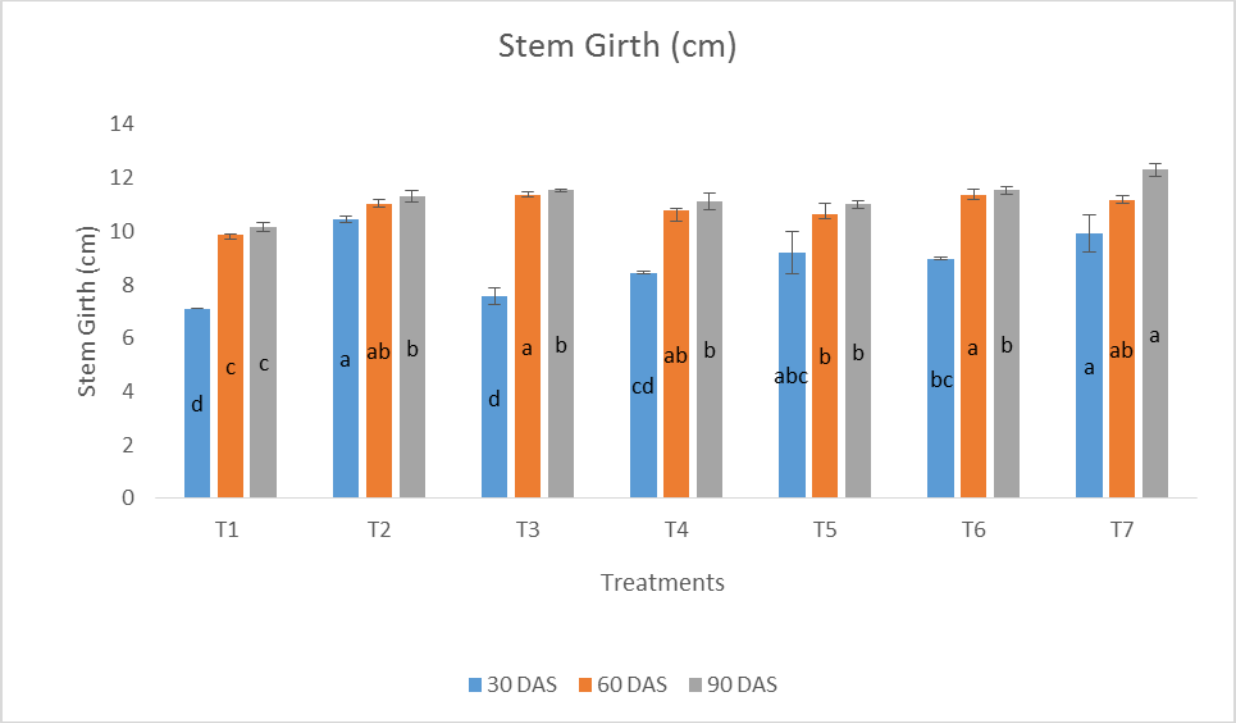
similar to each other. Least stem girth was recorded in treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) of 10.16 cm

The treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was 17.39 % thicker than control. Recorded data is given in table 4.2 and figure 4.2.

Table 4.2 Effect of different level of organic and mineral fertilizers on stem girth (cm) of maize at 30, 60 and 90 days after sowing:

Treatments	30 DAS	60 DAS	90 DAS
T_1 (control)	7.09d±0.13	9.87c±0.18	10.16c±0.17
T_2 (100% Recommended dose of NPK)	10.45a±0.31	11.03ab±0.12	11.29b±0.22
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	7.55d±0.05	11.36a±0.08	11.53b±0.03
T_4 (100% Vermicompost)	8.44cd±0.8	10.77ab±0.39	11.11b±0.32
T_5 (100% Farm Yard Manure)	9.21abc±0.05	10.66b±0.2	11.00b±0.15
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	8.98bc±0.7	11.37a±0.16	11.53b±0.13
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	9.9a±0.6	11.17ab±0.12	12.3a±0.23

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.2 Effect of different level of organic and mineral fertilizers on stem girth (cm) of maize at 30, 60 and 90 days after sowing

4.1.3. Number of green leaves:

This growth parameter is very important. If maize crop is used for fodder purpose then, more number of green leaves will give higher yield. In this research, data was collected at 30, 60 and 90 days after sowing. Different treatments have different result. It was found that some treatments were significantly better than other.

4.1.3.1 Effect of different level of organic and mineral fertilizers on green leaves at 30 days after sowing:

Data was collected at 30 days after sowing by counting the number of green leaves on a plant. By analysing the data statistically it was found that, treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) had significantly higher number of green leaves. It had 11.33 mean count of green leaves. It was followed by treatment T_2 (100% Recommended dose of NPK) with mean value 10.22. Treatment T_1 (control) has least number of green leaves (6.86) than all other treatments.

The treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) had 39.45 % more number of green leaves than control. Treatment T_2 (100% Recommended dose of NPK) had 32.87 % more green leaves than control.

Data recorded is expressed in table no 4.3 and figure no 4.3

4.1.3.2 Effect of different level of organic and mineral fertilizers on green leaves at 60 days after sowing:

During data collection of 60 days after sowing it was found that treatment T_2 (100% Recommended dose of NPK) and treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) were significantly better than control. It was followed by T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) and T_5 (100% Farm Yard Manure). Least number of green leaves were recorded in control of mean value 12.55.

The treatment T_2 (100% Recommended dose of NPK) had 15.55 mean green leaves, which is 19.29 % higher number of green leaves than control .The treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) had 16.10 green leaves, which is 22.04 % higher than control.

4.1.3.3 Effect of different level of organic and mineral fertilizers on green leaves at 90 days after sowing:

During data collection at 90 days after sowing it was found that plants were have less number of green leaves than 60 days of sowing. Treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) and T_2 (100% Recommended dose of NPK) were having

higher mean number of green leaves of 10.33 and 9.99, respectively. Control has least number of green leaves of mean value 6.99.

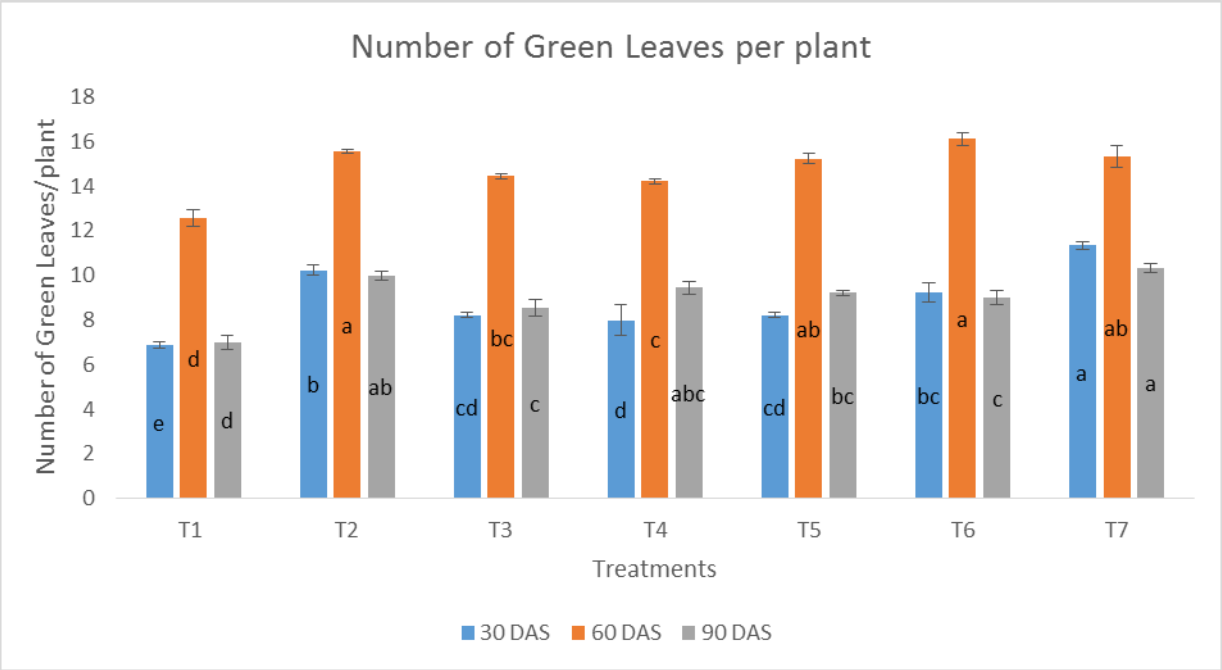
The treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has 32.33 % more number of green leaves than control.

The treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost), T_4 (100% Vermicompost) and T_2 (100% Recommended dose of NPK) were similar to each other and significantly higher than control.

Table 4.3 Effect of different level of organic and mineral fertilizers on green leaves at 30, 60 and 90 days after sowing:

Treatments	30 DAS	60 DAS	90 DAS
T_1 (control)	6.86e±0.13	12.55d±0.39	6.99d±0.33
T_2 (100% Recommended dose of NPK)	10.22b±0.22	15.55a±0.11	9.99ab±0.19
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	8.22cd±0.11	14.44bc±0.11	8.55c±0.39
T_4 (100% Vermicompost)	7.99d±0.69	14.22c±0.11	9.44abc±0.29
T_5 (100% Farm Yard Manure)	8.22cd±0.11	15.22ab±0.22	9.22bc±0.11
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	9.21bc±0.44	16.10a±0.29	8.99c±0.33
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	11.33a±0.19	15.33ab±0.50	10.33a±0.19

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.3 Effect of different level of organic and mineral fertilizers on green leaves at 30, 60 and 90 days after sowing

4.1.4 Number of internodes:

Number of internodes were counted from the plants. Data was analysed to check significant level at 95%. It was found that few treatments were significant than other. Data was taken on 30, 60 and 90 days after sowing.

4.1.4.1 Effect of different level of organic and mineral fertilizers on number of internodes at 30 days after sowing:

On 30 days after sowing, data was collected from main field. It was statistically analysed to found the level of significance. It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has 9.22 mean value of internodes, which is significant over control. It has 47.61 % higher number of internodes. It was followed by treatment T_2 (100% Recommended dose of NPK) which has 7 mean value of internodes, which is 31 % higher than control. Least number of internodes were observed in control, which have 4.83 number of internodes.

4.1.4.2 Effect of different level of organic and mineral fertilizers on number of internodes at 60 days after sowing:

During observation taken on 60 days after sowing, it was found that all treated treatments i.e, T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) were similar to each other and significant to the control.

4.1.4.3 Effect of different level of organic and mineral fertilizers on number of internodes at 90 days after sowing:

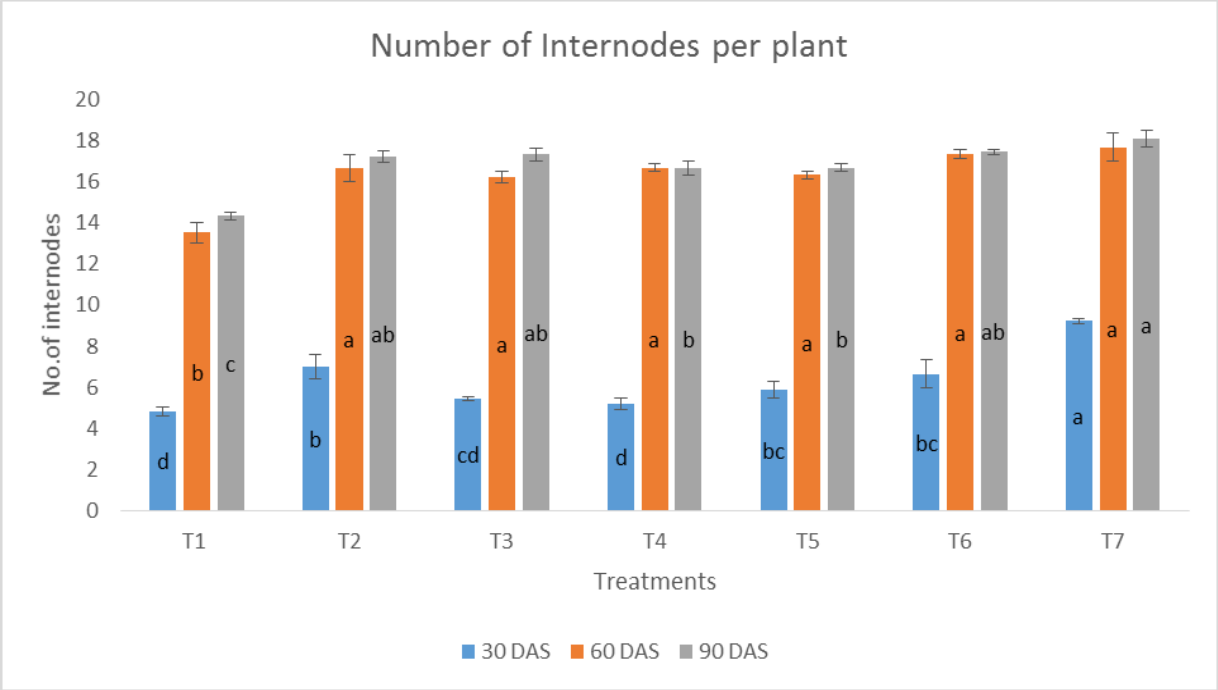
Next reading was taken at 90 days after sowing. Treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) having number of internodes 18.10 was significant over control. It has 20.82 % higher number of internodes than control. It was followed by treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure), T_3 (50% Recommended dose of NPK + 50% Vermicompost) and T_2 (100% Recommended dose of NPK) which has number of internodes 17.44, 17.32 and 17.21, respectively. These treatments are nearby similar to treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

Least result was recorded in treatment T_1 (control) which have 14.33 number of internodes.

Table 4.4 Effect of different level of organic and mineral fertilizers on number of internodes at 30, 60 and 90 days after sowing:

Treatments	30 DAS	6O DAS	90 DAS
T_1 (control)	4.83d±0.23	13.52b±0.49	14.33c±0.19
T_2 (100% Recommended dose of NPK)	7b±0.57	16.66a±0.66	17.21ab±0.29
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	5.44cd±0.11	16.21a±0.29	17.32ab±0.33
T_4 (100% Vermicompost)	5.21d±0.29	16.66a±0.19	16.66b±0.33
T_5 (100% Farm Yard Manure)	5.88bc±0.39	16.33a±0..19	16.66b±0.19
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	6.66bc±0.69	17.33a±0.21	17.44ab±0.11
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	9.22a±0.11	17.66a±0.69	18.10a±0.39

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.4 Effect of different level of organic and mineral fertilizers on number of internodes at 30, 60 and 90 days after sowing

4.2 YIELD AND YIELD ATTRIBUTES:

4.2.1 Number of cobs per plant:

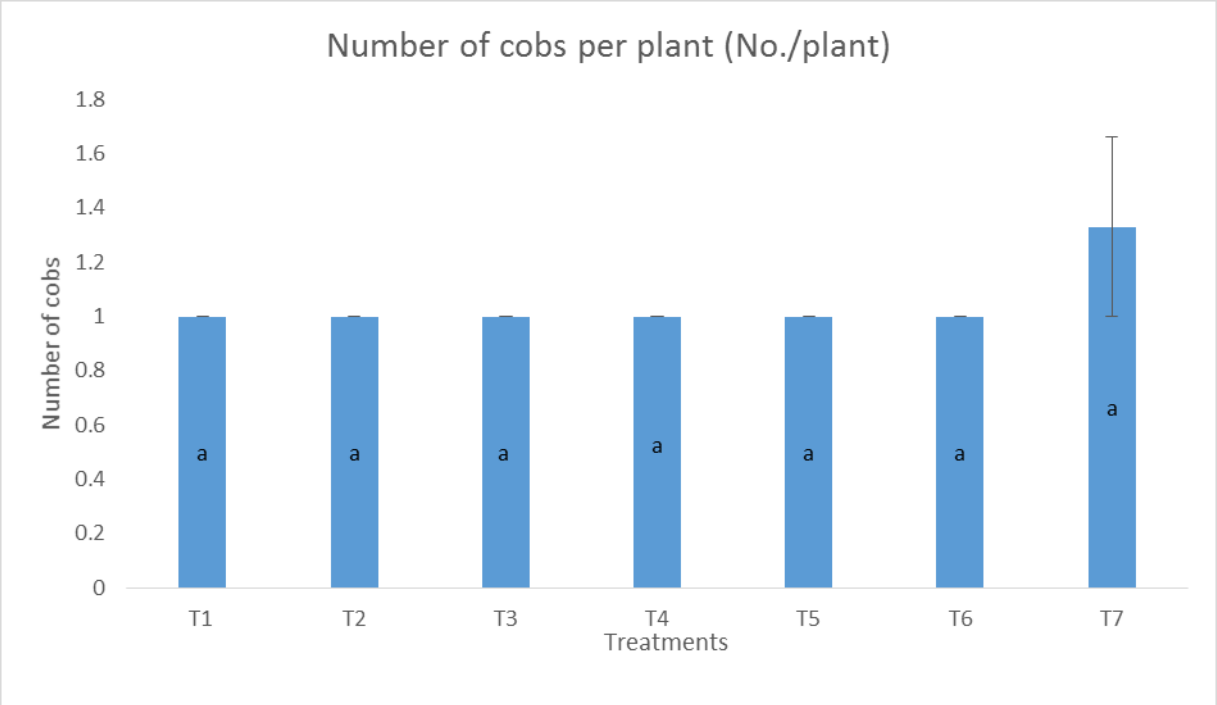
During harvesting of crop, yield parameters like cobs per plant were recorded. It was found that most of plants have one fully developed cob and one immature cob. In some case, there were two fully developed cobs. In this data, treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has highest number of cobs per plant, mean value of 1.33. It has 24.81% higher number of cobs per plant than all other treatments. This treatment was similar to all other treatments.

The treatments T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure) and T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) are similar to each other. These all has same number of cobs i.e, 1.

Table 4.5 Effect of different level of organic and mineral fertilizers on number of cobs per plant of maize:

Treatments	Value ± Std.Er
T_1 (control)	1a±0
T_2 (100% Recommended dose of NPK)	1a±0
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	1a±0
T_4 (100% Vermicompost)	1a±0
T_5 (100% Farm Yard Manure)	1a±0
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	1a±0
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	1.33a±0

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.5 Effect of different level of organic and mineral fertilizers on number of cobs per plant of maize

4.2.2 Cob length:

After harvesting, cob length was recorded with the help of measuring tape in cm. It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher cob length of 15.72 cm which is 35.75% higher than control. It was followed by treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) with cob length 15.33 cm, which is 34.11% higher than control.

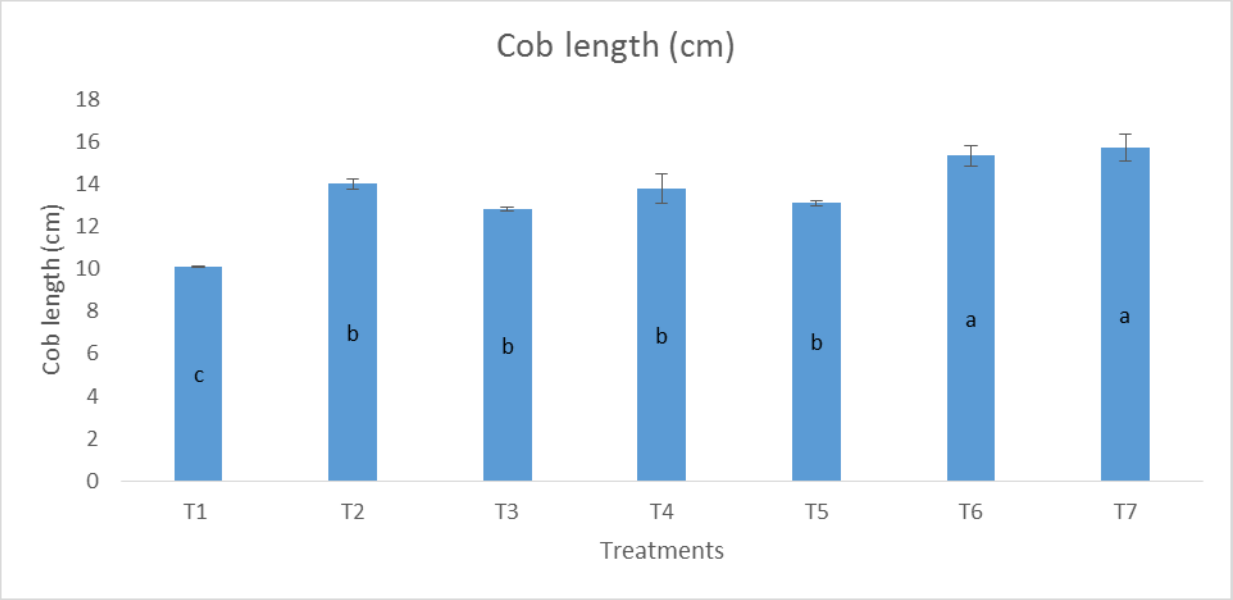
The treatments T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost) and T_5 (100% Farm Yard Manure) are similar to each other and significant to control.

Smallest cob length was recorded in control, which has cob length of 10.10 cm.

Table 4.6 Effect of different level of organic and mineral fertilizers on cob length of maize:

Treatments	Value ± Std.Er
T_1 (control)	10.10c±0.05
T_2 (100% Recommended dose of NPK)	14.02b±0.24
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	12.83b±0.09
T_4 (100% Vermicompost)	13.81b±0.7
T_5 (100% Farm Yard Manure)	13.1b±0.14
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	15.33a±0.5
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	15.72a±0.63

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.6 Effect of different level of organic and mineral fertilizers on cob length of maize

4.2.3 Number of grains per cob:

Number of grains per cob were counted. Data was recorded and it was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher number of grains in single cob. It has 459 grains in single cob, which is 49.72% higher number than control.

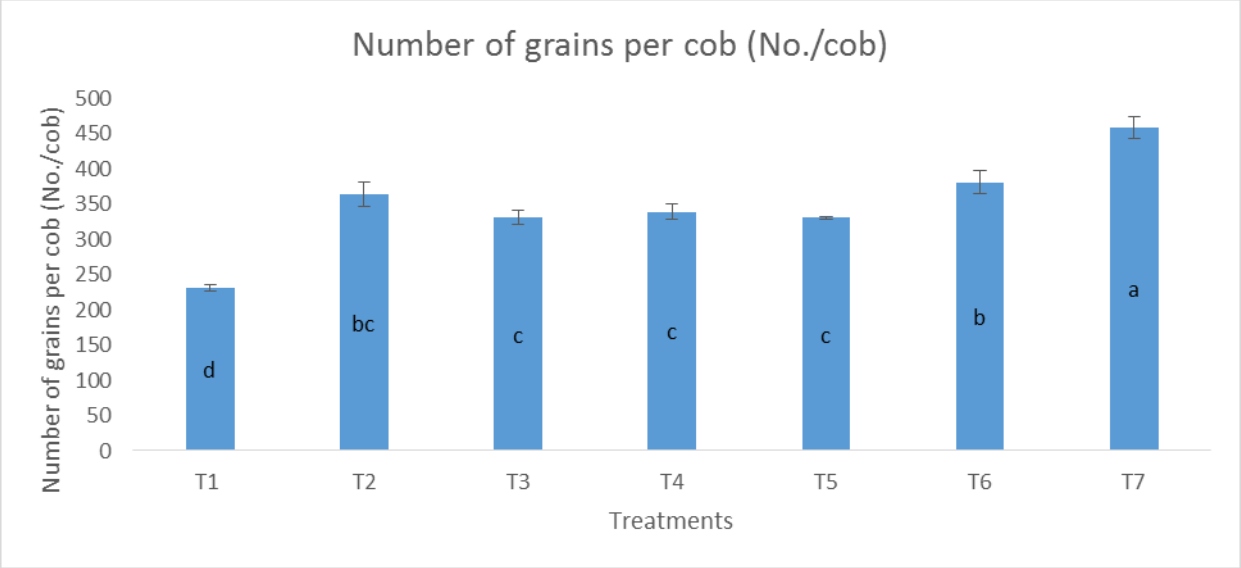
It was followed by treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_2 (100% Recommended dose of NPK) with grains number 381.22 and 363, respectively. These treatments are similar to each other and significantly higher over control.

Least number of grains were found in treatment T_1 (control) with 230.77 grains per cob.

Table 4.7 Effect of different level of organic and mineral fertilizers on number of grains per cob of maize:

Treatments	Value ± Std.Er
T_1 (control)	230.77d±4.61
T_2 (100% Recommended dose of NPK)	363.65bc±17.11
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	331.22c±10.4
T_4 (100% Vermicompost)	339.11c±10.96
T_5 (100% Farm Yard Manure)	330.44c±1.23
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	381.22b±15.8
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	459a±15.53

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.7 Effect of different level of organic and mineral fertilizers on number of grains per cob of maize

4.2.4 Test weight (1000 grains):

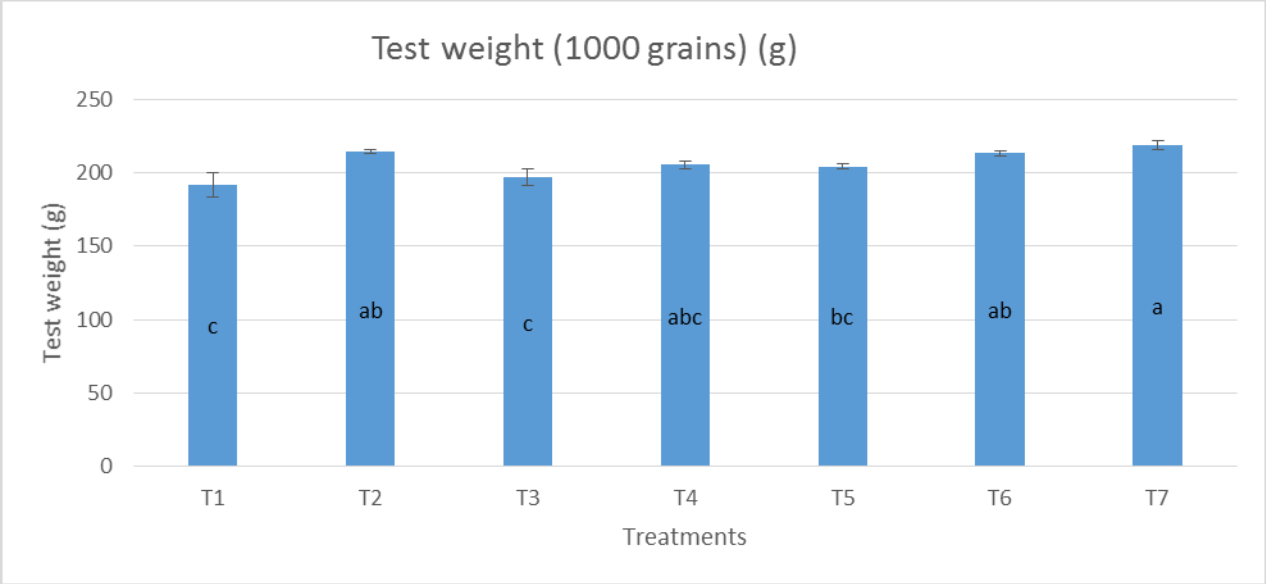
After drying the cobs in shadow for few days, separation of grains from cobs were done. 1000 grains were selected from each treatment for test weight. This parameter is one of major factor influencing quantitative and qualitative factor of maize crop. By analysing the data, it was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher test weight of 219 g which is 12.32 % heavier than grains of control. It was followed by treatment T_2 (100% Recommended dose of NPK) which has 214.33 g weight, 10.41% heavier than control. Both, T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) and T_2 (100% Recommended dose of NPK) were significant to control.

Control has the lighter weight than all treatments, of 192 g.

Table 4.8 Effect of different level of organic and mineral fertilizers on test weight (1000 grains):

Treatments	Value ± Std.Er
T_1 (control)	192c±8.32
T_2 (100% Recommended dose of NPK)	214.33ab±1.2
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	197c±5.68
T_4 (100% Vermicompost)	205.33abc±2.6
T_5 (100% Farm Yard Manure)	204.67bc±2.02
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	213.33ab±1.66
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	219a±3.05

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.8 Effect of different level of organic and mineral fertilizers on test weight (1000 grains)

4.2.5 Grain yield:

This is one of the most important factor to evaluate the crop on the basis of yield. Grains of all the plot were weighed and data was recorded.

It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher yield per plot of 3.24 kg. Yield recorded for per hectare of this treatment is 5400 kg ha^{-1}, 78.08% higher than control.

It was followed by treatment T_2 (100% Recommended dose of NPK) which has yield 2.99 kg per plot and 4983 kg ha^{-1}. It has 76.25 % more grain yield than control.

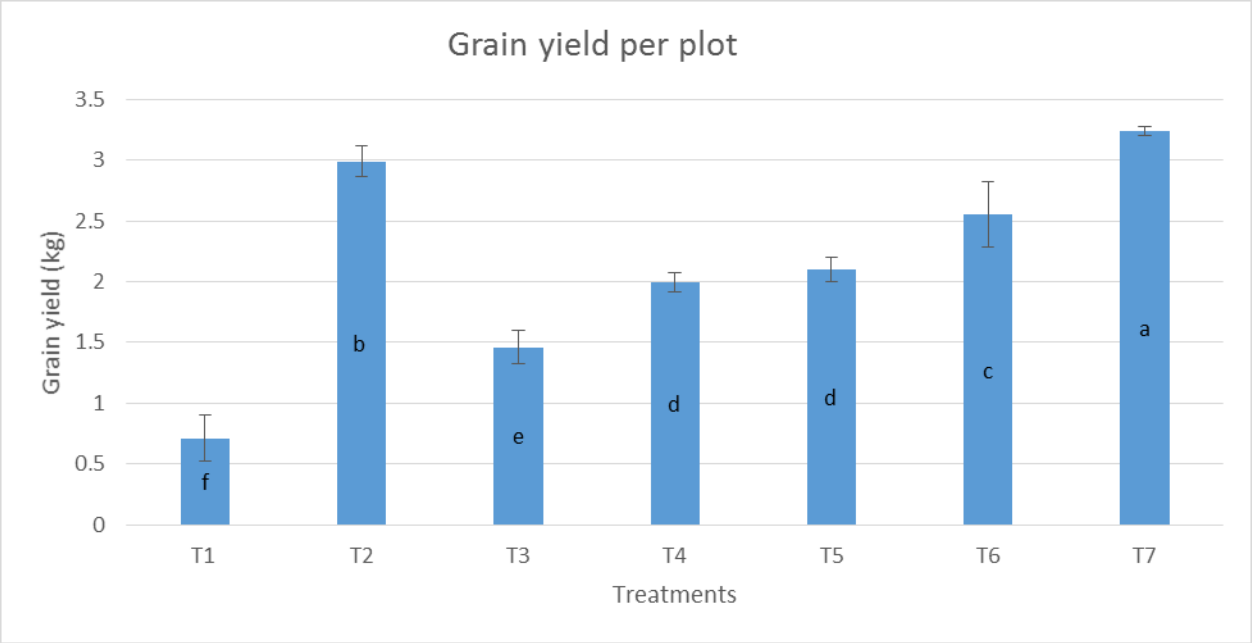
The treatment T_2 (100% Recommended dose of NPK) was followed by T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) with 2.55 kg per plot.

Least grain yield was observed in treatment T_1 (control) with 0.71 kg per plot. The treatment T_4 (100% Vermicompost) and T_5 (100% Farm Yard Manure) were similar.

Table 4.9 Effect of different level of organic and mineral fertilizers on grain yield of maize:

Treatments	Value ± Std.Er
T_1 (control)	0.71f±0.19
T_2 (100% Recommended dose of NPK)	2.99b±0.13
T_3 (50% Recommended dose of NPK + 50% Vermicompost)	1.46e±0.14
T_4 (100% Vermicompost)	1.99d±0.08
T_5 (100% Farm Yard Manure)	2.10d±0.1
T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure)	2.55c±0.27
T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost)	3.24a±0.04

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.



T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost).

The mean followed by different alphabets are significantly different at the $p<0.05$, according to Duncun's multiple range test (DMRTC) for separation of means.

Figure 4.9 Effect of different level of organic and mineral fertilizers on grain yield of maize

4.3 Economic calculation and analysis:

Economic analysis is done to calculate the net profit gained from the method followed. In this research, different sources of fertilizers were given. Different fertilizers have different cost of cultivation as well as different yield. In this analysis, we have calculate the maximum profit gained from treatments. For production of maize, on farmer level, B:C ratio must be more than 1. Less than 1 ratio has poor economic performance. Less than 0 has loss faced by crop grower.

Table 4.10 Economic analysis of different sources of nutrients:

Treatment	Cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
1	22550	30153	7603	0.33
2	25850	78253	52403	2.02
3	25450	41278	15828	0.62
4	32550	54082	21532	0.66
5	34550	56750	22200	0.64
6	28550	67625	39075	1.36
7	29700	84300	54600	1.83

Discussion

Plant height (cm) on 30, 60 and 90 days after sowing:

Plant height was found significantly higher in treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost). It was followed by T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_2 (100% Recommended dose of NPK). The higher results were obtained in the treatment with combine sources of nutrients from inorganic, vermicompost and FYM. Nitrogen is the main component of chlorophyll, hence it plays crucial role in photosynthesis process. Plant height depends on the food. More photosynthesis will possess more vegetative growth. In this case, inorganic source meets need of nitrogen during critical period because chemical sources provide quick nitrogen. FYM and vermicompost gives better result because of its slow mineralization. According to Channabasanagowda *et al*., (2008), nitrogen is released slowly through vermicompost due to slow mineralisation which helps plant to attain growth for longer period. Treatment T_2 (100% Recommended dose of NPK) was not significant because chemical source of nutrients has higher rate of nitrogen leaching. Hoque (1999) finds that when compost applied with chemical fertilizer, plant height was significantly increased.

Stem girth (g) on 30, 60 and 90 days after sowing:

Stem of a plant is that major part which connects roots to the leaves, branches and other parts of plants. Width of stem girth plays an important role in ease of transportation of product of photosynthesis, minerals and water. Wider the stem girth will result in higher ease to transportation through xylem and phloem.

From this research, it was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) shows significant result than other. But other treatments were similar to each other except control which is least in stem girth.

We can conclude that, combination of inorganic and organic sources gives better results. Vermicompost gives better plant growth due to presence of growth hormones, enzymes and other secretion of earthworms which stimulates the development and growth of plant.

Number of green leaves on 30, 60 and 90 days after sowing:

Plant which has higher number of green leaves represents that availability of nitrogen to the plant is sufficient. Plants have lesser number of green leaves during 90 days after sowing due to early maturity stage. Plants start yellowing from surface to upward.

In this research, T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has significant higher number of green leaves but it was similar to T_2 (100% Recommended dose of NPK) and T_4 (100% Vermicompost). It shows that combination gives best results, but 100% vermicompost also shows significant results. Humic acid is present in vermicompost improves morphological traits of the plant. It also increases the plant height and increases the period of slow growth. According to (Albayrak and Camas., 2005), it was found that humic acid increases leaf expansion and leaf area index.

Slow availability of nitrogen through FYM and vermicompost for longer period helps the plants to have higher green leaves.

Number of internodes on 30, 60 and 90 days after sowing:

Number of internodes does not vary much by providing different sources. Variation in length of internodes affects plant height. During this research it was found that T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher number of internodes. But it was similar to the T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost) and T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure). During 60 days after sowing almost all treatments were similar except control.

Number of cobs per plant:

In this research, it was found that most of plants have one fully developed cob and one immature cob. In some case, there were two fully developed cobs. Treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has highest number of cobs per plant, mean value of 1.33. It has 24.81% higher number of cobs per plant than all other treatments.

Vermicompost and FYM provides nitrogen for longer period that results almost same number of cobs.

Cob length:

After harvesting, cob length was recorded with the help of measuring tape in cm. It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher cob length. Higher the cob length will result in higher grain yield. If the cob length increases significantly than production of maize can be increased.

In this research, combination of FYM, vermicompost and inorganic sources gives better result. It proves that if integrated nutrient management is performed in field, quantitative and qualitative needs of maize crop can be meet. Inorganic source provides quick nitrogen to the plant, when it needs in abundance amount. Otherwise, organic sources like FYM and vermicompost provides nutrients on slow basis. Loss through leaching by inorganic sources can be reduced.

Sujatha (2008) suggests that if we use organic source such as vermicompost, with inorganic sources, it has positive result on assimilates remobilization. With integrated nutrient management, nutrition is balanced and adequate supply of photosynthesis is there for development of sink.

Number of grains per cob:

Number of grains per cob were counted. Data was recorded and it was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher number of grains in single cob. It has 459 grains in single cob, which is 49.72% higher number than control.

It was followed by treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_2 (Recommended dose of NPK) with grains number 381.22 and 363, respectively.

This proves that if a field is treated with combination of all available resources, in this case vermicompost, FYM and inorganic source, than number of grains can be obtained higher. FYM when applied in combination to inorganic also had significant results.

Test weight (1000 grains):

This parameter is one of major factor influencing quantitative and qualitative factor of maize crop. By analysing the data, it was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher test weight. It was similar to treatment T_2 (Recommended dose of NPK), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and (100% Vermicompost).

This result proves that grain size and grain weight is not much affected by different sources. Vermicompost when applied in full dose, it has no impact on test weight. Also, FYM when used in combination has good results.

Grain yield:

It was found that treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) has higher yield. Higher cob length, more number of grains per cob and more grains per plant results in higher grain yield.

Inorganic source provide NPK in good amount and other micronutrients as well as macro nutrients were fulfilled by vermicompost and FYM.

According to Choudhary and Jat (2006) vermicompost plays an important role in supplying the easily assimilated micro and macronutrients to plant and transporting the unavailable nutrients into available form.

Vermicompost and FYM indirectly improves the physical condition of soil and provides better aeration to plant roots and helps in the absorption of water (Mannivannan., (2009). Mahesh *et al*., (2010) finds that if FYM is applied with inorganic sources, it provides higher uptake of NPK. Increased mineralisation of nitrogen and constant release of N due to transformation process in FYM helps in higher uptake.

If inorganic salt are in abundance amount than fully organic condition have lower growth of plant (Arancon and Edwarads., 2009)

So we can conclude that, if organic sources are applied along with inorganic, than higher grain yield could be achieved.

CHAPTER 5

Summary and Conclusion

5.1 Summary:

A field experiment is designed in randomized block design, which consists of 7 treatments with three replications performed at the Agricultural Research Farm of Lovely Professional University, Jalandhar, Punjab during *kharif* season of year 2016. Aim was set to check the "Effect of Integrated Nutrient Management (INM) in *Kharif* Maize (*Zea mays*.L)". The experiment was conducted in the research field of Lovely Professional University located at 31°14'43.8"N &75°41'44.1"E. The site is situated above 252m mean sea level with an average elevation. This region comes under central plain zone of climatic zone of the state. The experiment was planned with 7 treatments and laid out in Randomized Complete Block Design with 3 replications. The unit plot has size of 2 x 3 = 6 m^2 and total number of plots were 21. The treatments consisted of T_1 (control), T_2 (100% Recommended dose of NPK), T_3 (50% Recommended dose of NPK + 50% Vermicompost), T_4 (100% Vermicompost), T_5 (100% Farm Yard Manure), T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure) and T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost). The high yielding variety P3396 was used. The salient result of investigation are given below:

Observations were recorded from treatments on growth (plant height, stem girth, number of green leaves and number of internodes), yield attributes (number of cob per plant, cob length, number of grains per cob) and yield aspects (1000-grain test weight and grain yield). Results obtained are summarised as below.

Application of combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) gave significantly higher plant growth at observation recorded on 30, 60 and 90 days after sowing (80.99 cm, 233.92 cm and 238.47 cm) over other treatments. Significantly wider stem girth was recorded on 30, 60 and 90 days after sowing (9.9 cm, 11.17 cm and 12.30 cm) by applying three sources of nutrients in combination. It gave higher number of green leaves and higher number of internodes on 30, 60 and 90 days after sowing (11.33, 15.33 and 10.33) and (9.22, 17.66 and 18.10), respectively. Combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) gave significantly higher number of cobs per plant at observation recorded on harvesting (1.33) over other treatments.

This treatment results significant higher cob length, number of grains per cob, test weight of 1000 grains and grain yield of 15.72 cm, 459, 219 g and 5400 kg per hectare, respectively.

Treatment T_2 (100% Recommended dose of NPK) also has good results. It has similar test weight of 214 g to treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost). It has second highest plant height of 195.51 cm but similar to treatment T_6 (50% Recommended dose of NPK + 50% Farm Yard Manure). It has stem girth, number of grains per cob, cob length and grain yield of 11.29 cm, 363, 14.02 cm and 4983 kg per hectare, respectively.

Treatment in which chemical fertilizer was given in combination with FYM (50% Recommended dose of NPK + 50% Farm Yard Manure) has cob length recorded 15.33 cm. It was significant over control and similar with treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost). It has similar test weight of 213.33 g to the treatment T_7 (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost). It has 381.22 no of grains per cob, 11.53 cm stem girth and 203.47 cm plant height.

Least observations were recorded from T_1 (control) where no fertilizers were used.

5.2 Conclusion:

On the basis of result obtained and summarised in the previous text, following is the fact concluded:

- Application of combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) was found the most suitable dose of fertilizer to be adopted as it gives significantly higher performance in growth parameters (plant height 238.47 cm, stem girth 12.3 cm, number of green leaves 15.33 and number of internodes 18.10), yield attributes (1.33 cobs per plant, cob length 15.72 cm and 459 grains per cob) and yield aspect (test weight 219 g and grain yield 5400 kg ha^{-1}).

- In view of above, it is concluded that cultivation of maize under agro-climatic condition of Punjab, apply combination of FYM, vermicompost and chemical fertilizer (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) to achieve higher productivity and best choice of sources for integrated nutrient management.

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Appendix-I

Work was done in agricultural research farm at Lovely Professional University during *kharif* 2016 on maize crop.

A1. Work timeline:

Date of Performance	Work Performed
13 June 2016	Allotment of field
13-16 June 2016	Field Preparation + Application of Vermicompost, FYM
17 June 2016	Application of fertilizers as per treatments
18 June 2016	Seed Treatment + Seed Sowing + Irrigation
19 June 2016	Atrazine (Herbicide) Spray
25 June 2016	Chloropyriphos (Insecticide spray)
7-8 July 2016	Hand Weeding + Earthing up
18 July 2016	30 DAS observation taken
18 July 2016	Irrigation
20 July 2016	2nd Split of fertilizers was applied
1 August 2016	Spray of insecticide
3-5 August 2016	Weeding
6 August 2016	Irrigation
16 August 2016	Irrigation
18 August 2016	60 DAS observations taken
19 August 2016	3rd Split of fertilizer was applied
23-25 August 2016	Hand weeding in the plots
18 September 2016	90 Days observation taken
25 September 2016	Harvesting + Observations
26–29 September 2016	Drying in main field
30 September 2016	Cobs shifted to Polyhouse field for drying

Appendix II

General cost of maize production (Rs/ha) during research trial according to market values of resources**.**

A-2: General cost for maize production:

Components	Cost of resources (Rs/ha)
Land preparation	5000
Seed, seed treatment insecticide, sowing	8500
Fertilisers	3600
Herbicides/insecticides	1000
Hand weeding (labour)	10000
Harvesting and threshing	6000
Total	34100

Appendix III

A-3: Standard chart of soil chemical properties to determining the fertility status of experimental soil.

Ingredients	Low	Medium	High
Soil pH	<6.0	6.0-8.7	>8.8
Organic matter (%)	<0.4	0.4-0.75	>0.75
Available N (%)	<0.10	0.1-0.2	>0.2
Available P_2O_5 (Kg/ha)	<30	30-55	>55
Available K_2O	<110	110-280	>2

Appendix IV

ANOVA

				Sum of Squares	df	Mean Square	F	Sig.
Replication	Between Groups	(Combined)		.000	6	.000	.000	1.000
		Linear Term	Contrast	.000	1	.000	.000	1.000
			Deviation	.000	5	.000	.000	1.000
	Within Groups			14.000	14	1.000		
	Total			14.000	20			
Plant Height 30 DAS	Between Groups	(Combined)		7114.075	6	1185.679	172.587	.000
		Linear Term	Contrast	3627.823	1	3627.823	528.063	.000
			Deviation	3486.252	5	697.250	101.491	.000
	Within Groups			96.181	14	6.870		
	Total			7210.256	20			
Plant Height 60 DAS	Between Groups	(Combined)		22742.689	6	3790.448	107.836	.000
		Linear Term	Contrast	12076.568	1	12076.568	343.571	.000
			Deviation	10666.121	5	2133.224	60.689	.000
	Within Groups			492.102	14	35.150		
	Total			23234.790	20			
Plant Height 90 DAS	Between Groups	(Combined)		21842.111	6	3640.352	38.914	.000
		Linear Term	Contrast	11879.537	1	11879.537	126.988	.000
			Deviation	9962.574	5	1992.515	21.299	.000
	Within Groups			1309.674	14	93.548		
	Total			23151.785	20			

Stem Girth 30 DAS	Between Groups	(Combined)		26.210	6	4.368	8.052	.001
		Linear Term	Contrast	5.462	1	5.462	10.067	.007
			Deviation	20.748	5	4.150	7.648	.001
	Within Groups			7.596	14	.543		
	Total			33.806	20			
Stem Girth 60 DAS	Between Groups	(Combined)		4.952	6	.825	6.372	.002
		Linear Term	Contrast	1.599	1	1.599	12.345	.003
			Deviation	3.353	5	.671	5.177	.007
	Within Groups			1.813	14	.130		
	Total			6.766	20			
Stem Girth 90 DAS	Between Groups	(Combined)		7.552	6	1.259	10.426	.000
		Linear Term	Contrast	4.329	1	4.329	35.860	.000
			Deviation	3.223	5	.645	5.339	.006
	Within Groups			1.690	14	.121		
	Total			9.242	20			
Number of Green Leaves 30 DAS	Between Groups	(Combined)		40.846	6	6.808	19.676	.000
		Linear Term	Contrast	13.884	1	13.884	40.128	.000
			Deviation	26.962	5	5.392	15.586	.000
	Within Groups			4.844	14	.346		
	Total			45.690	20			
Number of Green Leaves 60 DAS	Between Groups	(Combined)		24.708	6	4.118	16.275	.000
		Linear Term	Contrast	11.198	1	11.198	44.257	.000
			Deviation	13.510	5	2.702	10.679	.000
	Within Groups			3.542	14	.253		

	Total			28.251	20			
Number of Green Leaves 90 DAS	Between Groups	(Combined)		21.537	6	3.589	15.106	.000
		Linear Term	Contrast	8.048	1	8.048	33.867	.000
			Deviation	13.489	5	2.698	11.353	.000
	Within Groups			3.327	14	.238		
	Total			24.863	20			
Number of Internodes 30 DAS	Between Groups	(Combined)		40.149	6	6.691	13.706	.000
		Linear Term	Contrast	17.913	1	17.913	36.691	.000
			Deviation	22.236	5	4.447	9.109	.001
	Within Groups			6.835	14	.488		
	Total			46.983	20			
Number of Internodes 60 DAS	Between Groups	(Combined)		37.230	6	6.205	10.876	.000
		Linear Term	Contrast	20.632	1	20.632	36.164	.000
			Deviation	16.598	5	3.320	5.819	.004
	Within Groups			7.987	14	.571		
	Total			45.217	20			
Number of Internodes 90 DAS	Between Groups	(Combined)		26.109	6	4.352	18.313	.000
		Linear Term	Contrast	13.233	1	13.233	55.688	.000
			Deviation	12.877	5	2.575	10.838	.000
	Within Groups			3.327	14	.238		
	Total			29.436	20			
Number of Cobs per Plant	Between Groups	(Combined)		.286	6	.048	1.000	.463
		Linear Term	Contrast	.107	1	.107	2.250	.156
			Deviation	.179	5	.036	.750	.600

	Within Groups			.667	14	.048		
	Total			.952	20			
Cob Length	Between Groups	(Combined)		62.210	6	10.368	19.116	.000
		Linear Term	Contrast	41.736	1	41.736	76.950	.000
			Deviation	20.474	5	4.095	7.550	.001
	Within Groups			7.593	14	.542		
	Total			69.803	20			
Number of Grains per Cob	Between Groups	(Combined)		84239.381	6	14039.897	31.643	.000
		Linear Term	Contrast	55392.787	1	55392.787	124.845	.000
			Deviation	28846.594	5	5769.319	13.003	.000
	Within Groups			6211.708	14	443.693		
	Total			90451.089	20			
Test Weight	Between Groups	(Combined)		1708.571	6	284.762	5.269	.005
		Linear Term	Contrast	804.762	1	804.762	14.890	.002
			Deviation	903.810	5	180.762	3.344	.034
	Within Groups			756.667	14	54.048		
	Total			2465.238	20			
Grain Yield	Between Groups	(Combined)		12.590	6	2.098	28.656	.000
		Linear Term	Contrast	9.320	1	9.320	127.281	.000

	Term Deviation	3.270	5	.654	8.931	.001
	Within Groups	1.025	14	.073		
	Total	13.615	20			