EFFECT OF DIFFERENT LEVEL OF FERTILIZER COMBINATION AND SPACING ON THE YIELD OF WHITE MAIZE

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF DIFFERENT LEVEL OF FERTILIZER COMBINATION AND SPACING ON THE YIELD OF WHITE MAIZE"** *submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***ABUL HASAN RAZU,*** *Registration No. 11-04434 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

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EFFECT OF DIFFERENT LEVEL OF FERTILIZER COMBINATION AND SPACING ON THE YIELD OF WHITE MAIZE

ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during Kharif-2 season from June 2016 to October 2016 to study the effect of different level of fertilizer combination and spacing on the yield of white maize. The experiment comprised of two factors, Factor A: Different fertilizer doses i.e. F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; and four level of spacing i.e. S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25cm. The experiment was conducted following split plot design with three replications. Result revealed that, the highest plant height was observed in F_4 (268.55 cm) and S_2 (263.48 cm). Number of cobs plant^{-1} (2.33 and 2.08), cob length (18.61 cm and 17.62 cm), cob diameter (14.28 cm and 13.51 cm), number of rows cob^{-1} (13.15 and 12.84), number of seeds row^{-1} (32.02 and 28.96), number of seeds cob^{-1} (369.42 and 339.44), 1000 seeds weight (288.79 g and 276.41 g), and cob yield (8338.5 kg ha^{-1} and 7697.2 kg ha^{-1}) were highest in F_5 fertilizer and S_3 spacing. The combined effect of F_5 fertilizer and S_3 spacing on growth and yield of white maize indicated that the positive indication of using 25% more than recommended doses of fertilizer and 70 cm× 25cm spacing.

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AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agriculture Extension
DAS	Days after sowing
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
mg	Milligram
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world agricultural economy both as food for human and feed for animals. This cereal crop belongs to the family Poaceae. It has very high yield potential, there is no cereal on the earth which has so immense potentiality and that is why it is called “Queen of cereals”. It ranks 1st in respect of yield per unit area, 2nd in respect total production and 3rd after wheat and rice in respect of acreage in cereal crops. Maize grain contains 70% carbohydrate, 10% protein, 4% oil, 10.4% albumin, 2.3% crude fiber, 1.4% ash. Its world average yield is 27.8 q\ha maize ranks first among the cereals and is followed by rice, wheat, and millets, with average grain yield of 22.5, 16.3 and 6.6 q/ha respectively (Nasim *et al*., 2012). There are two types of white maize named Dent maize and Flint maize. They are largely associated with certain types of food products and dishes. Dent maize is soft and floury and is primarily used for making soups and porridges. The flint maize has a hard, vitreous endosperm, is primarily used for gruel or for a type of couscous which replaces rice or couscous from wheat in several countries of Africa. Recently white maize is becoming popular very rapidly as soup, pakora, chutney, cutlets chat, dry vegetable, kofta curry, masala, manchurian, chilly, raita, pickle, candy, jam, murabba, burfi, halwa, kheer, laddo and other favorite dishes for different Chinese hotels and restaurants in Bangladesh (Ahmed, 1994). Moreover stover, dry leaves and cob covering can be used as good fuel (Ahmed, 1994). Foreign exchange can be earned by exporting maize and its products.

Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties whose yield potentials are 5.5–7.0 t/ha and 7.4–12.0 t/ha, respectively, which are well above the world average of 3.19 t/ha (Nasim *et al*., 2012). Growth and yield of maize are affected by cultural management practices especially fertilizer application.

Appropriate fertilizer use leads to increased crop yields and high crop recovery of the applied nutrients. Some elements may be hazardous to the environment if used in various forms, i.e. nitrates and phosphates (Okalebo, 1987). Efficient fertilization is therefore important in ensuring crops attain maturity within specific growing seasons (Okalebo, 1987). Effectiveness of phosphorus fertilizers therefore depends on the chemical and physical properties, rate and method of application, soil and climatic conditions and the crop species grown (Mokwunye and Bationo, 2002). In recent years, there has been an increased use of high nutrient fertilizers, mainly for economic reasons. Examples of fertilizers used include diammonium phosphate (DAP), triple super phosphate (TSP) and Minjingu rock phosphate (MRP) fertilizers (Smalling *et al*., 1997). Several drawbacks have, however, been reported in the use of DAP. This includes young crops that have shown injury (Okalebo, 1987), low availability of soil magnesium, calcium and potassium ions by forming insoluble compounds (Wapakala, 1976). It is therefore, necessary to evaluate the influence of rate of phosphorus fertilizer application and how different fertilizers affect growth and yields of plants in a given area to allow the appropriate allocation of fertilizers to suit varying agricultural conditions (Russell, 1988). Maize nutrient (nitrogen, phosphorus, potassium, calcium and magnesium) uptake, use efficiency and yields in Nyanza Province have been on the decline. This may be associated with inefficiency of the fertilizers and manure currently applied and/or nutrient depletion. Lack of suitable fertilizer application rates and soil acidity could also result in the decline since the current research recommendations were developed more than two decades ago. The extent of nutrient depletion is unknown and phosphate fertilizer and manure application by farmers is not commensurate with the plant requirements and/or nutrient levels in the soil. Twenty years have elapsed since the last fertilizer use recommendation project was carried out in Kisii and Homabay counties in 1987 (FURP, 1994). Declining yields of maize, which accounts for a significant proportion of the food diet for smallholder mixed farms of Kisii and Homabay counties, have raised concerns about food insecurity. There is, therefore, a need to carry out determination of the nutrient use efficiency and residual value of phosphorus (P) upon application of different phosphate fertilizers and manure and their effects on acidic soils of smallholder mixed farms. There is a need for appropriate recommendations that can be used by smallholder resource poor farmers and extension agents.

Maximum and minimum nitrogen content differed in plants and also in different parts of the individual plant. The amount of nitrogen is generally much higher in leaves than in stems, leaf sheaths and roots, and it changes with plant age. More than a minimum level of nitrogen supply is necessary for N from vegetative parts to contribute to the formation of seed protein. Variation of plant density greatly affected the yield of maize. The closer plant spacing gave significantly the highest yield of cob. Increasing of plant spacing decreased the yield of cob

(Ahmed, 1994). Researchers have been conducted several researches on spacing and fertilizer doses of maize but white maize is a new introduction in our country. Very few or no research finding are available in our country on white maize. The appropriate recommendations of the proper rate and method of application of fertilizers in different soils and climatic conditions may help to check this decline and to improve food security in Bangladesh.

So, there is a wide scope to taken research on spacing and fertilizer doses of white maize. This study will help to evaluate the effect of different levels of fertilizer and different plant spacing on yield potential of white maize production.

Objectives of the Research work:

1. To find out suitable fertilizer doses on growth and yield of white maize.
2. To select suitable spacing for the cultivation of white maize, and
3. To find out suitable combination of fertilizer doses and spacing for higher productivity of white maize.

CHAPTER II

REVIEW OF LITERATURE

Maize is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. Specially, white maize used as human foods where yellow maize for cattle and poultry feeds. The growth and yield of maize are largely controlled by the environmental variables notably moisture regimes, temperature and varieties. The growth and yield also influenced by fertilizer management and agronomic practice. Research works have been done by various workers in many parts of the globe to study the effect of different level of fertilizer combination and spacing on the yield of white maize. The thinking has received much attention by the researchers on various aspects of its production and utilization for different consumers uses. Many studies on the growth and yield have been carried out in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings so far been done at home and abroad on this aspect have been reviewed in this chapter under the following headings:

2.1 Effect of fertilizer

Abebe and Feyisa (2017) reported that, despite the fact that maize productivity is relatively better than other major cereal crops, its current productivity is still far below its potential productivity. N rate and time of application are among the major abiotic factors limiting the productivity of the crop. Because of such gaps, the experiment was conducted at Bako Agricultural Research Center in 2013 and 2014 cropping seasons to determine optimum N rate and time of application. Four levels of N rates (46, 69, 92, and 115 N kg ha^{-1}) and four levels (T_1, T_2, T_3 and T_4) of different time of N application were arranged in factorial combinations. Moreover, previously recommended N and the control were arranged in a randomized complete block design with three replications. In 2013, the highest significant biomass yield (21.2 tha^{-1}) was obtained at 115 N kg ha^{-1} and T_4 followed by 69 N kg ha^{-1} at T_1 and T_2 and 92 N kg ha−1 at T_2. In contrast, the highest grain yield in 2013 was obtained at 92 N kg ha^{-1} at followed by 115 N kg ha^{-1} at either T_2 or T_4 and 69 N kg ha^{-1} at either T_1 or T_3 application time. Interestingly, a significant yield increases by 37% was obtained when 92 N kg ha^{-1} at the time of T_1 was applied compared to previous recommended 110 N kg ha^{-1} rate and time of application. In 2014, however, the highest yield was recorded when 92 N kg ha^{-1} at T_1 was used. Application of 46 N kg ha^{-1} at T_2 showed statistically similar yield performance when compared with previous N recommendation. The lowest yield was recorded from the control plot in both years. In 2013, the maximum net profit and acceptable marginal rate of return (MMR) were obtained when 92 N kg ha^{-1} was used for maize production during erratic and heavy rainfall distribution, particularly at a time of N application. However, the maximum net benefit (30743 ETB ha^{-1}) and acceptable MRR could be obtained when 92 N kg ha^{-1} was used if the rainfall amount and distribution are relatively uniform. In conclusion, application of 92 N kg ha^{-1} (10–15 DAP and 35–40 DAP) is the best N rate and time of application in good rainy seasons and hence recommended for the end users. However, in the case of erratic and heavy rainy seasons, application of $92\,\mathrm{N\,kg\,ha^{-1}}$ at three times application regimes (1/3 N at 10–15 days after planting (DAP), 1/3 N at 35–40 DAP and 55–60 DAP) should be used to get maximum profit and acceptable MRR.

Liverpool-Tasie *et al*. (2017) stated that, inorganic fertilizer use across Sub-Saharan Africa is generally considered to be low. Yet, the notion that fertilizer use is too low is predicated on the assumption that it is profitable to use rates higher than currently observed. There is, however, limited empirical evidence to support this. Using a nationally representative panel dataset, this paper empirically estimates the profitability of fertilizer use for maize production in Nigeria. We find that fertilizer use in Nigeria is not as low as conventional wisdom suggests. Low marginal physical product and high transportation costs significantly reduce the profitability of fertilizer use. Apart from reduced transportation costs, other constraints such as soil quality, timely access to the product, and availability of complementary inputs such as improved seeds, irrigation and credit, as well as good management practices are also necessary for sustained agricultural productivity improvements.

Woldesenbet and Haileyesus (2016) reported that, maize response to high nitrogenous fertilization levels is a means among other means to know maximum productivity, from this perspective, a field nitrogen management trial using five N levels (0, 23, 46, 69 and 92 kg N/ha) with three replications. The study was conducted in 2015 in Decha District, Modyo Gombera Kebele, Kaffa Zone of SNNPR State. The experiment was laid out in RCBD. The result of this study indicated that effects of different rates of N fertilizer had influenced the growth and yield components of maize. The tallest plant (360.66 cm) was recorded from the application of 92 kg N ha^{-1} and the shortest (347.33 cm) from no N application. The ANOVA for the number of kernels per ear showed that the lowest kernels per ear (497.86) were obtained from no N application and the highest kernels per ear (588) were obtained from the application of 92 kg N ha-1 although there was no significant difference between the application of 69 and 92 kg N ha^{-1}. Regarding to ear length the data showed that the longest ear (23.63 cm) was obtained from the application of 92 kg N ha^{-1}. The effect of N on grain yield indicated that there is no significant difference between the application of 69 and 92 kg N ha^{-1} even if there is a slight difference on yield. Generally, maximum N fertilization level (92 Kg N/ha) in this study area showed increase in growth and yield components (number of kernels per ear and ear length). However, the application of 69 kg N ha^{-1} seems adequate to get the optimum yield.

Maqbool *et al*. (2016) was conducted a field experiment for two consecutive years to study the effect of fertilizer application methods and inter and intra-row weed-crop competition durations on density and biomass of different weeds and growth, grain yield and yield components of maize. The experimental treatments comprised of two fertilizer application methods (side placement and below seed placement) and inter and intra-row weed-crop competition durations each for 15, 30, 45, and 60 days after emergence, as well as through the crop growing period.

Fertilizer application method didn't affect weed density, biomass, and grain yield of maize. Below seed fertilizer placement generally resulted in less mean weed dry weight and more crop leaf area index, growth rate, grain weight per cob and 1000 grain weight. Minimum number of weeds and dry weight were recorded in inter-row or intra-row weed-crop competition for 15 DAE. Number of cobs per plant, grain weight per cob, 1000 grain weight and grain yield decreased with an increase in both inter-row and intra-row weed-crop competition durations. Maximum mean grain yield of 6.35 and 6.33 tha^{-1}were recorded in inter-row and intra-row weed competition for 15 DAE, respectively.

Jolokhava *et al*. (2016) reported that, maize remains to be the most important cereal crop in Georgia. Total area of arable land under cereal crops production equals to 184 thousands hectares (FAO statistical yearbook, 2014), from which maize takes the biggest share. Leading position of maize among other cereal crops is caused by its dual purpose as food and feed product. In Spite of a relatively high production of maize to other cereals there is still a high demand on it, especially as feed for animal husbandry. The same tendency is seen in organic production, where producers of livestock and poultry products require organically grown maize, the average yield of which is much less than those produced conventionally. Therefore, it is important to increase productivity of maize in organic farms. Current study aimed to improve maize yield using locally produced organic fertilizers and to compare them to the effect of mineral fertilizers. The study was carried out in Eastern Georgia under dry subtropical climate conditions on local hybrid of maize. This is the first attempt to use hybrid maize (developed with organic plant breeding method) in organic field trials in Georgia. The results shown, that grain yield from two different types of organic fertilizers reached 70% of the yields achieved with industrial mineral fertilizers. As on farm level differences between organic and conventional maize production are much severe, the results from the field trials seems to be promising for future improvement of organic cereal crop production.

Dong *et al*. (2016) stated that, slow or controlled release fertilizers have been researched and used more and more widely, developing new slow or controlled release fertilizers is very important. To improve the use efficiency of inorganic fertilizers through the use of coated fertilizer and nitrification inhibitors, 3 newly developed fertilizers (FCRF1: coated fertilizer + 1% DCD, FCRF2: coated fertilizer + 2% DCD and FCRF3:coated fertilizer + 4% DCD) amended with nitrification inhibitors (DCD, $C_2H_4N_4$), and coated with fly ash were prepared by coating conventional compound fertilizer (N-P-K: 15-6.55-12.4). Using a coated fertilizer (resin coated compound fertilizer, N-P-K: 15-6.55-12.4, 90 day, CRF) made in China and a conventional compound fertilizer (CCF) as checks, their effects on physiological characteristics, yield and quality of maize were examined in a field experiment. The results indicated that, compared to CCF, 3 new developed fertilizers kept higher ammonium nitrogen （NH_4^+-N） and nitrate nitrogen (NO_3^--N) content at later stages and FCRF3 had the highest content, being similar to CRF treatment. At tasselling stage (TS) and filling stage (FS), the chlorophyll content, photosynthetic rate, transpiration rate and chlorophyll fluorescence parameters were significantly increased upon

FCRF1, FCRF2 and FCRF3 treatments. In addition, FCRF1, FCRF2 and FCRF3 treatments produced 24.0-35.8% more grain yield, 57.2%-74.4% more total yield, increased 11.20%-49.55% starch, 61.38%-113% protein and 2.67%-9.33% Vitamine C content than CCF, respectively. This product with excellent slow release capacity, being easy to get at a low price and environment-friendly, could be especially useful in agricultural application.

Admas *et al*. (2015) reported that, maize (*Zea mays* L.) is one of the most important staple food crops in Ethiopia although its yield is low. Intensive cultivation causes plant nutrient depletion and yield decline. The objective of this experiment was, therefore, to investigate the effects of combinedd application of organic and inorganic fertilizers on yield and yield components and nutrient contents of maize. Field experiments were conducted on Nitisols (acidic soils) for two consecutive cropping seasons at Wujiraba watershed, northwestern highlands of Ethiopia. The experiments were laid down in RCBD as factorial combinations of three levels of N (0, 60 and 120 kg N ha^{-1}), compost (0, 5 and 10 tn compost ha^{-1}) and S (0, 15 and 30 kg S ha^{-1}) fertilizers which were replicated three times. In this experiment, significant ($p \leq 0.05$) differences were observed on maize grain yield, total above ground dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N and S concentration of leaves and grains by such fertilizers combinations. The highest mean grain yield, dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N concentration in leaf and grain (7.9, 22.4 t ha^{-1}, 2.52 m, 486, 0.44 g, 492 g, 3.25 and 1.4%) were observed in plots treated with fertilizer combinations of 120 kg N ha^{-1}, 10 t compost ha^{-1}and 15 kg S ha^{-1}, respectively. From this study it is possible to infer that integrated application of organic and inorganic fertilizers increased crop yields. Hence, incorporation of compost with inorganic N and S fertilizers for maize enhanced grain yield by adding nutrients.

Ademba *et al*. (2015) stated that, phosphorus, nitrogen and *Striga hermonthica* are the major constraints to maize production in the Nyanza Province of Kenya. Field trials were conducted on-farm in Nyanza Province to investigate the effects of phosphate fertilizers and manure on maize yields. The experimental design was a Randomized Complete Block Design (RCBD) with maize as the test crop. The maize was top dressed with calcium ammonium nitrate (CAN) fertilizer at a uniform rate of 30 kg N/ha diammonium phosphate (DAP), Minjingu rock phosphate (MRP) and triple super phosphate (TSP) fertilizers were applied at 60 kg/ha P_2O_5, farmyard manure (FYM) at 10 t/ha and a non-phosphorus (P) treatment (control) plus lime only. Responses ($P \leq 0.01$) from grain yield, total dry matter yield and harvest index to phosphate fertilizers and manure treatments were found. Nutrient uptake and removal by the crop increased ($P \leq 0.01$) due to fertilizers and manure application. Phosphate fertilizers and manure application increased ($P \leq 0.01$)) available soil P, agronomic phosphorus use efficiency (APUE) and Physiological P use efficiency (PPUE). The results indicate that phosphate fertilizers and manure applications are essential to improve maize yield and nutrient P use efficiency.

Soro *et al*. (2015) reported that, importance of Corn's (*Zea mays* L.) crop is justified by its nutritious content especially because of the presence of high protein, minerals, vitamins and other energetic nutrients. In Côte d'Ivoire, maize production is insufficient and various strategies have been developed to improve its production. Present study was conducted in a ferralitic soil at the UJLoG's research station to evaluate the effect of two different ages (storage time) of chicken manure on growth and yield of GMRP-18 (an improved corn variety) and Bon-maïs (used for popcorn) varieties. Single doses of poultry manure at the rate of 7 t/ha was used in combination with 70 kg/ha. Various growth traits like germination rate, height, diameter, number of leaf, ear insertion level, number of ear per plant and yield have been evaluated. Results of study revealed positive impact of the manure on the growth and development of corn crops and highlighted the possibility of improving corn productivity in Daloa region by using poultry manure. Furthermore, higher plants growth was reported under the influence of fertilizer as compared to controls. Final yield is significantly enhanced by the contribution of manure and highest yield was reported on the six days wind stored poultry manure applied at the rate of 7 t. ha^{-1}.

Rudnick and Irmak (2014) stated that, one of the common methods for estimating actual evapotranspiration (ETa) is the two-step approach, which relates crop-specific crop coefficients (Kc) to a reference surface ET, typically alfalfa or grass (ETr and ETo, respectively). Minimal, if any, study has reported Kc values for water, nutrient, and both water and nutrient deficiencies. In this study, alfalfa (Kcr) and grass (Kco) reference maize (*Zea mays L.*) Kc values were developed as a function of growing degree days (GDDs) for 0, 84, 140, 196, and 252 kg ha−1252 kg ha−1 nitrogen (N) treatments under fully irrigated

(FIT), limited irrigation (75% FIT), and rainfed conditions at the University of Nebraska-Lincoln South Central Agricultural Laboratory (SCAL) near Clay Center, Nebraska, for the 2011 and 2012 growing seasons. The research also investigated a stress factor (Kstress) to assess the reduction in crop water use as compared with a nonlimiting water and N treatment (reference). In 2011, maximum Kcr values ranged from 0.95 to 1.27 and occurred between GDD values of 995 and 1,163°C (late July to early August), which corresponded to the R1 to R3 growth stages, whereas in 2012 (much drier), maximum Kcr values ranged from 0.84 to 1.19 for 75% FIT and FIT and existed between GDD values of 1,111 and 1,267°C (R2 to R4 growth stages). On average, greater Kcr values existed at higher N rates (e.g., 196 and 252 kg N ha−1252 kg N ha^{-1}) compared with lower N rates. Lower N treatments typically reached their maximum Kcr value earlier in the growing season and began to decrease towards harvest. Rainfed and 75% FIT experienced a greater reduction in Kstress as compared with FIT as well as lower N rate treatments as compared with higher N treatments. A water stress factor (Kw) was calculated to determine the portion of Kstress attributed with water stress alone. The monthly average values often experienced lower Kstress compared with Kw values, indicating that Kw alone was unable to account for the total reduction in Kcr from a nonlimiting water and N reference. Thus, an N stress factor (Kn) was also quantified by assuming Kstress was the product of water and N stress (e.g., Kstress=Kw×KnKstress=Kw×Kn). The seasonal average Kn was 1.15 in 2011 and 0.64 in 2012. Values of Kn were always lower in the drier year in 2012 than in 2011, ranging from 0.45 towards the end of the season in 2012 to a maximum of 1.27 in August 2011. In general, Kn decreased as N rate decreased and Kn had a decreasing trend (e.g., greater N stress) throughout the growing season, especially in the drier year in 2012. The reduction in Kn over time was due to the temporal reduction in readily available N as well as compounding effects of reduced N on plant growth and consequently crop water uptake over the growing season.

Hill (2014) reported that, current maize yields in Ghana average only one-third of their estimated potential, but this yield gap can be reduced by improving farming practices and growing conditions in Ghana; specifically, yields in Ghana can likely be increased by intensifying the use of fertilizer, other inputs, and irrigation systems. Recently, Ghana introduced a fertilizer subsidy program to help increase fertilizer-use rates, however, little work has been done to examine the effectiveness of this program, or to determine the viability of using fertilizer to increase yields in Ghana. This paper (1) determines the marginal effects of inorganic fertilizer on maize output using OLS and quantile regressions, (2) determines the profitability of fertilizer at the subsidized and unsubsidized prices using the value-cost ratio, and (3) examines alternate instruments for increasing fertilizer use using a linear probability model. I find that fertilizer use has a positive and significant effect on maize yields in all models that I consider; despite this positive correlation, however, I find that fertilizer is not sufficiently profitable for the average Ghanaian farmer to incentivize additional application. Finally, I find that the farmer's distance from the closest weekly market, whether the farmer has a pre-harvest contract, and whether the farmer has property rights on the field have significant correlations with fertilizer use.

Crista *et al*. (2014) stated that, the main purpose of the research undertaken to develop this work was the impact of chemical fertilization on maize yield in the experimental field of SDE Timisoara. Fertilizers make their best contribution to the enhancement only if it falls within a hierarchical system of good technological measures and the doses used are related to crop plants, soil, climate, and culture technology. The fertilization system influenced the maize harvest, leading to the production of 9034 kg of maize / ha. In recent years, the amount of fertilizer used has remained relatively constant while average yields have steadily increased. Because of the complex nature of soil and weather variability, farmers face significant challenges in optimizing the amount of nitrogen to apply to each field, year and area within a field. This results in under-application of nitrogen in some years and fields, with resulting yield losses, and over application of nitrogen in other years and field areas resulting in inefficient use of nitrogen resources.

Nasim *et al*. (2012) reported that, organic agriculture combined tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Furthermore, maize (*Zea mays* L.) crop is the 3rd cereal crop of Pakistan after wheat and rice. According to the economic survey of Pakistan, it is cultivated on the area of approximately, 1.11 million hectare and production from this area was 4.04 million tones. A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad-Pakistan to examine the effect of organic and inorganic fertilization on maize productivity. The experiment was laid out in Randomized Complete Block Design (RCBD), with four replications. Two maize hybrids were used in this experiment. The results showed that maize yield and its component such as cobs per plant, cob length, number of grains per cob, 1000 - grain weight were maximum when the plots were fertilized at 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure. Further research is desired to investigate maximum yield by using organic source of fertilizer than inorganic source of fertilizer to avoid lethal effects on human health created by inorganic fertilizers.

Amin (2011) was conducted a field experiment for two consecutive seasons in 2004/2005 and 2005/2006 at the demonstration farm of the Faculty of Agriculture, Omdurman Islamic University, Sudan, to investigate the effect of different nitrogen sources on growth, yield and quality of fodder maize (*Zea mays* L.). The nitrogen sources are urea, nitrophoska (NPK), ammonium sulphate nitrate (ASN) and ammonium sulphate (AS). The design used was completely randomized block design with four replicates. The growth attributes measured, were plant height, stem diameter, number of leaves, leaf area, leaf area index. Number of days to 50% tasseling, forage yield, crude protein and crude fiber were also investigated in this study. The results revealed that nitrogen sources significantly affected growth parameters at all sampling occasions during the two seasons. Remarkable results noticed at nitrogen sources ASN flowed by NPK and the AS, as compared with urea. The results showed that, the number of the days for 50% tasseling, fresh forage yield and dry forage yield were significantly affected by nitrogen sources during two seasons. Moreover, dry and fresh forage yield, increased progressively by ASN and NPK as compared with other nitrogen sources. The present data revealed that, the crude protein and crude fiber were significantly affected by nitrogen sources in both seasons. The urea gave the lowest crude protein compared with the other nitrogen sources. On the other hand, the lowest crude fiber content was recorded when plant was treated with (ASN) fertilizer, while the highest crude fiber content was recorded only under the control.

Orosz *et al*. (2009) stated that, in our experiment we tried to find out what kind of eventual changes in the environment and in plant chemical composition occurred in response to different fertilizer treatments applied to sweet corn (*Zea mays convar. saccharata*) grown on sandy soil with low humus content. The ploughed layer contained <1% CaCO3 and around 1% humus. The soil was very well supplied with P, well supplied with K, Mg, Mn and Cu, and weakly supplied with N and Ca. The treatments were planned in accordance with the recommendations, with a planned unhusked ear yield of 16 tons per hectare, of the new environmental friendly advisory system recently elaborated for field vegetable crops in Hungary. The treatments applied included: G1 (blank control) (N0P0K0), G2(N222.5P22.2K143), G3(N445 P22.5 K143), G4(N222.5 P22.5K143), G5(N222.5P22.5 K286), G6(N222.5 P22.5 K143) + Mg (1.52). According to our findings, of the composition parameters of the grains of the treatments with no fertilizer application, the invert and reducing sugar contents (4.42%, respectively

2.59% relative to fresh weight^{-1}) in grains were the highest among the treatments.The same conclusion was drawn on the K 120.2, Mg 13.3, Fe 0.24, Cu 0.66 mg 100 g^{-1}) grain dry weight levels among minerals. In the case of the basic treatment (G2) recommended by the advisory system we obtained favourable results for the measured parameters, including yields. Invert and reducing sugar contents were (3.26% respectively 1.97% relative to fresh weight^{-1}), and mineral contents K 101.9; Mg 11.8; Fe 0.21; Cu 0.56 mg 100 g^{-1}) dry weight. In the grains, no translocation of toxic elements was observed in response to the direct or indirect effect of the treatments.

Mugwira *et al*. (2007) reported that, the use of manure and fertilizer to increase maize yield is a common practice in the smallholder-farming sector of Zimbabwe. In this study the effects of manure and fertilizer on maize growth, yield, and nutrient uptake were evaluated at Grasslands Research Station and at Matiza in Chihota communal area from 1983/84 to 1988/89 as a part of a wider project on sandveld soils in Zimbabwe. Comparisons were made between 15 t ha^{-1}of manure applied biannually and annual applications of 150 and

300 kg ha^{-1} of Compound D (8% N, 14% P_2O_5, 7% K_2O, and 6.5% S) fertilizer. Feedlot manure applied at Grasslands increased grain yield by a seasonal average of 16% compared with 8–9% for the fertilizer additions; the residual effects of manure being about the same as the direct effects. At Matiza, three direct applications of smallholder area manure resulted in a mean yield increment of 59% while the fertilizer treatments enhanced yield by 34–63%; but there was little residual effect (10%) of manure. Increase in nutrient contents of young plants and cob-leaves due to manuring at Grasslands indicated that the three

feed lot manures applied, which had nitrogen:phosphorus:potassium (NPK) ratios of 5:1:3, 4:1:4 and 5:1:2 acted primarily as NPK fertilizers between 1984/85 and 1988/89. In the late growth stages, such as at tasseling, these manures were also good sources of magnesium (Mg). The smallholder area manures applied at Matiza acted principally as K fertilizers when NPK ratios were 7:1:7 (1983/84 to 1994/85) and 11:1:9 (1987/88 to 1988/89), but acted as NPK fertilizers when NPK ratio was 4:1:4 (1985/86). Feedlot manure was effective in correcting deficient or low N, P, or Mg status at Grasslands, but both manure and fertilizer did not effectively influence the assessed poor status of these nutrients at Matiza. Low NPK ratios of feedlot manures indicated greater potential for correcting the imbalance of P relative to N and K. Over the six seasons, increments in grain yield were in the order of 15 t ha^{-1} manure >300 kg ha^{-1} = 150 kg ha^{-1} fertilizer at Grasslands and 300 kg ha^{-1}>150 kg ha^{-1} and 15 t ha^{-1} at Matiza. The results reported. The results reported here were originally submitted to a local journal, which became defunct before publishing these data.

Silwana *et al*. (2007) stated that, previous studies have shown that black small-scale farmers in the Eastern Cape Region of South Africa paid high premium to intercropping of maize with Phaseolus beans in their farming system. As part of the effort to evolve proven agronomic package for such intercropping, two experiments were carried out between 2000 and 2002. Experiment 1 which was carried out between 2000 and 2001 was with two factors (a) four fertilizer combinations (organic kraal manure 0, 50 and 100 t/ha and NPK 300 kg/ha) and

(b) three crop combinations (sole maize at 40,000 plants/ha, sole beans at 175,439 plants/ha and maize/bean intercrop at 75% maize and 25% bean). The trial was a factorial experiment laid out in a randomized complete block design with three replications. This experiment was repeated during the next season without fertilizer treatments as Experiment 2. Fertilization, whether organic or inorganic, was found to enhance morphological parameters for both maize and Phaseolus bean when grown sole or intercropped. Kraal manure (100 t/ha) and NPK fertilizer (300 kg/ha) gave significantly higher total dry matter yields than the control treatment in sole maize and sole beans by 34 and 33% respectively. Intercropped maize and bean grown with kraal manure at 100 t/ha gave higher total dry matter yields than intercropped maize and bean grown without fertilizer by 24 and 45% respectively. Optimum grain yields were obtained at 300 kg/ha NPK (10.8 t/ha) for sole maize and at 50 t/ha kraal manure (8.0 t/ha) for intercropped maize and these yields were higher than those of control by 46 and 45% respectively. As for the sole bean, optimum seed yields were obtained at 50 t/ha kraal manure (3.2 t/ha) while 100 t/ha kraal manure gave optimum yield for intercropped bean (0.98 t/ha). These values were higher than the values obtained under the control treatment by 13 and 49% respectively. Grain yields of sole and intercropped maize in plots previously applied with organic manure (100 t/ha) had 40 and 83% increase in the second year while maize previously fertilized with inorganic fertilizer (NPK) had grain yield reduction of 5 and 50% for sole and intercropped maize respectively. The same trend was observed for the yields of beans. The importance of organic manure and its long time usefulness in

Increasing productivity of maize/bean intercrop for small-scale farmers in Eastern Cape of South Africa was highlighted by the study.

Mucheru-Muna *et al* (2007) reported that, soil nutrient depletion as a result of continuous cultivation of soils without adequate addition of external inputs is a major challenge in the highlands of Kenya. An experiment was set up in Meru South District, Kenya in 2000 to investigate the effects of different soil-incorporated organic (manure, *Tithonia diversifolia*, *Calliandra calothyrsus*, *Leucaena leucocephala*) and mineral fertilizer inputs on maize yield, and soil chemical properties over seven seasons. On average, tithonia treatments (with or without half recommended rate of mineral fertilizer) gave the highest grain yield (5.5 and 5.4 Mg ha^{-1} respectively) while the control treatment gave the lowest yield (1.5 Mg ha^{-1}). After 2 years of trial implementation, total soil carbon and nitrogen contents were improved with the application of organic residues, and manure in particular improved soil calcium content. Results of the economic analysis indicated that on average across the seven seasons, tithonia with half recommended rate of mineral fertilizer treatment recorded the highest net benefit (USD 787 ha^{-1}) while the control recorded the lowest (USD 272 ha^{-1}). However, returns to labor or benefit-cost ratios were in most cases not significantly improved when organic materials were used.

Xu *et. al* (2006) stated that, analyses of fertilization suggest the following key messages. Households that obtained fertilizer on time and used animal draft power or mechanical power in land preparation are more likely to find fertilizer use profitable than other groups of households located in the same district.

Subsidized fertilizer under government programs in Zambia has often been distributed late.

Adeniyan and Ojeniyi (2005) reported that, the comparative effects of 300kg/ha NPK 15-15-15 fertilizer, 7t/ha poultry manure (Pm), six combinations of reduced levels of NPK 15-15-15 fertilizer and poultry manure, and control (no fertilizer) on maize growth, nutrients uptake and soil chemical properties were investigated for two years at Akure, South West Nigeria. Application of poultry manure, and combination of poultry manure and or NPK fertilizer significantly increased soil chemical composition, maize plant dry matter yield, grain yield, plant height, leaf area and nutrients uptake. The highest grain yields were obtained with combinedd use of NPK fertilizer and poultry manure in 1996 and 1997. The highest values were recorded with combinedd use of 3t/ha poultry manure and 200kg/ha NPK fertilizer with respect to dry matter yield, grain yield and nutrients uptake in both years.

Rasheed *et al*. (2004) was laid out the experiment in randomized complete block design (RCBD) having three replications with net plot of 4.2 x 7.5 m to evaluate the effect of nitrogen and sulfur on growth, yield and quality of double cross hybrid (DCH) maize (Cargil-707). Application of fertilizers at the rate of 150 + 30 and 150 + 20 kg of nitrogen and sulfur per hectare respectively greatly increased dry weight per plant (DWP), plant grains number per ear (GNE) and grain weight per ear (GWE) over other treatments. Similarly, the highest grain yield of 8.59 tons per hectare was recorded from the plot fertilized at the rate of 150 kg N and 30 kg S per hectare, while maximum grain oil content (GOC) and grain protein contents (GPC) were recorded from plot fertilized at the rate of 150 + 30 and 150 + 20 kg N and S per hectare respectively.

2.2 Effect of spacing

Sabo *et al*. (2016) was conducted a field experiment at the Abubakar Tafawa Balewa University teaching and research farm Bauchi state of Nigeria, during the 2013 rainy season, to investigate the effect of variety and intra-row spacing on growth and yield of maize (*Zea mays* L.) in Bauchi state. The Treatments consist of three varieties of corn (DMR, TZEE and QPM) and three intra-rows spacing (20, 25 and 30 cm). The experiment was laid-out in a randomized complete block design, replicated three times. Data was collected on plant height, number of leaves, leaf area, leaf area index, number of cobs per plot, cob length, 100 seeds weight and grain yield. The results obtained showed that varieties differ significantly, in which, DMR significantly produced the highest yield, and followed by QPM and TZEE which are similar in yield performance. Intra-row spacing of 25 cm was observed to be significantly ($p=0.05$) higher than 20 cm and 30 cm spacing in all the characters studied. Based on the results of the study, it may be concluded that DMR variety and 25 cm intra-row spacing proved more promising in the study area.

Jiang *et al*. (2013) reported that, the objective of this study was to understand the effects of plant spacing on grain yield and root competition in summer maize (*Zea mays* L.). Maize cultivar Denghai 661 was planted in rectangular tanks (0.54 m × 0.27 m × 1.00 m) under 27 cm (normal) and 6 cm (narrow) plant spacing and normal plant spacing, narrow plant spacing generated less root biomass in the 0– 20 cm zone under both N rates, slight reductions of dry root weight in the 20– 40 cm and 40–70 cm zones at the mid-grain filling stage, and slight variation of dry root weights in the 70–100 cm zone during the whole growth period. Narrow plant spacing decreased root reductive activity in all root zones, especially at the grain-filling stage. Grain yield and above-ground biomass were 5.0% and 8.4% lower in the narrow plant spacing than with normal plant spacing, although narrow plant spacing significantly increased N harvest index and N use efficiency in both grain yield and biomass, and higher N translocation rates from vegetative organs. These results indicate that the reductive activity of maize roots in all soil layers and dry weights of shallow roots were significantly decreased under narrow plant spacing conditions, resulting in lower root biomass and yield reduction at maturity. Therefore, a moderately dense sowing is a basis for high yield in summer maize.

Sener *et al*. (2004) reported that, maize hybrids react differently to various plant density and intra-row spacing. A two-year study was conducted at Mustafa Kemal University, Agricultural Faculty, Research Farm to determine the optimum intra-row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. The experimental design was a Randomized Complete Block in a split-plot arrangement with three replications. Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626. Split-plots were intra-row spacing of 10.0, 12.5, 15.0, 17.5 and 20.0 cm. Split-plot size was 2.8 by 5.0 m with four rows per plot. The effects of intra-row spacings on the grain yield and some agronomic characteristics were statistically significant. Hybrid x intra-row spacing interaction effects were significant only at ear length and grain yield. The highest grain yields were obtained from Pioneer 3223 and Dracma at 15.0 cm intra-row spacing (11718 and 11180 kg ha-1, respectively).

Sangoi *et al*. (2001) stated that, the interest in reducing maize row spacing in the short growing season regions of Brazil is increasing due to potential advantages such as higher radiation use efficiency. This experiment was conducted to evaluate the effect of row spacing reduction on grain yield of different maize cultivars planted at different dates. The trial was conducted in Lages, in the State of Santa Catarina, Brazil, during 1996/97 and 1997/98 growing seasons, in a split-split plot design. Early (October 1^{st}) and normal (November 15) planting dates were tested in the main plot; two morphologically contrasting cultivars (an early single-cross and a late double-cross hybrids) were evaluated in the split plots and three row widths (100, 75 and 50 cm) were studied in the split-split plots. The reduction of row spacing from 100 to 50 cm increased linearly maize grain yield. The yield edge provided by narrow rows was higher when maize was sown earlier in the season. Differences in hybrid cycle and plant architecture did not alter maize response to the reduction of row spacing.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from June 2016 to October 2016 to study the effect of different level of fertilizer combination and spacing on the yield of white maize. The materials and methods of this experiment are presented in this chapter under the following headings.

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in 23041/N latitude and 90022/E longitude.

3.2 Soil of the experimental field

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28 and was shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. The characteristics of the soil of the experimental plot were analyzed by the Soil Testing Laboratory, SRDI, Dhaka and have been presented in Appendix II.

3.3 Climate

The experimental area is characterized by high temperature, high humidity and high rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during rabi season (October-March). Weather condition of the experimental field have been presented in appendix I.

3.4 Planting materials

For this research work, the seeds of white maize seed (PSC) were collected personally from Krishi Gobeshona Foundation (KGF), Dhaka, Bangladesh. The purity and germination percentage were leveled as around 95, respectively.

3.5 Factors and treatments of the experiment

The experiment comprised as two factors.

Factor A: Fertilizer doses-5

a) F_1 = 50% less than recommended doses of fertilizer

b) F_2 = 25% less than recommended doses of fertilizer

c) F_3 = Recommended doses of fertilizer

d) F_4 =25% more than recommended doses of fertilizer

e) F_5 = 50% more than recommended doses of fertilizer

Factor B: Spacing-4

a) S_1 = 50 cm × 25cm

b) S_2 = 60cm× 25 cm

c) S_3 = 70 cm× 25cm

d) S_4 = (30,70 cm) paired × 25 cm

3.6 Layout of the experiment

The experiment was laid out in split-plot design with three replications where fertilizer doses was assigned in the main plot and spacing in the sub-plots. There were 20 plots of size 4.2 m × 2.0 m in each of 3 replications. The doses of fertilizer and spacing of the experiment were assigned randomly for each replication.

3.7 Preparation of the main field

The plot selected for the experiment was opened in the first week of June 2016 with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in section 3.6. Recommended doses of well-rotten cow-dung and chemical fertilizers as indicated in section 3.8 were mixed with the soil of each unit plot. Chemical fertilizers were applied in each plot as per treatment as mentioned in section 3.5 and the rate used as indicated in section 3.8.

3.8 Application of manure and fertilizers

Decomposed organic matter was used @ 6.0 t ha^{-1} before final land preparation. The chemical fertilizers as Urea, TSP, MoP, Gypsum, Boric acid and Zinc sulphate were applied as per treatments at the rate of 230-20-100-45-1.7 and 1.8 kg ha^{-1} of N-P-K-S-B-Zn. The whole amounts of fertilizers were applied as basal doses except Urea. Only one-third Urea was applied as basal doses and the rest amount was applied at 15 DAS interval for three installments.

3.9 Sowing of seeds in the field

The maize seeds were sown in lines each having a line to line distance of 60 cm and plant to plant distance of 20 cm having 3 seeds $hole^{-1}$ under direct sowing in the well-prepared plot on June 2016. Another three level of spacing were maintained as 50 cm × 25 cm, 70 cm × 25 cm and (30,70 cm) paired × 25 cm while sowing of seeds.

3.10 After care

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of the maize seedlings.

3.10.1 Irrigation

First irrigation was given on August, 2016 which was 60 days after sowing. Second irrigation was given on October, 2016 which was 100 days after sowing.

3.10.2 Thinning and gap filling

Keeping one seedling in each hill, the excess plants were thinned out from all of the plots at 20 days after sowing (DAS) for maintaining optimum population as of the experimental treatments.

3.10.3 Weeding and mulching

Weeding and mulching were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The weeds were uprooted carefully after complete 30 emergence of maize seedlings as and whenever necessary. Breaking the crust of the soil, when needed was done through mulching.

3.11 Plant protection

After 30 days of planting, first spray of Darsban was applied against the pest such as cut worm on 30 July, 2016.

3.12 Harvesting, threshing and cleaning

The mature cobs were harvested when the husk cover was completely dried and black coloration was found in the grain base.The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The inner two lines were harvested for recording grain yield.

3.13 Data recording

The following yield and yield contributing attributes data were recorded

1. Plant height (cm)
2. Number of cobs plant^{-1}
3. Length of cob (cm)
4. Diameter of cob (cm)
5. Number of rows cob^{-1}
6. Number of seeds row^{-1}
7. Number of seeds cob^{-1}
8. 1000 seeds weight (g)

9. Seed yield (kg ha^{-1})
10. Shelling (%)

Data recording procedure

3.13.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 25, 50, 75, 100 DAS (days after sowing) and at harvest. Data were recorded as the average of 05 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.13.2 Number of cobs $plant^{-1}$

The mature cob was counted at each of the five randomly selected plants in each plot at harvest and averaged.

3.13.3 Number of rows cob^{-1}

The number of row of five cobs was counted at each of the five randomly selected plants in each plot and averaged.

3.13.4 Number of seeds row^{-1}

Number of seeds per rows was recorded for each row of five cobs.

3.13.5 Cob length

Cob length was measured in centimeter from the base to the tip of the ear for five cobs and average them to get length per cob.

3.13.6 Number of seeds cob^{-1}

Seeds number of five randomly selected cobs plot^{-1} were counted for total seeds from the base to tip of the ear and finally averaged.

3.13.7 1000-grains weight

From the seeds sample from five randomly selected plants in each plot, 1000-grains were taken to weigh them in gram (g).

3.13.8 Shelling percentage

Shelling percentage was calculated dividing grain weight by total cob weight and multiply with hundred.

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} \times 100$$

3.13.9 Grain yield ha^{-1}

Cleaned and well dried grains collected from each plot were weighed and converted into t ha^{-1}.

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed using Statistix 10 software. The significance of the difference among the treatments means was estimated by the Duncan's Multiple Range Test at 5% level of significant.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of different level of fertilizer combination and spacing on the yield of white maize. Data on different growth and other parameters, yield attributes and yield were recorded. The results have been presented with the help of graphs and table, and possible interpretations given under the following headings

4.1 Plant height (cm)

4.1.1 Effect of fertilizer combination

Due to application of fertilizer plant height showed positively significant result (Figure 1 and Appendix III). Figure revealed that, plant height increased gradually with the increased of fertilizer doses up to F_4 (250.34 cm) after that the height reduce slightly with further increase of fertilizer doses (F_5). Plant height range from 250.34 cm to 268.02 cm. The tallest plant (268.02 cm) was recorded in F_4 treatment and shortest plant (250.34 cm) was recorded in F_1 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper growth of plant. The finding is close conformity with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Woldesenbet and Haileyesus (2016), Maqbool *et al*. (2016), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015), Soro *et al*. (2015), Rudnick and Irmak (2014), Hill (2014), Crista *et al*. (2014), Nasim *et al*. (2012), Amin (2011), Orosz *et al*. (2009), Mugwira *et al*. (2007), Silwana *et al*. (2007).

4.1.2 Effect of spacing

Plant highest showed statistically non-significant impact due to different spacing of maize cultivation (Figure 1 and Appendix III). Although having non-significant influence of spacing the tallest plant was recorded in S_2 while shortest plant was in S_1. The plant height ranges from 256.27 cm to 263.48 cm. The present finding disagreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

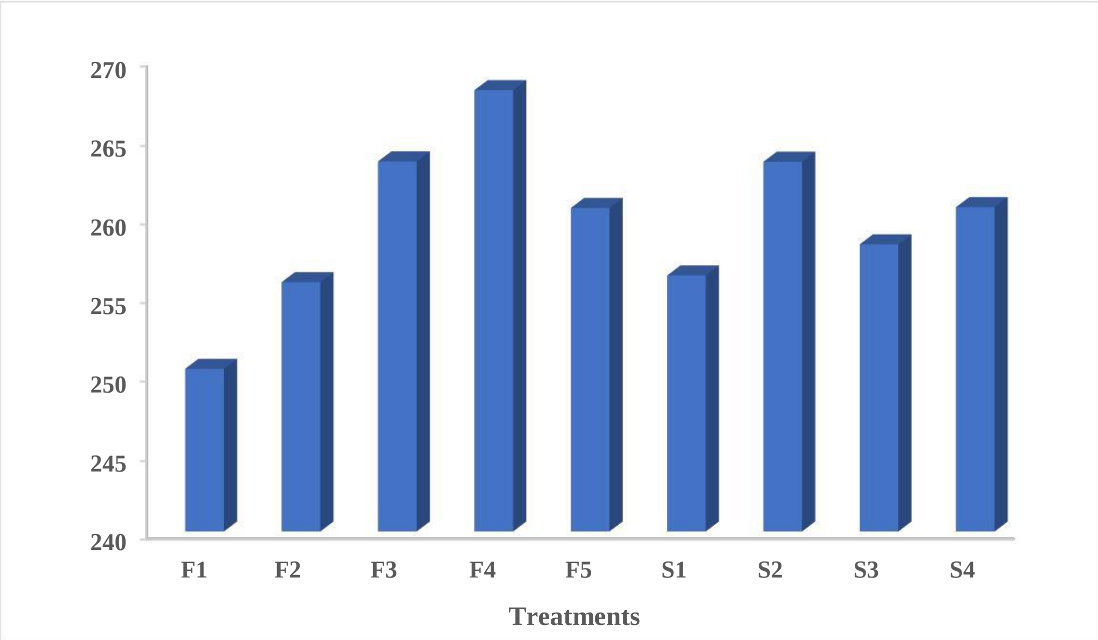

Figure 1. Individual effect of fertilizer and spacing on plant height of maize (SE=5.04 and 5.00)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.1.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant variation on plant height (Table 1 and Appendix III). For combined effect plant height ranges from 246.00 cm to 273.33 cm. The tallest plant was found in F_5S_2 and shortest plant was found in F_1S_1 combination compared to the others combination.

Table 1. Combined effect of fertilizer and spacing on plant height of maize

Treatments	**Plant height**
F_1S_1	246.00
F_1S_2	251.67
F_1S_3	254.70
F_1S_4	249.00
F_2S_1	250.33
F_2S_2	256.70
F_2S_3	259.67
F_2S_4	256.67
F_3S_1	259.67
F_3S_2	264.67
F_3S_3	267.00
F_3S_4	262.67
F_4S_1	262.37
F_4S_2	271.04
F_4S_3	273.00
F_4S_4	265.67
F_5S_1	263.00
F_5S_2	273.33
F_5S_3	236.85
F_5S_4	269.00
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**4.76**
Replication×Ferilizer×Spacing	**527**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.2 Number of cobs plant^{-1}

4.2.1 Effect of fertilizer

Number of cobs plant^{-1} showed significant difference at different doses of fertilizer application (Figure 2 and Appendix IV). The figure showed that, the values of cod plant^{-1} increased steadily with the increased fertilizer doses up to F_5 (2.33). The rate of increased in number of cobs plant^{-1} was more rapid up to F_4 doses after that the increment rate was much slower. Due to application of different levels of fertilizer, the range of number of cobs plant^{-1} was found 1.47 to 2.33. The highest number of cobs plant^{-1} was recorded in F_4 and F_5 while lowest number of cobs plant^{-1} was recorded in F_1. From the recorded data, finding showed that F_4 and F_5 gave the statistically similar result. This might be due to adequate nutrient was in F_4 and/or F_5 treatment. The result is close conformition with the findings of Liverpool-Tasie *et al*. (2017), Woldesenbet and Haileyesus (2016), Maqbool *et al*. (2016 Soro *et al*. (2015), Rudnick and Irmak (2014), Hill (2014), Crista *et al*. (2014), Nasim *et al*. (2012), Amin (2011).

4.2.2 Effect of spacing

Impact of spacing on maize showed non-significant effect for number of cobs plant^{-1} (Figure 2 and Appendix IV). In spite of having non-significant effect of spacing on number of cobs plant^{-1} of maize, the maximum number of cobs (2.09) was found in S_2 spacing while minimum number (1.91) of cobs was recorded in S_1 spacing. Numerically cobs number ranges from 1.91 to 2.09. The present finding is not agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

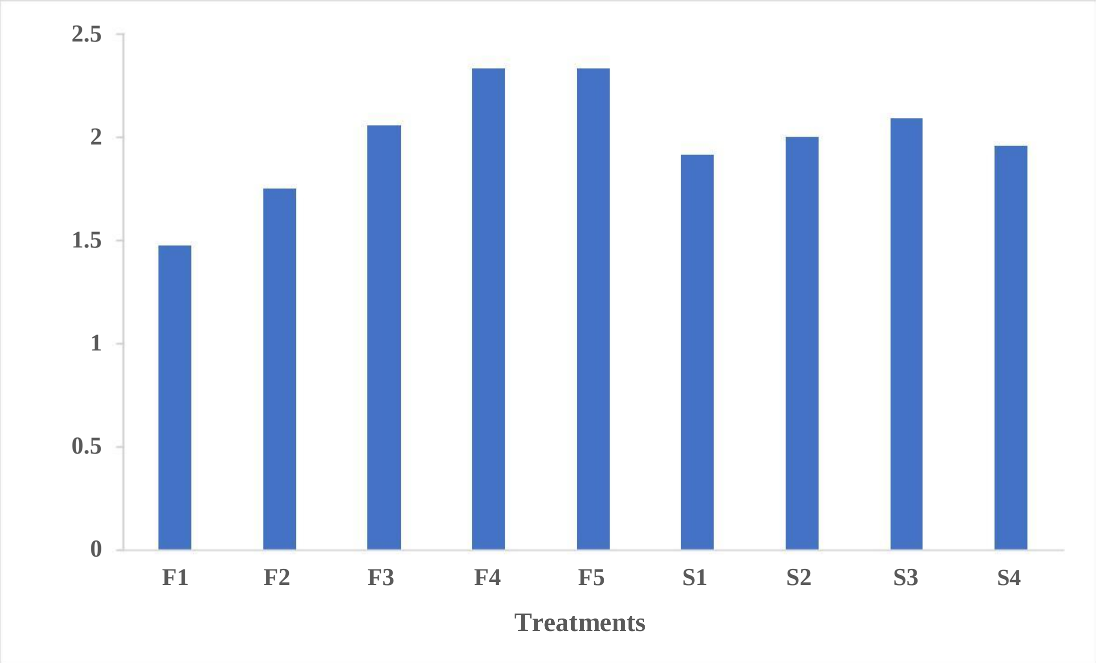

Figure 2. Effect of fertilizer and spacing on number of cobs plant^{-1} of maize (SE=0.091 and 0.091)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.2.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed non-significant impact on number of cobs plant^{-1} (Table 2 and Appendix IV). Number of cobs plant^{-1} ranges from 1.44 to 2.55 while F_4S_3 produced the maximum number of cobs (2.55) and F_1S_1 produced minimum number of cobs (1.44).

Table 2. Combined effect of fertilizer and spacing on number of cobs plant^{-1} of maize

Treatments	Number of cobs plant^{-1}
F_1S_1	1.4440
F_1S_2	1.5550
F_1S_3	1.4440
F_1S_4	1.4440
F_2S_1	1.6663
F_2S_2	1.7773
F_2S_3	1.8887
F_2S_4	1.6660
F_3S_1	1.9997
F_3S_2	1.9997
F_3S_3	2.1110
F_3S_4	2.1107
F_4S_1	2.2220
F_4S_2	2.3330
F_4S_3	2.5550
F_4S_4	2.2220
F_5S_1	2.2220
F_5S_2	2.3330
F_5S_3	2.4440
F_5S_4	2.3330
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**11.24**
Replication×Ferilizer×Spacing	**12.55**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.3 Cob length (cm)

4.3.1 Effect of fertilizer combinations

Cob length exerted significant effect (Figure 3 and Appendix V). Due to application of fertilizer the cob length showed similar trend with fertilizer doses.

Numerically, cob length ranges from 14.30 cm to 18.61 cm. The height cob length (18.61 cm) was recorded in F_5 treatment and lowest cob length (14.30 cm) was recorded in F_1 treatment. This might be due to the proper supply of nutrient from F_5 treatment facilitated proper reproductive growth of plant. The persent finding close conformity with the findings of Liverpool-Tasie *et al*. (2017), Woldesenbet and Haileyesus (2016), Ademba *et al*. (2015), Hill (2014), Nasim *et al*. (2012), Amin (2011), Orosz *et al*. (2009), Mugwira *et al*. (2007).

4.3.2 Effect of spacing

Cob length showed statistically significant impact due to different spacing of maize cultivation (Figure 3 and Appendix V). Due to influence of spacing the highest cob length was recorded in S_3 while lowest cob length was in S_1. The cob length ranges from 14.97 cm to 17.62 cm. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

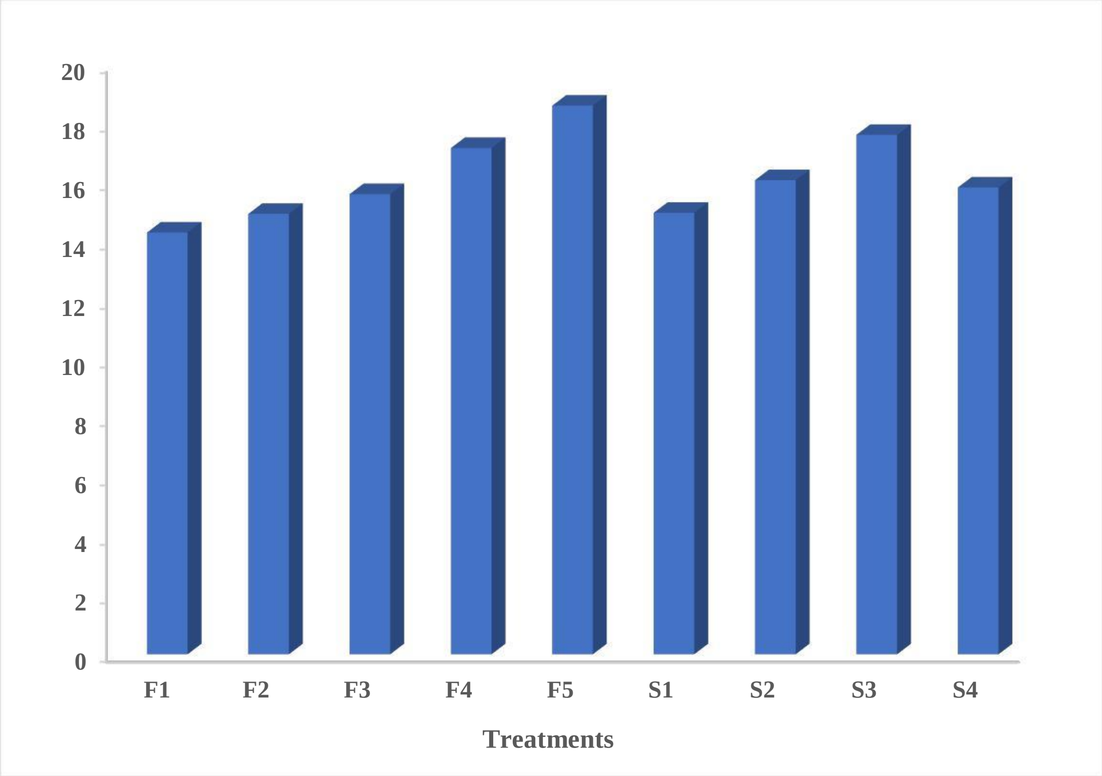

Figure 3. Effect of fertilizer and spacing on cob length of maize (SE=0.663 and 0.607)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.3.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant cob length (Table 3 and Appendix V). For combined effect cob length ranges from 12.36 cm to 19.96 cm. The highest cob length was found in F_5S_3 and lowest cob length was found in F_1S_1 combination compared to the others combination.

Table 3. Combined effect of fertilizer and spacing on cob length (cm)

Treatments	Cob length
F_1S_1	12.355
F_1S_2	14.168
F_1S_3	16.289
F_1S_4	14.400
F_2S_1	13.811
F_2S_2	14.722
F_2S_3	17.178
F_2S_4	14.033
F_3S_1	14.776
F_3S_2	15.556
F_3S_3	16.933
F_3S_4	15.155
F_4S_1	16.689
F_4S_2	17.377
F_4S_3	17.722
F_4S_4	16.900
F_5S_1	17.222
F_5S_2	18.589
F_5S_3	19.966
F_5S_4	18.667
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**10.08**
Replication×Ferilizer×Spacing	**10.32**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.4 Cob diameter (cm)

4.4.1 Effect of fertilizer

Cob diameter showed positive significant difference at different doses of fertilizer application in maize (Figure 4 and Appendix VI). Due to application of different levels of fertilizer, the range of cob diameter was found 12.58 cm to 14.29 cm. The highest cob diameter was recorded in F_5 (14.29 cm) while lowest cob diameter was recorded in F_1 (12.58 cm). From the recorded data, finding showed that F_4 and F_3 gave the statistically similar finding. The highest cob length in F_5 might be due to adequate nutrient was in F_5 treatment. The finding is close conformity with the findings of Abebe and Feyisa (2017), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015).

4.4.2 Effect of spacing

Impact of spacing on maize showed non-significant effect for cob diameter (Figure 4 and Appendix VI). In spite of having non-significant effect of spacing on cob diameter of maize, the highest cob diameter was found in S_3 spacing (13.51 cm) while lowest cob diameter was recorded in S_1 treatment (12.98 cm). The cobs diameter ranges from 12.98 cm to 13.51 cm. The present finding is not agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

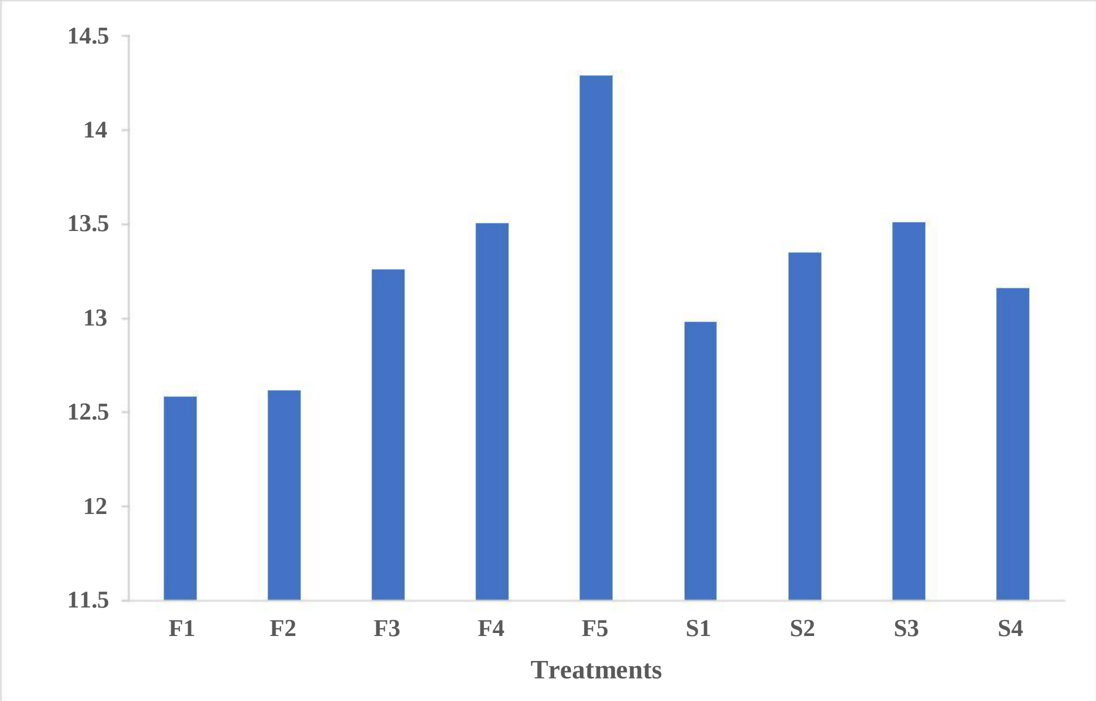

Figure 4. Effect of fertilizer and spacing on cob diameter of maize (SE=0.251 and 0.272)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.4.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing had non-significant effect on cob diameter of maize (Table 4 and Appendix VI). The cob diameter ranges from 12.30 cm to 14.66 cm while F_5S_2 combination produced the height cob diameter (14.66 cm) and F_1S_1 combination produced the lowest cob diameter (12.30 cm).

Table 4. Combined effect of fertilizer and spacing on cob diameter of maize

Treatments	Cob diameter
F_1S_1	12.299
F_1S_2	12.647
F_1S_3	12.707
F_1S_4	12.677
F_2S_1	12.099
F_2S_2	12.718
F_2S_3	13.088
F_2S_4	12.555
F_3S_1	13.184
F_3S_2	13.296
F_3S_3	13.436
F_3S_4	13.124
F_4S_1	13.189
F_4S_2	13.418
F_4S_3	14.022
F_4S_4	13.381
F_5S_1	14.137
F_5S_2	14.666
F_5S_3	14.300
F_5S_4	14.048
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**4.65**
Replication×Ferilizer×Spacing	**5.64**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.5 Number of rows cob^{-1}

4.5.1 Effect of fertilizer

Number of rows cob^{-1} showed positively significant result due to application of fertilizer (Figure 5 and Appendix VII). The number of rows cob^{-1} range from 11.69 to 13.15. The maximum number of rows cob^{-1} was recorded in F_5 treatment (13.15) and minimum number of rows cob^{-1} was recorded in F_1 treatment (11.69). This might be due to the proper supply of nutrient from F_5 treatment facilitated proper reproductive growth of plant. The present result is agreed with the findings of Woldesenbet and Haileyesus (2016), Maqbool *et al*. (2016), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015).

4.5.2 Effect of spacing

The number of rows cob^{-1} showed statistically non-significant impact due to different spacing of maize cultivation (Figure 5 and Appendix VII). Although having non-significant influence of spacing the maximum number of rows cob^{-1} was recorded in S_3 (12.84) while the minimum number of rows cob^{-1} was in S_1 (11.69). The number of rows cob^{-1} ranges from 11.69 to 12.84. The present finding is disagreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

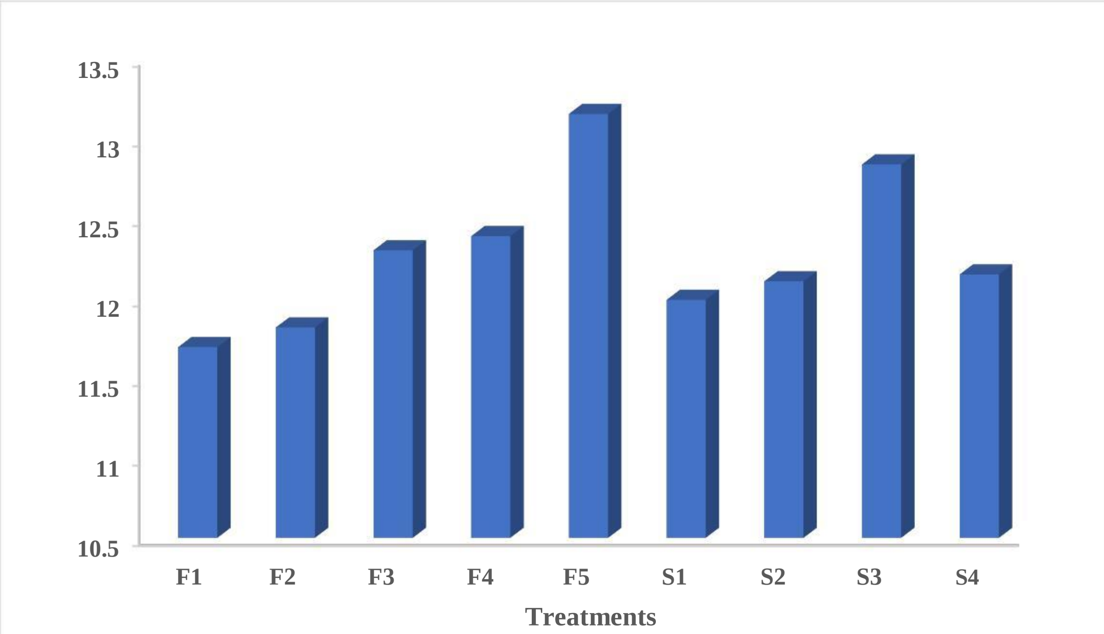

Figure 5. Effect of fertilizer and spacing on number of rows cob^{-1} of maize (SE=0.388 and 0.331)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.5.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant effect number of rows cob^{-1} in maize (Table 5 and Appendix VII). For combined effect number of rows cob^{-1} ranges from 11.44 to 13.32. The maximum number of rows cob^{-1} was found in F_5S_3 (13.32) and minimum number of rows cob^{-1} was found in F_1S_1 combination (11.44) compared to the others combination.

Table 5. Combined effect of fertilizer and spacing on number of rows cob^{-1}

Treatments	**Number of rows cob^{-1}**
F_1S_1	11.444
F_1S_2	11.555
F_1S_3	12.555
F_1S_4	11.222
F_2S_1	11.666
F_2S_2	11.788
F_2S_3	12.111
F_2S_4	11.703
F_3S_1	12.033
F_3S_2	12.111
F_3S_3	13.111
F_3S_4	11.944
F_4S_1	11.809
F_4S_2	11.877
F_4S_3	13.094
F_4S_4	12.777
F_5S_1	12.996
F_5S_2	13.200
F_5S_3	13.320
F_5S_4	13.100
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**7.46**
Replication×Ferilizer×Spacing	**7.40**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.6 Number of seeds line^{-1}

4.6.1 Effect of fertilizer

Number of seeds line^{-1} showed significant difference at different doses of fertilizer application (Figure 6 and Appendix VIII). Figure indicated that the seeds line^{-1} showed increasing trend with increases of fertilizer doses and it was also observed that the rate of increase was steady from the lowest to highest doses of fertilizers. Due to application of different levels of fertilizer, the range of number of seeds line^{-1} was found 22.89 to 32.03. The maximum number of seeds line^{-1} was recorded in F_5 (32.03) while the minimum number of seeds line^{-1} (22.89) was recorded in F_1. This might be due to adequate nutrient was in F_5 treatment. The present result supported by the Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Rudnick and Irmak (2014), Crista *et al*. (2014), Nasim *et al*. (2012), Xu *et. al* (2006), and Rasheed *et al*. (2004).

4.6.2 Effect of spacing

Spacing on maize showed non-significant variations for number of seeds line^{-1} (Figure 6 and Appendix VIII). The figure showed that seeds line^{-1} increased positively with the increment of spacing up to S_3 (70 cm× 25cm) after that seeds line^{-1} reduced slightly. However, the lowest seeds line^{-1} was found in closet spacing S_1 (50 cm × 25cm) and that of highest was recorded in S3 ((30,70 cm) paired × 25 cm) spacing treatment. The seeds number ranges from 25.39 to 28.96. The present finding is not agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

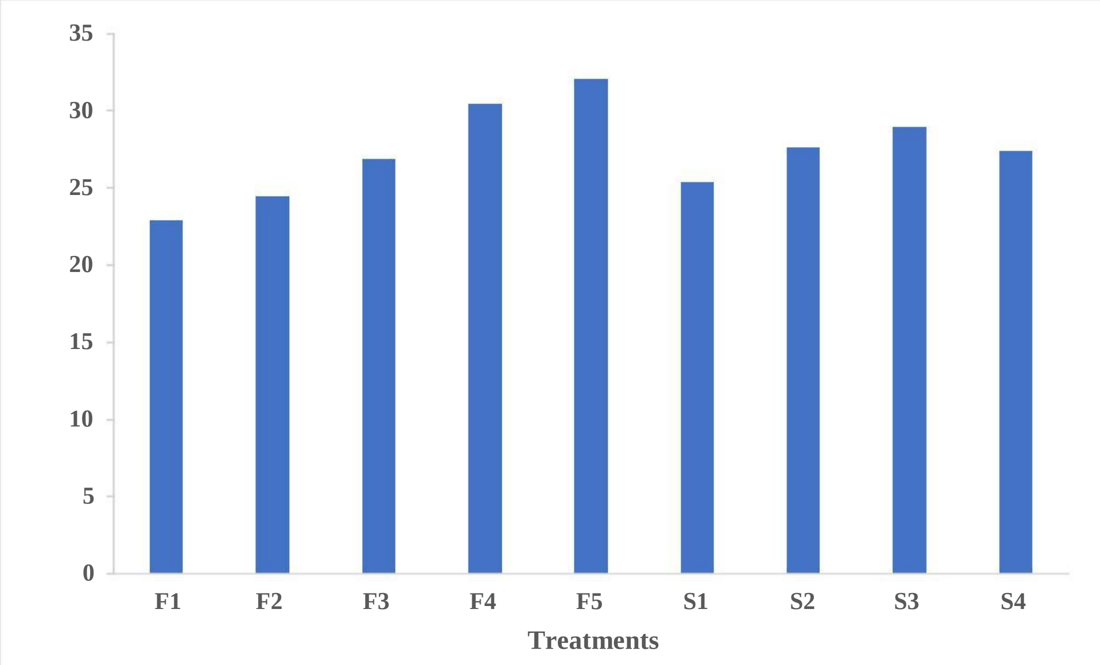

Figure 6. Effect of fertilizer and spacing on number of seeds line^{-1} of maize (SE=1.272 and 1.354)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.6.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed non-significant impact on number of seeds line^{-1} of maize (Table 6 and Appendix VIII). Number of seeds line^{-1} ranges from 20.89 to 33.22 while F_5S_3 (50% more than recommended doses of fertilizer and 70 cm× 25cm) combination produced the maximum number of seeds line^{-1} (33.22) and F_1S_1 (50% less than recommended doses of fertilizer and 50 cm × 25cm) combination produced minimum number of seeds line^{-1} (20.89).

Table 5. Combined effect of fertilizer and spacing on number of seeds line^{-1} of maize

Treatments	Number of seeds line^{-1}
F_1S_1	20.892
F_1S_2	23.111
F_1S_3	24.666
F_1S_4	22.888
F_2S_1	21.033
F_2S_2	25.666
F_2S_3	26.444
F_2S_4	24.553
F_3S_1	25.777
F_3S_2	26.555
F_3S_3	28.000
F_3S_4	27.111
F_4S_1	29.111
F_4S_2	30.111
F_4S_3	32.444
F_4S_4	30.111
F_5S_1	30.111
F_5S_2	32.666
F_5S_3	33.222
F_5S_4	32.111
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**11.40**
Replication×Ferilizer×Spacing	**13.57**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.7 Number of seeds cob^{-1}

4.7.1 Effect of fertilizer

Due to application of fertilizer number of seeds cob^{-1} varied significantly in maize (Figure 7 and Appendix IX). Number of seeds cob^{-1} increased steadily with the increment of fertilizer doses from the lowest to highest doses, but rate of increase was slower in the lower two doses after that the rate of increase was steady. The number of seeds cob^{-1} range from 268.18 to 369.42 due to different levels of fertilizers. The maximum number of seeds cob^{-1} was recorded in F_5 (50% more than recommended doses of fertilizer) treatment and minimum number of seeds cob^{-1} was recorded in F_1 (50% less than recommended doses of fertilizer) treatment. This might be due to the steady supply of nutrient from F_5 treatment facilitated proper growth of plant. The present finding is close conformity with the findings of Liverpool-Tasie *et al*. (2017), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Soro *et al*. (2015), Hill (2014), Nasim *et al*. (2012), Amin (2011), Orosz *et al*. (2009), Mugwira *et al*. (2007).

4.7.2 Effect of spacing

Number of seeds cob^{-1} showed statistically positively significant impact due to different spacing of maize cultivation (Figure 7 and Appendix IX). The significant influence of spacing facilitated maximum number of seeds cob^{-1} (339.00) in S_3 (70 cm× 25cm) while minimum number of seeds cob^{-1} (290.75) was in S_1 (50 cm × 25cm, S_2 = 60cm× 25 cm). The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

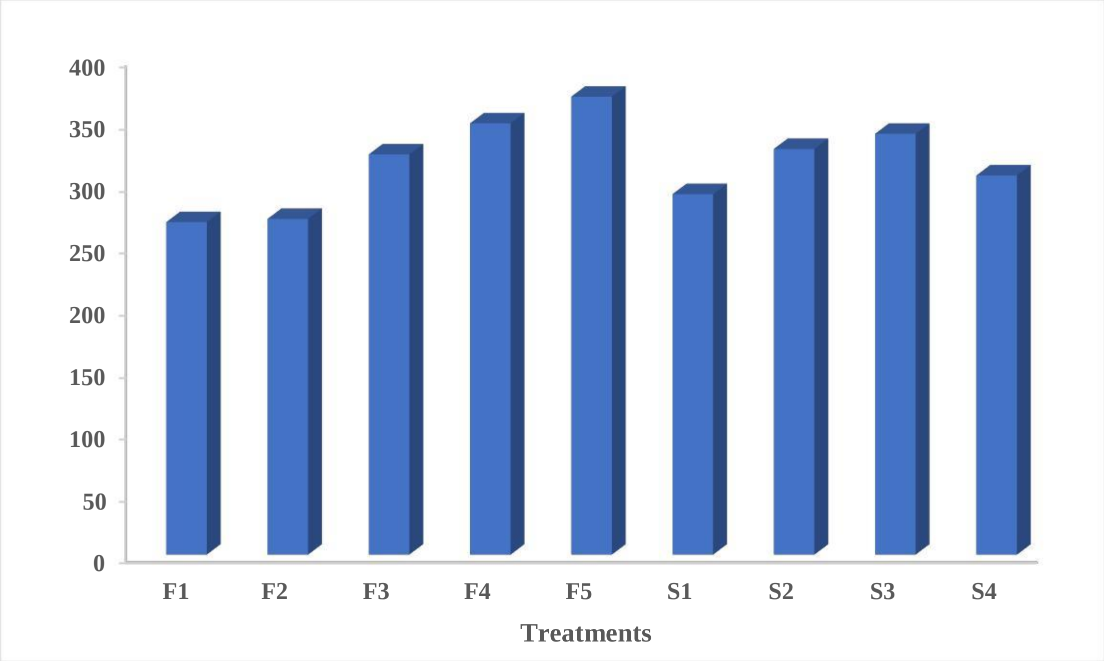

Figure 7. Effect of fertilizer and spacing on number of seeds cob^{-1} of maize (SE=10.82 and 15.03)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.7.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant variation on number of seeds cob^{-1} in maize (Table 7 and Appendix IX). Among the different combinations the number of seeds cob^{-1} ranges from 260.80 to 408.72. The maximum number of seeds cob^{-1} (408.72) was found in F_5S_3 combination (50% more than recommended doses of fertilizer and 70 cm× 25cm) and minimum number of seeds cob^{-1} (260.80) was found in F_1S_1 combination (50% less than recommended doses of fertilizer and 50 cm × 25cm) compared to the others combination.

Table 7. Combined effect of fertilizer and spacing on number seeds cob^{-1}

Treatments	Number seeds cob^{-1}
F_1S_1	260.80
F_1S_2	268.46
F_1S_3	278.06
F_1S_4	265.38
F_2S_1	261.64
F_2S_2	274.40
F_2S_3	282.71
F_2S_4	264.35
F_3S_1	292.14
F_3S_2	339.82
F_3S_3	343.67
F_3S_4	315.53
F_4S_1	312.35
F_4S_2	353.65
F_4S_3	384.03
F_4S_4	341.55
F_5S_1	326.85
F_5S_2	399.77
F_5S_3	408.72
F_5S_4	342.36
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**8.39**
Replication×Ferilizer×Spacing	**13.03**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.8 Weight of 1000 seeds (gm)

4.8.1 Effect of fertilizer

Weight of 1000 seeds exerted significant effect due to different levels of fertilizers in maize (Figure 8 and Appendix X). The weight of 1000 seeds increased sharply with the increases of fertilizers levels. Although the rate of increase was slower in the lower two doses but highest three doses showed higher increase in 1000 seeds weight. The 1000 seeds weight ranges from 274.00 g to 288.79 g among the doses. The highest 1000 seeds weight (288.79 g) was recorded in F_5 (50% more than recommended doses of fertilizer) treatment and lowest 1000 seeds weight (274.00 g) was recorded in F_1 (50% less than recommended doses of fertilizer) treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper dry matter partitioning of plant. Our finding is close conformity with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Soro *et al*. (2015), Rudnick and Irmak (2014), Hill (2014), Crista *et al*. (2014) and Rasheed *et al*. (2004).

4.8.2 Effect of spacing

The 1000 seeds weight showed statistically significant impact due to different spacing of maize cultivation (Figure 8 and Appendix X). It can be inferred from the figure that the value of seed weight increased sharply with the increases of spacing up to S_3 (70 cm× 25cm) spacing after that the value reduced slightly. However, the highest 1000 seeds weight was recorded in S_3 (70 cm× 25cm) spacing while lowest 1000 seeds weight was in S_1 (50 cm × 25cm) spacing. The 1000 seeds weight ranges from 257.03 g to 276.41 g among the spacing. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

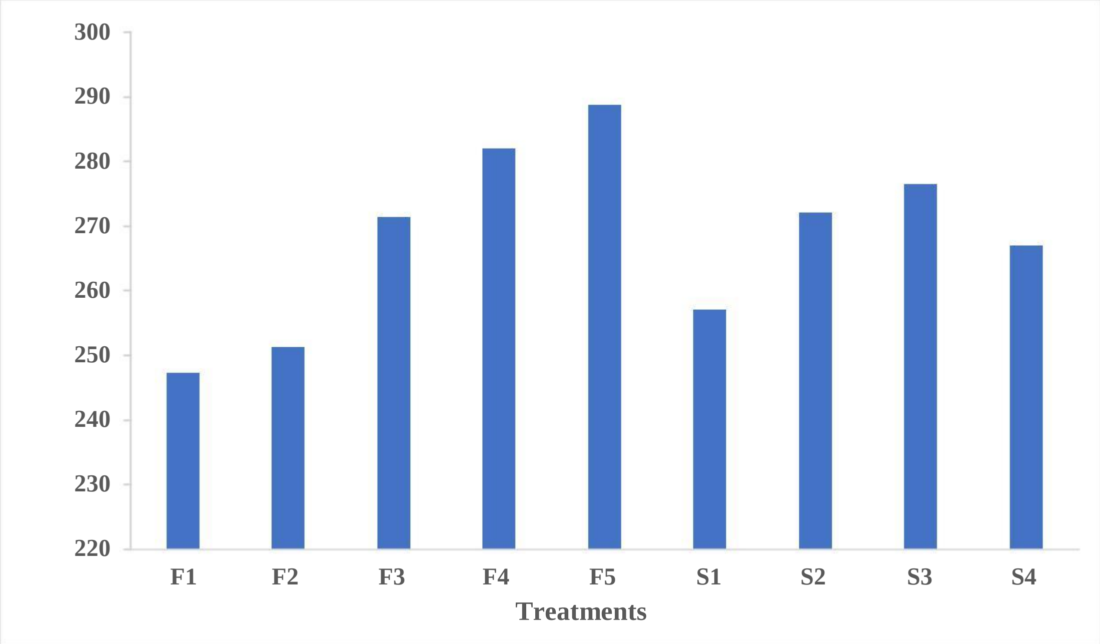

Figure 8. Effect of fertilizer and spacing on 1000 seeds weight of maize (SE=5.260 and 5.125)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.8.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant variations in 1000 seeds weight of maize (Table 8 and Appendix X). The 1000 values of seeds weight ranges from 243.80 to 303.33 g among the combinations. The highest 1000 seeds weight was found in F_5S_3 (50% more than recommended doses of fertilizer and 70 cm× 25cm) and lowest 1000 seeds weight was found in F_1S_1 (50% less than recommended doses of fertilizer and 50 cm × 25cm) combination compared to the others combination.

Table 8. Combined effect of fertilizer and spacing on weight of 1000 seeds of maize

Treatments	Weight of 1000 seeds
F_1S_1	243.80
F_1S_2	248.33
F_1S_3	252.37
F_1S_4	244.67
F_2S_1	245.33
F_2S_2	253.67
F_2S_3	255.66
F_2S_4	250.34
F_3S_1	253.36
F_3S_2	276.67
F_3S_3	281.33
F_3S_4	274.33
F_4S_1	273.33
F_4S_2	285.03
F_4S_3	289.33
F_4S_4	280.00
F_5S_1	269.33
F_5S_2	297.00
F_5S_3	303.33
F_5S_4	285.50
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**4.83**
Replication×Ferilizer×Spacing	**5.24**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.9 Seed yield (kg ha^{-1})

4.9.1 Effect of fertilizer

The seed yield of maize showed significant difference at different doses of fertilizer application (Figure 9 and Appendix XI). The figure indicated that, the two higher doses of fertilizers (F_4 and F_5) increased seed yield significantly than recommended doses. On the others hand, lower doses (F_1 and F_2) produced lower 56 seed yield than recommend doses (F_3) in maize. Due to application of different levels of fertilizer, the range of seed yield of maize was found 6857.50 to 8338.50 kg ha^{-1}. The highest seed yield (6857.50 kg ha^{-1}) was recorded in F_5 (50% more than recommended doses of fertilizer) while lowest cob yield (8338.50 kg ha^{-1}) was recorded in F_1 (50% less than recommended doses of fertilizer). This might be due to adequate nutrient was in F_5 treatment. The present finding is agreed with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Woldesenbet and Haileyesus (2016), Maqbool *et al*. (2016), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015), Soro *et al*. (2015), Rudnick and Irmak (2014), Hill (2014), Crista *et al*. (2014), Nasim *et al*. (2012), Amin (2011), Orosz *et al*. (2009), Mugwira *et al*. (2007).

4.9.2 Effect of spacing

Impact of spacing on maize showed significant effect for seed yield of maize (Figure 9 and Appendix XI). Due to the effect of spacing on seed yield of maize, the highest seed yield (7697.20 kg ha^{-1}) was found in S_3 (70 cm× 25cm) while lowest seed yield (7461.2 kg ha^{-1}) was recorded in S_1 (50 cm × 25cm) treatment. The cob yield ranges from 7461.2 to 7697.20 kg ha^{-1} among the spacings. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

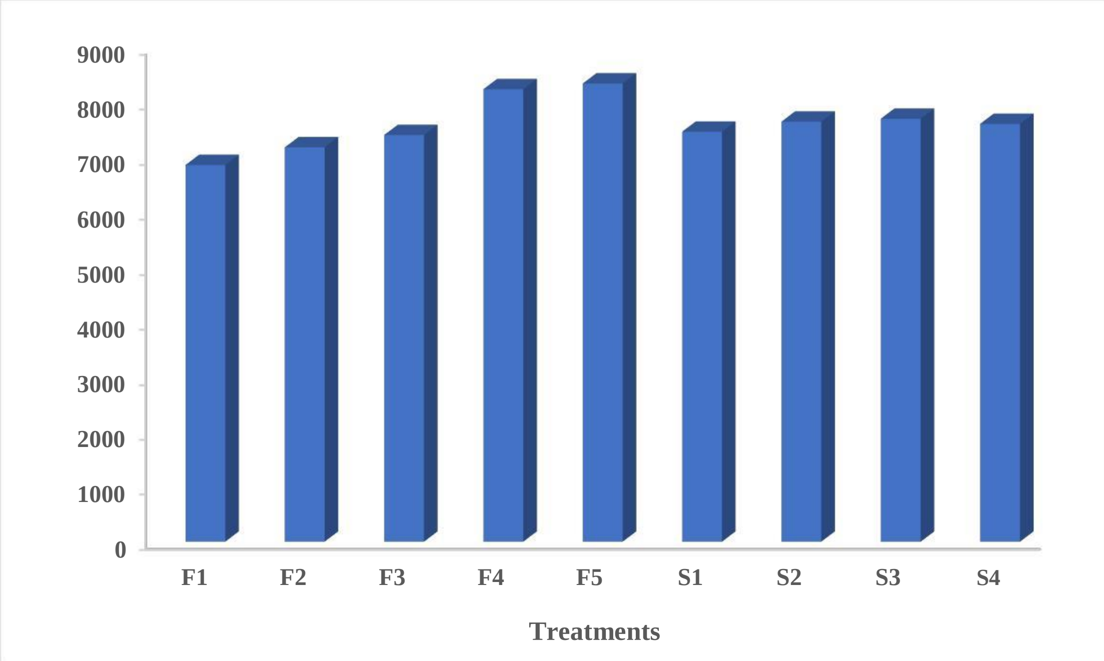

Figure 9. Effect of fertilizer and spacing on seed yield of maize (SE=23.525 and 36.186)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.9.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed non-significant impact on seed yield of maize (Table 9 and Appendix XI). The seed yield of maize ranges from 6795.00 to 8410.00 kg ha^{-1} while F_5S_3 (50% more than recommended doses of fertilizer and 70 cm× 25cm) produced the highest seed yield (8410.00 kg ha^{-1}) and F_1S_1 (50% less than recommended doses of fertilizer and 50 cm × 25cm) produced lowest seed yield (6795.00 kg ha^{-1}).

Table 9. Combined effect of fertilizer and spacing on seed yield of maize

Treatments	Yield (kg ha^{-1})
F_1S_1	6795.0
F_1S_2	6875.0
F_1S_3	6903.0
F_1S_4	6857.0
F_2S_1	7035.0
F_2S_2	7215.0
F_2S_3	7252.0
F_2S_4	7210.0
F_3S_1	7203.0
F_3S_2	7434.0
F_3S_3	7556.0
F_3S_4	7412.0
F_4S_1	8065.0
F_4S_2	8330.0
F_4S_3	8365.1
F_4S_4	8174.2
F_5S_1	8208.0
F_5S_2	8370.0
F_5S_3	8410.0
F_5S_4	8366.0
SE (±)	**NS**
CV (%)	
Replication×Ferilizer	**1.76**
Replication×Ferilizer×Spacing	**2.30**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.10 Shelling percentage (%)

4.10.1 Effect of fertilizer

Due to application of fertilizer shelling percentage showed positively significant result (Figure 10 and Appendix XII). The shelling percentage range from 76.48 % to 78.96% among the fertilizer doses. The highest shelling percentage

(78.96%) was recorded in F_2 (25% less than recommended doses of fertilizer) treatment and lowest percentage (76.48 %) was recorded in F_1 (50% less than recommended doses of fertilizer) treatment. Our finding is close conformity with the findings of Abebe and Feyisa (2017), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015), Soro *et al*. (2015), Mucheru-Muna *et al* (2007), Xu *et. al* (2006) and Adeniyan and Ojeniyi (2005).

4.1.2 Effect of spacing

The shelling percentage showed statistically significant impact due to different spacing of maize cultivation (Figure 10 and Appendix XII). The highest shelling percentage (78.86%) was recorded in S_2 (60cm× 25 cm) while lowest shelling percentage (77.75%) was in S_4 ((30,70 cm) paired × 25 cm). The shelling percentage ranges from 77.75% to 78.86%. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

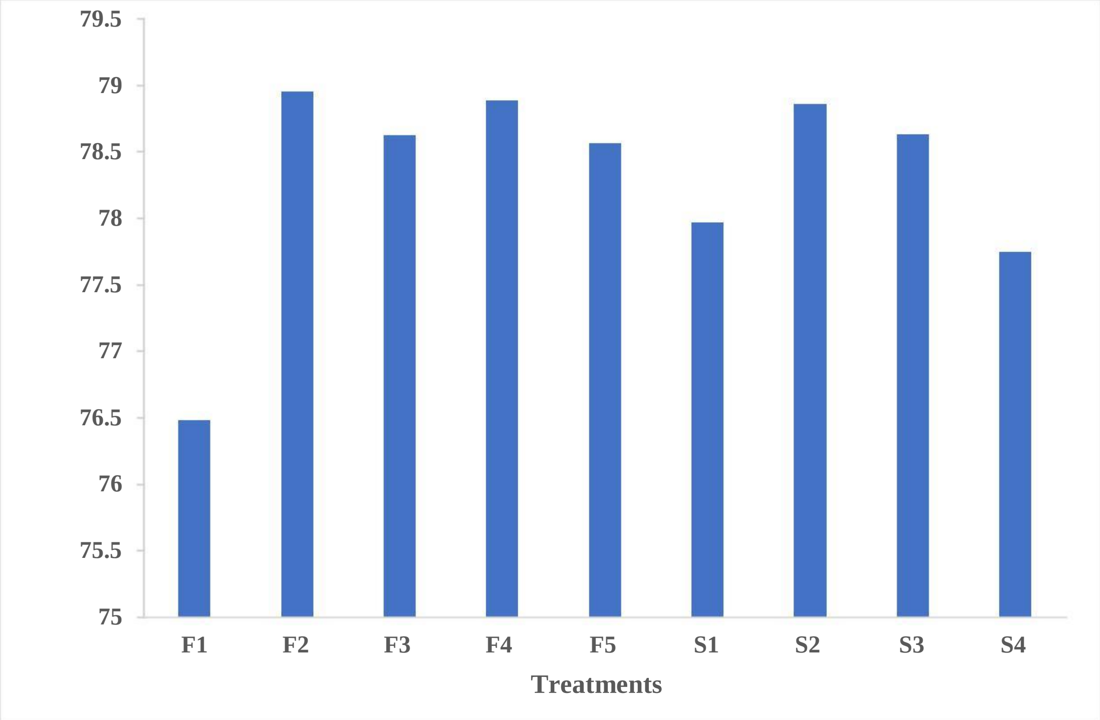

Figure 10. Effect of fertilizer and spacing on shelling percentage of maize (SE=0.381 and 0.348)

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = Recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer, F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

4.10.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically significant shelling percentage in maize (Table 10 and Appendix XII). For combined effect shelling percentage ranges from 75.00% to 80.46% due to different combinations. The highest shelling percentage (80.46%) was found in F_5S_4 (50% more than recommended doses of fertilizer and (30,70 cm) paired × 25 cm) combination which was statistically similar with F_2S_3 and F_3S_2. The lowest shelling percentage (75.00%) was found in F_1S_4 (50% less than recommended doses of fertilizer and (30,70 cm) paired × 25 cm) combination compared to the others combination.

Table 10. Combined effect of fertilizer and spacing on shelling percentage

Treatments	Shelling (%)
F_1S_1	75.981 de
F_1S_2	76.688 c-e
F_1S_3	78.245 a-d
F_1S_4	75.000 e
F_2S_1	79.000 a-c
F_2S_2	80.579 a
F_2S_3	79.132 a-c
F_2S_4	77.111 b-e
F_3S_1	79.011 a-c
F_3S_2	80.356 a
F_3S_3	78.121 a-d
F_3S_4	77.005 c-e
F_4S_1	79.183 a-c
F_4S_2	77.222 b-e
F_4S_3	79.979 ab
F_4S_4	79.166 a-c
F_5S_1	76.666 c-e
F_5S_2	79.455 a-c
F_5S_3	77.666 a-e
F_5S_4	80.455 a
SE (±)	**0.7757**
CV (%)	
Replication×Ferilizer	**1.19**
Replication×Ferilizer×Spacing	**1.22**

F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; S_1 =50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from June 2016 to October 2016 to study the effect of different level of fertilizer combination and spacing on the yield of white maize. The experiment comprised of two factors, Factor A: Different fertilizer doses i.e. F_1 = 50% less than recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = Recommended doses of fertilizer**,** F_4 =25% more than recommended doses of fertilizer**,** F_5 = 50% more than recommended doses of fertilizer; and four level of spacing i.e. S_1 = 50 cm × 25cm, S_2 = 60cm× 25 cm, S_3 = 70 cm× 25cm, S_4 = (30,70 cm) paired × 25 cm. The experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield were recorded and analyzed.

Plant height range from 250.34 cm to 268.02 cm. The tallest plant was recorded in F_4 treatment and shortest plant was recorded in F_1 treatment. Although having non-significant influence of spacing on plant height, the tallest plant (263.48 cm) was recorded in S_2 while shortest plant (256.27 cm) was in S_1. For combined effect plant height ranges from 246.00 cm to 273.33 cm. The tallest plant (273.33 cm) was found in F_5S_2 and shortest plant (246.00) was found in F_1S_1 combination compared to the others combination. Due to application of different levels of fertilizer, the range of number of cobs plant^{-1} was found 1.47 to 2.33. The highest number of cobs plant^{-1} was recorded in F_4

and F_5 while lowest number of cobs plant^{-1} was recorded in F_1. In spite of having non-significant effect of spacing on number of cobs plant^{-1} of maize, the maximum number of cobs was found in S_2 while minimum number of cobs was recorded in S_1 treatment. Number of cobs plant^{-1} ranges from 1.44 to 2.55 while F_4S_3 produced the maximum number of cobs and F_1S_1 produced minimum number of cobs.

The cob length ranges from 14.30 cm to 18.61 cm. The largest cob was recorded in F_5 treatment and shortest cob was recorded in F_1 treatment. Due to influence of spacing the longest cob was recorded in S_3 while shortest cob was in S_1. The cob length ranges from 14.97 cm to 17.62 cm. For combined effect cob length ranges from 12.36 cm to 19.96 cm. The longest cob was found in F_5S_3 and shortest cob was found in F_1S_1 combination compared to the others combination.

Due to application of different levels of fertilizer, the range of cob diameter was found 12.58 cm to 14.29 cm due to combined effect of fertilizer and spacing. The highest cob diameter was recorded in F_5 while lowest cob diameter was recorded in F_1. In spite of having non-significant effect of spacing on cob diameter of maize, the highest cob diameter was found in S_3 while lowest cob diameter was recorded in S_1 treatment. The cob diameter ranges from 12.30 cm to 14.66 cm while F_5S_2 produced the height cob diameter and F_1S_1 produced the lowest cob diameter.

The number of rows cob^{-1} range from 11.69 to 13.15. The maximum number of rows cob^{-1} was recorded in F_5 treatment and minimum number of rows cob^{-1} was recorded in F_1 treatment. Although having non-significant influence of spacing the maximum number of rows cob^{-1} was recorded in S_3 while minimum number of rows cob^{-1} was in S_1. For combined effect, number of rows cob^{-1} ranges from 11.44 to 13.32. The maximum number of rows cob^{-1} was found in F_5S_3 and minimum number of rows cob^{-1} was found in F_1S_1 combination compared to the others combination.

Due to application of different levels of fertilizer, the range of number of seeds line^{-1} was found 22.89 to 32.03. The maximum number of seeds line^{-1} was recorded in F_5 while the minimum number of seeds line^{-1} was recorded in F_1. In spite of having non-significant effect of spacing on number of seeds line^{-1} of maize, the maximum number of seeds was found in S_3 while minimum number of cobs was recorded in S_1 treatment. The seeds number ranges from 25.39 to 28.96. Due to combined effect of fertilizer and spacing number of seeds line^{-1} ranges from 20.89 to 33.22 while F_5S_3 produced the maximum number of seeds line^{-1} and F_1S_1 produced minimum number of seeds line^{-1}.

The number of seeds cob^{-1} range from 268.18 to 369.42 due to fertilizer doses. The maximum number of seeds cob^{-1} was recorded in F_5 treatment and minimum number of seeds cob^{-1} was recorded in F_1 treatment. The significant influence of spacing facilitated maximum number of seeds cob^{-1} in S_3 while minimum number of seeds cob^{-1} was in S_1. The number of seeds cob^{-1} ranges from 290.75 to 339. For combined effect number of seeds cob^{-1} ranges from 260.80 to 408.72. The maximum number of seeds cob^{-1} was found in F_5S_3 and minimum number of seeds cob^{-1} was found in F_1S_1 combination compared to the others combination.

The 1000 seeds weight ranges from 247 g to 288.79 g due to fertilizer doses. The highest 1000 seeds weight was recorded in F_5 treatment and lowest 1000 seeds weight was recorded in F_1 treatment. The highest 1000 seeds weight was recorded in S_3 while lowest 1000 seeds weight was in S_1. The plant height ranges from 257.03 g to 276.41 g. For combined effect, the 1000 seeds weight ranges from 243.80 to 303.33 g. The highest 1000 seeds weight was found in F_5S_3 and lowest 1000 seeds weight was found in F_1S_1 combination compared to the others combination.

Due to application of different levels of fertilizer, the range of seed yield of maize was found 6857.50 kg ha^{-1} to 8338.50 kg ha^{-1}. The highest seed yield was recorded in F_5 while lowest seed yield was recorded in F_1. Due to the effect of spacing on seed yield of maize, the highest seed yield was found in S_3 while the lowest seed yield was recorded in S_1 treatment. The seed yield ranges from 7461.2 kg ha^{-1} to 7697.20 kg ha^{-1}. The seed yield of maize ranges from 6795.00 kg ha^{-1} to 8410.00 kg ha^{-1} while F_5S_3 produced the highest seed yield and F_1S_1 produced lowest seed yield.

The shelling percentage range from 76.48 % to 78.96%. The highest percentage range was recorded in F_2 treatment and lowest percentage range was recorded in F_1 treatment. The highest shelling percentage was recorded in S_2 while lowest shelling percentage was in S_4. The shelling percentage ranges from 77.75% to 78.86%. For combined effect shelling percentage ranges from 75.00% to 80.46%. The highest shelling percentage was found in F_5S_4 and shelling percentage was found in F_1S_4 combination compared to the others combination.

Conclusion and recommendations

In conclusion, the highest plant height was observed in F_4 (268.55 cm) and S_2 (263.48 cm). Number of cobs plant^{-1} (2.33 and 2.08), cob length (18.61 cm and 17.62 cm), cob diameter (14.28 cm and 13.51 cm), number of rows cob^{-1} (13.15 and 12.84), number of seeds row^{-1} (32.02 and 28.96), number of seeds cob^{-1} (369.42 and 339.44), 1000 seeds weight (288.79 g and 276.41 g), and cob yield (8338.5 kg ha^{-1} and 7697.2 kg ha^{-1}) were more in F_5 fertilizer and S_3 spacing. The combined effect of F_5 fertilizer and S_3 spacing on growth and yield of white maize indicated that the positive indication of using 25% more than recommended doses of fertilizer and 70 cm× 25cm spacing.

The present experiment was conducted only one season even in a single location. So, it is difficult to recommend this finding without further study. By considering the results of the present experiment, further studies in the following areas are suggested below

I. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

II. In this study, few levels of fertilizer and spacing was used, it is recommended to increase the fertilizer levels and spacing to get accurate result.

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APPENDIX

Appendix I. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from June 2016 to October 2016.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall(mm)	Sunshine (hr)
	Maximum	Minimum			
June	37.4	19.2	79	280.4	6.3
July	36.7	22.1	82	107.3	6.5
August	35.4	24.7	72	92.7	7.6
September	34.1	25.5	72	28.9	6.5
October	34.5	20.4	64	25.8	7.2

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix II. Physical characteristics & chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.63
Organic mater	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41meq / 100 g soil

Source: Soil resource and development institute (SRDI), Dhaka

Appendix III. ANOVA for plant height

Source of variance	Plant height				
	DF	SS	MS	F	P
Replication	2	445.2	222.607		
Fertilizer	4	2241.5	560.380	3.67	0.0556
Error Replication*Fertilizer	8	1221.6	152.705		
Spacing	3	434.4	144.795	0.77	0.5187
Fertilizer*Spacing	12	2537.5	211.459	1.13	0.3756
Error Replication*Fertilizer*Spacing	30	5625.6	187.521		
Total	59	12505.9			

Appendix IV. ANOVA for number of cobs plant^{-1}

Source of variance	Number of cobs plant^{-1}				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	0.24801	0.12400		
Fertilizer	4	6.79113	1.69778	34.00	0.0000
Error Replication*Fertilizer	8	0.39951	0.04994		
Spacing	3	0.25921	0.08640	1.39	0.2660
Fertilizer*Spacing	12	0.20339	0.01695	0.27	0.9897
Error Replication*Fertilizer*Spacing	30	1.86974	0.06232		
Total	59	9.77099			

Appendix V.ANOVA for Cob length

Source of variance	Cob length				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	5.204	2.6019		
Fertilizer	4	147.351	36.8377	13.93	0.0011
Error Replication*Fertilizer	8	21.154	2.6443		
Spacing	3	54.730	18.2435	6.59	0.0015
Fertilizer*Spacing	12	11.253	0.9378	0.34	0.9747
Error Replication*Fertilizer*Spacing	30	83.079	2.7693		
Total	59	322.772			

Appendix VI. ANOVA for Cob diameter

Source of variance	Cob diameter				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	3.7479	1.87393		
Fertilizer	4	23.8687	5.96719	15.71	0.0007
Error Replication*Fertilizer	8	3.0385	0.37981		
Spacing	3	2.3770	0.79233	1.42	0.2565
Fertilizer*Spacing	12	1.4756	0.12297	0.22	0.9960
Error Replication*Fertilizer*Spacing	30	16.7461	0.55820		
Total	59	51.2538			

Appendix VII. ANOVA for number of row cob^{-1}

Source of variance	**Number of row cob^{-1}**				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	0.4013	0.20065		
Fertilizer	4	16.0040	4.00100	4.41	0.0356
Error Replication*Fertilizer	8	7.2575	0.90719		
Spacing	3	6.6435	2.21451	2.69	0.0641
Fertilizer*Spacing	12	3.4497	0.28748	0.35	0.9715
Error Replication*Fertilizer*Spacing	30	24.7108	0.82369		
Total	59	58.4669			

Appendix VIII. ANOVA for number of seeds line^{-1}

Source of variance	Number of seeds line^{-1}				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	35.59	17.795		
Fertilizer	4	721.77	180.442	18.58	0.0004
Error Replication*Fertilizer	8	77.68	9.710		
Spacing	3	97.66	32.553	2.37	0.0906
Fertilizer*Spacing	12	17.76	1.480	0.11	0.9999
Error Replication*Fertilizer*Spacing	30	412.60	13.753		
Total	59	1363.06			

Appendix IX. ANOVA for number of seeds cob^{-1}

Source of variance	Number of seeds cob^{-1}				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	3324	1662.1		
Fertilizer	4	98994	24748.6	35.21	0.0000
Error Replication*Fertilizer	8	5623	702.8		
Spacing	3	21236	7078.8	4.18	0.0138
Fertilizer*Spacing	12	8197	683.1	0.40	0.9510
Error Replication*Fertilizer*Spacing	30	50827	1694.2		
Total	59	188201			

Appendix X. ANOVA for weight of 1000 seeds

Source of variance	Weight of 1000 seeds (g)				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	456.0	227.98		
Fertilizer	4	16166.8	4041.71	24.06	0.0002
Error Replication*Fertilizer	8	1343.7	167.96		
Spacing	3	3136.3	1045.44	5.31	0.0047
Fertilizer*Spacing	12	997.1	83.09	0.42	0.9425
Error Replication*Fertilizer*Spacing	30	5911.2	197.04		
Total	59	28011.1			

Appendix XI. ANOVA for yield ha^{-1}

Source of variance	Yield (t ha^{-1})				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	29568.8	14784		
Fertilizer	4	2.059E+07	5146949	1550.03	0.0000
Error Replication*Fertilizer	8	26564.4	3321		
Spacing	3	460920	153640	15.64	0.0000
Fertilizer*Spacing	12	83531.3	6961	0.71	0.7310
Error Replication*Fertilizer*Spacing	30	294620	9821		
Total	59	2.148E+07			

Appendix XII. ANOVA for shelling percentage

Source of variance	Shelling (%)				
	DF	**SS**	**MS**	**F**	**P**
Replication	2	1.033	0.5167		
Fertilizer	4	51.177	12.7943	14.69	0.0009
Error Replication*Fertilizer	8	6.967	0.8708		
Spacing	3	12.558	4.1859	4.59	0.0092
Fertilizer*Spacing	12	79.243	6.6036	7.25	0.0000
Error Replication*Fertilizer*Spacing	30	27.333	0.9111		
Total	59	178.312			