YIELD PERFORMANCE OF WHITE MAIZE (SAUWM 9-3-3) UNDER VARYING FERTILIZER LEVELS AND SPACINGS IN KHARIF-2 SEASON

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CERTIFICATE

*This is to certify that the thesis entitled, "**YIELD PERFORMANCE OF WHITE MAIZE (SAUWM 9-3-3) UNDER VARYING FERTILIZER LEVELS AND SPACING IN KHARIF-2 SEASON**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the results of a piece of bona-fide research work carried out by **MD. AL-AMIN**, Registration No.* ***18-09090*** *under my supervision and my guidance. No part of the 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:

Dhaka, Bangladesh

Prof. Dr. Md. Jafar Ullah

Supervisor

DEDICATED TO MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted during May to September 2019 at Sher-e-Bangla Agricultural University, Dhaka-1207 to evaluate the yield performance of white maize as influenced by different levels of fertilizer under different spacing. The experiment comprised two different factors; (1) three levels of fertilizer application *viz*. F_1 (Recommended doses of fertilizer (RDF), F_2 (25% less than RDF) and F_3 (25% higher than RDF); and (2) three different plant spacing viz. S_1 (60 cm × 25 cm), S_2 (50 cm × 25 cm) and S_3 (40 cm × 25 cm). Both the fertilizer dose and spacing level along with their interactions had significant effect on almost all vegetative and reproductive parameters. The highest stover yield(14.8 t ha^{-1}) and the lowest stover yield (5.83 t ha^{-1}) was obtained from F_2S_3 (25% less than RDF and 40 cm × 25 cm) and F_3S_1 (25% higher than RDF and 60 cm × 25 cm) treatment combinations, respectively. The F_2 (25% less than RDF) in combination with S_2 (50 cm × 25 cm) performed the best and obtained the highest cob length (18.45 cm), number of rows cob^{-1}(13.67), number of grains row^{-1} (25.89) number of grains cob^{-1} (354.54), weight of grains cob^{-1} (89.56 g), weight of cob (118.56 g), 100- grain weight (35.70 g) which contributed to obtain the highest grain yield (8.44 t ha^{-1}) as well as biological yield (22.08 t ha^{-1}).

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Abbreviations	Extended words
AEZ	Agro-ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
SAU	Sher-e-Bangla Agricultural University
cm	Centimeter
cv.	Cultivar
CV	Coefficient of Variation
DAS	Days After Sowing
et al.	And others (*et alibi*)
FAO	Food and Agriculture Organization
g	Gram
ha	Ha
HI	Harvest Index
kg	Kilogram
LSD	Least Significant Difference
m^2	Square Meter
MoP	Muriate of Potash
No.	Number
NS	Non-Significant
%	Per cent
$plant^{-1}$	per plant
Seeds cob^{-1}	Seeds per cob
Grain row^{-1}	Grain per row
TSP	Triple Super-phosphate
t per ha	Ton (s) per ha
viz.	Namely

CHAPTER 1

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Poaceae is one of the most widely distributed crops of the world (Kaul *et al.*, 2011). It is also one of the most important cereal crops in the world agricultural economy both as food for human and feed for animals. This crop being the highest yielding cereal crop in the world has become an emerging crop in Bangladesh, where rapidly increasing population has already out stripped the available food supplies. Maize 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".

Maize is one of the most important food grains in the world as well as in developing countries. As per BBS 2018–19, its area has been 35 per cent more than that of the wheat. As such, maize had a gigantic leap leaving wheat production behind. After rice and wheat it must be second most important crop. Not only the yield productivity, but also a shorter life span has made this crop unique to be easily fitted in the existing cropping pattern. The cultivation of maize is increasing day by day due to its diverse use, where the total area coverage was 445297 ha with a production of 35 lakh metric tons during 2018-19 (BBS, 2018). It is high yielder in comparison to rice and wheat occupying first position among the cereals in terms of yield covering 335 thousand has with total per annum production of 2448 thousand m t year^{-1}. The productivity of maize is 5.36 t ha^{-1} and on the contrary that of wheat and rice are 2.21 t ha^{-1} and 2.15 t ha^{-1} respectively (Ullah *et al.*, 2018). It shows excellent adaptability to a wide range of agro-climatic regions and can be grown in all the three seasons viz., Pre-kharif, Kharif and Rabi. It is the most efficient crops which can give high biological yield as well as grain yield in a relatively short period of time due to its unique photosynthetic mechanism as C_4 plant.

The maize has 72% starch, 10% proteins, and 4% fat supplying an energy density of 365 Kcal/100 g (Ullah *et al.*, 2017). Moreover, 100 g maize grains contain 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin (Chowdhury and Islam, 1993). The maize is richer in nutrition than rice and wheat, where it contains 11% protein including higher amount of essential amino acid, tryptophan and lysine. Two types of maize are cultivated around the world, yellow maize and white maize. White maize, although is biologically and genetically very similar to yellow maize, it lacks in carotene pigments in its kernel, but worldwide it has more preference in the preparation of food items as compared to the yellow maize (Ullah *et al.*, 2018).

For diversification and value addition of maize as well as growing of food processing industries, an interesting development is of growing maize for vegetable purpose, which is known as "white maize". They are largely related with certain types of food products and dishes. Maize has more disease resistant capability compared with rice and wheat. Its seeds contain more protein and lower glycemic index and, as such, are superior to rice even for the diabetic patients. Recently, white maize is becoming popular very quickly 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 . The important industrial use of maize includes in the manufacture of starch and other products such as glucose, high fructose, maize oil, alcohols, baby foods and breakfast. Green parts of the plant and grain are used as the feed of livestock and poultry. Stover and dry leaves are used as good fuel (Ahmed, 1994).

It is not only a "cash crop'' but also a very good 'catch crop'. Thus, it is such a new crop which can improve the economic status of poor farmer.

Krishi Gobeshona Foundation in Bangladesh took an initiative to grow and popularize white grained maize with the view that towards fifties there may be a food shortage and worldwide white maize is more preferable than yellow one to use as human food. Under this suspicion the food supply may not be satisfied by two C_3 crops, namely rice and wheat which are low productive than that of maize (C_4) in terms of per space grain production. The inception of white maize in Bangladesh is necessary as this species are extensively used as human foods and again the yellow maize since having been initiated even before 40 years ago, it has not been popularized yet used to be used as human food. And still now it is almost solely used as poultry and livestock feed. (Ullah *et al.*, 2016)

Growth and yield of white maize are affected by cultural management practices especially fertilizer application, spacing etc. It is proven fact that without application of the fertilizer elements in the soil, no crop can be grown successfully in terms of seed yield as these nutrient materials are deficient. Proper nutrient management is crucial to get higher yield in any crop. Now white maize is comparatively popular worldwide but good agricultural management practices particularly nutrient management to maximize the production is the need of the day.

Fertilizer management is a vital window for sustainable crop production as it shows the most crucial role on growth and productivity of corn. Most of the works on fertility management are on corn production where the crop requires high doses of fertilizers application (Rakesh *et al.,* 2015). Maize is considered as most exhaustive crop after sugar cane and requires both micro and macro nutrients to obtain high growth and yield potentials. Nutrient management is a cautious use of organic and inorganic sources of nutrient to crop fields for sustaining and maintaining soil productivity. Judicious application of these combinations can withstand the soil fertility and productivity.

Maintaining appropriate plant spacing is an important agronomic management which modifies the population density in the crop field that affects crop yield. Next to soil fertility another factor of equal importance is spacing. The yield of any crop depends to a greater extent on the number of plants per unit area. It plays an important role in influencing the productivity of any crop. It is crucial to establish the optimum plant population for the yield concerned, because of non tillering habit, white maize cannot recompense the loss of space unlike other tillering cereals like rice and wheat. Optimum plant density is required for attaining high crop productivity. Maximum and minimum nitrogen levels differed in plants and also in different parts of the individual plant. The amount of nitrogen is generally greatly 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 significantly affected the yield of maize. The closer plant spacing gave significantly the highest yield of cob. Increasing of plant spacing reduced the yield of cob (Ahmed, 1994).

Again although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al.,* 2016). However, there is no high yielding white maize varieties in Bangladesh and so Bangladesh has to generate technologies for the cultivation of white maize which either are imported or developed (Ullah *et al.,* 2017).

Researcher have conducted several experiments on spacing and fertilizer doses of maize but white maize is a new introduction in our country. Very few or no research findings 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.

From reviewing the above points it may be commented that the overall fertility status in Bangladesh soil is not standard which emphasizes to add the deficient plant nutrients from fertilizing materials. So, there is a wide opportunity to taken research on spacing and fertilizer doses of white maize. This study will help to find out 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 optimize fertilizer doses for the production of the white maize (SAUWM 9-3-3) evaluating the effect on growth and yield in Kharif-2 season.
2. To select suitable spacing for the production of the white maize (SAUWM 9-3-3) evaluating the effect on growth and yield in Kharif-2 season, and
3. To evaluate the interaction effects of fertilizer doses and spacing while growing the white maize (SAUWM 9-3-3) evaluating the effect on growth and yield in Kharif-2 season.

CHAPTER 2
REVIEW OF LITERATURE

Fertilizer management and optimum plant spacing are considered to be one of the most important factors in white maize cultivation. A number of research works have been done in different parts of the world to study the influence of fertilizer and spacing on the yield performance of white maize. Some of the important and informative works and research findings associated with the fertilizer management and plant spacing of white maize done at home and abroad have been reviewed under the following sub headings:

2.1 Effect of fertilizer management

Fertilizer management is one of the most important factors that influence the growth and yield of maize crop. Maize is considered as most exhaustive crop after sugarcane and requires both micro and macro nutrients to obtain high growth and yield.

2.1.1 Growth characters

Patil (1997) conducted a field experiment and concluded that application of 120:40:20 kg NPK per ha had detectable variation in plant stand and plant height, leaf number and dry weight of white maize over 90:40:20 kg per ha. Application of 80 kg N per ha increased plant height of maize (Raju *et al.,* 1997). Application of N from 0 to 100 kg per ha with each increment of 50 kg per ha significantly increment plant height, beyond which the increase in height was not significant while dry-matter accumulation plant^{-1} registered significant increase up to 150 kg N per ha (Thakur *et al.*, 1997).

Gawade (1998) conducted a field trial on medium black soils on sweet corn and reported that plant height, number of functional leaves and dry matter production were significantly higher under 100 kg N+50 kg P2O5 + 50 kg K2O per ha than rest of the fertilizer levels and control.

It is recorded that 2.02 per cent increase in leaf area index with the application of 60 kg N and 30 kg P_2O_5 per ha as compared to control in sorghum. He also reported a significant increase in dry matter production by 2.22, 1.95 and 3.18 per cent with application of 60 kg N and 30 kg P2O5 ha1 at 30 and 60 DAS and at harvest as compared to control, respectively.

Similarly, Kulhari *et al.* (1998) from Udaipur observed 26.6 per cent increase in leaf area index of maize with the application of N @ 120 kg ha^{-1} over control (3.001) at 60 DAS. They further reported that application of 120 kg N per ha significantly improved dry matter production by 33.84, 16.21 and 10.60 per cent at 30 and 60 DAS and at harvest, respectively over control (32.50, 68.41, 106.53 g $plant^{-1}$).

From New Delhi, Arya and Singh (2001) reported that application of phosphorus @ 39.6 kg P per ha produced significantly taller plants (172.83 and 166.23 cm), more LAI (3.78 and 3.82), decreased days to 50 percent silking (56.27 and 55.37) and maximum dry matter accumulation (216.10 and 174.29 g) than other levels of phosphorus (0, 13.2 and 26.4 kg P per ha) during both years experiment of 2000-2001 in maize. On clay loam soils of Coimbatore (Tamil Nadu), increasing nitrogen levels up to 60 kg per ha significantly increased plant height, leaf area index and dry matter production of winter maize (Vadivel *et al.*, 2001).

A field trial conducted by Wagh (2002) at College of Agriculture, Pune, Maharashtra on sweet corn and concluded that LA, LAI and AGR were found significantly more with application of 100 per cent RDF (225:50:50 kg N, P2O5, K2O per ha, respectively).

Kalpana and Krishnarajan (2003) reported that significantly highest values of plant height (237.1 cm), leaf area index (4.16) and dry matter production (13.61 t per ha) of white maize were obtained with the application of 50 kg K per ha in 3 splits over other treatments.

A field trial conducted by Grazia *et al.* (2003) on sweet corn reported that total leaf number, height, leaf width and length, leaf area, plant height, stem diameter and shoot dry matter content were significantly higher under the combination of 200 kg N per ha along with 80 kg P_2O_5 per ha than rest of the treatment combinations.

In Bangladesh, almost all upland soils are low in organic matter and deficient in N. Soil organic matter has great influence on soil nitrogen status which also increases plant growth and yields. Phosphorus is deficient mainly in calcareous soils of Ganges floodplain and acidic soils of terrace and hill areas. In phosphorus deficient soil, maize responses positively to the applied phosphatic fertilizers. Potassium (K) is not a great problem in floodplain areas, but is deficient in terrace and Piedmont soils, where plants need it for their growth and grain filling. Irrespective of the difference in the availability of N, P and K, it was observed that addition of these three nutrients was necessary for getting higher yields of most of the crops. Sulphur and Zn is essential to be added in the irrigated rice based cropping patterns. Boron was also reported to be deficient in some regions. Magnesium is deficient in the coarse-textured soils of Old Himalayan Piedmont plain, Brown hill soils and Grey floodplain soils of the northern part of the country. Although currently Ca is not in deficient, its reserve in many floodplain soils is depleting due to decalcification process. Deficiencies of Cu and Mn are also reported in some places although it is very rare (Ullah *et al.*, 2016).

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 per ha) and four levels (T1, T2, T3 and T4) 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 per ha) was obtained at 115 N kg per ha and T4 followed by 69 N kg per ha at T1 and T2 and 92 N kg per ha at T2. In contrast, the highest grain yield in 2013 was obtained at 92 N kg per ha at followed by 115 N kg per ha at either T2 or T4 and 69 N kg per ha at either T1 or T3 application time. Interestingly, a significant yield increases by 37% was obtained when 92 N kg per ha at the time of T1 was applied compared to previous recommended 110 N kg per ha rate and time of application. In 2014, however, the highest yield was recorded when 92 N kg per ha at T1 was used. Application of 46 N kg per ha at T2 showed statistically similar yield performance when compared with previous N recommendation.

Kalpana and Anbumani (2003) observed that application of 50 kg K per ha applied in 3 splits (basal, 15 and 30 DAS) to white maize significantly improved the cobs plant^{-1}, cob length, cob width, cob and stover yields as compared to rest of the treatments.

Kunjir (2007) had conducted a field trial at College of Agriculture, Dapolion sweet corn and opined that weight of cob, number of grains per cob and weight of grains per cob were significantly higher under 225 kg N per ha than rest of the fertilizer treatments.

Kar *et al.* (2006) reported that application of 80 kg N per ha significantly increased number of prime cobs, length and girth of green cobs and green fodder yields. Consequently the highest green cob yield was obtained which was 220, 160, 48 and 21 per cent higher than that of the control, 20, 40 and 60 kg N per ha.

Zende, (2006) carried out two years experiment during 2004-05 and found that different yield attributes *viz.,* cob length, cob girth, number of grains per cob, weight of grains per cob and number of cobs per plant in the mean of two years significantly superior with 150% RDF over rest of the fertilizer levels. Number of cobs per ha, straw yield, harvest index, cob yield and biological yield were also significantly superior with 150% RDF over rest of the fertilizer levels including control.

Chillar and Kumar (2006) found that increasing levels of nitrogen from 0-120 kg per ha significantly increased plant height, LAI and dry weight plant^{-1} of sweet corn. At

Udaipur, maximum plant height and leaf area index of maize were recorded with the application of 150 per cent NPK.

Singh *et al.* (2015) found that application of 120 kg N per ha being on par with 250 kg N per ha significantly improved all yield attributes, *viz.* number of cobs per ha, weight of green cob, number of kernel cob^{-1} and 1,000 kernel fresh weight over preceded levels from experiment at Wadura, Sapore, Jammu and Kashmir on well drained silty clay loam.

Bindhani *et al.* (2007) conducted a field experiment and revealed that application of 120 kg per ha significantly increased white maize length, girth, white maize yield and green fodder yields over lower levels. The improvement in white maize yield due to 120 kg per ha was 28.6, 52.2 and 178.7 per cent over 80, 40 kg N per ha and control, respectively. 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 per ha 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 per ha) and acceptable MRR could be obtained when 92 N kg per ha was used if the rainfall amount and distribution are relatively uniform. In conclusion, application of 92 N kg per ha (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 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.

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 per ha 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 per ha although there was no significant difference between the application of 69 and 92 kg N per ha. Regarding to ear length the data showed that the longest ear (23.63 cm) was obtained from the application of 92 kg N per ha. The effect of N on grain yield indicated that there is no significant difference between the application of 69 and 92 kg N per ha 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 per ha seems adequate to get the optimum yield.

Maqbool *et al.*, (2016) 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 ton per ha were recorded in inter-row and intra-row weed competition for 15 DAE, respectively.

Sener (2004) conducted a two-year study at Mustafa Kemal University, Agricultural Faculty, Research Farm, Turkey to determine the optimum inter row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. Maize hybrids reacted differently to various plant density and intra-row spacing. 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 intrarow spacing on the grain yield and some agronomic characteristics were statistically significant. Hybrid × 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 (11 718 and 11 180 kg per ha, respectively).

Tank (2006) conducted a field experiment in Anand, Gujarat, India during the rabi seasons of 2001-02 to determine the effects of Azospirillum lipoferum inoculation of maize seeds, alone or in combination with N application (0, 60, 120 and 180 kg/ha) at one-third + one-third + one-third, one-half + one-fourth + one-fourth or one-fourth + one-half + one-fourth proportions on the growth and yield of the crop. Inoculation with A. lipoferum, application of 180 kg N/ha applied and N application at onefourth + one-half + one-fourth proportions gave the highest values for plant height at harvest, number of grains per cob, 1000-grain weight, protein content, grain yield, stover yield, net returns and benefit:cost ratio.

Ghulam (2005) conducted field study in Pakistan, during the 1997 and 1998 summer seasons, to assess the effects of irrigation and N rates on maize cv. Golden yield. Results revealed that the different yield parameters, i.e. cobs per plant, grains per cob and mean grain weight were influenced significantly by different irrigation schedules and N rates. Generally, the grain yield increased with increasing irrigation or N levels. Maximum grain yield (>7.0 t/ha) was recorded with I3 (-8 bars) irrigation schedule and N3 rate of 200 kg/ha.

Girma (2005) conducted a field experiment during the rainy season of 2003 to study the effects of nitrogen rates (0, 10, 20 and 30 kg/ha) and moisture conservation practices (flat bed, ridge furrow, flat bed + mulching and ridge furrow + mulching) on the soil, soil water, yield and yield components of maize (Zea mays) grown in a rift valley in central Ethiopia. Grain yield was affected by nitrogen fertilizer levels but 1000-grain weight, total biomass, straw yield, soil temperature, soil moisture content, and infiltration rate were not affected by the nitrogen rates. Significant effects in harvest index and water use efficiency of nitrogen rates were observed only at Dera and Melkassa, respectively. Moisture conservation practices improved grain and straw yields, harvest index, and total biomass compared to the use of flat beds due to the availability of moisture. Bulk density, infiltration rate, water use efficiency, and soil moisture content were also affected by moisture conservation practices. Mulching reduced soil temperature prior to maize maturity.

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.

Ogbaji (2003) conducted field experiments during the 1997 and 1998 cropping seasons to study the effect of 3 levels of N fertilizer (0, 45 and 90 kgN/ha) and 3 levels of intra-row spacing (30, 40 and 50 cm) on the growth and yield of a local white maize cultivar in Makurdi, Nigeria. The growth parameters measured were the number of leaves per plant, plant height and grain yield. N fertilizer application and spacing influenced maize growth at various weeks after planting. At 10 weeks after planting (10 WAP) in 1997, a combination of 90 kg N/ha and intra-row spacing of 50 cm gave a significantly higher mean number of leaves per plant (17.63) and plant height (270.21 cm) than the control. At the same period in 1998, similar results were obtained (25.01 and 289.45 cm, respectively). Significant differences in grain yield also existed between different N levels and spacing regimes. Higher mean grain yields of 1734.87 kg/ha and 2041.23 kg/ha were obtained in 1997 and 1998, respectively, in the treatment combination of 90 kg N/ha and intra-row spacing of 50 cm. It is recommended that farmers in the Makurdi environment adopt the application of 90 kg N/ha and an intra-row spacing of 50 cm when using the local white maize cultivar, which is very popular in the study area.

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 ha 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 per ha as urea+100 kg N per ha 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) 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.

Arun Kumar *et al.* (2007) conducted an experiment during *kharif,* 2002 at Main Agricultural Research Station, Agriculture College, Dharwad on vertisols of zone- 8 of Karnataka and found the growth parameters of sweet corn *viz.,* LAI and total dry matter production were influenced favourably with increasing levels of fertilizers (100%, 75% and 75% RDN and 100%, 75% RDP and 75%, 100% and 125% RDK) application.

Pinjari (2007) undertaken the field experiment during 2055-06 and 2006-07 to find out the effect integrated nutrient management on sweet corn and revealed that the plant height increased significantly with the application of 75 % RDN + 25 % N through PM as compared to all the remaining nutrient sources during 2005-06, 2006-07 and in the mean of two years at all the crop growth stages. The number of leaves was significantly superior with 100% RDN over rest of the nutrient sources except 75 % RDN + 25 % N as PM at all the crop growth stages during both the years and in the mean of two years. The total dry matter accumulation (plant-1) at 30 DAS, the dry matter accumulation (plant-1) in leaves, stem and total dry matter at 60 DAS, in the leaves, stem, cob and total dry matter (plant-1) at 90 DAS and in the leaves, stem, grains, cob sheath, cob axis and total dry matter (plant-1) at harvest were significantly higher with the application of 75 % RDN + 25 % N as PM during both the years of study and in the mean of two years than the remaining nutrient sources.

Bindhani *et al.* (2007) observed that application of 120 N per ha resulted in tallest plants with maximum dry matter and leaf area index of white maize which were significantly higher than those at remaining N levels (40 and 80 N per ha). Successive increase in nitrogen levels from 0 to 120 kg per ha significantly improved leaf area index and dry weight plant^{-1} at 40 to 60 days after planting and maturity stages of white maize over other treatments.

BARI has optimized the fertilizer recommendations for specific crops along with that for hybrid maize recommending N-230, P–48.91, K-166.66, S-25, Zn-4.5 and Boron – 1.02 kg per ha. However, Cultivars differ in their response to nutrient supply when planted in different geographical environments and soil conditions.

Shobhana and imyavaramban (2012) noticed that increasing NPK level from control to N187.5 P26.2 K62.5 recorded taller plants and dry weight plant^{-1} from a field experiment conducted at the Indian Agricultural Research Institute, New Delhi.

Sahoo and Panda (2001) reported that increasing P levels from 8.7 to 35 kg P2O5 ha1 increased number of white maizes plant^{-1} from 2.1 to 2.6 during 1997-1998 and from 2.2 to 2.7 during 1998-1999. The treatment comprising 210:90:150 kg NPK ha^{-1} resulted in higher grain yields of maize with an additional increase of 33.0 percent over the state recommendations of 100:60:40 kg NPK per ha.

Gaur (2002) from Udaipur (Rajasthan) reported that application of 150 kg N ha1 significantly enhanced white maize and green fodder yield by 16.22 and 52.31 per cent over 120 kg N ha^{-1} and 36.39 and 61.71 per cent over 90 kg N ha^{-1}, respectively.

Maize grain yield is closely associated with kernel number at maturity, and kernel number is affected by apical kernel abortion mainly occurring at early kernel filling stage. Improving apical kernel development and reducing apical kernel abortion can contribute to increment of kernels per ear. The objectives of this work were to evaluate the Effect of fertilizer supply on early kernel development and grain yield in 12 maize. In field condition, early development of apical kernel in summer maize hybrid Zhengdan 958 and its grain yield under different nitrogen supplies (0, 120, 180 and 240 kg/ha) and the activities of enzymes related to kernel development such as acid sucrose invertase (AI), neutral sucrose invertase (NI), sucrose synthase (SS), ADPGase and starch synthase were determined. The results showed that suitable nitrogen supply obviously increased the activities of enzymes above and promoted apical kernel development. At 5-20 days after pollination (DAP), higher activities of AI, NI, SS, ADPGase and starch synthase in apical kernel were obtained under nitrogen supply of 180 kg/ha, indicating the sucrose utilization and starch synthesis were improved. The fresh weight, size, dry weight, the contents of soluble sugar, nitrogen and starch in apical kernel in 5-20 DAP were higher under nitrogen supply of

180 kg/ha than under other nitrogen rates. With increasing supply of nitrogen ranging from 0 to 180 kg/ha, the kernel development were promoted and the kernel abortion were reduced which resulted in more kernels per ear and higher yield. Nitrogen deficiency or excessiveness affected apical kernel development, which resulted in higher kernel abortion and lower grain yield. (Shen *et al.,* 2006).

Auwal and Amit (2017) conducted a field experiment during the winter season to study the influence of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.). The yield parameters (number of grains per cob, cobs weight per plant, Test weight and stover yield) were significantly higher under INM compared to T_1 (100% RDF). Therefore, the integration of 50% RDF along with either 5 t per ha FYM or PM or both resulted in maximum maize productivity on par compared with sole used of 100% RDF. It was also observed that 100% RDF with additional nutrient supply resulted higher yield contributing parameters (cobs plant^{-1}, cob length and diameter, cob number for unit area and harvest index) of maize.

Zende, (2006) carried out two years experiment during 2004-05 and found that different yield attributes *viz.,* cob length, cob girth, number of grains per cob, weight of grains per cob and number of cobs per plant in the mean of two years significantly superior with 150% RDF over rest of the fertilizer levels. Number of cobs per ha, straw yield, harvest index, cob yield and biological yield were also significantly superior with 150% RDF over rest of the fertilizer levels including control.

Raja (2001) reported that all the yield attributing characters like ear weight and yield of green kernel of super sweet corn were significantly superior with 120 kg N per ha over 80, 40 kg N per ha and control.

Kumar *et al*. (2017) found that for gaining higher productivity of maize, it requires very high quantities of nitrogen during the period of efficient utilization. Application of 120 kg N per ha reduced the days to corn initiation but prolonged the harvesting period over 80 kg N per ha. Application of 30 kg P per ha is reported to beneficial and economical for white maize production under the normal management. Potassium regulates the osmotic potential of cells and imparts resistance to biotic and abiotic stresses. Application of S and Zn has resulted in significant improvement for crude protein, Ca, ash in white maize. Application of 125% RDF (187.5-93.7-75 kg per ha) and 50 kg S per ha along with 10 kg Zn per ha has great impact on corn production in maximizing corn yield, fodder yield, nutrient content and monetary returns to the growers.

Kumar *et al*. (2018) conducted a field experiment on white maize (*Zea mays* L.) in sandy loam soil to assess the effect of balanced fertilization (NPKS and Zn) on productivity, quality, energetics and soil health of white maize. Results revealed that application of 125% RDF (187.5, 93.75, 75.0 kg NPK per ha) produced significantly higher yields of total baby cob yield with husk (9.55 tons per ha) and total white maize yield without husk (2.15 tons per ha). Among different levels of S and Zn, application of 50 kg S and 10 kg Zn per ha produced significantly higher yields of total baby cob with husk (9.38 and 9.24 tons ha^{-1}) and total white maize without husk (2.15 and 2.10 tons per ha), respectively.

The nutrient demands of genotypes vary if the surrounding climatic factors change. Further, testing a certain genotype(s) under specific environmental regions needs to be evaluated under other areas having dissimilar environmental parameters. Furthermore, genotypes may have potentials even to adapt or acclimatize to areas having dissimilar environmental parameters and soil conditions. The crop responses to N, P, K. B, S and Zn depending on both the fertility status of soil and also on the fertilizer use efficiency; which in turn are also influenced by many other factors. So, the present study was planned to optimize the recommended dose of the yellow maize for the production of white maize in different agro-ecological conditions. (Ullah *et al.,* 2016).

2.2 Effect of plant spacing

Planting density vary widely in different parts of the world because great abundance of maize strains and their distribution over different climatic conditions. An increase or decrease in the plant density has been found to effect the growth of the crop and a number of experiments all over the world have been carried out to determine the optimum plant density for maximum production.

2.2.1 Growth characters

Dalvi (1984) conducted a field experiment during rabiseason and reported that number of functional leaves and dry matter accumulation were significantly higher at 60 cm × 30 cm spacings during all the growth stages as compared to 30 cm × 30 cm and 45 cm × 30 cm spacing.

Sahoo (1995) observed no influence of different populations on days taken to harvest initiation. Whereas, plant spacing of 45 cm × 15 cm produced significantly taller white maize plants both at grand growth stage and harvest compared to 45 × 30 and 60 × 15 cm spacing. However, leaf area and dry matter yield plant^{-1} at above stages remained significantly higher at 45 × 80 cm spacing.

Sukanya *et al.* (1999) studied the effect of spacing on growth, development and yield of white maize varieties during summer season under irrigated condition. It was found that the spacings of 45 cm × 15 cm recorded the maximum plant height of 181.8 cm, which was significantly superior to wider row spacings of 60 cm × 15 cm. Similarly, the 45 cm × 30 cm spacings produced significantly higher dry matter of 223.25 g plant^{-1} over other spacing. The lowest drymatter of 166.47 g palnt^{-1} was recorded in 60 cm × 15 cm spacings.

Thakur and sharma (2000) conducted a field trial to study the effect of planting geometry on white maize. They reported maximum plant height with wider spacings

(60 cm × 30 cm) than closer spacing (40 cm × 40 cm, 50 cm × 30 cm, 40 cm × 35 cm, 50 cm × 25 cm and 45 cm × 25 cm).

Pandey *et al.* (2002) reported that with increase in plant population from 111 K (lacs per ha) to 166 K plants per ha barrenness per cent increased significantly; however, the plant height remained unaffected under different plant densities. They also reported that with increase in plant population from 111 K (lacs per ha) to 166 K plants per ha days to harvest initiation showed significant delay, however, there was no effect on the plant height under different plant densities. However, increase in the plant density from 111 K to 166 K plants per ha, barrenness per cent and harvest initiation days increased significantly, however, duration reduced by two days.

Chougule (2003) conducted a field experiment on sweet corn at Rahuri and reported that plant height, number of functional leaves, leaf area and total dry matter production per plant were significantly higher with 60 cm × 20 cm spacings than the closer spacing viz. 45 cm × 15 cm, 45 cm × 20 cm and 60 cm × 15 cm.
Planting of two plants hill-1 at a spacing 50 cm × 20 cm was found optimum for white maize cultivation (Sahu *et al*, 2005). The trend of response to thicker stand was not similar in other plant characteristics viz. dry matter accumulation, stem diameter, leaf area, number of functional leaves and number of cobs plants^{-1}.

Zarapkar (2006) conducted a field experiment to study the effect of spacings on growth and development of white maize and revealed that plant height was significantly higher under the closer spacings of 30 cm × 20 cm than other spacing (40 cm × 20 cm and 60 cm × 20 cm). Whereas, number of functional leaves and dry matter accumulation per plant was higher in case of wider spacings (60 cm × 20 cm) as compared to closer spacings.

Kunjir *et al.* (2007) conducted a field trial to study the effect of spacings on the growth and development of maize (sweet corn). Results revealed that stated that the spacings of 45 cm × 20 cm produced significantly higher plant height of maize (sweet corn) than 60 cm × 20 cm and 75 cm × 20 cm spacings.

Shafi *et al.* (2012) conducted this present study to investigate the effect of planting density on plant growth and yield of maize varieties. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white with three plant densities of 45000, 55000 and 65000 plants per ha. Planting density had a significant ($p<0.05$) effect on leaf area index and plant height. Maximum leaf area index and plant height was recorded from planting density of 65000 plants per ha.

Kheibari *et al.* (2012) conducted an experiment to investigate the "effects of variety and plant density on yield and yield component of corn varieties. Three plant densities (75,000 115,000 and 155,000 plantsper ha) and 3 corn varieties (KSC403su, KSC600 and KSC704) were evaluated. The data on growth attributing characters like plant height, number of leaves, leaf area, leaf area index, dry matter accumulation in leaf, stem, husked white maize and total dry matter, stem girth, average growth and crop growth rate in white maize in per plant basis influenced by plant density and highest was from plant density of 75,000 plantsper ha.

Sarjamei *et al.* (2014) conducted an experiment to investigate the effect of planting method and plant density, on morpho-phenological traits of white maize (ZeamIays L.) variety KSC 704. Three levels of plant density (D1: 90,000; D2: 120,000 and D3: 150,000 plant/ha) were initiated. Ear number per plant, ear height, leaves number, leaves number above ear, ear leaf diameter, ear length, ear diameter, stalk fresh weight and husked ear yield affected by plant density. The highest ear per plant (2.3 ear/plant) produced by D2 treatment. Leaves number above ear, ear leaf length and diameter, fresh stalk weight and diameter affected by interaction between plant density and planting method respectively.

Bairagi *et al.* (2015) conducted this experiment to study the effect of crop geometry impacts on growth and yield of white maize (Var. G-5414). Three levels of plant population viz. 45 × 30 cm (S1), 45 × 20 cm (S2) and 45 × 10 cm (S3) were assigned. Plant height was higher when white maize planted in wider spacing of 45 × 30 cm. whereas, closer spacing of 45 × 10 cm resulted in shorter plant. Days to 50% flowering did not vary among the spacing.

Jiotode (2002) conducted a field experiment with Maize cv. AMC-1 (Akola maize Composite-1) was tested for its growth responses and water use influenced by irrigation levels at 40, 60 or 80 mm CPE and irrigation as per the critical growth stages of the crop, and three row spacings of 30, 45 and 60 cm during the rabi seasons of 1996-97 in Akola, Maharashtra, India. Irrigation at 40 mm CPE recorded the highest values in terms of all the growth parameters as well as consumptive use, potential evapotranspiration, soil moisture depletion, absolute water use rate and relative water use rate. However, water use efficiency was highest in the case of irrigation as per the critical growth stages of the crop and at 60-cm row spacing. A 16 row spacing of 60 cm recorded the highest number of leaves, leaf area, and dry matter per plant. Plant height and leaf area index were highest at the 30-cm row spacing.
Chamroy *et al.* (2017) carried out an experiment entitled "Growth and yield response of white maize (Zea mays L.) to geometry". Four levels of sowing periods (i.e. Last week of Aug., Sept., Oct. and Nov.) and five different crop geometry (30cm × 30cm, 45cm × 15cm, 45cm × 30cm, 60cm × 15cm and 60cm × 30cm) were used. Among the plant spacings, it was observed that S3 (45 × 30 cm) exhibited highest number of leaves plant-1 (13.63), leaf area (512.62 cm2) and LAI (3.62). Whereas S2 (45 × 15 cm) gives highest plant height (205.47 cm).

Kunjir *et al.* (2007) conducted a field experiment on sweet corn and observed that length of cob, rows per cob, girth of cob, weight of cob, weight of grains per cob, number of grain rows per cob, weight of grains per cob and 1000 grains weight increased significantly with wider spacing (75 cm × 20 cm) as compared to narrower spacing (45 cm × 20 cm and 60 cm × 20 cm). The experiment also showed that the close spacings of 45 cm × 20 cm reported significantly higher cob yield (114.99 q per ha), stover yield (73.79 q per ha) and total biomass yield (188.78 q per ha) than the remaining broader spacing (60 × 20 cm and 75 × 20 cm).

The results of a study on light interception and productivity of white maize as influenced by crop geometry, intercropping and integrated nutrient management practices revealed that barring at 25 DAS, plant spacing of 60 × 24 cm registered higher green cob yield and white maize equivalent yield compared to 45 × 25 cm spacing (Thavaprakaash and Velayudham, 2008).

Dalvi (1984) conducted a field experiment during rabi season and revealed that spacings of 60 cm × 30 cm recorded significantly higher length of cob, girth of cob, number of grains per cob, weight of grains per cob and 1000 grain weight than other narrow spacings of 45 cm × 30 cm and 30 cm × 30 cm.

2.2.2 Yield attributes and yield

Carlos (1990) reported that “super sweet” corn can be grown for young cobs at a population density of 60, 000 plants per ha, the population, however, can be increased up to 1, 80, 000 plants per ha.

Thakur *et al*. (1995) evaluated the performance of maize cultivar early composite for white maize production under different spacing regimes viz., 40 cm and 60 cm of inter-row spacing and 10 cm and 20 cm of intra-row spacing. They found 40 cm × 20 cm and 40 cm × 10 cm spacings as optimum for white maize and white maize + green fodder productions, respectively. Significantly higher yield of white maize (1737 kg per ha) was recorded by planting the crop at 40 × 20 cm spacings than the other spacing of 60 ×10 cm (1561 kg per ha), 40 ×10 cm (1588 kg per ha) and 60 × 20 cm (1555 kg/ha).

Experiments on three plant populations, at densities of 106666, 160000 and 213333 plants per ha resulting from the row spacing of 75 cm and 25 cm between hills with 2, 3 and 4 plants hill^{-1}, respectively showed that there was significant difference in husked and unhusked young cob weights and husk weights at different densities (Soonsuwon *et al.*, 1996).

The alteration of spatial distribution of plants is an option to increase the grain yield. For high-yielding materials more information about the influence of N application is needed. Thus, the influence of row spacing, population density and N rate on the leaf N concentration, estimated concentration of chlorophyll, number of grains per ear, mass of thousand grains, grain yield, and protein content were evaluated. A study was carried out in Jaboticabal, Sao Paulo, Brazil, in 2000/01. The treatments comprised 2 row spacings (0.60 and 0.80 m), 3 population densities (40 000, 60 000 and 80 000 plants per ha) and 4 N rates (0, 50, 100, and 150 kg N per ha). Increased N rates in top-dressing led to an increase in the leaf N and estimated chlorophyll concentration, number of grains per ear, mass of thousand grains, grain yield and protein content of grains. Higher grain yield was achieved with increasing top dressed N rates in combination with a 0.80 m row spacing and a plant density of 80 000 plants per ha (Amaral Filho, 2009).

Thakur *et al.* (1997) conducted a field experiment on white maize and indicated that the wider spacings of 60 cm × 20 cm increased significantly all the yield attributing character viz. cob per plant, cob number per unit area, cob weight with and without husk of white maize as compared to other spacing of 40 cm × 20 cm, 60 cm × 10 cm and 40 cm × 10 cm. But the spacings of 40 × 20 cm recorded significantly more white maize yield of 17.37 q per ha as compared to 40 × 10 cm (15.88 q per ha) and 60 × 20 cm (13.55 q per ha) spacing.

Thakur *et al.* (1995) reported that cob yield with husk and white maize yield was significantly higher under plant spacing of 40 cm × 20 cm compared to 60 cm × 20 cm and 60 cm × 10 cm, whereas green fodder yield was significantly higher under spacing 40 cm × 10 cm compared to other plant spacings.

Sahoo and Panda (1999) reported that plant spacing of 40 cm × 20 cm, being at par with 40 cm × 15 cm recorded significantly higher white maize yield in wet season compared to 40 cm × 25 cm spacing, whereas green fodder yield during winter season was significantly higher under 40 cm × 15 cm spacing compared to other spacings.

Sukanya *et al.* (1999) found that the green fodder yield of white maize increased significantly with reduction in plant spacing compared to other spacings.

Thakur and Sharma (2000) conducted a field experiment on white maize and showed significantly higher length of cob with husk and cobs per plant under wider spacings of 60 cm × 30 cm and 40 cm × 40 cm as compared to other closer spacing.

Raja (2001) conducted a field experiment and reported that green ear weight/ha and green kernel weight/ha of super sweet corn was significantly higher at the population density of 88,888 pants/ha (108.05 q per ha and 83.15 q per ha) than the other plant populations viz. 66,666 and 53,333 plants/ha.

Pandey *et al.,* (2002) conducted a field experiment and reported that the lower plant density (1,11,000 plants per ha) of white maize recorded significantly higher weight of green cob and white maize/plant than 1,33,000 and 1660 plants per ha. It was also reported that the white maize yield and fodder yield obtained respectively at plant density of 1660 plants per ha. (1,148 kg per ha and 24.5 t per ha) and 1,33,000 plants per ha (1,0536 kg per ha and 23.4 t per ha) were on par and significantly superior to that of 1,11,000 plants per ha (900 kg per ha and 20.3 t per ha).

Ramchandrappa *et al.* (2004) carried a field study and observed that the length and girth of white maize was adversely affected with the increase in plant densities and the differences were not significant. The wider spacings of 45 × 30 cm recorded higher number of baby ears per plant, husked white maize length, girth and weight. Wider spacings of 45 cm × 30 cm also recorded significantly higher white maize yield than other spacings (45 cm × 20 cm and 30 cm × 30 cm).

Sahoo and Mahapatra (2004) conducted a field trial on sweet corn and reported that higher plant population (83,333 plants per ha) with spacings of 60 cm × 20 cm produced maximum number of ears. But green cob weight and length of dehusked cob were maximum under lower plant population (55,555 plants per ha) which was at par with 66,666 plant population per ha. It was also reported, significantly higher green cob yield and fresh grain yield when sweet corn was sown with a spacings of 60 cm × 25 cm than that of 60 cm × 20 cm and 60 cm × 30 cm spacings.

Ochapong (2005) reported no significant difference in white maize yield among plant densities. The results suggested that planting of 2 plants hill-1 at the recommended plant density especially when field practices and cost of seed were also taken into consideration and application of nitrogen 40 kg ha^{-1} yielded the highest white maize production.

Kar *et al.* (2006) conducted a field experiment and reported that the spacings of 60 x 20 cm significantly increased the number of prime cobs, green cob yield, highest net return and benefit : cost ratio over the 45 × 30, 45 × 20 and 60 × 30 cm spacing.

Zarapkar (2006) observed from a field study that the yield attributing characters of white maize such as length of white maize, number of white maize per plant, white maize weight with husk and white maize weight without husk were significantly higher under wider spacings of 60 cm × 20 cm as compared to closer spacings of 30 cm × 20 cm. It was also found that white maize yield was significantly higher under the closer spacings of 45 cm × 20 cm than remaining spacing viz. 30 cm × 20 cm and 60 cm × 20 cm. However, green fodder yield and total biomass yield per ha were significantly higher under spacings of 30 cm × 20 cm than other spacing.

Prodhan *et al.* (2007) reported that the plant density of 1, 33,000 plants per ha gave significantly higher husked, dehusked yield and standard yield of white maize compared to plant densities of 66, 000 and 2,08,000 plant per ha whereas barrenness per cent was significantly higher in plant density of 66,000 plants per ha and fodder yield was significantly higher under density 1, 33, 000 compared to 2, 08, 000 plants per ha.

Long *et al.* (2009) carried out the study on effects of plant density on hybrid white maize production. Four plant densities (two plants/hill): D1 (114,000 plants/ha), D2 (133,000 plantsper ha), D3 (143,000 plants per ha) and D4 (167,000 plantsper ha) and 3 white maize varieties: RL1, RL4 and LVN23 (check) were assigned. At plant density D4 (167000 plantsper ha), total yield, green fodder yield and marketable yield of three hybrids were higher than other densities at significant level of P>95% while remaining at short growth duration and ensured to obtain exportation standard size. RL1 had highest yield (2.37) in plant density D4, higher than LVN23 (1.98) respectively at P>95%.

Shafi *et al.* (2012) conducted this present study to investigate the effect of planting density on plant growth and yield of maize varieties. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white with three plant densities of 45000, 55000 and 65000 plants per ha. Data indicated that planting density had a significant effect on ear length, number of grains ear^{-1}, grain weight ear^{-1}, 1000 grain weight, biological yield, stover yield, grain yield and harvest index. Maximum biological yield, stover yield, grain yield and harvest index was recorded from planting density of 65000 plants per ha. The combined effect of Sarhad white with planting density of 65000 plants per ha produced highest grain weight cob-1, biological yield, stover yield, grain yield and harvest index.

Kheibari *et al.* (2012) conducted an experiment to investigate the “effects of variety and plant density on yield and yield component of corn varieties. Three plant densities (75,000 115,000 and 155,000 plantsper ha) and 3 corn varieties (KSC403su, KSC600 and KSC704) were evaluated. The data on yield parameters influenced significantly by plant density. Plant density of 155,000 plantsper ha with variety KSC403su showed highest yield per ha.

Sarjamei *et al.* (2014) conducted an experiment to investigate the effect of planting method and plant density, on morpho-phenological traits of white maize (Zea mays L.) variety KSC 704. Three levels of plant density (D1: 90,000; D2: 120,000 and D3: 150,000 plantper ha) were initiated. The highest and lowest ear yield belonged to D2 and D1 plant density by 9987 and 8780 kg per ha ear production respectively. D3 produced the highest de husked ear yield by mean of 1969 kg per ha.

Bairagi *et al.* (2015) conducted this experiment to study the effect of crop geometry impacts on growth and yield of white maize (Var. G-5414). Three levels of plant population viz. 45 × 30 cm (S1), 45 × 20 cm (S2) and 45 × 10 cm (S3) were assigned. Corn yield and fodder yield were higher when white maize planted in wider spacing of 45 × 30 cm. whereas, closer spacing of 45 × 10 cm resulted in reduction of both corn and fodder yield per plant. The yield parameters of white maize were clearly indicative that they were thermo- sensitive and white maize cobs and fodder yield are higher at closer spacing.

Singh *et al.* (2015) conducted a field experiment to study the effect of two varieties (VL White maize-1 and HM 4), two spacings (45×25 cm and 60×25 cm) and three sowing dates (1st October, 30th October and 29th November) on performance of white maize (Zea mays L.). The results indicated that the maximum corn yield

(32.55%) and fodder yield (26.21%) was found to be higher from 45×25 cm spacing over 60×25 cm spacing.

Chamroy *et al*. (2017) carried out an experiment entitled "Growth and yield response of white maize (Zea mays L.) to geometry". Four levels of sowing periods (i.e. Last week of Aug., Sept., Oct. and Nov.) and five different crop geometry (30cm × 30cm, 45cm × 15cm, 45cm × 30cm, 60cm × 15cm and 60cm × 30cm) were used. It was observed that the yield attributing characters such as, number of cobs plant-1(3.43), cob weight (9.87 g) and cob yield plant-1 without husk (31.64 g) were found highest in S5 (60 × 30 cm). However, S2 (45 × 15 cm) exhibited the highest yield ha-1 (81.10 q).

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.

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 1st) 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.

Tank (2006) conducted a field experiment in Anand, Gujarat, India during the rabi seasons of 2001-02 to determine the effects of Azospirillum lipoferum inoculation of maize seeds, alone or in combination with N application (0, 60, 120 and 180 kg/ha) at one-third + one-third + one-third, one-half + one-fourth + one-fourth or one-fourth + one-half + one-fourth proportions on the growth and yield of the crop. Inoculation with lipoferum, application of 180 kg N/ha applied and N application at one fourth + one-half + one-fourth proportions gave the highest values for plant height at harvest, number of grains per cob, 1000-grain weight, protein content, grain yield, stover yield, net returns and benefit:cost ratio.

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.

Fertilizer application in proper ratio is one of the cultural practices to boost maize productivity in fields where plant nutrients are deficient. Application of fertilizer along with other agronomic practices regulates the grain number and grain weight. It has been reported in the earlier publications that a modern hybrid maize with moderate yield potential takes up 287 kg N, 50 kg P, 167 kg K, 26 kg S, 8 kg Zn and 1.3 kg B per ha. (Ullah *et al.,* 2016).

CHAPTER 3
MATERIALS AND METHODS

The field experiment was conducted during kharif-2 season from the month of May 2019 to September 2019 to study the influence of fertilizer dose and different spacing on the yield performance white maize (SAUWM 9-3-3). The materials and methodology followed this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The experiment was done at Sher-e-Bangla Agricultural University. It lies in Madhupur Tract (AEZ 28). The land was 8.6 m above from the sea level. For better understanding about experimental site it is shown in the Map of AEZ of Bangladesh in (Appendix- I).

3.2 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and little rainfall associated with moderately low temperature during the Rabi season (October-March).

3.3 Soil

The field belongs to the general soil type which was characterized by shallow red brown terrace soil. The selected experimental plot was medium high under the Tejgaon series. There was available sunshine during the experimental period. The top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. The physico-chemical properties of soil is presented in (Appendix II.)

3.4 Planting materials

For this research work, the seeds of white maize (SAUWM 9-3-3) were collected from the Department of Agronomy, Sher-e-Bangla Agricultural University. The purity and germination percentage were lebelled as around 96, respectively.

3.5 Factors and treatments of the experiment

The experiment consisted of two factors as follows:

Treatment Factor A: fertilizer doses-

a) F_1=Recommended doses of fertilizer (RDF)

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

c) F_3 = 25% more than recommended doses of fertilizer

Factor B: Spacing

a) S_1 = 60 cm × 25cm

b) S_2 = 50cm× 25 cm

c) S_3 = 40 cm× 25cm

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. Total 27 unit plots were made for the experiment with 9 treatments. Each plot size was 6.16 m^2 (2.8 m × 2.2 m).The number of replication were 3. The doses of fertilizer and spacing of the experiment were assigned randomly for each replication.

3.7 Preparation of the main field

The experimental plot was opened in the first week of April 2019 with a power tiller, and was exposed to the sunlight for a week, after one week the land was ploughing by using harrows and also cross-ploughed several times followed by laddering to obtain a good tilth condition. Finally, weeds and stubbles were removed to obtains a desirable tilth condition of soil for planting of maize seeds. The experimental plot was divided into the unit plots in accordance with the experimental design. Adequate amounts of chemical fertilizers were applied in each plot as per treatment as mentioned in the above section 3.5 and the used rate of fertilizers was indicated in section 3.8.

3.8 Application of manures and fertilizers

The recommended amounts of chemical fertilizers as Urea, TSP, MoP, Gypsum, Boric acid and Zinc sulphate were applied as per treatments at the rate of 500-250-200-250-10 and 7 kg ha^{-1} according to the treatments. The whole amounts of fertilizers were applied as basal doses except Urea. The total amount of nitrogenous fertilizer in the form of urea was divided into three equal portions; one third urea was applied during final land preparation. The rest two portions of nitrogenous fertilizer were applied as split doses as side dressing at 25 DAS and 45 DAS, respectively.

3.9 Seed sowing

The selected healthy white maize seeds were sown in lines maintaining plant to plant and row to row distance as per treatments having 2 seeds $hole^{-1}$ under direct sowing (dibbling method) in the well prepared plot on 12 May, 2019.

3.10 Intercultural operations

3.10.1 Irrigation

First irrigation was given on 18th May, 2019 which was at 7 days after sowing. Second irrigation was given on 12th June, 2019 which was at 30 days after sowing. Third irrigation was given on, 17th July, 2019 which was at 65 days after sowing.

3.10.2 Gap filling, thinning and weeding

Gap filling was done on 22nd May, 2019 which was at 10 days after sowing. During plant growth period one thinning and two successive weeding were done, thinning was done on 26th May, 2019 which was at 14 days after sowing and the weeding was done on 2nd June, 2019 and 27th June, 2019 which were at 20 and at 45 days after sowing.

3.10.3 Earthing up

Earthing up is a major intercultural operation for better growth, establishment and initiation of crown root of white maize. It was done on 7th June, 2019 which was at 25 days after sowing. It was done to protect the plant from lodging and for better growth and nutrition uptake.

3.10.4 Major diseases and management

Diseases: Mainly leaf blight disease infest at vegetative stage. Management: Clean cultivation with timely sowing and balanced fertilizer application when needed. Seed treatment with Sevin WP 85@ 2.5g kg^{-1} seed and burning of crop residues.

3.10.5 Plant protection measures

Insecticides were used to control stem borer named Cypermethrin (Ripcord 10 EC/Cymbush 10 EC) @ 2 ml litre^{-1} water sprayed to control this pest.

3.11. Harvesting

On 4th August, 2019, the cobs of five randomly selected plants of each plot were separately harvested with entire plants for recording yield attributes and other data. The five cobs were harvested for recording cob yield and other data. The crops were harvested when the husk cover was completely dried. The inner two line plants were harvested for recording grain yield and stover yield.

3.12 Drying

The fresh harvested plants were taken on the threshing floor and it was dried for about 4-5 days.

3. 13. Data collection

At harvesting, 5 plants were selected randomly from each plot to record the following data:

i. Plant height (cm)

ii. Number of leaves plant^{-1}

iii. Leaf area index

iv. Crop growth rate (g m^{-2} d^{-1})

v. Cob length (cm)

vi. Cob circumference (cm)

vii. Number of grains cob^{-1}

viii. 100 grains weight (g)

ix. Grain yield (t ha^{-1})

x. Stover yield (t ha^{-1})

xi. Biological yield (t ha^{-1})

xii. Harvest index (%)

3.13.1 Plant height

At different stages of crop growth (45, 75 DAS and at harvest), the height of five randomly selected plants from the inner rows per plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in note book in cm.

3.13.2 Number of leaves plant^{-1}

Number of leaves of 5 randomly selected plants were counted and recorded. Average value of 5 plants was recorded as number of leaves per plant.

3.13.3 Leaf Area Index

Leaf area index were estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a co-relation factor of 0.70 (Kluen and Wolf, 1986). It was done at 90 days after sowing (DAS).

$$\text{Leaf area index} = \frac{\text{Surface area of leaf sample (m}^2\text{) x correction factor}}{\text{Ground area from where the leaves are collected}}$$

3.13.4 Crop Growth Rate

The crop growth rate values at different growth stages were calculated using the following formula (Beadle, 1987).

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

Surface area of leaf sample (m^2) x correction factor

Ground area from where the leaves are collected

GA= Ground area (m^2)

3.13.5 Cob length

Five randomly selected cobs were taken from each plot to measure the length from the base to the tip of the ear. The average result was recorded in note book in cm.

3.13.6 Cob circumference

Five cobs were randomly selected plot^{-1} and the circumference was taken from each cob. Then average result was recorded in notebook in cm.

3.13.7 Number of grains cob^{-1}

The number of grains cob^{-1} was measured from the base to tip of the ear collected from five randomly selected cobs of each plot and finally averaged.

3.13.8 100 grain weight

From the seed stock of each plot 100 seeds were counted and the weight was measured by an electrical balance. It was also recorded in gram.

3.13.9 Shelling percentage

Five cobs were randomly selected plot^{-1} and shelling percentage was calculated by using the following formula –

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} X100$$

3.13.10 Grain yield

Grain yield was calculated from cleaned as well as well dried grains collected from the 6.16 m^2 area of all 2 inner rows of the each plot and expressed as ton ha^{-1}.

3.13.11 Stover yield

Stover yield was also calculated from the 6.16 m^2 of all 2 inner rows. After threshing, the sub sample was oven dried to a constant weight and finally converted to ton ha^{-1}

3. 13. 12 Biological yield

It was the total yield including both the economic and stover yield.

3.13 Harvest index (HI)

Harvest index is the ratio of economic (grain) yield and biological yield. It was calculated by dividing the economic yield grain from the harvested area by the biological yield of the same area (Donald, 1963) and multiplying by 100.

$$\text{Harvest index}(\%) = \frac{\text{Grain yield}}{\text{Biological yield}} \text{X}100$$

Here, Biological yield (ton ha^{-1}) = Grain yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.14 Statistical analysis

The obtained data for different characters were statistically analyzed with the computer based software Statistix 10 to evaluate the performance of white maize variety under different spacing and nitrogenous fertilizer management as well as the mean values of all characters were evaluated and analysis of variances were performed by the F value test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

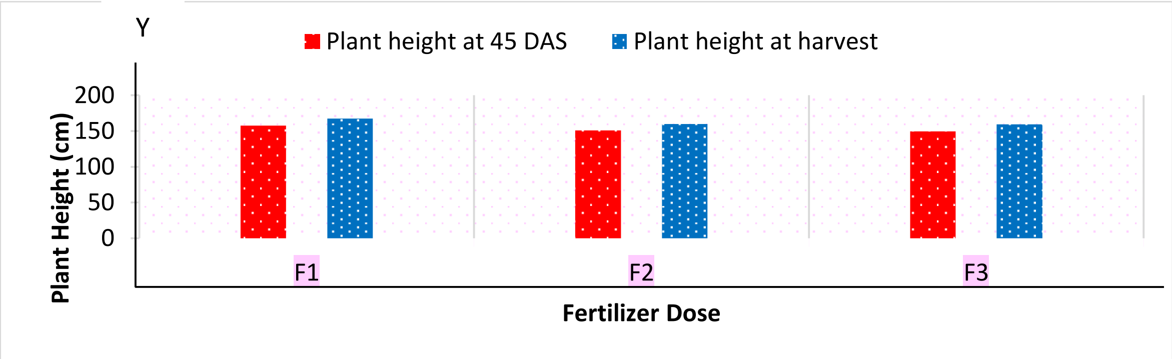
The study was conducted to determine the influence of fertilizer and spacing on the yield performance of white maize. Data on different growth, yield contributing characters and yield were recorded to find out of the optimum level of fertilizer and spacing for successful white maize production. Results obtained from the study have been presented and discussed in this chapter.

4.1 Growth parameters

4.1.1 Plant height

Effect of fertilizer

There was a significant variation on plant height of white maize influenced by different fertilizer levels (Fig. 1 and Appendix III). Results revealed that the highest plant height at vegetative and harvesting stage (157.48 cm and 167.41 cm respectively) was found from the treatment F_1 (RDF). Likewise, the lowest plant height at vegetative and harvesting stage (159.5 cm and 149.6 cm, respectively) was recorded from the treatment F_3 (25% more than RDF) which was statistically identical with the treatment F_2 (25% less than RDF). Similar result on plant height was also observed by Ullah (2016), Pinjari (2007), Chillar and Kumar (2006), Gawade (1998) and Patil (1997).



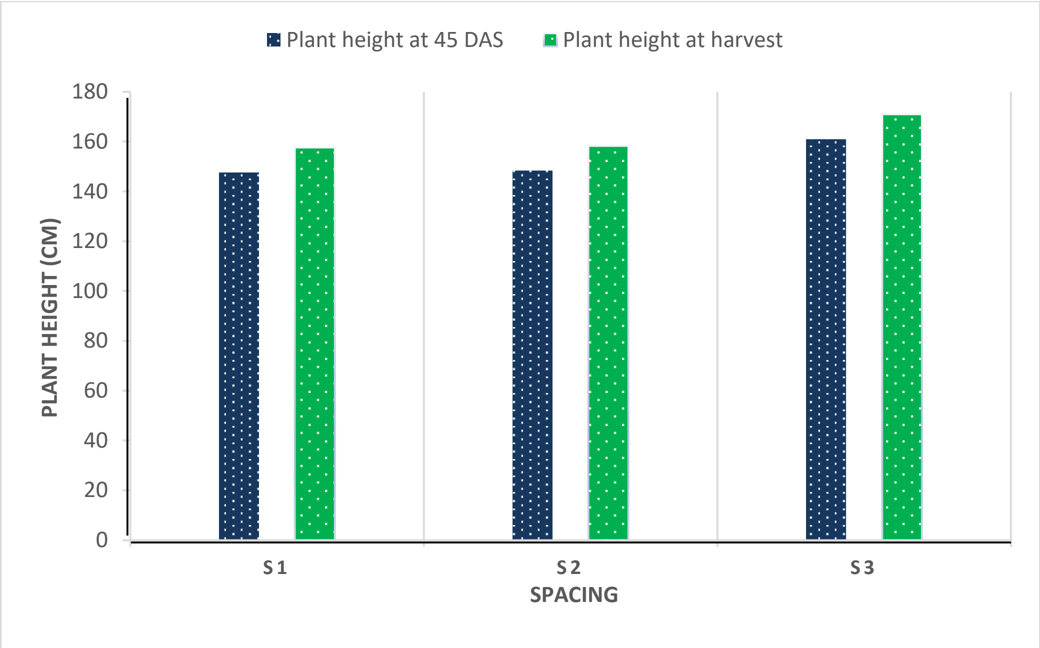
Here, F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

X

Figure 1: **Performance of plant height of white maize as influenced by different levels of fertilizer** ($LSD_{0.05}$ = 1.902 at 45 DAS and 0.821 at harvest).

Effect of spacing

Plant height was significantly influenced by different plant spacing of white maize (Fig. 2 and Appendix III). Results indicated that the highest plant height at vegetative and harvesting stage (160.97 cm and 171.01 cm, respectively) was found from the plant spacing S_3 (40 cm × 25 cm). The lowest plant height at vegetative and harvesting stage (147.55 cm and 157.5 cm, respectively) was obtained from the plant spacing S_1 (60 cm × 25 cm). The spacing S_2 (50 cm × 25 cm) showed intermediate height as compared to S_1 and S_3. Zarapkar (2006) also found that plant height was significantly higher under the closer spacings. Similar result was also observed by Chamroy *et al.* (2017).



S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Figure 2. **Plant height of white maize at vegetative and harvesting stage as influenced by different plant spacing** ($LSD_{0.05}$ = 1.109 at 45 DAS and 1.102 at harvest)

Combined effect of fertilizer and spacing

Plant height was significantly influenced by the combination of different levels of nitrogen and spacing at different growth stages of white maize (Table 1). Nitrogen F_2 (25% less than RDF) along with S_3 (40 cm × 25 cm) gave the tallest plant; 166.10 cm and 176.11 cm at 45 DAS and at harvest, respectively, which was statistically similar with F_1S_3 (165.89 cm and 175.67 cm, respectively) at 45 DAS and at harvest. The treatment combination F_2S_2 gave the lowest plant height at 45 DAS and at harvest (140.22 cm and 150.23 cm, respectively). The result finding under the present study was in conformity with Ogbaji (2003) and Ullah (2017).

Table 1: Performance on plant height of white maize as influenced by interaction of fertilizer levels and spacing

Interaction (fertilizer x spacing)	Plant height (cm) at 45 DAS	Plant height (cm) at harvesting
F_1S_1	151.01 c	161.0 c
F_1S_2	155.57 b	165.56 b
F_1S_3	165.89 a	175.67 a
F_2S_1	142.43 d	152.44 e
F_2S_2	140.22 e	150.23 f
F_2S_3	166.10 a	176.11 a
F_3S_1	149.21 c	159.22 d
F_3S_2	149.44 c	159.11 d
F_3S_3	150.92c	161.25 c
$LSD_{(0.05)}$	**2.447**	**1.754**
CV%	**0.71**	**0.66**

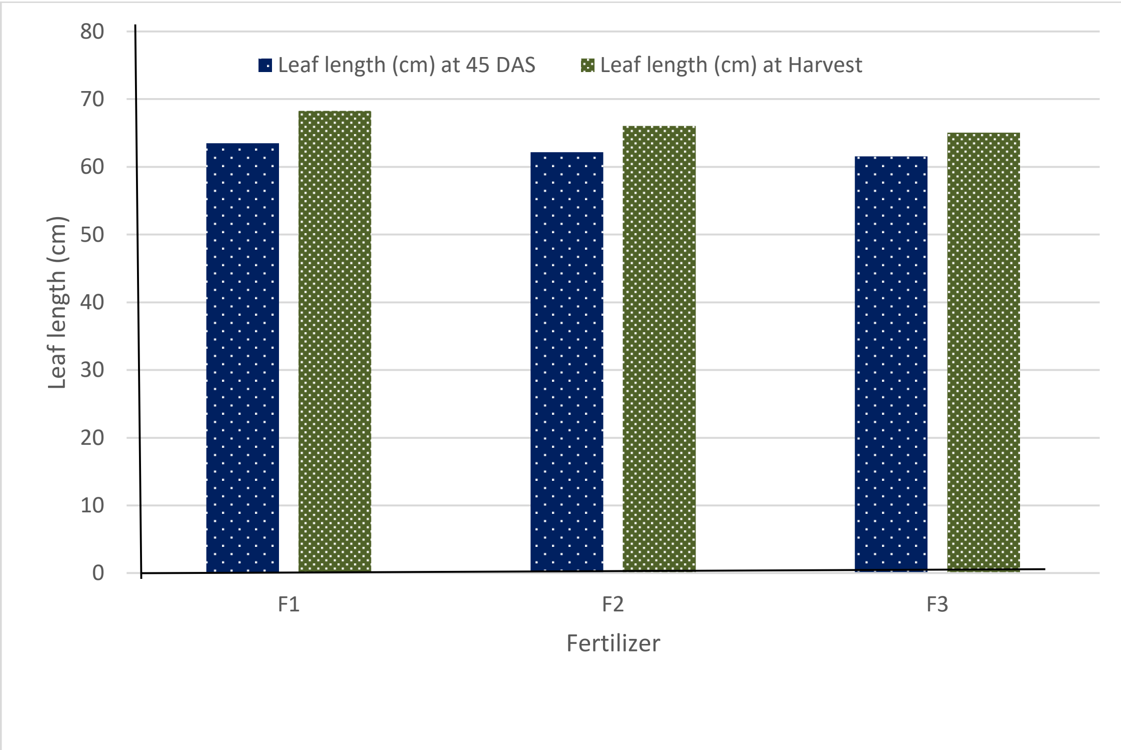
F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF,

F_3 = 25% higher than RDF and S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.1.2 Average leaf length (cm):

Effect of fertilizer

There was significant variation on leaf length (cm) of white maize influenced by different fertilizer levels (Fig. 3 and Appendix IV). Results revealed that the highest leaf length (63.5 cm and 68.28 cm, respectively) at vegetative and harvesting stage was found from the treatment F_1 (RDF). Likewise, the lowest leaf length (61.58 cm and 65.08 cm, respectively) at vegetative and harvesting stage was recorded from the treatment F_3 (25% higher than RDF) which was statistically identical with the treatment F_2 (25% lower than RDF).



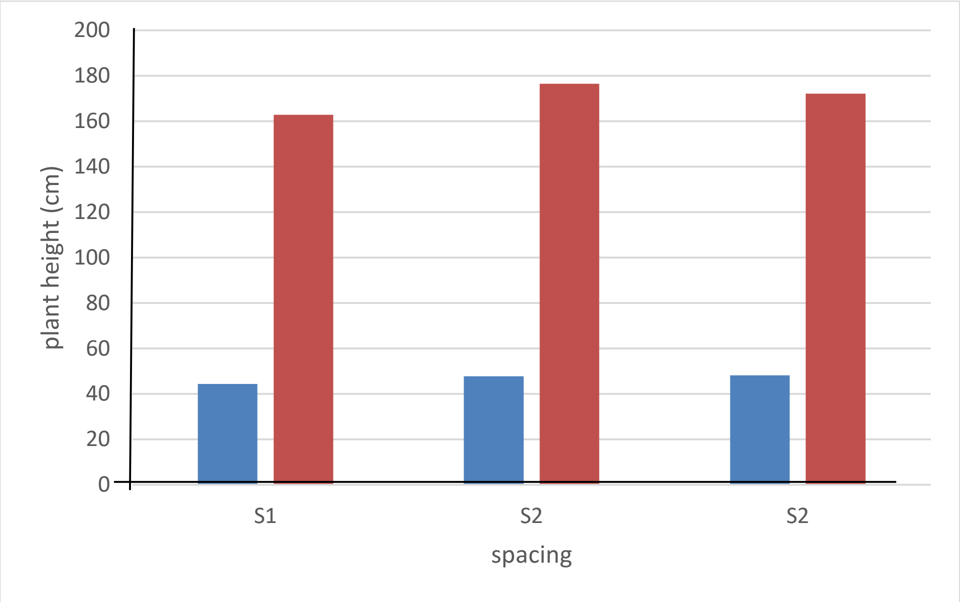
F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF,

F_3 = 25% higher than RDF

Figure 3: **Leaf length of vegetative and harvesting stage influenced by different levels of fertilizer** ($LSD_{0.05}$ = 1.187 at 45 DAS and 0.689 at harvest)

Effect of spacing

Leaf length was significantly influenced by different plant spacing of white maize (Fig. 4 and Appendix IV). Results indicated that the highest Leaf length at vegetative and harvesting stage (63.07 cm and 66.63 cm, respectively) was found from the plant spacing S_1 (60 cm × 25 cm). The lowest leaf length at vegetative and harvesting stage (62.01 cm and 66.33 cm, respectively) was obtained from the plant spacing S_3 (40 cm × 25 cm).



S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Figure 4. **Leaf length of white maize at vegetative and harvesting stage influenced by different plant spacing** ($LSD_{0.05}$ = 1.039 at 45 DAS and 0.093 at harvest)

Combined effect of fertilizer and spacing

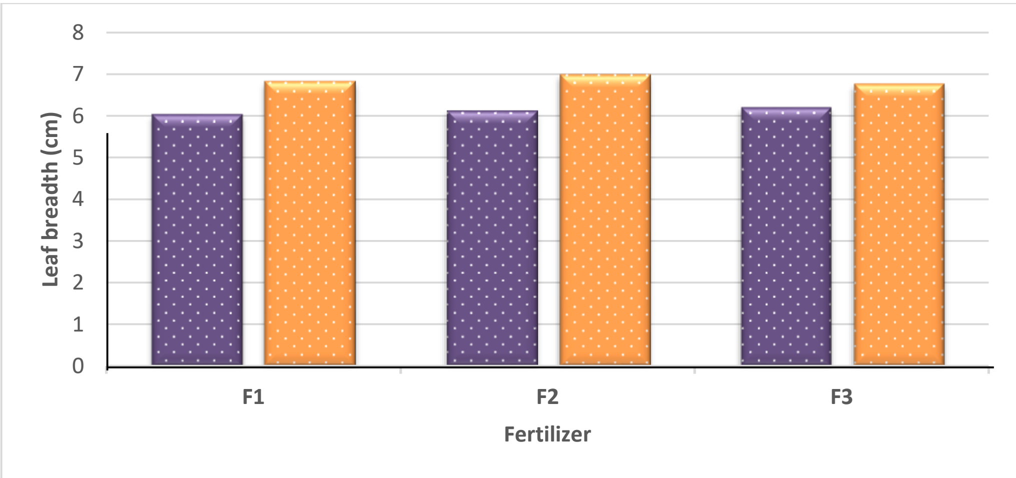
Leaf length was significantly influenced by the combination of different levels of nitrogen and spacing at different growth stages of white maize (Table 2). Fertilizer F_2

(25% lower than RDF) along with S_1 (60 cm × 25 cm) gave the tallest leaf; 65.01 cm and 70.10 cm at 45 DAS and at harvest, respectively, which was statistically similar with F_1S_3 (165.89 cm and 175.67 cm, respectively) and F_1S_2 (63.50 cm and 67.81 cm, respectively) at 45 DAS and at harvest. The treatment combination of F_2S_3 gave the lowest plant height at 45 DAS and at harvest (60.01 cm and 62.34 cm, respectively)

4.1.3 Average leaf breadth (cm):

Effect of fertilizer

There was no significant variation on leaf breadth of white maize influenced by different fertilizer levels (Fig. 5 and Appendix IV). Results revealed that the highest leaf breadth (6.99 cm) at harvesting stage was found from the treatment F_2 (25% less than RDF) but the highest leaf breadth (6.20 cm) at vegetative stage was found at F_3 treatment. Likewise, the lowest leaf breadth (6.04 cm) at vegetative stage and (6.77 cm) at harvesting stage was recorded from the treatment F_1 (RDF) and F_3 (25% more than RDF) which was statistically identical with the treatment F_2 (25% less than RDF).

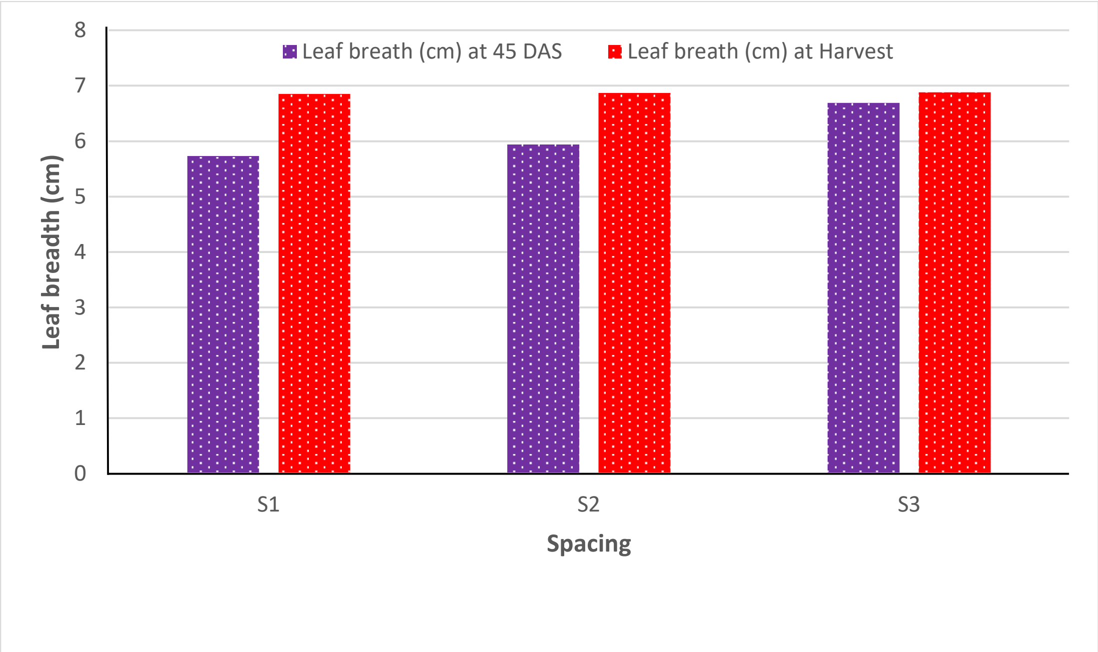


F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

Figure 5: **Leaf breadth of white maize vegetative and harvesting stage as influenced by different levels of fertilizer** ($LSD_{0.05}$ = 1.205 at 45 DAS and 0.444 at harvest)

Effect of spacing

Leaf breadth was significantly influenced by different plant spacing of white maize (Fig. 6 and Appendix IV). Results indicated that the highest leaf breadth at vegetative and harvesting stage (6.69 cm and 6.88 cm, respectively) was found from the plant spacing S_3 (40 cm × 25 cm). The lowest leaf length at vegetative and harvesting stage (5.73 cm and 6.85 cm, respectively) was obtained from the plant spacing S_1 (60 cm × 25 cm).



S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Figure 6. **Leaf breadth of white maize at vegetative and harvesting stage as influenced by different plant spacing** ($LSD_{0.05}$ = 0.710 at 45 DAS and 0.646 at harvest)

Combined effect of fertilizer and spacing

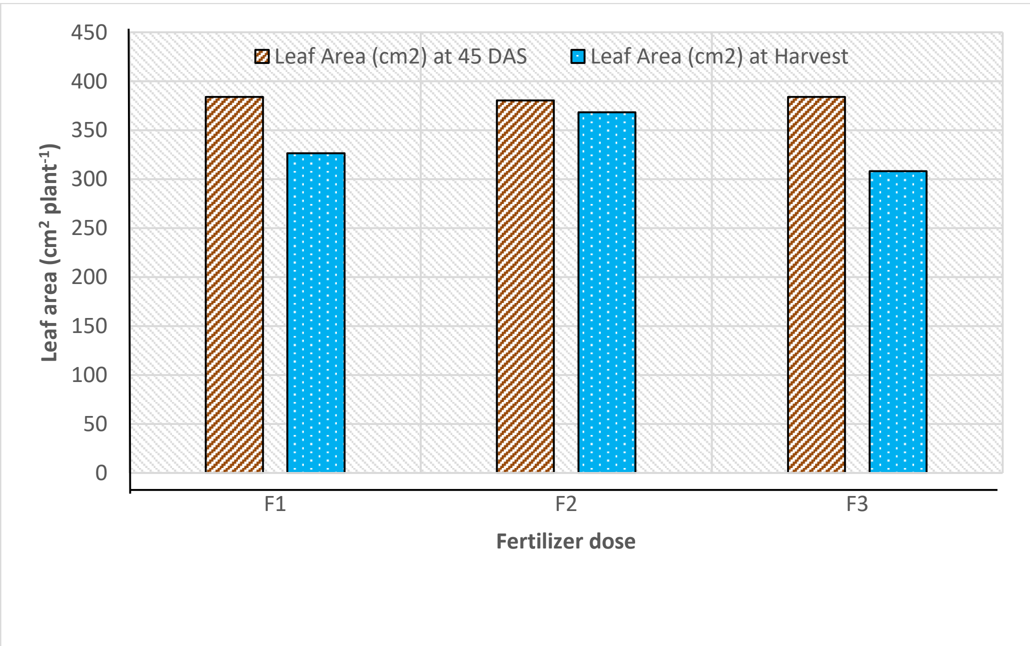
Leaf breadth was significantly influenced by the combination of different levels of fertilizer and spacing at different growth stages of white maize (Table 2). Fertilizer F_1 (RDF) along with S_3 (40 cm × 25 cm) gave the highest breadth of leaf (7.17 and 7.04 cm) at 45 DAS and at harvest respectively which was statistically similar with F_3S_3,

F_2S_2, F_3S_2, and F_2S_3 at 45 DAS and at harvest. The treatment combination F_1S_2 gave the lowest leaf breadth at 45 DAS and F_1S_1 gave the lowest leaf breadth at harvest

4.1.4 Average Leaf Area (cm^2 plant^{-1}):

Effect of fertilizer

There was no significant variation on leaf area of white maize influenced by different fertilizer levels at 45 DAS (Fig.7 and Appendix IV) but the results revealed that the highest leaf area (384.03 and 368.36 cm^2) at vegetative and harvesting stage was found from the treatment F_2 (25% less than RDF). Likewise, the lowest leaf area (381.95 and 308.39 cm^2) at vegetative and harvesting stage was recorded from the treatment F_3 (25% higher than RDF) which was statistically identical with the treatment F_1 (RDF).

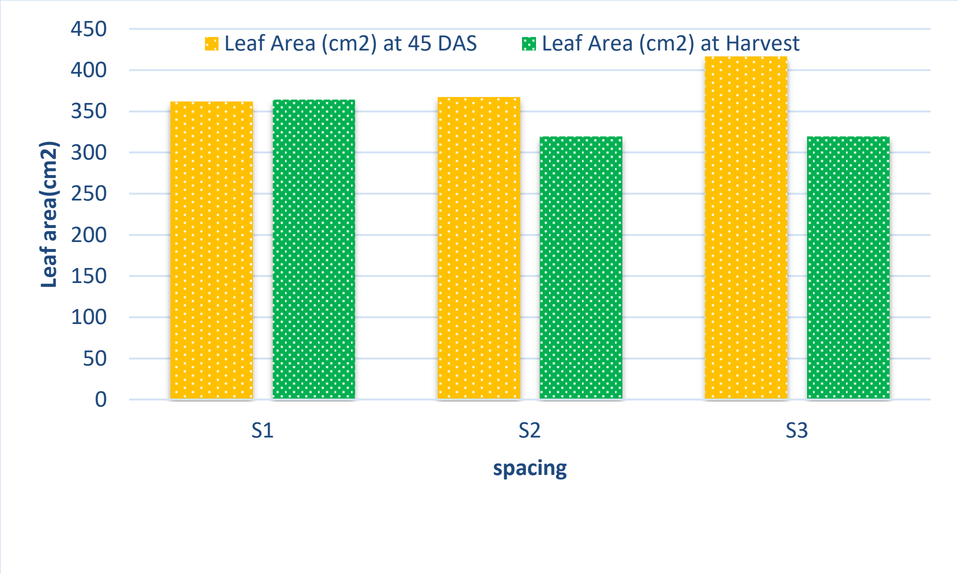


F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

Figure: 7: **Leaf area of white maize at vegetative and harvesting stage as influenced by different levels of fertilizer** ($LSD_{0.05}$ = 77.78 at 45 DAS and 50.76 at harvest)

Effect of spacing

Leaf area was significantly influenced by different plant spacing of white maize (Fig. 8 and Appendix IV). Results indicated that the highest leaf area at vegetative and harvesting stage (416.73 and 319.43 cm^2) was found from the plant spacing S_3 (40 cm × 25 cm). The lowest leaf area at vegetative and harvesting stage was obtained from the plant spacing S_1 (60 cm × 25 cm).



S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Figure 8. **Leaf area of white maize at vegetative and at harvesting stage as influenced by different plant spacing** ($LSD_{0.05}$ =41.20 at 45 DAS and 39.69 at harvest)

Combined effect of fertilizer and spacing

Leaf area was significantly influenced by the combination of different fertilizer levels and spacing at different growth stages of white maize (Table 2). Nitrogen F_1 (RDF) along with S_3 (40 cm × 25 cm) gave the highest area of leaf (458.95 cm^2) at 45 DAS and F_2S_1 (485.80 cm^2) at harvest respectively which was statistically similar with F_2S_1, F_2S_2, F_2S_3,F_3S_2 and F_3S_3 at 45 DAS. The treatment combination of F_3S_1 (339.91) gave the lowest leaf area at 45 DAS.

Table 2: **Performance on leaf length (cm) of white maize as influenced by interaction of fertilizer levels and spacing**

Interaction	**Leaf parameters at 45 DAS and at Harvest**					
	Average leaf length (cm)		**Average leaf breadth**		**Average area/leaf, cm^2**	
	At 45 DAS	**At harvest**	**At 45 DAS**	**At harvest**	**At 45 DAS**	**At harvest**
F_1S_1	63.01 bc	67.44 b	5.55 c	6.64	363.89 bc	313.69 b
F_1S_2	63.50 ab	67.81 b	5.19 c	6.81	329.26 c	323.15 b
F_1S_3	64.01 ab	69.59 a	7.17 a	7.04	458.95 a	342.99 b
F_2S_1	65.01 a	70.10 a	5.88 abc	7.19	382.53 abc	485.80 a
F_2S_2	61.50 cde	65.83 c	6.41 abc	6.99	393.82 abc	322.21 b
F_2S_3	60.01 e	62.34 d	6.08 abc	6.81	364.88 abc	297.08 b
F_3S_1	61.2 cde	62.44 d	5.56 c	6.71	339.91 c	293.35 b
F_3S_2	61.03 de	65.74 c	6.22 abc	6.81	379.62 abc	313.59 b
F_3S_3	62.51 bcd	67.07bc	6.82 ab	6.78	426.32 ab	318.21 b
$LSD_{(0.05)}$	**1.877**	**1.48**	**1.557**	**1.01**	**96.49**	**75.15**
CV%	**1.62**	**1.37**	**11.30**	**9.17**	**10.50**	**11.55**

F_1 = Recommended doses of fertilizer (RDF) S_1 = 60 cm × 25 cm

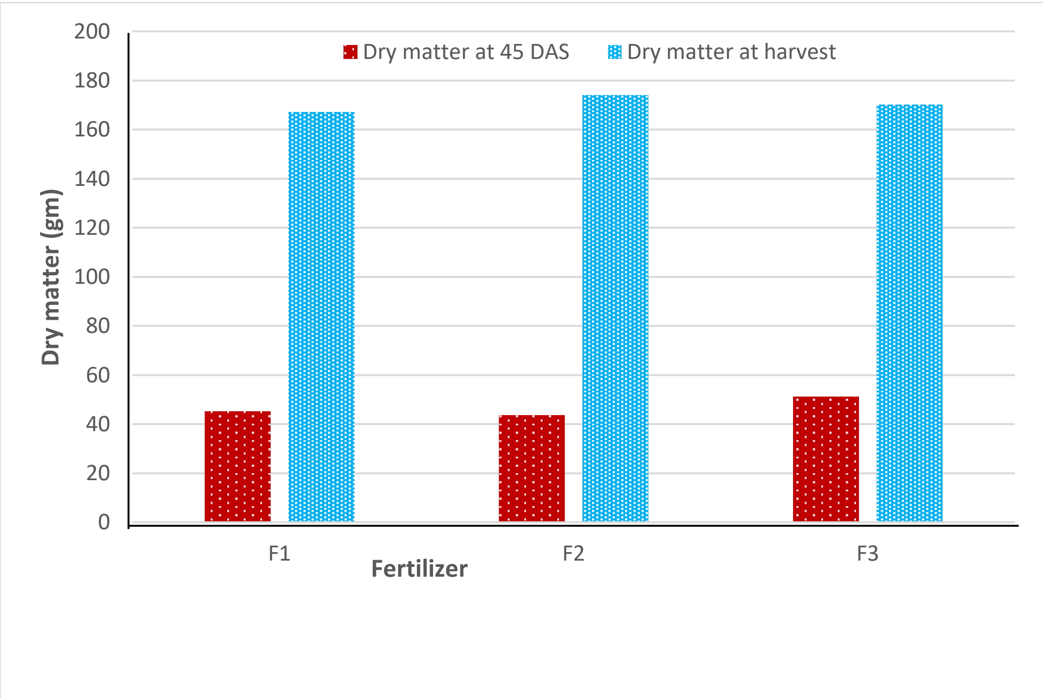
F_2 = 25% less than RDF S_2 = 50 cm × 25 cm

F_3 = 25% Higher than RDF S_3 = 40 cm × 25 cm

4.1.5 Total dry matter plant^{-1}

Effect of fertilizer

Dry weight plant^{-1} was found as significant among the treatments with the application of different fertilizer doses (Fig. 9 and Appendix V). Results indicated that the highest dry weight plant^{-1} at harvest (174.08 g) was found from the treatment F_2 (25% less than RDF). The lowest dry weight plant^{-1} at harvest (167.26 g) was recorded from the treatment F_1 (RDF). At 45 DAS the highest and the lowest dry weight (51.21 and 43.66 gm, respectively) was obtained from F_3 and F_2 treatments. The result on dry weight plant^{-1} obtained from the present study was similar with the findings of Pinjari (2007), Ullah (2017) Gawade (1998) and Patil (1997).

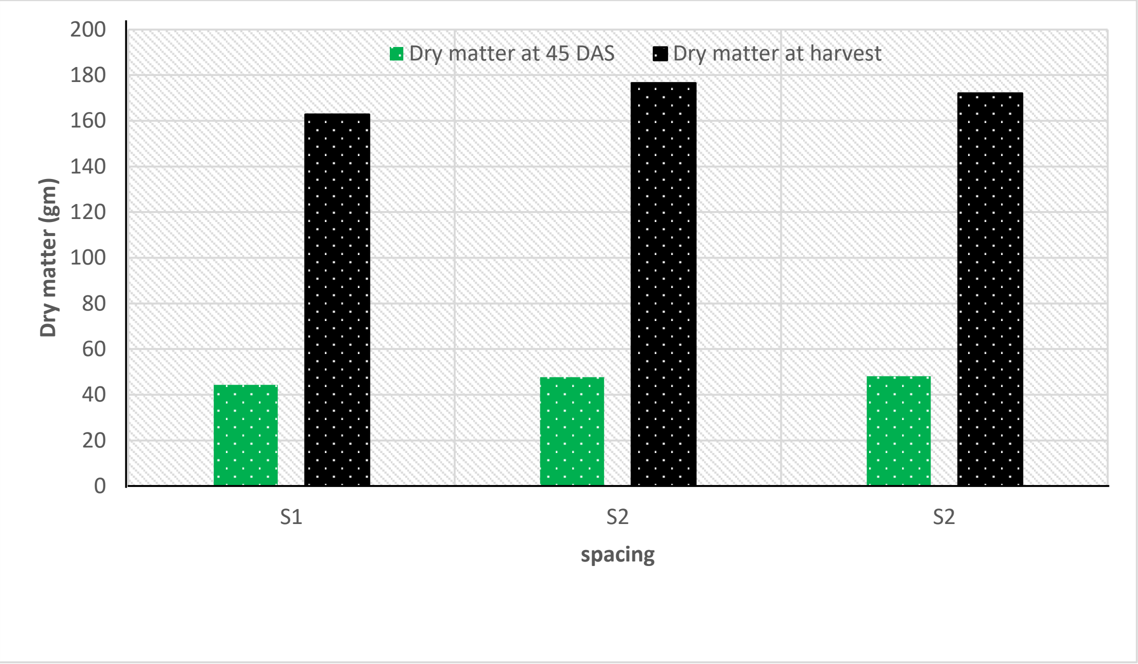


F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

Figure 9: **Total dry matter weight of white maize as influenced by different levels of fertilizer** ($LSD_{0.05}$ = 3.96 at 45 DAS and 2.864 at harvest)

Effect of spacing

Significant variation on dry weight plant^{-1} among the spacing was noted (Fig. 10 and Appendix V). It was observed that the highest dry weight plant^{-1} at 45 DAS and at harvest (48.12g and 176.52 g, respectively) was found from the plant spacing S_3 (40 cm × 25 cm) and S_2 (50 cm×25 cm). The lowest dry weight plant^{-1} at 45 DAS and at harvest (44.36g and 162.87g, respectively) was obtained from the plant spacing S_1 (60 cm × 25 cm). Zarapkar (2006) also found that dry matter accumulation plant^{-1} was higher in case of wider spacing compared to closer spacing. Similar results was also observed by Bairagi *et al*. (2015) and Chamroy *et al*. (2017).



S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Figure 10. **Total dry weight of white maize as influenced by different plant spacing** ($LSD_{0.05}$ = 4.41 at 45 DAS and 2.779 at harvest)

Combined effect of fertilizer and spacing

Significant variation was remarked on dry weight plant^{-1} as influenced by combined effect of fertilizer and spacing (Table 3 and Appendix V). It was found that the highest dry weight plant^{-1} at 45 DAS and at harvest (57.13 g and 182.74 g) was achieved from the treatment combination of F_3S_1 and F_2S_2 respectively, which was statistically similar with the treatment combination of F_1S_1, F_3S_2 at 45 DAS. The lowest dry weight plant^{-1} (43.66 g) was obtained from the treatment combination of F_1S_3 followed by the treatment combination of F_1S_2 and F_2S_1.

Table 3: Dry matter (gm) of white maize at 45 days and at harvest as influenced by interaction of fertilizer doses and spacing

Interaction (fertilizer×spacing)	Total dry matter at 45 DAS and at harvest (g)	
	At 45 days	**At harvest**
F_1S_1	51.73 ab	156.89 e
F_1S_2	44.33 bc	167.33 d
F_1S_3	39.7 cd	177.55 b
F_2S_1	35.65 d	159.07 e
F_2S_2	47.8 b	182.74 a
F_2S_3	47.55 b	180.44 ab
F_3S_1	45.7 bc	172.64 c
F_3S_2	50.81 ab	179.50 ab
F_3S_3	57.13 a	158.27 e
$LSD_{(0.05)}$	**7.35**	**4.83**
CV%	**9.19**	**1.59**

F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2 Yield contributing parameters

4.2.1 Cob length

Effect of fertilizer

Cob length of white maize was significantly affected by different levels of nitrogen application (Table 4 and Appendix VI). It was observed that the longest cob (16.99 cm) was found with F_2 (25% less than RDF) where the shortest (15.03 cm) was obtained with F_1 (RDF).

Effect of spacing

Different spacing had significant effect on cob length of white maize (Table 4 and Appendix VI). Results represented in Table 4 indicated that the longest cob (17.20cm) was attained with S_2 (50 cm × 25 cm) where the shortest (14.45 cm) was found with S_1 (60 cm × 25 cm).The another treatment, S_3 (40 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of cob length.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the cob length of white maize (Table 4 and Appendix VI). Results in table 4 showed that the longest cob (18.45 cm) was observed with the combined effect of F_2S_2. On the other hand the shortest cob length (13.34 cm) was observed by F_1S_1. The results obtained from all other treatments were significantly different from the highest and the lowest value of cob length.

4.2.2 Cob circumference (cm)

Effect of fertilizer

Cob circumference of white maize was not significantly affected by different levels of nitrogen application (Table 4 and Appendix VI). It was observed that the longest cob (13.35 cm) was found with F_1 (RDF) where the lowest (12.673 cm) was obtained with F_2 (25% less than RDF).

Effect of spacing

Different spacing had significant effect on cob circumference of white maize (Table 4 and Appendix VI). Results represented in table 4 indicated that the longest cob (14.02cm) was attained with S_1 (60 cm × 25 cm) where the shortest (12.56 cm) was found with S_2 (50 cm × 25 cm). The another treatment, S_3 (40 cm × 25 cm) showed similar results in respect of the lowest value of cob circumference.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing was not significantly influenced the cob circumference of white maize (Table 4 and Appendix VI). Results in table 4 showed that the longest cob circumference (14.90 cm) was found with the combined effect of F_3S_1. On the other hand the shortest cob circumference (11.87 cm) was observed by F_3S_2. The results obtained from all other treatments were significantly different from the highest and the lowest value of cob circumference.

4.2.3 Number of rows cob^{-1}

Effect of fertilizer

Number of rows cob^{-1} showed positively significant result due to application of fertilizer (Table 4 and Appendix VI). The number of rows cob^{-1} ranged from 12.67 to 13.52. The maximum number of rows cob^{-1} was recorded in F_2 treatment (13.52) and minimum number of rows cob^{-1} was recorded in F_3 treatment (12.67). This might be due to the proper supply of nutrient from F_2 treatment facilitated proper reproductive growth of plant. The present result is agreed with the findings of Woldesenbet and Haileyesus (2016), Maqbool *et al*. (2016).

Effect of spacing

The number of rows cob^{-1} showed statistically non-significant impact due to different spacing of white maize cultivation (Table 4 and Appendix VI). Although having non-significant influence of spacing the maximum number of rows cob^{-1} was recorded in S_2 (13.33) while the minimum number of rows cob^{-1} was recorded in S_1 (12.96). The numbers of rows cob^{-1} ranges from 12.96 to 13.33. The present finding is disagreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013) and Sangoi *et al*. (2001).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant effect number of rows cob^{-1} in white maize (Table 4 and Appendix VI). For combined effect number of rows cob^{-1} ranges from 12.56 to 13.67. The maximum number of rows cob^{-1} was found in F_2S_2 (13.67) and minimum number of rows cob^{-1} was found in F_3S_3 combination (12.56) compared to the others combination.

4.2.4 Number of grains row^{-1}

Effect of fertilizer

Number of grains row^{-1} showed significant difference at different doses of fertilizer application (Figure 4 and Appendix VI). Due to application of different levels of fertilizer, the range of number of grain row^{-1} was found 22.03 to 24.67. The maximum numbers of seeds grain row^{-1} was recorded in F_2 (24.67) while the minimum number of grain row^{-1} (23.04) was recorded in F_1. This might be due to adequate nutrient was in F_2 treatment. The present result supported by the study of Crista *et al*. (2014) and Nasim *et al*. (2012).

Effect of spacing

Spacing on white maize showed significant variations for number of grain row^{-1} (Table 4 and Appendix VI). The table showed that grain row^{-1} increased at the intermediate spacing S_2 (50 cm× 25cm). However, the lowest seeds line^{-1} was found in highest spacing S_1 (60 cm × 25cm). The seeds number ranges from 22.52 to 24.70. 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).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant impact on number of grain row^{-1} of white maize (Table 4 and Appendix V). Number of seeds line^{-1} ranges from 21.78 to 25.89 while F_2S_2 (50% less than recommended doses of fertilizer and (50 cm× 25cm) combination produced the maximum number of grain row^{-1} (25.89) and F_1S_1 (recommended doses of fertilizer and 60 cm × 25cm) combination produced minimum number of grain row^{-1} (21.78).

4.2.5 Grains cob^{-1}

Effect of fertilizer

Number of grains cob^{-1} of white maize was significantly affected by different levels of nitrogen application (Table 4 and Appendix VI). It was observed that the highest number of grains cob^{-1} (333.94) was found with F_2 (25% less than RDF) which was significantly different from F_1 (RDF) and F_3 (25% more than RDF). But the lowest number of grains cob^{-1} (293.93) was obtained with F_3 (25% more than RDF). The other fertilizer treatments; F_1 showed similar results compared to the lowest value of grains cob^{-1}. Similar findings was observed by Tank (2006) and Ghulam, A. (2005).

Effect of spacing

Different spacing had significant effect on grains cob^{-1} of white maize (Table 4 and Appendix VI). Results represented in table 4 indicated that the highest grains cob^{-1} (329.81) was found with S_2 (50 cm × 25 cm) where the lowest (292.15) was obtained with S_1 (60 cm × 25 cm).The another treatment, S_3 (40 cm × 25 cm) showed statistically similar results with S_1.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the grains cob^{-1} of white maize (Table 4 and Appendix VI). Results in table 4 showed that the highest number of grains cob^{-1} (354.54) was achieved with the combined effect of F_2S_2 where the lowest number of grain cob^{-1} (279.22) was observed in F_3S_1.

Table 4: Yield contributing parameters of white maize as influenced by interaction of fertilizer and spacing

Treatment	Yield contributing parameters				
	Cob length (cm)	Cob circumference(cm)	Number of rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}
Effect of fertilizer					
F_1	15.03 c	13.35 a	13.14 b	23.03 b	303.02 b
F_2	16.97 a	12.67 a	13.52 a	24.67 a	333.94 a
F_3	15.43 b	13.21 a	12.67 c	23.18 b	293.93 b
$LSD_{(0.05)}$	0.33	1.15	0.33	1.02	16.77
Effect of spacing					
S_1	14.45 c	14.02 a	12.96 a	22.52 c	292.15 b
S_2	17.20 a	12.55 b	13.33 a	24.70 a	329.81 a
S_3	15.79 b	12.65 b	13.04 a	23.66 b	308.94 b
$LSD_{(0.05)}$	0.36	0.94	0.51	0.70	19.84
Interaction (fertilizer x spacing)					
F_1S_1	13.34 e	12.51 ab	13.01 ab	21.78 e	283.05 de
F_1S_2	16.53 b	13.43 ab	13.44 a	24.0 bc	322.69 bc
F_1S_3	15.24 cd	13.07 b	13.01 ab	23.33 bcd	303.33 bcde
F_2S_1	15.34 c	12.37 ab	13.33 ab	23.56 bcd	314.19 bcd
F_2S_2	18.45 a	13.62 ab	13.67 a	25.89 a	354.54 a
F_2S_3	17.14 b	13.56 ab	13.56 a	24.56 b	333.10 ab
F_3S_1	14.67 d	14.90 a	12.56 b	24.56 de	279.22 e
F_3S_2	16.63 b	11.87 c	12.89 ab	24.22 bc	312.19 bcde
F_3S_3	15.01 cd	12.86 b	12.56 b	23.11 cde	290.39 cde
$LSD_{(0.05)}$	0.61	1.76	0.80	1.41	32.53
CV%	2.24	7.06	3.84	2.90	6.23

F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.3 Yield parameters

4.3.1 Chaff weight cob^{-1}

Effect of fertilizer

Chaff weight cob^{-1} of white maize was significantly affected by different levels of fertilizer application (table 5 and Appendix VII). It was observed that the highest Chaff weight cob^{-1} (17.11g) was found with F_1 (RDF) which was significantly different from F_2 (25% less than RDF) and F_3 (25% more than RDF). But the lowest Chaff weight cob^{-1} (14.41g) was obtained with F_2 (25% less than RDF). The other fertilizer treatments, F_2 showed similar results compared to the lowest chaff weight cob^{-1}.

Effect of spacing

Different spacing had significant effect on chaff weight cob^{-1} of white maize (Table 5 and Appendix VII). Results represented in table 5 indicated that the highest Chaff weight cob^{-1} (18.14g) was found with S_1 (60 cm × 25 cm) where the lowest (13.22g) was obtained with S_3 (40 cm × 25 cm). The another treatment, S_2 (50 cm × 25 cm) showed intermediate results.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the chaff weight cob^{-1} of white maize (Table 5 and Appendix VII). Results in table 5 showed that the highest chaff weight cob^{-1} (21.33g) was achieved with the combined effect of F_1S_1 where the lowest chaff weight cob^{-1} (12.44g) was observed with F_2S_3.

4.3.2 Shell weight cob^{-1}

Effect of fertilizer

Shell weight cob^{-1} of white maize was significantly affected by different levels of fertilizer application (Table 5 and Appendix VII). It was observed that the highest

Shell weight cob^{-1} (17.78g) was found with F_1 (RDF) which was significantly different from F_2 (25% less than RDF) and F_3 (25% more than RDF). But the lowest shell weight cob^{-1} (15.18 g) was obtained with F_2 (25% less than RDF). The other fertilizer treatments, F_3 showed similar result with F_2.

Effect of spacing

Different spacing had significant effect on shell weight cob^{-1} of white maize (Table 5 and Appendix VII). Results represented in table 5 indicated that the highest shell weight cob^{-1} (18.66g) was obtained with S_1 (60 cm × 25 cm) where the lowest (14.41g) was found with S_3 (40 cm × 25 cm). The another treatment, S_2 (50 cm × 25 cm) showed intermediate results.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the shell weight cob^{-1} of white maize (Table 5 and Appendix VII). Results in table 5 showed that the highest shell weight cob^{-1} (20.33g) was achieved with the combined effect of F_1S_1 where the lowest chaff weight cob^{-1} (13 g) was observed by F_2S_3.

4.3.3 Weight of grains cob^{-1}

Effect of fertilizer

Weight of grains cob^{-1} of white maize was significantly affected by different levels of fertilizer application (Table 5 and Appendix VII). It was observed that the highest weight of grains cob^{-1} (77.89 g) was found with F_2 (25% less than RDF) which was significantly different from F_1 (RDF) and F_3 (25% more than RDF). But the lowest weight of grains cob^{-1} (68.53 g) was obtained with F_1 (RDF). The other fertilizer treatments, F_3 (25% more than RDF) showed significantly different results compared to the highest and the lowest value of weight of grains cob^{-1} .

Effect of spacing

Different spacing had significant effect on weight of grains cob^{-1} of white maize (Table 5 and Appendix VII). Results represented in table 5 indicated that the highest weight of grains cob^{-1} (123.00 g) was attained with S_2 (50 cm × 25 cm) where the lowest (98.88 g) was found with S_1 (60 cm × 25 cm). The another treatment, S_3 (40 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of grains cob^{-1} weight.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the weight of grains cob^{-1} of white maize (Table 5 and Appendix VII). Results in table 5 showed that the highest weight of grains cob^{-1} (89.56 g) was achieved with the combined effect of F_2S_2 where the lowest weight of grain cob^{-1} (64.44 g) was observed by F_1S_1. The results obtained from all other treatments were significantly different from highest and lowest value of grains cob^{-1} weight.

4.3.4 Weight of cob

Effect of fertilizer

Weight of cob of white maize was significantly affected by different levels of fertilizer application (Table 5 and Appendix VII). It was observed that the highest weight of cob (107.48 g) was found with F_2 (25% less than RDF) which was significantly different from F_1 (RDF) and F_3 (25% more than RDF). But the lowest weight of cob (103.42 g) was obtained with F_1 (RDF). The other fertilizer treatments, F_3 (25% more than RDF) showed statistically similar results compared to the lowest value of cob weight.

Effect of spacing

Different spacing had significant effect on weight of cob of white maize (Table 5 and Appendix VII). Results represented in table 5 indicated that the highest weight of cob (108.15g) was found with S_2 (50 cm × 25 cm) where the lowest (101.07g) was with S_3 (40 cm × 25 cm). The another treatment, S_1 (90 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of cob weight.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the weight of cob of white maize (Table 5 and Appendix VII). Results in table 5 showed that the highest weight of grains cob^{-1} (118.06 g) was found with the combined effect of F_2S_2 where the lowest weight of grain cob^{-1} (94.67 g) was observed by F_3S_3. The results obtained from all other treatments were significantly different from the highest and the lowest value of weight of cob.

Table 5: Yield parameters of maize as influenced by different levels of fertilizer, spacing and their interactions

Interaction (fertilizer x spacing)	Yield parameters			
	Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (g)	Grain weight cob^{-1}(g)	Cob weight (g)
Effect of fertilizer				
F_1	17.11 a	17.77 a	68.53 c	103.42 b
F_2	14.40 b	15.18 b	77.89 a	107.48 a
F_3	14.66 b	16.18 ab	71.37 b	102.56 b
$LSD_{(0.05)}$	1.154	1.94	2.53	3.92
Effect of spacing				
S_1	18.40 a	18.66 a	67.00 c	104.24 b
S_2	14.55 b	16.07 b	77.35 a	108.15 a
S_3	13.22 c	14.40 c	73.44 b	101.07 c
$LSD_{(0.05)}$	1.08	0.84	1.53	1.61
Interaction (fertilizer x spacing)				
F_1S_1	21.33 a	20.33 a	64.44 e	105.60 b
F_1S_2	15.56 bc	17.11 bcd	67.94 d	101.11 cd
F_1S_3	14.44 cd	15. 89 cde	73.22 c	103.55 bcd
F_2S_1	17.11 b	17.22 bc	64.57 e	99.39 d
F_2S_2	13.67 cde	15.33 de	89.56 a	118.56 a
F_2S_3	12.44 e	13 f	79.55 b	105.0 bc
F_3S_1	16.78 b	18.44 ab	72.00 c	107.72 b
F_3S_2	14.44 cd	15.78 cde	74.56 c	105.28 bc
F_3S_3	12.78 de	14.33 ef	67.57 d	94.67 e
$LSD_{(0.05)}$	**1.90**	**2.26**	**3.31**	**4.51**
CV%	**6.85**	**5.03**	**2.06**	**1.51**

F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.3.5 Weight of 100 grains

Effect of fertilizer

100 grain weight of white maize was significantly affected by different levels of fertilizer application (Table 6 and Appendix VIII). It was observed that the highest 100 grain weight (33.71g) was found with F_2 (25% less than RDF) where the lowest (28.72 g) was obtained with F_1 (RDF). The other fertilizer treatments; F_3 (25% more than RDF) showed significantly different results compared to the highest and the lowest value of 100 grain weight. Similar findings was observed by Tank (2006).

Effect of spacing

Different spacing had significant effect on 100 grain weight of white maize (Table 6 and Appendix VIII). Results represented in table 6 indicated that the highest 100 seed weight (31.17 g) was found with S_2 (50 cm × 25 cm) where the lowest (29.76 g) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (40 cm × 25 cm) showed significantly different results in respect of the highest and the lowest 100 seed weight.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the 100 grain weight of white maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest 100 grain weight (35.70 g) was achieved with the combined effect of F_2S_2 where the lowest 100 grain weight (25.44 g) was observed with F_1S_1. The results obtained from all other treatments were significantly different from the highest and the lowest value of 100 grain weight. The result finding under the present study was conformity with Amaral Filho, (2009).

4.3.6. Stover yield

Effect of fertilizer

Stover yield ha^{-1} of white maize was significantly affected by different levels of fertilizer application (table 6 and appendix VIII). It was observed that the highest stover yield (10.82 t ha^{-1}) was found with F_3 (25% more than RDF) which was significantly different from all other fertilizer treatments. But the lowest stover yield (7.73 t ha^{-1}) was obtained with F_1 (RDF) which was not significantly different from F_2 (8.46 t ha^{-1}). Similar findings were observed by Tank (2006).

Effect of spacing

Different spacing had significant effect on stover yield (t ha^{-1}) of white maize (table 6 and appendix VIII). Results represented in table 6 indicated that the highest stover yield (10.81 t ha^{-1}) was attained with S_3 (40 cm × 25 cm) where the lowest (7.073 ton ha^{-1}) was with S_1 (60 cm × 25 cm).The another treatment, S_2 (50 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of stover yield (ton ha^{-1}). The result obtained by Girma (2005) was similar with the present findings.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the stover yield (t ha^{-1}) of white maize (table 6 and appendix VIII). Results in table 6 showed that the highest stover yield (14.8 t ha^{-1}) was recorded from the combined effect of F_2S_3. On the other hand the lowest stover yield (5.83 t ha^{-1}) was observed by F_3S_1. The results obtained from all other treatments showed significantly different result compared to the highest and the lowest value of stover yield (t ha^{-1}).

4.3.7 Grain yield (t ha^{-1})

Effect of fertilizer

Grain yield of white maize was not significantly affected by different levels of fertilizer application (table 6 and appendix VIII). It was observed that the highest grain yield (7.58 t ha^{-1}) was found with F_3 (25% more than RDF) which was not significantly different from F_2 (25% less than RDF). But the lowest grain yield (6.96 ton ha^{-1}) was obtained with F_1 (RDF). Similar findings were observed by Tank (2006).

Effect of spacing

Different spacing had significant effect on grain yield of white maize (Table 6 and Appendix VIII). Results represented in table 6 indicated that the highest grain yield (7.94 t ha^{-1}) was obtained with S_3 (40 cm × 25 cm) where the lowest (6.56 t ha^{-1}) was found with S_1 (60 cm × 25 cm). Another treatment, S_2 (50 cm × 25 cm) showed significantly different results in respect of highest and lowest value of grain yield. Similar results were also found by Sener (2004).

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the grain yield of white maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest grain yield (8.44 t ha^{-1}) was recorded from the combined effect of F_2S_2 where the lowest grain yield (6.0 t ha^{-1}) was observed by F_1S_1. The combined effect of F_1S_3, F_3S_2, F_2S_3 also showed higher grain yield but significantly different from F_2S_2. The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of grain yield. These results are in conformity with Amaral Filho (2009).

4.3.8. Biological yield

Effect of fertilizer

Significant variation was recorded in biological yield of white maize for different fertilizers and their combinations (appendix VIII). The highest biological yield was found in F_3 (17.81 t ha^{-1}) and that of the lowest 14.67 t ha^{-1} from F_1 which was statistically similar with F_2 (25% less than RDF) (Table 6).

Effect of spacing

Effect of spacing on biological yield of white maize was remarkable (Appendix VIII). Results represented in table 6 indicated that the highest biological yield (19.0 t ha^{-1}) was obtained with S_3 (40cm × 20 cm) where the lowest (13.632 t ha^{-1}) was with S_1 (60 cm × 20 cm). Another treatment, S_2 (50 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of biological yield.

Interaction effect of fertilizer and spacing

Interaction effect of spacing and fertilizer management had remarkable effect on biological yield of white maize (Appendix VIII). Results in table 6 showed that the highest biological yield (22.08 t ha^{-1}) was recorded from the combined effect of F_2S_3 where the lowest biological yield (12.55 t ha^{-1}) was observed by F_2S_1. The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of biological yield. This finding was indirectly related with Kumar *et al.* (2018).

4.3.9 Harvest index

Effect of fertilizer

Harvest index of white maize was significantly affected by different levels of nitrogen application (Table 6 and Appendix VIII). It was observed that the highest harvest index (47.39%) was found with F_1 (RDF) which was significantly different from F_2 (25% less than RDF) and F_3 (25% more than RDF). But the lowest harvest index (45.65%) was obtained with F_3 (25% more than RDF). The other fertilizer treatments; F_2 (25% less than RDF) showed significantly different results compared to the highest and the lowest value of harvest index.

Effect of spacing

Different spacing had non significant effect on harvest index (t ha^{-1}) of white maize (Table 6 and Appendix VIII). Results represented in table 6 indicated that the highest harvest index (48.467%) was attained with S_1 (60 cm × 25 cm) where the lowest (44. 71%) was found with S_3 (40 cm × 25 cm).The another treatment, S_2 (50 cm × 25 cm) showed statistically similar results in respect of the highest value of harvest index.

Interaction effect of fertilizer and spacing

Interaction effect of fertilizer and spacing significantly influenced the harvest index of white maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest harvest index (56.19 %) was recorded from the combined effect of F_1S_3 where the lowest harvest index (39.9%) was observed by F_1S_1. The combined effect of F_3S_1, F_2S_1, F_3S_3 also showed higher harvest index value but significantly different from F_2S_2 and F_1S_1. The results obtained from all other treatments showed intermediate result compared to the highest and the lowest value of harvest index.

Table 6: Yield parameters of maize as influenced by different levels of fertilizer, spacing and their interactions

Treatment	Yield parameters				
	100 Grain weight	Stover yield(t ha^{-1})	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of fertilizer					
F_1	28.71 c	7.73 b	6.93 b	14.66 b	47.39 a
F_2	33.71 a	8.45 b	7.56 a	15.78 b	46.94 b
F_3	30.57 b	10.8 a	7.58 a	17.81 a	45.65 c
$LSD_{(0.05)}$	0.74	0.95	0.20	1.89	1.39
Effect of spacing					
S_1	29.76 c	7.07 c	6.55 c	13.63 c	48.46 a
S_2	31.17 b	8.32 b	7.58 b	15.63 b	46.81 a
S_3	32.07 a	10.81 a	7.94 a	19.00 a	44. 71 b
$LSD_{(0.05)}$	0.51	0.77	0.13	1.22	1.79
Interaction (fertilizer x spacing)					
F_1S_1	25.44 f	9.05 c	6.0 e	15.04 de	39.9 f
F_1S_2	29.04 e	7.86 d	6.74 d	14.60 e	46.09 cd
F_1S_3	31.67 cd	6.23 e	8.06 b	14.35 e	56.19 a
F_2S_1	31.59 cd	6.33 e	6.21 e	12.55 f	49.35 b
F_2S_2	35.70 a	11.35 b	8.44 a	19.78 ab	35.26 g
F_2S_3	33.84 b	14.8 a	8.07 b	22.08 a	42.68 ef
F_3S_1	32.24 c	5.83 f	7.46 c	13.25 ef	56.15 a
F_3S_2	30.64 d	9.42 c	7.96 b	17.28 abc	45.55 de
F_3S_3	28.84 e	7.86 d	7.32 c	15.08 d	48.81 bc
$LSD_{(0.05)}$	**1.03**	**1.55**	**0.27**	**2.56**	**1.44**
CV%	**1.61**	**8.64**	**7.87**	**7.41**	**3.75**

F_1 = Recommended doses of fertilizer (RDF), F_2 = 25% less than RDF, F_3 = 25 % higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka to evaluate the performance of maize as influenced by different levels of fertilizer under different spacing. The experiment comprised of two different factors; (1) Three levels of fertilizer application viz. F_1 (RDF), F_2 (25% less than RDF) and F_3 (25% more than RDF) and (2) three different plant spacing viz. S_1 (60 cm × 25 cm), S_2 (50 cm × 25 cm) and S_3 (40 cm × 25 cm).

The experiment was set up in split plot design (factorial) with three replications. There were 9 treatment combinations. The experimental plot was fertilized as per treatment with fertilizer. Data on different growth and yield parameters were recorded and analysed statistically. Data were collected on plant height (cm), length of leaves plant^{-1}, breadth of leaves plant^{-1}, leaf area plant^{-1}, dry weight plant^{-1} (g), cob length, cob circumference, number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, weight of grains cob^{-1}, 100- grain weight (g), grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield and harvest index (%). Considerable effect was observed on growth, yield and yield contributing characters of maize with different levels of fertilizer application.

The growth parameters, plant height (157.48 and 167.41 cm) at 45 DAS and at harvest, respectively), were the highest with fertilizer doses of F_1 (RDF). Length of leaves plant^{-1} (63.50 and 68.28 cm at 45 DAS and at harvest, respectively) were also highest with fertilizer doses of F_1 (RDF),breadth of leaves/plant (6.20 and 6.99 cm at 45 DAS and at harvest, respectively) were the highest with fertilizer doses of F_3 (25% more than RDF) leaf area plant^{-1} (384.03 cm and 368.36 cm at 45 DAS and at harvest, respectively) were highest with fertilizer doses of F_1 (RDF) and F_2 (25% less than RDF) and dry weight plant^{-1} (51.21 g and174.08 g at 45 DAS and at harvest, respectively) were the highest with higher fertilizer doses of F_3 (25% more than RDF) and F_2(25% less than RDF). But the lowest plant height (149.6 and 159.59 cm respectively at 45 DAS and at harvest respectively) attained at F_2 (25% less than

RDF), the lowest leaf area plant^{-1} (380.41 and 308 cm at 45 DAS and at harvest respectively) attain at F_2 and F_3 treatment. The dry weight plant^{-1} (43.67 and 167g at 45 DAS and at harvest respectively) were with F_2 (25% less than RDF) and F_1 (RDF). Yield and yield contributing parameters was also affected significantly by different levels of fertilizer application. It was evident that the highest cob length (16.98 cm), number of rows cob^{-1} (13.52) number of grains row^{-1} (24.67), number of grains cob^{-1} (333.94) weight of grains cob^{-1} (77.89 g), 100-grain weight (33.71 g), and grain yield (8.44 t ha^{-1}), were achieved by F_2 (25% less than RDF). But the lowest cob length (15.03 cm), number of rows cob^{-1} (12.67), number of grains cob^{-1} (293.93) and harvest index (45.65%) were achieved by F_3 (25% more than RDF). But the lowest grain yield (6.56 t ha^{-1}) were achieved by F_1 (RDF). But in terms of stover yield (t ha^{-1}), the highest result (10.02 t ha^{-1}) was obtained with F_3 (25% more than RDF) where the lowest (7.73 t ha^{-1}) was with F_1 (RDF).

Results under the present study showed that growth, yield and yield contributing characters of maize were significantly influenced by different plant spacing. The lowest plant spacing, S_3 (40 cm × 25 cm) showed the highest plant height (160.97 and 171.01 cm at 45 DAS and at harvest, respectively) where the higher plant spacing S_1 (60 cm × 25 cm) showed the lowest plant height (147.55 and 157.55 cm at 45 DAT and at harvest respectively). But in terms of other growth parameters; the highest leaf area/plant (416.73 and 364.28 cm^2 at 45 DAS and at harvest, respectively) were achieved at S3 and S1 spacing. Dry weight plant^{-1} (47.65 and 176.52 g at 45 DAS and at harvest, respectively) were obtained from S_2 (50 cm × 25 cm) where the lowest Dry weight plant^{-1} (44.36 and 162.87 at 45 DAS and at harvest, respectively), leaf area plant^{-1} (362.11 and 319.65 cm^2 at 45 DAT and at harvest respectively), In case of yield and yield contributing parameters; the highest cob length (17.20 cm), number of row cob^{-1} (13.33), number of grains row^{-1} (24.70), number of grains cob^{-1} (329.81), weight of grains cob^{-1} (77.35 g), 100-grain weight (33.71gm), grain yield (7.56 t ha^{-1}) were achieved by S_2 (50 cm × 25 cm) where the lowest cob length (14.45 cm), number of row cob^{-1} (12.96), number of grains row^{-1} (22.52), number of grains cob^{-1} (292.15), weight of grains cob^{-1} (67.0 g), 100-grain weight (28.71g), grain yield (6.55 t ha^{-1}) were achieved by S_1 (60 cm × 25 cm) but the highest stover yield (10.81 t ha^{-1}) was obtained from S_3 (40 cm × 25 cm) where the lowest (7.07 t ha^{-1}) was from S_1 (60 cm × 25 cm).

The growth, yield and yield contributing parameters of maize were also significantly affected by different levels of fertilizer application along with different plant spacing. The highest plant height (166.10 and 176.11 cm at 45 DAS and at harvest respectively) was with F_2S_3 where the lowest (140.22 and 150.23 cm at 45 DAS and at harvest respectively) was by F_2S_2.The height leaf area $plant^{-1}$ (485.95 and 485.80 cm^2 at 45 DAS and at harvest respectively) were with F_1S_3 and F_2S_3 and dry weight $plant^{-1}$ (57.13 and 182.74 g at 45 DAS and at harvest respectively) were with F_3S_3 and F_2S_2.

Yield and yield contributing parameters were affected significantly by different treatment combinations. It was evident that the highest cob length (18.45 cm), number of rows cob^{-1} (13.67), number of grains row^{-1} (25.89), number of grains cob^{-1} (354.54), weight of grains cob^{-1} (89.56 g), weight of cob (118.06 g),100-grain weight (35.70 g) and grain yield (8.44 t ha^{-1} were achieved by $F_2 \times S_2$. But the lowest cob length (13.34 cm), number of grains cob^{-1} (283.05), weight of grains cob^{-1} (64.44 g), 100- grain weight (25.44 g), grain yield (6.0 t ha^{-1}), and harvest index (39.9%) were achieved by $F_1 \times S_1$. But in terms of stover yield (14.8 t ha^{-1}) the highest result was obtained with $F_3 \times S_1$ where the lowest (5.83 t ha^{-1}) was with $F_3 \times S_1$. It may be concluded from the results that fertilizer and plant spacing is very much promising for higher maize yield. The best fertilizer dose was F_2 (25% less than RDF) and plant spacing was F_2 (50 cm × 25 cm) under the present study.

The treatment 25% less than RDF along with 50 cm × 25 cm plant spacing (F_2S_2) proved to be optimum management and performed best in producing the highest yield as compared to other treatments. On the other hand interactions of fertilizer F_2 (25% less than RDF) and plant spacing of S_2 (50 cm × 25 cm) showed its superiority in producing the highest grain of white maize.

RECOMMENDATION

The present research work was carried out at the Sher-e-Bangla Agricultural University during kharif-2 season only. Further trial of this work in different locations of the country is needed to justify the present findings and make a definite conclusion.

REFERENCES

Abebe, Z. and Feyisa, H. (2017). Effects of nitrogen rates and time of application on yield of maize: rainfall variability influenced time of N application. *Int. J. Agron.*:25-32.

Ahmed, F. (1994). Maize Production Technology (*in Bengali*). International Fertilizer Development Center (IFDC)-Consultant of Ministry of Agriculture, Bangladesh.

Amaral Filho, J. P. R. (2009). Row spacing, population density and nitrogen fertilization in maize.Vicosa, Brazil: Sociedade Brasileira de Ciencia do Solo. *Revista Brasileira Ciencia Solo*. **29**(3): 467-473.

Amin, M. E. M. H. (2011). Effect of different nitrogen sources on growth, yield and quality of fodder maize (*Zea mays* L.). *J. Saudi Soci. Agric. Sci.* **10**(1): 17-23.

Arun Kumar, M.A., Gali, S.K and Hebsur, N.S. (2007). Effect of different levels of NPK on growth and yield parameters of sweet corn. *Karnataka J. Agric. Sci.* **20**(1): 41-43.

Arya, K.C. and Singh, S.N. (2001). Productivity of maize (*Zea mays)* as influenced by different levels of phosphorus, zinc and irrigation. *Indian J. Agric. Sci.* **71**: 57-59.

Auwal, T.W, and Amit, K. (2017). Effect of Integrated Nutrient Management on Growth and Yield Parameters of Maize (*Zea mays* L.) As well as Soil Physico-chemical Properties. *Biomed J. Sci. Tech. Res*. **1**(2): 178.

Bairagi, S., Pandit, M. K., Sidhya, P., Adhikary, S. and Koundinya, A.V.V. (2015). Impacts of date of planting and crop geometry on growth and yield of baby corn (*Zea mays var. rugosa*). *J. Crop and Weed*. **11**(2):127-131.

BBS (Bangladesh Bureau of Statistics). (2018). Statistical year book of Bangladesh, Ministry of Agriculture: *Crops, Livestock, Forestry & Fishery*. pp. 86-91.

Bindhani, A., Barik, K.C., Garnayak, L.M. and Mahapatra, P.K. (2007). Nitrogen management in baby corn (Zea*mays). Indian J. Agron.* **52** : 135-138.

Carlos Andam, (1990). Baby corn. A new vegetable from an old crop. *Int. Agric. Dev*, pp. 10-19.

Chamroy, T., Kale, V.S., Nagre, P.K., Dod, V.N., Wanjari, S.S. and Jahagirdar, S.W. (2017). Growth and Yield Response of Baby Corn (*Zea Mays L.*) To Sowing Time and Crop Geometry. *Chem Sci Rev Lett* 2017. **6** (22): 978-981.

Chillar, R.K. and Kumar, A. (2006). Growth and yield behaviour of sweet corn (Zeamays L. saccharata) under varying plant population and nitrogen level. In: Extended Summaries of Golden Jubilee National Symposium on Conservation Agriculture and Environment, held during 26-28 October, 2006 at Banaras Hindu University, Varanasi, pp: 277-278.

Chougule, S.D. (2003). Effect of different plant geometry on sweet corn growth. *Maharashtra J. Agric. Sci.* **34**(12): 122-125.

Dalvi, S.D. (1984). Effect of various spacings and nitrogen levels on growth, yield and quality of two varieties of maize *(Zea mays* L.) under Konkan conditions during *rabi*- cum hot weather. *M. Sc. Thesis*, Dr. B.S.K.K.V. Dapoli (unpublished).

Donald, C.M. (1963). Competition among crop and pasture plants. Adv. Agron. **15**: 1-18.

Gaur, B.L. (2002). Effect of cultivar, nitrogen, phosphorus and plant population on baby corn productivity. *Haryana J. Agron.***18**: 159-160.

Gawade, D.G.(1998). Response of sweet corn (Zea*mays* L. *saccharata)* to nutrient management. *M.Sc. (Agri.) Thesis*, Dr. Balasaheb Sawant 74 Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S).

Ghulam, A. (2005). Effect of irrigation schedules and nitrogen rates on yield and yield components of maize. *Agric. Social Sci*. **1**(4): 335-338.

Girma,W. (2005). Nitrogen fertilization and moisture conservation practices on maize (Zea mays L.) grown under dryland conditions of Ethiopia. Bangkok, Thailand: Kasetsart University. *Kasetsart Nat. Sci*. **39**(1): 1-11.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci., Pub., pp.28-192.

Grazia, J.D., Tittonell, P.A., Germinara, D and Chiesa, A. (2003). Phosphorus and nitrogen fertilization in sweet corn (*Zea mays* L. *saccharata*). *Spanish J. Agric. Res.* **1**(2): 103-107.

Jiang, W., Wang, K., Wu, Q., Dong, S., Liu, P. and Zhang, J. (2013). Effects of narrow plant spacing on root distribution and physiological nitrogen use efficiency in summer maize. *The Crop J.* **1**(1): 77-83.

Jiotode, D. J. (2002). Growth parameters and water use studies of maize as influenced by irrigation levels and row spacings. *Crop Res. Hisar*. **24**(2): 292-295.

Kalpana, R. and Anbumani, S. (2003). Response of baby corn to dose and time of potassium application. *J.Ecobiol.* **15**: 393-395.

Kar, P.P., Barik, K.C., Mahapatra, P.K., Garnayak, L.M., Rath, B.S., Bastia, D.K. and Khanda, C.M. (2006). Effect of planting geometry and nitrogen on yield, economics and nitrogen uptake of sweet corn (*Zea mays*). *Indian J.Agron.* **51**: 43-45.

Kaul, J., Kumar, R.S. and Das, S. (2011). Varietal improvement in maize development of single cross hybrids in India. National press. (http://krishisewa.com/articles/ 2011/vimaize.html).

Kheibari, M.N.K., Khorasani, S.K. and Taheri, G. (2012). Effects of plant density and variety on some of morphological traits, yield and yield components of baby corn (*Zea mays* L.). *Intl. Res. J. Appl. Basic. Sci*. **3**(10): 2009-2014.

Kulhari, R.K., Sharma, G.L. and Bansal, K.N. (1998). Effect of fertilizer, *Azotobacter*and growth stimulants on yield, N content and uptake by maize (Zea*mays* L.). *Haryana J.Agron.* **14**: 265-266.

Kumar, R., Bohra, J.S., Kumawat, N., Upadhyay, P. K. and Singh, A.K. (2018). Effect of balanced fertilization on production, quality, energy use efficiency of baby corn (*Zea mays*) and soil health. *Indian J. Agric. Sci*.**88** (1): 28–34.

Kumar, R., Kumawat, N., Kumar, S., Singh, A.K. and Bohra, J.S. (2017). Effect of npks and zn fertilization on, growth, yield and quality of baby corn-a review. *Int. J. Curr. Microbiol. App. Sci.* **6**(3): 1392-1428.

Kunjir, S.S., Chavan, S.A., Bhagat, S.B. and Zende, N.B. (2007). Effect of planting geometry, nitrogen levels and micronutrients on the growth and yield of sweet corn. *Crop Prot. Prod.*,**2**(3): 25-27.

Long, N.V., Hung, N.T., Loc, N.V., Hoang, D.T. and Nam. N.T. (2009). Effects of different plant densities on yield and quality of hybrid baby corn. *J. Sci. Dev*. **7**(2): 202 – 208.

Maqbool, M. M., Tanveer, A., Ali, A., Abbas, M. N., Imran, M., Ahmad, M. and Abid, A. A. (2016). Growth and yield response of maize (*Zea mays*) to inter and intra-row weed competition under different fertilizer application methods. *Planta Daninha* **34**(1): 47-56.

Nasim, W., Ahmad, A., Khaliq, T., Wajid, A., Munis, M. F. H., Chaudhry, H. J., and Hammad, H. M. (2012). Effect of organic and inorganic fertilizer on maize hybrids under agro-environmental conditions of Faisalabad-Pakistan. *African J. Agric. Res.* **7**(17): 2713-2719.

Ochapong, P. (2005). Appropriate variety, plant density and rate and time of nitrogen fertilization for Baby corn production in AmphoeKamphaengsaen, Thailand. *Res. J. Agric. Biol. Sci.* **1**(4): 303-307.

Ogbaji, M. I. (2003). Effects of nitrogen rates and intra-row spacing on local maize (Zea mays L.) in Southern Guinea Savannah zone of Nigeria. *Sust. Agric. Environ*. **5**(1): 147-152.

Pandey, A. K., Mani, V. P., Prakash, V., Singh, R. D. and Gupta, H. S. (2002). Effect of varieties and plant densities on yield, yield attributes and economics of baby corn (Zea*mays* L.). *Indian J.Agron.***47**: 221-226.

Patil, S.J. (1997). Agronomic investigation in baby corn at Arbhavi. *Annual Progress Report*, AICMIP, Directorate of Maize Research, Indian Agricultural Research Institute, New Delhi, pp: A-58-59.

Pinjari, S.S. (2007). Effect of integrated nutrient management and polythene mulch on the performance of sweet corn under lateratc soils of konkan. Ph. D. (Agri.) Thesis, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Daoli and Dist. Ratnagiri.

Prodhan, H. S., Bala, S. and Khoyumthem, P. (2007). Response to rate of nitrogen and effect of plant density on yield of baby corn. *J.Interacademica*. **11**(3): 265-269.

Raja, V. (2001). Effect of fertilizer and plant population on yield and quality of super sweet corn (*Zea mays*). *Indian J. Agron.* **46**(2): 246-249.

Raja, V.(2001). Effect of fertilizer and plant population on yield and quality of super sweet corn *(Zea mays* L.). *Ind. J. Agron.* **46**(2): 247-250.

Raju, M.S., Srinivas, A. and Raja, V. (1997). Performance of promising pre-release maize varieties to different nitrogen levels under rainfed conditions. *Annals of Arid Zone*.**36**: 377-379.

Rakesh Kumar, Bohra J.S., Narendra and Amitesh K. Singh (2015). *Res. on Crops*, **16** (2), 243-249.

Ramachandrappa, B.K., Nanjappa, H.V. and Shivakumar, H.K., (2004). Yield and quality of baby corn (Zea*mays* L.) as influenced by spacing and fertilizer levels. *Acta- Agronomica-Hungarica,* **52**(3): 237-243.

Sabo, M. U., Wailare, M. A., Aliyu, M. and Sanusi, J. (2016). Effect of Variety and Spacing on Growth and Yield of Maize (*Zea mays* L.) in Bauchi State, Nigeria. *Int. J. Plant Soil Sci.* **9**(6): 1-6.

Sahoo, S. C. (1995). Determination of optimum plant geometry for baby corn at Jashipur. Annual Progress Report, AICMP, Directorate of Maize Research, New Delhi A, 50.

Sahoo, S. C. and Panda, M. M. (1999). Effect of level of nitrogen and plant population on yield of baby corn (*Zea mays L.*). *Indian J. Agric. Sci.* **69**(2): 157-158.

Sahoo, S.C. and Mahapatra, P.K., (2004). Response of sweet corn *(Zea mays)* to nitrogen levels and plant population. *Ind J. Agril. Sci.* **74**(6): 337-338.

Sahoo, S.C. and Panda. M.M. (2001). Effect of phosphorus and detasselling on yield of baby corn (*Zea mays L.). Indian J. Agric. Sci.* **71**: 21-22.

Sahu, P., Ramachandrappa, B. K. and Nanjappa, H. V. (2005). Growth, yield and economics of baby corn as influenced by scheduling of irrigation and number of plants pee hill. *Mysore J. Agric. Sci*.**39** (2): 193-197.

Sangoi, L., Ender, M., Guidolin, A. F., Almeida, M. L. D., and Heberle, P. C. (2001). Influence of row spacing reduction on maize grain yield in regions with a short summer. *Pesquisa Agropecuária Brasileira* **36**(6): 861-869.

Sarjamei , F., Khorasani, S.K. and Nezhad, A.J. (2014). Effect of planting methods and plant density, on morphological, phenological, yield and yield component of baby corn. *Adv. Agric. Biol*. **2** (1): 20-25.

Sener, O. (2004). The effects of intra-row spacings on the grain yield and some agronomic characteristics of maize (*Zea mays* L.) hybrids. Asian J. Plant Sci. **3**(4): 429-432.

Shafi, M., Bakht, J., Ali, S., Khan, H., Khan, M.A. and Sharif, M. (2012). Effect of planting density on phenology, growth and yield of maize (*Zea mays* L.). *Pak. J. Bot*. **44**(2): 691-696.

Shen. L., Wei. Y. and Lan, L. W. (2006). Effect of fertilizer supply on early kernel development and yield in summer maize (Zea mays L.). Beijing, China: Science Press. Acta Agronomica Sinica. 32(11): 174-175. URL: http://www.chinacrops.org

Singh, G., Kumar, S., Singh, R. and Singh, S.S. (2015). Growth and yield of Baby Corn (*Zea mays* L.) as influenced by varieties, spacings and dates of sowing. *Indian J. Agric. Res*. **49** (4): 353-357.

Sobhana, V., Ashok, K., Idnani, L.K., Singh, I. and Shiva, D. (2012). *Indian J. Agron*. **57**(3): 294 -296.

Soonsuwon, W., Khongmee, M., Tongchawy, U. and Eksomtramage, T. (1996). Appropriate varieties and plant populations for baby corn production of Hat Yai district Thailand. *Sonklanakasin J. Sci. Tech.***18** (3): 243-252.

Sukanya, T. S., Nanjappa, H. V. and Ramachandrappa, B. K. (1999). Effect of spacings on the growth, development and yield of baby corn (Zea *mays* L.) varieties. *Karnataka J. Agric. Sci.* **12** (1-4): 10-14.

Tank, D. A. (2006). Nitrogen management in rabi maize (Zea mays L.). Crop Res. Hisar. **31**(2): 323-324. URL: www.cropresearch.org

Thakur, D. R., Prakash, O. M., Kharwara, P. C. and Bhalla, S. K. (1997). Effect of fertilizer and plant spacing on growth yield and economics of baby corn (Zea*mays* L.). *Ind. J. Agron.* **42** (3): 479-483.

Thakur, D.R. and Sharma, V. (2000). Effect of planting geometry on baby corn yield in hybrid and composite cultivars of maize. *J. Agric. Sci.***70** (4): 246-247.

Thakur, D.R., Kharwara, P.C. and Om Prakash, (1995). Effect of fertilizer and plant spacing on growth, development and yield of baby corn (*Zea mays* L.). *Him. J. Agric. Res.***21** (1 & 2): 5 **-** 10.

Ullah, M. J., Islam, M.M., Fatima., K., Mahmud, M.S. and Rahman, J. (2016). Evaluating yield and yield performance of transplanted white maize varieties under varying planting geometry. *J. Expt. Bioscience**s.*** **7**(2):21-28**.**

Ullah, M. J, Islam, M.M., Fatima, K., Mahmud, M.S., Akhter,S., Rahman, J. and Md. Quamruzzaman, M. (2017). Comparing modern varieties of white maize with landraces in Bangladesh: phenotypic traits and plant characters. *J. Expt. Biosci.* **8**(1):27-40.

Ullah M. J., Islam, M.M, Fatima, K., Mahmud, S., Rahman, J. and Akhter, S. (2017). Comparing modern varieties of white maize with local races: ear characters. *J. Expt. Biosci*. 8(2): 49-58.

Ullah M.J., Islam, M.M, Fatima, K., Mahmud, S. and Mannan, M.A. (2018). Performance of two exotic white maize hybrids as influenced by varying soil moisture regimes during seedling transplantation. *J. Expt. Biosci*. 9(2):59-70.

Ullah MJ, Linu SBB, Islam MM. (2018). Irrigation water management through using polyethylene mulch material. *Adv Agr Environ Sci*. (2018); **2**(2):54-63. DOI: 10.30881/aaeoa.00023.

Ullah MJ, Islam MM and Fatima K. (2018). Yield and yield attributes of two exotic white maize hybrids at different agroclimatic regions of Bangladesh under varying fertilizer doses. *Adv Agr Environ Sci*. (2018); 2(2):65-71. DOI: 10.30881/aaeoa.00024

Vadivel, N., Subbian, P. and Velayutham, A. (2001). Effect of integrated nitrogen-management practices on the growth and yield of rainfed winter maize (*Zea mays). Ind. J. Agron.* **46**: 250-254.

Wagh, D.S. (2002). Effect of spacing and integrated nutrient management on growth and yield of sweet corn (*Zea mays L. saccharata). M.Sc. Thesis* Mahatma Phule Krishi Vidyapeeth, Rahuri, dist. Pune.

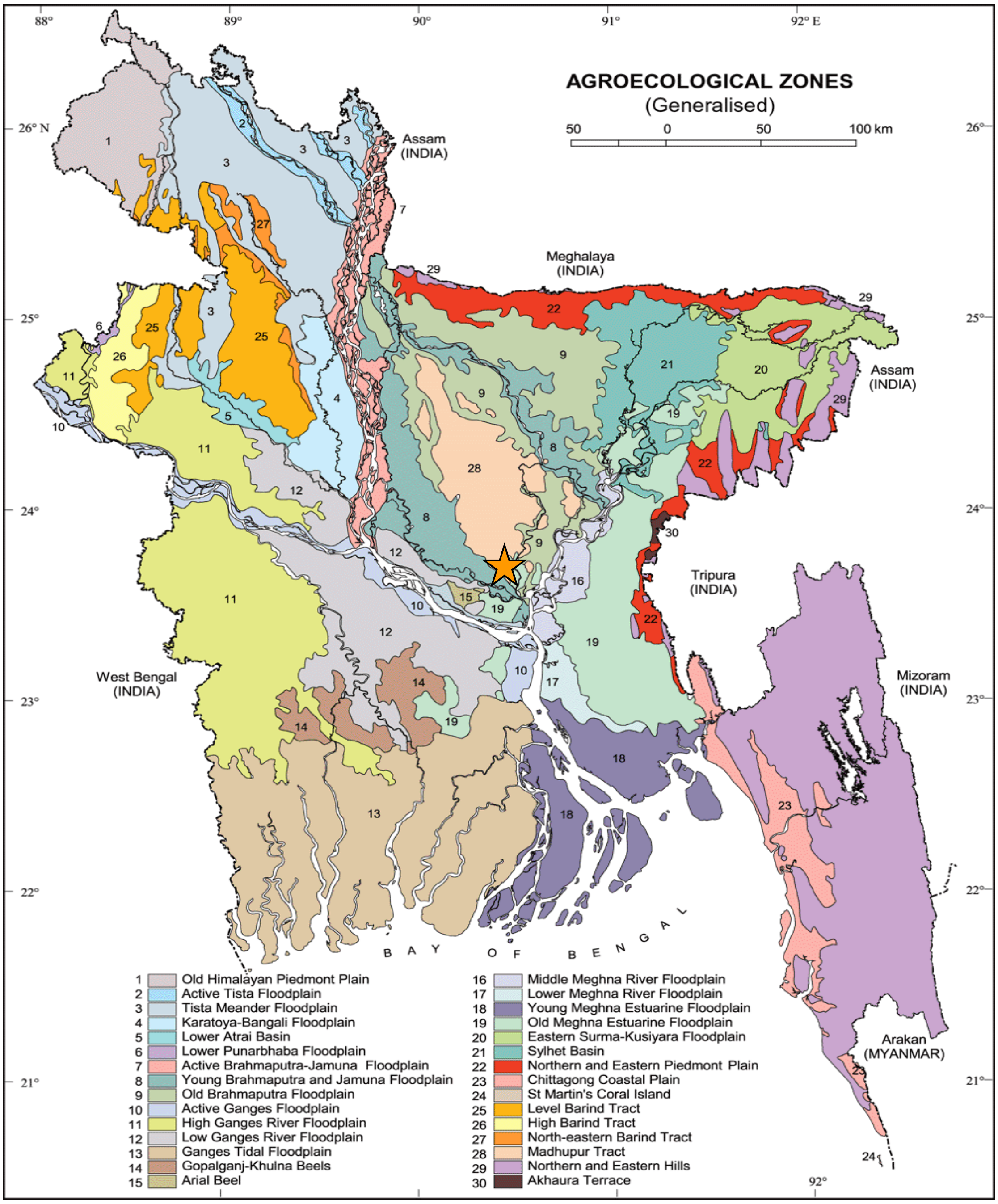
Woldesenbet, M. and Haileyesus, A. (2016). Effect of fertilizers on growth, yield and yield components of maize (Zea mays L.) in decha district, southwestern Etiopia. *Intl. J. Res.-granthaakayah* **4**(2): 95-100.

Zarapkar, D.S. (2006). Effect of spacing and yield on growth and yield of baby corn. *M. Sc. (Agri.) Thesis,* Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (India).

Zende, N.B. (2006). Effect of integrated nutrient management on the performance of sweet corn (Zea *mays* L. *saccharata).* Thesis submitted for Ph.D. (Agri.) degree to Konkan KrishiVidyapeeth, Dapoli, And Dist. Ratnagiri, Maharastra.

APPENDICES

Appendix I. Map showing the experimental sites under study



The experimental site under study

Appendix II: Characteristics of experimental soil was analysed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental soil

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
P^H	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix III. Mean square values for plant height of white maize

Sources of variation	df	Mean square of plant height(cm)	
		At 45 DAS	At harvesting time
Replication (A)	2	0.444	1.338
Fertilize (B)	2	180.739**	177.342**
Error A*B	4	2.111	0.393
Spacing (C)	2	507.993**	514.89**
B*C	4	143.454**	138.157**
Error A*B*C	12	1.167	1.152

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix IV. Mean square values for leaf parameters of white maize

Sources of variation	df	Mean square at 45 DAS		
		Leaf length (cm)	Leaf breadth (cm)	Area/leaf, cm^2
Replication(A)	2	0.48947	0.15745	557.87
Fertilizer(B)	2	8.74601*	0.05524^{NS}	29.71^{NS}
Error A×B	4	0.8228	0.84792	3531.51
Spacing(C)	2	2.93551^{NS}	2.28217^{NS}	8140.9^{NS}
Fertilizer(B)×Spacing(C)	4	9.77071**	1.12741^{NS}	5817.62*
Error	12	1.02471	0.47851	1609.36

* Significant at 5% level
** Significant at 1% level
NS Not significant

Appendix V. Mean square values for Total Dry Matter of white maize

Sources of variation	df	Mean square of total dry matter	
		At 45 DAS	At Harvest
Replication(A)	2	6.001	6.863
Fertilizer(B)	2	142.593*	105.711**
Error A×B	4	9.18	4.788
Spacing(C)	2	37.849^{NS}	436.795**
Fertilizer(B)×Spacing(C)	4	157.857**	373.298**
Error	12	18.435	7.323

* Significant at 5% level
** Significant at 1% level
^{NS} Not significant

Appendix VI. Mean square values for Yield contributing parameters of white maize

Sources of variation	df	Mean square of				
		Cob length (cm)	Cob circumference (cm)	No. of rows cob^{-1}	No. grains cob^{-1}	No. of grains cob^{-1}
Replication (A)	2	0.0575	2.05914	0.18574	1.2661	630.63
Fertilizer (B)	2	9.4428*	1.15643^{NS}	1.63363**	7.3492**	3959.29**
Error A×B	4	0.0655	0.78513	0.06653	0.6115	164.28
Spacing(C)	2	17.0596**	6.08443*	0.34323^{NS}	10.7347**	202.48**
Fertilizer(B)×Spacing(C)	4	0.6352*	1.68663^{NS}	0.02478^{NS}	0.1331^{NS}	2221.17**
Error	12	0.1252	0.85145	0.254	0.4689	373.47

* Significant at 5% level
** Significant at 1% level
^{NS} Not significant

Appendix VII. Mean square values for Yield parameters of white maize

Sources of variation	Degrees of freedom	Mean square of Yield parameters			
		Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (gm)	Grain weight cob^{-1}(gm)	Cob weight (gm)
Replicati (A)	2	0.7778	1.173	0.645	2.241
Fertilize (B)	2	20.0182**	15.3961*	207.278**	62.292*
Error A×B	4	0.7778	2.2086	3.76	9.009
Spacing (C)	2	65.266**	41.4076**	246.02**	113.1**
B×C	4	2.7185^{NS}	0.4087^{NS}	162.611**	160.887**
Error A×B×C	12	1.111	0.6777	2.244	2.485

* Significant at 5% level
** Significant at 1% level
^{NS} Not significant

Appendix VIII. Mean square values for Yield parameters of white maize

Source of variation	df	Mean square of				
		100 grain weight	Grain yield Ton/ha	Biological Yield (ton/ha)	Stover Yield (ton/ha)	HI
Replication(A)	2	0.8083	0.031	2.6172	0.411	3.189
Fertilizer(B)	2	57.328**	1.222**	22.861*	12.31**	7.35^{NS}
Error A×B	4	0.3226	0.024	2.1015	0.532	1.13
Spacing(C)	2	12.243**	4.666**	66.239**	32.57**	31.91**
Fertilizer(B)×Spacing(C)	4	19.244**	1.617**	21.998**	27.25**	269.72**
Error	12	0.251	0.016	1.422	0.569	3.06

* Significant at 5% level
** Significant at 1% level
^{NS} Not significant

PLATES

Plate 1. Experimental field under study at 7 days after sowing (DAS)

Plate 2. Experimental field under study at 60 days after sowing (DAS)

Plate 3. Cob at milking stage

Plate 4. Harvesting of white maize at 90 DAS at SAU research Field.