Effect of Integrated Nutrient Management on Growth, Yield and Quality Parameters of Maize (*Zea mays* L.)

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APRIL, 2014

DECLARATION

I hereby declare that the work presented in the Thesis entitled "**Effect of integrated nutrient on growth, yield and quality parameters of maize (*Zea mays* L.)"** is my own original research work. The work has been carried out by me at School of Agriculture, Lovely Professional University, Phagwara, Punjab, India under the guidance of **Dr. Amit Kesarwani,** Assistant Professor for the award of the degree Master of Science in Agronomy.

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I certified that the above statement made by the student is correct to the best of my knowledge and belief.

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CERTIFICATE

This is to certify that work embodied in this Thesis report entitled **"Effect of Integrated Nutrient Management on Growth, Yield and Quality Parameters of Maize (*Zea mays* L.)"** has been carried out by **Auwal Tukur Wailare, Registration No.: 11209834** under my guidance and supervision**.** To the best of my knowledge, the present work is the result of his original investigation and study. No part of this thesis has ever been submitted for any other degree or diploma. The work has been carried out by him at the School of Agriculture, Lovely Professional University, Phagwara, Punjab, India. He fulfilled the requirement for the award of the degree Master of Science in Agronomy.

Date:

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DEDICATION

This research project thesis is dedicated to my beloved Mother's Fatima Ibrahim Gaya and my Father Muhammad Tukur Wailare as well as my late sister Salma Tukur Wailare.

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LIST OF ABBREVIATION

S/No.	Abbreviations		
1	INM	-	Integrated Nutrients Management
2	RDF	-	Recommended Dose of Fertilizer
3	PM	-	Poultry Manure
4	FYM	-	Farm Yard Manure
5	TW	-	Test weight
6	kg/ha	-	Kilo grams per Hectare
7	dS/cm^2	-	desi Seimon per square centimeter
8	AGR	-	Absolute Growth Rate
9	cm^2	-	Square centimeter
10	M	-	Meter
11	OC	-	Organic carbon
12	EC	-	Electrical Conductivity
13	pH	-	Potentials of Hydrogen

14	t/ha	-	tonnes per hectare
15	g/plant	-	Grams per Plant
16	DAS	-	Days After Sowing
17	HI	-	Harvest Index
18	CP	-	Crude Protein
19	LA	-	Leaf Area
20	LAI	-	Leaf Area Index

ABSTRACT

A field experiment was conducted during the winter season of 2013 at a main research field of the School of Agriculture Lovely Professional University, Phagwara, India to study "Effect of integrated nutrient management on growth, yield and quality parameters of maize (Zea mays L.)" The trial was laid out in Randomized Complete Block Design (RCBD) replicated three (3) times. At the beginning of the trial the soil was analyzed and reported properties were sandy clay loam in texture with slightly alkaline pH (7.90) having a medium status of available nitrogen and phosphorus as well as high status of available potassium. Maize hybrid variety (DuPont Pioneer-31Y45) was used as experimental material for sowing purpose. Various sources of nutrients such as Recommended Dose of Fertilizers (RDF) i.e., 120:60:40 kg NPK/ha, Poultry Manure (PM), Farm Yard Manure (FYM) were used at different ratio. The treatments consisted of eight (8) various combinations viz. T_1 (100% RDF), T_2 (5t FYM + 50% RDF), T_3 (5t PM + 50% RDF), T_4 (5t FYM + 100% RDF), T_5 (5t PM + 100% RDF), T_6 (5t each of FYM & PM + 50% RDF), T_7 (2.5t each of FYM & PM + 50% RDF) and T_8 (2.5t each of FYM & PM + 100% RDF). The growth parameters such as leaf area (531cm^2), absolute growth rate (4.8 g/day/plant) and shoot dry matter production (78.1 g/plant) were found to be higher under either T_3 (PM 5t/ha + 60:30:20 kg NPK/ha) or T_6 (5t/ha each of PM+FYM+50% RDF) which are statistically on par but comparatively higher than T_1 i.e. 100% RDF (120:60:40 kg NPK/ha). The yield parameters like number of grains per cob (417), weight of cob with husk (356.7 g/cob), cobs weight (1171.3 g/plant), 100 grains weight (35.1 g) and stover yield (13.8 t/ha) were recorded maximum under INM (Integrated Nutrient Management) of T_3 (50% RDF + 5t/ha PM) compare to T_1 (100% RDF) and others. The effect of INM on quality parameters such as crude protein (11.7%) and moisture content were recorded higher under the effect of T_3 and T_4 respectively, than control where sole application of 100% RDF (120:60:40 kg NPK/ha) was used. The nutrients (NPK) uptake as well as soil organic carbon and available nitrogen were recorded higher under T_3 (PM 5t/ha + 50% RDF) treatment than T_1 where only 100% RDF was applied, whereas soil available phosphorus was recorded maximum under T_4 (5t/ha FYM + 100% RDF) compare to control and other treatments combination.

Key words: Maize shoots dry matter, organic farming, nutrients management, soil properties and poultry manure.

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CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) originated from Mexico which later spreads throughout the Europe during trading time and other parts of the World as a major staple food. Maize was introduced in the early 16^{th} century into Europe and spread to other European countries during the rest of their conquer period. It is among the most widely grown crops and its cultivation ranging from equatorial region of 50° NS and up to 3000m above mean sea level (Ma and Subedi, 2009). Maize was domesticated at about 7000 BC years ago (Chennankrishnan, *et al*., 2012). It is also called a 'miracle crop' and or a 'queen of cereals' due to high yield potential among other cereals. As a C4 plant; maize possesses higher energy efficiency converting the energy received from solar radiation into dry matter (Kannan *et al*., 2013).

Maize is one of the most important cereal crop in the world agriculture as food, feed and industrial raw material which ranked third largest cereals following rice and wheat respectively (Amanullah *et al*., 2007 and Dilshad *et al*., 2010). In India, it is grown in more than 8.33 m. ha, having a production of 16.68 mt and average productivity of 2002Kg ha^{-1} (Ravi, *et al*., 2012). It is grown across a wide range of agro ecological zones, due to its wider adaptability. In India, Andhra Pradesh was reported to be the largest producer of maize among the producing state contributing 21 per cent (%) of total production, followed by Karnataka 16%, Rajasthan 10%, Bihar and Maharashtra 9% each as well as Uttar Pradesh and Madhya Pradesh each contribute 6% (Chennanakrishnan, *et al*., 2012).

Maize was considered as a stable food for about 900 m consumers and about one third of all underfed children. However, it was reported that by the year 2050, the demand of maize in developing nations will be double and also by the year 2025 it will be rank globally and in developing nations the crop with highest production (CIMMYT and IITA, 2010). The contribution made by developing countries is less than developed countries sharing only about 46% to the world production but former occupying a largest percentage of the world maize cultivated land, whereas USA and China together produces approximately 60% of world maize production (Ghaffari, *et al*., 2011). However, several different factors contribute to low yield production in developing countries like selection of poor seeds, lack of hybrids, less optimal plant density in growing field, inadequate access to finance by producers, variable climatic condition and poor management practices at different stages of growth and development. FAOSTAT 2008 reported that, North America contributes largest share (38.8%) of world maize production, followed by Asia (28.5%), South America (11.2%), Europe (11.1%), Africa (6.9%) as well as Central America (3.4%) and Oceania (0.07%).

Majorly poor management of fertilizer has key role to play in obtaining low yield productivity, so in order to achieve optimum crop productivity management of nutrients through judicious application of organic sources, bio-fertilizers and micro-nutrients are required (Ghaffari, *et al*., 2011). Furthermore, the fertilizer management is one of the most important factors that influence the growth and yield of maize crop. Maize is considered as most exhaustive crop after sugar cane and requires both micro and macro nutrients to obtain high growth and yield potentials. In fact, organic nutrients not only provide plant with nutrients but also improve and or sustain the soil health. The micronutrients content in organic manure may be sufficient enough to meet the crop production requirement but problem of low soil fertility is one of the obstacles to maintain and sustain agricultural production and productivity (Verma, 2011, Ahmad, *et al*., 2011 and Kannan, *et al*., 2013).

Some of the beneficial effect of organic manure includes reduction in cultivation cost, production of highly nutritious food without residual toxicity which can deteriorate human health and also maintain ecological balance (Verma N.K., 2011). However, modern agriculture depends on intensive used of chemical fertilizer for higher production, though the negative impact have been reported as it deteriorate the health of soil and at the same time sole use of organic manure will not produce desired yield because of low status of nutrients(Ravi, *et al*., 2012). Furthermore, nitrogen is the major nutrient needed for optimum harvest approximately about 150 Kg N ha^{-1} and it has been reported that judicious application of Nitrogen from organic and inorganic sources may possibly maximize maize productions as well as improving grains quality (Verma, N.K., 2011).

Integrated nutrient management (INM) is a judicious use of organic and inorganic sources of nutrient to crop fields for sustaining and maintaining soil productivity. However, the use of appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solutions to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity. Hence, judicious application of these combinations can sustain the soil fertility and productivity.

However, due to above points the main purpose of this research is to find out the "Effect of Integrated Nutrient Management (INM) on growth, yield and quality of maize crop" on the bases of the following objectives;

1. To study the effect of INM on growth and yield parameters of hybrid maize crop species,
2. To study the effect of INM on quality parameters of hybrid maize crop species and
3. To study the physic-chemical properties before and after cultivation of hybrid maize.

CHAPTER TWO

REVIEW OF LITERATURE

Integrated nutrient management in maize has a paramount importance in sustaining and maintaining the soil health. However, the organic source sustained crop productivity and microbial populations at productive levels better than mineral fertilizer treatments, whereas the used of sole nitrogenous fertilizers was found to cause the hazardous effect on productivity of crop and soil living organism in the field.

Mahaja *et al*. (2007) reported that, the chemical fertilizers was found to be one of the imperative factors that contribute to the increase in productivity of our agricultural system of farming and these were also found to cause hazardous effect on soil environment if not apply judiciously. Hence, this chapter will focus on the effect of combine use of both organic manure and inorganic (mineral) fertilizers on maize productivity and uptake of nutrients by the plant at harvesting time.

2.1 Effect of INM on growth parameters of maize (*Zea mays* L.)

A field study conducted at Vanavavarayar Institute of Agriculture and the result shows that, integrated nutrient management has positive effect on growth parameters of maize such as leaf area and plant height (Kannan *et al*., 2013). Similarly, a field trial was conducted at University of Agriculture Faisalabad Pakistan in their Agronomic trial field and the result shows that, the combining ability of poultry manure with single super phosphate result in positive increase in growth parameter of maize such as leaf area index and crop growth rate (Ali *et al*., 2012). It was also reported that, the integrated nutrient management has significant effect on growth parameters of maize crop which was found in a field trial conducted at ICAR research field Umiam, Meghalaya (Panwar, 2008).

Haq, (2006) conducted a field trial at Shalimar Campus Kashmir and reported that, the combination of FYM and mineral fertilizer significantly increases the growth parameters of maize like plant height, leaf number and Leaf Area Index. Maize crop vigor was observed to be better under integrated nutrient management than sole application of FYM or Urea in a field trial conducted at Makawanpur District of Nepal (Chapagain, 2009, 2010). Similarly, Mahajan *et al*.

(2007) conducted a field trial at Kangra district of Himachal Pradesh and reported that, the integrated used of both organic and inorganic manure has positive effect on the total productivity of maize crop than sole used of mineral fertilizer.

Bhagade *et al*. (2008) conducted a field trial at Konkan region of India and reported that, the growth attributes (dry matter content) was found to be significantly increase through the use of organic and inorganic sources of nutrients. A field trial conducted at University of Agriculture, Faisalabad-Pakistan and reported that growth parameters of maize was found to be increased, due to effect of the use of different sources of nutrients (Ghaffari, *et al*., 2011). Similarly, the chlorophyll content of leaf of baby corn was found to be significantly increased due to combine application of bio-fertilizers with vermicompost which was found out during a field trial at central Institute of temperate Horticulture regional station Uttarakhand-India (Ranjan, *et al*., 2013).

Mujeeb *et al*. (2010) conducted a research trial in green house at Agricultural University, Faisalabad – Pakistan and suggested that, the integrated application of organic and inorganic P improved the agronomic parameters in maize field significantly than the application of P from single source. Ravi *et al*. (2012) in their research trial conducted at agricultural research station Arabhavi of Karnataka and they revealed that, the growth parameters of quality protein maize (plant height, leaf area index and dry matter production) were significantly higher with the application of both organic and inorganic sources of nutrients.

Uwah *et al*. (2011) conducted a field trial at University of Calabar, Nigeria and revealed that, the total dry matter of sweet maize was found to be maximum due to the application of 10t/ha poultry manure plus 80Kg N/ha. Furthermore, a field trial conducted at Institute of Agriculture, Sriniketan, Birbhum-West Bengal and reported that leaf area and total chlorophyll content of baby corn was found to be higher with integrated used of organic and inorganic sources as well as bio-fertilizer (Masedul *et al*., 2011). Leaf area and leaf area index were found to be significantly higher in plots with organic manure (vermicompost or FYM) treatment than in their absence (Jayaprakash *et al*., 2005).

Ashok *et al*. (2008) revealed that significant increase in dry matter production of maize crop was obtained with the application of 2 t vermicompost and 10t FYM per ha. Vasanti and

Kumar (2000) also revealed significant increase in plant height and dry matter content were found with application of 10t poultry or sheep/goat manure plus 50% recommended dose of fertilizer. Singh *et al*. (2009) reported that, significant increase in growth parameters were found through the integration of 75% and 25% nitrogen from inorganic and organic source, respectively and similar result were found with the application of 50% N each from inorganic and organic source.

Efthimiadou *et al*. (2009) revealed that the use of poultry manure can increase the rate of photosynthesis, stomatal conductance and the content of chlorophyll in plant. Similarly, it was revealed that all the growth parameters were significantly influenced with the substitution of 50% NPK through either poultry or goat manure along with Azospirillum and Phosphobacteria (Thavaprakaash *et al*., 2005). Akinrinde *et al*. (2006) reported that, the integration of poultry manure along with $ZnSO_4$ resulted in maximum shoot biomass.

The higher plant height and dry matter accumulation were obtained through the application of 75% RDF integrated with 2.25 t vermicompost per ha and bio-fertilizers than other treatments (Dadarwal *et al*., 2009). Similarly, it was observed that continous application of FYM enhanced the crop growth and also increases root biomass (Na'eem *et al*., 2009).

In a field experimental trial conducted at college of agriculture, Pune-India, the result revealed that application of 100 per cent RDF (225:50:50 Kg N: P_2O_5: K_2O per ha) plus 5t FYM along with Azotobacter and PSB resulted in significant increase in all the growth parameters of sweet corn (LAI, AGR, LA and total dry matter production) over application of other fertilizer with FYM (Wagh, 2002). Similarly, absolute growth rate (AGR) and crop growth rate (CGR) were found to be higher through the application of recommended package practices with the use of fertilizers and FYM (Bhupenchandra *et al*., 2009). It was also reported that, the drilling of 2 t/ha of vermicompost resulted in significant increase in LAI and dry matter accumulation at harvest and 40 DAS over application of 1t per ha of vermicompost (Narolia *et al*., 2009).

All the growth characteristics and total yield of maize crop were found to be influenced through integrated application of nutrients and were reported to be highest with 100% RDF, followed by 75% N through RDF plus 25% N through *Leucaena lopping* plus bio-fertilizer (Gable et al., 2008). Biradar *et al*. (2001) reported that, LAI and CGR were extremely higher due to the application of vermicompost on neem seeds as a potting medium. Rana and Shivran (2003) conducted a field experiment at IARI, New-Delhi and they suggested that, LAI and dry matter production of maize can be significantly enhanced due to integration of 5t per ha of FYM along with dust mulch over treatment without mulch or with sole application of mulch.

2.2 Effect of INM on yield parameters of maize (*Zea mays* L.)

Kannan *et al*. (2013) in their research trial conducted at Vanavavarayar Institute of Agriculture reported that, integrated nutrient management shown the superior result on yield characters of maize like 100 seed weight, number of grain per cob and yield of 4112 Kg/ha due to combined effect of vermicompost and recommended dose of NPK. Ali *et al*. (2012) in their field trial conducted at the University of Agriculture Faisalabad Pakistan in their Agronomic trial field and they reported that, significant increase in yield like 1000 seed weight and maize grain yield was obtained due to integration of both organic and inorganic manure. Ravi *et al*. (2012) in their research trial conducted at agricultural research station Arabhavi of Karnataka and they also confirmed that, the use of 75 per cent RDF with other organic and bio-fertilizer significantly increases the grain yield of quality protein maize.

Dilshad *et al.* (2010) in their trial conducted at Arid Agriculture University research field, Rawalpindi-Pakistan and they reported that, due to the effect of integrated nutrient management from both organic and inorganic sources highest economic and biological yield of maize was obtained. In a field trial conducted at Shalimar Campus Kashmir, the result shown that, yield parameters such as cob length, grain number per cob and 1000- seed weight are higher due to combine effect of FYM and Mineral fertilizer NPK (Haq, S.A., 2006). Chapagain (2009, 2010) conducted a field trial at Makawanpur District of Nepal observed that, maize crop grain yield was found to be better under integrated nutrient management with FYM and NPK than sole use of FYM or Urea as source of N. Dixit and Khatik (2002) reported that significant increased in grain yield (16.00q/ha) and straw yield (30.75q/ha) of soybean crop were obtained through the application of 50% RDF along with 10t FYM over sole application of either 100% or 10t FYM.

Panwar (2008) conducted a field trial at ICAR research field Umiam, Meghalaya and reported that, the yield parameters of maize show significant increase with the application of 50 per cent N each from FYM and recommended doses of NPK. Furthermore, a field trial was conducted at Konkan region of India and they suggested that substitution of 25 per cent recommended doses of fertilizer with FYM will positively result in better green fodder yield production of maize (Bhagade, *et al.*, 2008). Ghaffari *et al.* (2011) conducted a field trial at central Institute of temperate Horticulture regional station Uttarakhand-India and reported that, the grain yield of maize was significantly increased as a result of the application of different sources of nutrients to the maize plant.

In another field trial conducted at Agricultural research farm, Hamirpur, Uttar Pradesh-India and reported that, more grain yield of winter maize up to 23.07% can possibly be obtained, due to the application of both organic and inorganic sources such as 7.5 t FYM plus 100 Kg N per ha respectively (Verma, N.K. 2011). Sarwar, *et al.* (2012) conducted a field trial at National Agricultural Research Centre, Islamabad-Pakistan and shows that, significant improve in the grain and straw yield of maize crop was observed through the substitution of 25 or 50 per cent of N with FYM. Ranjan *et al*. (2013) conducted a field trial at central Institute of temperate Horticulture regional station Uttarakhand-India and revealed that, the combine used of vermicompost together with bio-fertilizers resulted in significant increase in baby corn yield up to 18.57 q/ha.

Rao *et al*. (2010) conducted a field experiment in the central Karnataka-India and they shown that, the integrated use of nutrients under rain-fed condition will improve the maize productivity and profitability. Uwah *et al*. (2011) conducted a field trial at University of Calabar, Nigeria and they reported that, the cob yield and total grain yield of sweet corn was found to be significantly higher with the application of 10t/ha PM with 80Kg/ha N compare with the rest of treatments. However, yield parameters of baby corn were reported to be higher with the integration of both organic and inorganic nutrient source (Masedul, *et al*., 2011). Parasuraman *et al*. (2000) reported that significant improved of both grains and fodder yield were obtained through integration of recommended dose of fertilizer (RDF) along with FYM at rate of 40:20 Kg NP and 10t per ha respectively over control.

Mithun and Mondal (2006) conducted a field trial at Mohanpur, Nadia-West Bengal and reported that, yield parameters of baby corn (dehusked corn yield and standard baby corn yield) were significantly improved if organic manure and inorganic fertilizer was judiciously applied in baby corn field. Ashoka *et al*. (2008) reported that, yield parameters (ear length, ear girth, yield and green fodder yield) were significantly higher due to the application of RDF (150:75:40 Kg NPK ha^{-1}) along with the 25Kg each of $ZnSO_4$ and Vermicompost along with 10 Kg $FeSO_4$.

Thavaprakaash *et al*. (2005 and 2008) conducted a field on baby corn at Tamil Nadu Agricultural University, Combatore and reported that all the yield parameters were significantly increased with the substitution of 50% NPK through either poultry or goat manure along with Azospirillum and Phosphobacteria. Brar *et al*. (2001) reported that significant increase in both grain and Stover yield were obtained through the application of 150KgN:41.3KgP_2O_5 along with 10t FYM per ha over rest of the treatments. Similarly, integration of 60Kg N: 30Kg P_2O_5 along with 12t FYM per ha were found to be significantly influenced the yield parameters (cob diameter, cob length, grain number per cob and grain weight per cob) over rest of the treatments (Tripathi et al., 2004).

Shipashree *et al*. (2012) reported that the significant production of grain yield was resulted due to the application of FYM and Vermicompost along with mineral fertilizers NPK since organic source served as store house of many macro and micro nutrients which are released for plant metabolic activities. Furthermore, the increase of maize grain yield from 83.9 to 108.7% was also observed due to the integration of both fertilizers source (Sial *et al*., 2007). Rana and Shivran (2003) conducted a field experiment at IARI, New-Delhi and reported that, the yield parameters of maize (cobs number, cob length, grain weight per cob, grain number per cob and cob weight per plot) were significantly improved through integration of 5t FYM per ha along with dust or straw mulch over treatments with no mulch.

Ebrahimpour *et al*. (2011) reported that highest grain yield (number of rows per ear, kernel weight, number of grain per ear and harvest index) was obtained through the application of bio-fertilizer and 50% chemical fertilizer using seed inoculation along with fertigation method. Karki *et al*. (2005) reported that, the application of 120 Kg N plus 5 Kg Zn along with 10t FYM per ha will significantly increase the both grain and Stover yield.

Singh *et al*. (2009 and 2010) reported that, significant higher yield parameters and yield were recorded through sole application of 100% N over integrated application (75% N through RDF and 25% N through FYM as well as 50% N from both sources) except for baby cobs per plant and baby corn girth which were found higher through integration of 75% and 25% N from inorganic and organic sources, respectively.

Sharma *et al*. (2003) and Mugwe *et al*. (2009) both reported that, the grain yield of maize and wheat were found to be significantly increased through the integration of mineral fertilizers along with FYM compare with sole application of mineral fertilizers. Mahajan *et al*. (2007) concluded that, the integration of FYM and lime will sustain crop productivity and sole use of nitrogenous will impart hazardous effect on productivity of crop plant.

The integration of 120 Kg N with 10t FYM along with 5 Kg Zn per ha resulted in significant increase in grain and Stover yields (Karki *et al*., 2005). Similarly, the significant increase in grain and straw yield were reported due to the substitution of 25% or 50% N with FYM along with 4Kg Zn/ha higher than sole application of 100% fertilizer (Muhammad *et al*., 2012).The application of FYM along with Tithonia mulch resulted in significant increase of grain yield and it was also suggested that a farmers can apply this technology to acidic soil in order to improve the productivity of maize (Achieng *et al*., 2012).

Yadhav *et al*. (2006) reported that, integrated application of N fertilizer and FYM along with Zn proved best in term of grain and Stover yield, gross return, net return and cost benefit ratio of maize over their sole application. Wagh (2002) reported that integration of 100% RDF (225:50:50 Kg NPK per ha) along with 5t FYM per ha plus Azotobacter and PSB were significantly enhanced all the yield parameters (Cobs number, cob length, cob girth cob weight, grains number per cob and test weight) over treatments containing RDF and FYM alone. Similarly, Chandrakumar *et al*. (2004) revealed that, integration of RDF along with either 10t FYM or 1t poultry manure can significantly enhanced all the yield attributing characters which lead to improvement in grain yield by 10 and 7% respectively over sole application of RDF.

Dhoke *et al*. (2007) revealed that significant increased of grain yield was obtained through the integration of RDF along with *Leucaena lopping* and azotobacter as seed treatment. Singh and Agarwal (2004) reported that significant increased in grain yield was obtained through integration of RDF (120Kg N: 26.2Kg P: 25Kg $ZnSO_4$ per ha) along with 10t FYM over treatment with 180Kg N along with 10t FYM. Ramesh *et al*. (2008) reported that, highest grain yield (5122Kg/ha) of maize was obtained through sole application of chemical fertilizers and in linseed highest grain yield of 1025 Kg/ha was obtained through application of poultry manure alone.

Maheshbabu *et al*. (2008) observed that significant increased in grain yield (22.35q/ha) and yield components were obtained through application of RDF (40:80:25 Kg NPK per ha) along with 5t FYM. Anup *et al*. (2010) reported that significant higher yield of maize *viz*; grain yield (3.21 t/ha), 1000 seed weight (261.1g), grain weight per cob(385.3g), cob length (16.87cm) and cobs per plot (7.45) were obtained through application of 100% RDF along with 2.5t azolla compost over application of 50% RDF along with 2.5t azolla compost. Bhupenchandra *et al*. (2009) reported that significant higher stalk yield (697.4 Kg/ha) of tobacco was obtained with the application of recommended package of practices and lowest in press mud.

Urkurkar *et al*. (2010) reported that, integration of 50% N each of RDF and green manure resulted in highest rice and wheat yield as maintaining the sustainability of the system. Kumpawat (2010) reported that significant highest grain yield of mustard (1642 Kg/ha) was recorded through the application of 5t FYM along with azotobacter and PSB over rest of the treatments.

2.3 Effect of INM on quality parameters of maize (*Zea mays* L.)

Bhagade *et al*. (2008) conducted a field trial at Konkan region of India and reported that, some quality parameters like crude fat; crude protein and nitrogen free extract shows a positive result through the application of FYM and Urea as a nutrients source. Ghaffari *et al*. (2011) conducted a field trial at central Institute of temperate Horticulture regional station Uttarakhand-India and reported that, the maize quality parameters particularly oil contents were found to be significantly increased due to integrated effect of multi-nutrients than under recommended dose of NPK alone.

Verma (2011) reported that, the maize quality parameter was increases due to the use of 100 Kg/ha N together with 7.5 t/ha FYM respectively, than rest of the treatments used. The protein content of baby corn was reported to be significantly improved with the application of organic manure along with inorganic sources of fertilizers (Mithun and Mondal, 2006). Furthermore, a field trial was conducted in University of Agriculture Faisalabad-Pakistan and reported that oil contents of maize grains are found to be significantly increased with the application of combinations of NPK with multi-nutrients (Saracoglu, *et al*., 2011).

The quality parameters of sweet corn were found to be significantly higher through the integrated application of RDF and organic manure (Waghmode, 2010). Similarly, the protein content in grain and green fodder yield were slightly enhanced through integration of 100% RDF (225:50:50 Kg NPK per ha) plus 5t FYM along with Azotobacter and PSB over only fertilizer and FYM (Wagh, 2002). Furthermore, highest total carotenoides (2.53 mg/100g) and vitamin C (100.65 mg/100g) were obtained due to integration of 7.5t FYM along with 50% RDF and 3.0t vermicompost (Naik and Gupta, 2010).

The protein content of wheat grain was found to be significantly higher with the application of nutrients from different source namely, vermicompost and poultry manure @ 3.8t and 2.45 t/ha respectively (Channabasanagowda *et al.*, 2008). Similarly, it was reported that, the application of 25% recommended dose of nutrient RDF through vermicompost prepared from different source of organic wastes will result in higher protein content and total soluble sugar than the use of 25% of RDN through FYM (Khadtare, *et al*., 2006).

Dalvi *et al*. (2009) revealed that, increase of supply of N either through inorganic fertilizers or in combination with organic manure (FYM or Vermicompost) in the proportion of 50% each resulted in significant increase of reducing sugar, non-reducing sugar and total sugar content of sweet corn. Brar *et al*. (2001) reported that, significant increase in protein content (13.57%) and carbohydrate (65.34%) were obtained through application of 150 Kg N plus 41.3 Kg P_2O_5 along with 10t of FYM per ha over the remaining treatments. Similarly, protein content in maize was effectively increased with the integration of both organic and inorganic fertilizers (Singh and Nepalia, 2009). Maheshbabu *et al*. (2008) reported that significant increase in quality parameters (protein content (36.54%) and oil content (20%) of soybean) in seeds were obtained through integration of 40:80:25 Kg NPK per ha along with 5t of FYM.

2.4 Effect of INM on soil nutrients availability

Kannan, *et al*. (2013) conducted a field trial at Vanavavarayar Institute of Agriculture and the result shows that, integrated nutrient management significantly influenced the maximum increase in organic carbon as a result of integrated used of vermicompost and recommended dose of NPK. In a field trial conducted at University of Agriculture Faisalabad Pakistan in their Agronomic trial field and the result shows that integrated nutrient management is one of the good approach for nutrients management in the environmental balance (Ali *et al*., 2012).

In a field trial conducted at Shalimar Campus Kashmir the result revealed that, the available NPK in the soil after crop harvest shown negative result at lower doses of applied NPK, whereas at higher doses positive result was reported (Haq, S.A., 2006). In a field trial conducted at Oromia National Regional State, Ethiopia and was reported that, significant increase in the uptake of NPK and improve some important chemical properties of soil due to integrated used of organic manure and NP (Negassa *et al*., 2007). Furthermore, it was also reported that, the integrated uses of bio fertilizer and mineral fertilizer significantly improve the uptake of NPK over sole used of organic/mineral fertilizers (Dilshad *et al*., 2010).

Ghaffari *et al*. (2011) reported that, the nutrients use efficiency was improved up to 11.5% due to combined effect of recommended dose of NPK along with single spray of multi-nutrients. Sarwar *et al*. (2012) reported that, both organic matter content and nutrients uptake in the soil will be increase if 25 or 50 per cent of N is replace with FYM. Rao *et al*. (2010) also suggested that, the integrated application of nutrients in maize grown under rain fed maintain and sustain soil resources.

Significant increased in P uptake was reported to be better under combine use of both organic and inorganic P than sole application of P from any source (Mujeeb, *et al*., 2010). Similarly, higher nutrients (NPK) uptake and organic carbon were obtained due to the use of 75% RDF together with the organic form of manure (Mithun and Mondal, 2006). Saracoglu *et al*. (2011) revealed that, macronutrients use efficiency was improved due to application of nutrients from different source.

Shilpashree *et al*. (2012) revealed that, in addition to release of plant nutrients from organic matter, the organic acid produce during decomposition process also release the native nutrients on soil and increases their availability to plant. Ebrahimpour *et al*. (2011) reported that, significance increased of soil nutrients were observed due to use of bio-fertilizer and they concluded that non-chemical sources of crop nutrition provide a reliable alternative to chemical fertilization in organic crop production. Dadarwal *et al*. (2009) reported that, continuous application of FYM enhances the availability of NPK status of soil after harvest of baby corn.

Sharma and Banik (2012) revealed that, integration of 30% N through organic manure either FYM or vermicompost along with 70% recommended dose of NPK resulted in higher nutrient use efficiency as well as soil fertility. Similarly, it was reported that, increased in Zn uptake through the use of 120Kg N and 10t FYM along with 5Kg Zn per ha (Karki *et al*., 2005). Furthermore, postharvest soil fertility status was found to be improved through the application of 100% N from FYM (Kumar *et al*., 2009).

Singh *et al*. (2010) reported that with application of 180Kg N plus 38.7Kg P_2O_5 plus 74.7Kg K_2O per ha and 50% N supplied through FYM resulted in significant increase in available NPK in soil after harvesting baby corn. Bokhtiar and Saurai (2005) revealed that, significant increase in organic matter, NPK and S were observed through site application of organic manure. Mahajan *et al*. (2007) reported that, the sole use of nitrogenous fertilizer impart more deleterious effect on biological soil environment. The uptake of Zinc was reported to be highest by the crop through integration of poultry manure along with $ZnSO_4$ (Akinrinde *et al*., 2006).

Jat *et al*. (2013) reported the, the integration of 6t FYM along with 150: 60: 40 kg NPK/ha resulted in significant increase in overall land productivity over sole application of 225:90:60 kg NPK/ha.

CHAPTER THREE

METHODOLOGY

A field experiment was conducted during the winter (*Rabi*) season of 2013 at a research field of the school of Agriculture Lovely Professional University, Phagwara (Punjab), India, to study the "Influence of integrated nutrients management and early sowing on growth, yield, quality parameters and soil fertility of maize (*Zea mays* L.)." The details of the materials used and techniques followed throughout the course of study are described below.

3.1 Experimental Site

The present experiment was conducted at main research field of the department of Agriculture, opposite 34 block of Lovely Professional University Phagwara (Punjab) situated at 31.25°N latitude and 75.70°E longitude and at an altitude of 105.5 m above sea level.

3.2 Soil characteristics of the experimental site

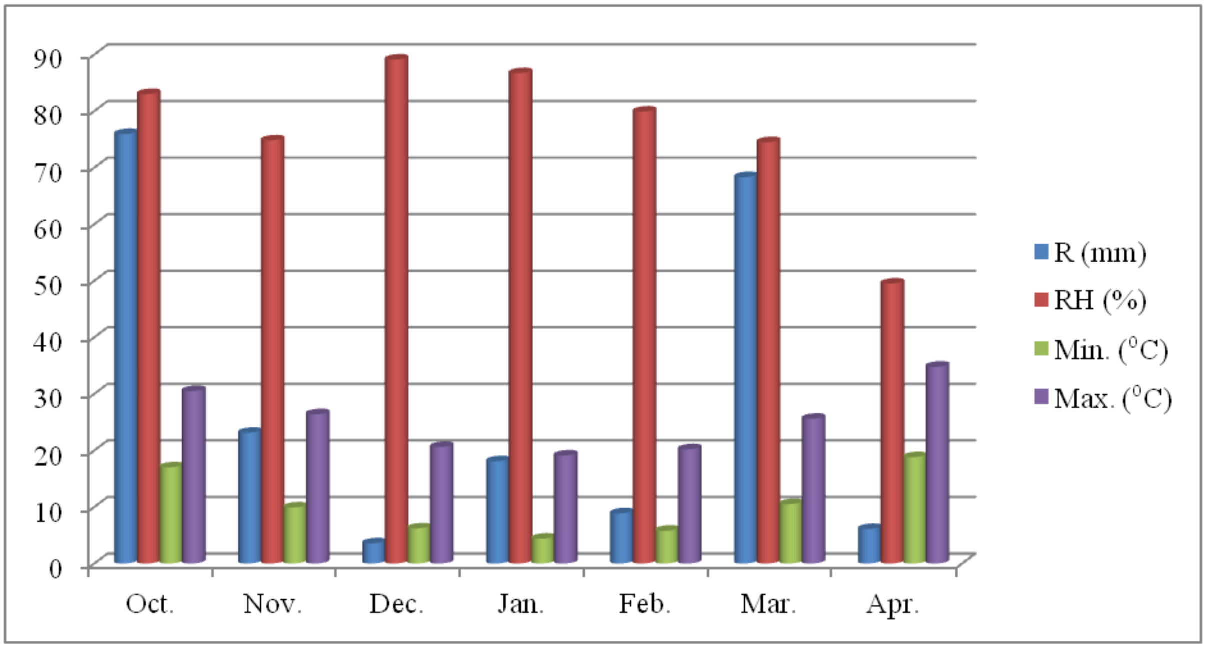
The soil in the trial field was found to be sandy clay loam which is well drain fertile soil. The composite soil samples of the trial sites were collected before and after the experiment up to a depth of 0 to 15cm and these samples were analyzed for various soil physic-chemical properties. The details of the soil analysis before sowing are given in Table 3.2.

3.3 Meteorological data

The data on weather parameters such as rainfall (mm), mean maximum and minimum temperature (°C) as well as relative humidity (%) from the month of October, 2013 up to the month of April, 2014 was collected from Amritsar weather forecast meteorological station and are presented in Table 3.1

The data in Table 3.1 is a data which shows a monthly record of rainfall (mm), relative humidity (%), minimum and maximum temperature (°C) during the period of INM field trial on hybrid maize crop and it shows that the total amount of rainfall received during the crop growing period is 204 mm while the average relative humidity received during the growing period is ranging from a maximum of 89.1% to a minimum of 49.5% and the minimum temperature was received in the month of January, 2013 (4.4°C) followed by month of February, 2013 (5.8°C), December, 2013 (6.2ºC), whereas maximum temperature was recorded in the month of April, 2014 (34.8ºC) followed by October, 2013 (30.5ºC).

Figure 3.1 Graph showing the climatic record data during crop growing period



R= rainfall, RH= relative humidity, Min.= minimum temperature, Max= maximum temperature and Oct= October, Nov= November, Dec= December, Jan= January, Feb= February, Mar= March and Apr= April

Table 3.2 Physic-chemical soil analysis of the trial site during winter season of the year 2013 period and NPK Composition in Organic Manure

Observation	Unit	Value
A. Physical Analysis		
Sand	%	54.00
Silt	%	32.00
Clay	%	14.00
Textural class		Sandy Clay Loam

B. Chemical Analysis		
pH	-	7.90
EC	dS/m	0.23
Organic carbon	%	0.32
Available N	kg/ha	314.66
Available P	kg/ha	13.14
Available K	kg/ha	393.00
C. Poultry Manure Composition		
N	%	3.03
P_2O_5	%	2.63
K_2O	%	1.4
D. Farmyard Manure Composition		
N	%	0.5
P_2O_5	%	0.2
K_2O	%	0.5

N= soil nitrogen, P= soil phosphorus, K= soil potassium and EC= electrical conductivity

3.4 Previous crops on experimental location

Vegetable crops like Egg-plant (brinjal) and lettuce were grown during the 2013 kharif season in similar experimental field.

3.5 Experimental details

The experiment consisted of eight (8) treatments combination including control treatment as 100% RDF (recommended dose of fertilizer). The experimental details are explained below.

3.5.1 Treatment details

The experiment consisted of eight (8) treatments combination involving organic manure and inorganic fertilizers. All the organic manure was applied as per treatments to each plot thirty-five (35) days before sowing. The details of the treatments are presented in Table 3.3.

Table 3.3 Detail of the treatments used in the INM trial on hybrid maize

Treatments (T)	Details of the treatments
T_1	Control (100% RDF)
T_2	5t FYM + 50% RDF
T_3	5t PM + 50% RDF
T_4	5t FYM + 100% RDF
T_5	5t PM + 100% RDF
T_6	5t FYM + 5t PM + 50% RDF
T_7	2.5t FYM + 2.5t PM + 50% RDF
T_8	2.5t FYM + 2.5t PM + 100% RDF

RDF= recommended dose of fertilizer, FYM= farm yard manure, PM= poultry manure, t = tones

3.5.2 Design and Layout

The experiment was laid out in a randomized complete block design (RCBD) consisting of 8 treatments replicated three (3) times. The plot size was the same for each treatment as follows;

3.5.3 Plot size

Gross plot size : 5.0 m × 4.2 m

Net plot size : 4.8 m × 3.6 m

3.5.4 Spacing : 60cm × 15cm

3.5.5 Design : Randomized Complete Block Design (RCBD)

3.5.6 Sowing date : 23rd October, 2013

3.5.7 Harvesting date : 18th April, 2014

3.6 Agronomic practices

All the cultural practices were kept on the basis of recommended practices and uniform for all the treatments except those under study. The agronomic practices carried out in the experiment are as follows:

3.6.1 Land preparation

The land was prepared by the use of MB plough and disc plough twice. The cultivator was used to brought the soil into fine tith by crushing the clods which are followed by planking twice times and the field was leveled which was laid out into experimental plots and replication as per plane followed by ridges were made per each plot.

3.6.2 Manure and fertilizer application

The required amount of FYM and PM were applied as per treatments in each plot uniformly at the same day which are incorporated into the soil 35 days before sowing using recommended dose of 5 tons per ha. The recommended dose of nitrogen, phosphorous and potassium in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP) were applied using 120Kg N: 60Kg P_2O_5: 40Kg K_2O per Ha. Half (½) of urea and complete dose of DAP and MOP were applied at sowing time as basal application and the remaining dose of nitrogen was top dressed at 36 DAS and 70 DAS as split dose as a source.

3.6.3 Sowing

Maize hybrid seed (DuPont pioneer-31Y45) was used for sowing on 23rd October, 2013 on the ridges as per recommended spacing (60 × 15cm). One seed per hill to a depth of 3 - 5cm was sown and covered with the soil. Seed rate of 25 kg/ha as recommended was used.

3.6.4 Inter cultivation practices

3.6.4.1 Gap filling

Two weeks after sowing gap filling operation was made in order to maintain optimum plant population where there was need.

3.6.4.2 Weeding

To check weed growth and to maintain minimum weed field, manual weeding was done at 7 DAS, 24 DAS, 42 DAS and 88 DAS.

3.6.4.3 Mulching

The plant was attacked severely by a frost in the early January, so in order to check the damage caused mulching material was applied through the use of rice straw in order to increase the soil temperature for better growth of the crop at 80 DAS due to extremes winter condition.

3.6.5 Irrigation

Four irrigations were given to each plot during the growing period of the crop. The first was given immediately after sowing, 2nd at 9 DAS, 3rd at 25 DAS and at 77 DAS.

3.6.6 Harvesting

The hybrid maize crop was harvested manually after attaining maturity stage of growth on 18th April, 2014

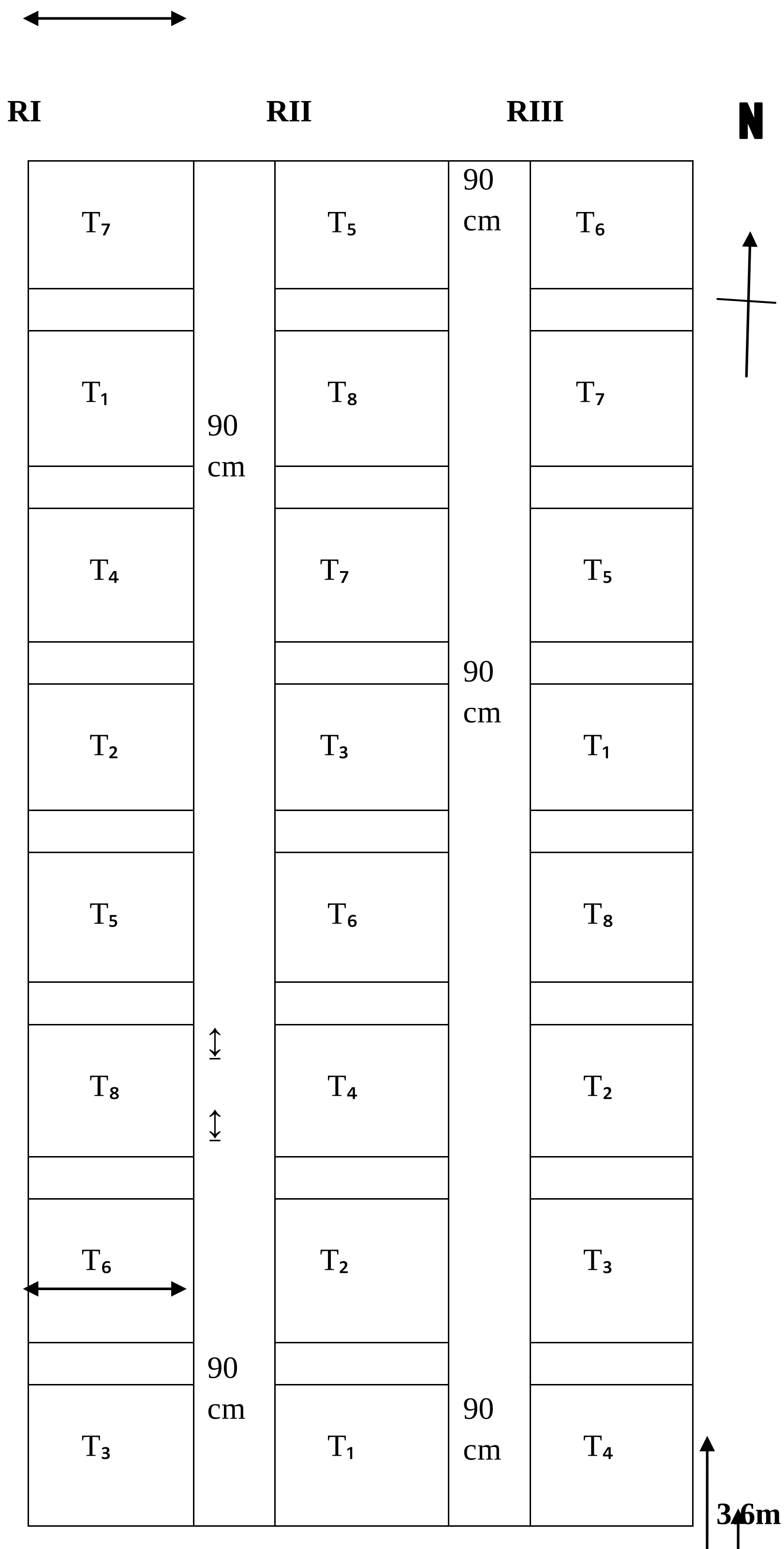


Figure 3.1 Experimental Layout

3.7 Data collections

In order to estimate the effect of each treatment on maize crop, five (5) plants were selected randomly and tagged in each plot for analysis of various growth parameters (Plant height, Number of leaves, leaf area, leaf area index, absolute growth rate, crop growth rate, net assimilation rate, dry matter accumulation), yield parameters (number of cobs, weight of cob per plant, number of grains per cob, fresh cob yield, weight of cob with husk per plant, weight of cob without husk per plant, 100 test weight, Stover yield and harvest index) and quality parameters (crude protein content, total ash and moisture content) parameters. The details of the important observations estimated are mention in Table 3.4 below of the appendix.

3.7.1 Procedures for recording growth parameters

Data regarding growth parameters were recorded at six (6) different stages of maize growing period namely; 30, 45, 60, 75, 120 DAS and at harvesting time and the details are explained below.

3.7.1.1 Plant height (cm)

The plant height of five randomly selected maize plants from each plot was measured from the base of the plant to the tip of the most prominent young leaf with the help of measuring scale and the average was recorded. This data was measured at 30, 45, 60, 75, 120 DAS and at harvest.

3.7.1.2 Number of leaves per plant (No. of leaves/plant)

The number of leaves of five randomly selected maize plants from each plot was counted and the average was calculated and recorded as number of leaves per plant. This parameters was taken at 30, 45, 60, 75, 120 DAS and at harvest.

3.7.1.3 Leaf area per plant (cm^2)

The leaf area of five randomly selected tagged maize plants from each plot was taken by measuring the length of the fully opened leaf lamina from the base to the tip of the leaf and leaf breadth was taken by measuring the middle point of the leaf lamina. The product of length and breadth of each leaf was multiplied by a factor 0.75 (Saxena and Singh, 1965) and the average of leaf area of all the leaves was expressed as cm² per plant. The reading was taken at 30, 45, 60, 75, 120 DAS and at harvest.

It was measured by the following formula below,

Leaf area (LA) = Leaf length × Leaf breadth × factor (0.75)

3.7.1.4 Leaf Area Index per plant (LAI)

The leaf area index (LAI) of maize plant was calculated based on the formula given by Sestak *et al.* (1971) and it's the ratio of crop leaf area to a unit ground area covered by crop during growing period.

The formula given is as follows;

$$\text{LAI} = \frac{\text{Leaf area}}{\text{Ground area covered}}$$

3.7.1.5 Absolute growth rate (AGR) (g/plant/day)

AGR indicates the rate at which crop is growing and was estimated through the use of the formulae given by Redford (1967) as shown below.

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

where,

AGR is Absolute growth rate (g/day/plant)

W_2 & W_1 is change in dry weight of whole plant (g) at time t_1 & t_2 respectively

T_1 and T_2 is Time interval (days)

3.7.1.6 Net Assimilation Rate NAR (g/cm²/day)

The NAR is the rate of increase in whole plant dry weight per unit leaf area per unit time (Watson, 1956) and it can be expressed as grams per dm² per day. This can be calculated by using a given formulae as follow;

$$\text{NAR} = \frac{(W_2 - W_1)(\text{In}L_2 - \text{In}L_1)}{(L_2 - L_1)(t_2 - t_1)}$$

where,

NAR is net assimilation rate

L_2 & L_1 is leaf area at time t_2 and t_1

W_2 & W_1 is dry weight of plant

In is logarithm function

3.7.1.7 Crop Growth Rate CGR (g/cm²/day)

CGR can be defined as the rate of crop growth per unit area and it's expressed in grams per square meter per day which are calculated by a formula proposed by Watson, 1956.

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where,

CGR is crop growth rate

P is ground area covered by crop (dm²)

3.7.1.8 Dry matter accumulation per plant (g/plant)

Five plants were selected randomly from each plot for the determination of dry matter production and its partitioning in different plant parts. The sample was separated into shoot (leaves and stems), root and cob with husk. These samples were dried at 65°C to 70°C to a constant dry weight of the entire sample. The dry weight was recorded separately to assess dry matter accumulation in plant shoot which was expressed in gram per plant.

3.8 Procedure for recording yield parameters

The yield parameters (number of cobs per plant, length of cob, weight of cob per plant, number of grains per cob, fresh cob yield, weight of cob with husk per plant, weight of cob without husk per plant, 100 test weight, Stover yield and harvest index) were recorded from the five randomly selected plant at the time of harvest under the following heading.

3.8.1 Number of cobs per plant (No. of cobs/plant)

The total number of cobs from five randomly tagged plants were counted and recorded. The average number of cobs was calculated and recorded as number of cobs per plant.

3.8.2 Weight of cobs per plant (g/plant)

The cobs from the five randomly selected plants were removed and weight per cob was measured and their average was recorded as cob weight per plant which is expressed in grams (g).

3.8.3 Length of Cob (cm)

The length of cobs from five randomly tagged plants was estimated by measuring from base of the cob to the tip and their average was determined which was expressed in centimeters (cm).

3.8.4 Number of grains per cob (No. of grains/cob)

The total number of grains per cob was calculated by counting the number of rows per cob and multiplying it by number of grains per rows and it can also be determine by following procedure below.

Number of grains per cob = No. of rows x No. of grains per rows.

3.8.5 Fresh cob yield per ha (t/ha)

The cobs was removed from all the plants per each plot and the total fresh cob yield per plot was taken and expressed in kg per plot which were used to determined the cob yield in tones per ha.

3.8.6 Weight of cob with husk per plant (g)

The total weight of cobs was measured from five randomly tagged plants along with the husk and the average weight of cob with husk per plant was recorded and it's expressed in grams (g).

3.8.7 Weight of cob without husk per plant (g)

The total weight of cob harvested without husk from five randomly tagged plant were calculated and their average was recorded as individual cob weight without husk per plant and is expressed in grams (g).

3.8.8 100 grains weight or Test Weight (g/100 grains)

The weight of randomly selected one thousands (1000) seed weight was measured from each plot to represent weight of each seed and their average was recorded per each treatment in order to estimate the effect of each treatments toward test weight and is expressed in grams (g).

3.8.9 Stover yield per ha (t/ha)

After harvesting of cobs from the plant, the stalk yield was measure per each plot and these was used to determined the Stover yield per ha and is expressed in tones per ha.

3.8.10 Harvest index HI (%)

The harvest index (HI) is the ratio of economic yield to biological yield and it can be expressed in per cent (%);

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100\%$$

3.9 Nutritional quality Analysis

The acceptability of any food products depends on nutritional and quality contents of such product. Therefore, the maize crop acceptability can be evaluated through these quality parameters namely: crude protein content, total ash content and moisture content.

3.9.1 Protein content (%)

Dry grains samples from each treatment were crushed separately into finely ground for determination of crude protein through the use of modified micro-kjeldhal assembly method and the procedure followed are;

0.5g of finely crushed sample was measured and put into a conical flask, 20 ml concentrated sulfuric acid was add to it followed by addition of 2.5g digestion mixture and it was kept overnight.

Next day the samples were digested using electric hot plate as source of heat until the colorless solution was obtained, after cooling the volume of the sample in the conical flasks was made to 100 ml by mixing it well.

5 ml of aliquot was pour in micro-kjeldhal apparatus followed by 10 ml of 40% NaOH which was distilled until about 50 ml was collected in 10 ml 4% boric acid with mixed indicator in a conical flask and then titrate the content against 0.02 H_2SO_4 till the color change to wine red from blue and the reading of acid volume used was recorded and blank was run without soil sample.

. However, the protein content of maize grain was obtain by multiplying the nitrogen value obtained in percentage by crude protein factor of maize grain (6.25) as shown by the formula.

$Per\ cent\ (\%)\ crude\ Protein = \%\ nitrogen\ N\ \times factor\ (6.25)$

3.9.2 Total Ash content (%)

Five (5g) grams of oven dry grains sample was measured and put into a clean known weighted China dish (W_1) and the dish containing the samples was put in a muffle furnace set at a temperature of 500-800^{o}C and kept for about 5 hours until the samples turn white or ash in appearance and then it was cool in a desiccators which was weighted again as W_2 and the total ash content from each treatments was calculated using the following formula.

$$Total\ Ash\ (\%) = \frac{W_2 - W_1}{weight\ of\ sample} \times 100$$

Where,

W_2 = weight of dish containing heated samples

W_1 = weight of empty china dish

3.9.3 Moisture content (%)

The moisture content from fresh grains of maize was obtained by putting a known quantity of fresh grains in a weighted Petri dish (W_1), the samples were put in an oven set at a temperature of 105^{o}C for about 2 hours and it then cool and weighted as dry weight (W_2) and it was calculated of using the following formula

$$Moisture\ content\ (\%) = \frac{W_1 - W_2}{sample\ weight} \times 100$$

where,

W_1 = fresh weight of sample plus weight of Petri dish

W_2 = dry weight of sample plus Petri dish weight

3.10 Chemical plant analysis

3.10.1 Plant analysis

The sample of the hybrid maize crop used for recording dry matter accumulation were grounded in a Wiley mill to pass through 40 mesh sieve, which was utilized for chemical analysis of hybrid maize crop at harvest. However, nitrogen was estimated through micro Kjeldhal's method as in crude protein estimation above, Phosphorus was estimated through Vanado molybdate phosphoric yellow color method and potassium was obtained by flame photometer method from the shoot sample of hybrid maize and they were expressed in percentage.

3.10.2 Plant nutrient uptake

The formula used for nutrient uptake determination is explained below and nutrients estimated are nitrogen, phosphorus and potassium from shoot part of hybrid maize at harvest time.

$$Nutrient\ uptake = \frac{\%\ \text{of nutrient concentration}\ \times \text{Biomass (Kgha}^{-1})}{100}$$

The nutrient uptake were expressed in Kg per ha as follow.

3.10.2.1 Nitrogen N uptake (Kgha^{-1})

Nitrogen uptake was estimated by multiplying % nitrogen concentration in shoot obtained in the same way with crude protein determination above using grounded shoot part instead of grains and the result was multiplied with a total biomass of shoot divided by 100.

$$N\ uptake = \frac{\%\ Nitrogen\ N\ \times total\ shoot\ biomass\ (kg/ha)}{100}$$

3.10.2.2 Phosphorus P uptake (Kgha^{-1})

The phosphorus uptake was determined by digestion as in nitrogen but instead of concentrated sulphuric acid, di-acid was used for digestions process and later 5 ml of aliquot was measured into a 250 ml volumetric flask which was mixed with 10 and 5 ml distilled water and vana- molybdate solution, the volume was made into 25 ml by mixing thoroughly with distill water and then the sample was kept until the yellow color was develop after about 20 minutes and the transmittance reading was recorded at 470 nm using spectro-photometry and phosphorus uptake was obtained by multiplying % phosphorus concentration in shoot with total shoot biomass divided by 100 and it was expressed in kg/ha.

$$P\ Uptake = \frac{\%\ Phophorus\ P\ \times total\ shoot\ biomass\ (kg/ha)}{100}$$

3.10.2.3 Potassium K uptake (Kgha^{-1})

The potassium uptake was also determined by the same method as in phosphorus but the only different was % potassium were obtained directly after the digestion solution was made to 100 ml using flame photometry and the uptake was obtained by multiplying % K with total shoot biomass and divided by 100 which was expressed in Kg/ha.

$$Potassium\ K\ Uptake = \frac{\%\ potassium\ K\ \times total\ shoot\ biomass\ (kg/ha)}{100}$$

3.11 Physical Properties of soil

3.11.1 Soil texture

The soil sampling was done twice for the analysis before and after cultivation of hybrid maize crop and soil texture was estimated using mechanical analysis by pipette method of texture determination, the detail of the method used for texture determination are explained below.

20 g of soil sample was added in 1 liter beaker followed by 20 ml hydrogen peroxide H_2O_2 (6%), then the solution into a water bath for about 3-4 hrs at about 60^{o}C until the reaction subsidies by adding the H_2O_2 continuously when the mixture dry in the water bath.

After cooling the sample, 25 ml sample was added for an hour and after then it was filtered via whatman paper no. 50 and the filtered solution was transferred to another beaker followed by addition of about 500-600 ml water and the sample was dissolved by mechanical stirrer for about 10 minute, 10 drop of phenolphthalein indicator plus 10 drop of 0.1N NaOH was dropped followed by mixing and filtering again into 1 liter measuring cylinder through a 70 mesh (0.25 mm) sieve placed in funnel mounted on cylinder mouth.

The left soil on the sieve was dried at 105^{o}C and recorded as coarse sand weight W_1, the cylinder was refilled up to 1 liter mark again followed by thorough shaking up side down and after about 5 minute 25 ml was pipette out for drying at same temperature and recorded as weight of clay + silt W_2 and the cylinder was refilled again and kept for overnight.

The next day the solution was shake very well and 25 ml was taken again for drying and recorded as a weight of clay W_3 and the next day same was done but as a weight of silt W_5 particle and the fine sand particle was obtained by subtracting the total particle percentage from 100 and represented as fine sand percentage (Practical Manual).

The following are the step by step formulae for soil particles calculations

$$\%\ Coarse\ sand = {W_1}/{20} \times 100$$

$$\%\ (Silt\ and\ Clay) = \frac{W_2}{25} \times \frac{1000}{20} \times 100$$

$$\%\ CLAY = \frac{W_3}{25} \times \frac{1000}{20} \times 100$$

$$\%\ SILT = \%(\ clay\ + silt) - \ (\%\ clay)$$

$$\%\ fine\ sand = 100 - (\%\ coarse\ sand\ + \%\ silt\ + \%\ clay)$$

3.12 Chemical analysis of soil

3.12.1 Soil sampling and analysis

At the beginning of this research project and end of it , soil samples was taken up to a depth of 15 cm from the top of the experimental field soil and it was dried, crushed and sieved through 2mm sieve and it was also preserved for the analysis. The soil analysis was conducted on electrical conductivity, pH, organic carbon, available nitrogen, available phosphorus and available potassium content from the soil sample.

3.12.2 Electrical conductivity EC (dS/m) and pH

The soil pH and EC was determined in 1:2 soils: water suspension by adopting potentiometric method and they were determined by using pH meter and electrical conductivity meter respectively and the procedure for their determination are as follow

For both pH and EC same solution of soil was used for their estimations by mixing 10 g of soil sample with 25 ml of distilled water which was mixing for about minute after connecting the pH meter and conductivity meter to power for about 30 minute and the reading was recorded after initial calibrations as recommended (Practical manual).

3.12.3 Organic carbon (%)

The soil organic carbon content was determined twice before cultivation from composite soil sample of the experimental plots and after cultivation by treatments wise analysis through wet digestion or rapid titration method and it was expressed in per cent and also the procedure used for organic carbon estimation are as follow.

1g soil was put in 500 ml conical flask followed by addition of 10 ml 1N $K_2Cr_2O_7$ solution and it was shake gently followed by addition of 20 ml concentrated sulfuric acid by shaking gently while adding it and 0.5 g sodium fluoride was added after cooling followed by 200 ml distilled water addition and 10 drop of diphenylamine indicator which was shake vigorously well.

After then titration was made against N/2 ferrous ammonium sulphate until the color was change to bright green from violet and the reading of volume of ferrous ammonium sulphate was recorded and the blank sample was conducted same as above but without soil sample and it was estimated using the formula below(Practical Manual and Kannan *et al*. 2013).

$$Per\ cent\ (\%)\ organic\ carbon = \frac{X-Y}{2} \times 0.003 \times \frac{100}{Z}$$

where,

X= volume of N/2 ferrous ammonium sulphate used for blank titration

Y= volume of N/2 ferrous ammonium sulphate used for sample titration

Z= weight of soil sample

3.12.4 Available nitrogen (kg/ha)

The soil available nitrogen was determined twice before cultivation from composite soil sample of the experimental plots and after cultivation by treatments wise analysis through alkaline potassium permanganate method which was expressed in Kg/ha and the procedure of its estimation is as follows.

5 g of soil sample was poured into kjeldahl's distillation flask followed by 25 ml of 0.32% $KMnO_4$ and 20 ml of 2.5% NaOH was also poured into kjeldahl's distillation flask. 10 ml of 2% boric acid solution and 3 drops of mixed indicators was added into a 125 ml conical flask followed by dipping of end of delivery tube into it for collecting ammonia gas from distillation flask.

After about 50 ml distillate with boric acid solution was collected, the solution containing dissolved ammonia was titrated against 0.02N H_2SO_4 until the bluish green color of the solution was changed to a pinkish/wine red color and from the obtained titre reading available soil nitrogen was estimated (Practical Manual).

3.12.5 Available Phosphorus (kg/ha)

The soil available phosphorus was determined twice before cultivation from composite soil sample of the experimental plots and after cultivation by treatments wise analysis through Olsen's extractant method using spectrophotometer instrument at 660 nm wavelength which was expressed in Kg/ha and the procedure of its estimation is as follow.

50 ml of bicarbonate extractant was added into a 100 ml conical flask containing 2.5 g soil sample, followed by addition of 1 g charcoal pinch (Darco-G-60) and the solution was transferred to a shaker for about 30 minute and after shaking the solution was filtered through whatman filter paper No. 1.

5 ml of the aliquot was pipette out into 25 ml volumetric flask and 5 ml of molybdate reagent was added into it, the contents was shake well, followed by dilution with distilled water until about 20 ml was obtained and shake again. 1 ml of stannous chloride was added to it and the volume was made to 25 ml with distilled water, the solution was shakes very well.

Blank sample without soil was made by following the same procedure and the blue color was observed about 10 minute after stannous chloride was added. The color intensity was measured in spectro-photometer instruments at a wavelength of 660 nm and transmittance and absorbance was recorded for soil available phosphorus estimation (Practical Manual).

3.12.6 Available potassium (kg/ha)

The soil available potassium was estimated twice before cultivation from composite soil sample of the experimental plots and after cultivation by treatments wise analysis through flame photometry method which was expressed in Kg/ha and the procedure used for soil available potassium estimation are as follows.

25 ml of 1N NH_4OAc was added into a beaker containing 2.5 g soil sample, the solution was shakes with hand followed by 5 minutes mechanical shaking and the solution was filtered into a 125 ml conical flask through a whatman filter paper No. 1 until a clear filtrated was obtained. Standard curve was prepared by adjusting 40ppm K solution to 100ppm and 0, 5, 10, 15, 20 ppm K solution to 100ppm respectively and K reading was taken from clear filtrate under the test, this reading was compare with standard curve reading and concentration of K was recorded. Blank sample was run again without soil in it (Practical Manual).

3.13 Statistical analysis

The data of the trial was analyzed at 5% (0.05) level of significance using F test. The mean value of the collected data from each plot was subjected to analysis of variance (ANOVA) using Duncan Multiple Range Test (DMRT) and the means in each tables followed by the same letter(s) within a column are not significantly different at 5% level of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results of field experiment conducted at Main Research Field Station of the School of Agriculture Lovely Professional University during the winter season of 2013 to study the 'Effect of integrated nutrient management on growth, yield and quality parameters of maize crop' are presented and explained in this chapter.

4.1 Growth parameters

4.1.1 Plant height (cm)

The data on plant height of hybrid maize crop were obtained at six (6) different stages of growth 30, 45, 60, 75, 120 DAS and at harvest as influence by different doses of organic and inorganic nutrient sources are presented in appendix and shown in figure 1.

At 30 DAS significant different was obtained on plant height among the treatments with T_7 (2.5t/ha each of FYM and PM along with 50% RDF or 60:30:20 kg NPK/ha) having higher plant height (24.8 cm) than rest of the treatments used, followed by T_1 (100% RDF or 120:60:40 kg NPK/ha) with a plant height of 24.6 cm and T_6 was found to have less effect in plant height (19.9 cm) than rest of the treatments applied in the trial, whereas at 45 DAS there was no significant different among all the treatments even though T_4 (5t/ha FYM along with 100% RDF) was recorded having higher plant height (33.5 cm), followed by T_5 (5t/ha PM along with 100% RDF) with a plant height of 32.9 cm, whereas T_2 (5t/ha FYM along with 50% RDF) was recorded with lowest height (30.9 cm) but statistically there is no significance differences among treatments used in the trial.

At 60, 75, 120 DAS respectively and at harvest there was no significant differences in plant height among all the treatments, although at harvest T_7 was recorded having greater height (153.400 cm), followed by T_2 (5t/ha FYM along with 60:30:20 kg NPK/ha) with a plant height of 144.9 cm and lower height (131.867 cm) was obtained at T_5 (5t/ha PM along with 120:60:40

kg NPK/ha) treatment among the treatments used but statistically there was no significance differences among the treatments at harvest with respect to the plant height. This problem occurred due to the onset of winter or early sowing which resulted in problems like less sunshine hours, high humidity, lower temperature below 10°C (Appendix 3.1) which are the major prerequisite for proper growth of maize crop, whereas in the case of first month after sowing the crop started to grown well due to availability of such prerequisite for proper functioning of crop which show significant differences among the treatments used in the trial but the subsequent months during the crop growth shows similar effect among the treatments. This result was found to be contrary with Kannan *et al*. (2013), Ali *et al*. (2012) and Panwar (2008) who reported that significant increased in plant height was observed among treatments with a combination of organic and inorganic sources.

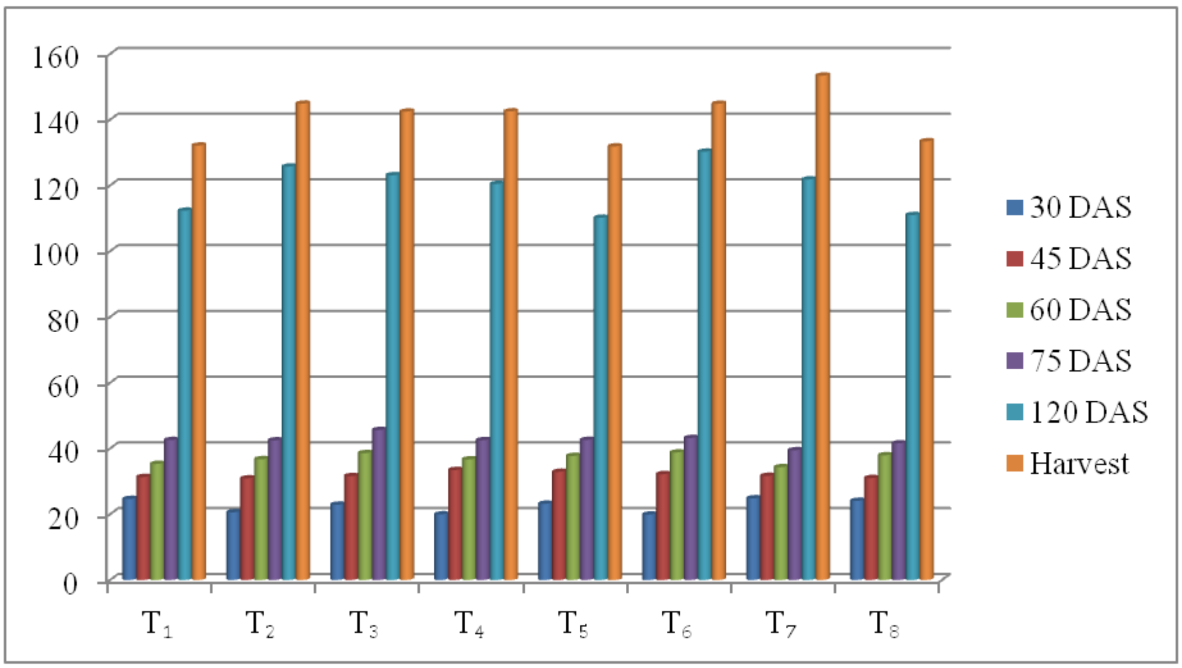


Figure 1: A graph showing result of effect of INM on plant height (cm) at six different stages of maize growth.

4.1.2 Number of leaves per plant

The effect of the integrated nutrients management (INM) on number of leaves were found to be statistically no significance differences among the treatments used in the trial at 30, 45, 60, 75, 120 DAS and at harvest (Appendix and fig. 2) respectively.

At 75 DAS T_3 (5t/ha PM along with 50% RDF or 60:30:20 kg NPK/ha) and T_6 (5t/ha each of FYM and PM along with 50% RDF) were recorded to produced significantly higher number of leaves per plant i.e., 13 each and T_4 (5t/ha FYM along with 100% RDF or 120:60:40 kg NPK/ha) was recorded to produced lower number per plant (11), whereas at 120 DAS T_3 were also resulted in higher number of leaves (14) and T_4 was having lower number of 12 leaves among all the treatments used in the trial.

At harvest, even though number of leaves per plant is insignificance, but T_3 resulted in higher number of leaves (15) in a maize crop as compare to T_4 (5t/ha FYM along with 50% RDF) having lowest number of 12 leaves. This result was found to be contrary to the result obtained by Ghaffari *et al*. (2011) and Mujeeb *et al*. (2010) who reported that significant increased was observed on number of leaves under integrated nutrient management over sole used of 100% recommended dose of fertilizer at 60 DAS and at harvest. The reason for obtaining insignificance differences among the treatment in number of leaves per plant is may be due to the onset of winter season at early period after sowing couple with the occurrence of frost in early January, 2014 which affect all the plant in the field by causing almost all the leaves to death which after stability of the weather they regenerate again at the same time.

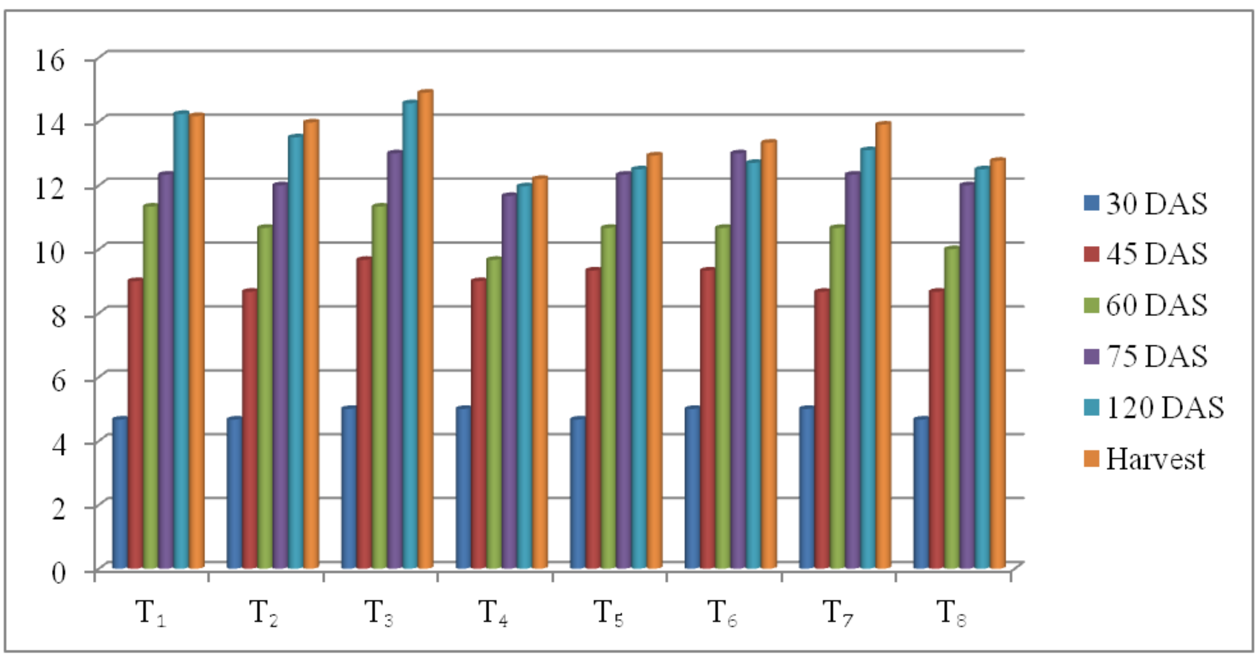


Figure 2: A graph showing result of the effect of INM on number of leaves per plant at six different growth stages of hybrid maize crop

4.1.3 Leaf area (cm^2)/ plant

The data about the leaf area/plant of hybrid maize crop at 30, 45, 60, 75, 120 DAS and at harvest are presented and shown in Table 3 of the appendix and figure 3 respectively.

At 30 DAS, the effect of treatments was found to be significant on leaf area of maize crop but significant higher leaf area of 92.7 cm^2/plant was obtained with the application of T_3 (50% RDF along with 5t/ha PM), followed by T_2 with 85.1 cm^2/plant which is a treatments containing 50% RDF(60:30:20 kg NPK/ha) along with 5t/ha FYM, whereas T_1 (100% RDF or 120:60:40 kg NPK/ha) having lower leaf area of 69 cm^2 among the treatments used in the trial due to the less availability of other essential elements needed for proper functioning of crop as in organic treated plots which was supported by Jayaprakaash *et al*. (2005) showing that leaf area (LA) was found to be significantly higher in organic manure treated plots compared to control.

At 45, 60 and 75 DAS there is no significant different among all the treatments with regard to leaf area statistically due to the onset of winter season couple with frost occurrence at early January, 2014 during growing period of the crop which resulted in poor crop growth and development owing to lower temperature, higher humidity, less sunshine hour which are all require for proper growth of plant (Appendices Table 3.1).

At 120 DAS highly significant difference was observed among the treatments effect on leaf area of maize crop with T_6 (50% RDF along with 5t/ha each of FYM and PM) was recorded to have higher leaf area of 535.5 cm^2, followed by T_3 (5t/ha PM along with 60:30:20 kg NPK/ha) with a leaf area of 503.9 cm^2, whereas T_7 was recorded with lowest leaf area/plant of 320.5 cm^2 among the treatments used in the trial.

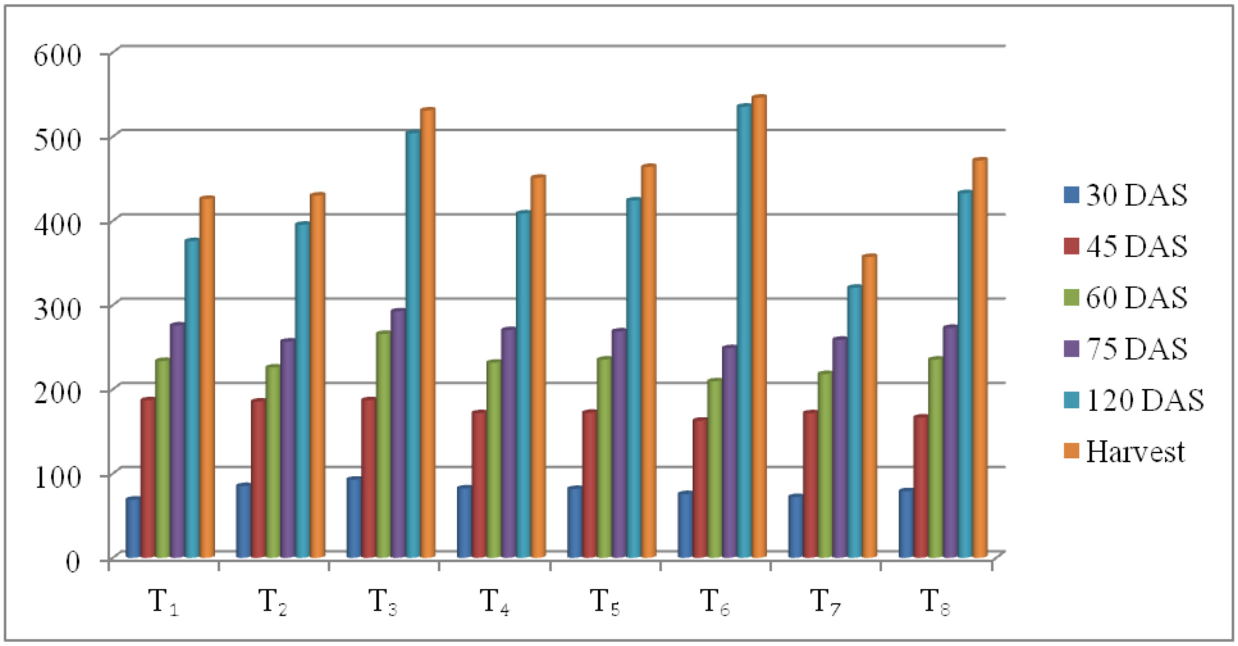


Figure 3: A graph showing result of the effect of INM on leaf area (cm^2) per plant at six different growth stages of hybrid maize crop

At harvest highly significant difference was also been found among the treatments effect on leaf area of maize crop with T_6 was recorded with highest leaf area of 546.2 cm^2, followed by T_3 recorded to have a leaf area of 531cm^2, whereas T_7 was also recorded with lowest effect on leaf area of 357.1 cm^2 as compare with the rest of treatments used in the trial. This was as a result of combined effect of both organic and inorganic manure which supplied the plant with other essentials nutrients necessary for proper functioning of the plant unlike plots which contains only inorganic manure. However, the results obtained regarding LA at 120 DAS and at harvest are in line with Kannan *et al*. (2013), Jayaprakaash *et al*. (2005) and Panwar (2008) who reported that significant increase in LA were observed due to integrated nutrient management effect more than sole application of recommended dose of fertilizer.

4.1.4 Leaf area index LAI per plant

The data regarding leaf area index of hybrid maize crop at 30, 45, 60, 75, 120 DAS respectively and at harvest are presented and shown in Table 4 of the appendix and figure 4 respectively.

In all the six growing stages of maize crop there was no significant different of treatments effect on maize crop except at 30 DAS and at harvest.

At 30 DAS, significant differences was observed on the effect of treatments on leaf area index of grown maize crop with T_4 (5t/ha FYM along with 50% RDF) having higher leaf area index (0.743) due to its effect on maize crop during first 30 DAS of the growing stage as compare to T_2 having lowest leaf area index (0.540) among rest of the treatments used in the trial.

At 45, 60 and 75 DAS there was no significance differences among the treatments effect on leaf area index of maize crop but based on the data obtained T_6 (5t each of FYM and PM along with 50% RDF) was found to be having high leaf area index due to its effect during maize growing stages at both 45 & 60 DAS (0.690 and 0.750 respectively) due to combined effect of both organic and inorganic manure which enhance the supply of essential elements and improving the activity of beneficial soil microbes compare with the treatments where only recommended dose of fertilizer was used, whereas at 75 DAS T_5 (5t/ha PM along with 100% RDF) was recorded to have high leaf area index (0.990) due to its effect during the growing stages of hybrid maize crop which gave the plant more strength to withstand natural calamity like diseases, frost and so on owing to the organic manure on it but same T_5 was observed to have lower effect at 45 and 60 DAS (0.544 and 0.680 respectively) and at 75 DAS T_4 (5t/ha FYM along with 100% RDF) was recorded to have lower effect on maize leaf area index (0.840) among the treatments used in the trial.

At 120 DAS there was no significant difference among the treatments effect on leaf area index but T_3 (5t/ha PM along with 50% RDF) was recorded to have high leaf area index (1.407) due to its influence during maize growing stages period and T_4 (5t/ha FYM along with 100% RDF) was recorded to have lowest leaf area index (1.183) among the rest of the treatments but all the treatments are found to be significantly same without different among them in their effect on leaf area index.

At harvest significant differences were observed among the treatments effect on leaf area index and T_3 was recorded to have high leaf area index (2.413) due to its effect on during growing stage of hybrid maize crop, whereas T_7 (2.5t/ha each of FYM and PM along with 50% RDF) was recorded to have lowest value (1.737) due to its effect on maize crop growing stage among the rest of the treatments.

The result obtained in LAI under INM was found to be contrary to many result except at 30 DAS and the reason for this insignificant differences are due to the early onset of winter during the growing period of the crop which affect total performance of the crop toward growth and development owing to insufficient light, heat, high humidity, lack of proper nutrients uptake due to reduction in transpiration process (Appendices Table 3.1) which are all needed for proper uptake of nutrients during crop growth.

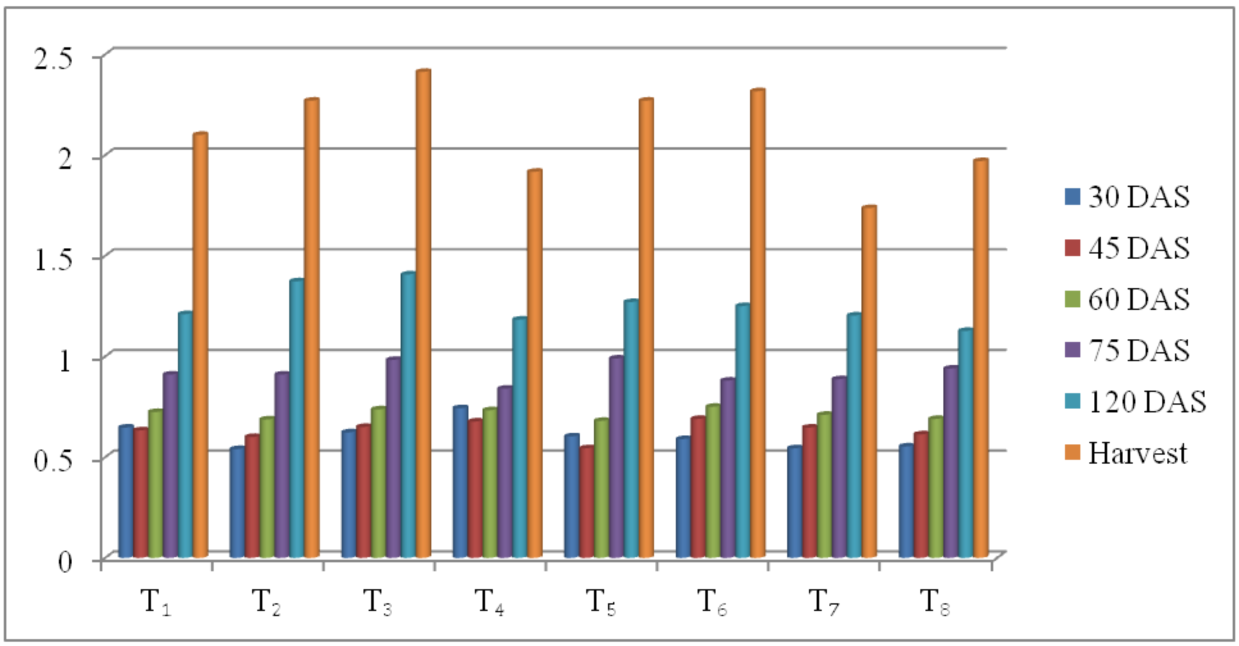


Figure 4: A graph showing result of the effect of INM on leaf area index per plant at six different growth stages of hybrid maize crop

4.1.5 Absolute growth rate AGR (g/day/plant)

The data regarding absolute growth rate observed due to the effect of integrated nutrients management on hybrid maize crop at six (6) different growing stages are presented in Table 5 of the appendix and shown in figure 5.

Out of these 6 stages of data recording growing stage it was found out that at 30, 120 DAS and at harvest time significant differences was observed, whereas at 45, 60 and 75 DAS there was no significant difference among the treatments effect during the three growing stages of hybrid maize crop which was as a result of the early onset of winter 30 DAS and this lead to malfunctioning of all the plants in the plots in term of growth due to lack of proper nutrients uptake owing to lack of proper sunlight.

At 30 DAS highly significant different effect was observed on hybrid maize crop among the treatments with T_3 (5t/ha PM along with 50% RDF) recorded to have high AGR value (0.4g/day) due to its effect on hybrid maize crop followed by T_2 with a value next to the highest (0.2g/day) and T_1 was recorded to have lowest AGR reading (0.1 g/day/plant) among the treatments used in the trial and was as a result of the availability of more sunlight couple with combined effect of two sources of manure during the first 30 DAS which is essential for proper growth of maize crop.

It was also found out that, at 120 DAS significant different was recorded on AGR among the treatments effect during growing period of hybrid maize crop with T_3 (5t/ha PM along with 50% RDF) was recorded with highest AGR of 2.8 g/day/plant, followed by T_6 (5t/ha each of FYM and PM along with 50% RDF) was recorded to have AGR value of 2.7 g/day/plant due to its effect on hybrid maize crop which are considered significantly same in their effect with T_3, whereas T_1 (100% RDF) was recorded to have lowest AGR (1.5 g/day/plant) value due to its effect during growing period of hybrid maize crop.

At harvesting period, significant difference was observed among treatments effect on hybrid maize crop AGR reading with T_3 (5t/ha PM along with 50% RDF) was found to produced significantly higher AGR of 4.8 g/day/plant, followed by T_6 (5t/ha each of FYM and PM along with 50% RDF) having recorded with 4.3 g/day/plant AGR, whereas T_1 was also recorded to have lowest AGR (2.9 g/day/plant) and this significance result was obtained due to combined effect of organic and inorganic manure couple with optimum sunlight for proper functioning of maize crop at 120 DAS and harvest. The results obtained at 30 DAS, 120 DAS and at harvest are found to be supported by Kannan *et al*. (2013), Ali *et al*. (2012), Haq (2006) and Singh *et al*. (2009) who reported that significant increase in growth parameters was observed due to integration of nutrients from different sources organic and inorganic sources.

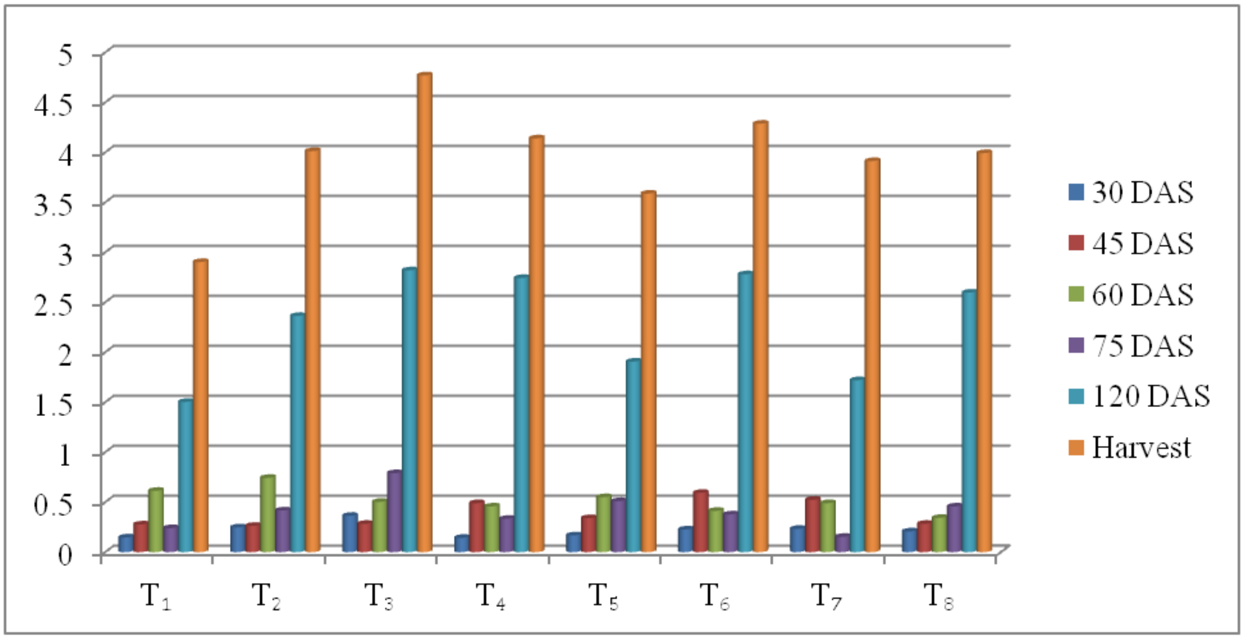


Figure 5: A graph showing result of the effect of INM on absolute growth rate (g/day) per plant at six different growth stages of hybrid maize

4.1.6 Net assimilation rate NAR (g/cm²/day)

The data regarding net assimilation rate (NAR) due to the effect of integrated nutrient managements during the growing period of maize crop at six (6) different stages of growth are presented on Table 6 of the appendix and shown in figure 6.

Out of these 6 growing stages of data recording it was found out that only at 30 DAS the net assimilation rate was found to be significantly different among the treatments.

At 30 DAS T_2 (5t/ha FYM along with 50% RDF) and T_3 (5t/ha PM along with 50% RDF) were recorded to have produced higher NAR (0.039 g/cm²/day each), whereas T_4 (5t/ha FYM along with 100% RDF) was recorded to have lowest NAR (0.017 g/cm²/day) value due to its effect on hybrid maize crop during growing period but at the rest of the data recording growth stages of this trial there was no significant differences among all the treatments effect on net assimilation rate of hybrid maize crop.

At harvesting period the result shows that there was no significant difference among the treatments effect on hybrid maize crop, but the higher NAR (0.109 g/cm²/day) value was observed due to the effect of T_7 on hybrid maize and T_1 resulted in lower NAR (0.067

g/cm²/day) at all crop growing period. These results are contrary to the result obtained by Singh *et al*. (2009) and Panwar (2008). However, similar results coincide at 30 DAS to above mentioned references probably due to chilling temperature which abrupt normal growth of crop in early period.

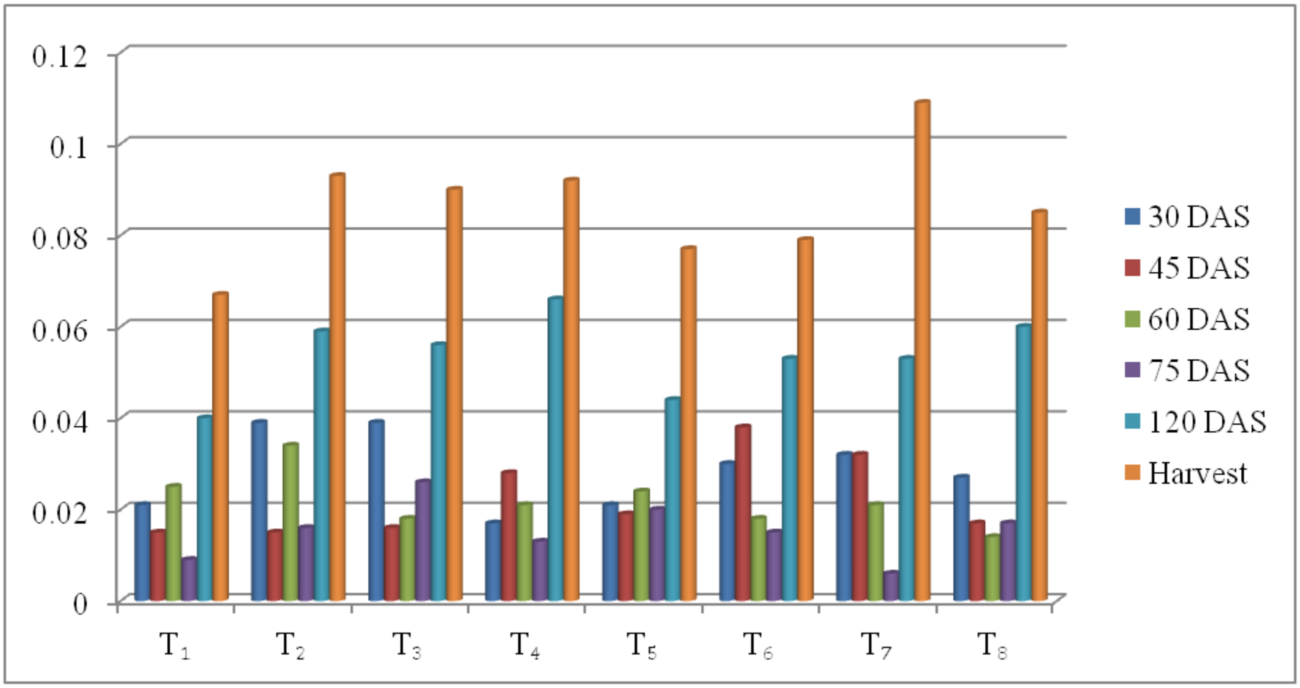


Figure 6: A graph showing result of the effect of INM on net assimilation rate (g/cm²/day) per plant at six different growth stages of hybrid maize

4.1.7 Crop growth rate CGR (g/cm²/day)

Further growth analysis conducted and data related to the crop growth rate of hybrid maize crop at various growing interval (30, 45, 60, 75, 120 DAS and harvest) are represented in Table 7 of the appendix and shown in figure 7.

The data recorded on CGR revealed that, statistically each growth stage there was no significant difference reported among the treatments effect on maize crop and the figure 7 shows how the hybrid maize crop was growing at an increasing rate of time.

These results are in contrary to result presented by Thavaprakaash *et al*. (2005) and Singh *et al*. (2009) showing significant influence in all growth parameters was observed due integration of organic with inorganic manure and Efthimiadou *et al* (2009) reported that integration of poultry manure increases the rate of photosynthesis.

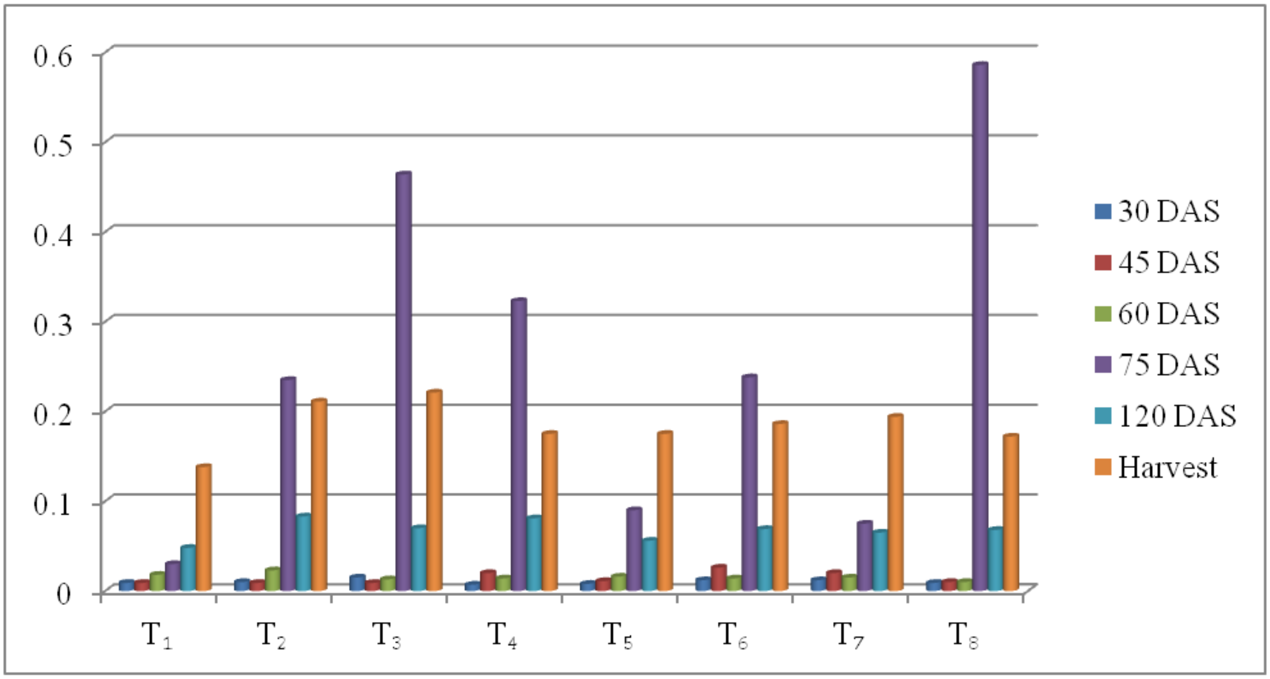


Figure 7: A graph showing result of the effect of INM on crop growth rate (g/cm²/day) per plant at six different growth stages of hybrid maize crop

4.1.8 Dry matter production DMP (g/plant)

The dry matter production of hybrid maize crop at various stages as influenced under different treatments was recorded and presented in Table 8 of the appendix and shown in Figure 8.

The effect of the treatments used on hybrid maize crop dry matter production was observed to be significantly different in all the 6 stages of growth except at 60 and 75 DAS which is as result of chilling temperature due to onset of winter season which is associated with very low temperature and higher humidity (refer to Appendices in Table 3.1) which lead to improper functioning of the plants during the periods of 60 and 75 DAS.

At 30 DAS, the result shows that the effect of the treatments on hybrid maize crop was found to be significantly highly different with T_3 (5t/ha PM along with 50% RDF) recorded to have higher DMP (8.7g/plant), followed by T_2 (5t/ha FYM along with 50% RDF) was recorded to produced a DMP of 6.6 g/plant whereas T_4 (5t/ha FYM along with 100% RDF) was also found to have the lowest SDMP (4.8 g/plant) among the treatments due to their effect on maize crop.

At 45 DAS, the result shows that the effect of the treatments on hybrid maize crop was found to be significantly different with T_6 (5t/ha each of PM and FYM along with 50% RDF) was recorded with highest production of 12.9 g/plant dry matter, followed by T_3 which was recorded with production of 12.7 g/pant dry matter, whereas T_1 (100% RDF) was found to have produced lowest Shoot dry matter production of 7.5 g/plant among the treatments.

At 120 DAS, significant different was observed due to the effect of integrated nutrient management on hybrid maize crop with T_6 was found producing highest dry matter of 42.8 g/plant, followed by T_3 producing shoot dry matter of 39.9 g/plant compare to the rest of the treatments, whereas T_5 (5t/ha PM along with 100% RDF) was recorded to have produced least shoot dry matter of 26.8 g/plant among the treatments used in the trial.

At harvest highly significant difference was observed due to the treatments effect on shoot dry matter production of hybrid maize crop owing to the availability of sunlight which made the plants to utilized available soil nutrients properly and increased in the rate assimilation and T_6 was recorded with highest production of 78.1 g/plant of shoot dry matter, followed by T_3 producing 75.2 g/plant of dry matter compare to the rest of the treatments used in the trial, whereas T_7 (2.5t each of FYM and PM along with 50% RDF) was recorded to have produced least shoot dry matter of 60.1 g/plant among the treatments. However, this significance increased in shoot dry matter may be obtained due to availability and improvement in sunlight which are required by any plants for optimum utilization and uptake of nutrient for proper growth function

These results of the analyzed data of the shoot dry matter content are in line with another finding such as Ravi *et al*. (2012), Bhagade *et al*. (2008), Kumar (2000) and Singh *et al*. (2009) who reported that integration of organic from PM or FYM or goat/ sheep or vermicompost along with 50% or 75% or even 25% RDF resulted in significant increase in dry matter production.

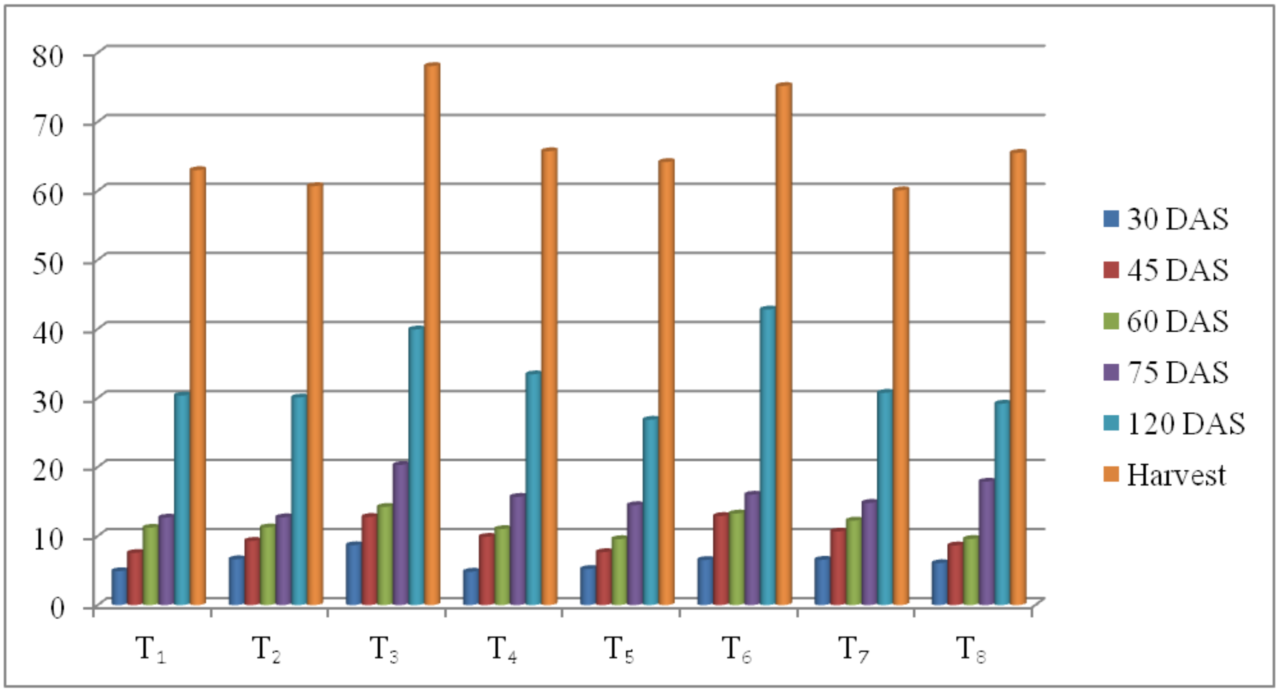


Figure 8: A graph showing result of the effect of INM on Dry matter production per plant at six different growth stages of hybrid maize.

4.2 Yield Parameters

4.2.1 Number of Cobs per plant (no. of cobs/pant)

The data regarding cobs number per plant after harvest are presented and shown in table 9a of the appendix and figure 9 respectively.

The result of the analyzed data of number of cobs per plant was found to be not significant among the different treatments effect on maize crop with T_6 (5t/ha each of FYM and PM along with 50% RDF) was recorded with highest cob number of 3.3/plant and the least cobs number of 2.8/plant was recorded under T_7 (2.5t/ha each of FYM and PM along with 50% RDF) but this result shows that all the treatments can produce same cobs number per plant statistically. This may be due to optimum uptake of nutrients owing to proper metabolic activity by the plants in all the treatments as well as genetic makeup of the variety used which lead to production of almost same number of cobs per plant and this result was found to be similar with Uwah *et al*. (2011) as well as Shad and Arif (2000) who reported that there is no significant difference among the treatments used in term of cob number per plant.

4.2.2 Length of cob (cm)

The length of cobs/plant remains in similar result as in number of cobs per plant which shows no significance difference caused by any source of nutrients in maize plant. These data are presented and shown in Table 9a of the appendix and figure 10 respectively.

The result of the analysis of variance shows that all the applied treatments are statistically same in term of their effect toward the length of the cob but T_6 (50% RDF along with 5t/ha each of FYM and PM) was found to have the longer cob compare with T_5 (100% RDF along with 5t/ha PM) was found to have the shorter cob length among the treatments whereas the rest of the treatments are considered to have similar or same effect statistically as in either T_6 or T_5 and this result was supported by Anup *et al*. (2010) who reported that significant higher yield (length of cob) was obtained as a result of the application of 100% RDF along with organic manure.

4.2.3 Number of grains per cob (No. of grains/cob)

The data regarding the grains number per cob of hybrid maize crop are presented and shown in Table 9a of the appendix and figure 11.

Highly significant differences was observed number of grains per cob due to the effect of different treatments applied and it was observed that T_6 (50% RDF along with 5t/ha each of FYM and PM) was found to produced more number of grains per cob (423 grains/cob), followed by T_3 (5t/ha PM along with 50% RDF) was also found to produced 416 grains per cob which are non significance, whereas T_1 (100% RDF) was found to produced least grains number per cob (341 grains/cob) among the rest of the treatments used in the trial. The result of the analysis was in line with the report shows by Uwah *et al.* (2011) who reported that the grains number was found to be significantly increased in treatment with PM along with RDF together, whereas Sial *et al*. (2007) and Sarwar *et al.* (2012) were reported that significant increased in grains yield was observed due to combined effect of organic and inorganic fertilizer which are resulted as a result of significant increased in grains number per cob and Thavaprakaash *et al*. (2005 and 2008) as well as Kannan *et al*. (2013) reported the same. This was as a result of continuous supply of nutrients to plant in plots under integrated nutrients management over plots with recommended dose of fertilizer alone.

4.2.4 Weight of cob with husk (g)

The data regarding the cob weight with husk under the influence of INM on hybrid maize are presented and shown in Table 9a of the appendix and figure 11 respectively.

Significant different was obtained with regard to the weight of cob with husk due to the effect of treatments on hybrid maize crop and out of these treatments T_3 (5t/ha PM along with 50% RDF) was recorded to produce cob with highest weight (356.7 g/cob) followed by T_6 (5t/ha each of FYM and PM along with 50% RDF) with a cob weight of 321 g/cob and they are considered to have same effect statistically, whereas the lowest weight was observed in T_8 (259 g/cob) and this result are similar with the finding who reported that all yield parameters were found improved due to integration of 50% recommended dose of fertilizer along with either poultry or goat manure (Thavaprakaash, *et al.*, 2005 and 2008). This was as a result of supply of optimum nutrients requirement during the growing period of hybrid maize.

4.2.5 Weight of cob without husk (g)

The data regarding the weight of cob without husk shows that, there was no significant different on the effect of the eight treatments on cob without husk weight and the data are presented and shown in Table 9a of the appendix and figure 11 respectively.

The result of the analysis shows that all the treatments used in the trial was found to have same effect toward cob weight without husk on hybrid maize but T_3 (50% RDF along with 5t/ha PM) was found to have more weight (223.7 g/cob) than any one of the treatments used in the trial and the least weight (177.7 g/cob) was obtained in T_5 (5t/ha PM along with 100% RDF). However, similar result was presented by Thavaprakaash *et al*. (2005 and 2008) and Panwar (2008) who reported that integration of 50% recommended dose of fertilizer along with poultry or farm yard or goat manure will result in improvement of yield parameters.

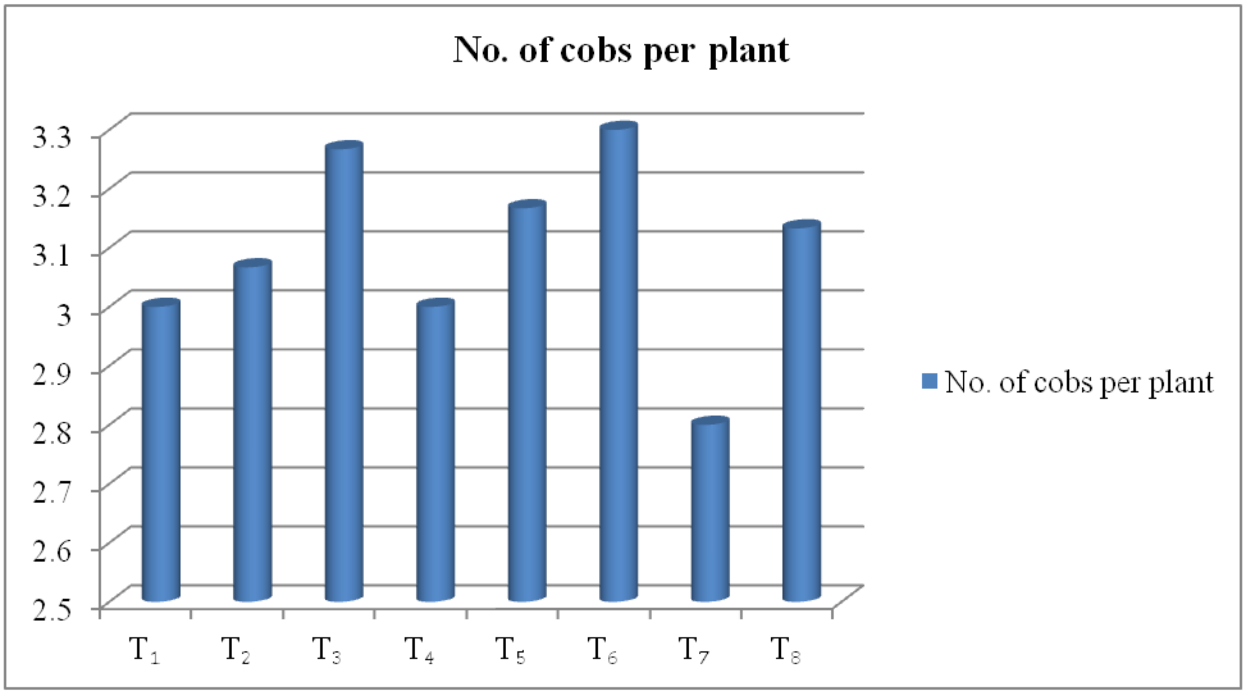


Figure 9: A graph representing effect of INM on number of cobs per plant

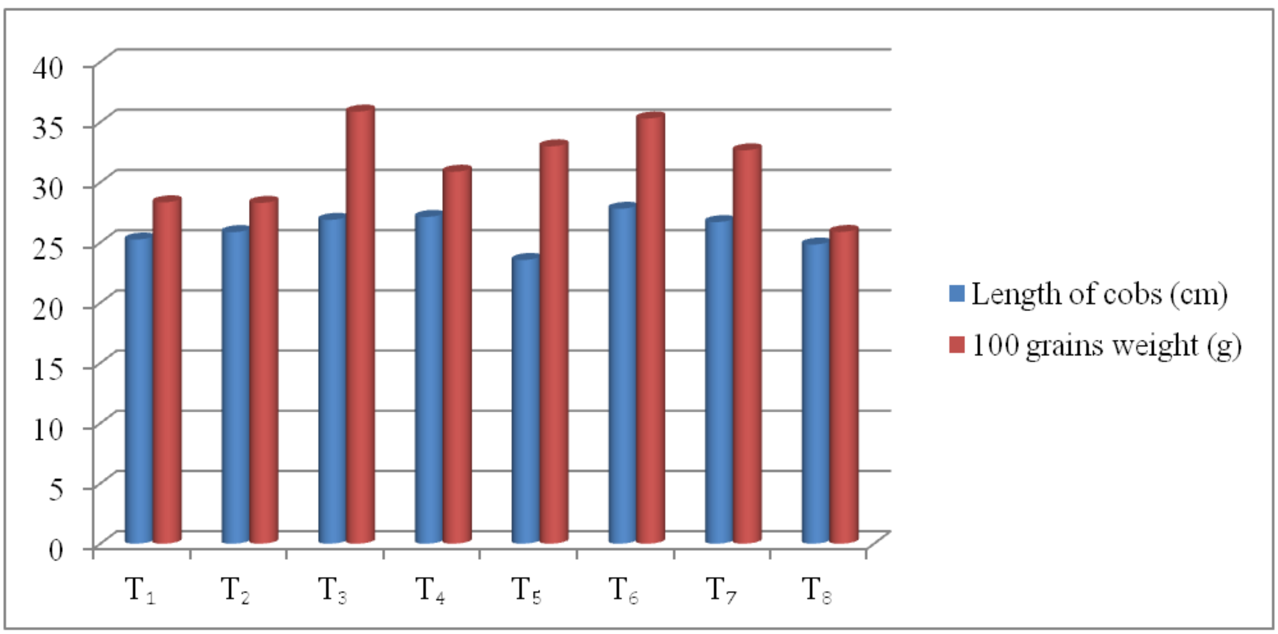


Figure 10: A graph showing effect of INM on cob length (cm) and grains test weight (g)

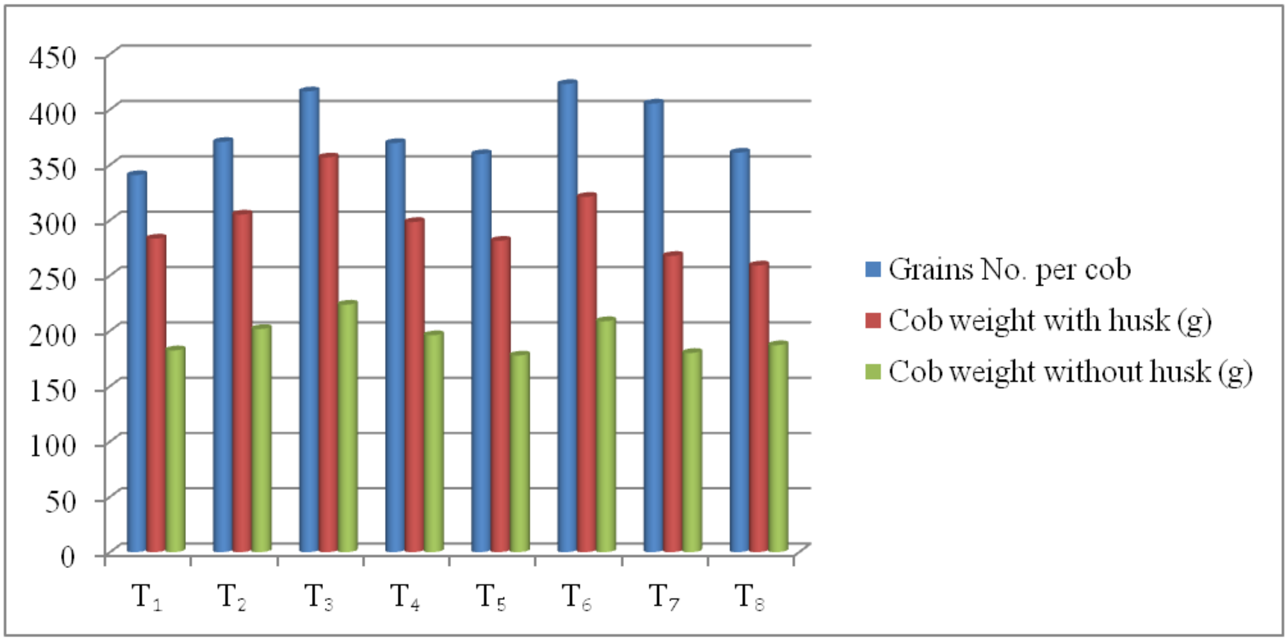


Figure 11: A graph showing the result of the effect of INM on grains number per cob, weight of cob with and without husk (g).

4.2.6 Weight of cob per plant (g)

The data regarding total weight of cobs per plant was found to be significantly different due to various treatments on hybrid maize crop and it was presented and shown in Table 9b of the appendix and figure 13.

The result of the data analysis shows that treatments T_3 (5t/ha PM along with 50% RDF) was recorded with highest total cobs weight per plant (1171.3 g/plant) followed by T_6 (5t/ha each of FYM and PM along with 50% RDF) with a total cobs weight per plant of 1059.2 g/plant due to their effect on maize crop cobs which are significantly same, whereas T_7 was also recorded with lowest total cobs weight per plant (749.5 g/plant) compare with the rest of the treatments used in the trial. The result obtained is similar to Dilshad *et al.* (2010) and Masedul *et al*. (2011) who reported that the effect of INM from different sources resulted with highest economic and biological yield of maize, whereas Panwar (2008) and Thavaprakaash *et al*. (2005 and 2008) found out that application of 50% RDF along with PM or FYM or goat manure resulted in significant increased in yield parameters than sole application of 100% RDF. This was resulted may be owing to continuous availability of nutrients throughout the growing period of the plant.

4.2.7 Fresh cob yield per ha (t/ha)

The data regarding the fresh cob yield with respect to the effect of integrated nutrients management on maize crop are presented and shown in Table 9b of the appendix and figure 12 respectively.

The result of the data analysis revealed that there is no significant different among the eight treatments effect on fresh cob yield of hybrid maize crop. However, interestingly T_3 and T_6 were found to have highest fresh cob yield per ha among the treatments used which are considered significantly same (18.1 t/ha and 16.4 t/ha respectively) whereas T_1 was recorded with least fresh cobs yield per ha than rest of the treatment (10.8 t/ha). This result was supported by Panwar (2008) and Thavaprakaash *et al*. (2005 and 2008) who found out that application of 50% RDF along with PM or FYM or goat manure resulted in significant increased in yield parameters than sole application of 100% RDF. The better availability of nutrients throughout the growing period of plant through integration of organic and inorganic sources supported the plant to increase yield production.

4.2.8 Test weight (g)

The data regarding the 100 grains test weight obtained under INM effect on hybrid maize crop are presented and shown in Table 9b of the appendix and figure 10 respectively.

The result of the analyzed data shows that, significant different exist among the treatments effect on 100 grains weight of hybrid maize crop and it shows that T_3 and T_6 were also found to produced highest grains weight compare to the rest of the treatments used in the trial (35.9 g and 35.3 g per 100 grains, respectively) which was considered significantly same in term of their effect toward obtaining maximum weight of grains, whereas T_1, T_2 and T_8 were recorded with lowest grains weight (28.3 g, 28.3 g and 25.9 g per 100 grains, respectively) among the rest of the treatments used in the trial. However, the result obtained are same line with the finding reported by Kannan *et al*. (2013), Haq (2006), Tripathi *et al*. (2004) and Muhammad *et al*. (2012) were reported that, application of INM through organic (PM or FYM or vermicompost) and inorganic RDF produced significantly higher grains weight over sole application of 100% RDF.

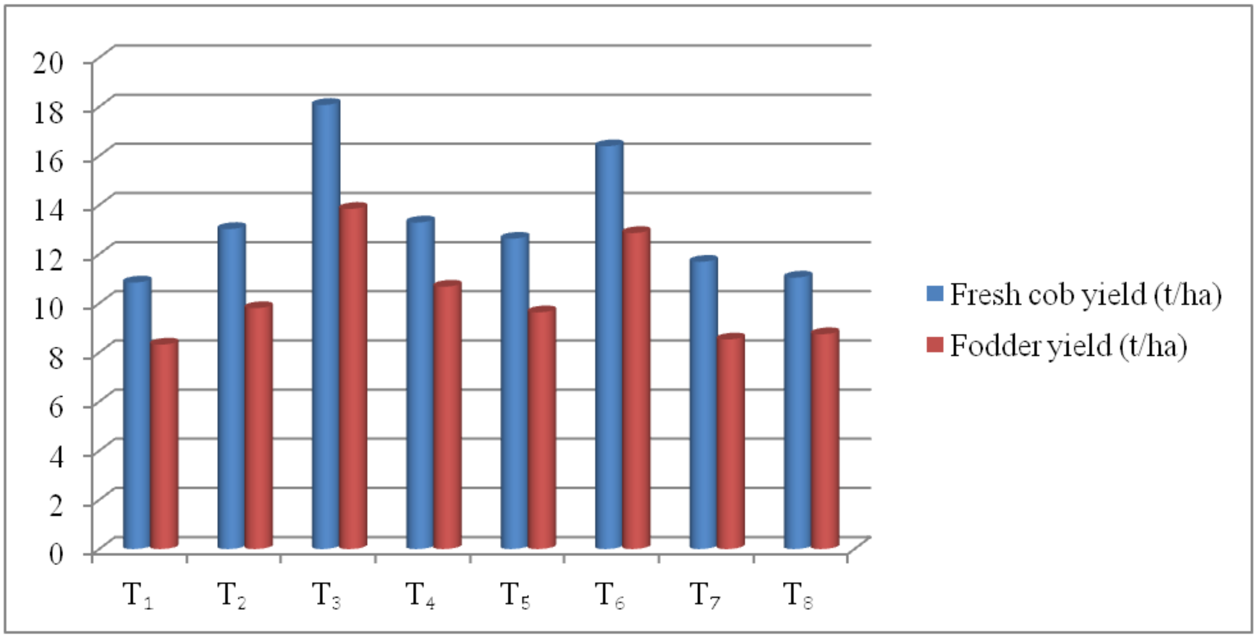


Figure 12: A graph showing the effect of the INM on fresh cob yield (t/ha) and green fodder yield (t/ha)

4.2.9 Stover yield (t/ha)

The data regarding the stover (fodder) yield production under INM or organic effect are presented and depicted in Table 9b of the appendix and shown in figure 12.

The result of the analyzed data revealed that highly significant differences exist among the treatments used and it was shows that T_3 and T_6 resulted in significant increased of stover yield (13.843 t/ha and 12.861 t/ha respectively) more than rest of the treatments applied, followed by T_4 which is having the second highest stover yield (10.679 t/ha) whereas T_1 and T_7 were also found to produced lowest stover yield (8.321 t/ha and 8.529 t/ha respectively) among the treatments used in the trial but T_2, T_5 and T_8 are considered significantly of having same effect as T_1, T_7 or T_4. this result are in line with Dixit and Khatik (2002) who reported that significant increased in straw yield was observed due to integration of 50% RDF along with 10t FYM over sole application of either 100% RDF or 10t FYM. Sarwar *et al.* (2012) and Brar *et al.* (2001) are in support that INM produced significant higher stover yield than sole application of either of them. This significance result was obtained owing to continuous supply of nutrients to the plant throughout growing period in the field due to integration of organic as well as inorganic source which sustain and increase the crop productivity and availability of sunlight.

4.2.10 Harvest Index HI (%)

The data regarding harvest index of hybrid maize crop under the influence of INM are presented and shown below in Table 9b of the appendix and figure 14.

The result of the analyzed data of harvest index was revealed that there was no significant different among all the treatment applied in the trial of this experiment, but despite that statistically they are all same but T_7 (2.5t/ha each of FYM and PM along with 50% RDF) was shown to have highest HI of 57.3% but the least HI of 54.8% was obtained in T_4 (5t/ha FYM along with 100% RDF) among the treatment and the result of this analysis shows that significant higher economic yield was obtained which are in line with Ebrahimpour *et al*. (2011) who reported that highest grain yield due to number of rows in ear, kernel weight, number of grains in ear and harvest index was observed through application of INM either 75 % or 50% RDF and rest part organic sources.

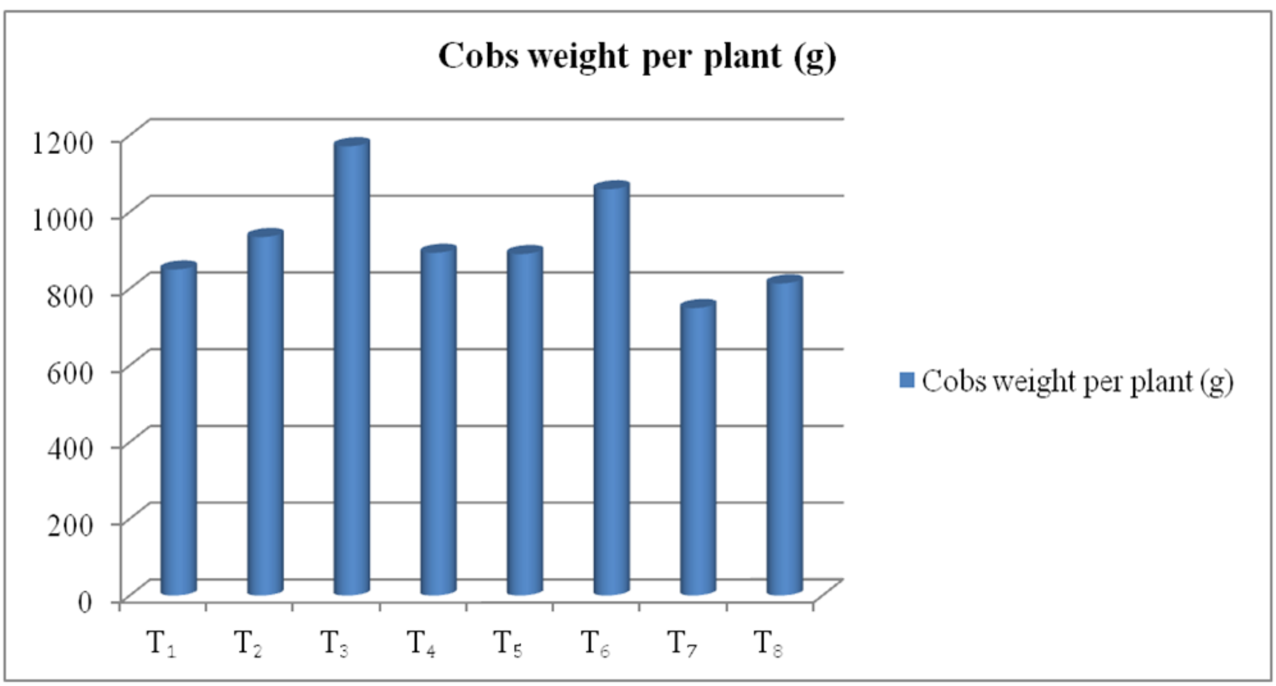


Figure 13: A graph showing the effect of the INM on the weight of cobs per plant (g) of grown hybrid maize crop

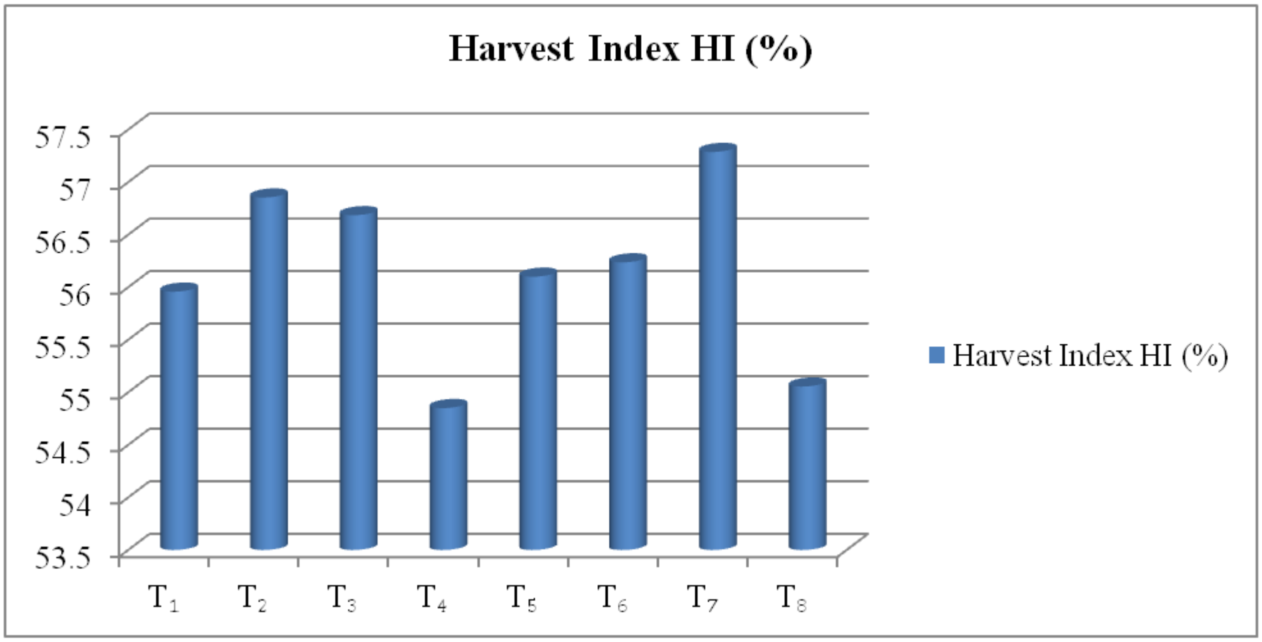


Figure 14: A graph showing the effect of the INM on Harvest index HI (%) of grown hybrid maize

4.3 Quality parameters

For better understanding the influence of various nutrients sources, further investigation was conducted on quality standard on corn. The result have shown significance changes except for few caused by organic sources. The data are presented in Table 11 of the appendix contains data regarding % moisture content, total ash content % and % crude protein content of harvested hybrid maize grains.

4.3.1 Per cent moisture content (% MC)

These data regarding the % MC observed under INM effect on hybrid maize crop are presented in Table 11 of the appendix and depicted in figure 15.

The result of the analyzed data of % MC of fresh hybrid maize grains was found to be significantly different among the treatments and maximum MC of 82.9% was obtained in T_4 (5t/ha FYM along with 100% RDF), followed by T_6 (5t/ha each of FYM and PM along with 50% RDF) with a moisture content of 80.9% but they are considered to be same statistically, whereas minimum MC was observed in T_8 (2.5t/ha each of FYM and PM along with 100% RDF) and T_5 (5t/ha PM along with 100% RDF) where 64.3% and 64.7% respectively are obtained and are also considered same statistically compare to the rest of the teatments used in the trial and this result are supported by finding from Waghmode (2010) who reported that significant increase in quality parameters was observed due to integration of organic and inorganic sources of fertilizer.

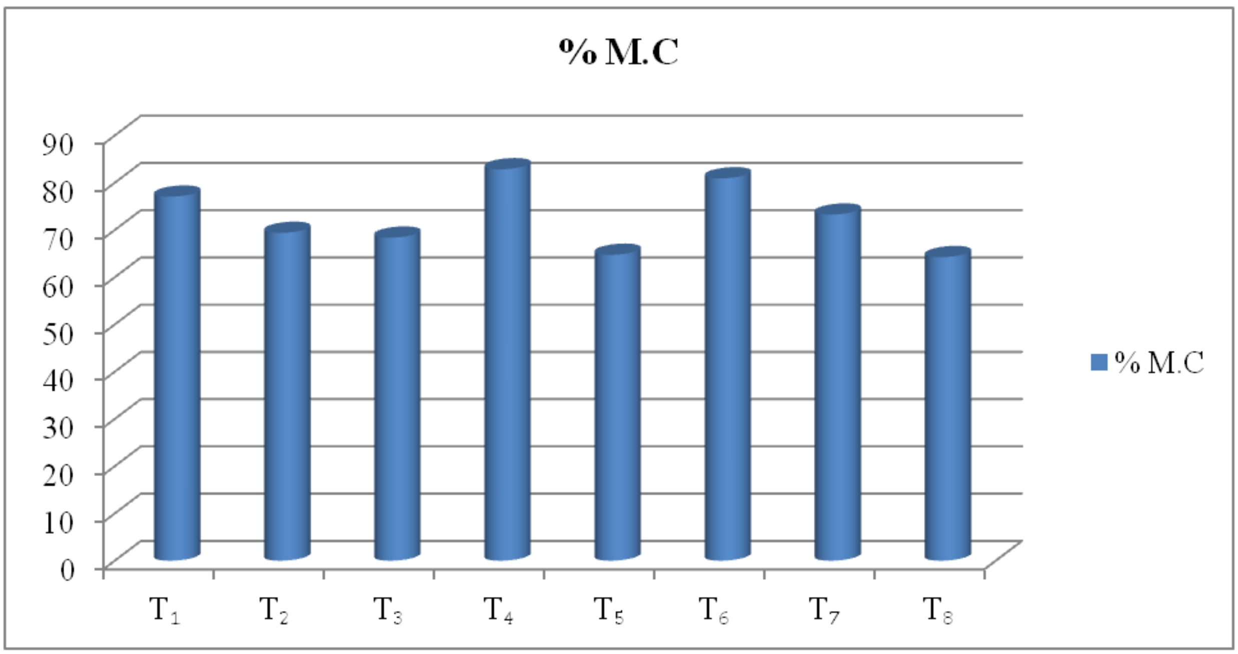


Figure 15: A graph showing the result of the effect of INM on per cent moisture content in hybrid maize grains

4.3.2 Total ash content TA (%)

The data regarding % mineral content of grains of harvested hybrid maize are presented in Table 11 of the appendix and shown in figure 16.

The result of the analyzed data of total ash content of hybrid maize grains revealed that, there was no significant difference among the treatments effect on grown hybrid maize and this result shows that T_3 produced maximum ash (2.024%) than any of the treatments whereas T_4 was recoded to produce lowest % ash content (1.4%) compare to the rest of the treatments used but all the treatments used in the trial are found to be insignificant in their effect towards total ash content in the hybrid maize grains and this result was in contrary state with Waghmode (2010) who reported that significantly higher quality parameters was obtained due to integration of both RDF and organic manure. This was happened as a result of availabilty of nutrients throughout crop growing period which resulted in maximum uptake of nutriens by all the plants in all the plots.

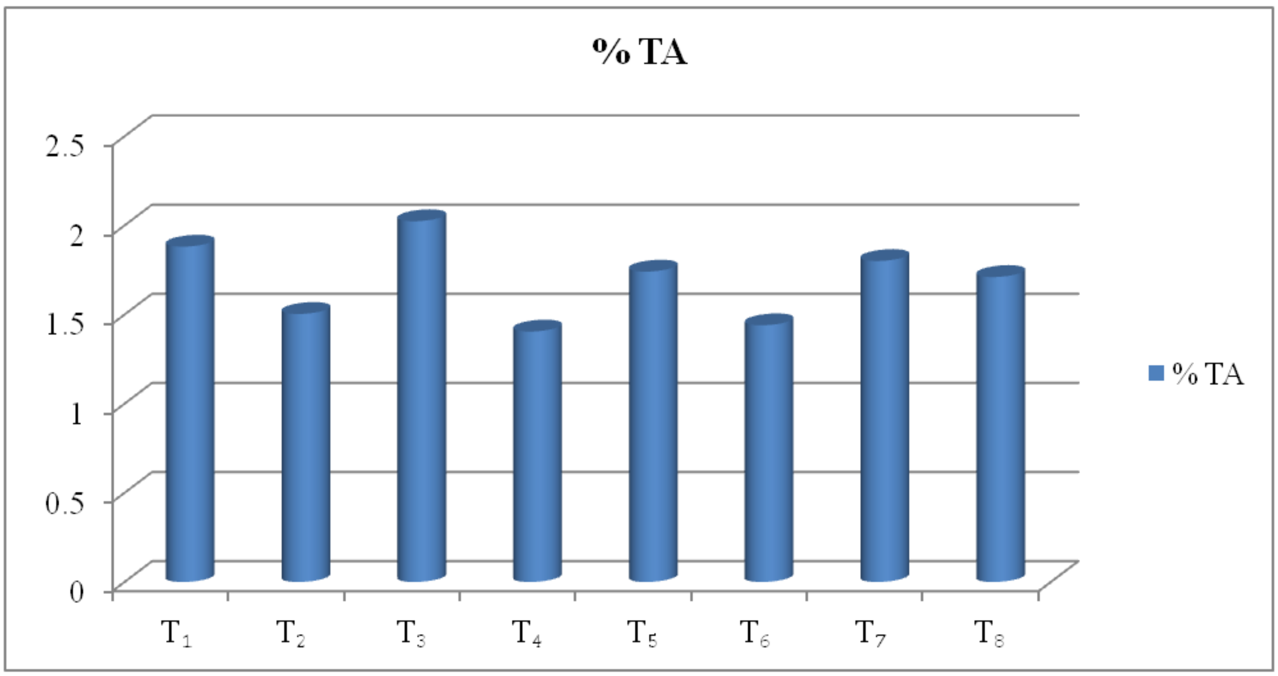


Figure 16: A graph showing the result of the effect of INM on total ash content (% TA) of hybrid maize grains

4.3.3 Per cent crude protein content (% CP)

The data regarding the % CP in hybrid maize grains as influence by integrated nutreint management are presented in Table 11 of the appendix and shown in figure 17 of this chapter.

The result of the analyzed data of % CP of hybrid maize grains shows that, there was no significant differences among the treatments effect on hybrid maize crop but the T_3 and T_8 recorded the maximum % CP (11.713% and 11.646 %) than any of the treatments used in the trial and they are corsidered to be statistically same in the effect toward CP, whereas T_7 was recorded with the lowest (10.104 %) effect regarding the % CP among the rest of the treatments used in the trial but the rest of the treatments used can also produced the same result as in either T_3 , T_8 or T_7 in the trial and this result was suported by many result like Wagh (2002), Verma (2011), Khadtare *et al*. (2006) and Bhagade *et al*. (2008) as well as Channabasanagowda *et al*. (2008) who reported that integration of organic and inorganic nutrient sources resulted in significance increased in protein content in maize grains.

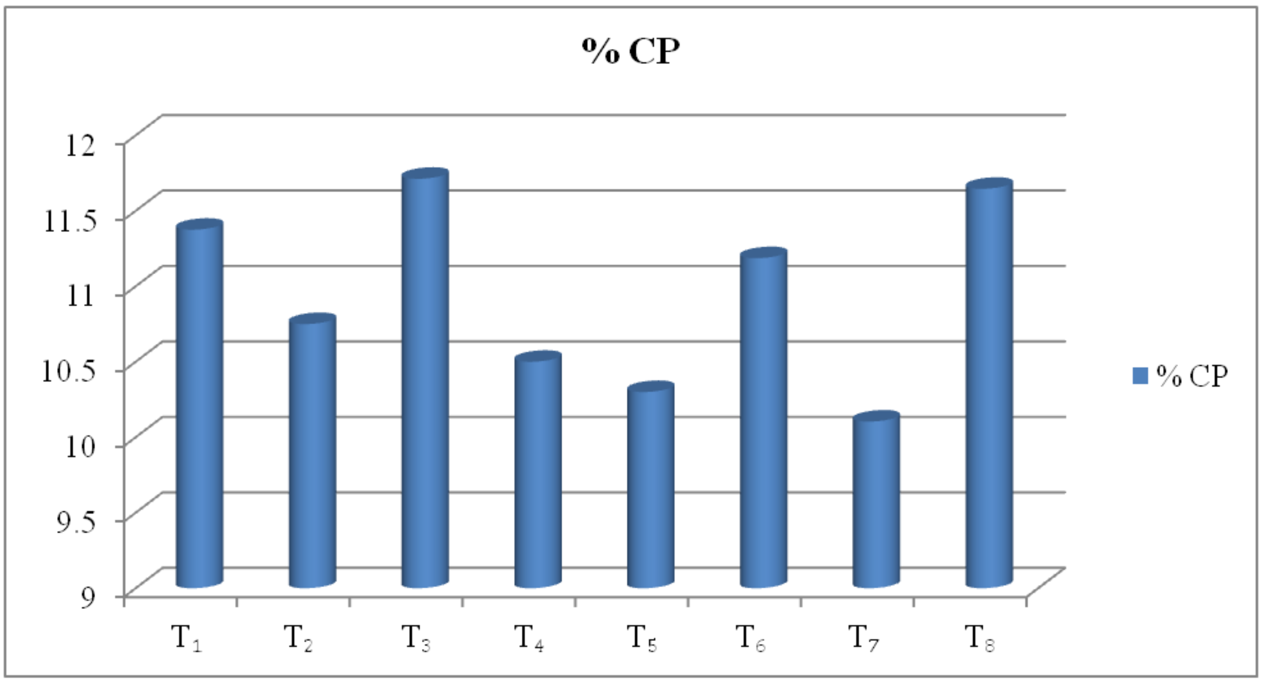


Figure 17: A graph showing the result of the effect of INM on per cent CP content of hybrid maize grains

4.4 Nutrient content in shoot (%)

The data regarding nutrients (Nitrogen, Phosphorus and Potassium) content in the hybrid maize shoot are presented in the table 12 of the appendix.

4.4.1 Nitrogen content N (%)

The data regarding the content of nitrogen in the shoot of hybrid maize crop grown under the effect of INM are presented in Table 12 of the appendix and depicted in figure 18.

The result of the analyzed data shows a highly significant different among the treatment used in the trial and T_3 (5t/ha PM along with 50% RDF) and T_6 (50% RDF along with 5t/ha each of PM and FYM) shows a higher nitrogen content in the shoot (3.2% and 3.2% respectively) more than rest of the treatments used in the trial but are considered to be non significant, followed by T_5 (5t/ha PM along with 100% RDF) with a N content of 3.023%, whereas T_1 and T_8 produced lowest N content in the shoot (2.887% and 2.893% respectively) among the rest of the treatments and this result was supported by Sarwar *et al*. (2012) who reported that, more N was available to plant from organically substituted treatments more than treatments under 100% RDF and Bokhtair and Saurai (2005) reported that addition of organic manure enhance the readily available nutrients for plant growth and development.

4.4.2 Potassium content K (%)

The data regarding the content of K in the shoot of hybrid maize grown under the influence of INM are presented in Table 12 of the appendix and shown in figure 18.

The result of the analyzed data of K content in shoot of hybrid maize revealed that highly significant different exist among the treatments used in the trial and its revealed that T_6 and T_3 was found to have significantly higher K content in the shoot (2.257% and 2.250% respectively) more than any of the treatments used in the trial and they are statistically same, followed by T_4 and T_5 (2.190% and 2.197%) which are also having same effect toward the crop in term of K content whereas, T_8 and T_7 were found to have lowest K content in the shoot (2.153% and 2.157%) more than rest of the treatments but T_1 and T_2 can either be having the same effect as T_8 and T_7 or T_4 and T_5 statistically. This result was found to be contrary to Sarwar *et al*. (2012) who reported that, nutrients uptake will be increase if 25 or 50% N are replace with FYM or organic manure. Bokhtair and Saurai (2005) reported that addition of organic manure enhance the readily available nutrient for plant growth and development.

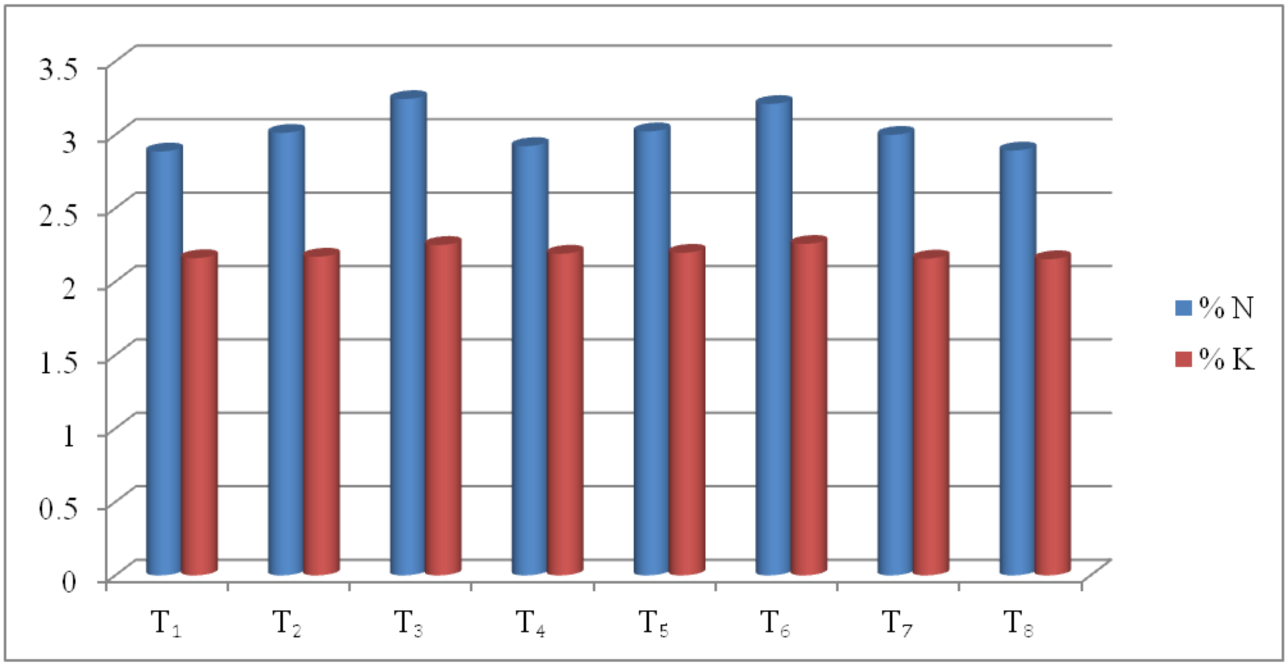


Figure 18: A graph depicting the effect of INM on Nitrogen N (%) and potassium K (%) content in shoot of grown hybrid maize

4.4.3 Phosphorus P content (%)

The data regarding the content of P in the shoot of hybrid maize grown under the influence of INM are presented in Table 12 of the appendix and shown in figure 19.

The result of the analyzed data of P content in the shoot revealed that, highly significant difference exist among the treatments used in the trial with T_6 and T_3 were found to have significantly higher P content in the shoot (0.32% and 0.31%) more than rest of the treatments used which are considered to be non significant followed by T_4 (5t/ha FYM along with 100% RDF) with P content in the shoot of 0.27%, whereas T_1 was found to have the lowest P content in the shoot (0.25 %) among the rest of the treatments. This result was found to be supported by Bokhtair and Saurai (2005) reported that addition of organic manure enhance the readily available nutrient for plant growth and development.

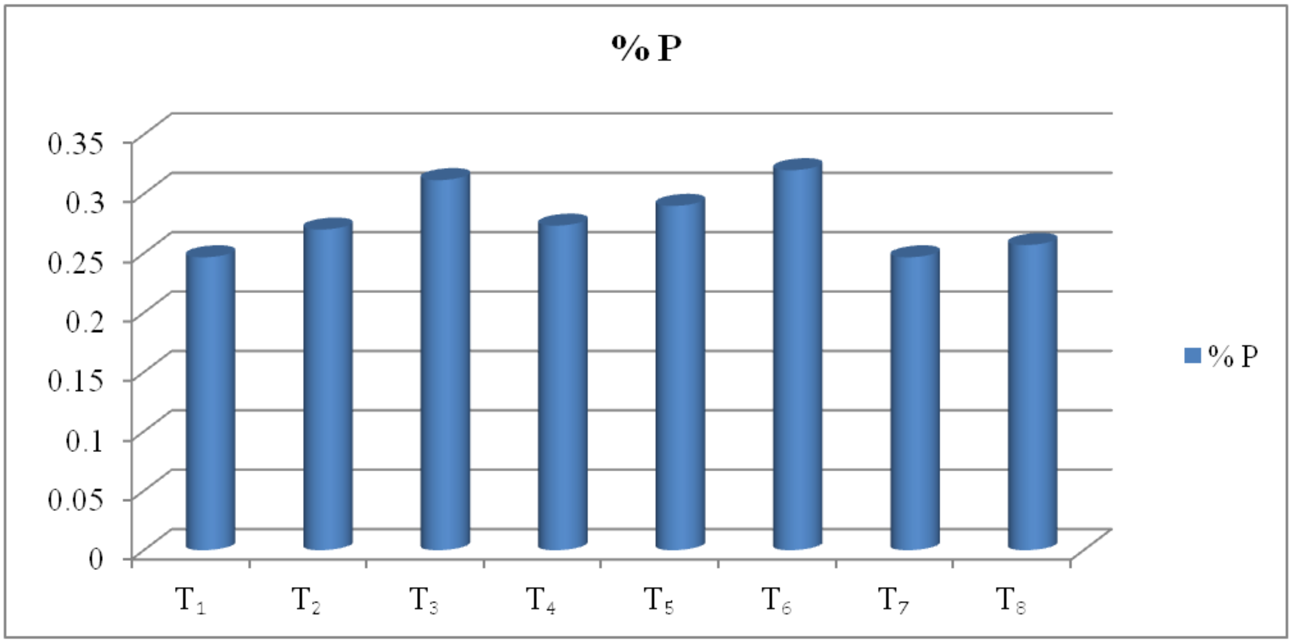


Figure 19: A graph showing the effect of INM on content of phosphorus (%) P in shoot of grown hybrid maize

4.5 Nutrients Uptake (kg/ha)

The data of nutrients (NPK) uptake by the hybrid maize crop grown under the influence of INM are presented in Table 13 of the appendix.

4.5.1 Nitrogen N uptake (kg/ha)

The data regarding the N uptake under the effect of INM on hybrid maize crop through its shoot are presented in Table 13 of the appendix and shown in figure 20.

The result of the analyzed data of N uptake through the shoot of harvested hybrid maize shows that highly significant different were obtained among the treatments used in the trial with T_3 (5t/ha PM along with 50% RDF) was found to be significantly higher in term of N uptake (455.1 kg/ha) more than any of the treatments used in the trial, followed by T_4 (5t/ha FYM along 100% RDF) which has a record of 314.9 kg/ha while T_1 (100% RDF) was found to have the lowest N uptake (242.4 kg/ha) compare to the rest of the treatments. This result was supported by Dilshad *et al*. (2010) who suggested that integration of nutrients from different source increase nutrients uptake more than application of inorganic or inorganic alone and Sarwar *et al*. (2012)

who reported that, nutrients uptake will be increase if 25 or 50% N are replace with FYM or organic manure

4.5.2 Phosphorus P uptake (kg/ha)

The data regarding the P uptake under the influence of INM on hybrid maize are presented in Table 13 of the appendix and shown in figure 21. The data was analyzed under analysis of variance to find out the actual differences among the treatments effect on P uptake.

The result of the analyzed data of P uptake obtained through the shoot of harvested hybrid maize shows that highly significantly different among the treatments used in the trial with T_3 was found to produced significantly higher P uptake (46.8 kg/ha) followed by T_6 who was found to have 40.7 kg/ha whereas T_1 and T_8 were also found to have lowest P uptake (20.6 and 22.6 kg/ha respectively) and statistically same with each other in term of their effect compare to the rest of the treatments used in the trial. Similar result was obtained by Mujeeb *et al*. (2010) who revealed that significant increased in P uptake occur due to combine used of organic and inorganic P over sole application of P from one sources and Dilshad *et al*. (2010) who suggested that integration of nutrients from different source increase nutrients uptake more than application of inorganic or inorganic alone.

4.5.3 Potassium K uptake (kg/ha)

The data regarding the K uptake under the influence of INM on hybrid maize are presented in Table 13 of the appendix and shown in figure 20. Potassium help in disease resistance, improving the quality of produce and overall plant vigour (Practical Manual).

The result of the analyzed data of K uptake obtained through the shoot of harvested hybrid maize shows that highly significant difference was obtained among the treatments used in the trial and T_3 was resulted in significantly higher K uptake (311.7 kg/ha), followed by T_6 with a record of 290.3 kg/ha than rest of the treatments used but they are statistically same in their effect towards K uptake, whereas T_1 and T_7 were also found to have the lowest K uptake statistically (179.5 and 184.05 kg/ha respectively) among the rest of the treatments used in the trial. The present trial are similar to Sarwar *et al*. (2012) who reported that, nutrients uptake will be increase if 25 or 50% N are replace with FYM or organic manure and Dilshad *et al*. (2010)

who suggested that integration of nutrients from different source increase nutrients uptake more than application of inorganic or inorganic alone.

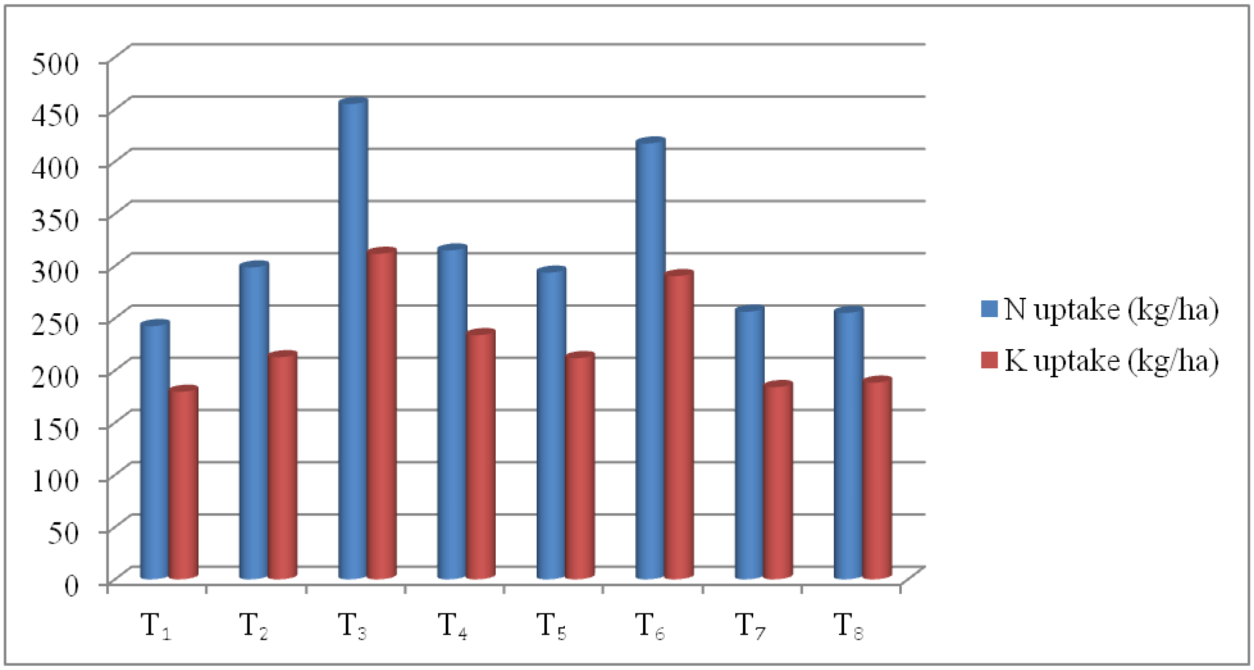


Figure 20: A graph showing the effect of INM on nitrogen N and potassium K uptake by the shoot of hybrid maize crop

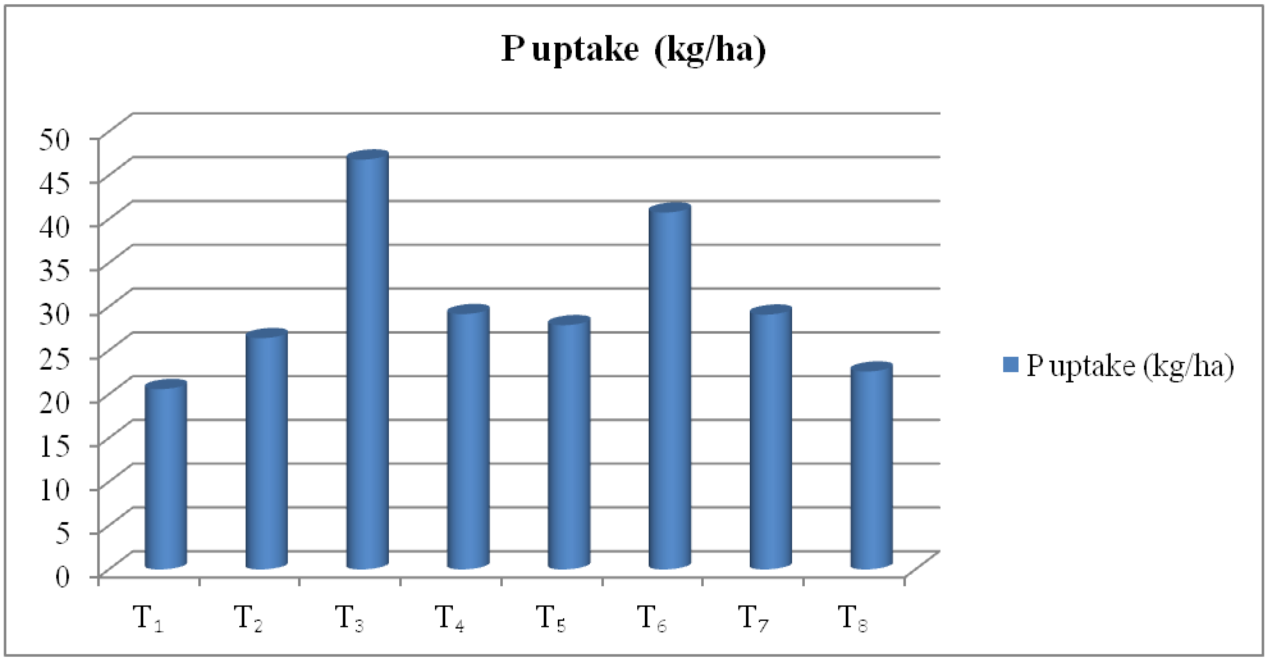


Figure 21: a graph showing the effect of INM on phosphorus P uptake by the shoot of hybrid maize crop

4.6 Soil Available Nutrients and Organic carbon

The data regarding the soil available nutrients (NPK) including the organic carbon after harvesting of the cultivated hybrid maize under the effect of INM are presented in Table 14 of appendix.

4.6.1 Soil Organic Carbon SOC (%)

Carbon was considered as the major constituent of organic matter and the estimation of organic matter are carried out through organic carbon which are considered to be about 58% of soil organic matter (Practical Manual). The soil organic carbon data after harvesting of hybrid maize are presented in Table 14 of appendix and shown in figure 22. The data was analyzed under analysis of variance ANOVA.

The result of the analyzed data shows a highly significant increased of SOC among the treatments effect on soil after harvest. The maximum increased of SOC after harvest was observed in plots containing the T_3 (1.5%) and T_6 (1.5%) which are statistically the same where 5t PM along with 50% RDF and 5t each of PM and FYM along with 50% RDF were used respectively and these resulted in superior growth and development of crop in such plots during the period of the trial and the lowest increased (0.7%) among the treatments was observed in T_1 where only 100% RDF was used. This result are similar to the reports shown by Sarwar *et al*. (2012) who reported that replacement of 25% or 50% N with organic manure increases the organic matter content in the soil after harvest and Kannan *et al*. (2013) who shows that integration of organic and inorganic nutrients sources resulted in maximum organic carbon whereas Chaudhry *et al*. (2009) who found out that soil organic matter increases when poultry litter was applied on wheat.

4.6.2 Available Soil Nitrogen N (kg/ha)

The soil available nitrogen represents a fraction of the total nitrogen susceptible to absorption by plant. Nitrogen is generally taken up by the plant in the form of nitrate $N0_3$ form under aerobic and as NH_4 ions under anaerobic condition of plant growth (Practical Manual). The data regarding the available soil N are presented in Table 14 and shown in figure 24.

The result of the analysis of soil available nitrogen revealed that highly significant different exist among the treatments effect on available N in the soil after harvest. Compare to control T_1 which resulted in lower available soil N (385.2 kg/ha) and rest of the treatments used, T_3 (5t/ha PM along with 50% RDF) and T_8 (2.5t/ha each of FYM and PM along with 100% RDF) resulted in maximum soil available N (565.4 kg/ha and 558.1 kg/ha respectively) which contains a combination of organic and inorganic sources of nutrients and they are statistically same in term of their effects on soil available N improvement. The above result are in similar position with Jat *et al*. (2013) who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer as well as Sharma and Banik (2012) shows that integration of organic and inorganic sources of nutrient improved soil fertility status.

4.6.3 Soil Available Phosphorus P (kg/ha)

The available soil P performed so many function including root development, carbohydrate metabolism, flowers, seeds and fruit formation, formation of high energy bond in ATP and so on (Practical Manual). The analyzed data regarding soil available P due to the effect of INM are presented in Table 14 of appendix and shown in figure 25 of this chapter.

The result of the data regarding available soil P shows that highly significant increase of P was resulted due to the effect of the on the soil after harvest. T_1 (100% RDF) was found to have lowest P value (9.4 kg/ha) compared to the rest of the treatments of the trial and T_5 (19.6 kg/ha) was found to be significantly increased more than any of the treatments used where 5t PM along with 100% RDF was applied. T_6 and T_3 was also resulted in significant increase in available soil P (15.5 kg/ha and 15 kg/ha respectively) which are found to be statistically the same with each other in their action towards soil improvement of P. The result obtained are in similar position with Jat *et al*. (2013) who reported that application of FYM along with RDF increases overall land productivity than sole use of inorganic fertilizer as well as Sharma and Banik (2012) shows that integration of organic and inorganic sources of nutrient improved soil fertility status.

4.6.4 Soil Available Potassium SAP (kg/ha)

The soil potassium help in disease resistance, improving the quality of produce and overall plant vigour. The data with regard to SAP as influence by INM are presented in Table 14 and shown in figure 24 of this chapter .

Highly significant increase in SAP was observed among the treatments used in the trial plots soil after harvest with T_1 (100% RDF only) and T_8 (2.5t each of PM and FYM along with 100% RDF was applied) was recorded with maximum increase in SAP (415.3 kg/ha and 401.5 kg/ha respectively) compare to the rest of the treatments used, which are found to be same statistically in term of their effect on SAP and T_6 (176.9 kg/ha) was recorded with lowest SAP compare to the rest of the treatments used in the trial due to the high uptake of potassium by crop plant during growing period in plots containing T_6 more than in T_1 and T_8 which recorded with lowest potassium uptake compare with the T_1 and T_8 treatments.The result of this trial are similar to that of Kannan *et al*. (2013) who found out that more available soil potassium was found in inorganic plots than organic plots. This result was due to the application of 100% RDF in both the two treatments T_1 (100% RDF) and T_8 (2.5t/ha each of FYM and PM along with 100% RDF) and less uptake of potassium by the plant during the growing period couple with high available potassium status in the soil sample before application of any treatments in respective plots at the beginning and hence this reasons may caused the maximum increased in available soil potassium after harvest.

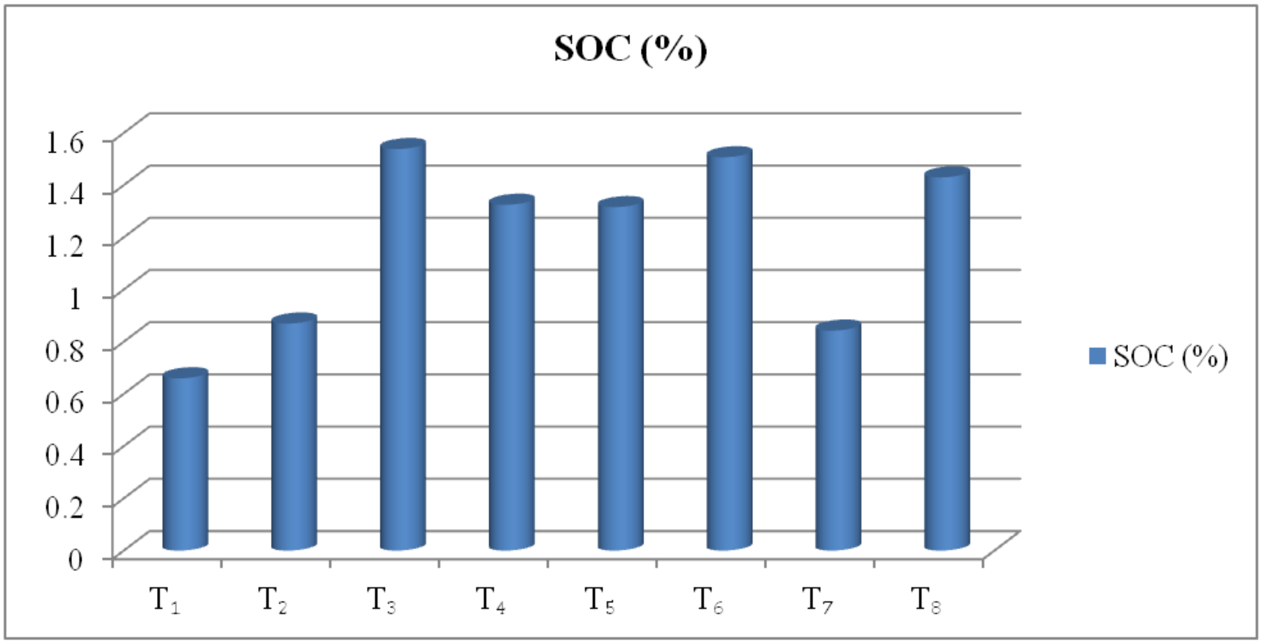


Figure 23 A graphs showing the effect of INM on organic carbon content in the soil after cultivation of hybrid maize

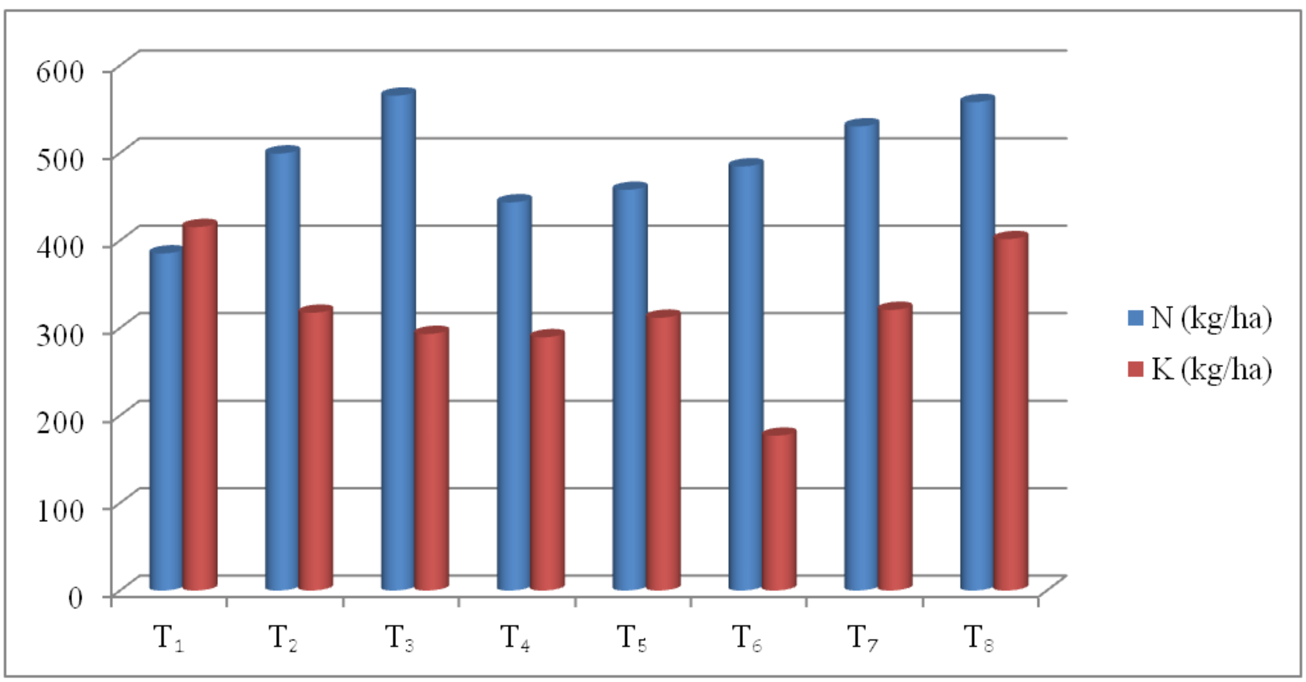


Figure 24 A graphs showing the effect of INM on soil available nitrogen and potassium after cultivation of hybrid maize

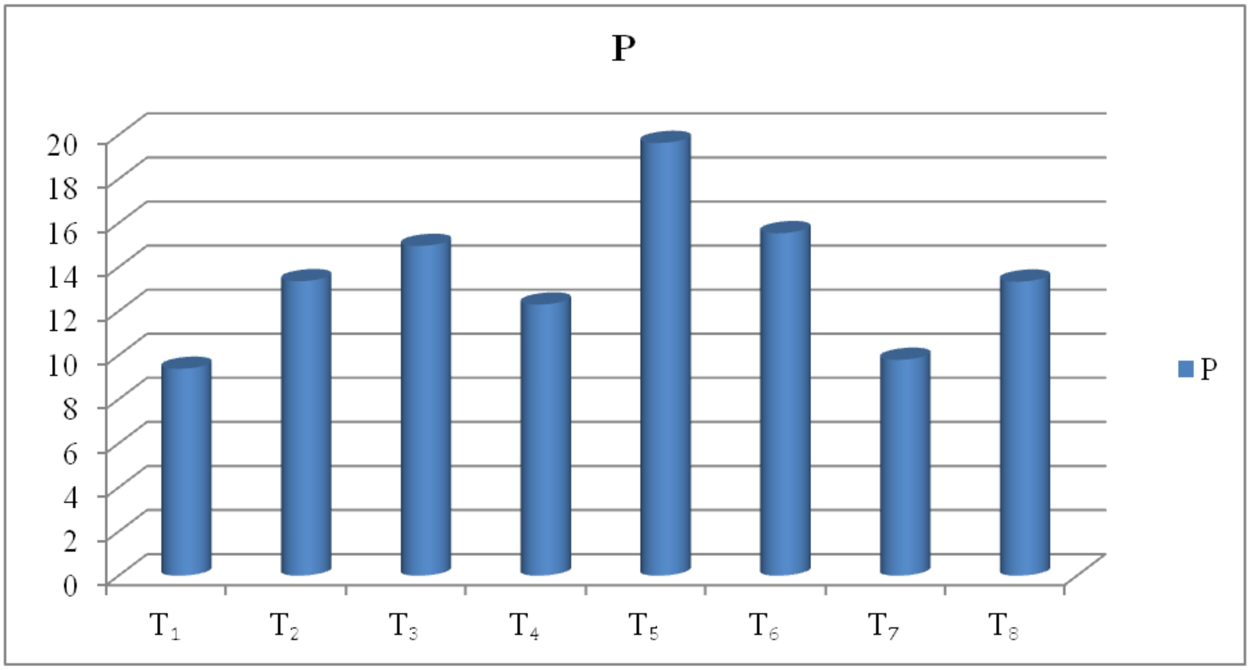


Figure 25 A graphs showing the effect of INM on soil available phosphorus after cultivation of hybrid maize crop

PLATE 1: Experimental plots at early tasseling stage of maize crop

PLATE 2: Maize at tasseling and silking stage of growing period

PLATE 3 Experimental plot during growing Period

CHAPTER FIVE

SUMMARY AND CONCLUSION

A field experiment was conducted during the winter season of 2013 at a Main Research Field of the School of Agriculture Lovely Professional University, Phagwara, India to study "Effect of integrated nutrient management on growth, yield and quality parameters of maize (*Zea mays* L.) The trial was laid out in randomized complete block design (RCBD) replicated three (3) times with eight (8) treatments in sandy clay loam soil of Punjab with slightly alkaline pH (7.90). The summary of the result obtained are outlined in this chapter.

The result obtained at harvest due to the effects of INM on growth parameters was found to have significant effect on some parameters such as leaf area (531 cm^2), Absolute growth rate (4.8 g/day/plant) and shoot dry matter production (78.1 g/plant) and in these growth parameters application of 50% recommended dose of fertilizer RDF (60:30:20 kg NPK/ha) along with 5t/ha poultry manure (PM) or 5t/ha each of PM and farm yard manure (FYM) along with 50% RDF were found superior compare to control where 100% RDF (120:60:40 kg NPK/ha) was applied alone but for growth parameters like Plant height (cm), number of leaves, leaf area index, Net assimilation rate (g/cm^2/day) and crop growth rate (g/cm^2/day) insignificant different were observed among the treatments effect on such parameters at harvest.

The result obtained after harvesting the crop under the influence of INM on yield parameters was also found that some parameters are influenced significantly while others are not, parameters such as number of grains per cob (416.6), weight of cob with husk (356.7 g/cob), cobs weight per plant (1171.3 g/plant), 100 grains weight (35.9 g/100 grains) and Stover yield (13.8 t/ha) shows significant different among the treatments effect with T_3 (5t/ha PM plus 50% RDF (60:30:20 kg NPK/ha)) yielded more than control where 100% RDF (120:60:40 kg NPK/ha) was applied whereas parameters such as fresh cob yield (t/ha), No. of cobs per plant, length of cobs per plant (cm), weight of cob without husk (g) and harvest index (%) all shows insignificant different toward treatments effect on them but even in these parameters INM treatments shows little more higher value over control.

The three (3) quality parameters result shows that some parameters were positively shown differences in their response toward the treatments applied while other not, parameters such as crude protein content (11.7%) shows significant different among the treatments effect in which T_3 a combination of 5t PM along with 50% RDF (60:30:20 kg NPK/ha) produced superior result than treatment containing sole 100% RDF (120:60:40 kg NPK/ha), whereas moisture content in fresh grains was also found to be significantly different with T_4 (5t FYM along with 100% RDF) found to have more moisture content (82.9%) than any of the treatments used in the trial but the total ash content in the grains shows that the effect of the treatments were resulted in same effect among the treatments used, mean insignificant different exit.

The result obtained in nutrients (NPK) content in the shoot of harvested crop were observed to be significantly different in all the three parameters such as nitrogen content (3.24%) which T_3 resulted in high nitrogen content more than rest of the treatments used, but for phosphorus content T_6 a combination of 5t each of PM and FYM along with 50% RDF (60:30:20 kg NPK/ha) shows high P content (0.32%) and potassium content in the shoot was obtained higher (2.26%) under the influence of T_6 5t/ha each of PM and FYM along with 50% RDF per ha more than control whereby 100% RDF (120:60:40 kg NPK/ha). The uptake of such nutrients during the crop growing period were also found to shows significant different among the treatments whereby the treatments involving INM 50% RDF (60:30:20 kg NPK/ha) along with 5t PM shows high uptake of nitrogen, phosphorus and potassium (455.1, 46.8 and 311.7 kg/ha respectively) resulted in more high uptake over sole application of 100% RDF (120:60:40 kg NPK/ha)

The obtained result of the available soil nutrients (NPK) and organic carbon content after harvesting the crop shows that the treatments involving a combination of 50% RDF along with 5t PM were found to have high soil organic carbon (1.538 kg/ha) and available nitrogen (565.447 kg/ha) more than T_1 containing 100% RDF(120:60:40 kg NPK/ha) while the soil available phosphorus was found to be higher under treatment with 5t PM along with 100% RDF more than control, but the available soil potassium was found to be significantly higher under control (415.325kg/ha) whereby 100% RDF was applied alone.

CONCLUSION

The result obtained from the field experiment conducted to study the growth, yield and quality parameters of hybrid maize as influenced by integrated nutrient management revealed that, maximum maize productivity can be obtained through application of integrated nutrient management involving a combination of either 5t/ha poultry manure (PM) along with 50% RDF (60:30:20 kg NPK/ha) or 5t/ha each of FYM and PM along with 50% RDF but based on the result obtained under this research a treatments containing 5t/ha poultry manure (PM) along with 50% RDF was concluded to be best treatments among all the treatments used in the trial because its more economical than T_6 (50% RDF along with 5t/ha each of FYM and PM) since both the two treatments were producing same result and this treatments not only increased productivity of maize but also enhanced the fertility status of the soil, in terms of available nitrogen, available phosphorus and organic carbon content in the soil more than rest of the treatments or combination containing of both organic and inorganic sources as well as sole application of 100% RDF (120:60:40 kg NPK/ha) which will sustain the land productivity for a period of time owing to residual effect of organic manure in the soil.

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APPENDIX

Table 3.1 Summary of climatic record during the growing period of the hybrid maize

Months	**Rainfall (mm)**	**Relative humidityRH (%)**	**Minimum Temperature (^{0}C)**	**Maximum Temperature (^{0}C)**
October, 2013	75.9	83.0	17.0	30.5
November, 2013	23.1	74.8	9.9	26.4
December, 2013	3.6	89.1	6.2	20.6
January, 2014	18.1	86.7	4.4	19.1
February, 2014	8.9	79.9	5.8	20.2
March, 2014	68.3	74.5	10.5	25.6
April, 2014	6.1	49.5	18.8	34.8
Total	204.0	-	-	-

Table 3.3: Biometric observations of hybrid maize crop

S/No	Parameters	Frequency	Observation period
1.	**Pre-harvest observations**		
a.	Plant height (cm)	6	30, 45, 60, 75, 120 DAS & at harvest
b.	Number of leaves per plant	6	30, 45, 60, 75, 120 DAS & at harvest
c.	Leaf Area (cm^2/plant)	6	30, 45, 60, 75, 120 DAS & at harvest
d.	Leaf Area Index	6	30, 45, 60, 75, 120 DAS & at harvest
e.	Absolute Growth Rate AGR (g/plant/day)	6	30, 45, 60, 75, 120 DAS & at harvest
f.	Net Assimilation Rate NAR (g/m^2/day)	6	30, 45, 60, 75, 120 DAS & at harvest
g.	Crop Growth Rate CGR (g/m^2/day)	6	30, 45, 60, 75, 120 DAS & at harvest
h.	Dry matter accumulation (g/plant)	6	30, 45, 60, 75, 120 DAS & at harvest
2.	**Post harvest observations**		
a.	Number of cobs per plant	1	At harvest
b.	Length of cob (cm)	1	At harvest
c.	Weight of cob (g)	1	At harvest

d.	Number of grains per cob	1	At harvest
e.	Fresh cob yield ($kgha^{-1}$)	1	At harvest
f.	Weight of cob with husk (g)	1	At harvest
g.	Weight of cob without husk (g)	1	At harvest
h.	Test weight (g)	1	At harvest
i.	Stover yield ($t\ ha^{-1}$)	1	At harvest
j.	Harvest index HI (%)	1	At harvest
3.	**Physical properties of soil**		
a.	Textural class (% sand, silt and clay content)	1	Before sowing
b.	pH	1	Before sowing
c.	Electrical conductivity (dS/m)	1	Before sowing
4.	**Chemical properties of soil**		
a.	Available Nitrogen (kg/ha)	2	Before sowing and after harvest
b.	Available Phosphorus (kg/ha)	2	Before sowing and after harvest
c.	Available potassium (kg/ha)	2	Before sowing and after harvest

d.	Organic Carbon (%)	2	Before sowing and after harvest
5.	**Nutrients Uptake**		
a.	N uptake of shoot (kg/ha)	1	After harvest
b.	P uptake of shoot (kg/ha)	1	After harvest
c.	K uptake of shoot (kg/ha)	1	After harvest
6.	**Quality observations**		
a.	Protein content (%) in grains	1	After harvest
b.	moisture content (%) in grains	1	After harvest
c.	Total ash content (%) in grains	1	After harvest

Table 1: Plant height at different stages of maize growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	24.633[b]	31.333[a]	35.333[a]	42.567[a]	112.333[a]	132.133[a]
T_2	20.600[ab]	30.900[a]	36.733[a]	42.466[a]	125.733[a]	144.867[ab]
T_3	22.900[ab]	31.600[a]	38.600[a]	45.633[a]	123.100[a]	142.467[ab]
T_4	19.967[a]	33.467[a]	36.683[a]	42.533[a]	120.467[a]	142.533[ab]
T_5	23.200[ab]	32.900[a]	37.733[a]	42.600[a]	110.167[a]	131.867[a]
T_6	19.900[a]	32.200[a]	38.800[a]	43.200[a]	130.267[a]	144.833[ab]
T_7	24.833[b]	31.663[a]	34.333[a]	39.467[a]	121.833[a]	153.400[b]
T_8	24.067[b]	31.000[a]	37.933[a]	41.567[a]	111.00[a]	133.433[a]
CD @ 5%	3.481	7.434	9.918	9.288	22.407	21.986
S.E m (±)	1.148	2.451	3.270	3.026	7.388	7.249

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 2: Number of leaves at various stages of maize growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	4.667[a]	9.000[a]	11.333[a]	12.333[a]	14.233[ab]	14.167[a]
T_2	4.667[a]	8.667[a]	10.667[a]	12.000[a]	13.500[ab]	13.967[a]
T_3	5.000[a]	9.667[a]	11.333[a]	13.000[a]	14.567[b]	14.900[a]
T_4	5.000[a]	9.000[a]	9.667[a]	11.667[a]	11.967[a]	12.200[a]
T_5	4.667[a]	9.333[a]	10.667[a]	12.333[a]	12.500[ab]	12.933[a]
T_6	5.000[a]	9.333[a]	10.667[a]	13.000[a]	12.700[ab]	13.333[a]
T_7	5.000[a]	8.667[a]	10.667[a]	12.333[a]	13.100[ab]	13.900[a]
T_8	4.667[a]	8.667[a]	10.000[a]	12.000[a]	12.500[ab]	12.767[a]
CD @ 5%	1.106	1.730	2.644	2.981	2.565	2.827
S.E m (±)	0.365	0.570	0.872	0.983	0.846	0.932

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 3: Leaf Area LA (cm²) at various stage of maize crop growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	68.990[a]	186.957[a]	233.550[b]	275.797[d]	375.854[ab]	426.017[ab]
T_2	85.123[b]	185.427[a]	225.873[b]	256.570[d]	395.358[ab]	430.000[ab]
T_3	92.677[b]	186.973[a]	265.724[b]	292.436[d]	503.938[d]	530.955[d]
T_4	82.297[b]	171.637[a]	231.523[b]	270.273[d]	408.627[b]	451.037[b]
T_5	81.667[b]	172.027[a]	235.200[b]	268.596[d]	424.138[b]	463.925[bd]
T_6	75.590[ab]	162.707[a]	209.447[b]	248.773[d]	535.492[d]	546.160[d]
T_7	72.080[ab]	171.480[a]	218.050[b]	258.780[d]	320.542[ab]	357.117[a]
T_8	78.957[ab]	166.423[a]	235.150[b]	272.780[d]	432.806[bd]	471.638[bd]
CD @ 5%	11.331	47.998	66.187	70.56	77.479	79.361
S.E m (±)	3.736	15.826	21.823	23.265	25.546	26.167

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 4: Leaf Area Index LAI at various stages of maize growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	0.647[ab]	0.633[ab]	0.724[b]	0.910[b]	1.210[d]	2.100[eg]
T_2	0.540[a]	0.600[ab]	0.687[b]	0.910[b]	1.373[d]	2.270[g]
T_3	0.623[a]	0.650[ab]	0.737[b]	0.983[b]	1.407[d]	2.413[g]
T_4	0.743[b]	0.677[b]	0.733[b]	0.840[b]	1.183[d]	1.917[eg]
T_5	0.603[a]	0.544[a]	0.680[b]	0.990[b]	1.270[d]	2.270[g]
T_6	0.590[a]	0.690[b]	0.750[b]	0.880[b]	1.250[d]	2.317[g]
T_7	0.544[a]	0.647[ab]	0.710[b]	0.887[b]	1.203[d]	1.737[e]
T_8	0.553[a]	0.613[ab]	0.690[b]	0.940[b]	1.127[d]	1.970[eg]
CD @ 5%	0.112	0.119	0.108	0.167	0.336	0.42
S.E m (±)	0.116	0.082	0.069	0.079	0.163	0.177

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 5: Absolute Growth Rate AGR (g/day/plant) at various stages of maize growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	0.147^{a}	0.277^{a}	0.613^{a}	0.240^{a}	1.503^{a}	2.903^{a}
T_2	0.247^{b}	0.263^{a}	0.743^{a}	0.417^{a}	2.363^{b}	4.013^{b}
T_3	0.363^{c}	0.283^{a}	0.503^{a}	0.790^{a}	2.820^{b}	4.770^{b}
T_4	0.143^{a}	0.490^{a}	0.457^{a}	0.333^{a}	2.743^{b}	4.140^{b}
T_5	0.167^{ab}	0.340^{a}	0.550^{a}	0.510^{a}	1.907^{ab}	3.587^{ab}
T_6	0.227^{ab}	0.593^{a}	0.413^{a}	0.377^{a}	2.780^{b}	4.287^{b}
T_7	0.233^{ab}	0.523^{a}	0.490^{a}	0.153^{a}	1.720^{ab}	3.913^{b}
T_8	0.207^{ab}	0.283^{a}	0.343^{a}	0.457^{a}	2.597^{b}	3.993^{b}
CD @ 5%	0.965	0.345	0.595	0.635	0.856	0.973
S.E m (±)	0.318	0.114	0.196	0.209	0.282	0.321

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 6: Net Assimilation Rate NAR ($g/cm^2/day$) at various stages of maize crop growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	0.021^{ab}	0.015^{a}	0.025^{b}	0.009^{b}	0.040^{a}	0.067^{a}
T_2	0.039^{b}	0.015^{a}	0.034^{b}	0.016^{b}	0.059^{ab}	0.093^{ab}
T_3	0.039^{b}	0.016^{a}	0.018^{b}	0.026^{b}	0.056^{ab}	0.090^{ab}
T_4	0.017^{a}	0.028^{a}	0.021^{b}	0.013^{b}	0.066^{b}	0.092^{ab}
T_5	0.021^{ab}	0.019^{a}	0.024^{b}	0.020^{b}	0.044^{ab}	0.077^{a}
T_6	0.03^{b}	0.038^{a}	0.018^{b}	0.015^{b}	0.053^{ab}	0.079^{ab}
T_7	0.032^{b}	0.032^{a}	0.021^{b}	0.006^{b}	0.053^{ab}	0.109^{b}
T_8	0.027^{ab}	0.017^{a}	0.014^{b}	0.017^{b}	0.06^{ab}	0.085^{ab}
CD @ 5%	0.011	0.023	0.024	0.025	0.024	0.03
S.E m (±)	0.004	0.007	0.008	0.008	0.008	0.010

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 7: Crop Growth Rate CGR (g/cm²/day) at various stages of maize crop growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	0.009[a]	0.009[a]	0.018[a]	0.030[a]	0.048[a]	0.138[a]
T_2	0.010[a]	0.009[a]	0.023[a]	0.235[a]	0.083[b]	0.211[b]
T_3	0.015[a]	0.009[a]	0.013[a]	0.464[a]	0.07[ab]	0.221[b]
T_4	0.007[a]	0.020[a]	0.014[a]	0.323[a]	0.081[ab]	0.175[ab]
T_5	0.008[a]	0.011[a]	0.016[a]	0.090[a]	0.056[ab]	0.175[ab]
T_6	0.012[a]	0.026[a]	0.014[a]	0.238[a]	0.069[ab]	0.186[ab]
T_7	0.012[a]	0.020[a]	0.015[a]	0.075[a]	0.065[ab]	0.194[ab]
T_8	0.009[a]	0.010[a]	0.010[a]	0.586[a]	0.068[ab]	0.172[ab]
CD @ 5%	0.006	0.014	0.017	0.601	0.034	0.070
S.E m (±)	0.002	0.005	0.006	0.200	0.012	0.023

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry manure, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 8: Dry matter production SDMP (g/plant) at different stages of maize growth

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	120 DAS	Harvest
T_1	4.910^{ab}	7.550^{a}	11.203^{b}	12.663^{b}	30.337^{a}	63.003^{a}
T_2	6.637^{b}	9.297^{ab}	11.250^{b}	12.710^{b}	30.060^{a}	60.860^{a}
T_3	8.667^{c}	12.763^{b}	14.220^{b}	20.297^{b}	39.920^{b}	78.070^{b}
T_4	4.827^{a}	9.88^{ab}	11.007^{b}	15.673^{b}	33.420^{ab}	65.733^{a}
T_5	5.223^{ab}	7.667^{a}	9.553^{b}	14.467^{b}	26.840^{a}	64.173^{a}
T_6	6.527^{ab}	12.893^{b}	13.260^{b}	15.990^{b}	42.810^{b}	75.187^{b}
T_7	6.553^{b}	10.647^{ab}	12.230^{b}	14.800^{b}	30.740^{a}	60.073^{a}
T_8	6.073^{ab}	8.633^{a}	9.573^{b}	17.873^{b}	29.170^{a}	65.503^{a}
CD @ 5%	1.707	3.490	4.875	5.916	8.902	8.545
S.E m (±)	0.563	1.151	1.607	1.951	2.935	2.642

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), DAS= Days after Sowing, RDF= recommended dose of fertilizer (NPK), FYM= farm yard manure & PM= poultry, T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 9a: A yield parameters of maize crop after harvest

Treatments	No. of cobs per plant	length of cobs (cm)	No. of grains per cob	Cob weight with husk (g)	Without Husk cob weight
T_1	3.000[ab]	25.250[ab]	340.667[a]	283.333[ab]	182.333[ab]
T_2	3.067[ab]	25.867[ab]	370.667[ab]	305.000[ab]	201.667[ab]
T_3	3.267[b]	26.883[ab]	416.333[b]	356.667[b]	223.667[b]
T_4	3.000[ab]	27.130[ab]	369.667[ab]	293.333[ab]	196.000[ab]
T_5	3.167[b]	23.553[a]	359.667[a]	281.333[ab]	177.667[a]
T_6	3.300[b]	27.803[b]	423.000[b]	321.000[b]	208.667[ab]
T_7	2.800[a]	26.270[ab]	405.333[b]	267.667[a]	180.000[ab]
T_8	3.133[ab]	24.837[ab]	361.000[a]	259.000[a]	187.000[ab]
CD @ 5%	0.357	3.874	41.400	50.408	44.595
S.E m (±)	0.118	1.277	13.654	16.621	14.704

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 9b: A yield parameters of hybrid maize crop after harvest

Treatments	Weight of cob (g/plant)	fresh cob yield (t/ha)	Test weight (g)	Stover yield (t/ha)	Harvest index (%)
T_1	850.000[a]	10.847[a]	28.340[a]	8.321[a]	55.958[a]
T_2	934.600[ab]	13.023[ab]	28.293[a]	9.804[ab]	56.854[a]
T_3	1171.267[b]	18.074[b]	35.870[b]	13.843[c]	56.686[a]
T_4	893.533[ab]	13.291[ab]	30.883[ab]	10.679[b]	54.850[a]
T_5	890.333[ab]	12.630[ab]	32.987[ab]	9.634[ab]	56.101[a]
T_6	1059.200[b]	16.394[b]	35.300[b]	12.861[c]	56.237[a]
T_7	749.533[a]	11.690[ab]	32.660[ab]	8.529[a]	57.288[a]
T_8	813.667[a]	11.049[a]	25.883[a]	8.743[ab]	55.065[a]
CD @ 5%	204.85	5.080	6.274	1.972	9.952
S.E m (±)	67.543	1.675	2.027	0.118	3.281

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 11: Quality parameters of hybrid maize grain under the effect of INM

Treatments	% moisture content	Total ash (%) TA	% Crude Protein CP
T_1	77.067[b]	1.881[b]	11.375[ab]
T_2	69.400[ab]	1.504[b]	10.75[ab]
T_3	68.394[ab]	2.024[b]	11.713[b]
T_4	82.874[b]	1.405[b]	10.500[ab]
T_5	64.758[a]	1.741[b]	10.300[ab]
T_6	80.942[b]	1.440[b]	11.187[ab]
T_7	73.275[ab]	1.801[b]	10.104[a]
T_8	64.262[a]	1.711[b]	11.646[b]
CD @5%	11.758	1.022	1.481
S.E m (±)	3.519	0.306	0.488

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 12: Per cent (%) nutrients (NPK) content in shoot at harvest

Treatments	Nitrogen N content in Shoot (%)	Phosphorus content in shoot (%) P	Potassium K content in sh (%)
T_1	2.887[a]	0.247[a]	2.160[ab]
T_2	3.013[b]	0.270[b]	2.170[ab]
T_3	3.243[c]	0.312[c]	2.250[c]
T_4	2.923[ab]	0.273[b]	2.190[b]
T_5	3.023[b]	0.290[bc]	2.197[b]
T_6	3.21[c]	0.320[c]	2.257[c]
T_7	3.000[b]	0.247[a]	2.157[a]
T_8	2.893[a]	0.257[ab]	2.153[a]
CD @ 5%	0.961	0.218	0.319
S.E.m (±)	0.317	0.078	0.105

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 13: Nutrients (NPK) uptake at harvest of hybrid maize crop

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T_1	242.398[a]	20.593[a]	179.535[a]
T_2	298.612[ab]	26.408[b]	212.671[ab]
T_3	455.110[c]	46.805[d]	311.702[c]
T_4	314.896[b]	29.161[b]	233.778[b]
T_5	293.610[ab]	27.891[b]	211.736[ab]
T_6	417.309[c]	40.757[c]	290.323[c]
T_7	256.197[ab]	29.097[b]	184.057[a]
T_8	255.109[ab]	22.597[a]	188.293[ab]
CD @ 5%	70.105	5.700	46.138
S.E m (±)	23.115	1.879	15.213

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF

Table 14 Available soil nutrients after hybrid maize cultivation

Treatments	Organic Carbon SOC (%)	(kg/ha) Available Nitrogen N	(kg/ha) Available Phosphorus P	(kg/ha) Available Potassium K
T_1	0.660^{a}	385.224^{a}	9.391^{a}	415.325^{d}
T_2	0.870^{b}	499.392^{bc}	13.365^{b}	317.375^{c}
T_3	1.538^{d}	565.447^{c}	14.966^{c}	293.175^{bc}
T_4	1.325^{c}	443.540^{ab}	12.308^{b}	289.400^{b}
T_5	1.316^{c}	457.856^{b}	19.642^{d}	311.665^{c}
T_6	1.507^{d}	484.628^{b}	15.545^{c}	176.875^{a}
T_7	0.843^{b}	530.4^{b}	9.799^{a}	320.650^{c}
T_8	1.430^{cd}	558.12^{c}	13.348^{b}	401.525^{d}
CD @ 5%	0.155	69.911	1.482	21.768
S.E m (±)	0.041	20.924	0.444	6.515

Mean followed by same letter(s) within a column are not significantly different at 5% level of significance using Duncan Multiple Range Test (DMRT), T_1= 100% RDF, T_2= 5t FYM +50% RDF, T_3= 5t PM + 50%RDF, T_4=5t FYM + 100% RDF, T_5= 5t PM + 100% RDF, T_6= 5t FYM + 5t PM + 50% RDF, T_7= 2.5t FYM + 2.5t PM + 50% RDF and T_8= 2.5t FYM + 2.5t PM + 100% RDF