EFFECTS OF SOWING DATES AND TIME OF BASAL FERTILIZER APPLICATION ON GROWTH ANDYIELD OF MAIZE (*Zea mays* L.) IN THE SUDAN AND NORTHERN GUINEA SAVANNAS OF NIGERIA

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
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DEPARTMENT OF AGRONOMY,
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DECLARATION

I declare that the work in this dissertation entitled:**''EFFECTS OF SOWING DATES AND TIME OF BASAL FERTILIZER APPLICATION ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.)'' IN THE SUDAN AND NORTHERN GUINEA SAVANNAS OF NIGERIA** has been performed by me in the Department of Agronomy under the supervision of Dr. A. Namakka and Dr. R. A.Yahaya. The information derived from the literature is duly acknowledged in the text and list of references provided. No part of this dissertation has been previously presented for another degree or diploma at any University.

________________________________ __________________

Aishatu YUNUSA Date
(Student)

CERTIFICATION

This dissertation entitled: **'EFFECTS OF SOWING DATES AND TIME OF BASAL FERTILIZER APPLICATION ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.) IN THE SUDAN AND NORTHERN GUINEA SAVANNAS OF NIGERIA,**presented by Aishatu, YUNUSA meets the regulations governing the award of the degree of MASTER OF SCIENCE. Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my parents MallamYunusa Adziba and Hajiya Habiba Yunusa and my husband for their foresightedness and sacrifice towards my education. Special dedication goes to my relatives and siblings for their moral support during the course of the study.

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ABSTRACT

Field trials were conducted in 2016 wet seasons at the Institute for Agricultural Research farms, Samaru and Kadawa to assess the Effects of sowing dates and time of basal fertilizer application on growth and yield of Maize in the Sudan and Northern Guinea Savannas of Nigeria. The treatments consisted of 4 sowing dates which were at 7 days intervals (2^{nd} week of June, 3^{rd} week of June, 4^{th} week June and 1st week of July) and 3 times of basal fertilizer application periods (at sowing, 10 days after sowing and 20 days after sowing). The treatments were factorially combined and laid out in a randomized complete block design (RCBD) which was replicated 4 times. Parameters measured were plant height (cm), leaf area per plant (cm^2), leaf area index, shoot dry matter per Plant (g), crop growth rate ($gm^{-2}wk^{-1}$), relative growth rate ($g\ g^{-1}wk^{-1}$), net assimilation rate ($gm^{-2}wk^{-1}$), number of days to 50% tasseling, number of days to 50% silking, number of cobs per plant, cob length (cm), cob diameter (cm), cob weight (g), threshing percentage (%), harvest index (%), weight of 100- grain weight (g) and grain yield per hectare (kg). At both locations, the result obtained revealed that sowing Maize at 2^{nd} week of June significantly positively influenced plant height, number of leaves per plant, leaf area index, shoot dry matter per Plant (g), crop growth rate, relative growth rate, net assimilation rate, number of days to 50% silking, cob length, 100- grain weight and grain yield per hectare. Time of basal fertilizer application at sowing significantly influenced plant height, leaf area index, shoot dry matter, crop growth rate, relative growth rate, net assimilation rate, cob diameter, cob length, 100 - grain weight and grain yield per hectare at both locations. Similarly, interaction between sowing dates and time of basal fertilizer application indicated that sowing at 2^{nd} week of June and application of fertilizer at sowing positively influenced plant height and grain yield per hectare. The correlation result showed that grain yield was positively and significantly correlated with all parameters except number of days to 50% silking and net assimilation rate. Based on the result obtained from this study, it can be concluded that Sowing Maize in 2^{nd} week of June and Time of Basal Fertilizer Application at Sowing resulted in better growth and highest yield and are therefore recommended to farmers around Samaru and Kadawa.

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%	Percent
AGDP	Agricultural Gross Domestic Product
ANOVA	Analysis of Variance
C	Carbon
Ca	Calcium
CD	Cob Diameter
CEC	Cation Exchange Capacity
CGR	Crop Growth Rate
CL	Cob Length
CM	Centimetre
CV	Coefficient of Variation
CV	Cultivar
CWT	Cob Weight
DAE	Radiation Use Efficiency
DAS	DaysAfter Sowing
DMRT	Duncan Multiple Range Test
et al.,	And Other
FAOSTAT	Food and Agriculture Organization Statistics
g	gram
Ha	Hectare
HGWT	Hundred Grain Weight
HI	Harvest Index
IAR	Institute for Agricultural Research Zaria
IITA	International Institute of Tropical Agriculture
K	Potassium
Kg	Kilogram
LAI	Leaf Area Index
LL	Leaf Length
M	Metre
MAX	Maximum

Mg	Magnesium
MIN	Minimum
MM	Millimetre
MMT	Million Metric Tons
N	Nitrogen
NAR	Net Assimilation Rate
NARIS	National Agricultural Research Institute
NS	Not Significant
OAU	Organization of Africa Unity
OC	Organic Carbon
OPV	Open Pollinated Varieties
P	Phosphorous
PAR	Photo-synthetically Active Radiation
PLHT	Plant Height
PPM	Parts Per Million
RCBD	Randomized Complete Block Design
RGR	Relative Growth Rate
RUE	Radiation Use Efficiency
SAMMAZ	Samaru Maize Zaria
SD	Standard Deviation
SSA	Sub- Saharan Africa
TZEESR	Tropical *Zea mays* Extra Early
WAS	Week After Sowing
YLD	Grain Yield

CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin and Distribution

Even though most scientists believe that Maize originated from Mexico, other scientists have also proposed multiple- origins of the crop; According to Dowswell *et al*, (1996) The Maize is believed to have originated in Maxico and Central America, It from where it was later taken to latin America, the Caribbean, the United States of America and Canada (Ikisan, 2013) further stated that Maize was taken to Spain by Columbus from where it was further distributed to West Africa by the Portuguese merchants in the 10^{th} Century. Matsouka *et al.*(2002) proposed that Maize was dispersed from its proposed centre of origin via two routes; the northward route which traces from Mexico's highlands throughout northern Mexico into South western United States and the southward route from Mexico's highlands to western and southern lowlands of Mexico into Guatemala and the Caribbean Islands. Maize was brought to Europe in the 16^{th} century by Columbus who took the seeds from Cuba to Spain and later spread to Italy and other parts of the world (GTZ/MoFA, 2006). Furthermore the Portuguese introduced Maize to Africa for planting in the Congo basin and the crop spread throughout the continent due to its high yield and numerous uses. (Benz 2001). The ability of the crop to be grown under a wide range of conditions ranging from soil type, soil fertility, moisture level, temperature and cultural practice have supported its wide distribution (Abdulai *et al.*, 2007).Maize (*Zea mays* L.) belongs to the grass family *Poaceae* and it's cultivation is globally, being one of the most important cereal crops after Wheat and Rice (FAOSTAT, 2016). Maize, because of its wide adaptation it is cultivated in more environments than other cereals including wheat and rice (Koutsika-Sotirious, 1999).

1.2 Production of Maize

The World's total Maize production was estimated by FAO's in the new forecast of global cereal stocks for crop years at the endof2019 as scaled up since the previous report by almost 11 percent (82 million tonnes to 849 million tonnes) largely reflecting revisions to Maize, wheat and rice inventory estimates in china (FAO, 2019). Global Maize production in 2018 has been lowered slightly to 1046 million tonnes with large downward revision in China (main land) reflecting area contractions as farmers shift to more profitable crops, and in Brazil, where a continuation of dry weather is foreseen to curb plantings and yields of the second season crop (FAOSTAT, 2018). Global trade in coarse grain in 2018/2019 (July /June) is estimated to be 187.2 million tonnes , up 0.9 percent from 2017/2018, with Maize trade expected to rise to 147 million tonnes, 1.1 percent higher than in 2017/2018 production (FAOSTAT, 2018).

The world's six largest corn producers are United State, China, Brazil, Argentina, India, and Mexico. Mexico's corn production was pegged at 27.4 million metric tons, but the country does not export it, In fact, it's a major importer of corn in order to meet domestic demand (FAOSTAT, 2019).The United States is by far the world's largest producer and exporter of corn, with production in the 2017-2018 season pegged at 371 million metric tons (FAO, 2016). The acreage dedicated to planting corn changes from season to season, but in all more than 90 million acres of American land is planted with corn each season. Domestic consumption was about half the total, and most of that was used as a feed grain for livestock. China current season corn production is estimated at 215.9 million tons and almost all of it is consumed domestically. Brazil is a major producer of many crops, including coffee, sugar, and soybeans and in 13th May 2019 early indication for the 2019/ 2020 trade season point to

Maize exports from Brazil rising to 29.5 million tonnes, some 15% higher than in 2018/2019. According to FAO's, this would place Brazil as the second largest Maize exporting country in the world, after the United State (FAO, 2019). Argentina is a significant producer of corn and also a significant exporter of it. Its annual corn production is estimated at 46 million metric tons (Statista, 2020). In 2018 about 10.2 million tons of Maize was produced from 4.8 million hectares, making Nigeria the highestproducer in Africa (FAO, 2018).

Nigerian overtook South Africa and becomes the largest Maize producer in 2018/2019. Nigeria Maize yield for 2018/2019 was about 1.6 tonnes per hectare (Agbiz, 2019). Nigeria harvested 14% of the total sub regions Maize production platform of 6.5 million hectares. The most recent data from the International Grains Council put Nigeria 2018/2019 Maize production estimate at 11 million tonnes, which equates to 16.1 share of Sub-Saharan Africa's Maize harvest (Agbiz, 2019). Maize is also sparingly grown as a field crop in the semi-arid zones of the Sudan and Sahel savannah (Ado *et al*., 1999).

According to the Nigeria Gross Domestic Product Report – GDP (Q4 and full year 2018 released by the Nigeria Bureau of statistics – NBS Nigeria's Agriculture Sector grew by 2.12% in 2018, the Nigeria 18.58% year on year in nominal terms in 4 quarter 2018, showing an increase of 8.45% points from the same quarter of 2017 and 0.26% points increase from 3 quarter 2018. Crop production remains the major driver of the sector, accounting for 89.84% of nominal Agriculture GDP, an annual basis, Agriculture GDP grew by 14.27 % higher than 11.29% recorded in 2017, (GDP. FEBRUARY14, 2019 by Africa Harvester).

Maize is widely grown all over the country. However, the leaders in this crop production are Niger, Taraba, Kaduna, Adamawa, and Plateau States. They have the biggest plantations of Maize and in previous years, they sold the crop with profit (Rachael, 2018).

Maize production has improved with the adoption of improved technologies by farmers. These technologies include the use of improved seeds, timely sowing, appropriate spacing, and timely weeding, harvesting, use of fertilizers for soil improvement as well as the use of minimum tillage. Other reasons that can be attributed to the popularity of Maize as reported by Onwueme and Sinha (1991) are high yield per unit area, higher nutritional content, easy to harvest and non-shattering.

1. 3 Economic Importance and used of Maize

In Sub- Saharan Africa Maize is regard as one of the most importance cereal crops (IITA, 2007) and is considered as the most importance cereal crop in humid and sub humid Savanna of West and Central Africa (Oyetunji *et al.* 2001).

Maize crop is a key source of food and livelihood for millions of people in many countries of the world.Maize is an important staple food in Nigeria and Maize had grown to be local 'cash crop' most especially in the north and south western part of Nigeria, where at least 30 % of the crop land have been devoted to a small- scale Maize production under various cropping system (IITA, 2009). It is not only an important source of human nutrient, but also a basic element of animal feed and raw material for manufacturing of many industrial products such as corn starch and corn oil. It is produced extensively in Nigeria, where it is consumed roasted, baked, fried, pounded or fermented (Agbato, 2003). In developed countries, Maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, Maize is consumed directly and serves as a staple diet for some 200 million people (Anon, 2003). In Sub-Saharan Africa, Maize is a staple food for an estimated 50% of the population. It is an important source of Carbohydrate, Protein, Iron, Vitamin B, and Minerals. Hamayun (2003) noted that Maize grain is a valuable source of Protein (10.4%), Fat (4.5%), Starch (71.8%), Fibre (3%), Vitamins and Minerals like Ca, P, S and small amounts of Na. Its flour is considered to be a good diet for heart patients due to its low gluten (protein) content (Hamayun, 2003). The endosperm contains approximately 80% of the Carbohydrates, 20% of the Fat and 25% of the Minerals while the embryo contains about 80% of the Fat, 75% of the Minerals and 20% of the Protein found in the kernel (Chaudhary *et al.,* 1993).

The dried grain is used for the preparation of porridge after milling and boiling. It is also used for the production of livestock feeds and in industries for the production of alcohol and non-alcoholic beverages, corn starch and production of bio-fuel (Fajemisin, 1991). In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol (Dutt, 2005). Corn oil is used for salad, soap-making and lubrication. Maize is a major component of livestock feed and it is palatable to poultry, cattle and pigs as it supplies them energy (Iken *et al.,* 2001). The stalk, leaves, grain and immature ears are cherished by different species of livestock (Dutt, 2005).

Maize has different varieties with different maturity period, can be stored well is easily transportable and has high consumer preferencefurthermore; research in the past two to three decades has helped to understand the crop environment and has generated agronomic options and Maize varieties that are more appropriate to the ecology (Fajemesin, 1991). Research and Development Agency (SAFGRAD) and intervention by the Organization of

African Unity (OAU) in response to the recurrent drought of the late 1960's and early 1970's, provided a focus for the development of maize especially for the sub humid zones of Africa. The IITA – SAFGRAD scientists, through resident research in Burkina Faso and collaboration with National Agricultural Research Institutes (NARIS) in the region, developed intermediate, early and extra early maize germplasm. They also identified constraints to effective crop management (especially in semi-arid zone) and investigated several agronomic options for increased and sustainable Maize yield (Ado *et al.*, 1999). Among the early varieties developed are the IITA's streak resistant open pollinated varieties (TZEESR and TZESR-7) are selected at Gusau in Sudan Savannah (Ado *et al.*, 1999). A number of early and extra-early Maize varieties and their characteristics were given by Fajemesin (1997) as reported by Ado *et al.* (1999). In the report, early Maize varieties were classified to mature between 85-95 days, which were further classified into white open pollinated and yellow open pollinated. The Maize varieties mature between 80-85 days and have also white and yellow open pollinated types.

1.4 Soil and Climatic Requirements

Maize needs a regular supply of water and does not tolerate drought. It requires rainfall of about 600-1,200mm per annum and this must be well distributed throughout the year (Awuku *et al.,* 1991). Maize is grown between latitude 58° N and 40° S of the equator, varying altitude affects the number of days to flowering and maturity. This is as a result of the high temperature at lower altitude, which accelerates growth conversely, the lower prevailing temperature at high altitude retards growth and extends the time taken to reach maturity. According to Awuku *et al.*(1991), Maize requires an average temperature of

13-40°c and does not grow at higher temperatures. Tweneboah (2000), however, stated that the optimum temperature for maize growth ranges from 18-21°c. The most suitable soil for Maize must be deep, well drained and have favourable physical properties, an optimal moisture regime, sufficient and balanced quantities of plant nutrients and chemical properties. A pH of 5.5-7.5 is best for its production (Anon, 2003).

1.5 Justification of the Study

Maize has a great potential of higher yield and one of the most populous cereal crop under cultivation and if managed properly, it can go a long way in increasing food security through increased production in Nigeria. Unfortunately, in spite of its high yielding potentials, the average yield in Nigeria is still very low 1.6 t/ha (IITA, 2017 and FAOSTAT, 2019). According to Saidou *et al*. (2012); Balogoun *et al*. (2013) Poor soil fertility coupled with inappropriate timing of fertilizer application and the use of nonspecific sowing date for the crop caused low yield of the crop, with sowing date has been shown to be an important factor influencing the growth and yield of crops (Nafzinger, 1994).

Cirilo and Andrade (1994) observed that sowing before or after the optimum date results in crop yield reduction. With the fluctuation of rainfall pattern in the savannah agro ecological zone of Nigeria due to climate change, the traditional or long period when rain is believed to have established is also changing accordingly there is an urgent need to re-evaluate optimum sowing date for the new crop varieties in orderto escape the problem of drought or excess rain at various stages of the crop growth cycle.

According to Kamara (2020) Maize is one of cereal crops that respond to fertilization better than most cereals therefore the time for the fertilizer application is very critical for crop performance, Maize production requires an understanding of various management practices as well as environmental conditions that affect the crop performance. These low yields could be due to several factors including low soil fertility, drought during critical stages of the crop growth, weed and pest infestation, and limited use of inputs such as fertilizer and improved seeds (Adu *et al.* 2014).

One of the major effects of global warming is changing in the rainfall intensity and distribution pattern, hence the optimum sowing date for most crops is also affected, and accordingly hence farmers have no definite sowing date (Wheeler and Von 2013). In the face of the visible impact of global warmingor the period when basal fertilizer should be applied for optimum response atinappropriate times of basal fertilizer application can result to low yield (FAO, 2006).

1.6 Objectives of the Study

It was based on the above mentioned problems that this study was designed to:

1. Determine the Effects of Sowing Dates on Growthand Yield Components of Maize.
2. Determine the Effects of Time of Basal Fertilizer Application on Growth and Yield Components of Maize.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effects of Sowing Date on Growth, and Yield Components of Maize

Sowing date is an important management option to optimize Maize Production. Numerous publications (Mendhe *et al.,* 1992; Namakka *et al*., 2008; andMaryam *et al.,* 2013) have reported an increased in Maize yield with early planting at first week of June and reduction in yield when planting is delayed after the optimum time. The delay in planting does not only affect yield, but also it affects the yield components and other aspect of the growth and development.

Sowing date hasan influence on seedling emergence of Maize (Mock and Erbach, 1977). The initial growth of late sowing maize is generally poor, after which growth stages could be slow, and the plant fails to perform better. According to Ahmadi *et al.* (1993) revealed that the sowing date is one of the most important components of a Maize cropping system that can influence grain yield and yield components significantly. It thus remains small with low carbohydrate production during grain filling stages (Venon, 1953 and Jones, 1974). The vegetative stage of growth as the measured at the plant height, number of leaves per plant and leaf size declined with late sowing (El-sharkawy *et al.,* 1975). It has found that crop sown at the optimum time make the best use of the available temperature and solar radiation at the different growth stages for height productivity, (Jiban *et al.,* 2018).

It generally associated with a reduced kernel weight, reduced number of ears per plant, grain number per plant and LAI (Elemo, 1991; Cirilo and Andrade, 1996; Valencia and Steven, 1999; Maryam *et al.,* 2013). However, planting too early may result in crop failure due to drought that occurs at seedling stage, which necessitate farmers to replant their crops and, in turn, planting too late might reduce valuable growing time and crop yield (Kamara *et al*., 2003). In order for crops to utilize moisture, nutrients and solar radiation, for higher yield crops must be grown on an optimum sowing date. The significant reduction in cob length, cob diameter and cob weight with delay in sowing date could be due to the significant increase in the leaf area index of early sown crop which resulted in a more light interception and probably higher photosynthesis by Valencia*et al.* (1999).

Cane *et al.*(1994); Phillips *et al*. (1998), reported that choosing appropriate sowing date is essential for increasing crop productivity taking advantage of the available climatic resources under conditions in which farmer has no access to inputs such as synthetic fertilizers or pesticides. According to Shimono *et al.*(2009) report that Maize flowering date was delayed by 8 to 46 days from the delayed sowing date and that delayed in sowing clearly reduced both plant height and biomass. According to Namakka *et al*. (2008), Maize sown at the end of June and mid-July had significantly heavier cob than the end of July sown Maize.Sowing date for Maize varies from one area to another, depending on the establishment of rains, Maize sowing should be done when the rains are well established and immediately after a good rain. Much emphasis is usually placed on early planting to enable the crops to benefit from the early nitrates released in the soil (Anon, 1987; Mehdi 2012). Sowing date had always been known to have marked effects on growth and yield of crops (Anon, 1987; Rowland 2013). Matta *et al.*(1996)Yield declined with delaying sowing date when four cultivars of Maize were sown at two weekly intervals between the beginnings of May to mid-July. Sowing in July reduced time of flowering by eight days, delayed sowing after mid-June decreased leaf number per plant, leaf area per plant and ear weight. Roy and Singh (1994) observed that delays in sowing dates hastened development between seedling emergence to silking and decreased cumulative incident radiation on Maize during the vegetative period. However, late sowing decreased crop growth rate during grain silking because of low radiation use efficiency and low incident radiation. Moreover, Maize sown late accumulated more dry matter before silking physiological maturity, while the inverse was true for early sowing, thus delayed sowing strongly decreased dry matter partitioning to grain yield, (Shen and Duang 1990; Leee and Tollenaar 2007; Peng – Ning 2018). It was also observed by Bajai*et al.*(1992) that delayed sowing date significantly reduced leaf number at tasseling and length and width of the first leaf above the ear (Boateng*et al.*, 2006) found that highest grain yields were generally obtained when sowing was completed early and that yield declined as sowing was delayed in Ghana from mid-June to early August. Various works that supported early sowing included that of (Singh *etal.*, 1992; Jaliya *et al.*, 2008; and Kamara *et al.*2009) who reported that early sowing is the best way to minimize environmental constraints of Maize in West Africa.

There were a progressive decrease in leaf area, leaf area index and decreased biomass and grain yield resulting from late sowing. Rossini *et al.* (2011) reported that the yield of Maize is a function of many plants and environmental factors which are often interrelated. Miller *et al.* (1984) conducted experiments on the effect of planting dates on sunflower performance under sub-humid conditions of USA and concluded that planting in early June in Arlington and mid-May at Spooner maximized seed yield (1008 and 1309 seeds head^{-1}), oil content

(46.5 and 46.3 %,) and test weight 9.4 and 9.9 g,) and reported a decline in test weight with each successive delay in planting and lowest test weight (7.4 g 200 seeds^{-1}) was recorded in late June planting. Silva and Sangoi (1985) found higher seed and oil yields from sowings in August or September than from later sowings in sunflower. (Gardner, Nieson and Shock 1992) in his trials to determine the optimum date of sowing in sunflower hybrids under the frequently cool, short growing season of North Dakota, reported that late May is the best time in terms of seed yield and also oil content.

Environmental changes associated with different sowing dates (sunshine, temperature) have a modifying effect on the growth and development of maize plants. Each hybrid has an optimum sowing date, and the greater the deviation from this optimum (early or late sowing), the greater the yield loss (Sarvari and Futo,2000). Rahman *et al*. (2001) observed that sowing date had a significant effect on yield and yield components of Maize. October sowing (4097 kg ha^{-1}) out yielded November and December sowings by 36.5 and 53.0%, respectively, (Abdelrahman *et al.* 2004).

The Maize needs nutrients to achieve high yield. The variety of crop and nature of the fertilizer determine the appropriate time of application. The Maize plant if starved of the nutrients at any development stage will result in the reduction of grain yield, (Johnson, 1972). An adequate supply nutrient at a later stage will often not overcome the early deficiency. It is therefore important that fertilizers are applied to the maize at the appropriate time. Leonard (1983) reported that in Maize, the best time of N application is at sowing to encourage vigorous vegetative growth and at flowing to ensure the very best grain filling. Various researchers have recommended that N fertilizer be applied in two time doses, one half of the N fertilizer at sowing and the other half of the N fertilizer four to six weeks after sowing (Goldsworthy, 1967b; Fox 1972; Jones 1976; Lombin, 1985). Stanley and Rhoads (1976); Daubin (1978); Bouldin and Selleck(1979)obtained significantly lower yield when NPK fertilizer application was delayed up to six weeks after sowing while treatments which received NPK fertilizer at sowing produced the highest grain yield.

Ologunde (1981) found N fertilizer to be most effective if applied at sowing than any other time.Indicating that delayed application of N as a side dressing should be more efficient. Fayemi (1966) found that applying all N at sowing did not increase yield and delaying application 60 days after sowing significantly reduced yields. Fayemi (1966) also obtained increase N and Crude protein content of the grain when N was applied 30 days after sowing, Pawson (1957a) and Brah and Khehra (1977) concluded independently that the maximum grain yield of Maize was expected with time rather than the sowing time single application. Spaldon and Zuzi (1972) found that Maize responses were great with half the N fertilizer and three quarters of P fertilizer were applied to the seedbed and the balance being applied four to six weeks after sowing.

Shukla (1970) found Maize yield to be highest when time of half of the N fertilizer was applied at sowing and the other half of the N fertilizer applied at tasseling. At location where rainfall and leaching losses were high Jaynes (2013) and Fernandez *et al* (2016) found the best treatment to be one third of the N fertilizer applied at sowing one third of the N fertilizer applied at the high stage and a third of N fertilizer applied at tasseling. Split application of nitrogen is essential in Maize production (Nnamdi *et. al.,* 1998). The proper timing of nitrogen application has been known to be one of the most important factors that influence the recovery efficiency of nitrogen fertilizer (Jones, 2008). The application of nitrogen to Maize at sowing promotes early growth because it supplies the nutrient in the zone where the roots are active (Berger, 1982).

In order to ensure adequate supply of added N at critical stages of the plant growth and reduce N leaching and losses due to heavy rainfall, Balasubramanian *etal.*(1978) reported that the N fertilizer should be split into two equal doses and applied first at sowing and then at four to six weeks after sowing. Reeves and Touchton(1986) obtained greater yields with N applied at five weeks after sowing compared to application at sowing. Pawson (1957b) earlier found that applying N fertilizer application at six weeks after sowing was superior to applying N fertilizer application before sowing. Time of N application is especially important in sandy soils where leaching losses may be high. El-sharkawy *et al.* (1976);Brah and khehra 1977) independently recommended three periods of N application on sandy loamy soils. Brown (1966) found no relationship between time of N application and maize grain yield. Esechie (1982) also obtained no advantage of split over single application.

Abendroth *et al.* (2011) observed that N fertilizer applied at sowing could be lost to early emerging weeds before it becomes available to the Maize. It could also be lost through the nitrification, volatilization, leaching or fixation. Carpenter *et al.* (1998) observed that the magnitude of both adsorption and N loss depend on soil type, tillage, fertilizer management, crop rotation and weather condition.

Apart from higher grain yield obtained from the delayed N fertilizer application, Olson (1987) reported a greater residual N fertilizer for subsequent crops.

The recommended time for P application to Maize in the savanna zones had been a single application prior to sowing (Jones and Bromfield, 1974; Jones 1976).The early application of P is recommended because of its immobility in the soil so it is essential to the seed on germination to enhance its utilization easily. Ologunde (1981) observed response of most field crops to P fertilization as the greatest early in the season and decreases as the crop matures. Black (1968) indicated that P availability decreases with time due to mostly to fixation, preferential depletion by crops and extension of roots into soil that does not contain the fertilizer. The early application of P is considered necessary to stimulate root enlargement (Annonymous, 1970 and Leonard, 1983).

Ignatieff and Page (1958)and Bundy (1998) recommended that the K fertilizer application be done at or just before sowing. However, considering the large quantity of K removed by maize, the ease with which K is lost through leaching and the fact that excess K may be subjected to fixation, Ologunde (1981) recommended that its application be spread three to five times over the growing period. Hanway (1966) and Bowyer (2010) recommended that time of application of K be spread between zero to five weeks when corn plants require this nutrient most. This time corresponds to the time when maize is sown to silking. Time of application and delayed basal application are effective fertilizer strategies to reduce nutrient leaching (Sitthapanit *et al.,* 2009).

According to Sitthaphanit *et al.*(2010) delaying application of fertilizer by 7-15 day after emergence (DAE) and pre-plant application gave a higher crop growth rate (CGR) with the 30 DAE than with the 21 DAE applications. Delaying application to 15 DAE produced a higher crop growth rate (CGR) during the period of 30- 60 DAE (46% greater than the pre – plant treatment). There was no significant difference in the CGR values of fertilized treatments in the period of 60-90 DAE, but they were significantly higher than the control. After 90 DAE, the delayed application to 7 DAE had the highest CGR, whereas the others showed no significant difference in CGR. The fertilizer application treatments had a higher relative growth rate(RGR) values than the control treatment during the period from sowing to 60 DAE, but pre- plant and the delay to 15 DAE were not significantly different in RGR from sowing to 30 DAE. Delaying the application until 15- 21 DAE had the highest RGR (19% greater than pre-plant at 30-60 DAE). For periods beyond 60 days after emergence (DAE), the relative growth rate (RGR) was not significantly different among treatments.

Growth analysis suggested that a delayed time of basal application during the period of low nutrient requirements and reducing the amount of fertilizer supplied when the plant was small were effective in increasing fertilizer use efficiency. Sainz*et al.* (2004) found that maize can recover 43-53%of total N fertilizer application at sowing compared to 62-74%when applied. Several reports showed that the time of basal fertilizer applications could improve the yield and growth component. Delaying the final application from 45 to 50 DAE decreased the yield and shoot dry matter when the fertilizer was split into three applications. Even though the maximum, Maize nutrient uptake occurs near silking (Richie *et. al.,* 1993), the final fertilizer application of fertilizer at 50 DAE seemed too late for plant uptake and utilization to produce grain yield. Binder *et al.* (2000) report that late application of N fertilizer in the growth stage decreased Maize grain yield compared with earlier application, this suggests that either root activity declined at this stage and was less effective in nutrient uptake, or else the delay in fertilizer application to 50 DAE caused a temporary deficiency before tasseling which impeded subsequent growth.

2.2 Effects of Time of Basal Fertilizer Application on the Growth, Yield and YieldComponents of Maize

In Maize, planting date modifies the radiation and thermal conditions during growth. The amount of incident radiation and the proportion of this radiation that is intercepted by the crop directly determine crop growth rate. Delay in planting date determined important reductions in the amount of incident radiation accumulated from emergence to silking, because it hastened development. Low temperatures during grain filling in late plantings limited seed growth as well as crop photosynthesis. Thus, the ratio between the final seed number and dry matter at silking dropped dramatically for later plantings, indicating a predominance of vegetative growth over reproductive growth (Cirilo and Andrade 1994; Ali *et al*., 2011; Ahsan *et al*., 2013;). Planting Maize too early and too late resulted in a reduced leaf area index, leaf area, dry matter production and yield (Stephen and Wallace 1996). Berzsenyi *et al*. (1998) opined that growth indices in the vegetative stage were greater within late sowings as compared to early sowings. However, the values were greater in early sowings during reproductive growth stages. In general, late plantings result in higher crop growth rates during the vegetative period because of high radiation use efficiency (RUE) and high percentage radiation interception, but conversely result in lower crop growth rates during grain filling because of low RUE and low incident radiation. Cirilo and Andrade (1994). In addition, Maddonni *et al*., (1998) found that in late Sowing, both solar radiation and temperature decline during grain filling, indicating a possible source limitation. On the other hand, low temperature may have a negative effect on seed weight through reductions in both radiation use efficiency and assimilate partitioning to the grains (Andrade *et al*., 1993; Ali *et al*., 2012; Ali *et al*., 2013d).

Maize planted earlier develops better and has a higher yield potential because the vegetative period of its development occurs in the cooler part of the season when moisture stress is less likely (Aldrich *et al*., 1986;Adam *et al*., 1989;Ali *et al*., 2013a;Ali *et al*., 2013b;Ali *et al*., 2013c; Ali *et al*., 2014b;). Generally, there are many benefits related to early planting date compared to late planting date and this include a long growth duration that allows a greater choice of hybrid maturities and wider window of opportunities for replant decisions. In addition, Sheperd *et al*. (1991) reported that early planting date could contribute significantly to higher Maize yields. The authors also highlighted that higher yield is not the only advantage of early planting because other benefits can also be achieved from high plant density and high fertilizer rates. It also allows harvesting earlier in the season when conditions are usually better and field and time losses can be minimized (Hicks *et al*., 1993). In addition, very simply early planting increases net returns without adding production costs. On the other hand, late planting or planting after the optimum period consistently resulted in lower yields. Delayed planting shortens the effective growing season for Maize, increasing the risk of exposure to lethal cold temperatures late in the season before grain maturation. According to Aldrich *et al*. (1975), yield reduction in late plantings could be attributed to a short growth duration, insect and disease pressure, heat and moisture stress during pollination. These results were in agreement with those by Otegui and Melon (1997), who reported that delayed plantings are generally accompanied by increased temperatures during the growing season, which accelerate crop development and decrease accumulated solar radiation, resulting in less biomass production, seed set and grain yield. However, the results of planting date experiments can be highly inconsistent between seasons and sites. For example, it is usual for a relatively late sown crop to out yield the control crop sown within the optimum period (Green and Armstrong 1985; Ali *et al*., 2014a; Ali *et al*., 2014d). There are several reasons for such inconsistencies and unexpected results. First, the soil conditions at different planting dates will inevitably be different and unfavourable conditions (excess or deficiency of soil moisture, serious incidence of diseases, etc.) can occur at almost any point during the normal planting dates. Consequently, the observed differences in the performance of crops sown on different dates, are commonly a reflection of differences in established plant density. Secondly, crops sown at different dates pass through each developmental stage at slightly different times and, therefore, under different environmental conditions (especially photoperiod and temperature); Thus, any one of the developmental stages which determine the components of yield could conceivably occur under more or less favourable conditions in late-sown crops. For these reasons, it is not easy to carry out a critical comparison of the grain yields and their components of the different crops in a sowing date experiments.

2.3 Interactionbetween Sowing Dates and Time of Basal Fertilizer Application on Growth, Yield and Yield Componentsof Maize

Effect of sowing time was observed to be significant on crop well fertilized with nitrogen and phosphorus (Jones, 1976). Yield reduction in a well fertilized (nitrogenous) crops sown before the beginning of June appeared to be due partly to a limitation on the cob development at pre-silking stage. Charles *et al*. (2015) evaluated CERES-Maize Model using planting dates and nitrogen fertilizer in Zambia and showed that the model can be used to accurately determine optimum planting date (November 24), biomass yield and nitrogen application rate (168 Kg N ha^{-1}) under the local condition with reasonable accuracy furthermore the results showed that grain yield reduced with delay in planting and there was no interaction between planting date and nitrogen application rates. According to Abayomi and Adedoyin (2004b), the difference in growth characters due to planting date was mainly attributable to inadequate moisture in June planting which did not enhance the efficiency and effective usage of the supplied N fertilizer for better growth of leaves and development of maize plant and hence the reduced grain yield.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Sites

The Field trials were conducted during the 2016 wet season at two locations; Institute for Agricultural Research Farm (I.A.R), Ahmadu Bello University, Samaru which is located at latitude 11^0 11'N, 07 38'E, 686m above sea in the northern Guinea savannah and Institute of Agricultural Research Farm, Kadawa research farm which is located at latitude 11^0 39'N, 08 20'E, 500m above sea level in the Sudan Savannah ecological zone of Nigeria.

3.2 SoilAnalysis

Soil from the two experimental sites were randomly sampled to the depth of 0-30 cm using a soil augerand the samples were analysed for physico-chemical properties in the Department of Agronomy laboratory, Ahmadu Bello University Zaria, Nigeria. The samples were bulked, air dried, grinded and sieved through a 2mm mesh sieve. A composite sample was taken and then subjected to routine laboratory analysis for its physical and chemical properties. The soil particle size analysis was determined by the hydrometer method (Day, 1965) and the textural class was determined using textural triangle (USDA, 1960). The soil sample was mixed with 50ml water and shaken vigorously in a graduated cylinder. The soil suspension was allowed to settle overnight. The soil texture was analysedfrom its volumetric content of sand, silt and clay. Soil pHwas determined using apHmeter by taking soil and water in the ratio of 1:1 (Black 1965; Carter and Gregorich 2007). Total nitrogen was determined using CHNS/O Analyzer (Euro Vector, Model: EuroEA3000) (Bremner, 1965), available phosphorus P_2 was extracted by Bray No. 1 method (Bray and Kurtz (1945), and available potassium (K_2O)by Jackson (1973), Organic carbon (OC) was determined by Walkey Black wet oxidation method (1934). Exchangeable bases were determined in the neutral NH4 OAC extract by atomic absorption spectrophotometer (Black, 1968). The cation exchange capacity (CEC) was estimated by summing.

3.3 Meteorological Data.

Records of temperature (maximum and minimum), rainfall, relative humidity and sunshine hours for the period of the trials were obtained from the Institute for Agricultural Research (I.A.R) Meteorological Unit, Zaria, Samaru and Kadawa Research Farm. Details of the meteorological Data for both locations are presented as Appendix 1 and 11 for Kadawa and Samaru respectively.

3.4 Treatments, Experimental Design and Plot size

The treatments consisted of 4 sowing dates; which were at 7 days intervals (2^{nd} week of June, 3^{rd} week of June, 4^{th} week of June and 1st week of July) and 3times of basal fertilizer application (at sowing, at 10 days after sowing and at 20 days after sowing). The treatments were factorially combined and laid out in a randomised complete block design (RCBD) which was replicated 4 times. The Gross plot was 4 m x 3.75 m (15 m^2), the two centre ridges formed the net plot while the 4 sides ridges were the discard for destructive sampling.

3.5 Seed Source and Varietal Description

The seeds were obtained from the seed production unit ofI. A.R Samaru, Ahmadu Bello University, Zaria.SAMMAZ 15 an intermediate in maturity (110 days) was used.Adapted toNigerian Savannah, resistant to *striga hermonthica* and has a potential yield of 6.9 tonnes ha^{-1}. The seed is white and the plant is highly tolerant to root and stalk lodging with good earand excellent husk cover.

3.6 Cultural Practices

3.6.1 Land Preparation

The experimental sites were cleared, harrowed and ridged at 75cm interval. Pegs were used for the demarcation of the land into plots and replications according to treatments.

3.6.2 Sowing

Two seeds were manually sown per hill at the depth of 3cm and at the spacing of 25 cm between stands on the 10^{th} of June, 17^{th} of June, 24^{th} of June, 1^{st} of July at Samaru and 11^{th} of June, 18^{th} of June, 25^{th} of June, and 2^{nd} of July at Kadawa, the seedling were later thinned to one plant per stand at 2^{nd} weeks after sowing (WAS) which gave the total plant population of 53,300 per hectare.

3.6.3 Fertilizer Application

The recommended fertilizer rate for Maize is 120 $KgNha^{-1}$, $60KgPha^{-1}$ and $60kgKha^{-1}$. (Ewenzor *et. al.*, 1989) where NPK 15:15:15(60KgN, $60KgP_20_5$, $60Kgk_20$) was applied as time of basal application application at sowing, at 10 days after sowingand at20 days after sowing while urea (46%N) was applied as 2^{nd} dose at 4^{th} week after each time of basal fertilizer application to augment for the remaining nitrogen in all the treatment plots.

3.6.4 Weed Control

Four litres of Primextra Gold per hectare (290g / litre S- metolachlor, 370g litre Atrazine) was applied 1 day after sowing. The spraying was done with a knapsack sprayer in each location to keep the field weed free. The ridges were earthed up at 6

WAS to protect plants against possible lodging in the season and aided in controlling the weeds.

3.6.5 Pest and Disease Control

There was stem borer infestation in both locations at 5 WAS in last sowing date plots in Samaru and Kadawa and it was controlled by applying Magic force (Lambda- cyhalothrin 15 g /L + Dimethoate 30 % g/ L) at the rate of 1.5 L/ haand Sharpshooter (cypermethrin 4% Emulsifiable Concentrate (E. C) + profenofos 40%) at 100ml per 20L of water.

3.6.6 Harvesting

The crop was harvested in September, 22ndand October 1st, 2016 at Samaru and Kadawa respectively. Harvesting was done when cobs became physiologically matured (when the point of grain attachment to the cob turned black). The cobs were harvested, dehusked dried, threshed while the chaff was separated from the dried grains by winnowing to obtain clean grain.

3.7 OBSERVATION ANDDATA COLLECTION

3.7.1 Growth Parameters and Yield Parameters

3.8.1Growth Parameters

Sampling for measurement of growth parameters was based on 5 randomly picked and tagged plants from the net plot, (tied loosely tied with pink colored wool cloth material within the net plot for ease of identification), while the destructive samples were taken from within the two outer ridges of the gross plot. The following parameters were measured on the basis of the above mentioned five tagged plants at 2, 4, 6, 8, 10 and 12 WAS.

3.8.1 Plant Height (cm)

Plant height was measured from ground level to the tip of the topmost leaf of the plant using a meter rule. The height in cm of the five plants was then added and divided by five for the average. This was carried out at 2, 4, 6, 8, 10 and 12 WAS, there after the average was computed and recorded.

3.8.2 Leaf Area Index (LAI)

This was determined at 2, 4, 6, 8, 10 and 12 WAS using the leaf area meter in the laboratory of the Agronomy Department. Theleaf area for the five selected plants were added and divided by five for the average. The LAI was calculated using the formula below:

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Ground Area covered by plants}}$$

as describe by (Watson, 1958). Leaf area index was determined at 2, 4, 6, 8, 10 and 12 WAS.

3.8.3Shoot Dry Matter (g) Plant $^{-1}$

The shoot dry matter was determined at 2, 4, 6, 8, 10 and 12 WAS by cutting five plants from the base in each plot of the discard ridges. The sampled plants were oven dried at 70^{o}C to a constant weight using Gallenkamp oven. The weights of dried plants were taken using Mettler Toledo balance icon 3100 models. The total shoot dry matter of the five plants was then divided by 5 for the average.

3.8.4Crop Growth Rate (CGR) (gm^{-2}wk^{-1})

The crop growth rate was at 2, 4, 6, 8, 10 and 12 WAS determined using the increase in the dry weight of plant per unit area of land per unit time which is given by (Radford, 1967) as:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \frac{1}{GA} = \frac{dw}{dt} \cdot \frac{1}{GA} (gm^{-2}wk^{-1})$$

Where W_1 and W_2 were whole plant dry weights at respective times T_1 and T_2 respectively.

3.8.5 Relative Growth Rate (RGR) ($gm^{-2}wk^{-1}$)

This is the increase in plant Weight per unit of plant weight per unit of time. (Increase plant weight / unit plant weight / unit time). The relative growth rate was determined at 2, 4, 6, 8. 10 and 12 WAS from dry weight of plant dry matter as described by Radford (1967).

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1} \ gg^{-1}wk^{-1}$$

Where W_2 and W_1 = total dry weight at time t_2 and t_1 respectively.

3.8.6 Net Assimilation Rate (NAR) (gm^{-2} wk^{-1})

NAR represents photosynthesis efficiency of assimilation surfaces. It was determined at 2, 4, 6, 8, 10 and 12 WAS using the formula suggested by Watson (1958):

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e A_2 - Log_e A_1}{A_2 - A_1}$$

Where W_2 and W_1 = total dry weight at time t_2 and t_1 and A_2 and A_1 = leaf area at t_2 and t_1 respectively.

3.8.7Number of Days to 50% Tasseling

The number of days from sowing to the time when about 50% of the plants per plot have tasselled was determined on treatment plot basis.

3.8.8Number Days to 50% Silking

The number of days from sowing to the time when about 50% of the plants per plot produced silk was determined on treatment plot basis.

3.9 Yield Parameters

3.9.1 Number of Rows per Cob

This was determined by counting the number of rows per cob from the five randomly sampled cobs in each treatment plot. The total numbers of rows for the five cobs were then divided by 5 for the average.

3.9.2 Cob Length (cm)

The lengths of each cob of the five randomly selected cobs were measured with a meter rule after which values of the five cobs were added and then divided by five for the average.

3.9.3Cob Diameter (cm)

This was determined from the five sampled cobs. The diameter of each cob was measured using vernier caliper in the middle of the cob after which the values were summed up and then divided by five for the average.

3.9.4 Cob Weight (g)

This was determined by weighing each of the five sampled cobs was dry after which the weights of the five cobs were summed up and divided by five for the average.

3.9.5 Threshing Percentage (%)

The threshing percentage was determined by dividing the weight of the threshed grain by the weight of the unthreshed cobs of each net plot and multiplied by 100.

$$\text{Threshing \%} = \frac{\text{Weight of grains x}}{\text{Unthreaded weight of cobs}} \ 100$$

3.9.6Harvest Index (HI) (%)

The harvest index was determined through dividing the grain yield weight by the shoot dry Matter x 100

$$HI = \frac{\text{Grain weight}}{\text{Dry matter weight}} \times 100$$

3.9.7 100 –Grain Weight (g)

The 100 - Seed Weight was determined after counting 100 - seed from the five sampled cobs as per treatment plot. The seeds were weighed using Mettler Toledo SB 16001 weighing balance and there after recorded.

3.9.8 Grain yield per hectare (kg)

This was determined after harvesting the net plot, dehusking, drying, threshing, winnowing and weighing of grains from the total cobs of each net plot. The grain weight was then expressed in kg per hectare.

3.9.9 Statistical Analysis

The data collected was subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS)for determination of the level of significance of the treatment as described by Snedecor and Cochran (1978). Significant differences among the treatments were compared and separated as described by the Duncan Multiple Range Test (DMRT)(Duncan1955). The relationship between yield, growth characteristics, yield components and their quantitative contribution to grain yield were determined by correlation coefficient analysis as described by Steel and Torrie (1984).

CHAPTER FOUR

4.0 RESULTS

4.1: Soil Analysis

The result of soil (0 – 30cm depth) was analysis fromKadawa and Samaru (0-30 cm depth) revealed that the soil were loamy and Sandy loam respectively, with the percentage of sand, 720% at Kadawa and 450% at Samaru, while that of silt 230% at Kadawa and 430% at Samaru and clay was 50% at Kadawa and 120 % at Samaru as shown in the Table 1. The soil at kadawa and samaru were slightly acidic (P^H = 6.62 and 5.70 respectively) with percentage Organic Carbon 1.02% at Samaru and 1.06%at Kadawa respectively. The total Nitrogen at Samaru and Kadawa were 0.21% and 0.16% indicating low content in both locations. Available phosphorus (mg kg^{-1}) which were 8.51mg kg^{-1} at Samaru and 4.84mg kg^{-1}at Kadawa and the exchangeable potassium (cmo1kg^{-1}) were also recorded as 0.015cmo1kg^{-1} in Samaru and 0.087cmo1 kg^{-1} in Kadawa.

4.2 Plant Height (cm) at Samaru

Effects of sowing dates and time of basal fertilizer application on plant height at 2, 4, 6, 8, 10 and 12 WAS is presented in Table 2. At 4 WAS, sowing in 2^{nd}, 3^{rd}, and 4^{th} weeks of June produced significantly taller plants than sowing in the 1^{st} week of July. At 8, 10 and 12 WAS plant height decreased significantly with delay in sowing up to 1 week of July. At 2 and 6 WAS sowing date had no significant effect on plant height at 2 and 3 WAS. At 2, 4 and 6 WAS. Time of basal fertilizer application had no significant effect on plant height while at 8, 10 and 12 WAS, plant height decreased significantly with delay in basal fertilizer

Table 4.1: Soil Physical and Chemical Properties of the Experimental Sites Kadawa and Samaru during 2016 Wet Season

Physical properties	Kadawa	Samaru
Physical composition unit		
Sand (%)	720	450
Silt (%)	230	430
Clay (%)	50	120
Textural class	Sandy loam	loam
Chemical properties		
pH(H_2O) 1: 2.5	6.62	5.70
pH 0.01M$CaCl_2$	6.10	5.33
Available Phosphorus (mgkg^{-1})	8.51	4.84
Total Nitrogen (%)	0.21	0.16
Organic Carbon (%)	1.02	1.06
Exchangeable bases (cmol kg^{-1})		
Calcium	3.50	3.80
Magnesium	0.41	0.71
Potassium	0.05	0.09
Sodium	0.17	0.22
CEC	3.90	4.71

Source: Soil Analysis done at Department of Agronomy, Soil Analysis Laboratory, Ahmadu Bello University, Samaru, Zaria, Kaduna State.

Table 2 : Effects of Sowing Dates and Time of Basal Fertilizer Application on Plant Height (cm) of Maize at 2, 4, 6, 8, 10 and 12 WAS at Samaru in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	17.3	50.7a	115.1	253.0a	274.1a	284.3a
3rd week June	17.4	51.6a	116.1	237.0b	256.0b	264.1b
4th week June	16.3	52.3a	106.7	214.2c	245.3c	253.7c
1st week July	15.2	41.2b	100.2	184.8d	223.9d	237.0d
SE ±	0.76	2.28	7.86	1.58	1.69	0.54
Time of Basal Fertilizer Application (F)						
At sowing	15.9	49.6	107.9	231.4a	257.3a	266.3a
10 days after sowing	16.3	48.4	114.3	225.1b	255.3a	260.5b
20 days after sowing	17.4	48.8	106.4	210.3c	240.8b	252.6c
SE ±	0.66	1.97	6.82	1.37	1.45	0.47
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant, WAS = Week After Sowing.

application up to 20 days after sowing. There was no significant interaction between sowing date and time of basal fertilizer application on plant height all the sampling periods.

4.3 Plant Height (cm) at Kadawa

Table 3 showed the effects of sowing dates and time of basal fertilizer application on plant height at Kadawa during the 2016 wet season. At 2 WAS, sowing in 2nd and 3rdat par week of June produced significantly taller plants than sowing in 4th week of June and 1st week of July, at 4th and 6th weeks after sowing, sowing in the 2nd week of June produced significantly taller plants than sowing in the 1st week of July, at 8 and 10 WAS, plant height decreased significantly with delay in sowing up to 1st week of July while at 12 WAS, sowing date had no significant effect on plant height.

Time of basal fertilizer application, at 2 WAS, Basal fertilizer application at sowing and at10 days after sowing produced significantly taller plants than applying the fertilizer at 20 days after sowing at 4 WAS applying basal fertilizer at 10 days after sowing produced significantly taller plants than applying fertilizer at 20 days after sowing. At 6 and 12 WAS, time of basal fertilizer application had no significant effect on plant height while at 8 and 10 WAS, plant height decreased significantly with delay in basal fertilizer application up to 20 days after sowing. There was significant interaction between sowing date and time of fertilizer application at 8 and 10 WAS.(Table 4) Interaction between Sowing Dates and Time of Basal Fertilizer Application At 8and 10 WAS at Kadawa During 2016 Wet Season, When Sowing dates were held constant, it was observed that the tallest plant was recorded when basal fertilizer was applied at sowing while the shortest plants were recorded when basal fertilizer was applied 20 days after sowing. At fixed time of basal fertilizer application sowing in the 2nd week of June consistently produced the tallest plants at 8 weeks after

Table 3: Effects of Sowing Dates and Times of Basal Fertilizer Application on Plant Height (cm) of Maize at 2, 4, 6, 8, 10 and 12 WAS at Kadawa in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2^{nd} week June	17.56a	49.88a	130.75a	241.65a	252.20a	249.34
3^{rd} week June	14.89a	44.68a	112.77ab	227.10b	236.67b	234.93
4^{th} week June	14.48b	43.25a	109.25ab	202.72c	216.18c	238.16
1^{st} week July	13.79b	37.03b	97.55b	149.167d	185.90d	233.39
SE ±	0.622	2.404	7.357	0.999	0.985	6.745
Time of Basal Fertilizer Application (F)						
At sowing	15.59a	44.31ab	113.29	217.13a	231.63a	245.64
10 days after sowing	15.96a	46.56a	115.24	209.06b	223.71b	236.05
20 days after sowing	13.99b	40.26b	109.21	189.21c	212.88c	235.18
SE ±	0.539	2.082	6.301	0.866	0.853	5.842
Interaction						
S x F	NS	NS	NS	**	**	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant.****** - Highly Significant at 1% WAS = Week After Sowing.

Table 4: Interaction between Sowing Dates and Time of Fertilizer Application on Plant Height of Maize at 8 and 10 WAS at Kadawa

	Time of Basal Fertilizer Application		
	8WAS		
	At sowing	**10 days**	**20 days**
2nd week June	245.1a	242.4a	237.4b
3rd week June	232.5bc	228.7cd	220.1d
4th week June	214.3e	203.f	190.7g
1st week July	176.6h	162.1i	108.9j
SE ±		**1.731**	
	10 WAS		
2nd week June	262.4a	250.3b	243.9b
3rd week June	238.5c	237.4c	234.0c
4th week June	224.2d	214.7e	209.6f
1st week July	201.3g	192.4h	163.9i
SE ±		**1.705**	

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Week After Sowing.

sowing. Sowing dates was observed that the tallest plant was recorded when basal fertilizer was applied at sowing that is at 2nd week of June, while the shortest plant were recorded when basal fertilizer application was applied at 20 days after sowing. At fixed time of basal fertilizer application sowing in the 1st week of July consistently produced the tallest plant at 8 weeks after sowing.

4.5 Number of Leaver Plants^{-1} at Samaru

The effects of sowing dates and time of basal fertilizer application on a number of leaf plant^{-1} at Samaru in 2016 wet season is presented in Table 5. At 2, 8 and 10 WAS, sowing date had no significant effect on the number of leaves plant^{-1}. In 4 and 6 WAS, sowing on the 2nd, 3rd and4th week of June produced a significantly more number of leaf plant^{-1} than sowing in the 1st week of July while sowing in the 2nd week of June produced a significantly more number of leaf plant^{-1} than sowing on the 1st week of July. The time of basal fertilizer application had no significant effect on the number of leaf plant^{-1} at 2, 4, 6, 8, and 12 WAS while at 10 WAS, time of basal fertilizer application after sowing produced a significantly more number of leaf plant^{-1} than applying the fertilizer at sowing. There was no significant interaction between sowing dates and time of basal fertilizer application in all the sampling periods.

4.6 Number of Leaves Plant^{-1} at Kadawa

The effect of sowing dates and time of basal fertilizer application on the number of leaf plant^{-1} at Kadawa during the 2016 wet season is presented in Tables 6. At 2 WAS, sowing in the 2nd week of June produced significantly more number of leaves plant^{-1} than sowing in the 3rdweek of June, 4th week of June and 1st week of July, at 4th and 12 WAS , sowing in the

Table 5: Effects of Sowing Dates and Time of Basal Fertilizer Application on Number of Leaves Plant^{-1} of Maize at 2, 4, 6, 8, 10 and 12 WAS at Samaru in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	5	10a	11a	12	13	14b
3rd week June	5	10a	11ab	12	13	14ab
4th week June	5	10a	11ab	12	13	14b
1st week July	5	9b	10b	12	13	14b
SE ±	0.140	0.248	0.24	0.238	0.187	0.143
Time of Basal Fertilizer Application (F)						
At sowing	6	10	11	12	13a	14
10 days after sowing	5	10	11	12	12b	14
20 days after sowing	5	9	11	12	12b	14
SE ±	0.121	0.215	0.214	0.206	0.162	0.124
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 6: Effects of Sowing Dates and Time of Basal Fertilizer Application on Number of Leaves Plant^{-1} of Maize at 2, 4, 6, 8, 10 and 12 WAS at Kadawa in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	6a	11a	12	14a	14a	16a
3rd week June	5b	9b	12	14	14a	16a
4th week June	5b	9b	11	14	14a	16
1st week July	5b	9b	11	13b	14a	15a
SE ±	0.128	0.295	0.332	0.340	0.284	0.226
Time of Basal Fertilizer Application (F)						
At sowing	6a	10	12	13.56	14.21	15.57a
10 days after sowing	6a	10	12	13.81	14.74	15.80a
20 days after sowing	5b	9	11.46	13.34	14.28	15.56a
SE ±	0.111	0.255	0.287	0.294	0.246	0.196
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS= Weeks After Sowing.

2nd week of June produced significantly more number of leaves plant^{-1} than sowing in the 4th week of June, at 6 and 8 WAS , sowing dates had no significant effect on the number of leaves plant^{-1} while 10 WAS, sowing in the 2nd week of June produced significantly more number of leaves plant^{-1} than sowing on the 1st week of July. Time of basal fertilizer application ; At 2 WAS, basal fertilizer application at sowing and 10 days after sowing produced significantly more number of leaves plant^{-1} than applying the fertilizer at 20 days after sowing , at 4, 6, 8, 10 and 12 WAS, time of basal fertilizer application had no significant effect on the number of leaves plant^{-1}. There was no significant interaction between sowing date and time of basal fertilizer application on number of leaves plant^{-1} throughout the sampling periods.

4.7 Leaf Area Index (LAI) at Samaru

The effect of sowing date and time of basal fertilizer application on leaf area index at Samaru during the 2016 wet season is presented in Table 7. At 2, 4 and 6 WAS, sowing date had no significant on leaf area index. At 8 and 10 WAS, leaf area index decreased significantly with delay in sowing up to 1st week of July while at 12 WAS, sowing in 2nd week of June produced significantly higher leaf area index than sowing in the 1st week of July, But similar to 3rd and 4th week. Time of basal fertilizer application had no significant effect on leaf area index at 2,4,and 6 WAS. At 8 and 10 WAS leaf area index decreased significantly with delay in basal fertilizer application up to 20 WAS. Basal fertilizer application at 10 days after sowing, at sowing produced significantly higher leaf area index than at sowing and 20 WAS.There was no significant interaction between sowing dates and time of basal fertilizer application throughout the sampling period.

Table 7: Effects of sowing dates and time of basal fertilizer application on leaf area index plant^{-1} of Maize at 2, 4, 6, 8, 10 and 12 WAS at Samaru in 2016 wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	0.02	0.03	0.07	0.18a	0.19a	0.18a
3rd week June	0.01	0.03	0.08	0.15b	0.17b	0.17ab
4th week June	0.03	0.04	0.07	0.13c	0.15c	0.17ab
1st week July	0.01	0.04	0.08	0.11d	0.14d	0.16b
SE ±	0.008	0.011	0.006	0.001	0.001	0.004
Time of Basal Fertilizer Application (F)						
At sowing	0.02	0.05	0.07	0.15a	0.17a	0.16b
10 days after sowing	0.01	0.03	0.08	0.14b	0.16b	0.18a
20 days after sowing	0.006	0.03	0.08	0.13c	0.15c	0.17b
SE ±	0.007	0.010	0.005	0.001	0.001	0.004
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

4.8 Leaf Area Index at Kadawa

The effects of sowing date and time of basal fertilizer on leaf area index at Kadawa during the 2016 wet season is presented in Table 8. At 2, 4, 6, and 12 WAS, sowing date had no significant effect on leaf area index while at 8 and 10 WAS, leaf area index per plant decreased significantly with delay in sowing up to 1st week of July.

Time of basal fertilizer application had no significant effect on leaf area index plant^{-1} at 2, 4, 6 and 12 WAS while at 8 and 10 WAS, leaf area index decreased significantly with delay in basal fertilizer application up to 20 days after sowing. There was no significant interaction between sowing date and time of basal fertilizer application throughout the sampling periods.

4.9 Shoot Dry Matter at Samaru

Table 9 showed the effects of sowing dates and time of basal fertilizer application on the shoot dry matter of Maize at Samaru in 2016 wet seasonare presented in Table 9. At 4, 8, 10, and 12 WAS, sowing in the 2nd, 3rd and 4th week of June produced significantly higher shoot dry matter than sowing in the 1st week of July. At 4, 8, 10 and 12 WAS, shoot dry matter decreased significantly with delay in sowing up to 1st week of July while at 6 WAS, Sowing in 2nd and 3rd week of June produced significantly higher shoot dry matter than sowing in the 4th week of June and 1st week of July. Time of basal fertilizer application had no significant effect on shoot dry matter at 2 WAS. At 4 and 6 WAS, time of basal fertilizer application at sowing and 10 days after sowing produced significantly higher shoot dry matter than the basal fertilizer application applied at 20 days after sowing, while at 8, 10 and 12 WAS, shoot dry matter decreased significantly with delay in basal fertilizer application up to 20 days after sowing.

Table 8: Effects of Sowing Dates and Time of Basal Fertilizer Application on Leaf Area Index Plant^{-1} of Maize at 2, 4, 6, 8, 10 and 12 WAS at Kadawa in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date(S)						
2nd week June	0.02	0.09	0.16	0.31a	0.41a	1.40
3rd week June	0.01	0.07	0.16	0.26b	0.34b	1.41
4th week June	0.01	0.06	0.13	0.21c	0.29c	1.42
1st week July	0.01	0.07	0.16	0.17d	0.24d	1.38
SE ±	0.001	0.007	0.013	0.002	0.002	0.018
Time of Basal Fertilizer Application (F)						
At sowing	0.01	0.08	0.15	0.26a	0.34a	1.41
10 days after sowing	0.02	0.07	0.16	0.24b	0.32b	1.39
20 days after sowing	0.01	0.07	0.15	0.22c	0.30c	1.42
SE ±	0.001	0.007	0.011	0.002	0.002	0.016
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 9: Effects of Sowing Dates and Time ofBasal Fertilizer Application on Shoot Dry Matter Plant^{-1} (g) of Maize at 2, 4, 6, 8, 10 and 12 WAS at Samaru in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	1.88a	11.79a	31.86a	177.85a	253.10a	374.56a
3rd week June	1.62a	9.95b	34.84a	126.26b	187.83b	296.65b
4th week June	1.11ab	7.31c	23.37b	99.24c	163.43c	249.58c
1st week July	0.48b	6.28d	23.24b	66.75d	124.50d	196.66d
SE ±	0.265	1.567	2.454	1.427	5.047	2.075
Time of Basal Fertilizer Application (F)						
At sowing	1.21	9.67a	29.84a	135.09a	205.96a	298.44a
10 days after sowing	1.14	9.26a	30.47a	116.48b	175.61b	282.00b
20 days after sowing	1.48	7.58b	24.67b	101.0c	165.07c	256.89c
SE ±	0.230	1.357	2.125	1.235	4.371	1.798
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

There was no significant interaction between sowing dates and time of basal fertilizer application on shoot dry matter Maize throughout the sampling periods.

4.10 Shoot Dry matter at Kadawa

Table 10 showed the effect of sowing dates and time of basal fertilizer application on the shoot dry matter at Kadawa during the 2016 wet season. At 2 WAS, sowing in the 2^{nd} and 3^{rd} week of June produced significantly the highest shoot dry matter while sowing in the 1^{st} week of July produced the least shoot dry matter. At 4 and 6 WAS, sowing date had no significant effect on shoot dry matter except at 8, 10 and 12 WAS, shoot dry matter decreased significantly with delay in sowing up to 1^{st} week of July. Time of basal fertilizer application had no significant effect on shoot dry matter at 2, 4 and 6 WAS while at 8, 10 and 12 WAS; shoot dry matter decreased significantly with delay in time of basal fertilizer application up to 20 days after sowing. There was no significant interaction between sowing date and time of basal fertilizer application on shoot dry matter Maize throughout the sampling periods.

4.11 Crop Growth Rate (CGR) at Samaru

Table 11 showed the effect of sowing dates and time of basal fertilizer application on crop growth rate at Samaru during the 2016 wet season. At 2- 4 WAS, sowing in the 2^{nd} week of June produced plant by significantly the highest crop growth rate while sowing in the 1^{st} week of July produced the lowest CGR. At 4 - 6 WAS, sowing date had no significant effect on crop growth rate. At 6 - 8 and 10 -12 WAS, crop growth rate decreased significantly with delay in sowing up to 1^{st} week of July while at 8-10 WAS, sowing in the 2^{nd} week of June produced plant with significantly highest crop growth rate as 1^{st} week of July sown crop produced the lowest CGR. At 2- 4 WAS, time of basal fertilizer application

Table 10: Effects of Sowing Dates and Time of Basal Fertilizer Application on Shoot Dry Matter plant^{-1} (g) of Maize at 2, 4, 6, 8, 10 and 12 WAS at Kadawa in 2016 Wet Season

	WAS					
Treatment	**2**	**4**	**6**	**8**	**10**	**12**
Sowing Date (S)						
2nd week June	4.93a	21.28	45.08	110.51a	258.27a	353.04a
3rd week June	3.57a	22.27	45.93	95.33b	176.50b	265.48b
4th week June	3.03b	14.71	36.82	85.38c	138.63c	191.40c
1st week July	1.43c	16.03	44.94	69.53d	112.90d	131.32d
SE ±	0.552	4.463	4.365	0.929	3.065	2.821
Time of Basal Fertilizer Application (F)						
At sowing	3.03	16.84	41.83	97.93a	196.42a	259.38a
10 days after sowing	2.96	19.80	43.34	89.28b	167.84b	231.83b
20 days after sowing	3.73	19.07	44.41	83.36c	150.46c	214.73c
SE ±	0.478	3.865	3.780	0.804	2.654	2.443
Interaction						
S x F	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 11: Effects of Sowing Dates and Time of Basal Fertilizer Application on Crop Growth Rate ($gg^{-1}wk^{-1}$) of Maize at 2, 4, 6, 8, 10 and 12 WAS at Samaru in 2016 Wet Season

	WAS				
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	4.95a	10.03	72.99a	37.63a	60.73a
3rd week June	4.42ab	12.45	45.71b	32.09b	53.91b
4th week June	3.41b	8.54	37.94c	30.79ab	43.08c
1st week July	2.33c	7.97	21.75d	28.88c	36.08d
SE ±	0.794	1.524	1.469	2.031	2.678
Time of Basal Fertilizer Application (F)					
At sowing	4.23a	10.09	52.62a	35.44a	46.24b
10 days after sowing	3.22b	11.45	43.01b	32.03ab	53.19a
20 days after sowing	3.89b	7.71	38.17c	29.57b	45.91b
SE ±	0.688	1.320	1.272	1.759	2.320
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

at sowing produced significantly plants with higher crop growth rate than the fertilizer applied at 10 and 20 days after sowing. At 4 - 6 WAS, sowing date had no significant effect on crop growth rate. At 6-8 crop growth rate decreased significantly with delay in basal fertilizer application up to 20 days after sowing. At 8-10 WAS, time of basal fertilizer application at sowing produced significantly higher CGR than the fertilizer applied at 20 days after sowing while at 10-12 WAS, time of basal fertilizer application at 10 days after sowing produced significantly higher CGR than the fertilizer application at sowing and 20 days after sowing. There was no significant interaction between sowing date and time of basal fertilizer application throughout the sampling periods.

4.12Crop Growth Rate (CGR) at Kadawa

The effects of sowing dates and time of basal fertilizer application on crop growth rate at Kadawa in the 2016 wet season are presented in Table 12. At 2-4 and 4-6 WAS, sowing date had no significant effect on crop growth rate. At 6-8 WAS, sowing in the 2nd week ofJune produced significantly the highest CGR while sowing in the 1st week of July produced the least. At 8 - 10 WAS, crop growth rate decreased significantly with delay in sowing up to 1st week of July while at 10 - 12 WAS, sowing in the 2nd and 3rd week of June produced significantly higher crop growth rate as sowing in the 1st week of July produced the least. Time of basal fertilizer application had no significant effect on crop growth rate at 2 -4, 4 - 6 and 10 -12 WAS. At 6 - 8 WAS, time of basal fertilizer application at sowing produced significantly higher crop growth rate than the fertilizer application at 10 and 20 days after sowing while at 8-10 WAS, crop growth decreased significantly with a delay in time of basal fertilizer application up to 20 days after sowing. There was no significant interaction

Table 12: Effects of Sowing Dates and Time of Basal Fertilizer Application on Crop Growth Rate ($gg^{-1}wk^{-1}$)of Maize at 2, 4, 6, 8, 10 and 12 WAS at Kadawa in 2016 Wet Season

		WAS			
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	8.18	11.89	32.72a	73.88a	47.39a
3rd week June	9.62	11.62	24.70b	40.59b	44.49a
4th week June	5.57	11.05	24.28b	26.63c	26.39b
1st week July	7.30	14.46	12.30c	21.68d	9.21c
SE ±	2.328	2.252	2.266	1.277	1.565
Time of Basal Fertilizer Application (F)					
At sowing	6.91	12.49	28.05a	49.25a	31.48
10 days after sowing	8.42	11.77	22.97b	39.28b	31.99
20 days after sowing	7.67	12.67	19.47b	33.55c	32.14
SE ±	2.016	1.950	1.962	1.106	1.354
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Week After Sowing.

between sowing dates and time of basal fertilizer application on crop growth rate of Maize throughout all the sampling periods.

4.13 Relative Growth Rate (RGR) at Samaru

The effects of sowing dates and time of basal fertilizer application on the relative growth rate of Maize at Samaru in 2016 wet season are presented in Table 13. At 2-4 WAS, sowing in 2nd and 3rd week of June produced plants with significantly higher relative growth rate than sowing in the 1st week of July. At 4–6 and 10 – 12 WAS, Sowing date had no significant effect on the relative growth rate. At 6-8 WASsowing on the 2nd week of June produced significantly the highest relative growth while sowing in the 1st week of July produced plants with the relative growth rate least. At 8-10 WAS, relative growth rate decreased significantly with delay in sowing up to 1st week of July while at 10-12 WAS, sowing date had no significant effect on relative growth rate.

Time of basal fertilizer application had no significant effect on the relative growth rate of 2-4 and 6-8 WAS. At 4-6 WAS,time of basal fertilizer application produced significantlyhigher relative growth rate than fertilizer application at 20 days after sowing. At 8 - 10 WAS, time of basal fertilizer application at sowing produced significantly higher relative growth than the application at 10 and 20 days after sowing while at 10 - 12 WAS, time of basal fertilizer application at sowing and 10 days after sowing produced significantly higher relative growth than the application at 20 days after sowing.

There was no significant interaction between sowing date and time of basal fertilizer application on relative growth rate throughout the sampling period.

Table 13: Effects of Sowing Dates and Time of Basal Fertilizer Application on Relative Growth Rate (gg $^{-1}$ wk^{-1}) of Maize at 2-4, 4-6, 6-8, 8-10, and 10-12 WAS at Samaru in 2016 Wet Season

	WAS				
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	1.36a	0.56	0.89a	0.32a	0.20
3rd week June	1.30a	0.67	0.67bc	0.25b	0.23
4th week June	0.98ab	0.72	0.75b	0.20c	0.21
1st week July	0.89b	0.63	0.58c	0.17d	0.23
SE ±	0.131	0.086	0.046	0.008	0.008
Time of Basal Fertilizer Application (F)					
At sowing	1.22	0.77a	0.75	0.27a	0.24a
10 days after sowing	1.05	0.67ab	0.69	0.22b	0.22a
20 days after sowing	1.13	0.50b	0.73	0.22b	0.20c
SE ±	0.113	0.075	0.039	0.007	0.007
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

4.14 Relative Growth Rate (RGR) at Kadawa

The effects of sowing dates and time of basal on the relative growth rate at Kadawa are presented in Table 14. At 2 - 4, 4 - 6 and 6 - 8 WAS, sowing date had no significant effect on the relative growth rate. At 8 - 10, relative growth rate decreased significantly with delay in sowing up to the 4th week of June while at 10 - 12 WAS, sowing in the 2^{nd} week of June produced plants with significantly higher relative growth rate than the other sowing dates.

Time of basal fertilizer application had no significant effect on the relative growth rate of 2 - 4, 4 - 6, 6 - 8 and 10 - 12 WAS While at 8 - 10 WAS, relative growth rate decreased significantly with delay in time of basal fertilizer application up to 20 days after sowing. There was no significant interaction between sowing dates and time of basal fertilizer application on relative growth rates on Maize throughout the sampling periods.

4.15 Net Assimilation Rate (NAR) at Samaru

Response of Maize to sowing dates and time of basal fertilizer application on the net assimilation rate at Samaru in 2016 is presented in Table 15. At 2 - 4 WAS, sowing in the 2^{nd} week of June significantly produced plants with higher net assimilation rate than the other sowing dates. At 4 - 6 WAS, sowing date had no significant effect on the net assimilation rate. At 6 - 8 WAS and 8 - 10 WAS, sowing in the 2^{nd} week of June produced significantly plant with the highest net assimilation rate, while sowing in the 1^{st} week of July produced plants net assimilation rate while the least, at 10 - 12 WAS, sowing in the 2^{nd} and

Table 14: Effects of Sowing Dates and Fertilizer Application Time on Relative Growth Rate ($gg^{-1}wk^{-1}$) of Maize at 2-4, 4-6, 6-8, 8-10, and 10-12 WAS at Kadawa in 2016 Wet Season

	WAS				
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	0.72	0.47	0.48	0.42a	0.20a
3rd week June	1.00	0.53	0.43	0.31b	0.17b
4th week June	0.65	0.66	0.48	0.24c	0.16b
1st week July	1.11	0.68	0.30	0.24c	0.17b
SE ±	0.174	0.117	0.064	0.005	0.007
Time of Basal Fertilizer Application (F)					
At sowing	0.95	0.59	0.47	0.32a	0.14
10 days after sowing	0.83	0.83	0.41	0.30b	0.15
20 days after sowing	0.83	0.53	0.38	0.29c	0.16
SE ±	0.150	0.101	0.058	0.004	0.006
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 15: Effects of Sowing Dates and Time of Basal Fertilizer Application Time on Net Assimilation Rate ($gm^{-2}wk^{-1}$) of Maize at 2-4, 4-6, 6-8, 8-10 and 10-12 WAS at Samaru in 2016 Wet Season

	WAS				
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	2.81a	4.54	37.47a	2.94a	2.09a
3rd week June	1.97ab	6.68	14.44b	1.92b	1.87a
4th week June	1.33b	3.97	12.73b	1.67b	1.47b
1st week July	1.50b	4.22	5.28c	0.94c	1.11c
SE ±	0.377	0.911	2.063	0.118	0.114
Time of Basal Fertilizer Application (F)					
At sowing	2.01	5.06	22.29a	2.43a	1.53
10 days after sowing	1.73	5.09	15.72b	1.68b	1.79
20 days after sowing	1.97	4.40	14.44b	1.50b	1.58
SE ±	0.327	0.789	1.786	0.102	0.099
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

3rd week of June produced significantly the highest net assimilation rate while sowing in the 1st week of July produced the least.

Time of basal fertilizer application had no significant effect on the net assimilation rateof 2-4, 4-6 and 10-12 WAS. At 6-8 WAS and 8-10 WAS, time of basal fertilizer application at sowing produced significantly plant with higher net assimilation rate than the application at 10 and 20 days after sowing.There was no significant interaction between sowing date and time of basal fertilizer application on the net assimilation rate of Maize throughout the sampling periods.

4.16 Net Assimilation Rate (NAR) at Kadawa

Table 16 showed the effect of sowing dates and time of basal fertilizer application on the net assimilation rate at Kadawa in the 2016 wet season. At 2-4 and 4-6 WAS, sowing date had no significant effect on the net assimilation rate. At 6-8 and 8-10 WAS, sowing in the 2nd week of June produced plants with the significantly higher net assimilation rate, while sowing in the 1st week of July produced plants with significantly the least. At 10-12 WAS, sowing in the 2nd week of June produced significantly higher net assimilation rate than sowing in the 1st week of July. Time of basal fertilizer application had no effect on the net assimilation rate of 2 - 4, 4 - 6 and 10 - 12 WAS. At 6 - 8, time of basal fertilizer applicationat sowing significantly produced plants with higher net assimilation rate than the application at 10 and 20 days after sowing. At 8 - 10 WAS, time of basal fertilizer application at sowing and 10 days after sowing produced significantly plants with higher net assimilation rate than the application at 20 days after sowing. There was no significant interaction between sowing dates and time of basal fertilizer application on the net assimilation rate at Kadawa throughout the sampling periods.

Table 16: Effects of Sowing Dates and Time of Basal Fertilizer Application on Net Assimilation Rate ($gm^{-2}wk^{-1}$) of Maize at 2-4, 4-6, 6-8, 8-10 and 10-12 WAS at Kadawa in 2016 Wet Season

	WAS				
Treatment	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**
Sowing Date (S)					
2nd week June	6.86	3.89	12.21a	9.53a	5.04a
3rd week June	7.73	4.61	6.59b	5.35b	3.39ab
4th week June	4.27	3.84	6.76b	3.42c	2.10b
1st week July	6.43	5.53	0.76c	3.42c	1.37c
SE ±	1.837	1.018	1.201	0.164	0.774
Time of Basal Fertilizer Application (F)					
At sowing	5.73	3.72	8.87a	5.87a	2.44
10 days after sowing	6.89	6.89	5.78b	5.54a	1.24
20 days after sowing	6.36	6.36	5.09b	4.87b	3.20
SE ±	1.591	0.881	1.040	0.142	0.670
Interaction					
S x F	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

4.17 Number of Days to 50% Tasseling at Samaru and Kadawa

Table 18 showed the effects of sowing dates and time of basal fertilizer application on a number of days to 50% tasseling at Samaru and Kadawa in the 2016 wet season. At both locations, sowing date had no significant effect on the number of days to 50% tasselling. Similary time of basal fertilizer application had no significant effect on the number of days to 50% tasseling at both locations. There was no significant interaction between sowing dates and time of basal fertilizer application on number of days to 50% tasseling at both locations.

4.18 Number of Days to 50% Silking at Samaru and Kadawa

The effects of sowing dates and time of basal fertilizer application on a number of days to 50% silking at Samaru and Kadawa is presented in Table 17.At Samaru, sowing date did not significantly affect the number of days to 50% silking while at Kadawa, sowing in the 2nd week of June had significantly more numbers of days to silking than sowing in the 1st week of July.Time of basal fertilizer application had no significant effect on number of days to 50% silking at Samaru and Kadawa. There was no significant interaction between the sowing dates and time of basal fertilizer application on number of days to 50% silking at both locations.

4.19 Number of Rows Cob^{-1} at Samaru and Kadawa

Effects of sowing dates and time of basal fertilizer application on number of rows per cob are presented in Table 19. At Samaru, sowing in 2nd, 3rd and 4th weeks of June produced a significantly higher number of rows per cob than sowing in the 1st week of July while at Kadawa, sowing dates had no significant effect on the number of rows per cob. Time of basal fertilizer application had no significant effect on the number of rows per cob at both

Table 17: Effects of Sowing Dates and Time of Basal Fertilizer Application on Number of Days to 50% Tasseling of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	56	59
3rd week June	55	58
4th week June	54	60
1st week July	53	58
SE ±	0.794	1.226
Time of Basal Fertilizer Application (F)		
At sowing	55	59
10 daysafter sowing	54	59
20 days after sowing	54	59
SE ±	0.688	1.061
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS= Week After Sowing.

Table 18: Effects of Sowing Dates and Time of Basal Fertilizer Application on Number of days to 50% Silking of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	59	63a
3rd week June	59	62ab
4th week June	57	61ab
1st week July	57	60b
SE ±	0.863	81.103
Time of Basal Fertilizer Application (F)		
At sowing	59	61
10 daysafter sowing	57	61
20 days after sowing	58	62
SE ±	0.747	0.955
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS= Weeks After Sowing.

Table 19: Effects of Sowing Dates and Time of Basal Fertilizer Application on Number of Rows Cob^{-1} of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	15a	16
3rd week June	16a	15
4th week June	15a	15
1st week July	14b	15
SE ±	0.318	0.237
Time of Basal Fertilizer Application (F)		
At sowing	15	15
10 days after sowing	15	15
20 days after sowing	15	15
SE ±	0.275	0.206
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS= Weeks After Sowing.

locations. There was no significant interaction between sowing dates and time of basal fertilizer application on number of rows per cob at both locations.

4.20 Cob Diameter (cm) at Samaru and Kadawa

Table 20 showed the effects of sowing dates and time of basal fertilizer application on the cob diameter of Maize at Samaru and Kadawa in the 2016 wet season. At Samaru, sowing date had no significant effect on cob diameter while at Kadawa, cob diameter decreased significantly with delay in sowing up to 1st week of July.

At Samaru, time of basal fertilizer application time had no significant effect on cob diameter while at Kadawa, cob diameter decreased significantly with delay in time of basal fertilizer application up to 20 days after sowing. There was no significant interaction between sowing dates and time of basal fertilizer application on cob diameter at both locations.

4.21 Cob Length (cm) at Samaru and Kadawa

Effects of sowing dates and time of basal fertilizer application on cob length of Maize at Samaru and Kadawa in the 2016 wet season are shown in Table 21. At both locations, cob length decreased significantly with delay in sowing up to 1st week of July. Cob length decreased significantly with delay in time of basal fertilizer application up to 20 days after sowing at both locations. There was no significant interaction between sowing dates and time of basal fertilizer application on cob length at both locations.

Table 20: Effects of Sowing Dates and Time of Basal Fertilizer Application on Cob Diameter (cm) of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	4.56	4.91a
3rd week June	4.53	4.69b
4th week June	4.44	4.51c
1st week July	4.63	4.15d
SE ±	0.018	0.067
Time of Basal Fertilizer Application (F)		
At sowing	4.64	4.68a
10 days after sowing	4.49	4.56b
20 days after sowing	4.49	4.46c
SE ±	0.016	0.058
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS= Week After Sowing.

Table 21: Effects of Sowing Dates and Time of Basal Fertilizer Application on Cob Length (cm) of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	18.50a	17.80a
3rd week June	17.44b	16.57b
4th week June	16.80c	15.52c
1st week July	15.02d	13.78d
SE ±	0.049	0.113
Time of Basal Fertilizer Application (F)		
At sowing	17.48a	16.48a
10 days after sowing	17.11b	15.86b
20 days after sowing	16.23c	15.41c
SE ±	0.042	0.097
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

4.22 100 - Grain Weight (g) at Samaru and Kadawa

Table 22 showed the effects of sowing dates and time of basal fertilizer application on 100-grain weight of Maize at Samaru and Kadawa in the 2016 wet season. 100-grain weight decreased significantly with delay in sowing up to 1st week of July at both locations.

Timing of basal fertilizer application influenced 100- grain weight signification. The grain weight decreased significantly with delay on time of basal fertilizer application up to 20 days after sowing. There was no significant interaction between sowing date and time of basal fertilizer application in both locations.

4.23 Grain Yield (kg ha^{-1}) at Samaru and Kadawa

Table 23 showed the grain yield as affected by sowing dates and time of basal fertilizer application of Maize at Samaru and Kadawa in the 2016 season wet season. At Samaru, grain yield decreased significantly with delay in sowing date up to the 4th week of June while in Kadawa grain yield decreased significantly with delay in sowing up to 1st week of July. At both locations, grain yield decreased significantly with delay on time of basal fertilizer application up to 20 days after sowing.

There were significant and highly significant interaction between sowing dates and time of basal fertilizer application on grain yield at Samaru and Kadawa respectively.Table 24 Interaction between Sowing Dates and Time of Basal Fertilizer Application on Grains Yield at Samaru.When sowing dates were held constant, at Samaru it was observed that the highest grain yield was recorded when time of basal fertilizer was applied at sowing and 2nd week of June sowing date while the lowest grain yield were recorded when time of basal

Table 22: Effects of Sowing Dates and Time of Basal Fertilizer Application on 100- Grain Weight (g) of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	33.75a	33.67a
3rd week June	31.17b	31.33b
4th week June	28.58c	28.67c
1st week July	27.00d	25.92d
SE ±	0.107	0.113
Time of Basal Fertilizer Application (F)		
At sowing	30.94a	30.63a
10 days after sowing	30.19b	30.60b
20 days after sowing	29.25c	29.00c
SE ±	0.093	0.098
Interaction		
S x F	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 23: Effects of Sowing Dates and Time of Basal Fertilizer Application on Grain Yield (kg ha^{-1}) of Maize at Samaru and Kadawa in 2016 Wet Season

Treatment	Samaru	Kadawa
Sowing Date (S)		
2nd week June	6254.5a	6054.7a
3rd week June	5237.2b	4807.8b
4th week June	2890.3c	3079.6c
1st week July	3168.7c	2090.0d
SE ±	91.735	171.690
Time of Basal Fertilizer Application (F)		
At sowing	4838.9a	4651.1a
10 days after sowing	4246.8b	4122.8b
20 days after sowing	4077.4b	3250.1c
SE ±	79.442	148.683
Interaction		
S x F	*	**

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

Table 24: Interaction between Sowing Dates and Time of Basal Fertilizer Application on Grain Yield (kgha^{-1}) of Maize at Samaru and Kadawa in 2016 Wet Season

	Time of Basal Fertilizer Application		
Sowing Dates	At sowing	10 Days	20 Days
		Samaru	
2nd week June	6908.1a	6133.3ab	5722.0bc
3rd week June	5446.3bc	5297.8bcd	4967.4cd
4th week June	4489.3de	2439.5f	1742.0g
1st Week July	2511.5f	3116.3f	3878.0e
SE ±		297.35	
		Kadawa	
2nd week June	7027.5a	5885.4b	5251.4c
3rd week June	5101.2c	4811.6cd	4510.4d
4th week June	3903.3e	3170.8f	2164.5h
1st week July	2572.5gh	2623.3g	1074.1i
SE ±		158.88	

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability. NS = Not significant. WAS = Weeks After Sowing.

fertilizer was applied at 20 days after sowing with sowing dates at 1st week of July At fixed time of basal fertilizer application at sowing in 2nd of June consistently production the highest grain yield plant at 10 days after sowing , at sowing 2nd week of June with the lowest was at 4th week of June.

At Kadawa it was observed that the highest grain yield was recorded when time of basal fertilizer was applied at sowing dates which is at sowing date at 2nd week of June , while the sowing date at 2nd week of June . While the lowest grain yield was recorded when time of basal fertilizer was applied at 20 days after sowing, sowing date at 1st week of July. At fixed time of basal fertilizer application sowing in the 2nd week of June consistently produce the highest grain yield at Kadawa at 10 days after sowing with sowing date at 2nd week of June while the lowest was at 10 days after sowing, with sowing day of the 1st week of July.

4.2 Correlation Analysis

4.2.1. Correlation analysis at Samaru

The result of correlation analysis between grain yield, growth and yield components of Maize in the 2016 wet seasonat Samaru is shown in Table 25. Grain yield was found to be significantly and positively correlated with plant height (r=0.655**), leaf area index (r = 0.818**), shoot dry matter (r = 0.724**),cob length (0.566**) and 100 -grain weight (r = 0.814**) while the grain yield was not significantly correlated with crop growth rate (r = 0.338) and cob diameter (r = 0.038).However, plant height was positively and significantly correlated with leaf area index (r = 0.945**), shoot dry weight (r=0.869**), crop growth rate (r = 0.386*),relative growth rate (r = 0.874**), cob length (r = 0.982**) and 100-grains

Table 25: Matrix of Correlation between Grain Yield, Growth and Yield Components of Maize at Samaru in 2016 Wet Season

SAM	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.655**	1.000										
3	-0.113	-0.062	1.000									
4	0.818**	0.945**	-0.049	1.000								
5	0.724**	0.869**	0.024	0.909**	1.000							
6	0.338*	0.386**	0.114	0.407**	0.725**	1.000						
7	-0.534**	0.874**	0.123	-0.811**	0.604**	0.049	1.000					
8	-0.309*	0.808**	0.093	-0.654**	-0.565**	-0.053	0.867**	1.000				
9	0.109	0.245	0.356	0.211	0.417**	0.551**	-0.069	-0.154	1.000			
10	0.038	0.078	-0.103	0.034	-0.111	-0.273	-0.176	0.118	0.248	1.000		
11	0.566**	0.982**	-0.078	0.892**	0.805**	0.314*	-0.906**	-0.867**	0.247	0.094	1.000	
12	0.814**	0.917**	-0.018	0.979**	0.907**	0.405*	-0.813**	-0.658**	0.230	-0.001	0.863**	1.000

DF = N-2 (48-2=46) *= significantly different at 5% = **0.288** level of probability, **= Highly significantly different at 1% = **0.372** level of probability.

1. Grain yield
2. Plant height
3. Number of leaves
4. Leaf area index
5. Shoot dry matter
6. Crop growth rate
7. Relative growth rate
8. Net assimilation rate
9. Days to 50% silking
10. Cob diameter
11. Cob length
12. 100- grain weight

weight (r = 0.917**). Net assimilation rate was significant and negatively correlated with 100-grain weight with (- 0.309) at Samaru.

4.2.2. Correlation analysis at Kadawa

The result of correlation analysis between grain yield, growth and yield components of Maize in the 2016 wet season at Kadawa is shown in Tables 26. Grain yield was found to be significantly and positively correlated with plant height (r = 0.945**), number of leave (0.370*), leaf area index (r = 0.955**), shoot dry matter (r = 0.905**), crop growth rate (r = 0.866**), relative growth rate (r = 0.834**), cob diameter (0.946**) cob length (0.946**) and 100 - seed weight (r = 0.955**) and net assimilation rate (r = 0.842). Positive and significant correlation was found between plant height and all the parameters studied except number of days to 50% silking. However, the number of days to 50% silking had no positive and significant correlation with other parameters studied.

Table 26: Matrix of Correlation between Grain Yield, Growth and Yield Components of Maize at Kadawa in 2016 Wet Season

KADW	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.954**	1.000										
3	0.370*	0.418*	1.000									
4	0.955**	0.934**	0.397*	1.000								
5	0.906**	0.852**	0.314*	0.926**	1.000							
6	0.866**	0.793**	0.286	0.887**	0.993**	1.000						
7	0.834**	0.754**	0.268	-0.811**	0.953**	0.972**	1.000					
8	0.842**	0.751**	0.318*	0.899**	0.918**	0.931**	0.963**	1.000				
9	**0.063**	**0.141**	**0.136**	**0.040**	**0.167**	**0.166**	**0.121**	**0.043**	**1.000**			
10	0.946**	0.982**	0.406**	0.946**	0.877**	0.820**	0.766**	0.768**	0.132	1.000		
11	0.946**	0.980**	0.390**	0.967**	0.881**	0.828**	0.797**	0.798**	0.108	0.983**	1.000	
12	0.955**	0.961**	0.373**	0.973**	0.864**	0.820**	0.824**	0.841**	0.063	0.955**	0.976**	1.000

DF = N-2 (48-2=46) *= significantly different at 5% = **0.288** level of probability, **= Highly significantly different at 1% = **0.372** level of probability.

1. Grain yield
2. Plant height
3. Number of leaves
4. Leaf area index
5. Shoot dry matter
6. Crop growth rate
7. Relative growth rate
8. Net assimilation rate
9. Days to 50% silking
10. Cob diameter
11. Cob length
12. 100 - grain weight

CHAPTER FIVE

5.0 DISCUSSION

5.1 GeneralDiscussion

The effects of sowing dates, time of basal fertilizer application were investigated. Highest grainyields were obtained from the first sowing date (2^{nd} week of June) at both location. This could be due to favourable weather conditions at this early point of the season and also favourable agro- climatic conditions particularly temperature. Maize requires a temperature range of (Min. 21 and Max. 32^{o}C (Kumar*et al.*, 1982, Onwueme and Sinha, 1991) and the temperatures recorded during the first sowing date were optimum, (Min. 23.2^{o}C and Max. 31.4^{o}C).

Rainfall per day was 166.1mm during the 1^{st} sowing date (2^{nd} week of June) and total rainfall of 1, 056.8mm and the rainfall in the subsequent months was adequate for crop establishment and growth at Samaru (Appendix II) while at Kadawa (Appendix I), Temperature (Min.26.9^{o}C and Max. 28.5^{o}C) and rainfall of 150mm and total rainfall of 628.4mm. At both locations, the overall performance of Maize as exemplified by plant height, leaf area index per plant, shoot dry matter, crop growth rate and grain yield might be as a result of favourable weather conditions during the trial.

5.2 Effects of Sowing Date on Growth, Yield and Yield Components of Maize

According to this study, growth, yield and yield components were significantly affected by sowing date, growth component of Maize such as plant height, number of leaves per plant, leaf area index, shoot dry matter, crop growth rate, relative growth rate, net assimilation rateat both locations were significantly affected by sowing dates. Sowing date for Maize varies from one area to another, depending on the establishment of rains. Significant response of these parameters to sowing dates might be due to early sowing which provided optimum temperature (Min. 26.9 and Max. 28.5^{o}C), sunlight and rainfall 1,056.8mmfor effective physiological development through photosynthesis. Environmental changes (Sunshine and Temperature) associated with different sowing dates have a modifying effect on the growth and development of Maize plant, this result agreed with the work of El-sharkawy *et al.* (1975) which states that growth parameters such as plant height, leaf size and number declined with late sowing as crop sown at optimum time has sufficient time for vegetative and reproductive phases as it makes the best use of available temperatures and solar radiation at different stages of growth in higher productivity. Also Moentono (1989) and El-Shaer (1991) reported that delayed sowing significantly reduced leaf area index and biomass, in the plant in Maize. Number of days to 50% silking was significantly influenced by sowing date, this could be due to the longer period taken to utilize more nutrients, light and moisture to produce enough assimilate which hastened vegetative and reproductive growth. This agreed with the work of Isai and Chung (1984) who reported that late sowing prolonged the growth period from sowing to 50% silking as well as maturity. Roy and Singh (1994) observed that delay in sowing date hastened development between seedling emergences to silking and decreased cumulative incident radiation on Maize during vegetative period.

On early sown Maize, the yield attributes were positively affected by sowing date such as number of rows per cob at Samaru and diameter at Kadawa, cob length, grain yield and 100-grain weight at both locations were due to the longer availability of time for the early sown crops to utilize most of the available environmental resources. The results confirmed by the work of Namakka *et al.* (2008), who reported that sowing Maize at the 3rd week of June had significantly heavier cob than the end of July sown Maize. Various works reported that early sowing is the best way to effectively harness environmental resources such as sunshine and temperature.

5.3Effects of Time of Basal Fertilizer Application on Growth, Yield and Yield Components of Maize

According to this study, growth components such as plant height, number of leaves per plant, leaf area index, shoot dry matter, crop growth rate, relative growth rate and net assimilation rate responded positively to time of basal fertilizer application at both locations. This could be attributed to the role of early fertilizer (NPK) application which help in earlier and faster establishment of the crop through provision of nutrients for the plant growth. This result agreed with the work of Berger, (1982) who reported that application of nitrogen to Maize at sowing promotes early growth because it supplies the nutrient in the zone where root are active. Also early application of P is recommended because of its immobility in the soil and it roles of root development, especially in cereals, good phosphorus nutrition strengthens structural tissues such as those found in straw or stalks, thus helping to prevent lodging (falling over).The significant effect of time of basal fertilizer application to yield attributes such as cob diameter at Kadawa, cob length, 100 - seed weight at both locations could also be due to early fertilizer application that provided nutrients, especially N for effective photosynthesis which in turn facilitated the optimum production of assimilate for growth and storage. This finding conformedto the work of Bouldin and Selleck (1979) who obtained significantly lower yield when NPK fertilizer application was delayed up to six weeks after sowing while treatments that received NPK fertilizer at sowing produced the highest grain yield and yield components. Application of fertilizer generally supplied enough nutrients required by the plant for vigorous growth and production of wider leaves for efficient light interception. Maize plant if starved of NPK nutrient at any development stage will result in the reduction of the grain yield, an adequate supply of nutrient at a later stage will often not overcome the effect of the early deficiency. It is therefore important that fertilizers are to be applied to Maize crop at certain times.

5.4 Interactionbetween Sowing Date and Time of Basal Fertilizer Application Time

The taller plants recorded in 8 and 10 WAS with basal fertilizer application at sowing at second weeks of June revealed that a combined application of fertilizer at sowing and early sowing produced better growth and development of Maize. The result of this study confirmed with the findings of Jones(1976) which stated that sowing time effect was observed to be significant on crop well fertilized with nitrogen and phosphorus that is crop sown at the recommended time to make the best use of the available temperature and solar radiation at the different growth stages for yield productivity.

5.5 Correlation Analysis

Knowledge on interrelationship of plant character like grain yield with other characters such as plant height, number of leaves, leaf area index, shoot dry matter, cob length, crop growth rate, relative growth rate, 100- grain weight is of paramount importance to breeders in making decision for improvement in complex quantitative character like grain yield for which direct selection is not much effective. The positive significant relationship which was recorded between grain yield and most of the growth parameters measured signifies an interdependency between the parameters, such consistent correlation in both Samaru and Kadawa is a proof that the growth parameters such as plant height, number of leaves, leaf area index, shoot dry matter, crop growth rate, relative growth rate, cob length and 100 -

grain weight contributed to grain yield of Maize. This observation signifies the importance of these parameters in the production of assimilates and that distribution as reported by Aliyu *et al.*(1994), Hassan, (1999) and Dauda *et al*. (2005a)who also reported positive and significant relationship between growth and yield parameters.The positive and significant association between grain yield and growth and yield attributes suggest that priority be given to these traits when making a selection for improvement. Plant height, crop dry matter, leaf area index exhibited a maximum positive correlation with grain yield indicated their importance in determining this complex character and therefore, should be kept in mind while practicing selection aimed at improving grain yield. This is because the attribute which is in association do not perform effectively individually, but are linked to other components.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Field trials were conducted in 2016 wet seasons at the Institute for Agricultural Research, Samaru and Kadawa to assess the effects of sowing dates and time of basal fertilizer application on growth, yield and yield components of Maize. The treatments consisted of 4 sowing dates which were at 7 days intervals (2^{nd} week of June, 3^{rd} week of June, 4^{th} week June and 1st week of July) and 3times of basal fertilizer application periods (at sowing, 10 days after sowing and 20 days after sowing). The treatments were factorially combined and laid out in a randomized complete block design (RCBD) which was replicated 4 times. Parameters measured were plant height (cm), leaf area plant^{-1} (cm^2), leaf area index, shoot dry matter, crop growth rate (gm^{-2}wk^{-1}), relative growth rate (gg^{-1}wk^{-1}), net assimilation rate (gm^{-2}wk^{-2}), number of days to 50% tasseling, number of days to 50% silking, number of cobs plant^{-1}, cob length (cm), cob diameter (cm), threshing percentage (%), harvest index (%), 100 - seed weight (g), grain yield per hectare (kg). At both locations, the results obtained revealed that sowing Maize at 2^{nd} week of June positively influenced plant height (cm) , number of leaves plant^{-1}, leaf area index, shoot dry matter, crop growth rate, relative growth rate, net assimilation rate, number of days to 50% silking, cob length, 100- grain weight and grain yield ha^{-1}. Time of basal fertilizer application at sowing significantly influenced plant height, leaf area index, shoot dry matter, crop growth rate, relative growth rate, net assimilation rate, cob diameter, cob length, 100- seed weight and grain yield per hectare at both locations. Similarly, interaction between sowing dates and time of basal fertilizer application indicated that sowing at 2^{nd} week of June and application of fertilizer at sowing positively influenced plant height and grain yield ha^{-1}. The correlation result showed that grain yield was positively and significantly correlated with all parameters except number of days to 50% silking and net assimilation rate.

6.2 Conclusion

Based on the results obtained from this study,it can be concluded that sowing Maize in 2^{nd} week of June at Samaru and Kadawa gave (6254.5 $kgha^{-1}$) and(6054.7$kgha^{-1}$) respectively, however, time of basal fertilizer application at sowing resulted in in the following yield (4838.9$kgha^{-1}$) at Samaru and (4651.1$kgha^{-1}$) at Kadawa.

6.3Recommendation

From the result obtained, sowing at 2^{nd}week of June and time of basal fertilizer application at sowing are recommended to farmers around Samaru and Kadawa.

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Appendix 1: Meteorological Data Showing Monthly Rainfall, Air Temperature, Relative Humidity and Sunshine hours in 2016Wet Season Kadawa.

	% RELATIVE HUMIDITY		**TEMPERATURE (^0C)**		**EARTH TEMPERATURE (30cm)**				
MONTH	**10 a.m**	**3p.m**	**Max**	**Min**	**10 a.m (0C)**	**3 p.m (0C)**	**SUNSHINE HOURS**	**RAINFALL (mm)**	**EVAPORATION (mm/day)**
MARCH	35.8	18.2	27.0	26.8	NA	NA	NA	0.00	NA
APRIL	39.7	40.5	40.1	29.9	NA	NA	NA	0.00	NA
MAY	23.1	14.4	38.3	29.7	NA	NA	NA	150	NA
JUNE	36.6	20.2	28.5	26.9	NA	NA	NA	65.1	NA
JULY	55.7	47.0	26.8	25.1	NA	NA	NA	192.2	NA
AUGUST	59.5	52.3	29.9	20.6	NA	NA	NA	232.5	NA
SEPTEMBER	50.1	38.2	35.1	26.0	NA	NA	NA	105.0	NA
OCTOBER	43.0	33.6	35.1	24.5	NA	NA	NA	18.0	NA
Total								638.4	

NA: Not Available

Source: Meteorological Unit of Institute for Agricultural Research (IAR), Ahmadu Bello University, Kadawa, Kano State.

Appendix 2: Meteorological Data Showing Monthly Rainfall, Air Temperature, Relative Humidity and Sunshine Hours in2016 Wet Season Samaru.

	% RELATIVE HUMIDITY		TEMPERATURE (^0C)		EARTH TEMPERATURE (30cm)		SUNSHINE HOURS	RAINFALL (mm)	EVAPORATION (mm/day)
MONTH	**10a.m**	**4p.m**	**Max**	**Min**	**10 a.m (0C)**	**4 p.m (0C)**			
MARCH	33.3	23.10	34.7	24.1	28.8	29.9	6.5	0.0	7.9
APRIL	50.9	30.4	39.5	25.8	30.9	41.7	7.8	0.0	9.9
MAY	66.4	45.8	35.2	24.2	28.6	29.8	7.8	166.1	7.4
JUNE	75.5	65.4	31.4	23.2	52.6	28.4	7.1	181.3	4.6
JULY	80.4	71.5	30.8	22.9	26.9	26.6	5.9	218.6	3.7
AUGUST	81.9	74.3	30.6	21.9	26.2	26.8	6.7	261.6	5.5
SEPTEMBER	74.7	NA	NA	24.6	26.0	26.5	3.0	229.2	6.0
OCTOBER	60.4	54.7	34.3	18.3	27.3	28.2	8.4	0.0	6.7
Total								1,056.8	

NA: Not Available

Source: Meteorological Unit of Institute for Agricultural Research (IAR) Ahmadu Bello University, Samaru-Zaria. Kaduna.

BIOGRAPHY

OBJECTIVE: To work in a challenging environment where potentials could be developed, thus adding value to my employer and also achieving self satisfaction.

SKILLS AND COMPETENCE

- ✓ Ability to work with team and deliver on specifications.
- ✓ Ability to work under minimal supervision and in team spirit.
- ✓ Ability to initiate, direct and coordinate action plans.
- ✓ Excellent communication and good report writing skill

PERSONAL DATA

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Marital Status:	Married

INSTITUTIONS ATTENDED	DATE
• East – West Seeds International Academic, Thailand	2019 – 2020
• Kwame Nkrumah University of Science and Technology, Kumasi, Ghana	2016 – 2019
• AGRA – KNUST, Kumasi, Ghana	2017
• West Africa Seed Program (WASP)	2016
• University of Nairobi , Seed Enterprise Management Institute (SEMIs)	2015
• Ahmadu Bello University, Zaria	2015 - Date
• National Teachers' institute Kaduna (Gusau Study Centre)	2013 - 2015
• University of Maiduguri, Borno State	2005 - 2012
• Borno College of Agriculture, Maiduguri	2000 - 2003
• Kur Moh'd Day Secondary School Bama, Borno State (NECO/NABTEB)	2003/2012
• Army Children School Yola, Adamawa State	1989 - 1994
• Sterpro Computer Institute, Maiduguri	2012 - 2012
• Institute of Customer Relationship Management	2013 - 2013

ACADEMIC/PROFESSIONAL QUALIFICATIONS DATE

Qualification	Date
• General Vegetables Production Program- Crops Advisor Trainer Level (CAT)	2019-2020
• Master of Philosophy ((Plant Breeding)	2019
• Certificate of Proficiency in English	2019
• Certificate of Participation in Quantitative Genetics	2017
• Certificate of Participation in Internal Seed Control and Assurance System	2016
• International Training on Seed Quality Assurance, Management and Control Progresses (AGRA)	2015
• Master of Science in Agronomy (M. Sc Agronomy)	(In View)
• Postgraduate Diploma in Education(PGDE)	2015
• Bachelor of Agriculture in (Crop Production)	2012
• National Diploma in Agricultural Technology	2013
• Senior Secondary School Certificate (SSCE/NABTEB)	2003/2012
• First School Leaving Certificate (FSLC)	1994
• Diploma in Computer Appreciation	2012
• Professional Postgraduate Diploma	2013
• National Business and Technical Certificate (NABTEB)	2012

WORKING EXPERIENCE DATE

- **SIWES:** Agricultural Development Programme (ADP) 2001
  Role: Trainee on Agricultural Practices

- **SIWES:** Agric Research Farm, University of Maiduguri 2009
  Role: Trainee on Cropping Methods, Poultry Keeping, Livestock Rearing.

- **NYSC:** National Agricultural Seed Council (NASC) 2013 - 2014
  Supervised Maslaha Seeds Company, Gusau, Zamfara State
  Role: Seed Certification Officer and Crop Breeding

- Maslaha Seeds Company, Gusau 2014 - Date
  Role: Quality Control Officer

- East - West Seeds International 2019- 2020
  Training on Vegetable Production

EXTRAL CURRICULUM ACTIVITIES AND ANY OTHER INFORMATION

Reading, Community Service and Making Friends.

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