Comparative Study on Effect of Various Fertilizers on Maize Crop

By

Liona Sangma

Thesis Submitted To

Lovely Professional University

In Partial Fulfilment of the Requirements for the Award of the Degree of

Master of Science in Agriculture (Agronomy)

Under the Guidance of Dr.Mayur Gopinath Thalkar

Department of Agronomy

Lovely Professional University,

Phagwara – 144402

Punjab

2017

Certificate-I

Ms. Liona K Sangma (Registration No.11502212) has satisfactorily prosecuted the course of research and that the thesis entitled "**Comparative Study on Effect of Various Fertilizers on Maize Crop**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree or diploma.

(Signature of Supervisor)
Dr.Mayur Gopinath Thalkar
UID – 21028
Assistant Professor
School of Agriculture
Lovely Professional University
Jalandhar, Punjab.

Certificate-II

This is to certify that the thesis entitled "**Comparative Study on Effect of Various Fertilizers on Maize Crop**" submitted in partial fulfilment of the requirements for the award of degree of **Master of Science** in Agriculture to the Lovely Professional University, Punjab, is a record of the bonafide research work carried out by Ms. Liona K Sangma under our guidance and supervision. No part of the thesis has been submitted by the student for the award of any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis and it is approved by Advisory Committee after an oral examination of the student in collaboration with an External Examiner

(Dr. Mayur Gopinath Thalkar)
UID – 21028
Chairperson Advisory Committee

External Examiner

(Dr. Arun Kumar)
UID - 18703
Head of the Department

Member of External

(Dr. Ramesh Sadavarti)
UID -19212
Dean, School of Agriculture

Declaration

I hereby declare that the project work entitle " **Comparative Study on Effect of Various Fertilizers on Maize Crop"** is an authentic record of my work carried out at Lovely Professional University as requirements of project work for the award of degree of Master of Science in Agronomy, under the guidance of Dr. Mayur Gopinath Thalkar, Assistant professor, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India.

Signature of the student

Liona Sangma

Registration No. 11502212

Acknowledgement

First and foremost I would like to thank my God and want to give all the glory to my awesome God for His uncountable blessings that He has bestowed upon me. It is because of His eternal grace I have been able to complete my degree and present this humble piece for which I am perpetually indebted.

I am really thankful and tribute my highest respects with deep sense of honour to my most beloved parents Danny Marak and Suraya Sangma, my siblings Ian, Linekar and Yasmin for their everlasting love, persistent encouragement and inexorable efforts in moulding me as a responsible person.

It gives me immense pleasure to express my deep sense of respect and gratitude to my advisor Dr. Mayur Gopinath Thalkar, Assistant Professor (Agronomy), Lovely Professional University, Punjab for his encouragement, meticulous guidance, constructive criticism and constant help at every step, during entire course of this study.

I owe my vociferous obligations to Dr. Arun Kumar, Associate Professor and Head, Department of Agronomy, Lovely Professional University for his amiable suggestions, benevolent and noble ideas during my research work.

Diction is my predilection to express my heartfelt thanks to my joyful friends' arcade Nikse, Banjurip, Bindiya, Theresa, Yugraj, Amanpreet, Sumeet, Abhilasha, Parminder, Paras, Sukhjinder and a lot more.

I sincerely thank all who helped me directly and indirectly to bring out this humble piece of work.

Liona K Sangma…

Index

Table of Contents

CONTENTS **Page No.**

List of Tables

List of Illustrations

List of Appendices

List of Abbreviations and Symbols

% : Percent

@ : At the rate of

a.i. : Active ingredient

°C : Degree Celsius

Cm : centimetre

G : gram

dSm^{-1} : Deci Siemen per metre

EC : Electrical Conductivity

cm^2 : Square centimetre

et al. : and others

etc. : and so on

Fig. : Figure

$mg\ kg^{-1}$: Milligram per kilogram

$mm\ day^{-1}$: Millimetre per day

NS : Non-significant

pH : Potential of Hydrogen ion concentration

SEm± : Standard error of mean

TEM : Transmission Electron Microscopy

SEM : Scanning Electron Microscopy

ICP-MS : Inductively Coupled Plasma-Mass Spectrophotometer

FT-IR : Fourier Transform Infrared spectrophotometer

SVI : Seedling Vigour Index

Mm : Millimetre

DAS : Days after Sowing

viz., : Namely

$ml\ l^{-1}$: Millilitre per litre

$kg\ ha^{-1}$: Kilogram per hectare

nm : Nanometer

ppm : Parts per million

Zn : Zinc

Abstract

Name of the Author: Liona K Sangma
Title of the Thesis: Comparative Study on Effect of Various Fertilizers on Maize Crop
Major advisor: Dr. Mayur Gopinath Thalkar
Submitted for the award of the degree: Master of Science
Faculty: Agriculture
Department: Agronomy
University: Lovely Professional University, Phagwara, Punjab
Year of submission: 2017

A field experiment was conducted at a Research Farm, Division of Agronomy, Lovely Professional University, Phagwara, Punjab during Rabi 2016 and 2015 on sandy loam soil with 7.8 pH and 0.4 dSm^{-1}. The study was done to evaluate the effect of various fertilizers on maize crop. The maize cultivar used in this study was pioneer P3396. The trial has total eight treatments: T_0 (Control), T_1 (Inorganic Fertilizers), T_2 (Azotobacter), T_3 (Organic manure), T_4 (Nanoparticles), T_5 (Nanoparticles + Inorganic Fertilizer), T_6 (Nanoparticles + Organic manure) and T_7 (Nanoparticles + Azotobacter) and was arranged in Randomized Block Design and was replicated thrice. The different parameters of growth, yield such as plant height (cm), number of leaves, stem girth (cm), dry matter accumulation (g), number of cobs, cob length, number of grains per cob, 1000 grain weight, grain yield, straw yield, biological yield and harvest indices was evaluated. It was reported that T_5 shows the maximum records of plant height (168cm), number of leaves (8.55), dry matter accumulation (241.5g), cob length (24.45cm), number of grains per cob (412.51), 1000 grain weight (203.33g), grain yield (2.85kg), straw yield (3529kg/ha) and biological yield (5592kg/ha). The least was recorded from control. The growth and yield of a crop has shown more responses to the combine application of nanoparticles and inorganic fertilizer than the other treatments. The combination of fertilizers has an anticipated command on the maize cultivar.

Key words: Nanoparticles, Inorganic Fertilizer, Maize cultivar, Azotobacter

Chapter 1. Introduction

Maize which is botanically known as Zea mays is an American Indian term for corn. The term corn comes after wheat and rice which means “to sustain life” that provides nutrients for human and animals worldwide. (Elamin et al., 2001). It is cultivated in tropical, temperate and subtropical regions of the world. The nutritional value of maize is high as it contains 72% starch, 10%, 8.5% fibre, 4.8% oil, 3.0% sugar and 1.7% ash (Hokmalipour et al., 2010). Comparatively maize gives more yield than other cereal crops such as rice, wheat etc. hence it is known as the king of cereals. Maize is an important staple food in many regions of the world. Maize is also used as a fodder crop and as a feed to a livestock. Maize has an important uses not just as food but serves in industries as well. It is a major source of starch, cooking oil and of maize gluten. Maize starch can be hydrolysed and enzymatically treated to produce syrups, particularly high fructose corn syrup, and a sweetener; and also fermented and distilled to produce grain alcohol. Grain alcohol from maize is traditionally the source of Bourbon whiskey. Maize is sometimes used as the starch source for beer. (Mohammadi et al., 2012). One of the source of biomass fuel is maize cob. The cob produces a huge amount of biomass. The production of biomass in maize is more than other cereal crops. It is used as a fodder for the livestock. It is considered to be more digestible and palatable when it is fermented and preserved. Maize is relatively cheap and home-heating furnaces have been developed which use maize kernels as a fuel. They feature a large hopper that feeds the uniformly sized maize kernels (or wood pellets or cherry pits) into the fire. Maize is increasingly used as a feed stock for the production of ethanol fuel. Ethanol is mixed with gasoline to decrease the amount of pollutants emitted when used to fuel motor vehicles (Anonymous).

According to 2013-2014 statistic, the total area under maize cultivation in India is 9.43 million hectare. The total maize production and yield in India is estimated of 24.35 million tonnes and 2583 kg/ha. The highest production of maize in the state of India is 4.97 million tonnes in Andhra Pradesh and percentage to all India is 20.40 million tonnes. The total area under maize cultivation in Andhra Pradesh is 1.06 million hectare and percentage to all India is 11.28 million hectare. The yield obtained is 4673 kg/ha. Punjab covers an area of 0.13 million hectare and percentage to all India is 1.38 million hectare. The production of maize in Punjab is 0.51 million tonnes and percentage to all India is 2.08 million tonnes and the yield obtained is 3900 kg/ha (Agricultural Statistics at a Glance 2014).

Maize is an exhaustible crop so very high nutritional requirement are required for their growth. The productivity of the crop depends on nutrient management system. Inherent fertility cannot be maintained as the exploitive agriculture is growing in India. The soil fertility is declining due to the different uses of chemicals and mistreatment of the soil. It is estimated in 2014-15 that an increase in of maize production over last two years and it has reached 24.35 million tonnes, which is the highest so far in the history of maize production in India. The trends in last three years indicate that area under maize cultivation expanding not only in rabi but also kharif season. The use of optimum levels of N, P and K failed to maintain yield levels probably due to increasing secondary and micronutrient deficiencies and also unfavourable alterations in the physical and chemical properties of soil. Apart from soil the fertility and productivity issues, use of chemical fertilizers is also becoming more and more difficult for the farmers due to their high costs and scarcity during peak season. On thus, increasing awareness is being created on the use of organics including bio fertilizers which are the sources of macro, micro and secondary nutrients to sustain the soil fertility and productivity (Umesha et al., 2014).

The staple food crop in sub-Saharan Africa (SSA) is maize. SSA has a varied agro-ecological zones and a diverse farming system. Most people in SSA consumes maize with different food preferences and socio-economic background. Maize being the staple food in SSA is a crux and plays a very important role as in Asia the staple food is rice or wheat. The consumption of maize is recorded to be maximum in east and southern Africa (ESA). In the world, 22 countries are regarded to consume their daily calorie intake from maize and 16 countries belong to Africa. Maize accounts for almost half of the calories and protein consumed in ESA, and one-fifth of the calories and protein consumed in West Africa. An estimated 208 million people in SSA depend on maize as a source of food security and economic wellbeing. Maize occupies more than 33 million ha of SSA’s estimated 200 million ha of cultivated land. Considering the low average maize grain yields that are still pervasive in farmers’ fields, meeting the projected increase demand for maize grain in Africa presents a challenge (Anonymous).

Maize is grown throughout the year in India. It is predominantly a kharif crop with 85 per cent of the area under cultivation in the season. Maize is the third most important cereal crop in India after rice and wheat. It accounts for ~9 per cent of total food grain production in the country.

Over the last ten years, the production of maize has increased at a CAGR of 5.5% from 14 MnMT in 2004-2005 to 23MnMT in 2013-2014. The production of kharif maize was decline in the year of 2009-2010 as it was affected by a drought. Also there is an increase of area under maize cultivation over a period at a CAGR of 2.5% from 7.5 Mn hectare in 2004-2005 to 9.4 Mn ha in 2013-14. However there is a rise in yield which drastically ascends the production of maize. There are some important factors which has played an important role in expansion of acreage such as the vast agro climatic conditions, cheap price of labours. Maize is considered as an important commodity for the production of starch. The total operating costs for the production of starch composes of 60-70 percent. The starch content in maize is about 60-65 percent. Due to high content of starch, it cannot be replaced by other raw materials (anonymous).

During the olden days, the consumption of maize was more whereas it was not use much for industrial purposes. As the income level and the population is increasing over a period. Direct consumption of maize has also reduced as almost everyone in the world prefers to have a ready to eat meal. Breakfast cereals are on demand as it is easy more easy to eat. In countries like USA and Europe, maize is mostly used for the industrial purposes such as to produce ethanol, to manufacture starch and in production of feed. Direct consumption of maize is less as compared to the commercial purpose. The demand of commercial production is high in the developed countries. However, the developing countries like Africa and Central America maize is a staple food.

Agriculture is one of the biggest factor in Indian economy. The pattern of consumption of maize in India is lower as compared to other developed countries. Maize ranking third in cereal production after rice and wheat. As the Indians feeds more on wheat and rice.

There are lots of reasons in declining of fertility so in order to make soil productivity and to increase the productivity, fertilizer is used. There are various kind of fertilizers that is easily available in market. Chemical fertilizers are mostly on demand. Farmers go for inorganic rather going for inorganic as it gives the instant result whereas organic takes longer period to come into action. But organic is much beneficial to soil. It reduces the acidity of soil and do not cause leaching. It do not kill the beneficial microorganisms and aids the soil to replenish and restore its health.

Inorganic fertilizers are most widely used all over the world as it gives higher yield and the end result is much better also. Efficient use of Nitrogen is important for maize production as it increases the yield and maximize economic return and minimize NO3 leaching to ground (Saeid Hokmalipour et al 2010). The only disadvantage of using inorganic is that it is highly toxic to the environment if used in high amount. On the other side, bio fertilizer is an alternate cheap resource and plays an important role in maintaining soil fertility. They are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers. Nitrogen fixing and P-solubilizing inoculants are important bio fertilizers used in maize. The bio-fertilizers provide nutrients to the plants and maintain soil structure. Bio fertilizers are gaining importance in sustainable cropping systems (Soleimanzadeh et al., 2013). The presence of microorganism in biofertilizers has a very unique feature; for an instance azospirillum functions in fixing nitrogen whereas P solubilizing bacteria solubilizes P from the soil and make the fertilizers readily available for plants. It has been observed that application of biofertilzer in maize has increased the growth rate and yield (Farnia et al., 2015).

Organic fertilizers involves those manures which are free from synthetic compounds and chemicals. Poultry manure, FYM, Vermicompost are the examples of organic manure.

Nanotechnology is emerging as a rapidly growing field with its wide application in science and technology for manufacturing of new materials at nanoscale level (Berekaa 2015). It deals with nano particles that are atomic or molecular aggregates characterized by size less than 100nm. These are actually modified form of basic elements derived by altering their atomic as well as molecular properties of elements (Sabir et al 2014). The functions of nanotechnologies in the promotion biological metabolism have been applied in many aspects. It is observed that seed treatment by nanotechnology devices can promote the crop growth, increase the yield, and improve the quality of many crop products, including cereal crops and cash crops. Although nanotechnology application in food and agriculture is in its budding stage (Huang et al., 2015). Micronutrients is an imperative component which aids in grain yield in maize. Zinc is considered important among all the micronutrients as it has a major role in metabolism of nitrogen, photosynthesis and promotes the concentration of auxin plants. Indian soil has reported to have a zinc deficiency. In the early stages of maize, deficiency of phosphorous, potassium and zinc inhibit the growth due to its small root interface. Prior to the full development of root system the essential nutrients should be supplied to a juvenile maize which may likely promote the growth (Raskar et al. 2013).

The objectives of the research is described below:

1. The effect of various fertilizers used in the research is assessed by using inorganic, organic, bio fertilizers and nano particles on maize crop

2. Assessment of treatment of various fertilizer using nano particles on maize crop

3. To study the effect of various treatments onto the nutritional quality of maize crops

4. To assess the effect of various fertilizers on phenotypical characters of maize crops

Chapter 2. Review of Literature

2.1 Effects of various fertilizers on the growth and yield of maize

Maize (Zea mays L.) grain yield is determined by the growth and development of the maize plant, the amount of photosynthesis during the growing season, and how efficiently the photosynthate is partitioned into grain. Yield can also be considered to be the result of the interaction of genotype, radiation, water and temperature. These factors cannot be controlled by the grower and vary with growing season. Management practices such as tillage, irrigation, nutrient supply, and pest management strive to maximize economic yield, but responses to these practices vary across environments. Maize is a determinate plant and its growth can be broken down into vegetative, and reproductive growth stages. After the crop has reached physiological maturity, environmental stress can not affect yield, only events that result in damage to the plant such as lodging, stalk breakage or ear droppage can decrease harvestable yield. Yield is composed of physical components that directly correlate to the amount of grain produced by the crop. Yield components are interrelated, have compensatory effects, and develop sequentially at different stages (Milander 2015).

Fertilizers are essential for the production of maize as it increases the growth rate and yield. For an instance grain protein content is increased with the addition of nitrogen (Hassan Amin 2011).

2.1.1 Effect of Inorganic Fertilizers on growth and yield of maize

Maize cultivars with fertilizer levels: All the yield attributes showed an increasing trend with increasing levels of nitrogen. It might have been owing to the poor nutrient status of the soil. Both the maize cultivars responded well to the increased nitrogen application. The maximum grain yield in both the cultivars was observed with the application of 140, 90, 70 kg NPK/ha. Application of nitrogen along with phosphorus and potassium resulted in increase in the yield of maize significantly (Varghese et al., 2006).

K. Chomba et al., (2013) has reported that the use of inorganic fertilizer has a great impact on the stalk volume and the rate of growth in maize. The study has shown the single application of nitrogen and phosphorous fertilizer does not have much effect on the growth. It has been reported that the combine use of both the nitrogen and phosphorous fertilizer has the stimulation effect on the growth of maize.

Wisdom G.O et al., (2012) has observed that inorganic fertilizer has the higher performance on the growth indices and yield aspects comparatively to organic manure and control. But there is a slight significant difference with the application of farm yard manure. It is suggested that the combine use of farm yard manure with inorganic fertilizer can have a very good effect on the overall performance of a crop.

Mokhum Hammad et al., (2011) has studied on the maize cultivar how well the growth and other attributes responses to the nitrogen fertilizer when it is applied during different growth stages and the amount used. The main plot was allotted to the application of nitrogen during different developmental stages. Whereas different concentration of Nitrogen fertilizer taken are: N1 @ 100 kg/ha, N2 @150kg/ha, N3 @200 kg/ha, N4 @250kg/ha and N5 300 kg/ha and the rate of fertilizers was allotted as subplot. Maximum plant height, number of grains present in an ear (419) and grain yield of 8.27 ton/ha was recorded in N4.

Szulc et al., (2012) has conducted a research on the two maize hybrids and the effect of the nitrogen and dose of magnesium application on the dry matter accumulation in the early stage. It has been found that the inorganic fertilizer used and the amount of concentration of magnesium has no such effect on the dynamics of dry matter accumulation. However the dry matter accumulation at 5-6 leaf stages shows a higher response towards it.

Kisetu et al., (2014) has observed that the use of inorganic fertilizers has a stimulant effect on the plant growth. However, a study has done on inorganic fertilizers (nitrogen and phosphorous) and its effect on maize at different depths. The different depths of 5cm, 10cm and 15cm was taken and nitrogen was supplied @ 60kg/ha and phosphorous @60kg/ha. It was recorded that the highest yield was obtained in a plot where the plant depth is of 10cm. The plant at a depth of 5-10cm is found to be more favourable for maize.

Lu et al., (2010) has studied on excess collection of inorganic (nitrogen) in a soil and to decrease such storage of large amount of N and to reduce the leaching of nitrogen. It has been reported the integrated use of inorganic fertilizer and maize straw with a high carbon nitrogen ratio is essential for decreasing the excess storage of nitrogen fertilizer as soil inorganic N to subsequently lower its loss.

Bashir et al., (2012) has observed that the concentration of inorganic fertilizer has a great impact on the maize cultivars. C-20 and C-79 are the two cultivars and it is supplied with different levels of nitrogen at the concentration of 0kg ha^{-1}, 50 kg ha^{-1}, 100kg ha^{-1}, 175 kg ha^{-1} and 225 kg ha^{-1}. It has found that the cultivar C-20 possess an important nutrients such as nitrogen, phosphorous, potassium, magnesium and zinc. Due to its unique feature it is found to have the maximum yield and has the positive effect on the plant growth with the application of nitrogen fertilizer at the concentration of 175 kg/ha.

Juan Valero et al., (2005) has conducted a research on the different levels of nitrogen fertilizer and its effect on the growth and yield of maize. No (Nitrogen at the rate of 0 kg/ha), Nop (Nitrogen at the rate of 175kg/ha, 150kg/ha and 130kg/ha in the year 1999, 2000 and 2001) and Nc (Nitrogen at the rate 0f 300kg/ha) are the diiferent concentration of nitrogen supplied to a crop. In the year of 1999, a crop was not responsive to the supply of nitrogen fertilizer due to the presence of high NO_3^- level in soil was observed as it persisted or was retained in a soil from the preceding year. In the year 2000, Nop and Nc does not show any significant difference on the grain production of a crop. However in 2001, there is a significant difference between Nop and Nc due to the reduction of fertilizer from 175 to 130 kg/ha.

Woldesenbet et al., (2016) has reported that high concentration of nitrogen fertilizer has a great impact on the growth and yield components of maize. The different levels of nitrogen fertilizer was taken: 0kg/ha, 23kg/ha, 46kg/ha, 69kg/ha and 92kg/ha respectively. The application of 92 kg/ha has recorded to give the maximum plant height of 360.66 cm and the shortest was found to be 347.33cm which is from the plot where there is no application of nitrogen fertilizer. The application of 92 kg/ha has a significant effect on the number of grains per cob but does not show any significant difference with the application of 69 kg/ha. The plot where there is no application of nitrogen fertilizer has the lowest number of grains per cob of 497.86 and the highest number of grains per cob of 588 was found from the application of 92 kg/ha. The longest cob length of 23.63 cm was found from the application of 92kg/ha. It has been reported that there is no significant difference between the application of 69 and 92 kg/ha on grain yield.

Hokmalipour et al., (2010) has studied on the nitrogen use efficiency and the effect of nitrogen levels on different cultivars of maize. Two factors were included where the different levels of nitrogen at the rate of 0, 60, 120 and 180 kg/ha was assigned as main plot. The three cultivars of maize in sub plots namely Kenez410, Korduna and Konsur. Korduna× Nitrogen @180 kg/ha has recorded to give the maximum yield. Application of nitrogen @60kg/ha in Korduna cultivar shows the maximum NUE. It is observed that nitrogen use efficiency is reduced with the increasing level of nitrogen.

The increase in plant height with different nitrogen sources can be attributed to the fact that nitrogen promotes plant growth, increases the number and the length of the internodes which results in progressive increase in plant height. LAI is also increased with the addition of nitrogen. Application of different sources of nitrogen has led to an increase in number of leaves and total leaf area per plant and their effect on enlargement of leaves cells (Hassan Amin 2010).

Leaf area and the number of leaves per plant are important elements in the evaluation of photosynthesis of maize genotype. In a study a significant effect of the type of nitrogen fertilizer and the type of maize hybrid on the number of leaves formed on the plant has observed. Significantly fewer leaves were recorded at no application of nitrogen fertilizer in comparison to the other nitrogen variants, for which the number of formed leaves on a plant was statistically comparable (10.6 per plant). The results recorded in the study were in concordance with previous literature reports indicating that maize genotypes differ in the number of formed leaves, growth rate and the production of biomass at varied amounts of available water and nitrogen (Szulc et al., 2015).

Poshtdar et al., (2012) has observed that the combine application of filter cake and inorganic fertilizer has attained the maximum ash content as compared to the other treatments used whereas the minimum content of ash was in control. Inorganic fertilizers shows the highest silage in maize.

2.1.2 Effect of Organic manure on growth and yield of maize

Achieng et al., (2010) has observed that among the organic sources, farmyard manure (FYM) is most important as it contains all the nutrients needed for crop growth including trace elements, although in small quantities. The efficiency of manure utilization by a crop is determined by the method of application, time to incorporation and the rate of decomposition in the soil. Characteristically, not all of the nutrients in manure are directly available after its incorporation in the soil. Organic forms of nutrients must first be mineralized into plant-available forms such as nitrate. The rate of mineralization is variable and depends on soil type, moisture, temperature, and manure composition. When cow dung and urine are mixed, a balanced nutrition is made available to the plants.

Memon et al., (2012) has observed that farmyard manure (FYM), banana waste (BW) and pressmud (PM) are very important agro wastes in the province of Punjab. Of the total nutrient contents of banana plant as a whole, BW contains almost 50% nutrient and another 50% nutrients are present in banana bunch. Only banana leaves contain 2.69% N, 0.15 to 0.2% P and 3.14 to 4.15% K. Apart from being rich source of micronutrients, colloidal organic matter, it contains 2.2, 4.4 and 0.8% N, P and K respectively. Farmyard manure is an excellent source containing all the plant nutrients needed for crop growth including trace elements. Approximately 70 to 80% of the N, 60 to 85% P and 80 to 90% of K in feed is excreted in the manure. It is estimated that one ton of dropping of cattle, horses, sheep and poultry yield approximately 10 kg N, 16 kg P2O5 and 23 kg K2O. Many strategies are being adopted to dispose organic wastes, yet it has to be safer for environment and sustainable for nutrient conservation. The composting technology is the rapid breakdown of organic matter, which produces humus. It is regarded as fully sustainable practice, since it aims at both conservation of the environment, human safety and economically convenient production. Composted material has more concentration of nutrients, narrower C: N ratio, free from pathogens and other potential contaminants that cause pollution. Incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses. Application of PM improves soil structure, aeration, water holding capacity, porosity, increases stress tolerance and also reduces the use of chemical fertilizers thus saving huge amount of foreign exchange incurred for import of fertilizers.

Ezeibekwe et al., (2009) has reported that the application of poultry manure has shown to have a significant effect on growth and yield of maize as compared to the application of urea and control.

Agyenim Boateng et al., (2006) has studied that poultry manure has a beneficial effect LAI (leaf area index), plant height and biomass. 8 treatments: 0 tons of poultry manure per hectare, 2 tons of poultry manure per hectare, 4 tons of poultry manure hectare, 6 tons of poultry manure per hectare and 8 tons of poultry manure (pm) per hectare, NPK @60:40:40 kg ha^{-1}, Poultry manure of 2 × 2 ton/ha and 2 ton per hectare + N:P:K @30:20:20 kg ha^{-1} 30-20-20 kg NPK/ha were supplied and RCBD is used as an experimental design. The maximum grain yield was obtained from the application of 4 ton of poultry manure per hectare of 2.07 ton per hectare. The application of poultry manure improves the soil and increases the nitrogen levels in the soil. It has found that exchangeable cations are also enhanced with the application of organic manure. Organic manure has a good impact on the soil and increases the fertility level of a soil.

Elamin et al., (2001) has observed that the organic manure has a significant effect on the growth of fodder maize. Six treatments were used in this study namely: green manure, poultry manure, urea (Nitrogen), superphosphate (Phosphorous), potassium sulphate (Potassium) and integration use of NPK. It has been found that the organic manure especially poultry manure has the maximum fresh weight as compared to the inorganic fertilizers used. Poultry manure has a great effect on the leaf nitrogen and phosphorous comparatively with the inorganic fertilizers.

Soro et al., (2015) has studied on two crop cultivars: GMRP-18 (an improved variety) and Bon-maïs (used for popcorn) varieties respectively. And the effect of poultry manure on the growth and yield of the cultivars used. 7 ton ha^{-1} of chicken manure is supplied as a single dose and with the integration application of nitrogen @70kg ha-^{1}. The different parameters (plant height, stem girth, number of ears, number of kernels present in ear and yield) were considered for the scrutiny. It has been observed that the corn is more responsive to the combine application as compared to the single dose and control.

Okoroafor et al., (2013) has evaluated the outcome of organic manure on the growth parameters and yield attributes of maize. The conducted study consisted of three treatments replicated thrice in a randomized complete block design. The different characteristics that was taken into gaccount for the evaluation are: plant height, no of leaves, stalk diameter, frequency of ear per plant and weight of ear after the harvest. It has been observed that the treatment where poultry dropping is supplied has shown to give a significant effect on the growth and yield of maize.

Okonmah et al., (2012) has reported to used three organic manures namely pig manure, chicken manure and farmyard manure were supplied with different doses of 0kg, 4kg, 8 kg and 12kg. The different growth parameters (such as plant height, no of leaves, stem diameter) and yield attributes (number of ear per cob, number of kernels per cob, 1000 kernel weight) has found that with the application chicken manure at the concentration of 12 kg has shown to have a maximum effect on all the parameters that is taken into for an evaluation. However, pig manure and farmyard manure has also shown a slight significance on the growth and yield. The treatment where there is no application of manure does not show any significant effect and recorded the least value.

Dania et al., (2014) has studied on the nutrient concentration of Moringa oleifera leaves in which the study has concentrated on three fertilizers namely inorganic, chicken manure and organomineral fertilizer. A research was conducted in a greenhouse where CRD is used as an experimental design with four treatments and 3 replications. The study contemplates more on the growth indices such as plant height, stem diameter and number of leaves per plant. It has found that the maximum growth indices was found from the application of chicken manure more than the inorganic fertilizer (NPK) and organomineral fertilizer and the minimum was recorded in control. It is observed that in 8 weeks of planting, the number of leaves has increased to 66%, 62% and 39% with the application of chicken manure, inorganic fertilizer (NPK) and organomineral fertilizer. The application of chicken manure is found to have an induction effect of the nutrients of leaves and has significantly enhanced the nutrient concentration level as compared to the other treatments.

Mucheru-Muna et al., (2007) has observed that in Kenya due to the excessive soil cultivation and inadequate external inputs has decreased the fertility status of a soil. The research has focused on using the mineral fertilizer, organic manure as soil incorporation (Tithonia diversifolia, Calliandra calothyrsus, Leucaena leucocephala) and different inorganic fertilizers and its effect on the growth and yield of maize during its cropping period. Tithonia diversifolia has recorded to give the maximum grain yield of 5.5 and 5.4 mg/ha and the minimum was recorded in the control. It is reported that within two years of experiment, the soil fertility has increased. The organic manure has triggered to increase the soil carbon and N content in soil. It is also found that the integrated use of tithonia with mineral fertilizer has recorded to have the maximum benefit cost ratio.

2.1.3. Effects of Bio fertilizers on growth and yield of maize

Bio fertilizer is a material containing microorganism(s) added to a soil to directly or indirectly make certain essential elements available to plants for their nutrition. Various sources of bio fertilizers include nitrogen fixers, phytostimulators, phosphate solubilizing bacteria, plant growth promoting rhizobacteria, etc. Application of bio fertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution. One of more important factors that impact the physiology of plants growth and development is the availability of nutrients which can uptake by plants from soil (Mohammed A.A 2012).

A numerous microorganism have been used for preparation of biofertilizers such as azotobacter, azolla, rhizobium, blue green algae, azospirillum etc. 10-15% of yield is increased with the addition of azotobacter. Azospirillum facilitates the vegetative growth in maize (anonymous).

Mycorrhizal function is an elementary natural process in soil. Mycorrhiza is a symbiosis between most crops and certain soil fungi. It has a major contribution to soil aggregate formation and stabilization, phosphorus cycling and crop health. A variety of studies suggest that phosphorous uptake by plant root can be enhanced when they are infected by arbuscular mycorrhiza (AM) fungi. Bio fertilizer and interaction of it with cropping system had significantly effects on leaf chlorophyll, leaf area index, and plant height (Hossein et al., 2013).

Rajeshwar et al., (2010) has studied the effect of biofertilizers on the yield of rabi maize, kharif maize and rice and the effect of biofertilizers on the soil status. It has been observed that the maximum yield in rice was recorded from the combine use of biofertilizer @6800kg/ha and recommended dose of fertilizer. The high yield in maize was recorded from combine application of biofertilizer @6500kg/ha and recommended dose of fertilizer.

Raj Baral et al., (2013) has conducted a research on the effect of azotobacter on the growth and yield of maize. There were eight treatments which is replicated thrice and laid on randomized complete block design. Treatments used were: no treatment, NPK @ 120 kg/ha:60kg/ha:40kg/ha, Farmyard manure @10 kg/ha, azotobacter as seed inoculants, azotobacter as soil application, NPK and azotobacter, FYM and azotobacter and NPK, FYM and azotobacter. It has reported that grain yield, plant height in cm, cob length, number of cobs, number of grains per cob, 1000 grain weight has shown to response to the treatments that was subjected to a crop. It is observed that the azotobacter which is used as an inoculation has a greater impact on the growth and yield of maize even in the absence of chemical fertilizer.

Hajnal-Jafari et al., (2012) has studied the influential effect of azotobacter on the grain yield of maize. The maize cultivars used were ZP 555 su, NS 609b, 620k and NS 6030. It also includes the use of rate of application of azotobacter. The study has evaluated the grain yield during the end of vegetation phase. The maximum grain yield of 1000 kg ha^{-1} was recorded in ZP 555 su variety. The hybrid NS 609b was not influenced and does not show any significant effect on the grain yield. Whereas NS 6030 has shown to give a gradual rise of grain yield to 280 kg ha^{-1} and in 620 k to 450 kg $ha\text{-}^{1}$.

Umesha et al., (2014) has observed that the integration use of all the fertilizers has shown to achieve the highest performance on the growth indices and yield components. There were total 14 treatments which was replicated thrice and the experimental design used was RCBD. Recommended dose of inorganic fertilizer + Azotobacter chroococcum + Bacillus megaterium + Pseudomonas fluorescence + enriched compost is the very treatment which has response well to all the parameters which was evaluated. The maximum plant height of 31cm, 70 cm, 180.93cm, 186.07cm and 188.13 cm was recorded at 30 DAS, 60 DAS, 90 DAS and at the harvest. The maximum dry matter accumulation of 375.80g was also recorded from the combined application. The various yield components such as ear weight of 207.63g, kernel yield per plant of 158.93 g and grain yield per hectare of 54.53 quintal was recorded to be maximum as compared to other treatments that was used in this study. It has also reported with the combine application of recommended dose of inorganic fertilizer + Azotobacter chroococcum + Bacillus megaterium + Pseudomonas fluorescence + enriched compost imparts a nutrients to a soil. It has shown to enhanced the soil fertility status of a soil by increasing the available nitrogen, phosphorous and potassium content to 185.40 kg/ha, 38.83 kg/ha and 181.47 kg/ha.

Farnia et al., (2015) has studied on different phosphorous biofertilizers and different nitrogen fertilizers and its outcome on the yield components and yield of maize cultivar. Nitroxin, Nitrokara and azot barvar1 are the nitrogen fertilizers which was served as treatment. Phosphate barvar2, biosuperphosphate and Phosphatin are the phosphorous biofertilizers which was also a treatment and along with no treatment plot. It has been resulted that the combine application of nitrogen and phosphorous biofertilizer has shown to influence on all the components excluding the number of row cob^{-1} and harvest indices. It has found that the combine application of Nitroxin + phosphate barvar2 treatment has recorded the maximum ear weight, ear length and biomass. The maximum 1000 grain weight and grain yield was recorded from the integrated application of Nitroxinand + Biosuperphosphate treatment. It has found that the sole supply of Nitrokara has also recorded a maximum number of row cob^{-1}. Ultimately, the outcome of the study has shown that with supply of nitrogen fertilizer and phosphorous biofertilizer has a significant impact on the components of yield and the yield of maize.

Hellal et al., (2014) has evaluated the use of inorganic fertilizer, organic manure that includes town refuse and biogas manure + biofertilizer which includes effective microorganism (EM) and N fixer Compomax (CoM) and along with control on the yield of maize. The combine application of farmyard manure + effective microorganism has recorded the maximum yield attributes then secondly recorded in treatment supplied with town refuse. The minimum was recorded to be in biogas manure. Application of manure has shown to have an influence on 1000 grain weight, grain yield and stover yield of maize.

Meynard Banayo et al., (2012) has studied on various biofertilizers. Azospirillum, Trichoderma, or unidentified rhizobacteria were the three different biofertilizers used and four different inorganic fertilizers with 3 different recommended dose of 100%, 50% and 25% were served as a treatment along with control during four cropping seasons between 2009 and 2011. The application of biofertilizer has a positive impact on the yield during the trial.

Mikhailouskaya et al., (2009) has reported that the use of azotobacter in cereal crops has shown to stimulate the growth. Enhancement of nutrient concentration has also observed. It has also found to increase the protein content in cereal crop.

Moshabaki Isfahani et al., (2012) has studied on different biofertilizers namely PGPR which is produced by Pseudomonas sp. and phosphate bio fertilizers produced by Pseudomonasputida strain P13 and Pantoeaagglomerans strain P5 and 0, 25%, 50%, 75% and 100% recommended dose of inorganic fertilizers that has an effect on yield and the different aspects of yield. The study has revealed that the application of biofertilizer has the most significant effect on the yield and on different parameters of yield. It has the capacity increase the availability of primary nutrients and to increase the uptake of nutrients by the crop.

Roychowdhury et al., (2017) has evaluated a study on the use of biofertilizers and Vermicompost and its effect on the growth in maize. It has found the application of inorganic fertilizer has a deleterious effect on human health. The inorganic fertilizers may increase the crop production but is harmful to human. It is suggested to adopt an eco-friendly fertilizers which supports the plant and human health. It has revealed that biofertilizer and Vermicompost increases the yield and different parameters of yield. It does not only has an influential effect on the yield but also improves the soil fertility. The crop with the application of organic manure will not have a toxic effect on human health.

2.1.4. Effects of Nanoparticles on growth and yield of maize

Nanoparticles are materials small enough to fall within the nanometric scale, with at least one of their dimensions being less than a few hundred nanometers. This minute scale of nanoparticles represents significant changes in their physical properties compared with those in bulk materials (Berahmand et al., 2012).

In the last decade various nanoparticles for the precision application of fertilizers has been used. Various types of nano particles such as dendrimers, magnetic field, liposomes, polymeric nanoparticles, micelles, solid lipid nanoparticles etc. have found tremendous effect onto the growth of crop due to accurate application of fertilizers. SNPs is important in maize for the improvement of growth. Silicon (Si) is an agro-nomically important nutrient that accumulated in plants to total concentrations of dry matter similar to other essential macronutrients. Si deficiency causes imbalances of other nutrients resulting in poor growth. Previous studies of Si application to maize plants have revealed that leaf transpiration rates under water stress, antioxidant processes, and Si deposition are improved (Suriyaprabha et al., 2015).

In a study carried out by Berahmand et al., 2012, has shown an experiment which has tested seven treatments based on a randomized complete block design in four replications. The treatments were as follows: magnetic field and silver nanoparticles+Kemira commercial fertilizer (T1), magnetic field and silver nanoparticles+Humax commercial fertilizer (T2), magnetic field and silver nanoparticles (T3), Kemira fertilizer (T4), Librel commercial fertilizer (T5), Humax fertilizer (T6), and a control (T7). In each plot, a distance of 75 cm was set between the rows, and the final plant density was 11.1 plants per square meters. The maize variety was SC 704. A plot size of 3.5×6 m was used. For all treatments, nitrogen fertilizer (as urea) on the basis of 250 and 250 kg ha−1; phosphorus fertilizer (as phosphate ammonium), 250 and 150 kg ha−1; and potassium fertilizer (as potassium sulfate), 120 and 50 kg ha−1, were applied, respectively. The average size of silver nanoparticles was around 20 nm, determined by transition electron microscope (TEM) in the Central Laboratory of Ferdowsi University of Mashhad, Iran. Agronomic traits of maize such as fodder fresh yield, fodder dry yield, plant dry matter, plant height, and plant components (leaf, stem, and ear) were measured at harvest time. Results indicated that treatments of silver nanoparticles with magnetic field (T3) had the highest fodder fresh yield (74.5 tons ha−1) followed by the Kemira fertilizer treatment (T4) (64.9 tons ha−1) in 2008. Silver nanoparticles with magnetic field treatment (T3) showed about 35 % more fresh yield in comparison to the control. Although the greatest fodder fresh yield was in T3 in 2008, it did not show significant difference compared to the other treatments in 2009. It has been reported that germination and early growth of maize seedlings improved when seeds were exposed to a continuously stationary magnetic field.

Farooqui et al., (2016) has revealed that zinc oxide nanoparticle has a great impact of seed germination. It has been found that the higher dose of zinc oxide has a deleterious effect on the germination. Shoot and root length, shoot and root biomass has also found to be induced with the application of zinc oxide.

Iqbal et al., (2016) has conducted research on different fertilizers used and its effect on the growth in maize. The different concentration of nitrogen fertilizer @100kg/ha, 150 kg/ha and 200 kg/ha with the integrated use of zinc at different doses of o, 5, 10 and 15 kg/ha. It has found that the combine application of nitrogen fertilizer and zinc has a significant effect on the growth and yield components of maize than the single application of fertilizers.

Raskar et al., (2013) has evaluated a study on the beneficial of nitrogen, phosphorous and zinc on the growth of maize. It has been revealed the integrated application of all the fertilizers has shown to increase the grain yield.

Mahdi et al., (2012) has reported that the maximum yield was recorded with the combine use of inorganic fertilizer and zinc. The growth parameter and yield attributes has also shown to have a responsive feature.

Chapter 3. Materials and Methods

A field experiment entitled "Comparative Study on Effect of Various Fertilizers on Maize Crop'' was conducted during rabi season of the years 2016-2017 at school of Agriculture Lovely Professional University, Jalandhar Punjab. The details of materials used, procedures followed and criteria adopted for evaluation of treatments during the course of investigation are presented in this chapter. It consists of a short description of location of the experimental plot, characteristics of soil, climate, material used, treatments, layout and design of experiment, land preparation, sowing method, harvesting and collection of data. These are describing below under following sub headings:

3.1 Description of Experimental Site:

3.1.1 Location of experimental site:

The experiment was conducted at Lovely Professional University farm, Department of Agronomy, Lovely Professional University, Jalandhar (Punjab) during session 2016-2017. This farm is situated at 31^0 22'31.81 North Latitude and $75^0$23'03.02 East longitude, with an average elevation and with a mean sea level of 252m. It is at a distance of 350km from Delhi on Delhi-Amritsar the region falls under the central plain zone of agro climatic zone of Punjab.

3.1.2 Climate and Weather Conditions:

The experiment site enjoyed sub-tropical type of weather situation with cool winters, hot summers and a distinct rainy period with yearly rainfall of 1919.5mm. The lowest temperature never goes down to sub-zero point even during the coldest months (December-January) and the series of lowest temperature was $6\text{-}10^0$. The greatest winter temperature rises up to 27^0C.

3.1.3 Soil characteristics

The experiment was conducted at the student research farm, School of Agriculture, Lovely Professional University Jalandhar, Punjab. Previously, soil sample was collected randomly from the experimental site was found to be sandy clay loam and pH of the soil varied from 7.83 to 7.98. The soil of this farm represents the sandy loam soil tract of Punjab.

1) pH

We measure the pH of soil with pH meter. First we weigh 12.5g of soil and put in a 150 ml flask/beaker and add 25 ml of distilled water. After this we stir at least 4 times in a period of half an hour. After half an hour, again stir the solution and measure the pH with the help of pH meter. The pH value of the soil where the experiment is conducted has recorded the value of 7.8.

2) Electric conductivity (EC)

Electrical conductivity is measured with the help of EC meter. First, 10gm of soil is weighed and 50 ml of distilled water is added. The solution is stirred continuously 4-5 times and then measure the EC using EC meter. The electrical conductivity of a soil is recorded to 0.4 dSm^{-1}

3) Soil Texture

Mechanical composition of experimental soil *i.e*., proportion of sand, silt and clay size particles was determined by hydrometer method (Bouyoucos, 1962). The texture of the soil was determined according to textural triangle proposed by USDA (Brady and Weil, 2002). The soil texture which has been observed for the experiment is sandy loam.

4) Total Organic Carbon

The determination of soil organic carbon is based on the Walkley-Black chromic acid wet oxidation method (Allison, 1965). Weigh 2 g of soil in a 250 ml conical flask and then add 10 ml of 1N $K_2Cr_2O_7$ solution and mix it properly after these add 20 ml concentrated H_2So_4. Leave the flask for sometimes so that it remained cool. Then add 2 g of fluoride powder, 100ml distilled water and shake vigorously. Add 10 drops of diphenyl amine indicator which give violet colour to suspension. Titrate the content with ferrous ammonium sulphate solution. When colour of titrate the content with ferrous ammonium sulphate solution. When colour of titrate changes from violet to light green that it is the end point. Then, we note down the volume of ferrous ammonium sulphate solution. The available organic carbon 8.50 g/kg^{-1}.

5) Available Nitrogen

Soil available nitrogen was determined after Subbiah and Asija (1956). The ammonical nitrate is 45 mg/kg and nitrate nitrogen is 28 mg/kg.

6) Available Phosphorus

Soil available phosphorus was determined after Olsen et al. (1954). The available phosphorous is 262kg/ha.

3.2 Treatment Details and Experimental Design:

3.3.1 Treatments

The experiment consists of 8 treatments as given below:

T0=Control

T1=Inorganic Fertilizer (Urea 70g)

T2=Biofertilizer (Azotobacter 1×10^8 cfu/ml)

T3=Organic manure (Farmyard manure FYM@0.83kg/plot)

T4=Nanoparticles (Zinc Oxide 0.42g)

T5=Nanoparticles+ Inorganic

T6=Nanoparticles+ Organic manure

T7=Nanoparticles+ Biofertilizer

3.3.2. Experimental Details

Treatment combinations: 8

Replications: 3

Design: RCBD

Row to row distance: 60 cm

Plant to plant distance: 20 cm

Plot size: 3× 1.75m^2

Total no of plots: 3×8 = 24

Area: 210m^2

Nutrient application: As per treatment

Test crop/Variety: hybrid pioneer corn hybrid P3396

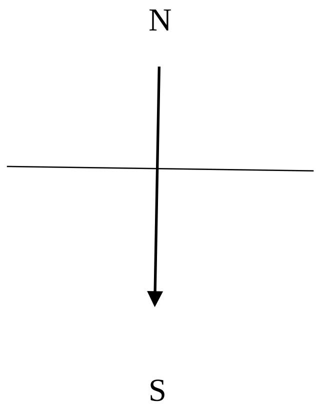
Seed rate: 1kg

Irrigation: Lifesaving irrigation

3.2.3 Experimental layout:

The experimental design used is Randomized Block Design with 3 replications and 8 treatments. The block is divided into four blocks to represent four replications. Each block was divided into sub plots which represents the treatments.

Layout plan of the experimental field:



R1	R2	R3
T0	**T3**	**T7**
T1	**T5**	**T6**
T2	**T4**	**T5**
T3	**T7**	**T3**
T4	**T6**	**T2**
T5	**T2**	**T4**
T6	**T1**	**T0**
T7	**T0**	**T1**

3.3 Details of Crop Raising:

Details on cultivation practices adopted for rabi maize are presented here under.

3.3.1 Land Preparation

The experimental field was ploughed twice by a tractor drawn cultivator followed by rotavator for obtaining fine tilth. Bunds are made and ridges are constructed with the help of shovel and hoe. Irrigation channel is made in between replication 1 and replication 2. The other irrigation channel is on the side of replication 3.

3.3.2 Treatment application

(a)Farmyard manure was thoroughly mixed in soil as per the treatment allocation one month before sowing of maize FYM @5 t ha^{-1}.

(b)Urea is applied in two split dose. 70 g is applied prior to sowing.

© The seeds were treated with azotobacter @ 1×10^8cfu/ml inoculants as per the treatment. The seeds were thoroughly mixed with bio fertilizer slurry in such a way that all the seeds were uniformly coated with azotobacter and then allowed to dry in the shade before the sowing of crop.

(d) In this study, zinc oxide nanoparticle is used and there are various methods for the synthesis of zinc oxide nanoparticles. But in this experiment, chemical synthesis of zin oxide is followed. Sabir et al., 2014 has reported to synthesis zinc oxide different alcoholic media can be used (ethanol, propanol). In this study, 0.42g of zinc oxide is added to 5ml of ethanol. It is then sonicated for 20 minutes and then autoclave where it is left for heating at 2^0C to 200^0C per minute for 24 hours. It is then followed by centrifugation of 3000rpm for 15 minutes to restore the product and then it is washed dried.

3.3.3 Fertilizers and manure application:

Organics, Inorganic, Nanoparticle and biofertilizers were applied to the soil as a recommended dose of each plot depending on treatment details. The full dose of fertilizers was applied to the soil after sowing of crop.

Table 3.1 Fertilizer Recommendation

S.NO	Fertilizers plot^{-1}	Dosage per plot
1.	Control	NIL
2.	Urea	70g
3.	Azotobacter	5ml/kg seed
4.	FYM	0.83 kg
5.	Zinc Oxide	0.42g
6.	Zinc Oxide + Inorganic	0.42g + 70g
7.	Zinc Oxide + Organic	0.42g + 0.83kg
8.	Zinc Oxide + Biofertilizer	0.42g + 5ml/kg seed

3.3.4 Variety:

A popular maize hybrid pioneer corn hybrid P3396 was selected for rabi season is a short duration crop with a crop period of 90 days of maize. It's a high yielding variety. It is tolerant to stalk rots and possess a unique plant structure that makes this hybrid suitable for growing in high population.

3.3.5 Seed rate and sowing:

Date of sowing is on 15th September 2016. Sowing is done on ridges. 1kg of seed is taken for sowing. Seed is treated with bavistin @3g/kg seed. Healthy and bold seeds of maize were dibbled into the soil @ 2 seeds hill-1 at a spacing of 60 cm X 20 cm at a depth of 3cm. Prior to sowing seed is treated with azotobacter 5ml/kg seed.

3.3.6 Gap filling

Gap filling is done for the plots where the germination does not occur. Gap filling is done after the emergence of seedlings.

3.3.7 Irrigation

Generally, 4-6 irrigations are supplied to a crop. The first irrigation is given at the time of sowing. Second irrigation is supplied after 24 days of sowing and the 3^{rd} irrigation is given at 51 days of sowing.

3.3.8 Weeding

Pre emergence application (spray) of Atrazine @ 2 g L-1 was taken up on the next day of sowing to control weeds. The most common weed observed is Amaranthus spp, Cyperus rotundus and Cynodon dactylon. Weeding is done manually after 30 days of sowing.

3.3.9 Thinning:

In order to maintain plant to plant distance of 20cm, thinning was done 25 days after sowing.

3.3.10 Plant Protection:

One prophylactic spray measure chloripyriphos was sprayed @ 5 ml l^{-1} was performed against stem borer at knee high stage of a crop.

3.3.11 Harvesting and Threshing:

The crop was harvested when the stalks and leaves are somewhat green but the cover of the husk becomes dried and brown in colour. The crop was harvested 100 days after sowing.

The harvested crop of each plot was bundled separately and brought to threshing field. The harvested crop was threshed plot wise on 104, 105 and 106 days of sowing.

3.4 Treatment Evaluation:

3.4.1 Growth parameters:

a) Plant height at 30 DAS, 60 DAS and 90 DAS:

Three plants were tagged in each net plot area for recording observations that did not involve destructive sampling. Plant height was measured from ground level to the tip of the top most leaf of every tagged plant and it was expressed in cm. All the observations were recorded on these plants at 30, 60 and 90 days of sowing.

b) Stem girth at 30 DAS, 60 DAS and 90 DAS:

The stem girth of three plants were measured from each plot. Stem girth was recorded at middle position of the plant in cm by using a measuring tape. It was recorded at 30, 60 and 90 DAS.

c) Leaves plant^{-1} at 30 DAS, 60 DAS and 90 DAS:

Three plants were selected randomly from each block and the number of leaves were counted at 30, 60 and 90 days of sowing. These were averaged and expressed as number of leaves plant^{-1}.

3.4.2 Yield attributes:

a) Number of cobs per plant:

Number of cobs of three tagged plants were counted at harvest and the mean value per plant under each experiment unit was worked out.

b) Length of cob (cm):

Length of cobs of three selected plants was measured. The average was worked out and expressed as length per cob in (cm).

c) Number of grains per cob (g):

To calculate the average number of seeds per cob, three randomly selected mature cobs from three consecutive plants. The average value were mentioned as number of seeds per cobs.

d) Grain yield (kg ha^{-1}):

Cobs of harvested plants of net plot area after proper sun drying were separated from plants, dehusked and shelled with the help of cob sheller. The produce was cleaned, weighed and expressed in terms of grain yield kg ha^{-1}.

e) 1000-grain weight (g):

The sun dried 1000-grains were counted from produce of each plot for recording 1000-grain weight in (g).

f) Biological yield:

The weight of thoroughly sun-dried plants of net plot along with cobs were recorded and expressed as biological yield in kg ha^{-1}.

g) Harvest index:

The harvest index was obtained by dividing the economic yield (grain yield) by total biological yield and expressed as percentage (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.5 Economics of Treatments:

The economics of different treatments was estimated in terms of net profit ha^{-1}. The cost of cultivation for each treatment was subtracted from gross return and net profit was worked out. Further, to ascertain profitability on per rupee investment, cost benefit ratio was also calculated. Both of these parameters were calculated for individual crop as well as for the crop sequence.

Net returns (Rs ha^{-1}) = (Gross return ha^{-1} – Cost of cultivation ha^{-1})

$$\textbf{Benefit – Cost ratio} = \frac{\textbf{Net returns (Rs)}}{\textbf{Total cost [Cost of cultivation + Treatment (Rs)]}}$$

3.6 Statiscal Analysis:

In order to test the significance of variation in experimental data obtained for various treatment effects, data were statically analysed as described by Panse and Sukhatme (1954). The critical difference was calculated to assess the significance of treatment mean wherever, the 'F' test was significant at 5 percent level. The analysis for all the characters was carried out after finding out the homogeneity between error mean sum of square as per methodology given by Gomez (1984). The ANOVA is extracted with the help of Agri Stat software. To estimate inter-relationship between various characters, correlation coefficients were computed. Further, in order to establish cause and effect relationship, regression equations were calculated**.**

3.7 Demonstration of the Experiment

Figure: Field Preparation

Figure: Sowing

Figure: 30 DAS

Figure: 60DAS

Figure: Plant at maturity at 90 days

Chapter 4. Results and Discussion

The results of the field experiment entitled “**Comparative Study on Effect of Various Fertilizers on Maize Crop**’’ was conducted during September-December at school of Agriculture, Lovely Professional University, Jalandhar, Punjab are discussed in this chapter. The parameters observes such as the physical attributes (plant height, stem girth and number of leaves plant^{-1}), yield attributes (number of cobs plant^{-1}, length of cob, cob length, number of grain cob^{-1}) yield and economics on the cultivation of maize is obtained from different treatments which is applied to the experimental plot.

4.1 Effect of Various Treatments on Different Growth Parameters of Maize at 30 days, 60 days and 90 days

4.1.1 Plant Height

The plant height from each replication was measured at different growth stages during the crop period at 30, 60 and 90 DAS.

4.1.1.1 30 DAS

Table 1 shows that T5 (Zinc Oxide 0.42 g + Urea 70 g) has the maximum record of plant height of 41.41cm. T4 (Nanoparticle 0.42 g) shows the minimum record of plant height 36.31cm. T1 (Urea70 g), T2 (Azotobacter 5ml kg^{-1} seed), T3 (FYM 0.83 kg), T6 (Zinc Oxide 0.42 g + FYM 0.83 kg), T7 (Zinc Oxide 0.42 g + Azotobacter 5ml kg^{-1} seed) and T0 (Control) shows a record of 39.97 cm, 38.82 cm, 37.10 cm, 37.62 cm, 37.72 cm and 37.45 cm. Asif et al., 2013 has reported that the increase in plant height is due to N and Zn which helps in the production and expansion of more leaf area which results more assimilates production. Similarly more vegetative development by nitrogen resulted in increased mutual shading and intermodal expansion.

Figure: Plant Height at 30 days

4.1.1.2 60 DAS

T5 (Zinc Oxide @0.42 g + Urea @70 g) shows the maximum record of plant height of 76.23 cm and the minimum record is 63.02 cm in T0 (Control). T1 (Urea @70g), T2 (Azotobacter @5ml kg^{-1} seed), T3 (FYM @0.83 kg), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83kg) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a plant height of 70.89 cm, 74.05 cm, 68.85 cm, 69.89 cm, 68.41 cm and 68.22 cm (Table 1). Ullah et al., 2015 has stated that the growth is influenced by nitrogen. Zinc plays an important role in metabolism of enzymes and also promotes cell division and cell elongation helps in enzymes metabolism and faster cell divisions, cell elongation. Application of nitrogen in maize has shown to increase in plant height as amino acid present in nitrogen is known for building blocks which promotes the cell expansion.

Figure: Plant Height at 60 days

4.1.1.3 90DAS

Table 1 illustrates that nanoparticle + inorganic fertilizer (Zinc Oxide @0.42g + Urea @70g) records the highest plant height of 168.00cm. The minimum record was found in T0 (no treatment) of plant height 159.22cm. T1 (Urea @70g), T2 (Azotobacter @5ml kg^{-1} seed), T3 (FYM @0.83kg), T4 (Zinc Oxide @0.42g), T6 (FYM @0.83kg) and T7(Zinc Oxide @0.42g) recorded a plant height of 165.11cm, 166.11cm, 160.56cm, 162.11cm, 159.67cm and 166.78cm. Masood et al., 2014 has stated the increment in height is due to the application of nitrogen and zinc.

Figure: Plant Height at 90days

Asif et al., 2013 has reported that the increase in plant height is due to N and Zn which helps in the production and expansion of more leaf area which results more assimilates production. Similarly more vegetative development by nitrogen resulted in increased mutual shading and intermodal expansion. Figure 1 shows that the combine application of nanoparticles and inorganic fertilizer @0.42g + 70 g has a significant effect at 0.05% on plant height and has a significant difference between all the treatments in 30 and 60 DAS. T_0, T_3, T_6 and T_7 shows a small significant difference in 30 DAS. The sole application of zinc oxide shows no significant effect on plant height in 30 days of observation. T_3, T_6 and T_7 shows little significant difference at 60 DAS.T_4 and T_5 shows a little significant difference and is significantly different from T_0,

T_3, T_6 and T_7 at 60DAS. Zinc Oxide @0.42 g + Urea @ 70 g shows a significant effect at 1% on the plant height at 90DAS. T_5 shows a significant difference between all the treatments. T_0 and T_6 shows little significant difference but shows no significant effect on plant height at 90 DAS. T_2 and T_7 also shows little significant difference among it.

4.1.2 Stem Girth

Stem girth was recorded in different growth stages in maize at 30, 60 and 90 DAS.

4.1.2.1 30DAS

Table 2 illustrates that T1 (Urea @70g) shows the maximum record of stem girth of 4.38cm and T2 (Azotobacter @5ml kg^{-1} seed) shows the minimum record of 3.61 cm. T0 (Control), T3 (FYM @0.83 kg), T4 (Zinc Oxide @0.42 g), T5 (Zinc Oxide @0.42 g + Urea @ 70 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 kg) and T7 (Zinc Oxide @0.42 g + Azotobacter 5ml kg^{-1} seed) recorded a stem girth of 3.86 cm, 4.17 cm, 3.77 cm, 4.34 cm, 3.82 cm and 3.77 cm.

4.1.2.2 60DAS

Table 2 shows the maximum stem girth in T1 (Urea @70g) of 6.49 cm and the minimum recorded in T0 (no treatment) of 5.16 cm. T2 (Azotobacter @5ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T5 (Zinc Oxide @0.42 g + Urea @ 70 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter 5ml kg^{-1} seed) recorded a stem girth of 5.16 cm, 6.08 cm, 5.71 cm, 5.49 cm, 6.48 cm, 5.67 cm and 5.91 cm.

4.1.2.3 90DAS

Table 2 recorded a maximum stem girth in T5 (Zinc Oxide @0.42 g + Urea @70 g) of 7.13 cm. The minimum was recorded in T0 (No Treatment) of 6.71 cm. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 kg), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 kg) and T7 (Zinc Oxide @0.42 g + Azotobacter 5 ml kg^{-1} seed) has recorded a stem girth of 6.75 cm, 6.90 cm, 6.85 cm, 6.87 cm, 6.75 cm and 6.98 cm.

Figure 2 illustrates that T1 (Urea @70 g) shows a significant effect at 5% on stem girth but shows no significant difference with the integrated application of zinc oxide @0.42 g + Urea @70 g. The similar result has obtained during the growth period of maize when measured at 60DAS. However, there is a huge significant difference between all the treatments. T0, T2, T4, T6 and T7 shows little significant difference among each other in 30 and 60 DAS. Application of nitrogen at the dose of 70 g has increased the stem girth. The use of nitrogen fertilizer has shown some result on the maize crop hence by increasing the stem girth. However at 90 days, there is no significant effect on the stem girth.

4.1.3. Number of leaves

The number of leaves plant^{-1} were counted and recorded during the different growing period viz 30, 60 and 90 DAS.

4.1.3.1 30DAS

Table 3 shows a maximum record in T1 (Urea @70 g) of 6.45 and the minimum was recorded in T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) of 5.56. T0 (No Treatment), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T5 (Zinc Oxide @0.42 g + Urea @70 g) and T6 (Zinc Oxide @0.42 g + FYM @0.83 g) shows a record of 5.56, 5.78, 6.33, 5.89, 6.11 and 6.

4.1.3.2 60 DAS

Table 3 has recorded a maximum leaves in T1 (Urea @70 g) and the minimum is recorded in T5 (Zinc Oxide @0.42 g + Urea @70 g) that is 6.11. T0 (No Treatment), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a number of leaves as follows: 6.55, 6.67, 6.44, 6.33, 6.67 and 6.55. Szulc et al., (2015) has reported that leaf area and the number of leaves per plant are essential in the assessment of photosynthesis of maize genotype which has shown to give a significant effect on plants.

4.1.3.3 90 DAS

Table 3 shows that T5 recorded a maximum number of leaves of 8.55. T0 (No Treatment), T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded of 7.78, 8.33, 8, 7.78, 8.22, 8.22 and 8.44. L. Venkata Subbaiah 2014 has considered the outcome of nanoparticles on maize which displays an encouraging consequence on the growth and has shown a maximum number of leaves. According to Szulc et al 2015, the number of leaves is highly responsive to the application of nitrogen. Figure 3 shows that the application of nitrogen has shown a significant effect at 5% on the number of leaves in 30 days of observation but has a little significant difference with T3. T5 and T6 shows no significant difference and T0, T2, T4 and T shows no significant difference at the growth period of 30 days of sowing. Anyhow the treatments does not show any significant effect on the number of leaves in the growing period of maize at 60 days of sowing. Whereas the combination application of zinc oxide with N has shown a significant effect at 5% on the number of leaves after 90 days of observation. T3 and T0 does not show any significant difference also T4 and T6 does not show any significant difference.

4.1.4 Dry Matter Accumulation

The dry matter accumulation of maize was taken during its growing stages of 30, 60 and 90 days of sowing.

4.1.4.1 30 DAS

Table 4 shows that T4 (Zinc Oxide @0.42 g) has the maximum record of dry matter accumulation of 29.67 g/plant. T0 (No Treatment) having the minimum record of 20.87 g/plant of dry matter accumulation at 30 days of observation. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T5 (Zinc Oxide @0.42g + Urea @70 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @ 5ml kg^{-1} seed) recorded a dry matter accumulation of 27.07 g, 26.27 g, 25.57 g, 23.27 g, 27.07 g and 26.07 g.

4.1.4.2 60 DAS

Table 4 has recorded a maximum dry matter accumulation $plant^{-1}$ in T5 (Zinc Oxide @0.42 g + Urea @70 g) that is 102.10 g. T0 recorded the minimum dry matter accumulation $plant^{-1}$ of 75.54 g. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @ 5ml kg^{-1} seed) recorded a dry matter accumulation of 99.30 g, 83.40 g, 91.60 g, 88.10 g, 87.77 g and 80.60 g.

4.1.4.3 90 DAS

T5 (Urea @ 70 g) has recorded a maximum dry matter accumulation plant^{-1} of 241.51g. The minimum dry matter accumulation plant^{-1} is recorded in T0 (No treatment). T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a dry matter accumulation plant^{-1} of 221.11 g, 202.41 g, 227.41 g, 192.41 g, 219.08 g and 209.01 g.

Figure 4 illustrated that T4 shows a significant effect at 1% on dry matter accumulation. Application of Zinc Oxide @ 0.42 g has shown a significant effect on dry matter accumulation of plant^{-1} was recorded at 30 days of sowing. T5 shows a significant effect at 1% on dry matter accumulation of plant^{-1} during the growing period of 60 and 90 days of sowing. The combination application of ZnO and N at the rate of 0.42 g + 70 g shows a positive effect on the dry matter accumulation of maize. It has increased the bulk of dry matter accumulation. T6 and T1 shows no significant difference while as T2 and T7 has a slight significant difference at 30 days of sowing.T5 shows a greater amount of significance between all the treatments at 60 and 90 DAS. In 60 DAS, T4 and T6 shows a slight significant difference.

4.2. Effect of Various Treatments on Yield Attributes of Maize

4.2.1 Number of cobs plant^{-1}

Number of cobs per plant were recorded during the growth stages of 60 and 90 days of sowing.

4.2.1.1 Number of cobs plant^{-1} at 60 DAS

Table 5 shows that T5 (Zinc Oxide @0.42 g + Urea @ 70 g) has recorded a maximum number of cob plant^{-1} of 1.67. T0 (No treatment), T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a number of cobs plant^{-1} are 1.20, 1.21, 1.00, 1.00, 1.11, 1.23 and 1.00.

4.2.1.2 Number of cobs plant^{-1} at 90 DAS

Table 5 shows that T5 (Zinc Oxide @0.42 g + Urea @ 70 g) has recorded a maximum number of cob plant^{-1} of 1.67. T0 (No treatment), T1 (Urea @70 g), T2 (Azotobacter @5ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a number of cobs $plant^{-1}$ are 1.11, 1.22, 1.00, 1.00, 1.11, 1.24 and 1.00.

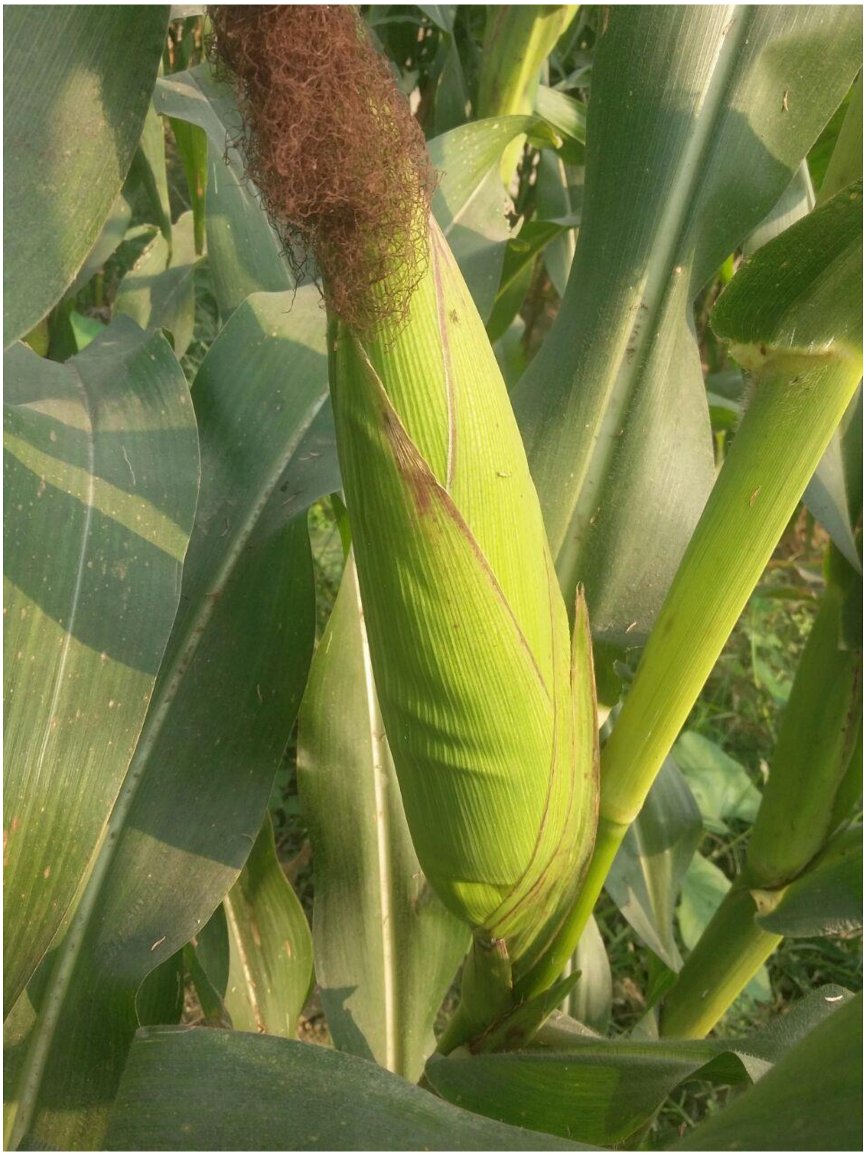


Figure: Cob in a plant

The research conducted by Milander 2015, has observed that the integration application of nitrogen fertilizer gives more number of cobs per plant. Figure 5 shows that integrated application of zinc oxide and inorganic fertilizer (urea) @0.42 g + 70 g has shown a significant effect ($p<0.01$) on the number of cobs per plant. The effect of nitrogen and zinc oxide has a good effect on maize plant as it increases the number of cobs per plant but does not much significant difference with T6 that is combine application of zinc oxide and organic manure

(FYM) at the concentration of 0.42 g + 0.83 g which gives a positive response to the number of cobs. T2, T3 and T7 shows no significant difference at 60 and 90 days when recorded.

4.2.2 Cob Length

The important feature in maize is a cob length. The cob length is measured in centimetre. Table 6 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) has recorded a maximum cob length of 24.44 cm. The minimum record of cob length is 18.28 cm which is T0 (control). T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6(Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) has recorded a cob length of 22.61 cm, 20.01 cm, 20.84 cm, 19.83 cm, 19.33 cm and 21.78 cm. Iqbal et al., (2016) has identified the syndicate of nitrogen and zinc oxide contributes in mounting the number of cobs.

Figure 6 shows that the integration application of nanoparticles (Zinc Oxide 0.42 g) and inorganic fertilizer (urea 70 g) has a significant effect on the cob length. Application of urea at the concentration of 70 g shows a significant effect on cob length and the application of zinc oxide at the concentration of 0.42 g and azotobacter 5 ml/kg of seed shows an effect on the cob length. T5 shows a great amount of significant difference between all the treatments and a very little difference with T1 and T7. Whereas T1 and T7 shows a slight significant difference but has a good impact on the cob length. T2 and T3 does not have much significant difference. Whereas there is no much effect on the cob length of maize when no treatment is given. In many studies by different scientist has shown a result that the integration use of nitrogen fertilizer has increased the cob length and has a shown a good effect on maize. Szulc et al., 2015 has conducted a research on maize where the nitrogen plays an important role in the growth of maize. The increase concentration of nitrogen has shown a good effect on the maize.

4.2.3 Number of Grains Cob^{-1}

The grains content in cob is very important as it plays a role in marketing. The more number of grains the better in marketing. The grains are used for different purposes. The presence of grains in a cob is significant. Table 7 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) has a maximum record of number of grains cob^{-1} that is 412.51.T0 (No treatment) recorded a minimum number of grains cob^{-1} that is 220.67. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-}

^{1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a number of grains cob^{-1} of 336.00, 275.00, 249.00, 273.67, 320.33 and 284.67. Akbar et al. 2002 has reported that by increasing nitrogen level has positively induced the number of kernels per ear. Due to the formation of protein in grain and the synthesis of enzyme with the assistance of zinc has escalated the number of kernels per ear.

Figure 7 shows that T5 has shown a significant effect at 1% on the number of grains cob^{-1}. The integration use of zinc oxide at the concentration of 0.42 g and urea at the concentration of 70 g has significantly increased the number of grains. The combination application of nitrogen and zinc oxide has a positive effect on the production of grains in maize. T5 shows a huge significant difference between all the treatments. T1 (urea at the concentration of 70 g) and T6 (combination of zinc oxide at the concentration of 0.42 g and FYM at the concentration of 0.83 g) also has a significant effect on the number of grains per cob. But there is a slight significant difference between the two treatments. There is no much significant difference between T2 (azotobacter 5 ml/kg of seed), T3 (FYM 0.83 g), T4 (zinc oxide 0.42 g) and T7 (zinc oxide 0.42 g and azotobacter 5 ml/kg of seed). Whereas T0 shows a huge significant difference with all the treatments and can be reported that it has a negligible significant effect on the number of grains per cob. Varghese et al., 2006 has studied the increase application of nitrogen has a great impact on the number of cobs per plant.

4.2.4 1000 Grain Weight

Table 8 shows the maximum record of 1000 grain weight in T5 (Zinc Oxide @0.42 g + Urea @70 g) is 203.33 g. The minimum 1000 grain weight is recorded in TO (No Treatment) is 179.33 g. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5ml kg^{-1} seed) recorded a 1000 grain weight are 197.17 g, 187.67 g, 181.33 g, 184.67 g, 193.33 g and 189.67 g. It has been demonstrated that zinc has a probable trait to intensify 1000 grain weight (Taheri et al., 2015).

Figure 8 illustrates that the combine application of zinc oxide 0.42 g and urea 70 g has a significant effect at 1% on 1000 grain weight. The integration application of nitrogen fertilizer and zinc oxide has a positive impact on 1000 grain weight and also on the growth of maize as comparison to other treatments that is conducted in this research. T5 also shows that there is a huge significant difference with all the treatments that is used in the experiment. It has been exhibited that zinc has a potential feature to increase the yield and the aspects of yield in maize (Taheri et al., 2015). T1 (Urea @70 g) and T6 (zinc oxide @0.42 g and @FYM 0.83 g) has no much significant difference but has a positive impact on 1000 grain weight. T2, T3, T4 and T7 has no much significant difference among it and has a little effect on the grain weight. Whereas T0 shows a negligible significant effect on the 1000 grain weight.

4.2.5 Grain yield plot^{-1} (kg)

Rafiq et al. 2010 has confirmed the result as the study has stated that the integrated use of zinc and nitrogen has a positive effect on the grain yield. Table 9 recorded a maximum grain yield plot^{-1} in T5 (Zinc Oxide @0.42g + Urea @ 70 g) of 2.85kg. T0 (No treatment) has recorded a minimum grain yield plot^{-1} of 1.72 kg. T1 (Urea @70 g), T2 (Azotobacter @5 ml kg^{-1} seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) recorded a grain yield plot^{-1} of 2.11 kg, 1.89 kg, 2.06 kg, 1.75 kg, 2.06 kg and 1.79 kg.

Mukhtar et al. 2011 has evaluated that nitrogen has a great impact on the grain yield. Figure 9 shows that the combine application of zinc oxide @0.42 g + urea @70 g has a significant effect at 1% on the grain yield. T5 has recorded to have a great amount of significant difference from all the treatments. T1 (urea @70 g) has a good impact on the grain yield. T3 (FYM @0.83 g) and T6 (zinc oxide @0.42 g + FYM @0.83 g) has no significant difference but shows a little significant effect on the grain yield. There is no significant difference between T2, T4 and T7. T0 has negligible significant effect on the grain yield.

4.2.6 Grain Yield

Table 10 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) has the maximum record of grain yield of 2863 kg/ha while T0 (No treatment) shows the minimum record of grain yield is 1730 kg/ha. T1 (Urea @70 g) has recorded a grain yield of 2132 kg/ha, T4 (Zinc Oxide @0.42 g) has recorded a grain yield of 2063 kg/ha, T3 (FYM @0.83 g) has recorded a grain yield of 2103 kg/ha, T2 (Azotobacter @5 ml/kg of seed) has recorded 1910 kg/ha, T6 (Zinc Oxide

@0.42 g + @FYM 0.83 g) has recorded 1793 kg/ha and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml/kg of seed) has recorded 1737 kg/ha.

4.2.7 Straw Yield

Table 10 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) has recorded a maximum yield of 4850 kg/ha. T1 (Urea @70 g) has recorded 3586 kg/ha, T4 (Zinc Oxide @0.42 g) has recorded 3529 kg/ha, T3 (FYM @0.83 g) of 3512 kg/ha, T2 (Azotobacter @5 ml/kg seed) of 3218 kg/ha, T6 (Zinc Oxide @0.42 g + FYM @0.83 g) of 3047 kg/ha, T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml/kg seed) of 2977 kg/ha and T0 (control) of 2929 kg/ha.

4.2.8 Biological Yield

Table 10 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) shows the highest record of biological yield of 7713 kg/ha. T1 (Urea @70 g) shows a record of 5718 kg/ha of biological yield. T2 (Azotobacter @5 ml/kg seed), T3 (FYM @0.83 g), T4 (Zinc Oxide @0.42 g), T6 (Zinc Oxide @0.42 g + FYM @0.83 g) and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed) has shown a record of 5128 kg/ha, 5615 kg/ha, 5592 kg/ha, 4840 kg/ha and 4714 kg/ha. T0 (Control) shows the minimum record of biological yield of 4659 kg/ha.

4.2.9 Harvest index

From table 10, we have recorded a data on harvest index where the maximum harvest index was observe in T3 (FYM @0.83 g) of 37.56. The data on other treatments are as following; T0 (Control) 37.13, T1 (Urea @70 g) 37.32, T2 (Azotobacter @0.83 g) 37.27, T4 (Zinc Oxide @0.42 g) 36.89, T5 (Zinc Oxide @0.42 g + Urea @70 g) 37.13, T6 (Zinc Oxide @0.42 g + FYM @0.83 g) 37.04 and T7 (Zinc Oxide @0.42 g + Azotobacter @5 ml kg^{-1} seed).

Ehsanullah et al. (2015) has stated that combine effect of zinc and nitrogen has a governing end product on grain yield, straw yield and biological effect. Zinc is a fundamental part in blend of protein in grain and other enzymes which spontaneously intensifies the grain, straw and biological yield.

From figure 10, we can make an analysis on grain yield, straw yield, biological yield and harvest index. Zinc Oxide at the concentration of 0.42 g and urea at the concentration 70 g has a significant effect at 1% on the grain yield. The single application zinc oxide has no much effect on the grain yield as compared to the interaction between zinc oxide and urea. T1, T3 and T4 does not have much significant difference but has significantly increased the grain yield. There is a significant difference between T2 and T6 but it is observed that T0, T6 and T7 shows a slight significant difference and has a little effect on grain yield (figure10).

Straw yield is increased significantly with the integration application of zinc oxide and urea. T5 shows a significant effect at 1% on straw yield and has a significant difference between all the treatments. However, it is observed there is no significant difference between T1, T4, T3, T2 and T6 and it has a little significant effect on the straw yield. T7 and T0 has no significant difference but has no significant effect (figure 10).

Biological yield is significantly increased at 1% with the application Zinc Oxide + Urea. T5 shows a significant difference between all the treatments. However T1, T2, T3 and T4 does not show any significant difference among it and has a positive impact on the biological yield. T6, T0 and T7 has no significant difference among the three (figure 10).

Figure 10 shows that T3 has a significant effect at 5% on harvest index but no significant difference between T0, T1, T2, T3, T5 and T6. There is negligible significant difference among T4 and T7. The maize plant has a fewer response to the sole application of zinc oxide.

4.3 Economic Analysis

4.3.1 Gross Net Return

Syed Sheraz Mahdi 2008 has reported the integrated application of nitrogen and zinc contributes to the economy as it has been observed in the increment of gross net return. Gross net return in maize plays a major role in farmer's life and in the production. It mainly depends on the yield and production. Table 11 shows that T5 (Zinc Oxide @0.42 g + Urea @70 g) has the highest gross net return of Rs.145499 and the lowest gross net return is found in T0 (No Treatment) of Rs.89316.

4.3.2 Net Return

T5 (Zinc Oxide @0.42 g + Urea @70 g) shows the highest net return of Rs.86980 and the lowest net return of Rs.38547 is found in T0 (No Treatment) shown in table11.

4.3.3 Benefit Cost Ratio

Table 11 recorded a maximum benefit cost ratio of 2.32 in TO (No Treatment). T5 has recorded the minimum benefit cost ratio of 1.67.

Table 4.1: Effect of Various Treatments on Plant Height at 30 days, 60 days and 90 days

Symbol	Treatment	Plant height (cm)		
		30 day	60 day	90 day
T_0	No treatment	37.45±1.62	63.02±2.32	159.22±1.59
T_1	Inorganic (Urea)	39.97±0.45	70.89±3.96	165.11±3.39
T_2	Azotobacter	38.82±1.12	74.05±1.23	166.11±2.11
T_3	Organic (FYM)	37.10±0.39	68.85±1.96	160.56±2.40
T_4	ZnO (Nanoparticles)	36.31±0.38	69.89±1.53	162.11±2.03
T_5	ZnO + Inorganic	41.41±0.49	76.23±0.81	168.00±2.32
T_6	ZnO + Organic	37.62±0.38	68.41±3.43	159.67±1.33
T_7	ZnO + Azotobacter	37.72±0.38	68.22±0.38	166.78±2.79
	S.Em.±	1.04	2.31	1.59
	CD at 5%	3.16	7.01	4.84
	Significance	*	*	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.2: Effect of Various Treatments on Stem Girth at 30 days, 60 days and 90 days

Symbol	**Treatment**	**Stem girth (cm)**		
		30 day	**60 day**	**90 day**
T_0	No treatment	3.86±0.21	5.16±0.12	6.71±0.22
T_1	Inorganic (Urea)	4.38±0.12	6.49±0.04	6.75±0.19
T_2	Azotobacter	3.61±0.10	6.08±0.28	6.90±0.28
T_3	Organic (FYM)	4.17±0.21	5.71±0.14	6.85±0.19
T_4	ZnO (Nanoparticles)	3.77±0.02	5.49±0.20	6.87±0.08
T_5	ZnO + Inorganic	4.34±0.08	6.48±0.10	7.13±0.24
T_6	ZnO + Organic	3.82±0.01	5.67±0.09	6.75±0.14
T_7	ZnO + Azotobacter	3.77±0.02	5.91±0.07	6.98±0.23
	S.Em.±	0.15	0.18	0.26
	CD at 5%	0.45	0.55	0.80
	Significance	*	**	Ns

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.3: Effect of Various Treatments on Number of leaves at 30 days, 60 days and 90 days

Symbol	Treatment	Number of leaves $plant^{-1}$		
		30 day	**60 day**	**90 day**
T_0	No treatment	5.66±0.26	6.55±0.17	7.78±0.17
T_1	Inorganic (Urea)	6.45±0.18	6.89±0.17	8.33±0.26
T_2	Azotobacter	5.78±0.20	6.67±0.15	8.00±0.39
T_3	Organic (FYM)	6.33±0.05	6.44±0.09	7.78±0.09
T_4	ZnO (Nanoparticles)	5.89±0.23	6.33±0.26	8.22±0.09
T_5	ZnO + Inorganic	6.11±0.17	6.11±0.09	8.55±0.17
T_6	ZnO + Organic	6.00±0.26	6.67±0.05	8.22±0.38
T_7	ZnO + Azotobacter	5.56±0.09	6.55±0.17	8.44±0.23
	S.Em.±	0.18	0.19	0.20
	CD at 5%	0.55	0.57	0.62
	Significance	*	Ns	*

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.4: Effect of Various Treatments on Dry Matter Accumulation at 30 days, 60 days and 90 days

Symbol	Treatment	Dry matter accumulation (g $plant^{-1}$)		
		30 day	60 day	90 day
T_0	No treatment	20.87±0.25	75.54±1.14	176.87±0.25
T_1	Inorganic (Urea)	27.07±0.41	99.30±0.43	221.11±9.04
T_2	Azotobacter	26.27±1.53	83.40±0.43	202.41±0.25
T_3	Organic (FYM)	25.57±0.36	91.60±2.71	227.41±0.25
T_4	ZnO (Nanoparticles)	29.67±0.25	88.10±3.33	192.41±4.23
T_5	ZnO + Inorganic	23.27±1.53	102.10±2.89	241.51±9.04
T_6	ZnO + Organic	27.07±1.71	87.77±3.39	219.08±7.51
T_7	ZnO + Azotobacter	26.07±0.25	80.60±0.43	209.01±3.49
	S.Em.±	0.89	2.47	7.65
	CD at 5%	2.72	7.49	23.22
	Significance	**	**	**

Table 4.5: Effect of Various Treatments on Number of cobs/plant at 60 days and 90 days

Symbol	Treatment	Number of cobs/plant	
		60 day	90 day
T_0	No treatment	1.20±0.09	1.11±0.09
T_1	Inorganic (Urea)	1.21±0.09	1.22±0.09
T_2	Azotobacter	1.00±0.02	1.00±0.01
T_3	Organic (FYM)	1.00±0.04	1.00±0.03
T_4	ZnO (Nanoparticles)	1.11±0.09	1.11±0.08
T_5	ZnO + Inorganic	1.67±0.05	1.67±0.05
T_6	ZnO + Organic	1.23±0.17	1.24±0.17
T_7	ZnO + Azotobacter	1.00±0.07	1.00±0.07
	S.Em.±	0.096	0.09
	CD at 5%	0.29	0.29
	Significance	**	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.6: Effect of Various Treatments on Cob Length

Symbol	Treatment	Cob length (cm)
T_0	No treatment	18.28±0.17
T_1	Inorganic (Urea)	22.61±0.56
T_2	Azotobacter	20.01±0.19
T_3	Organic (FYM)	20.84±0.90
T_4	ZnO (Nanoparticles)	19.83±0.39
T_5	ZnO + Inorganic	24.44±0.62
T_6	ZnO + Organic	19.33±0.40
T_7	ZnO + Azotobacter	21.78±0.19
	S.Em.±	0.57
	CD at 5%	1.75
	Significance	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.7: Effect of Various Treatments on Number of grains/cob

Symbol	Treatment	Number of grains/cob
T_0	No treatment	220.67±9.32
T_1	Inorganic (Urea)	336.00±20.20
T_2	Azotobacter	275.00±15.47
T_3	Organic (FYM)	249.00±11.34
T_4	ZnO (Nanoparticles)	273.67±19.85
T_5	ZnO + Inorganic	412.51±5.33
T_6	ZnO + Organic	320.33±45.35
T_7	ZnO + Azotobacter	284.67±22.57
	S.Em.±	27.58
	CD at 5%	83.65
	Significance	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.8: Effect of Various Treatments on 1000 Grain Weight

Symbol	Treatment	1000 grain weight (g)
T_0	No treatment	179.33±1.13
T_1	Inorganic (Urea)	197.17±2.97
T_2	Azotobacter	187.67±2.62
T_3	Organic (FYM)	181.33±2.62
T_4	ZnO (Nanoparticles)	184.67±2.02
T_5	ZnO + Inorganic	203.33±1.29
T_6	ZnO + Organic	193.33±2.58
T_7	ZnO + Azotobacter	189.67±5.14
	S.Em.±	3.66
	CD at 5%	11.10
	Significance	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.9: Effect of Various Treatments on Grain yield/plot

Symbol	Treatment	Grain yield/plot (kg)
T_0	No treatment	1.72±0.03
T_1	Inorganic (Urea)	2.11±0.18
T_2	Azotobacter	1.89±0.10
T_3	Organic (FYM)	2.06±0.24
T_4	ZnO (Nanoparticles)	1.75±0.02
T_5	ZnO + Inorganic	2.85±0.08
T_6	ZnO + Organic	2.06±0.10
T_7	ZnO + Azotobacter	1.79±0.04
	S.Em.±	0.16
	CD at 5%	0.50
	Significance	**

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.10: Effect of Various Treatments on Grain yield, straw yield, biological yield and harvest index

Symbol	Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index
T_0	No treatment	1730±24	2929±42	4659±65	37.13±0.10
T_1	Inorganic (Urea)	2132±165	3586±298	5718±462	37.32±0.17
T_2	Azotobacter	1910±90	3218±168	5128±257	37.27±0.13
T_3	Organic (FYM)	2103±213	3512±401	5615±613	37.56±0.41
T_4	ZnO (Nanoparticles)	2063±98	3529±158	5592±256	36.89±0.07
T_5	ZnO + Inorganic	2863±68	4850±138	7713±206	37.13±0.13
T_6	ZnO + Organic	1793±43	3047±65	4840±107	37.04±0.06
T_7	ZnO + Azotobacter	1737±14	2977±34	4714±48	36.85±0.10
	S.Em.±	150.46	278.56	428.74	0.22
	CD at 5%	456.34	844.84	1300.32	0.69
	Significance	**	**	**	*

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.11: Effect of Various Treatments on Economics

Symbol	**Treatment**	**Gross returns (Rs.)**	**Net return (Rs)**	**B:C ratio**
T_0	No treatment	89316	38547	2.32
T_1	Inorganic (Urea)	107590	57571	1.93
T_2	Azotobacter	96538	45768	2.16
T_3	Organic (FYM)	105368	59106	1.88
T_4	ZnO (Nanoparticles)	105859	59589	1.79
T_5	ZnO + Inorganic	145499	86980	1.67
T_6	ZnO + Organic	91424	44529	2.06
T_7	ZnO + Azotobacter	87882	40181	2.19

* Significant at 5% level of probability

** Significant at 1% level of probability

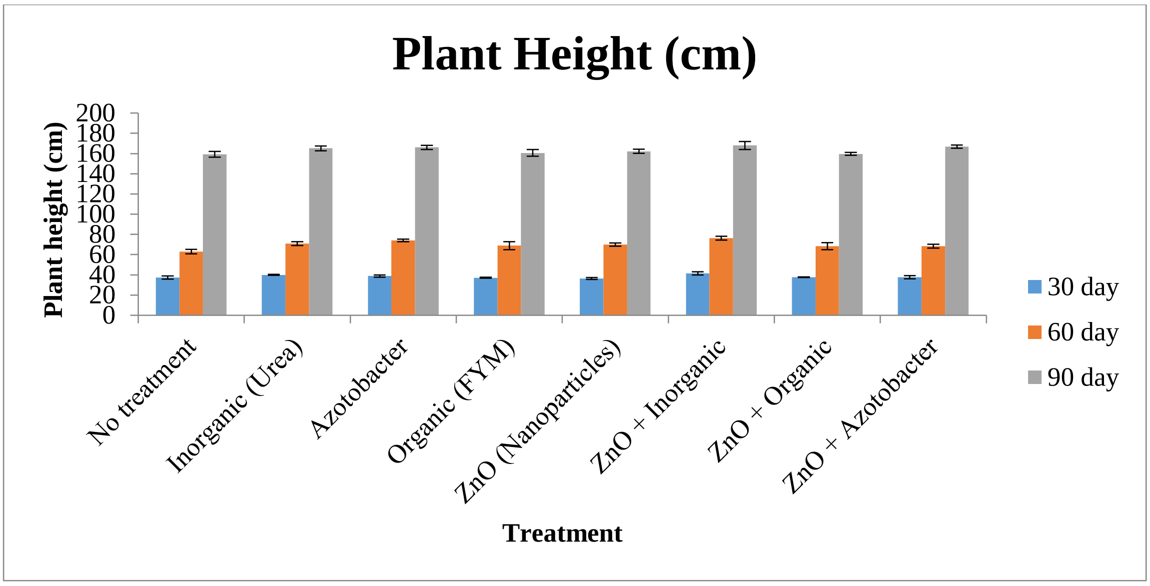


Figure 4.1: Effect of various treatments on plant height at 30 days, 60 days and 90 days

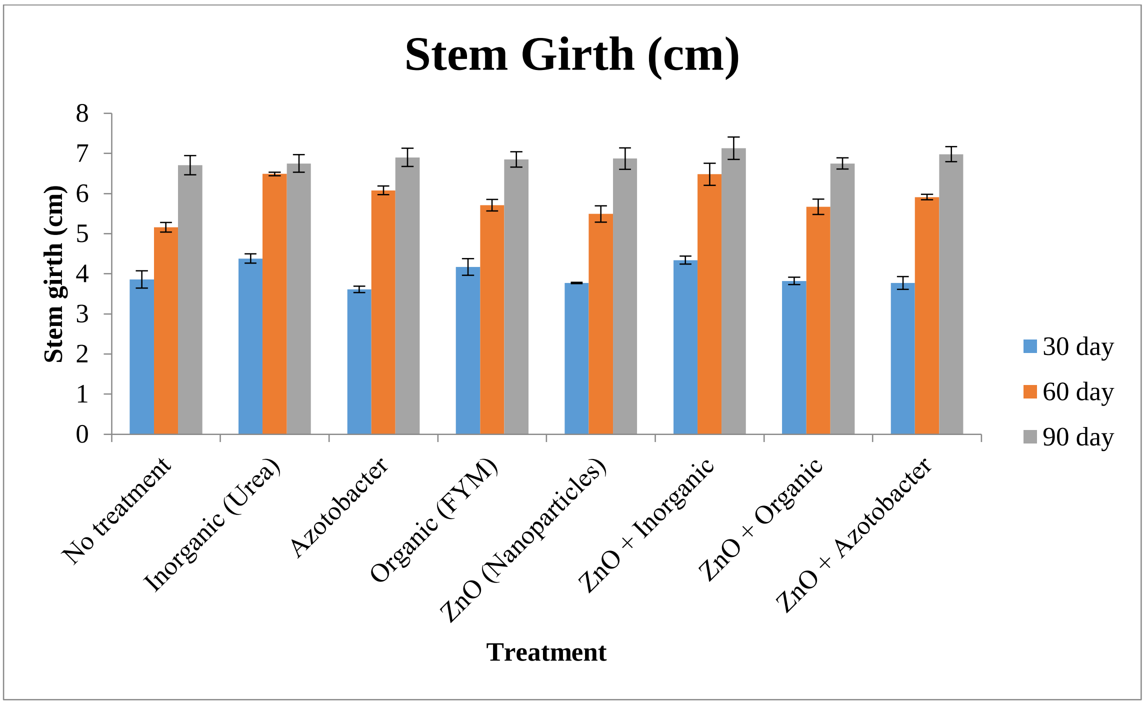


Figure 4.2: Effect of various treatments on stem girth at 30 days, 60 days and 90 days

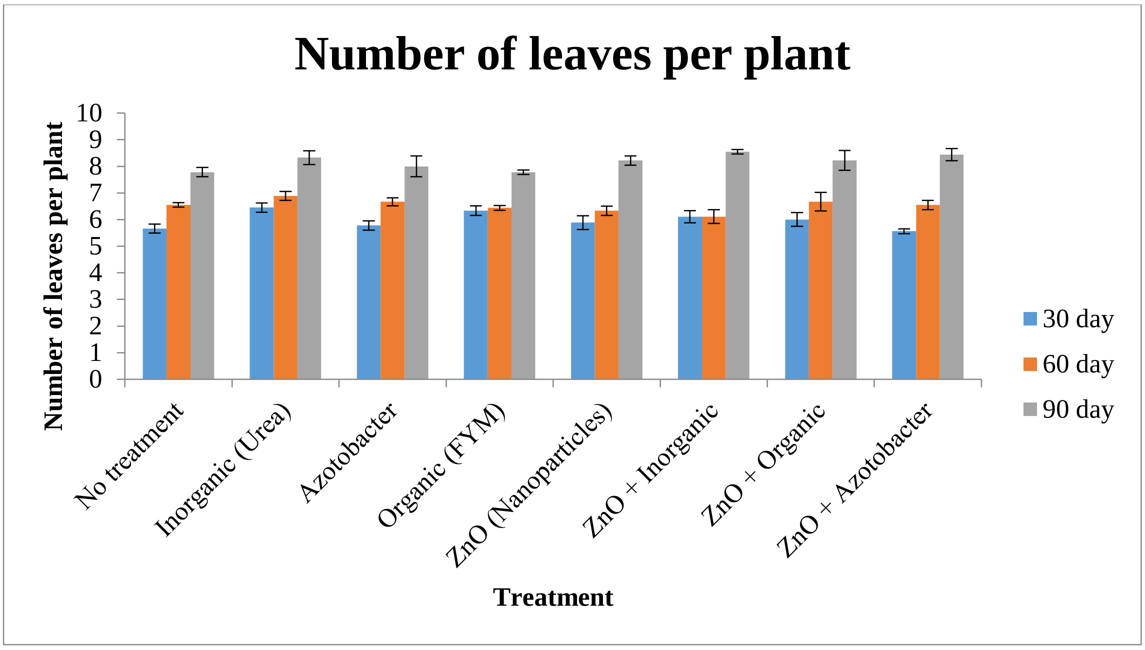


Figure 4.3: Effect of various treatments on number of leaves at 30days, 60days and90days

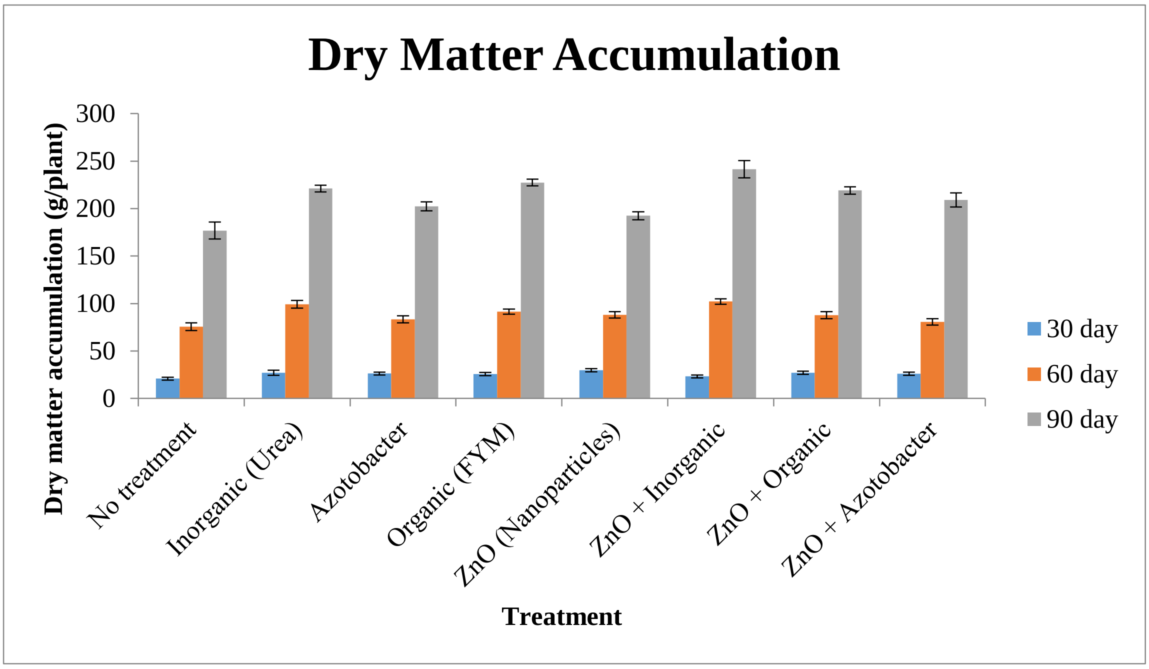


Figure 4.4: Effect of various treatments on dry matter accumulation at 30 days, 60 days and 90 days

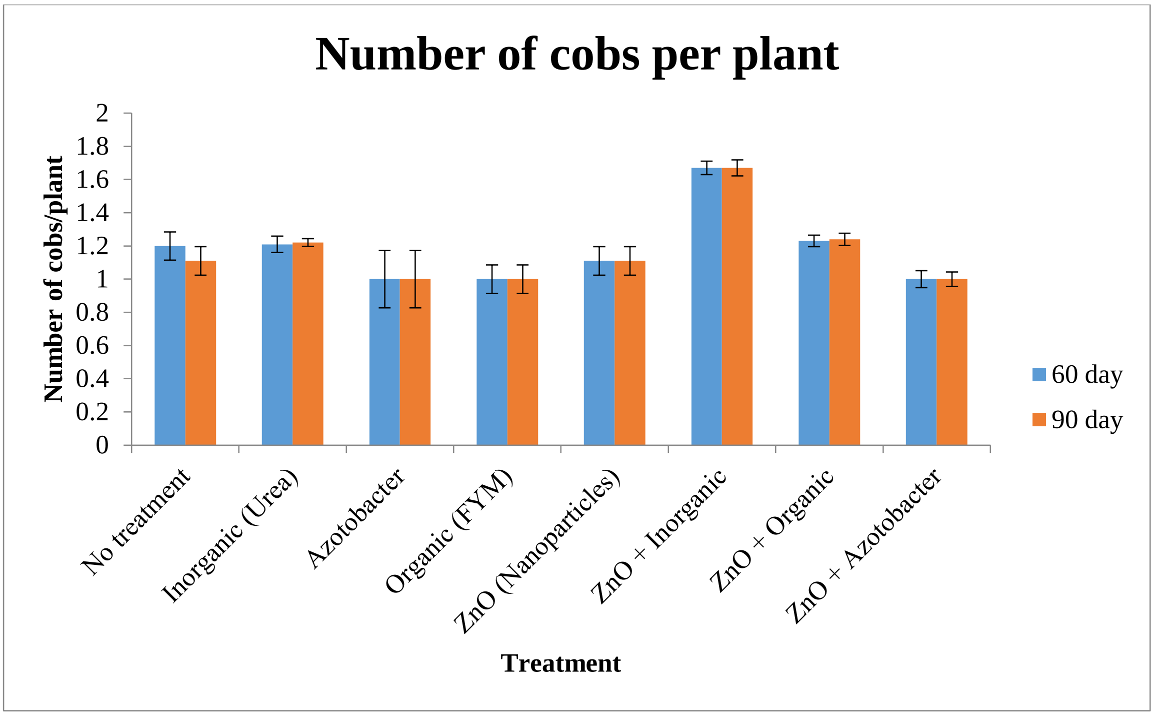


Figure 4.5: Effect of various treatments on number of cobs/plant at 60 and 90 days

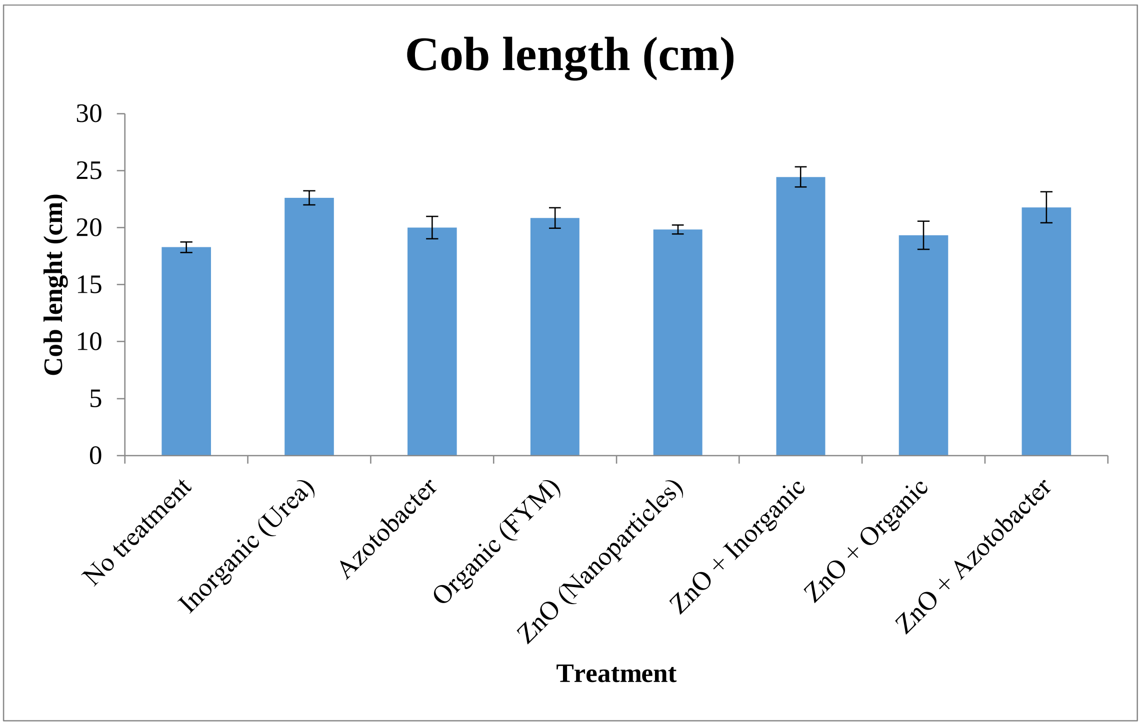


Figure 4.6: Effect of various treatments on cob length

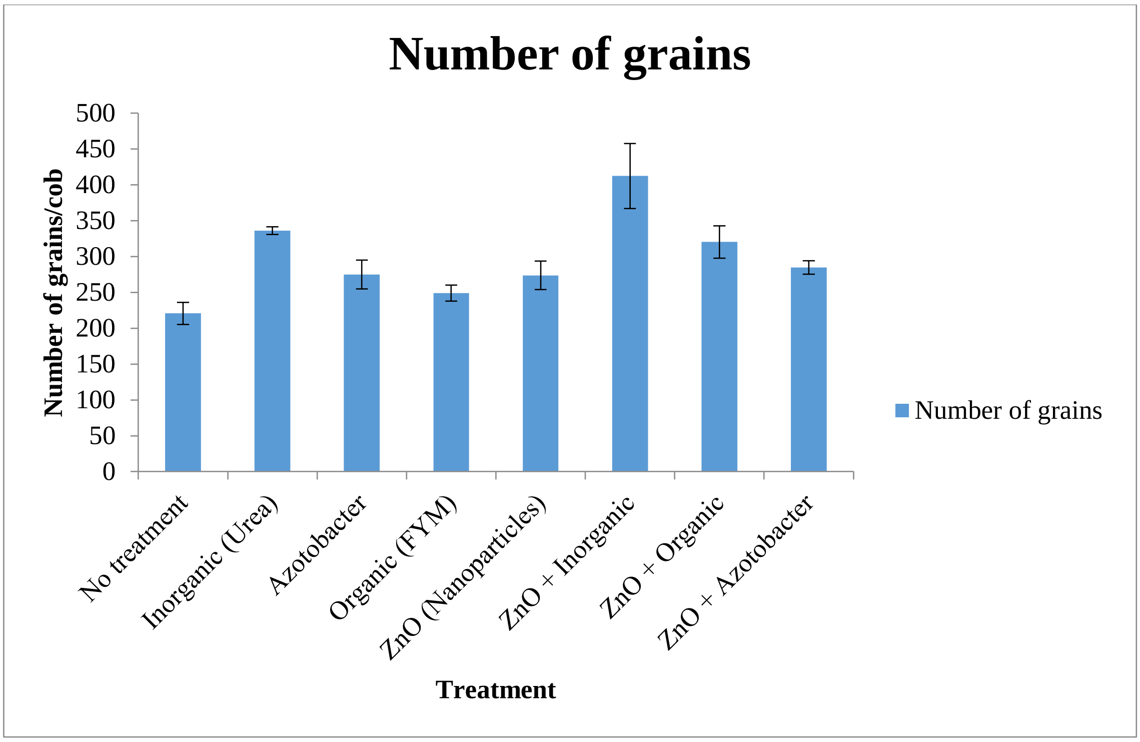


Figure 4.7: Effect of various treatments on number of grains cob^{-1}

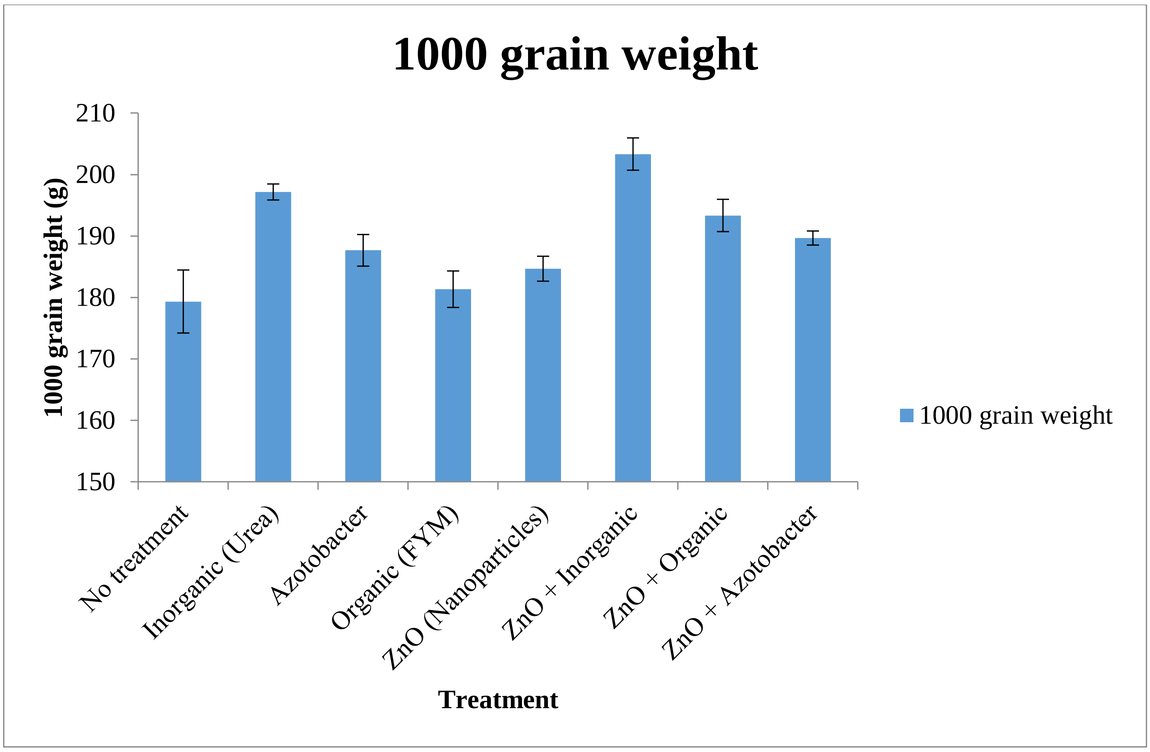


Figure 4.8: Effect of various treatments on 1000 Grain Weight

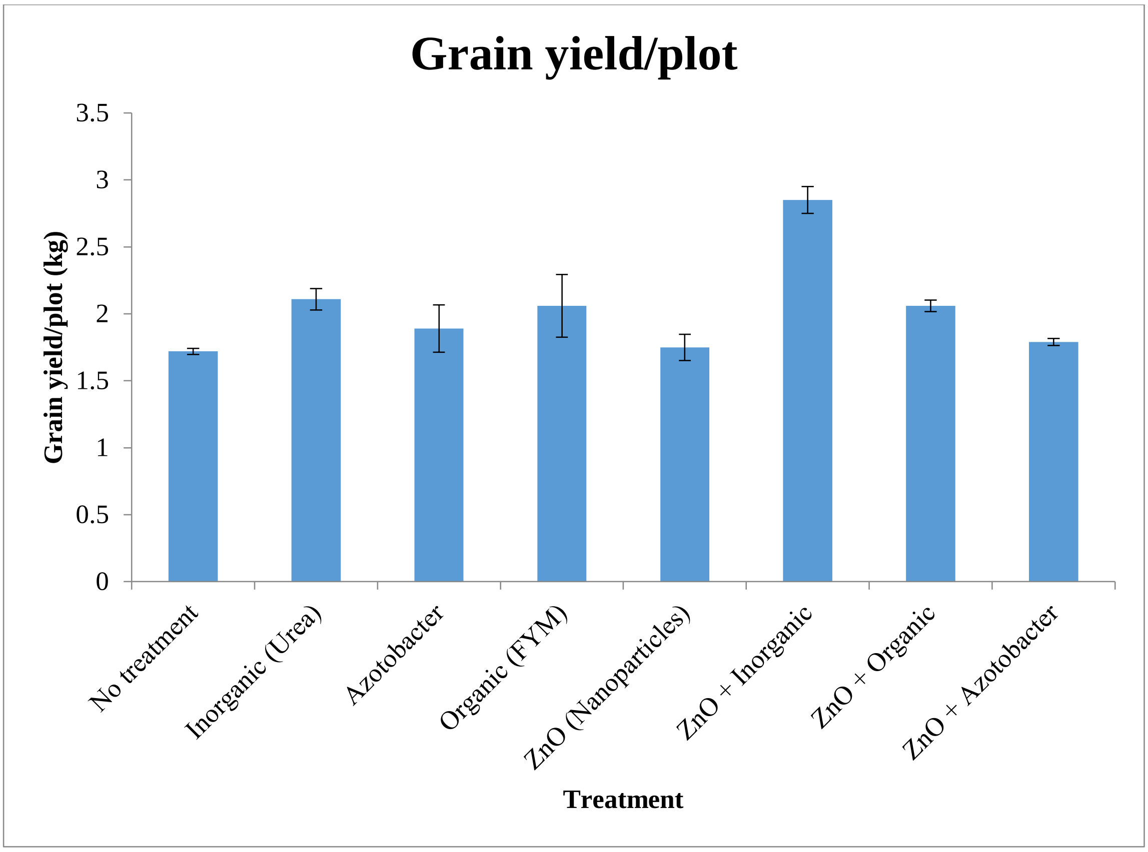


Figure 4.9: Effect of various treatments on grain yield/plot

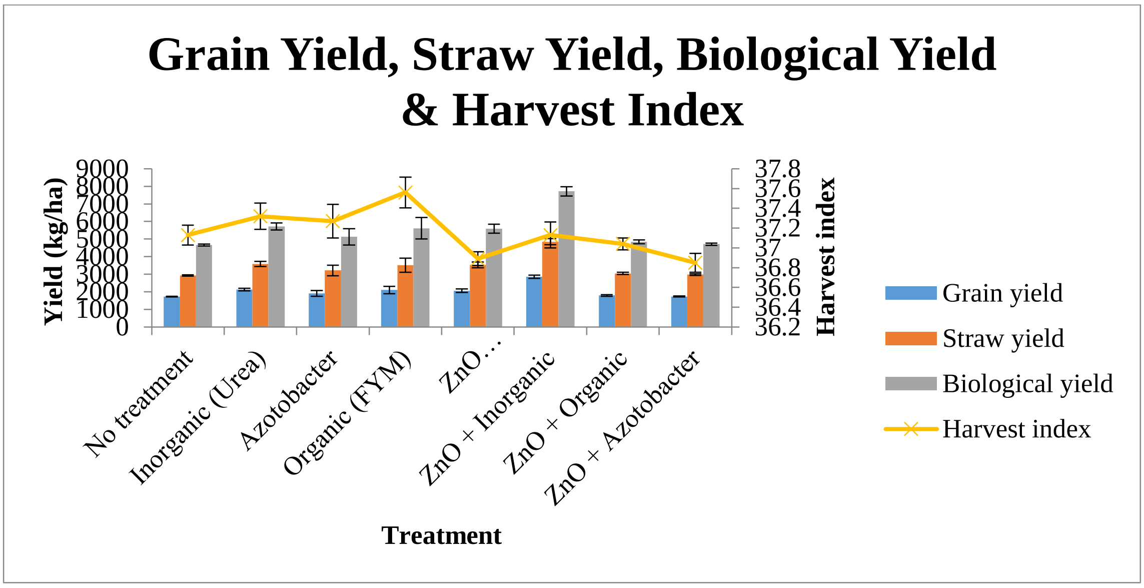


Figure 4.10: Effect of various treatments on Grain Yield, Straw Yield, Biological Yield and Harvest Index

Discussion

The results of the study entitled “Comparative study on the effect of various fertilizer on maize’’ will be discussed in this chapter. The data of the effect of different treatments on the growth of maize was recorded from different growth parameters, yield attributes, yield and economics.

5.1 Effect of Zinc Oxide and Inorganic Fertilizer

5.1.1 Growth parameters

Iqbal et al., 2016 reported that the combine use of nitrogen and zinc has a beneficial effect on the growth. The plant height of 231.9 cm is observed in a plot where the integrated application of zinc and nitrogen fertilizer is used. The integration application of nanoparticles and inorganic fertilizer has a positive impact on all the growth attributes that is considered in the experiment as it shows significant effect on the growth of maize (from figure1). In this experiment, zinc oxide and nitrogen (urea as a source) is allotted for treatment 5 and the data which was attained has shown to give a good response towards the growth statistic of maize.

K. Chomba et al., 2013 has observed that the integration use of nitrogen fertilizer with different fertilizers has increased the stalk volume and the growth indices of a plant. The growth is more responsive unto the application of such combine doses.

Application of zinc oxide @0.42 g + Urea @70 g has shown to give a positive impact on the plant height during all the growth stages of maize. It has been observed that the plant height recorded during 30, 60 and 90 days of sowing has not been induced by any treatments except from the integrated application of nanoparticles and inorganic fertilizer. The plant has attained a height of 41.41 cm in 30 DAS, 76.23 cm in 60DAS and 168 cm in 90 DAS from the combine application of zinc oxide and nanoparticles (from table1).

L. Venkata Subbaiah 2014 has studied on the effect of nanoparticles on maize and has used 1500 ppm of zinc oxide which shows a positive effect on the plant growth and plant height.

On the basis of plant height, it can be analysed that the integration application of nanoparticles with inorganic fertilizer has a significant effect on the plant height and significantly increases the plant height as compared to the single application of inorganic fertilizer and nanoparticles.

The single application of both the treatments are not as that effective as the combine application.

The study has done on two corn cultivars: C-20 and C-79 and the effect of urea on it is conducted where the different levels of urea is used @ 0kg/ha, 50 kg/ha, 100 kg/ha, 175 kg/ha and 225 kg/ha. It has been observed that the cultivar C-20 has shown a greater response to the application of urea @175 kg/ha due to the mineral nutrient which is present in a cultivar such as nitrogen, phosphorous, potassium, copper, iron, manganese and zinc (Bashir et al., 2012). All the micronutrients are an essential in the growth of maize. The deficiency of zinc deficiency delays the stages of silking and tasselling. Hence, the crop requires its nutrition in optimum amount.

Ullah et al., 2015 has stated that the growth is influenced by nitrogen. Zinc plays an important role in metabolism of enzymes and also promotes cell division and cell elongation helps in enzymes metabolism and faster cell divisions, cell elongation. Application of nitrogen in maize has shown to increase in plant height as amino acid present in nitrogen is known for building blocks which promotes the cell expansion. Asif et al., 2013 has reported that the increase in plant height is due to N and Zn which helps in the production and expansion of more leaf area which results more assimilates production. Similarly more vegetative development by nitrogen resulted in increased mutual shading and intermodal expansion. The result has been confirmed by Masood et al., 2014.

In table 2 and figure 2, it has been observed that the application of zinc oxide and urea has no such effect on the stem girth at 30 and 60 days of growth period. However, in 90 days T5 shows the maximum volume of 7.13 cm in table 2. But T5 shows no significant difference with all the treatments. Therefore, the integration application of zinc oxide and urea has no influence on the stem girth of maize.

It is observed that a number of leaves in maize is not influenced by T_5 in 30 and 60 days of sowing. Inorganic fertilizer and nanoparticles does not show any significant effect on the number of leaves in maize shown in figure 3. In 90 days of growth period the treatment where zinc oxide + urea is used attains a maximum number of leaves of 8.55 shown in table 3.

Maize is sensitive to zinc deficiency as it affects the leaves of a plant and the integrated application of zinc and nitrogen boost the number of leaves in maize. Maize is more responsive to the integration application of zinc oxide + urea rather applying it individually to each plots.

The production of more assimilates as a consequences of synergistic effect on nitrogen and zinc has increased the number of leaves.

The application of nitrogen has a significant effect on dry matter accumulation at 5-6 leaf stages (Szulc et al., 2012). In figure 4, it is observed that ZnO @0.42 g + Urea @70 g does not show any significant effect on the dry matter accumulation at 30 days of sowing. However, there is increased in dry matter accumulation with the increase in number of days. The crop is responsive to the combine application of zinc oxide @0.42 g + Urea @70 g. The dry matter accumulation is estimated to be 102.10 g and 241.51 g in 60 and 90 days of showing which is shown in table 4.

Assimilation of important nutrients in plants is the key to a healthy crop. The growth parameters (plant height, stem girth, number of leaves per plants and dry matter accumulation) has been influenced by the synergistic effect of zinc and nitrogen. The crux of the research is mostly on the comparison of different fertilizers and manures that is used in the experiment. It has been observed that the treatment where the integrated use of zinc oxide and urea is more influential on the growth parameters of maize hybrid (pioneer corn hybrid P3396).

5.1.2 Yield Attributes

Yield attributes which comprises of number of kernels in ear, ear length, number of ears per plant are recorded to make an analysis on different treatments that is used on maize. The effect of inorganic fertilizers and nanoparticles on yield attributes has shown the positive result on the growth in maize crop. The combine application of N @ 200 kg ha^{-1} and zinc @ 15 kg ha^{-1} were observed to give a higher performance in yield components (Iqbal et al., 2016).

A study is conducted on the maize cultivar with intercrop of urad under two levels of nitrogen. The different levels are: 120, 60, 60 kg NPK/ha and 140, 90, 70 kg NPK/ha. It is observed that the number of ear $plant^{-1}$, ear length, kernel weight, number of kernels present in ear and 1000 kernel weight has shown to increased (Varghese et al., 2006). From the research conducted by most of the scientist, it can be derived that the combine application of nitrogen with other fertilizers has shown to increase the yield attributes as well as the growth indices.

Application of zinc oxide @0.42 g + Urea @70 g has shown a significant effect on the number of cobs per plant shown in figure 5. The data was collected twice, one at 60 and the other at harvesting time. It has been observed that a treatment where integration application of zinc oxide and urea is used has attained a maximum number of cobs per plant of 1.67 at 60 days of sowing and during the harvesting shown in table 5.

It is found that T_5 is an effective treatment in increasing the number of cobs as it is one of the main factor in increasing the production. Increase in number of cobs will lead to a higher economic benefit. The functions of nitrogen and zinc oxide are important in the growth of a plant. The magnitude of cob has escalated due to the application of nitrogen.

Farooqui et al., 2016 has reported that zinc oxide nanoparticles stimulates the yield factors and aids in the growth of a plant.

The combine application of zinc oxide @0.42 g + Urea @70 g has shown a positive effect on the ear length (shown in figure 6). The maximum cob length is 24.44 cm (from table 6) obtained by T_5. The combine application of urea and zinc oxide can be regarded best due to all the positive effects on the yield attributes and the growth indices as compared to the other treatments used in the research.

Woldesenbet et al., 2016 concluded that the optimum use of nitrogen fertilizer on the growth is important as the increase level of nitrogen fertilizer can also decrease the yield but the optimum use can increase the yield. Therefore, the nitrogen use efficiency is important in cultivation of crops.

The main goal of this research is to analyse different fertilizers used and its effect on the growth parameters, yield attributes and yield. To obtain which combination of treatments are the most effective on the crop.

The number of kernels per ear is observed to response more to zinc oxide @0.42 g + urea @70 g. In table 7 the maximum number of grains per cob is 412.51 g which is attained by T_5. The kernels present in the cob is induced with the application of zinc and nitrogen. Nitrogen and zinc has a good effect on the leaves as it enhances the physiological activity of a plant (anonymous). Due to the presence of vivid leaf and the luxuriant growth of the cultivar in a particular treatment has induced the number of grains. The lush leafy plant is directly proportional to the production of grains in a cob. Figure 7 shows that integration application of zinc oxide and nitrogen has a significant effect on the number of grains per cob in a plant.

Maize requires a proper fertilization and a proper nutrient should be supplied for the proper growth. Nitrogen has a direct effect on the growth of a crop. If a crop has the luxuriant growth and also provided with all the nutrient requirements, it will directly influence the yield of the crop. The optimum supply of nitrogen in maize has a significant effect on the 1000 grain weight of maize (Varghese et al., 2006). Akbar et al. 2002 has reported that by increasing nitrogen level has positively induced the number of kernels per ear. Due to the formation of protein in grain and the synthesis of enzyme with the assistance of zinc has escalated the number of kernels per ear. Ehsanullah et al. 2015 has stated due to soil fertility status and genetic make-up has rendered the number of grains. The evident is supported by Rehman et al. 2010 by stating that the optimal use of both N and ZnO has a significant effect on the number of grains per cob.

In table 8, it observed that the integration application of zinc oxide and nitrogen based fertilizer has obtain a maximum 1000 grain weight of 203.33 g and has shown to have a significant effect on the 1000 grain weight (figure 8). The single application of nitrogen based fertilizer does not have much significant like the combine application. Likewise the sole application of zinc oxide does not have a beneficial effect on the crop. It has observed that the integration application has the most beneficial effect on the crop. It has been exhibited that zinc has a potential feature to increase the yield and the aspects of yield in maize (Tehua et al., 2015). The result has been confirmed by Sharar et al. 2003 as the study has stated that the combine application of nitrogen and zinc has a unique feature that has a significant effect on the yield. It is considered as a vital yield dependent indices. It infers the size of seed formation and development. The interaction between nitrogen and zinc has shown to increase 1000 weight and formation of heavier grains due to increase in uptake and more absorption of nutrient by a crop.

The grain yield plot^{-1} is evaluated to be maximum in T_5. It gives the grain yield plot^{-1} of about 2.85 kg which is shown in table 9. The supply of optimum nutrients are recommended for a crop. Humans also requires a balance diet for proper growth. If humans are also lacking an important vitamin in a diet than it renders hindrance to the functional body. Likewise, plants require a balanced and optimum nutrients for proper functioning so that it will not create any obstacle to the plant metabolism. The grain yield is significantly increased with the combine use of an important fertilizers that is required in the growth of maize. Maize is supplied with an important nutrients like nitrogen and zinc oxide which spontaneously induces the grain yield (anonymous). Saeed et al. 2010 and Mukhtar et al. 2011 has evaluated that nitrogen has a great impact on the grain yield. Rafiq et al. 2010 has confirmed the result as the study has stated that the integrated use of zinc and nitrogen has a positive effect on the grain yield. The increment in grain yield was probably due to more number of rows per cob, number of kernels per cob, 1000 grain weight. Promotion of rapid growth, photosynthesis is enhanced and formation of green foliage increases the grain yield which has been effected with the combine doses.

The grain yield, straw yield and biological yield has observed to be maximum in T_5 of 2863 kg/ha, 4850 kg/ha and 77.13 kg/ha (table 10). The effect of inorganic fertilizer and nanoparticles on the yield has shown to be more effective than the other treatments. In figure 10, it is illustrated that the integration use of nanoparticles and inorganic fertilizer gives a higher significant performance and has shown to have greater significant effect on the yield attributes of a maize cultivar.

Zinc is an essential components in plant physiology as it helps in the photosynthetic metabolites, cell wall integrity, phytohormone activities and deficiency in zinc renders in yield reduction (Y. Hosseiny et al., 2008). If the plant can uptake both the nutrition hand in hand than there is probability of achieving a plant which gives an excellent performance. One of the reason why T_5 is giving a better performance is the crop is getting the nutrients from the combine application of zinc oxide and urea.

It is reported that the rate of fertilizer application plays a major role in yields. It has been found that the maximum grain yield of 8.27 t ha^{-1} if application of fertilizer is supplied in optimization (Mohkum Hammad et al., 2011). Due to synergistic effect of zinc and nitrogen has influential effect on grain yield, straw yield and biological effect. Zinc plays an important role in synthesis of protein in grain and other enzymes which spontaneously escalates the grain, straw and biological yield supported by Ehsanullah et al. 2015.

5.1.3 Economic

The combine application of Zinc and Nitrogen fertilizer has reportedly gave the highest gross and net return (Syed Sheraz Mahdi 2008).

The gross net return of Rs.145499 and net return of Rs. 86989 is observed in the combine application of inorganic fertilizer and nanoparticles (table 11). However, the benefit cost ratio is reduced and is found to be minimum of 1.67 as shown in table 11.

The study focuses more on the different fertilizers that is supplied to the crop. The phenotypical factor and the yield factor is triggered with the combine application of ZnO + N. The crop has shown more responses towards T_5 than organic manure, inorganic fertilizer, biofertilizer, nanoparticles and control. The crop responses more to the integrated application of inorganic fertilizer and nanoparticles.

Chapter 6. Summary and Conclusion

A field experiment entitled "Comparative Study on the Effect of Various Fertilizers on the Growth in Maize" was conducted during Rabi season 2016-2017 in Lovely Professional University, Phagwara, Punjab. The experiment was laid out in a randomized block design with eight treatments with three replications. The unit plot size was 3×1.75m^2 and the total number of plots was 24. The treatments consisted of T_0 (No Treatment), T_1 (Urea @ 70 g plot^{-1}), T_2 (Azotobacter @5ml kg^{-1} seed), T_3 (FYM @0.83 g plot^{-1}), T_4 (Zinc oxide @0.42 g kg^{-1} seed), T_5 (zinc oxide @0.42 g + urea @70 g), T_6 (Zinc oxide @0.42 g + FYM @0.83 g), T_7 (zinc oxide @0.42 g + azotobacter @ 5ml/kg seed).The variety used in this experiment is hybrid pioneer corn hybrid P3396 . The salient findings of the investigation are summarized below.

Observations were recorded on growth (plant height, stem girth, number of leaves, dry matter accumulation), yield attributes (cob length, number of grain per cob, grain weight per cob, number of cobs per plant), yield and economics aspects (1000 grain weight, grain yield, straw yield, harvest index, biological yield, net return and cost benefit ratio).

- Application of zinc oxide @0.42 g/kg seed + urea @70 g plot^{-1} gave significantly higher plant height at 30 DAS, 60 DAS and at harvest (41.41 cm, 76.23 cm and 168 cm respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + Urea @ 70 g/plot gave significantly a greater number of leaves at harvest of 8.55 respectively over azotobacter, inorganic fertilizer, control, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g plot^{-1} gave significantly higher dry matter accumulation at 60 DAS and at harvest (102.10 g and 241.51 g respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g plot^{-1} gave significantly higher number of cobs plant^{-1} at 60 DAS and at harvest (1.67 and 1.67 respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.

- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher cob length of 24.44 cm respectively over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher number of grains cob^{-1} of 412.51g respectively over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher 1000 grain weight (203.33 g respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher grain yield $plot^{-1}$ (2.85 kg respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher grain yield (2863 kg/ha respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher straw yield (4850 kg/ha respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher biological yield (7713 kg/ha respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of organic manure @0.83 g gave a higher harvest index of 37.56 over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + inorganic + nanoparticles, organic manure and nanoparticles + azotobacter.
- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher gross net return (Rs.145499 respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.

- Application of zinc oxide @0.42 g/kg seed + urea @70 g $plot^{-1}$ gave significantly higher net return (Rs.86980 respectively) over azotobacter, control, inorganic fertilizer, nanoparticles, nanoparticles + organic manure, organic manure and nanoparticles + azotobacter.
- Application of no fertilizer gave a higher benefit cost ratio of 2.32 over azotobacter, organic manure inorganic fertilizer, nanoparticles, nanoparticles + inorganic + nanoparticles, organic manure and nanoparticles + azotobacter.

Conclusion

The inferences may be drawn from the reported work in this proposal:

- Integration application of nanoparticles and inorganic fertilizer has an influential effect on the growth of a crop. It has a significant effect on the growth parameters, yield attributes, yield and economies.
- The study has evaluated that comparatively integrated application of zinc oxide at the dose 0.42 g and nitrogen at the dose of 70 g has shown a synergistic effect on the growth and yield in maize crop as to other fertilizers that was served as a treatment. It was concluded due to synergistic effect it has attributed an escalation in plant height, number of leaves, grain yield and other aspects of yield. Zinc serves as an imperative feature in the synthesis of protein in grains and other enzymes which is a key in plant metabolites. Nitrogen is essential in the plant growth which is the chief function in the increment of plant height.
- Combine application of zinc oxide @0.42 g kg-^{1} seed+ urea @70 g plot^{-1} gives a higher performance on a growth parameters (plant height of 168 cm, number of leaves plant^{-1} of 8.55, dry matter accumulation of 241.5 g), yield components (number of cobs^{-1} plant of 1.67, cob length of 24.44 cm and number of grains cob^{-1} of 412.51g), yield (1000 grain weight of 203.33 g, grain yield plot^{-1} of 2.85 kg, grain yield of 2863 kg/ha, straw yield of 4850 kg/ha and biological yield of 7713 kg/ha) and economic (gross net return of Rs.145499 and net return of Rs.86980).
- Therefore, it can be concluded that the integrated application of zinc oxide and urea has shown to be the best fertilizer comparatively to the other fertilizers that is used in this experiment. The crux of the research is to compare which fertilizer gives the higher performance in plants. The result has been obtained that the integrated use of zinc oxide and urea has the most influential effect on the growth as compared to the other treatments.

Literature Cited

Achieng, J. O., Ouma, G., Odhiambo G. and Muyekho F. 2010. Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, western Kenya. AGRICULTURE AND BIOLOGY JOURNAL OF NORTH AMERICA, ISSN Print: 2151-7517, ISSN Online: 2151-7525 © ScienceHuβ, http://www.scihub.org/ABJNA

Agricultural Statistics at a Glance 2014. Published in India by Oxford University Press

Agyenim Boateng S., Zickermann J. and Kornahrens M. 2006. Poultry Manure Effect on Growth and Yield of Maize West Africa. Journal of Applied Ecology (WAJAE)., 4307 Volume 9 (Jan – Jun 2006) www.wajae.org

Akbar, H., M.T. Miftahullah, A. Jan, and Ihsanullah, 2002. Yield potential of sweet corn as influenced by different levels of nitrogen and plant population. Asian J. Pl. Sci., 1(6): 631-633.

Asif, M., M.F. Saleem, S.A. Anjum, M.A. Wahid and M.F. Bilal, 2013. Effect of nitrogen and zinc on growth and yield of maize (Zea mays L.). J. Agric. Res., 51(4): 455-464.

Asif, M., M.F. Saleem, S.A. Anjum, M.A. Wahid and M.F. Bilal, 2011. The effect of nitrogen and zinc sulphate on growth and yield of maize. Department of Agronomy, university of Agriculture, Faisalabad. J. Agric. Res., 51(4): 455-464.

Bashir N., Ahmad Malik S., Mahmood S., Mahmood-ul-Hassan, Habib-urRehman Athar and Athar M. 2012. Influence of urea application on growth, yield and mineral uptake in two corn (Zea mays L.) cultivars. African Journal of Biotechnology Vol. 11(46), pp. 10494-10503

Berahmand A.A., Panahi A.G., Sahabi H., Feizi H., Moghaddam P.R., Shahtahmassebi N., Fotovat A., Karimpour H., Gallehgir O. 2012. Effects Silver Nanoparticles and Magnetic Field on Growth of Fodder Maize (Zea mays L.) Springer Science+Business Media, LLC

Berekaa M.M. 2015. Nanotechnology in Food Industry; Advances in Food processing, Packaging and Food Safety. International Journal of Current Microbiology and Applied Sciences

Dania S.O., Akpansubi P. and Eghagara O.O. 2014. Comparative Effects of Different Fertilizer Sources on the Growth and Nutrient Content of Moringa (Moringa oleifera) Seedling in a Greenhouse. Trial Hindawi Publishing Corporation Advances in Agriculture Volume 2014, Article ID 726313, 6 pages http://dx.doi.org/10.1155/2014/726313

Ehsanullah., A., M.A. Tariq, S.A. Randhawa, M. Anjum, Nadeem and M. Naeem, 2015. Exploring the role of zinc in maize through soil and foliar application. Uni. J. Agri. Res., (3): 69-75.

Elamin, A. E. and M.A. Elagib 2001. Comparative Study of Organic and Inorganic Fertilizers on Forage Corn (Zea mays L.) Grown on Two Soil Types. Qatar Univ. Sci. J. (2001), 21: 47-

Ezeibekwe, I.O, Ogbonnaya, C.I and Onuoha, C.I 2009. Comparative Effect of Poultry Manure and Urea on the Growth and Yield of Maize (Zea mays). Report and Opinion, 2009; 1(4),

Farnia A. and Mehdi Omidi M. 2015. Effect of Nano-Zinc Chelate and Nano-Biofertilizer on Yield and Yield Components of Maize (Zea mays L.), Under Water Stress Condition. Indian Journal of Natural Sciences Vol.5 / Issue 29/ April 2015

Farooqui A., Tabasum H., Ahmad A., Mabood A., Ahmad A. and Zareen Ahmad I. 2016. Role of Nanoparticles in Growth and Development of Plants. Int J Pharm Bio Sci 2016 Oct ; 7(4): (P) 22 – 37

Gomez, K.A. and A.A. Gomez 1984. Statiscal Procedure for Agricultural Research (2ed.)

HAJNAL-JAFARI T., LATKOVIĆ D., ĐURIĆ S., MRKOVAČKI N., NAJDENOVSKA O. 2012. The Use of Azotobacter in Organic Maize Production. Research Journal of Agricultural Science, 44 (2)

Hassan Amin 2011. Effect of different nitrogen sources on growth, yield and quality of fodder maize (Zea mays L.). Journal of the Saudi Society of Agricultural Sciences 10, 17–23

Hellal, F.A., R.M Zewainy, A.A. Khalil and A.A.M. Ragab 2014. Effect of organic and bio-fertilizer management practices on nutrient availability and uptake by Faba bean- Maize sequence. American-Eurasian Journal of Sustainable Agriculture ISSN: 1995-0748 2014 April; 8(5): pages 35-42.

Hokmalipour S., Shiri-e-Janagard M., Hamele Darbandi M., Peyghami-e-Ashenaee F., Hasanzadeh M., Naser Seiedi M. and Shabani R. 2010. Comparison of Agronomical Nitrogen Use Efficiency in Three Cultivars of Corn as Affected by Nitrogen Fertilizer Levels. World Applied Sciences Journal 8 (10): 1168-1174

Huang S. & Wang L. & Liu L. & Hou Y. & Li L. 2015. Nanotechnology in agriculture, livestock, and aquaculture in China. A review' Agron. Sustain. Dev.

Iqbal J., Khan R., Wahid A., Sardar K., Khan N.,Ali M., Hussain M., Ali W., Ali M. and Ahmad R. 2016. Effect of nitrogen and zinc on maize (zea mays l.) Yield components and plant concentration. Advances in Environmental Biology, 10(10) October 2016, Pages: 203-208

Juan Valero, M. Maturano, A. Artigao Ramírez, J. M. Tarjuelo Martín-Benito and J. F. Ortega Álvarez 2005. Growth and nitrogen use efficiency of irrigated maize in a semiarid region as affected by nitrogen fertilization. Spanish Journal of Agricultural Research (2005) 3(1), 134-144

K. Chomba S., R. Okalebo J., Imo M., K. Mutuo P. and G. Markus W. 2013. Predicting maize response to fertilizer application using growth curves in western Kenya. International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 3(6) pp. 200207

Karasu, A., 2012. Effect of nitrogen levels on grain yield and some attributes of some hybrid maize cultivars (zea mays indentata sturt.) grown for silage as second crop. Bulgarian Journal of Agricultural Science, 18 (No 1): 42-48.

Kisetu E., Lily S., James Temba W. and Projestus Rwebangila A. 2014. Effect of nitrogen and phosphorus on performance of maize planted at the varying soil depths. International Journal of Agricultural Policy and Research Vol.2 (3), pp. 090-097, March 2014 Available online at http://www.journalissues.org/ijapr/ © 2014 Journal Issues

L. VENKATA SUBBAIAH 2014. Effect of Nanoscale Zinc Oxide Particles on the Yield and Yield Attributes of Maize

Lu C., Ma J., ChenX., Zhang X., Shi Y., and Huang B. 2010. Effect of Nitrogen Fertilizer and Maize Straw Incorporation on NH_4+-15N and NO_3^{--}15N Accumulation in Black Soil of North East China among Three Consecutive Cycles. J. Soil Sci. Plant Nutr. 10 (4): 443 - 453

Mahdi, S.S., B. Hasan, L. Singh and A.M. Ganie, 2012. Quality of fodder maize (Zea mays L.) and soil health influenced by nitrogen, seed rate and zinc in Kashmir Valley. Ind. J. SoilConser. , 40: 147-151.

Masood., T. Naz, M . Javed, I. Ahmad, H. Ullah and M. Iqbal, 2014. Effect of short term supply of nitrogen and farm yard manure on maize growth and soil parameters. Archives of agronomy and soil science, 60(3): 337-347.

Memon M., Memon K.S., Mirani S. and Jamro G.M. 2012. Comparative evaluation of organic wastes for improving maize growth and NPK content. African Journal of Biotechnology Vol. 11(39), pp. 9343-9349

Meynard Banayo N., Pompe C. Sta. Cruz, Edna A. Aguilar, Rodrigo B. Badayos and Stephan M. Haefele 2012. Evaluation of Biofertilizers in Irrigated Rice: Effects on Grain Yield at Different Fertilizer Rates. Agriculture 2012, 2, 73-86; doi:10.3390/agriculture2010073

Mikhailouskaya N. and I. Bogdevitch 2009. Effect of biofertilizers on yield and quality of long-fibred flax and cereal grains. Agronomy Research 7(Special issue I), 412–418

Milander J.J. 2015. Maize Yield and Components as Influenced by Environment and Agronomic Management. University of Nebraska - Lincoln DigitalCommons@University of Nebraska – Lincoln

Mohammadi G.R., Ghobadi M.E., Sheikheh-Poor S. 2012. Phosphate Biofertilizer, Row Spacing and Plant Density Effects on Corn (Zea mays L.) Yield and Weed Growth. American Journal of Plant Sciences, 2012, 3, 425-429

MohammedA.A. 2012. Effect of Bio-Fertilizer on physiology of growth and development of maize (Zea mays L.) in Sulaimani region Mesopotamia. J. of Agric, Vol. (40) no. (1).

Mokhum Hammadi H., Ahmadi A., Wajidi A. and Akhter J. 2011. Maize Response to Time and Rate of Nitrogen Application. Pak. J. Bot., 43(4): 1935-1942

Moshabaki Isfahani F., Hossein Besharati 2012. Effect of biofertilizers on yield and yield components of cucumber. Journal of Biology and Earth SciencesJ Biol Earth Sci 2012; 2(2): B83-B92

Mucheru-Muna M., Mugendi D., Kung'u J., Mugwe J., Bationo A. 2007. Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South District, Kenya. Agroforest Syst (2007) 69:189–197 DOI 10.1007/s10457-006-9027-4

Mukhtar, T., M. Arif. S. Hussain, M. Tariq and K. Mehmood, 2011. Effect of different rates of nitrogen and phosphorus fertilizers on growth and yield of maize. J. Agric. Res., 49(3): 333-339.

Okonmah, L. U. 2012. Effects of Various Organic Manure on the Growth and Yield of Maize in Asaba Agro-Ecological Zone. Asian Journal of Science and Technology Vol. 4, Issue, 11, pp. 006-009

Okoroafor, I. B, Okelola, E. O, Edeh, O. N emehute, V. C., Onu, C. N., Nwaneri, T. C. and Chinaka, G. I. 2013. Effect of Organic Manure on the Growth and Yield Performance of Maize in Ishiagu, Ebonyi State, Nigeria. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 5, Issue 4 (Sep. - Oct. 2013), PP 28-31

Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. United States Department of Agriculture, circular number: 939.

Panse and P.V. Sukhatme 1954. Statiscal methods for Agricultural workers

Poshtdar A., Ata siadat S., Abdali mashhadi A., Amir Moosavi S., Hamdi H. 2012. Comparison between application of PGPR bacteria and chemical fertilizers on quality and total silage yield of Maize under different organic seed bed. International Journal of Agriculture and Crop Sciences. Available online at www.ijagcs.com IJACS/2012/4-11/713-717

Rafiq, M.A., A. Ali, M.A. Malik and M. Hussain, 2010. Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. Pak. J. Agri. Sci., 47(3): 201-208.

Raj Baral B. and Adhikari P. 2013. Effect of Azotobacter on Growth and Yield of Maize. SAARC J. Agri., 11(2): 141-147

Rajeshwar M. and Aarif Khan M.A. 2010. Effect of biofertilizers on crop yield and soil available nutrients of rice and maize in alfisols of Nagarjuna Sagar left canal command area of Andhra Pradesh, India. An Asian Journal of Soil Science, (June, 2010) Vol. 5 No. 1 : 200-203

Raskar, V.V Sonani and P.A. Patil 2013. Study of Economics of Maize as influenced by different levels of Nitrogen, Phosphorus and Zinc. International Journal of Scientific and Research Publications, Volume 3, Issue 10

Rehman, H., A. Ali, M. Waseem, A. Tanveer, M. Tahir, M.A. Nadeem and M.S.I. Zamir, 2010. Impact of nitrogen application on growth and yield of maize (Zea mays L.) grown alone or in combination with cowpea (Vigna unguiculata L.). American-Euroasian J. Agric. & Environ. Sci., 7(1): 43-47.

Roychowdhury D., Mondal S. and Kumar Banerjee S. 2017. The Effect of Biofertilizers and the Effect of Vermicompost on the Cultivation and Productivity of Maize - A Review. International Advances in Crop Science and Technology 2017, 5:1 DOI: 10.4172/2329-8863.1000261

Saeid Hokmalipour R.S., e-Ashenaee, Mohammad Hasanzadeh, Mir Naser Seiedi and Manochehr Shiri-e-Janagard, Maryam Hamele Darbandi, Fariborz Peyghami 2010. Comparison of Agronomical Nitrogen Use Efficiency in Three Cultivars of Corn as Affected by Nitrogen Fertilizer Levels. World Applied Sciences Journal 8 (10): 1168-1174, 2010

Saeed, M., A. Khaliq, Z.A. Cheema and A.M. Ranjha, 2010. Effect of nitrogen levels and weed-crop competition durations on yield and yield components of maize. J. Agric. Res., 48(4): 471-481.

Sani B. 2012. Energy Efficiency Management (EEM) by Use of Nanoparticles in Maize Seedling Growth. Pelagia Research Library European Journal of Experimental Biology, 2 (5):1918-1921

Sharar, M.S., M. Ayub, M.A. Nadeem and N. Ahmad, 2003. Effect of different rates of nitrogen and phosphorus on growth and grain yield of maize. Asian J. Pl. Sci., 2(3): 347-349

Sabir S., Arshad M., and Khalil Chaudhari S. 2014. Zinc Oxide Nanoparticles for Revolutionizing Agriculture: Synthesis and Applications. Hindawi entific World Journal Volume

Soleimanzadeh H. and Ghooshchi F. 2013. Response of growth and yield of maize to biofertilizers in organic and conventional cropping systems. International Journal of Agriculture and Crop Sciences

Soro D., Ayolié K., Gohi Bi Zro F., Yao Yéboua F., Konan-Kan Kouadio H., BakayokoS., Téhua Angui P. and Yatty Kouadio J. 2015. Impact of Organic Fertilization on Maize (Zea mays L.) Production in a Ferralitic Soil of Centre – West CÔTE D'IVOIRE. Journal of Experimental Biology and Agricultural Sciences, December - 2015; Volume – 3(6)

Subbaiah, B.V and Asija, G.L. 1956. A rapid procedure for determination of available nitrogen in soils. Current Science. 25: 259-260

Suriyaprabha R., Karunakaran G., Yuvakkumar R., Prabu P., Rajendran V., Kannan N. 2012. Growth and physiological responses of maize (Zea mays L.)to porous silica nanoparticles in soil. J Nanopart Res 14:1294 DOI 10.1007/s11051-012-1294-

Syed Sheraz Mahdi 2008. Response of fodder maize (Zea mays L.) to levels of nitrogen, zinc and seed rate under temperate conditions.

Szulc P. 2013. The Effects of Soil Supplementation with Different Nitrogen Fertilizers on Select Fertilization Indices in Two Types of Maize Hybrids (Zea mays L.) and on Mineral Nitrogen (Nmin) Contents in Soil. Pol. J. Environ. Stud. Vol. 22, No. 4 (2013), 1185-1195

Szulc P., Piechota T., Jagła M., Kowalski M. 2015. A comparative analysis of growth in maize (Zea mays L.) hybrids of different genetic profiles depending on type of nitrogen fertilizer and magnesium dose. INTERNATIONAL JOURNAL OF THE FACULTY OF AGRICULTURE AND BIOLOGY, WARSAW UNIVERSITY OF LIFE SCIENCES – SGGW, POLAND

Szulc P.,Bocianowski J. 2012. Effects of application of different nitrogen fertilizer forms and magnesium on dynamics of dry matter accumulation in two maize (Zea mays L.) hybrids in their early growth stages. Polish Journal of Agronomy 2012, 11, 65–80

Taheri M., Ataiei Qarache H., Ataei Qarache A., and Yoosefi M. 2015. The Effects of Zinc-Oxide Nanoparticles on Growth Parameters of Corn (SC704) 10.17975/sfj-2015-011

Ullah, M.I., A.A. Khakwani, M. Sadiq, I. Awan, M. Munir and Ghazanfarullah, 2015. Effects of nitrogen fertization rate on growth, quality and economic return of fodder maize (Zea mays L.). Sarhad J. agric., 31(1): 45-52.

Umesha S., Srikantaiah M, Prasanna K.S, Sreeramulu K.R., Divya M. and Lakshmipathi R.N 2014. Comparative Effect of Organics and Biofertilizers on Growth and Yield of Maize (Zea mays. L). Current Agriculture Research Journal Vol. 2(1), 55-62

Varghese K., Ghosh G. 2006 Comparative Study of Maize Cultivars (Zea Mays L.) with Intercrop (Vigna Mungo L.) under Two Levels of Fertilizers. Agric. Sci. Digest , 26 (1) : 75 - 76

Walkley, A and Black, C.A. 1934. An estimation of degtjareff method for determining soil organic matter and proposed modification of chromic acid titration method. Soil Science. 37: 29-37.

Wisdom G.O S., Ndana R.W. and Abdulrahim Y. 2012. The Comparative study of the effect of organic manure cow dung and inorganic fertilizer N.P.K on the growth rate of maize (Zea Mays L). International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 2(12) pp. 516519

Woldesenbet M., Haileyesu A. 2016. Effect of Nitrogen Fertilizer on Growth, Yield and Yield Components of Maize (Zea Mays L.) in Decha District, South Western Ethiopia. International Journal of Research Woldesenbet Vol.4 (Iss.2)

Y. Hosseiny and M. Maftoun 2008. Effects of Nitrogen Levels, Nitrogen Sources and Zinc Rates on the Growth and Mineral Composition of Lowland Rice J. Agric. Sci. Technol. (2008) Vol. 10: 307-316

Appendices

Appendix-1

Calendar of Operations

Proposed Plan of Work (Calendar of Work Done)

Sr.No	Operation	Rabi 2016-2017
1.	Land Preparation a. Ploughing of field with cultivator b. Layout of the field experiment c. Formation of ridges	 14.9.2016 16.9.2016 18.9.2016
2.	Sowing, irrigation and basal application of fertilizers as per the treatment	23.9.2016
3.	Pre emergence application of herbicide	24.9.2016
4.	Thinning and gap filling of the field	1.10.2016
5.	Irrigation Second Irrigation Third Irrigation	6.10.2016 10.11.2016 21.11.2016
6.	Weeding a. First weeding b. Second Weeding	 27.10.2016 12.11.2016
7.	Harvesting	2.1.2017
8.	Threshing	6.1.2017,7.1.2017 and 8.1.2017

Appendix 2

Weather Condition during Crop Growth

Monthly air temperature and total precipitation from September 2016-December 2016

Months	Temperature (^0C)			Precipitation
	Maximum	Minimum	Average	(mm)
September	34^0C	28^0C	22^0C	90mm
October	31^0C	23^0C	15^0C	62mm
November	26^0C	18^0C	9^0C	0mm
December	21^0C	13^0C	6^0C	31mm

(Source: www.accuweather.com)