ADAPTIVE STRATEGIES FOR DELAYED ONSET OF RAINFALL FOR MAIZE PRODUCTION IN TROPICAL RAINFOREST OF SOUTHEASTERN NIGERIA

BY

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DEDICATION

To

My wife and my son for always standing beside me.

CERTIFICATION

We certify that this work was carried out by **Adikuru, Ndubuisi Chinedu** of the Department of Crop Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Delayed onset of rainfall constrains farmers across the humid southern Nigeria to delay planting, until the rain is established, as a means of avoiding the moisture stress imposed. Field experiments were therefore conducted in 2009 and 2010 to assess the impacts of delayed onset of rainfall with a view to determining appropriate adaptation strategies for the production of maize in the southeastern rainforest zone of Nigeria. The study was a split-split plot laid out in randomized complete block design with three replications. Four sowing dates (February 28, March 15, March 30 and April 14) were the main plots, three maize varieties (TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA) the sub-plots and two poultry manure rates (0 and 10 tons/ha) constituted the sub-sub plots. The main plots measured 13.25 x 7m, subplots were 3.75 x 7m and sub-subplots were 3.75 x 3m. Maize was sown at a population of 53,333 plants ha¬-1 (0.75 x 0.25m). Plant parameters measured included vegetative growth parameters (at 2, 4 and 6weeks after planting), reproductive growth parameters and grain yield. Other measurements were soil temperature and moisture content. The results showed that in 2009 and 2010 maize planted on February 28 and March 15 generally had reduced vegetative growth compared to maize planted on March 30 and April 14 due to moisture deficit. Stem dry matter was reduced by 85.3% in 2009 when maize planted on March 15 and April 14 was compared and by 81.4% in 2010 when maize planted on March 15 and March 30 was compared. Moisture stress also delayed attainment of maize physiological maturity by 6.0 and 11.0 days in 2009 and 8.0 and 10.0 days in 2010 when maize planted on February 28 was compared to maize planted on March 30 and April 14 respectively. Grain yield reduction was 26.6% in 2010. The late maturing varieties (TZL COMP4 C3 and OKA AWAKA) were superior to the early maturing variety with regard to vegetative and reproductive growth.Variety TZL COMP4 C3 which had the lowest anthesis-silking interval(5.0 days) is considered the most physiologically desirable among the three maize varieties. Application of 10tons/ha of poultry manure significantly increased vegetative growth and hastened maturity in maize. Poultry manure significantly increased maize yield components and resulted in 33.3 and 61.3% increase in grain yield in 2009 and 2010 respectively. The results from this study showed that poultry manure application, selection of variety and time of planting are effective strategies for adaptation to the impacts of delayed onset of rainfall in the humid rainforest zone of Nigeria.

Keywords: Maize production, Rainfall, Poultry manure, Grain yield and Tropical rainforest.

CHAPTER ONE

INTRODUCTION

The occurrence of global climate change has been incontrovertibly demonstrated. The Intergovernmental Panel on Climate Change (IPCC) in its third assessment report concluded that global average surface temperature increased by 0.6^0C (± 0.2^0C) over the 20th century and predicted increase by 1.4 to 5.8^0C between 1990 and 2100. The report also indicated that average precipitation increased over tropical latitudes by about 2-3% throughout the 20th century. These changes are responsible for environmental impacts such as changes in rainfall patterns, increased frequency and severity of floods, droughts, storms and heat waves, changes in growing seasons and regions, changes in water quality and quantity and sea level rise (Postnote, 2006).

Change in rainfall pattern, which is a manifestation of climate change (Jones and Thornton, 2003), is generally noticeable in Nigeria in the form of rainfall variability. Across the humid southern Nigeria in particular, it is characterized by delayed onset and early cessation leading to the shortening of the growing season (NIMET, 2008). Delayed onset of rain constrains farmers to delay planting (until the rain is established) because it leads to moisture deficit, high solar radiation, reduced humidity and high evapotranspiration thereby creating moisture stress (drought) condition at the early season. According to Hillel and Rosenzweig (2002) and Campos *et al.* (2004), global climate change is expected to result in a long term trend towards higher temperatures, greater evapotranspiration and an increased incidence of drought in specific regions. This scenario threatens food security in Nigeria and particularly southern Nigeria where rainfed agriculture is practiced (Uyigue and Agho, 2007).

Maize is the principal cereal cultivated in southern Nigeria and always a component of the major cropping systems (Obi, 1999; Ibeawuchi and Ofoh, 2000). Consumption of maize is projected to increase by 50% globally and 93% in sub-Saharan Africa from 1995-

2020 (Ringler *et al.*, 2010). According to Iken and Amusa (2004) maize yields decline with lateness of planting after an optimum time, usually the start of the rains and response of varieties to other inputs is dependent upon planting time. Due to extreme weather events, there is currently a delay of about 10 to 20 days in the onset of rainfall in southern Nigeria (NIMET, 2008). Consequently, planting is delayed and a variation in planting time within the cropping season is established. This variation is due to the fact that while some growers follow the conventional beginning of the planting season in March, others follow the time of establishment of the rains in April. Therefore maize planted early may face a period of moisture stress while maize planted late may encounter excess moisture (Massey and Warsi, 2009). Food security in these areas (southern Nigeria) may therefore become increasingly precarious. Already the Nigerian Food Security Update for May/June 2008 shows that household food security is deteriorating in both the South and North (FEWS NET, 2008). The importance of maize in household food security derives mainly from the fact that maize can be stored for longer periods and it provides food for resource poor farmers early in the season, when the major food crops (mainly tubers) are yet to mature. Delayed onset of rainfall may however, introduce sharp variations in soil moisture and thermal conditions in the early part of the rainy season (early vegetative stage of maize growth) thereby imposing different degrees of drought stress on the crop (Agele, 2006). Consequently, yield losses may be inevitable. Jones and Thornton (2003) predicted a maize yield reduction of 10% in Africa and Latin America by 2055, while recognizing the possibility of increases in some areas. They therefore called for urgent assessment of climate change at the local level.

Adaptation is necessary if the negative impacts of climate change are to be reduced. Possible adaptation options include altered planting dates, selection of a crop variety more adaptable to the new climate, application of irrigation, changes in levels of fertilization and changes in agricultural systems (Adejuwon, 2004). Studies conducted in Imo and Abia states on adaptation measures by crop farmers in the southeast to climate change show that while **farmers in this area mainly adopt portfolio diversification and soil conservation practices for** adaptation, lack of information on appropriate adaptation option (50% of farmers surveyed) and lack of finance (35% of farmers surveyed) constitute their greatest barrier to adaptation to climate change (Onyeneke and Madukwe, 2010).

It is therefore necessary to assess the impacts of climate change on delayed onset of rainfall with a view to determining appropriate adaptation options for the production of maize (and other crops in the intercropping systems) in the rainforest zone of Nigeria. The development and application of such adaptation strategies will improve maize productivity by supporting early planting to take advantage of the abundant solar radiation available at the beginning of the growing season since maize development follows the C_4 photosynthetic pathway. Consequently, this study evaluated the combined use of sowing date, organic manure application and varietal selection as adaptation strategies for delayed onset of rainfall. The objectives of the study were to:

(i) determine the effect of sowing date on the growth and yield of maize;

(ii) determine the effect of poultry manure application on maize growth and yield; and

(iii) assess the response of different varieties of maize to variation in sowing date.

CHAPTER TWO

LITERATURE REVIEW

2.1 Classification and Nutrient Requirement of Maize

Maize (*Zea mays* L.) is the only species usually included in the genus zea of the tribe Maydeae (or Tripsaceae) of the family Poaceae. It is commonly classified into five groupings based on amount, quality and arrangement patterns of kernel endosperm. They are dent (*Zea mays indentata*), flint (*Zea mays indurata*), floury (*Zea mays amylacea*), pop-corn (*Zea mays everta*) and sweet corn (*Zea mays sacharata*). It ranks after wheat and rice as the third most important crop in the world (Rouanet, 1987) and also the most important cereal in the rain forest and Southern savanna regions of West Africa.

Optimum growth and yield of maize requires an adequate supply of nutrients particularly nitrogen, phosphorus and potassium. Sulphur, zinc and magnesium are the most important micronutrients particularly in the savanna zone and under continuous cropping in the forest ecology (Iken and Amusa, 2004). Most Nigerian soils are however low in organic matter and native soil nitrogen and also deficient in phosphorus and sulphur (Amhakhian *et.al*., 2012). Therefore maize requires some form of mineral and/or organic inputs for optimum growth (Kamara, 2013). In southeastern Nigeria, fertilizer requirement recommended for optimum yield of maize is 300 – 450 kg/ha of NPK (Uguru and Obi, 1991; Enwezor *et.al*., 1995). From studies based on soil data in three locations of southeastern Nigeria, Ezeaku (2008) reported a single dose application of NPK at rates of 493, 566 and 540 kg/ha for optimum maize grain yield. To ensure adequate supply of plant nutrients and sustain maximum crop yield and profitability, a combination of both organic and inorganic fertilizer has been advocated (Eneji *et.al*., 1997). The application of fertilizer from both organic and inorganic sources significantly improves the growth and yield of maize (Boateng *et.al*., 2006).

2.2 Pattern of Maize Growth and Development

Maize growth and development generally follows a pattern distinctively divided into vegetative and reproductive stages. During the vegetative stage the development of the vegetative organs take place beginning with seed germination and seedling growth. The vegetative organs, which include a thick web of fibrous roots (Onwueme, 1978) and some brace or prop roots, unbranched and herbaceous stems and about 20 parallel veined leaves (Smith, 1995) mainly serve the purpose of intercepting radiant energy and converting same to dry matter (Maddonni and Otegui, 1996) using the highly efficient C4 photosynthetic pathway in contrast to the C3 pathway. The name (C4) derives from the first product of carbon fixation – a 4-carbon acid (phosphoenol pyruvic acid). Two distinctive features of C4 plants are a special kind of leaf anatomy (Kranz anatomy) and an extra biochemical pathway which fixes CO_2 and then re-releases it for incorporation into the Calvin Cycle (found in C3 plant). Consequently, C4 plants exhibit no photorespiration and they can fix CO_2 until the internal concentration of CO_2 reaches zero (Moore *et al.*, 1998). Thus C4 plants have higher rates of net production at high light levels than C3 plants because they use the available CO_2 more efficiently (Open University, 1991). The dry matter produced accumulates in the maize stem, to be later remobilized to the kernels during the period of rapid kernel growth (Setter and Meller, 1984). Thus, the vegetative stage of development is physiologically designed for dry matter production and accumulation.

Approximately 30 days after sowing, the growing point switches from producing leaves to producing the tassel (the terminal reproductive structure). Pollen is produced in the male spikelets of the tassel and under favourable conditions the anthers emerge, break up at the tips and pollen is shed (anthesis). Anthesis marks the transition to the reproductive stage (Kling and Edmeades, 1997). The reproductive organs are the male inflorescence (tassel) and the female inflorescence (ear). The styles also called silks, exit the ear in order to receive pollen for fertilization of the maize kernel. While pollen retains viability for only a few hours, silks are receptive for several days and fertilization can occur within 28 hours after pollination (Obi, 1991). After fertilization, silks wilt and turn brown while carbohydrates and nutrients rapidly accumulate in the kernels.

At maximum dry weight, the kernel moisture content is about 35%. When transport of assimilates to kernel ceases, a “black layer” (abscission layer) forms at the base of the kernel and this serves as indicator of physiological maturity (Kling and Edmeades, 1997) and also the end of the reproductive stage of development.

The vegetative stage (emergence to tasseling) according to the number of fully expanded leaves, n, is designated by Vn, while the reproductive stage (silking to physiological maturity) according to the degree of kernel development, is designated by Rn (Vina *et al.,* 2004). Therefore the number of days from sowing taken by a maize plant to attain each stage of growth can be determined. Thus the vegetative stage runs from VE (coleoptile emergence above the soil surface) which takes about 5 days, to VT (the last branch of the tassel is completely visible) which takes about 55 days. Similarly, the reproductive stage runs from RO (pollen shed begins –anthesis) which takes 57 days, to R6 (black layer is visible – physiological maturity) which takes about 112 days (Kling and Edmeades, 1997).

2.3 Weather and Climate of the Southeast Zone

Crop production critically depends on weather and climate, which are primarily products of the atmospheric general circulation. That is, all aspects of the three dimensional global flow and energetics of the whole atmosphere (Lockwood, 1979). The state of the atmosphere at a given point in time at a given location is known as weather, while climate is the synthesis of weather at a given location over a period (about 30-35 years) (Ayoade, 1983). Climate therefore refers to the characteristic condition of the atmosphere deduced from repeated observations over a long period. It goes beyond the average weather conditions over a given area to include considerations of departures from averages (i.e. variabilities), extreme conditions and the probabilities of frequencies of occurrences of given weather conditions (Schneider, 1992). The main elements of weather are temperature, rainfall, dew, humidity, wind, sunshine, mist, haze and clouds. Therefore the climate of a place is described by the collective pattern of expression of these elements over time (Oyekale, 2009).

The Southeast Zone of Nigeria is located between latitudes 5^0 06'N to $6^0$34'N of the equator and longitudes $6^0$38'E and $8^0$08'E of the Greenwich (Prime) Meridian (Onyeneke and Madukwe, 2010). Average maximum temperature is highest in February and March, while July and August have the lowest values (Onyeneke, 2009). The rainfall pattern is seasonal and double maxima with a short dry season period (commonly referred to as August break) from July to August (Odjugo, 2005). According to Okonkwo and Mbajiorgu (2010) the highest mean annual rainfall of 2380mm in the area occurred at Owerri while the lowest of 1860mm occurred at Enugu. The area experiences two seasons – the wet season (March through November) and the dry season (December through February). Humidity and temperature are high year-round.

2.4 Definition and Causes of Climate Change

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) defined climate change as a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period typically decades or longer (IPCC,2007). While the length of time it takes the changes to manifest matters, the level of deviation from the normal and its impacts on the ecology are most paramount (Odjugo, 2010a). Climate change differs from climatic fluctuations or climatic variability. Considering the fact that no year is the same as another in climate averages, climatic variability denotes inherent dynamic nature of climate on various temporal scales which could be monthly, seasonal, annual, decadal, periodic, quasi-periodic or non-periodic (Odjugo, 2010a). Climate change is a long-term shift, alteration or change in the type of climate prevailing over specific location, region or the entire planet (Ayoade, 2004).

The causes of climate change are both natural and anthropogenic. The natural causes include terrestrial, astronomical and extraterrestrial. Terrestrial causes of climate change refer to changes in climate resulting from variations in terrestrial conditions such as changes in the distribution of land and oceans, volcanicity which would provide aerosols and other pollutants that will affect the transparency of the atmosphere and consequently the amount of energy reaching or leaving the earth's surface. Variations in carbon-dioxide, ozone and water vapour also affect the climate. According to Eagleman (1985) the physical effects of mountain chains built up by volcanic activity influence the climate and this may have led to the suggestion that the ice ages of the past were caused by volcanic-mountain building.

Astronomical theories of climate change which was put forward by James Croll in 1875 but later refined and elaborated by Milutin Milankovitch in 1941 are based on changes in the earth's geometry (Goodess *et al.*, 1992). The relevant elements of this geometry include the changes in the eccentricity of the earth's orbit, changes in the obliquity of the plane of ecliptic and changes in orbital procession (Odjugo, 2010a). Generally orbital geometry variations cause only small variation in the global annual receipt of solar radiation. The major effect is on the seasonal and latitudinal distribution of radiation.

Extraterrestrial causes of climate change refer to changes in the amount of solar energy reaching the earth either because of changes in the solar output or changes in the amount of solar radiation absorbed outside of the Earth's atmosphere (Ayoade, 1983).

Anthropogenic causes of climate change refer to changes in climate resulting from human activities including industrialization, urbanization, deforestation, population explosion and agriculture (Odjugo, 2010b). These activities either emit large amounts of greenhouse gases into the atmosphere that depletes the ozone layer or reduce the amount of carbon absorbed from the atmosphere. The greenhouse gases include carbondioxide (CO_2), methane (CH_4), nitrous-oxide (N_2O) and chlorofluorocarbons (CFCs) (Glantz and Krenz, 1992). Increasing the concentrations of these gases, which keep the earth warm when they trap solar radiation leaving the earth, amount to an increase in atmospheric temperature. Carbon emissions from fossil fuels are believed to be the main factor behind the rise in atmospheric concentrations and global temperatures. According to Sawin (2005) nearly three times as much carbon was released in 2004 as in 1960. This supports the declaration by IPCC in their Third Assessment Report of 2001 that most of the warming of the past 50 years was attributable to human activities (Gardner, 2002).

2.5 Present Climate and Evidence of Change

Atmospheric greenhouse gases (GHG) (water vapour, carbon dioxide, nitrous oxide, methane, halocarbons, including chlorofluoro carbons (CFCs), and Ozone) trap some of the solar energy radiated by the earth, thereby retaining heat like the glass panels of a greenhouse. Without this natural "greenhouse effect", temperatures would be much lower than they are now and life as known today would not be possible. However, problems may arise because increasing concentrations of GHG are likely to accelerate the rate of climate change (EPA, 2000). Carbon-dioxide (CO_2) has become the most important GHG as a result of progressive increase in the quantity added to the atmosphere, mainly from large-scale combustion of carbon based fossil fuels. When the industrial revolution began more than two centuries ago, the CO_2 concentration was estimated at 280 parts per million (ppm). By 1959 when detailed measurements began, using modern instruments the CO_2 level was 316 ppm, a rise of 130 % over two centuries. By 1998, it had reached 367 ppm, climbing 17.0 % in just 39 years (Brown. 2000). In 2004 the average atmospheric CO2 concentration reached 377.4

ppm (Sawin, 2005). According to samplings of air bubbles trapped in the world's deepest ice core in Vostok, Antarctica, current CO_2 levels "unprecedented" in relation to the last 420,000 years and analysis of fossilized plankton suggest that they may be at their highest points in 20million years (Dunn, 2001). The consequence of this rise in CO_2 concentration is a warming or increase in temperature of the Earth's surface known as global warming.

Based on measurements in the northern hemisphere, the average global surface temperature rose more during the twentieth century than during any other century in the last 1000 years. According to the Third Assessment Report of the IPCC, the 1990s were likely the warmest decade (and 1998 the warmest year) since instrumental record taking began in the 1860s (Dunn and Flavin, 2002). Since the early 1900s, average global temperature has risen by 0.6^0C, but the rates of change since 1976 has been triple that for the century as a whole. The average global temperature actually fell slightly in 2004, but at 14.48^0C the year was still the fourth warmest since 1980. Other climate analysis centers using roughly the same network of land and sea-based weather stations also ranked 2004 behind only 1998, 2002 and 2003 (Sawin, 2005).

The impacts of rising CO_2 concentrations and temperature are already visible worldwide. The modest temperature rise in recent decades is melting ice caps and glaciers, causing shrinkage of ice cover in the Arctic, Antarctic, Alaska, Greenland, the Alps and the Andes. It was reported in mid-1999 that the two ice shelves on either side of the Antarctic Peninsula were in full retreat. About a half-century through 1997, they lost 7,000 sq.km. Then about a year later they lost 3,000 sq.km. United States and British scientists attributed the accelerated ice melting to a regional rise in average temperature of some 2.5^0C since 1940 (Brown, 2000).

As a consequence of the melting ice, sea levels are rising. During the last century, they rose 20cm (1-2 mm/year) (Abramovitz, 2001), which is significantly larger than the rate averaged over the last several thousand years (NOAA, 2006). By exposing darker land and water surface that absorb heat, ice melt is already accelerating warming at the poles. This proves that the disappearance of the Earth's ice cover would significantly alter the global climate, though the net effect remains unknown (Mastny, 2005).

2.6 Change in Rainfall within the Rainforest Zone of Nigeria

Most studies on climate change in Nigeria are based on rainfall and temperature which are the climate variables most critical to measure with regard to food systems (Ziervogel *et al.,* 2006). Rainfall however, is by far the most important element of climate change in Nigeria (Ayinde *et al.,* 2010). As explained by Adejuwon (2004) the country experiences large spatial and temporal variations in rainfall and less variation in evaporation and evapotranspiration. In a study of variability in some weather parameters between 1971 and 2003, Oyekale (2009) found that rainfall exhibited the highest variability.

According to Oguntoyinbo (1978) and Afiesimama *et al.,* (1999) a higher proportion of the rainfall totals in Nigeria was above normal prior to 1970. Between 1980 and 2002 (23 years) only 8 years (35%) were either normal or above normal while the remaining 15 years (65%) were clearly below normal. On a decadal scale rainfall decreased from 1354mm (1971-1980) to 1255mm (1999-2000) indicating a 99mm (7%) decrease in rainfall amount between the two decades (Odjugo, 2005). Although there is a general decrease in rainfall in Nigeria (Odjugo, 2010b) there is a decreasing trend in rainfall in Northern Nigeria, while the Southern coastal area is experiencing a slightly increasing trend (Obot *et al.,* 2010). According to Odjugo (2005), rainfall in Calabar and Warri which used to be below 2900 mm (1941-1970) is now slightly above 2900mm, while Okitipupa and Ondo that received rainfall below 2000 mm are now above 2000 mm. Using the least square regression model to conduct trend analysis of annual rainfall for 1971-2006 (35 years), Afangideh *et al.,* (2010) observed significantly declining trends for Uyo and Umuahia, and increasing though statistically insignificant trend for Calabar. Ezemonye and Emeribe (2011) conducted correlogram analysis of trends and cycles in rainfall for 8 towns (Enugu, Owerri, Onitsha, Port Harcourt, Uyo, Ikom, Ogoja and Calabar) in Southeastern Nigeria for a period of 24 years (1982-2005). The study concluded that there has been a general increase in rainfall amounts in all the stations from the early 1980's to the 20th century, although no significant trend was observed in the pattern of rainfall fluctuations in all the stations except for Uyo. Furthermore the observed gradual decline or steady slope in rainfall trends up to the end of 20th century for some climatic stations may suggest a changing rainfall pattern with the wake of 21st century.

The changing pattern of rainfall manifests as rainfall variability, which may be evaluated by measuring onset, cessation and amounts of annual rainfall. Below 6^0N of the equator in Nigeria, Oguntoyinbo (1978) noted that onset of rains was late February and ceased in December. But analysis of rainfall patterns in Nigeria conducted by Odjugo (2005) showed that rains hardly established until late March and ends in November. Furthermore, while Oguntoyinbo (1978) noted 360 rainy days per year in the Niger Delta coastal area, Odjugo (2005) reported that average for the period of study (1970-2002) stood at 280 days, which implies a 22 % drop in rainy days. These facts corroborate earlier studies by IITA scientists, using rainfall data in Nigeria over a period of 30 years (1961-1990), which revealed that the greatest changes occurred in the onset of the rainy season and the extent of early rainfall. Thus the delayed onset of rains had tended to shorten the growing season overall by about a month and there were fewer wet days per season, although the intensities of rainfall were greater (CGIAR, 1996). The gradual shift in the short dry season period (August break) from August to July (Odjugo, 2010a) is an indication of a change in rainfall pattern over Southern Nigeria. The short dry season was prominent in the month of August (Oguntoyinbo, 1978). But for the past 33 years (1970-2002) the short dry season occurred in July for 21 years (64%) while in August it was only 12 years (36%) (Odjugo, 2005).

2.7 Drought Spells in the Rainforest Zone

The shift in rainfall pattern which is evident across Nigeria is confirmed by the fact that delayed onset and early cessation which used to be limited to a small part of the country is now being experienced in almost all parts (Anuforom, 2009). The consequence on crop growth and development depends on specific ecological zone and the magnitude of change in the prevailing meteorological parameters. The Nigerian landmass of 923,766 km^2 is divided into seven ecological zones according to Federal Government of Nigeria report on drought management (FGN, 1999) as presented by Sowunmi and Akintola (2010). The ecological zones, which are based on the similarity of climatic elements and the type of vegetation that can be supported, are the mangrove swamp, rainforest, montane forest/grassland, derived savannah, Guinea Savannah, Sudan Savannah and the Sahel Savannah.

In the rainforest region solar radiation receipts are highest around October/November (rainfall cessation) and February/March (rainfall onset) while lowest values are recorded around June/July (rainfall peak) (Augustine and Nnabuchi, 2010). With a mean maximum temperature between 30^{o}C and 32^{o}C almost through the year (Adejuwon, 2004), evapotranspiration exhibits similar trend as solar radiation with high rates between February and March and lowest rates between July and September (Chineke *et al.*, 2011). As onset of rainfall is delayed and temperature maintains an increasing trend (Odjugo, 2010a) probably due to increase in solar radiation, evapotranspiration is also likely to increase. There is therefore a tendency for spells of soil moisture deficit (drought) to occur in these humid areas (Adejuwon, 2004) particularly between February and April.

2.8 Crop Responses to Moisture Stress

Moisture stress is the major abiotic stress factor limiting crop productivity worldwide (Sharp *et al.,* 2004; Barnabas *et al.,* 2008). It refers to situations in which plant water potential and turgor are reduced enough to interfere with normal functioning. According to

Taiz and Zeiger (2002) water deficit can be defined as any water content of a tissue or cell that is below the highest water content exhibited at the most hydrated state. Moisture deficits develop during periods when water loss in transpiration exceeds absorption or when water supply to the roots becomes difficult (Kramer, 1983; Anjum *et al.,* 2011a). Several changes occur in plants during moisture stress, most of which are actually resistance mechanisms to enable the plant survive under the unfavourable environment. These changes which often commence within the cells (biochemical) affect plant processes (physiological) and manifest on the whole plant (morphological).

Cell growth is the result of meristematic cell divisions and subsequent massive expansion of young cells. As the water content of the plant decreases, its cells shrink and the cell walls relax causing decrease in cell volume, lowering of turgor pressure and the subsequent concentration of solutes in the cells (Taiz and Zeiger, 2002). Cell expansion and elongation being turgor driven processes are extremely sensitive to water deficits. According to Nonami (1998) inhibition of cell elongation in higher plants during water deficiency, is the effect of interruption of water flow from the xylem to the surrounding elongating cells. Since leaf expansion depends mostly on cell expansion, inhibition of cell expansion results in a slowing of leaf expansion early in the development of water deficits. Thus, the most obvious effect of even mild stress is to reduce growth through impairment of growth related traits. In maize for instance, overall reduction in growth was due to noticeable decrease in plant height, stem diameter, leaf area, number of leaves/plant, cob length, shoot fresh and dry weight/plant (Khan *et al.,* 2001; Anjum *et al.,* 2011a). Reduction in leaf area can be considered a first line of defense against drought because smaller leaf area transpires less water thereby effectively conserving limited water supply in the soil over a longer period (Taiz and Zeiger, 2002; Tardieu, 2005).

In contrast, roots may continue to elongate at low water potentials which completely inhibit shoot growth (Westgate and Boyer, 1985; Sharp *et al.*, 1988). This is so because a greater proportion of the plants assimilates is distributed to the root system as inhibition of leaf expansion reduces the consumption of carbon and energy. Increase in supply of assimilates promote further root growth and proliferation of deep roots as water in top layers of the soil is depleted. Hence, there is an increase in root: shoot ratio of plants when water availability is limited because roots are less sensitive than shoots to growth inhibition by low water potentials (Wu and Cosgrove, 2000). Deeper root growth into wet soil can be considered a second line of defense against drought (Taiz and Zeiger, 2002). As drought increases and roots begin to dehydrate, increased production of certain chemical substances (mainly hormones) is induced in the roots. These substances are translocated as chemical signals to the shoots via xylem causing physiological changes which determine the level of adaptation to the stress. Abscisic acid (ABA), cytokinins, ethylene, malate and other unidentified factors have been implicated in the root-shoot signaling (Anjum *et al.,* 2011a). This drought induced root-to-leaf signaling through the transpiration stream results in stomatal closure which is one of the earliest responses to drought (Chaves *et al.,* 2003). Studies have shown that stomata closes in response to drying soil even with shoot water status maintained at high turgor (Gowing *et al.,* 1990; Schurr *et al.,* 1992). Among a number of plant growth regulators which may be involved, the clearest evidence is for abscisic acid (ABA). According to Jones (1992) externally applied ABA closes stomata, levels of endogenous ABA increases rapidly in stress (often in parallel to stomatal closure) and mutants that are deficient in the capacity for ABA synthesis (as found in tomato and potato) are not able to close their stomata. Evidence of ABA activity in maize primary roots under drought have been reported by Chaves *et al.* (2003).

Stomatal closure deprives the leaves of CO_2 and photosynthetic carbon assimilation is decreased (Chaves *et al.,* 2002) in favour of photorespiration (Anjum *et al.,* 2011a). Chaves (1991) reported that during the onset of drought the decline of stomatal conductance before photosynthesis suggested that the inhibition of photosynthesis under mild stress can be mostly explained by a restriction of CO_2 diffusion. Limitation of photosynthesis under water stress can result from both stomatal and non-stomatal effects depending on drought intensification and species (Chaves *et al.,* 2003; Xu and Zhou, 2008). While stomatal mechanisms involve drought induced root-to-leaf signaling promoted by soil drying through the transpiration stream, non-stomatal mechanisms include changes in chlorophyll synthesis, functional and structural changes in chloroplasts and disturbances in processes of accumulation, transport and distribution of assimilates (Aujum *et al.*, 2011a).

Water stress also brings about osmotic adjustment. It is the active accumulation of solutes in plant tissue in response to an increasing water deficit which provides a means for maintaining cell turgor when tissue water potential declines (Manavalan *et al.,* 2009). During osmotic adjustment, the accumulation of ions seems to be confined to the vacuoles where the ions are kept out of contact with enzymes in the cytosol and subcellular organelles. Therefore other solutes must accumulate in the cytoplasm to maintain water potential equilibrium within the cell (Taiz and Zeiger, 2002). These solutes referred to as compatible solutes or compatible osmolytes include amino acids (like proline, aspartic acid and glutamic acid), quaternary ammonium compounds (glycine betaine and alanine betaine), carbohydrates (fructans and sucrose), cyclitols (mannitol) and proteins (Chaves *et al.,* 2003). Proteins synthesized in response to drought stress are called dehydrins (dehydration induced) and belong to the group II late embryogenesis abundant (LEA) proteins (Close and Chandler, 1990). The function of LEA proteins is not well understood, but because they strongly bind water (hydrophilic) their protective role might be associated with an ability to retain water and to prevent crystallization of important cellular proteins and the molecules during desiccation (Taiz and Zeiger, 2002).

The accumulation of compatible solutes is brought about when genes coding for enzymes associated with osmotic adjustment are turned on (up-regulated) by osmotic stress. Studies have shown that these genes are induced by the ABA accumulated during the stress (Chaves *et al.,* 2003). However, not all genes that are up-regulated by osmotic stress are ABA regulated. Thus osmotic stress regulates genes either by signal transduction pathways mediated by the action of ABA (ABA-dependent genes) or by an ABA-independent osmotic stress responsive signal transduction pathway (Bruce *et al.,* 2002).

2.8.1 Drought Escape Avoidance and Tolerance

The responses described above are part of an array of moisture stress adaptation (drought resistance) mechanisms found in different crops. These mechanisms of drought resistance are grouped into three categories, - drought escape, drought avoidance and drought tolerance (Turner *et al.,* 2001).

Drought escape allows the plant to complete its life cycle during the period of sufficient water supply before the onset of drought. This mechanism involves rapid phenological development (early flowering and early maturity), developmental plasticity (variation in duration of growth period depending on the extent of water deficit) and remobilization of preanthesis assimilates to grain (Mitra, 2001). Phenological adjustment to escape from the drought period has proved to be most successful for C_3 cereals such as wheat or barley in environments such as those of the Mediterranean region, which experience terminal drought at the end of the growing season (Lopes *et al.* 2011). In many crop plants, the most drought-tolerant cultivars are usually those that flower and mature earliest, thus completing the reproductive stage before the period of possible drought. Better partitioning of assimilates to developing fruits is also included in improved reproductive success. According to Chaves *et al.* (2003) this is associated with the ability of the plant to store reserves in some organs (stems and roots) and to mobilize them for fruit production. This ability to mobilize reserves is increased in droughted plants, most likely due to stimulation of sink capacity of seeds and pods by water stress as found in lupins (Chaves *et al.* 2002). Thus, a large photosynthetic accumulation prior to flowering is an important factor for plant production and survival during a drought event that does not disrupt the flowering process.

Drought avoidance or dehydration avoidance is the ability of plants to maintain relatively high tissue water potential despite a shortage of soil moisture. Performance of drought avoidance involves a number of mechanisms including maintenance of turgor through increased rooting depth, efficient root system and increased hydraulic conductance and by reduction of water loss through reduced epidermal (stomatal and lenticular) conductance, reduced absorption of radiation by leaf rolling or folding and reduced evaporation surface or leaf area (Mitra, 2001). According to Chaves *et al.* (2003) each of these mechanisms may either minimize water loss (stomata closure, leaf rolling, increased reflectance or steep leaf angles, and reduced canopy leaf area or shedding of older leaves) or maximize water uptake (increased investment in the roots).

Drought tolerance involves maintenance of turgor through osmotic adjustment (a process which induces solute accumulation in cell), increase in elasticity in cell and decrease in cell size and desiccation tolerance by protoplasmic resistance (Mitra, 2001). Osmotic adjustment usually develops slowly (at least in shoots) and is triggered above a certain threshold of cell water deficit. The decrease in solute potential is typically limited to about 0.2 to 0.8 MPa, except in plants adapted to extremely dry conditions (Taiz and Zeiger, 2002). As already reported (Manavalan *et al.*, 2009) the capacity for osmotic adjustment in soybean ranges from 0.3 to 1.0 MPa while in chickpea (*Cicer arietinum*) and pigeon pea (*Cajanus cajan*) it ranges from 0.1 to 1.3 MPa.

2.8.2 Effects of Moisture Stress on Maize Growth and Development

Moisture stress affects the growth of maize at all stages of development, directly and indirectly (Jacobs and Pearson, 1991; Schussler and Westgate, 1991; Danquah *et al.,* 2001). At the vegetative growth stage, reduction in plant height, stem diameter and leaf area with increasing water stress causes reduction in total biomass accumulation (Otegui *et al.,* 1995; Khan *et al.,* 2001). Water deficit imposed at various developmental stages of maize reduced total biomass accumulation at silking by 37%, at grain-filling period by 34% and at maturity by 21% (Kamara *et al.,* 2003). Dry matter production is reduced when maize encounters water deficit as a result of decline in photosynthesis per plant. Decline in photosynthesis can be due to a reduction in light interception as leaf expansion is reduced or as leaves senesce, and to reductions in carbon fixation per unit leaf area as stomata closes or as photo-oxidation damages the photosynthetic mechanism (Bruce *et al.,* 2002). According to Anjum *et al.,* (2011b) drought stress in maize led to considerable decline in net photosynthesis (33.22%), transpiration rate (37.84%), stomatal conductance (25.54%) water use efficiency (50.87%), intrinsic water use efficiency (11.54%) and intercellular CO_2 (5.86%) in comparison with well watered control.

The reproductive stage, particularly between tassel emergence and early grain filling is the most sensitive to drought stress (Grant *et al.,* 1989). During the period the number of kernels per plant is defined (Otegui *et al.*, 1995). Usually, under favourable conditions, maize silks emerge 2-3 days after pollen shed (anthesis). Since pollen shed continues for 14days or more, there is an overlap with silk emergence and period of receptivity (Danquah *et al.,* 2001). Therefore a close synchrony between anthesis and silk emergence is required for high kernel set in maize (Barnabas *et al.,* 2008). When drought stress occurs just before or during flowering, silk emergence is delayed while anthesis is largely unaffected (Faud-Hassan *et al.,*

2008) resulting in an increased anthesis-silking interval (Bolanos and Edmeades, 1996; Kamara *et al.,* 2003; Ali *et al.,* 2011). As a result there is a distortion of the synchrony in flowering which leads to increase in number of unfertilized kernels that are eventually aborted. Generally, abiotic stress factors characteristically reduce kernel number in maize by increasing anthesis-silking interval (Bolanos and Edmeades, 1993). Kernel number is more associated with grain yield than other yield components (Adikuru, 2008) and its reduction is the major cause of reduction in grain yield of maize (Jacobs and Pearson, 1991; Andrade *et al.,* 2000; Barbieri *et al.,* 2000). Therefore, the overall effect of drought on maize is a reduction in grain yield. According to Munyiri *et al.,* (2010) water stress delayed silking by 3days and increased anthesis-silking interval by 2days with the resultant effect being yield reductions of between 17 and 81 %. It is now sufficiently established that moisture stress result in maize grain yield reduction through reduction in kernel number brought about by asynchronous flower development (Boyer and Westgate, 2004; Fuad-Hassan *et al.,* 2008; Rupitak *et al.,* 2011). However, amount of yield loss during water stress depends on the crop growth stage. Drought at the emergence to V8 stage will cause minor reductions in leaf size which will have little impact on yield, while major reductions (all leaves removed from the crop) could reduce potential yield as much as 20 %. From V8 to V14 when ear size is set, drought will reduce ear size and potential yield losses can range from 10-30 %. From V14 to tasseling when the number of kernels that can be fertilized are determined, drought stress can reduce maize yields by 10-50 % (Heiniger, 2011).

2.9 Adaptation to Climate Change in Southeastern Nigeria

Climate change is a global issue but the impacts are felt locally. Estimates by the IPCC 4th African Assessment Report on climate change indicates that by 2020 between 75 and 250 million people may be exposed to increased water stress and that rain fed agricultural yields could be reduced up to 50 % in Africa if production practices remain unchanged

(IPCC, 2007). This makes Africa one of the most vulnerable continents to climate change and climate variability (Calzadilla *et al.,* 2009; UNDP, 2009). Reduction of climate change impacts require concurrent application of mitigation and adaptation measures.

Mitigation involves actions that tackle the causes (anthropogenic in particular) of climate change such as reducing greenhouse gas emissions, while adaptation involves actions that minimize the consequences of actual and expected changes in climate. Therefore, while the effect of mitigation may take a longer time to be felt, adaptation provides quicker relief. Adaptation attempts to reduce vulnerability, increase resilience, moderate the risk of climate impacts on lives and livelihoods and take advantage of opportunities posed by actual or expected climate change (Postnote, 2006).

In the southeast rainforest zone, there is a high level of awareness of climate change (96%) and its effect on agriculture (97%) among farmers (Enete and Onyekuru, 2011). According to Onyeneke and Madukwe (2010) some adaptation measures adopted by crop farmers in the zone include portfolio diversification (including use of improved crop varieties, intercropping and use of crop varieties that survive in adverse climatic conditions), soil conservation (including mulching, planting of cover crops, applying fertilizer and organic manure), changing planting dates, changing tillage operations, planting trees and irrigation. However, a number of factors influence the farmers' level of investment in these climate change adaptation practices. Among nine variables evaluated among farmers in Imo and Enugu States, Enete and Onyekuru (2011) found that age of the farmer, farmer's number of years of formal education, farmer's knowledge that climate change will affect agriculture and farmer's knowledge that agriculture contributes to climate change were positively, and significantly related with the level of investment in climate change adaptation practices by the farmers. Major factors constraining them from adapting to climate change were poverty, farmland scarcity and high technology input problem, information and training constraints as well as land tenure and labour constraints. Therefore there is need for farmers' education, awareness creation, poverty alleviation and the provision of appropriate technology inputs as potent tools for climate change adaptation in the rainforest states of Southeastern Nigeria (Enete *et al.,* 2011).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of Experimental Site

The study was conducted in 2009 and 2010 at the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri situated in the humid forest zone of Southeastern Nigeria. Owerri lies between latitudes 5^0 20'N and 5^0 27'N and longitudes 7^0 00'E and 7^0 07'E. Owerri has mean annual rainfall of 2500mm and minimum and maximum annual ambient temperature of 20^0C and 32^0C respectively (Nwosu and Adeniyi, 1980). The rainfall pattern, which is controlled by the movement of the Inter-tropical Convergence Zone (ITCZ), is characterized by a long wet season from April to July, with a short dry season in August, followed by a short wet season from September to October (Monanu, 1975). The soils which have been developed from coastal plain sands (Osodeke and Ojeniyi, 2005) are classified as sandy Ultisols (Eshett and Anyahucha, 1992). The soils have low mineral reserve and are therefore of low fertility (Opara, 2002).

3.2 Climatic Parameters at the Location of Study

The rainfall, number of rain days, temperature (maximum and minimum) and relative humidity data for Owerri in 2009 and 2010 were retrieved from the weather records of Agrometeorology unit of the department of agricultural engineering, Imo state Ministry of Agriculture, Owerri. The retrieved data were presented using descriptive tools.

3.3 Soil Sampling and Analysis

Soil samples were collected at random from the experimental site within 0-15 cm and 15-30 cm depths using soil auger. After land preparation in 2009 and 2010, 20 core samples were randomly collected across the experimental site. The samples were bulked, air-dried and sieved through a 2 mm sieve. Standard analytical procedures were applied to determine the physical and chemical properties of the soil including particle size, pH, organic carbon, exchangeable bases, exchangeable acidity, available phosphorus and total nitrogen.

The percentage of the different fractions (sand, silt and clay) in the soil were determined by dispersing 50 g of the sample in 50 ml of Calgon (Sodium hexameta phosphate) according to Bonyoucos (1962). Soil pH was determined in water using 1:2.5 soil: water ratio and a pH meter. After leaching with 1N neutral ammonium acetate, the exchangeable bases in the soil sample were determined with the flame photometer (sodium and potassium) and atomic absorption spectrophotometer (calcium and magnesium). Exchangeable acidity (aluminum and hydrogen) was determined by titrating with NaOH after extracting with KCl. Percentage organic carbon was determined by oxidizing the soil sample with $K_2 Cr_2O_7$ and H_2SO_4 for 30minutes following the method of Walkley and Black (1934). Available P was determined using Bray 1 method (Bray and Kurtz, 1945).

3.4 Organic manure analysis

The nutrient content of organic (poultry) manure applied was analyzed for total nitrogen (Micro Kjeldahl) phosphorus, potassium, calcium and magnesium (dry ashing) and organic carbon according to the methods described by Peters *et al.* (2003).

3.5 Treatments

The treatments comprised four sowing dates, two organic manure rates and three maize varieties. The sowing dates were based on expected onset of rainfall (March 10-20) as predicted by the Nigerian Meteorological Agency (NIMET, 2008). For the purpose of this experiment, March 15 (mean of March 10 and 20) was determined as the onset of rainfall. The sowing dates therefore included February 28, March 15, March 30 and April 14. The poultry manure rates were 0 and 10 tons per hectare of poultry manure applied by surface broadcast. Two of the maize varieties used in the experiment, TZE COMP3C3 (early maturing) and TZL COMP4C3 (late maturing) were obtained from the International Institute for Tropical Agriculture (IITA) while the third variety, OKA AWAKA, was a landrace obtained from Awaka in Owerri North Local Government Area of Imo State. There were a total of 24 treatment combinations.

3.6 Land preparation

The experimental site was manually cleared using cutlasses. After packing the cut plant materials (tree branches and leaves) to the land bordering the site, the land was demarcated into plots according to the appropriate experimental design and plant spacing.

3.7 Experimental Design

The experiment was split plot laid out in randomized complete block design with three replications. Each replication had four main plots consisting of one main plot for each sowing date. Each main plot had three sub plots, while each sub plot had two sub-subplots. Maize varieties constituted the sub-plots, while organic manure rates constituted the sub-subplots. The main plots measured 13.25 x 7 m subplots were 3.75 x 7 m and sub-subplots were 3.75 x 3 m. These measurements were inclusive of 1m alleys between subplots and sub-subplots.

3.8 Organic Manure Application and Crop Management.

Cured poultry manure collected from the University poultry farm was applied at 10 tons per ha (11.25 kg per plot) during planting. This rate is based on the recommendation of Uduma and Eka (2006). The manure was evenly broadcast on each plot intended for manure application. Maize after viability test was sown at a population of 53,333 plants ha^{-1} (0.75 x 0.25 m). Two maize seeds were sown per hill but thinned down to one seed per hill at three weeks after planting (WAP). Five rows of maize constituted the sub-subplot. The seeds were dressed with Aprom Star to prevent soil insect pest attack. NPK fertilizer (20:10:10) as starter and booster doses was applied at 3 WAP and tasseling, at the rate of 600 kg/ha (0.675

kg/plot). This was based on the recommended rate of 120 kg/ha N, 60 kg/ha $P_2 0_5$ and 60 kg/ha K_2O (IITA, 1994). To control stem borer (*Sesamia calamistis*), Furadan 3G was applied 3WAP at 4 kg/ha by dressing 0.075 g into the planting hill. Manual weeding was carried out at 3 and 6 WAP. At 15WAP when the cobs were mature and dry, maize cobs from the central row were harvested, dehusked and sun dried for 4 weeks to attain a constant weight and used for yield measurements.

3.9 DATA COLLECTION

The following data were collected for two planting seasons of this study.

3.9.1 Maize height

Plant height was measured at 2, 4 and 6 WAP using a meter rule. On five sample plants from the 3 central rows of each plot, measurements were taken from the ground level to the ligule of the last fully opened leaf. The mean height for the five plants was determined.

3.9.2 Dry matter

Dry matter of stem and leaves was determined at 2, 4 and 6 WAP . From each plot, five sample plants were cut at ground level, separated into stem and leaves, dried in the oven at 60^0 C to constant weight. The average leaf and stem dry matter yield per plant was determined for each plot.

3.9.3. Leaf area index

The leaf index at 2, 4 and 6 WAP was obtained by dividing the leaf area per plant for each plot by the land area occupied by one plant. The area occupied by one plant was calculated by multiplying the between-row spacing (75 cm) by the within-row spacing (25 cm) to give 1875 cm^2.

Leaf area was determined following the method described by Francis *et al.,* (1969) and Imonide and Obi (1991). The length (L) and maximum width (W) of the leaves on five representative maize plants from each plot, and for one replication alone, were measured. The area of each leaf was determined by:

$$\text{Leaf area} = L \times W \times 0.75 \qquad \text{(i)}$$

After determining the total leaf area of a maize plant by adding all the individual leaf areas, the leaf with the average largest leaf area for each treatment was determined. Average leaf area per plant was obtained from the 5 plants. A leaf area factor was calculated for each treatment as follows:

$$\text{Leaf Area Factor } (F_{LA}) = \frac{\text{Total Leaf Area}}{\text{Area of Leaf with maximum Leaf Area}} \qquad \text{(ii)}$$

To determine leaf area in other replications, five representative plants were selected in each plot. The length and maximum width of the leaf determined to have the average largest leaf area for a corresponding treatment were measured on each of the five representative plants in each plot. The average area of this particular leaf using the five plants was determined according to (i) above. The total leaf area per plant was then determined as:

Total leaf area plant^{-1} = Area of Leaf x Corresponding F_{LA}

3.9.4 Number of green leaves on maize

This was determined at 2, 4 and 6 WAP by physically counting the number of leaves on each of the sample plants from each plot and determining the mean.

3.9.5 Days to 50% Tasseling

From the commencement of tasseling, the field was visited daily to count the number of tasseled maize till 50 % of the maize in each plot had tasseled. This was done by physical count and reckoned from sowing.

3.9.6 Days to 50% Silking

The number of days taken by 50 % of the plants in each plot to silk was determined as days to 50 % silking. This was determined by physical count and reckoned from sowing.

3.9.7 Anthesis-Silking Interval

This was calculated as the difference between the days to 50 % silking and 50 % tasseling for each plot.

3.9.8 Ear Height

Ear height was measured as the distance from ground level to the insertion point of the uppermost ear of the maize plant. Five sample plants were measured in each plot and the mean determined.

3.9.9 Physiological maturity

About 20 to 25 days from silking, plots were visited every 2 to 3 days. On five ears harvested from the central rows of each plot, five or more kernels were examined for black layer formation. The maturity date was taken to be when more than half of the kernels examined per plot had reached black layer.

3.9.10 Grain filling duration

Grain filling duration (GF) was calculated as the difference between the number of days to 50 % black layer formation (physiological maturity) and 50 % silking.

3.9.11 Number of Rows Per Cob

From a random sample of five ears from each plot, the number of rows on each cob was determined and the mean calculated.

3.9.12 Number of Grains Per Row

From a random sample of five ears from each plot, the number of grains on one row was determined for each cob and the mean was calculated.

3.9.13 Number of Grains Per Cob

The number of grains per cob was estimated by multiplying the rows per cob by the grains per row.

3.9.14 Weight of Hundred Seeds

After harvesting, drying and shelling, 100 grains were randomly picked from each plot and weighed to determine the weight of 100 seeds in grammes.

3.9.15 Grain Yield

The dried cobs obtained after harvesting were shelled and the grains weighed. The yield per plot was used to calculate the proportionate yield per hectare.

3.9.16 Soil Temperature and Moisture Measurements

Average soil temperature measurements were taken weekly up to 14 WAP for the different treatments at 10 cm soil depth using soil thermometer. Measurements were taken at 1300 hrs.

Soil moisture content for each plot was determined biweekly up to 14 WAP. Soil samples were collected from 0-15 cm soil depth using a soil auger. Soil moisture was determined by the gravimetric method.

3.9.17 Statistical Analysis

All the data were analysed using analysis of variance procedures for a split-split plot design using Genstat 7.2 (Discovery Edition 3). Mean separation was carried out using the least significant difference (LSD) at 5 % level of significance. Spearman Rank correlation analysis was performed for grain yield and yield components using the SPSS package.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Pre-Planting Soil Physical and Chemical Properties

The results of laboratory analyses showed that the soils from the site of the 2009 and 2010 experiment were similar in physical and chemical properties (Table 1). The average topsoil texture for 2009 was loamy sand overlying a sandy loam subsurface. In 2010 both topsoil and subsurface were loamy sand in texture. Base saturation of the soil units were 77.7 and 82.0% for the topsoil and 79.1 and 70.6% for the subsurface for 2009 and 2010 respectively. This fairly high percentage base saturation may have resulted from the fairly good amount of clay in the soil units which provided adequate sites for adsorption of basic cations. Aluminum accounted for 69.2 and 66.7% of exchangeable acidity and 62.5 and 63.6% of subsurface exchangeable acidity for 2009 and 2010 respectively. Generally, values of the soil parameters analyzed and presented are characteristic of soils formed over coastal plain sands of southeastern Nigeria (Akpan-Idiok; Onweremadu and Okereke-Ejiogu, 2012) and considered moderately or marginally suitable for maize production (Ukaegbu *et al.*, 2012).

4.1.2 Some Chemical Properties of Poultry Manure used in the Study

Some chemical properties of poultry manure used in this study are presented in Table 2. The poultry manure was generally high in the major nutrients (particularly nitrogen) and organic matter. This must have contributed to the significant impact of the poultry manure on maize plants.

Table 1: Physical and chemical properties of soil from the experimental site

	2009		2010	
Soil property	0 – 15 cm	15 – 30 cm	0 – 15 cm	15 – 30 cm
Sand (g kg^{-1})	848.00	828.00	868.00	848.00
Silt (g kg^{-1})	20.00	20.00	20.00	20.00
Clay (g kg^{-1})	132.00	152.00	112.00	132.00
Textural class	Loamy sand	Sandy loam	Loamy sand	Loamy sand
pH (H_2O)	6.68	6.21	6.85	6.92
pH (KCl)	5.19	5.67	5.57	6.62
Total N (%)	0.06	0.06	0.06	0.05
Organic C (%)	0.72	0.69	0.78	0.59
Organic matter (%)	1.24	1.20	1.34	1.03
Available P (mg kg^{-1})	2.73	1.64	3.37	1.92
Exch. Cations (cmol kg^{-1})				
Ca	2.80	1.80	2.60	1.60
Mg	1.40	1.00	1.20	0.80
Na	0.12	0.09	0.14	0.15
K	0.21	0.14	0.18	0.10
Al	0.90	0.50	0.60	0.70
H	0.40	0.30	0.30	0.40
ECEC	5.83	3.83	5.02	3.75

Table 2: Some chemical properties of the poultry manure used in the experiment

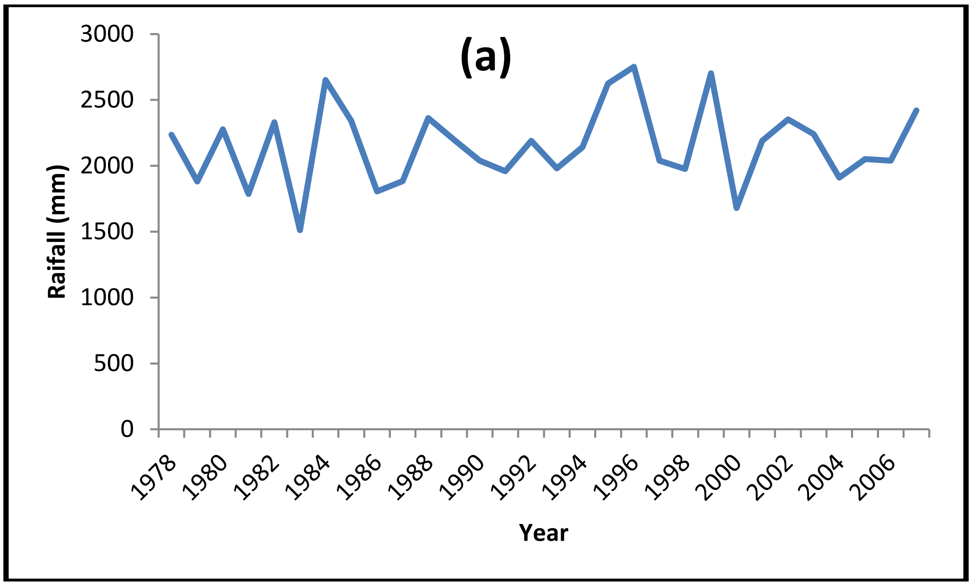
Chemical property	
Total N (%)	4.06
Organic C (%)	5.12
Organic matter (%)	8.83
Available P	0.46
Ca (%)	1.82
Mg (%)	1.34
K_2O (%)	0.58

4.1.3 Trend of Rainfall for 1978-2007 (30 years)

Analysis of 30 years (1978 -2007) rainfall data for the study area is presented in Figure 1. The first graph (Figure 1a) reveals the existence of inter-annual variability with annual rainfall total ranging between 2000 and 2500 mm although a few of the years were below 2000 mm or above 2500 mm. While there may not have been wide departure in the average annual rainfall, there was a declining trend particularly from 1998 and beyond. This was also reported by Afangideh *et al.* (2010). The graph however does not reveal the impact of delayed onset of rainfall resulting from climate change. In Figure 1b the trends of monthly rainfall totals for January to April over 30 years (1978-2007) are presented. Generally, the pattern remained consistent till 1998, beyond which marked shifts became manifest. January remained the month with the lowest rainfall while April had the highest. But for February and March, it was observed that while February showed an increasing trend from 1998, March showed a decreasing trend. The result of this scenario is that increased rainfall in the month of February entices farmers to plant, only to encounter a spell of drought in March. Consequently, many farmers delay planting till April. This situation formed the bases for this research.

4.1.4 Some climatic parameters at the location of study

The rainfall, number of rain days, temperature (maximum and minimum) and relative humidity data at the location of study for 2009 and 2010 are presented in Figures 2 and 3. The annual rainfall totals for 2009 and 2010 were 2732.9 mm and 2114.5 mm which corresponded to a monthly average of 227.7 mm and 176.2 mm respectively (Figure 2a). Average monthly rainfall for the period of the experiment (February – August) in 2009 and 2010 were 259.5 mm and 170.3 mm respectively. In 2009 and 2010, the location experienced 123 and 100 rain days respectively (Figure 2b). In 2009, the location experienced average



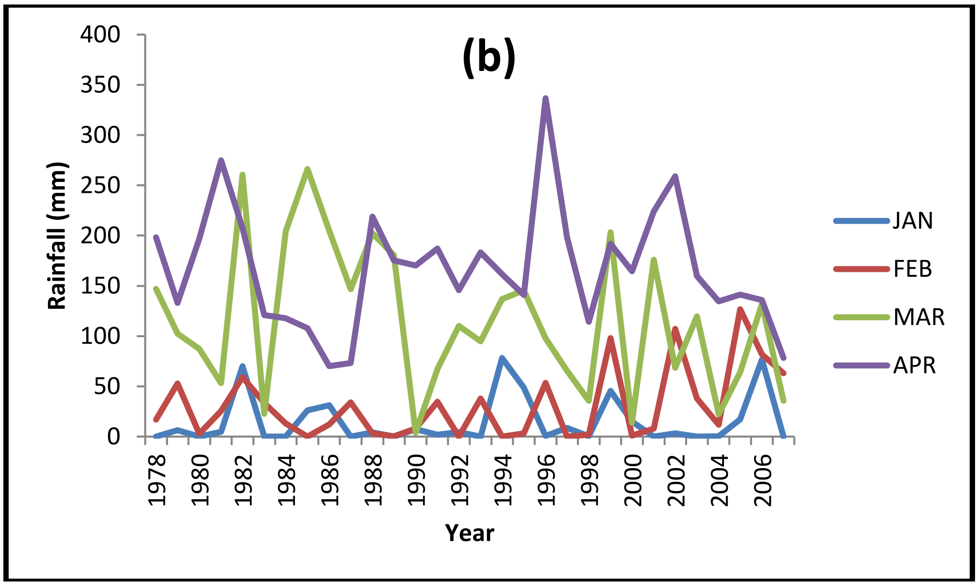


Figure 1: Annual rainfall totals (mm)(a), and pattern of rainfall for January to April (b) for thirty years (1978 - 2007) in the study area

Source: National Root Crops Research Institute (NRCRI) Umudike

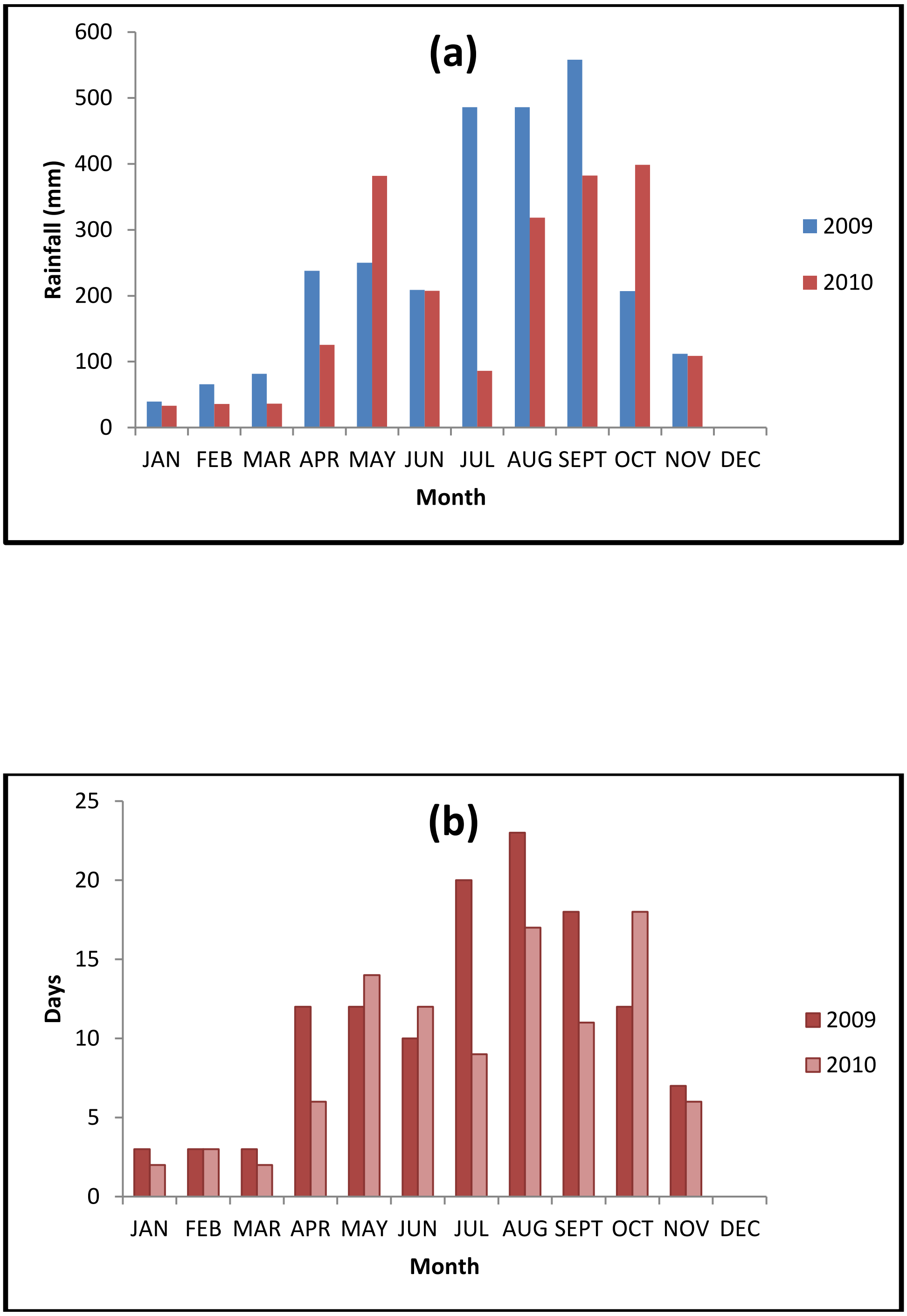


Figure 2: Amount of rainfall in mm (a) and number of rain days (b) at Owerri in 2009 and 2010

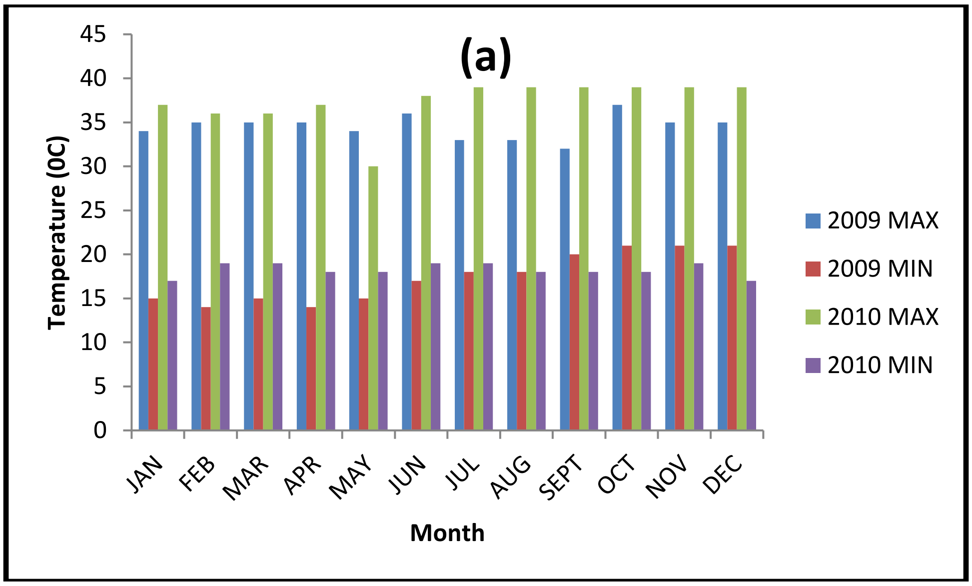
maximum and minimum temperature of 34.5 and 17.4^{0}C, while in 2010 it was 37.3 and 18.3^{0}C respectively (Figure 3a). Average relative humidity at the location was 79.5 and 76.6% for 2009 and 2010 respectively (Figure 3b). The weather information above shows that the location received more rainfall in 2009 than 2010. Consequently, this resulted in higher relative humidity and lower temperature in 2009. Therefore 2010 was generally drier than 2009 thereby indicating inter-annual variability in climatic condition in the study location.

4.1.5 Soil temperature at the location of study

The pattern of variation in soil temperature at the study location for 2009(Figure 7a-7d) and 2010(Figure 8a-8d) was generally similar across the sowing dates and years. Soil temperature remained high throughout the period but temperatures were slightly higher in the first 5-7 weeks after planting, then it gradually reduced. Variation in soil temperature was also greater in the first 5-7 weeks after planting. Temperatures of the soil in the manured plots were generally lower and this was more obvious after the first 5-7 weeks after planting. This situation can be attributed to the fact that solar radiation was high in the first few weeks, rainfall was low and because a closed plant canopy had not been achieved, solar radiation was more directly incident on the soil. However, after the first 5-7 weeks after planting, greater canopy cover was achieved due to increased rainfall. As a result, less radiation was incident on the soil, thereby reducing the soil temperature. Furthermore, the plots which received manure treatments supported greater and faster canopy cover than the plots without manure treatments and this further reduced the soil temperature.

4.1.6 Soil moisture content at the location of study

The soil moisture content data at the location for 2009 and 2010 are presented in Figures 9a-9d and 10a-10d respectively. In 2009 and 2010 soil moisture content was low in the first 4-6 weeks after planting. This can be attributed to the low amount of rainfall at the



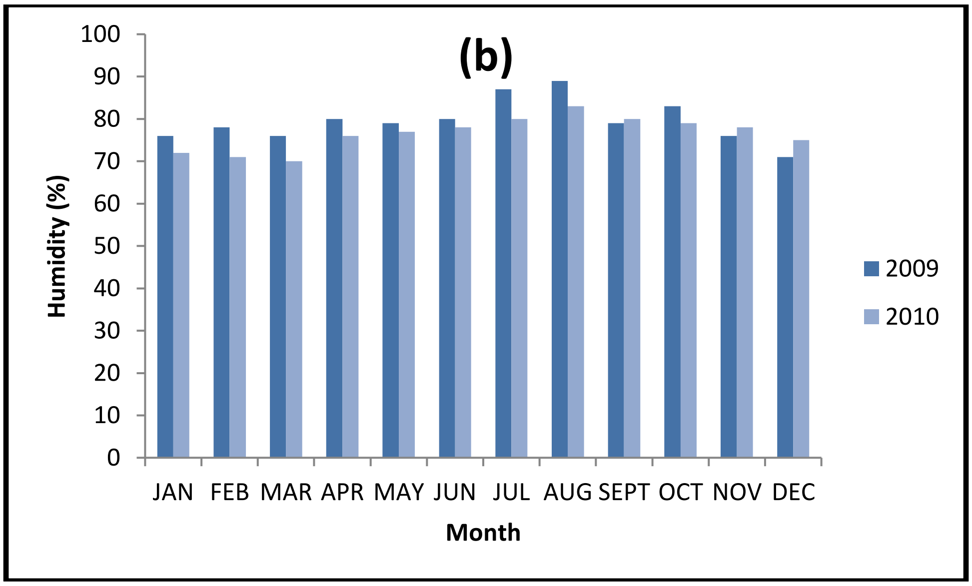
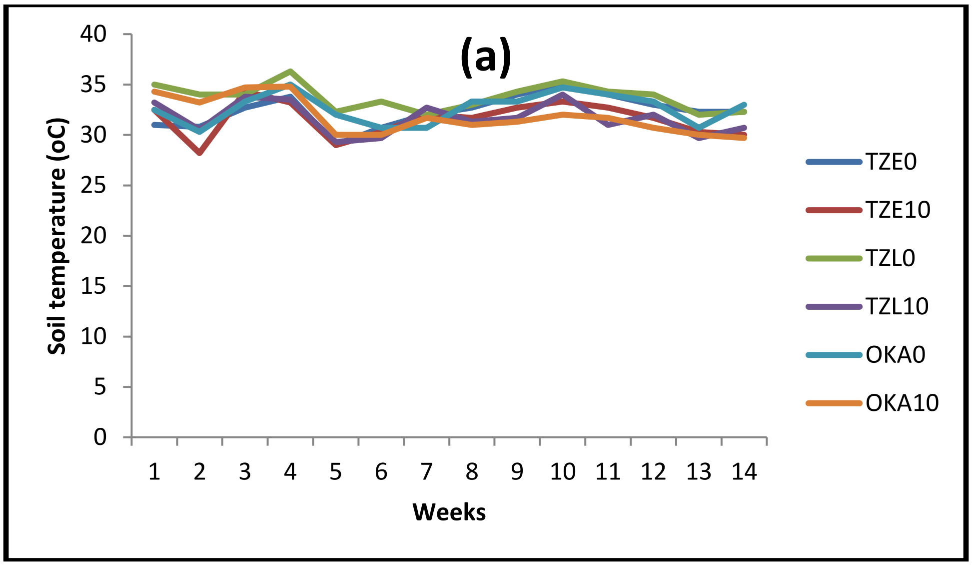


Figure 3: Maximum and minimum temperature in degree Celsius (a), and relative humidity (b) for Owerri in 2009 and 2010



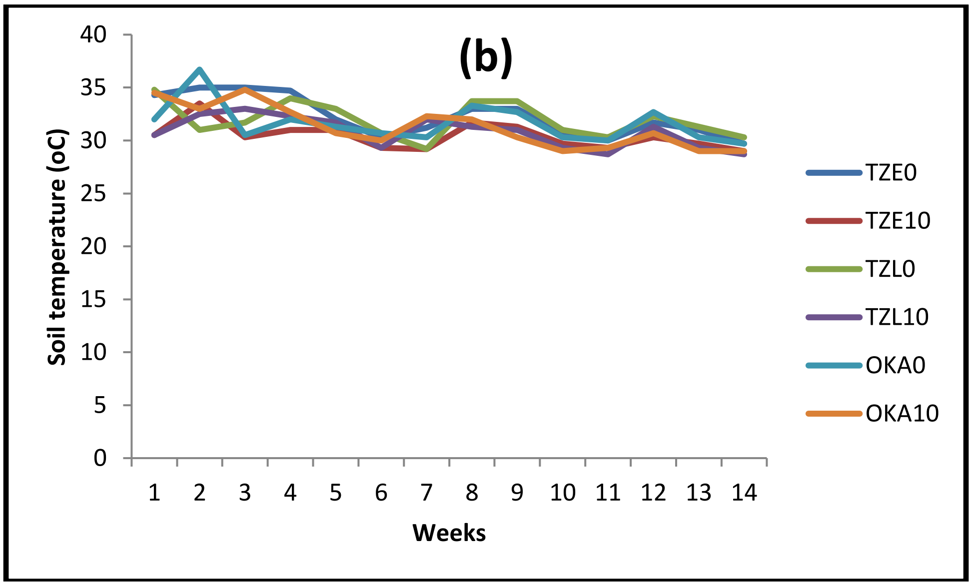
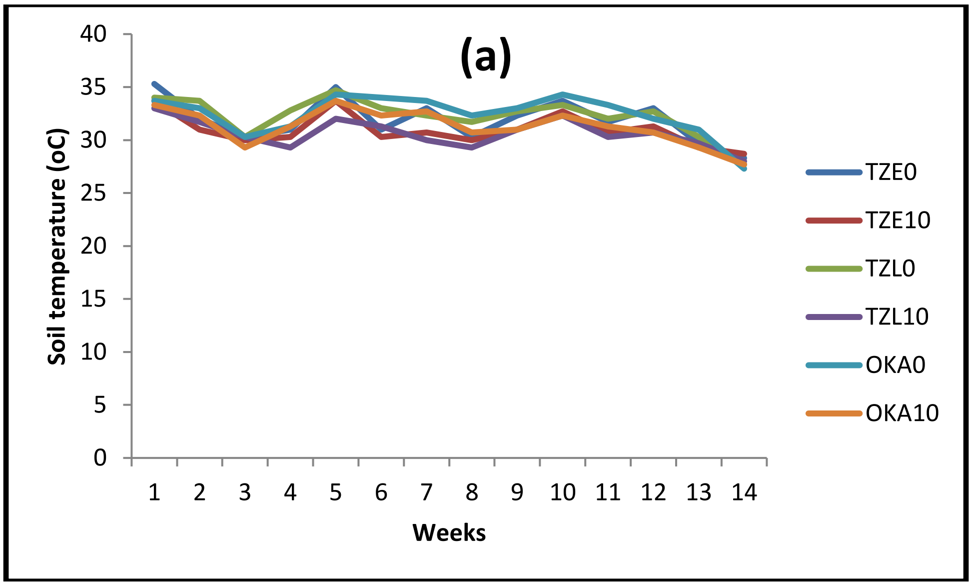


Figure 4: Soil temperature in degree Celsius for maize planted on February 28 (a) and March 15 (b) in 2009

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



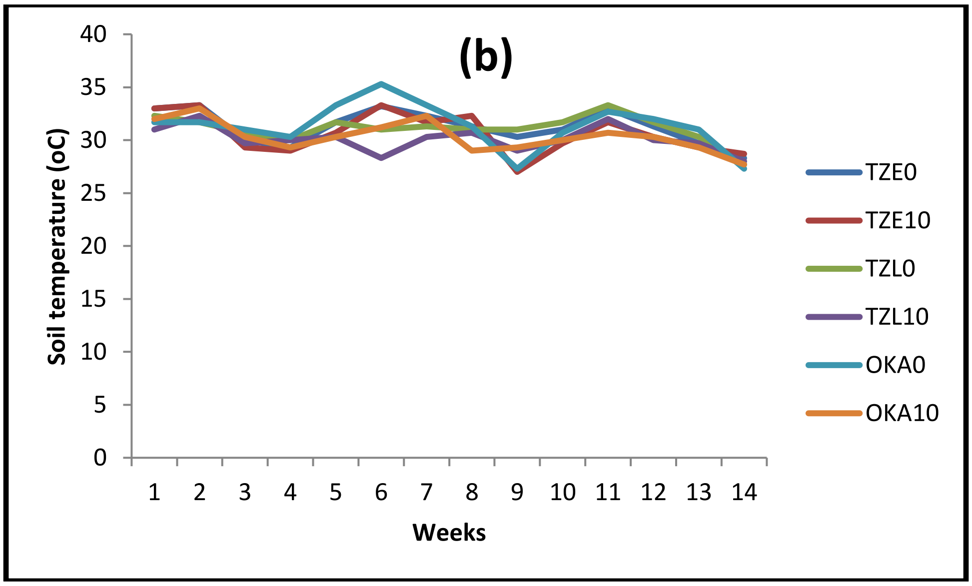
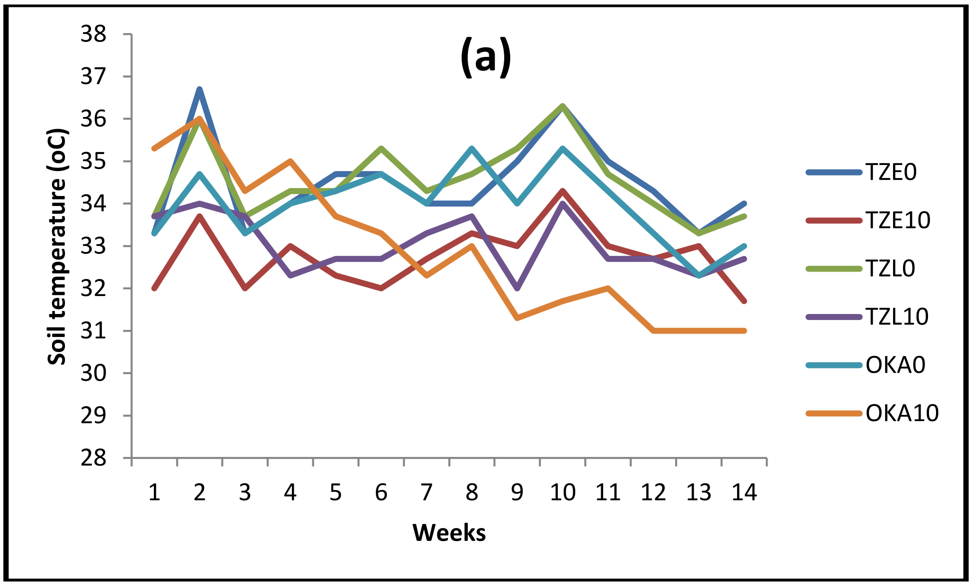


Figure 5: Soil temperature in degree Celsius for maize planted on March 30 (a) and April 14 (b) in 2009

TZE0 =TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0 = TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10 = TZL COMP34 C3 WITH POULTRY MANURE
OKAO =OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



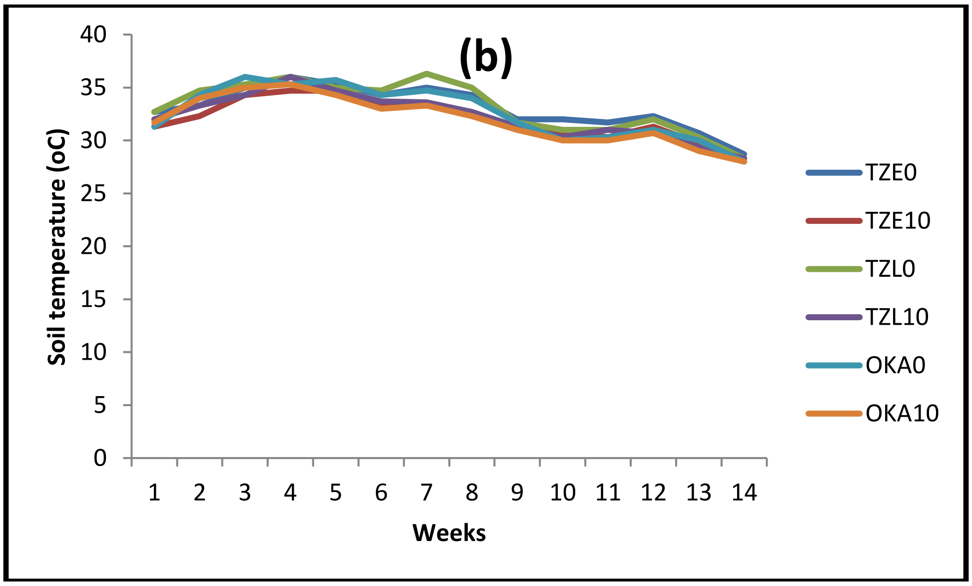
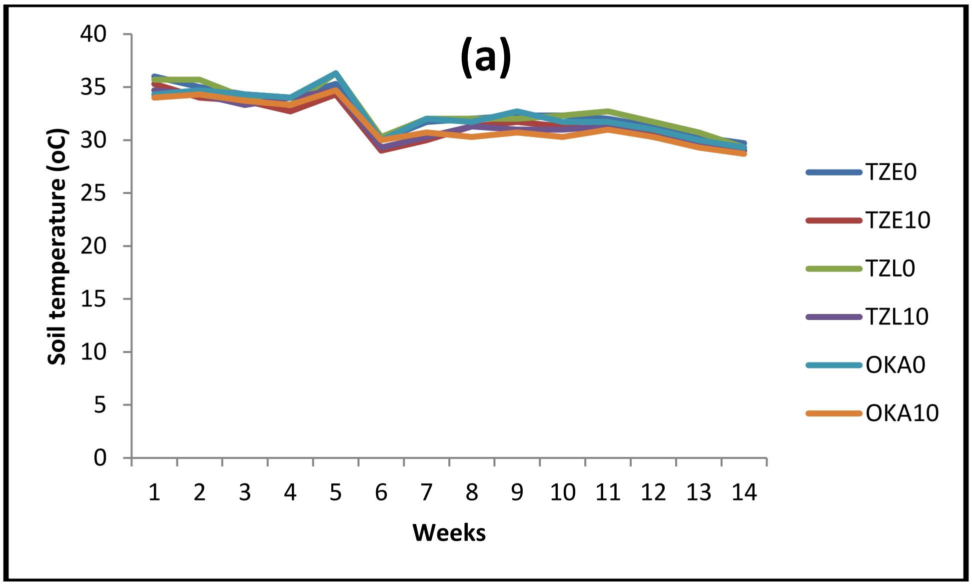


Figure 6: Soil temperature in degree Celsius for maize planted on February 28 (a) and March 15 (b) in 2010

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



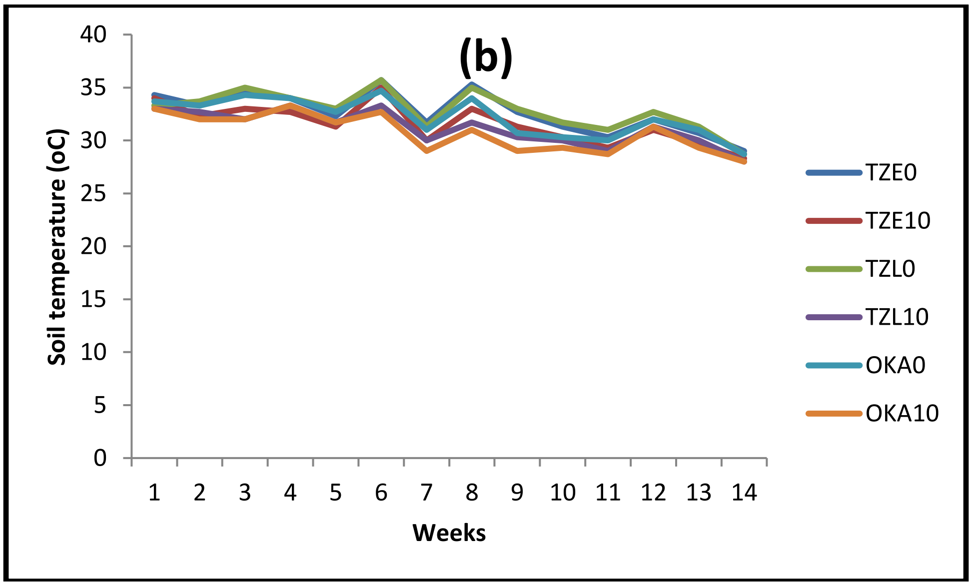
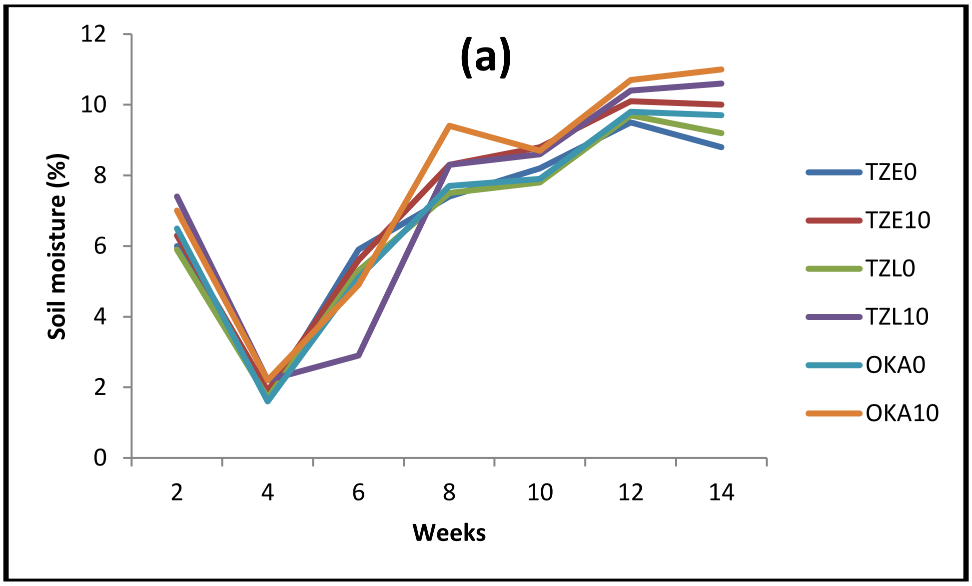


Figure 7: Soil temperature in degree Celsius for maize planted on March 30 (a) and April 14 (b) in 2010

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



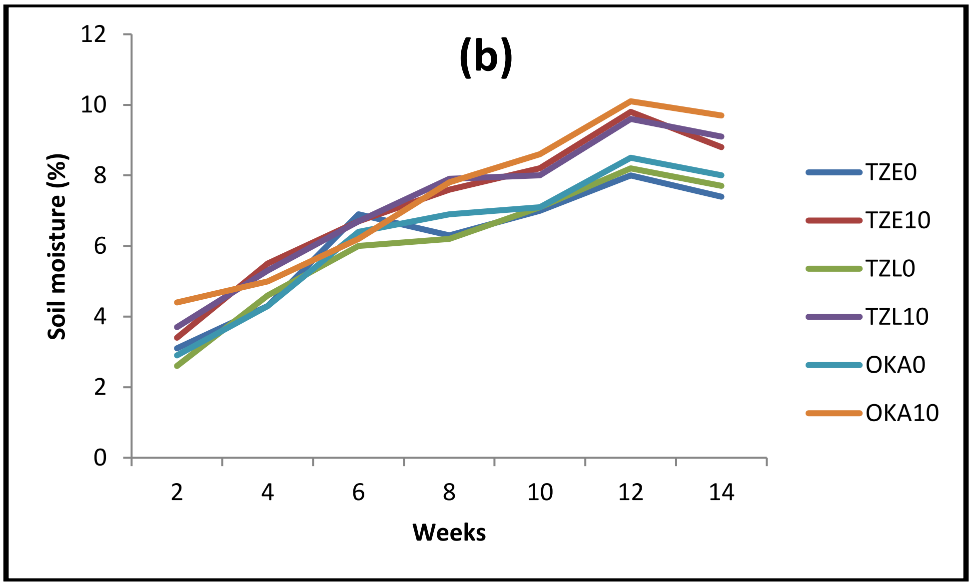
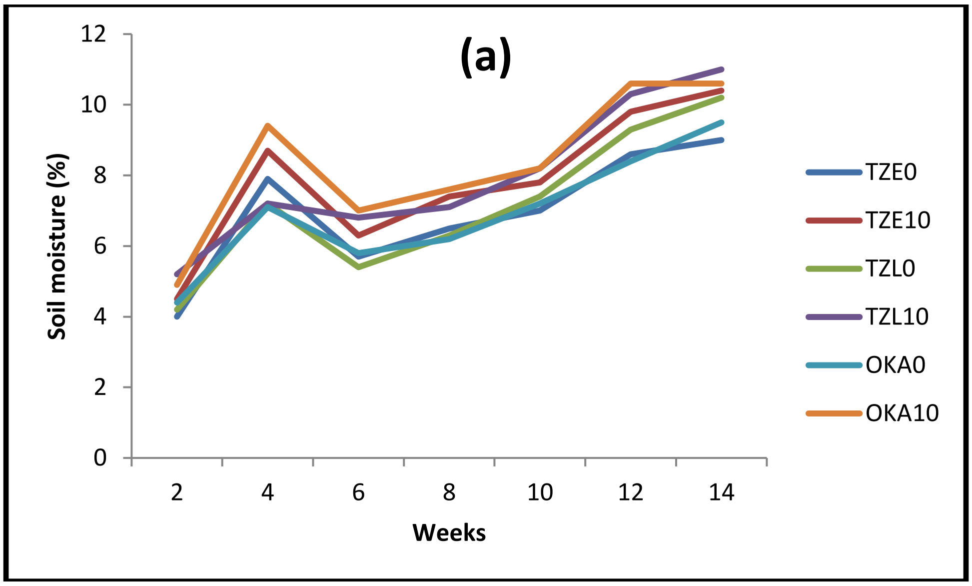


Figure 8: Soil moisture content in percentage for maize planted on February 28 (a) and March 15 (b) in 2009

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



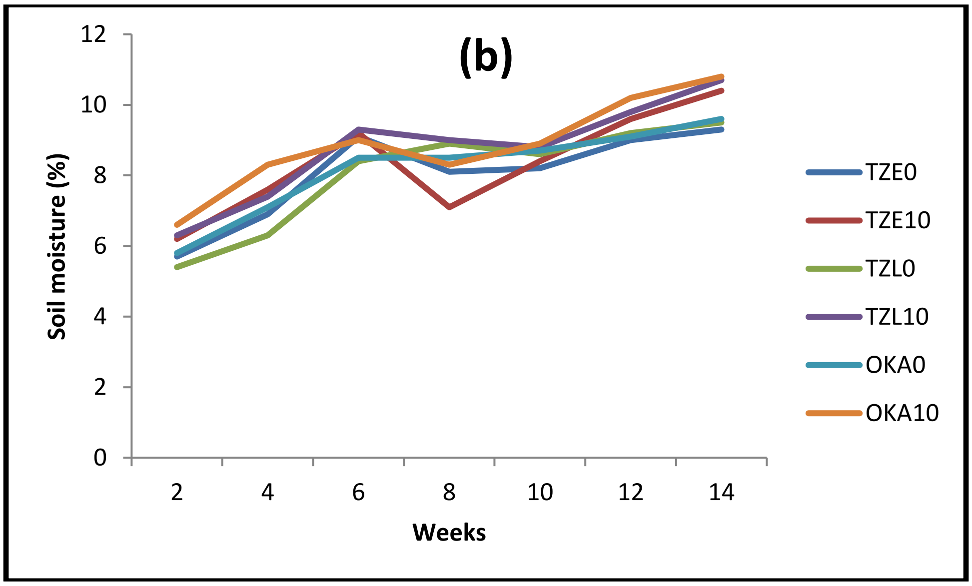
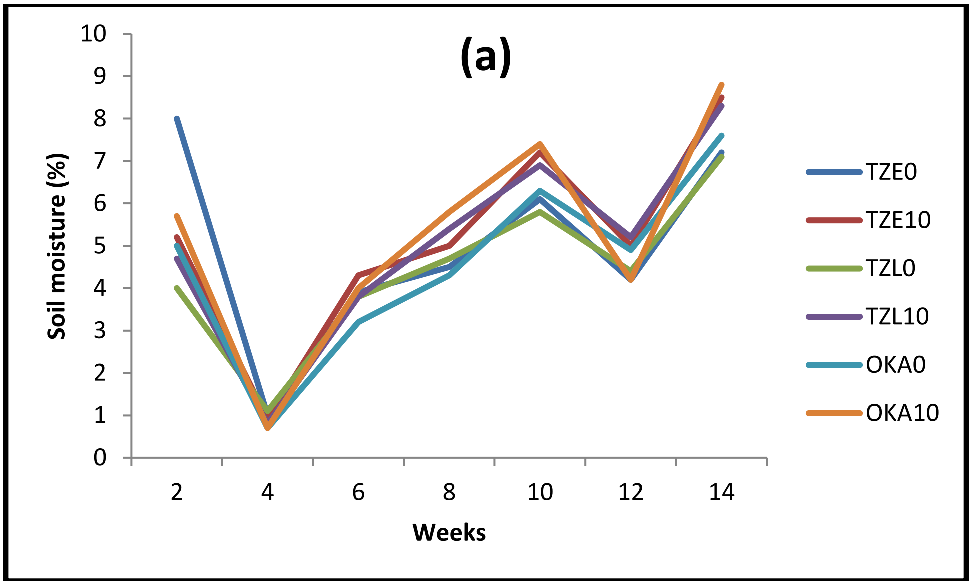


Figure 9: Soil moisture content in percentage for maize planted on March 30 (a) and April 14 (b) in 2009

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



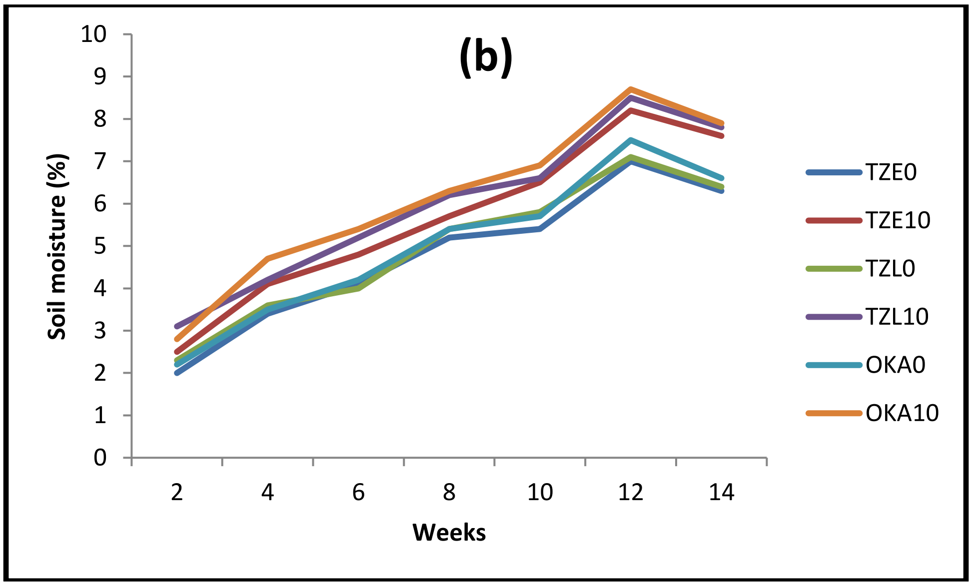
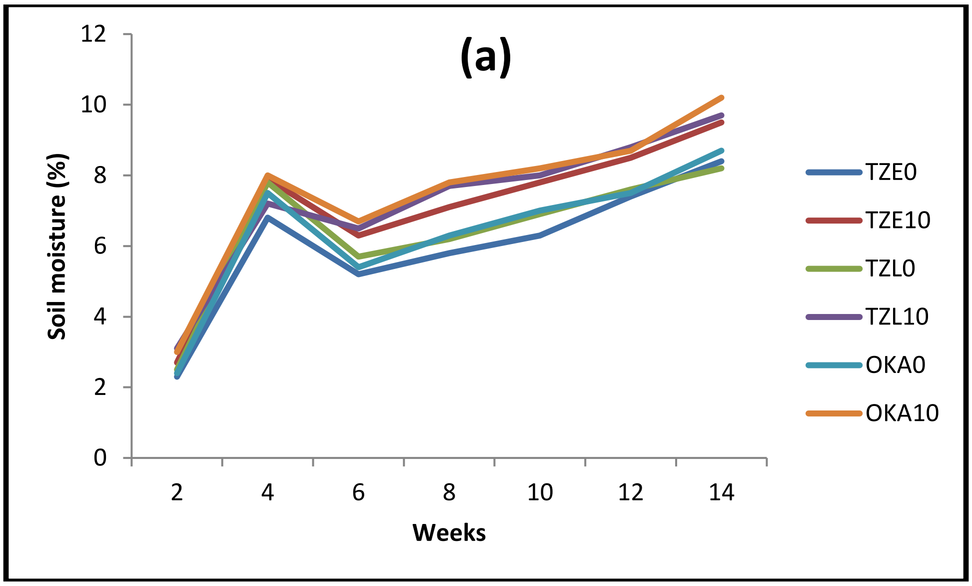


Figure 10: Soil moisture content in percentage for maize planted on February 28 (a) and March 15 (b) in 2010

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE



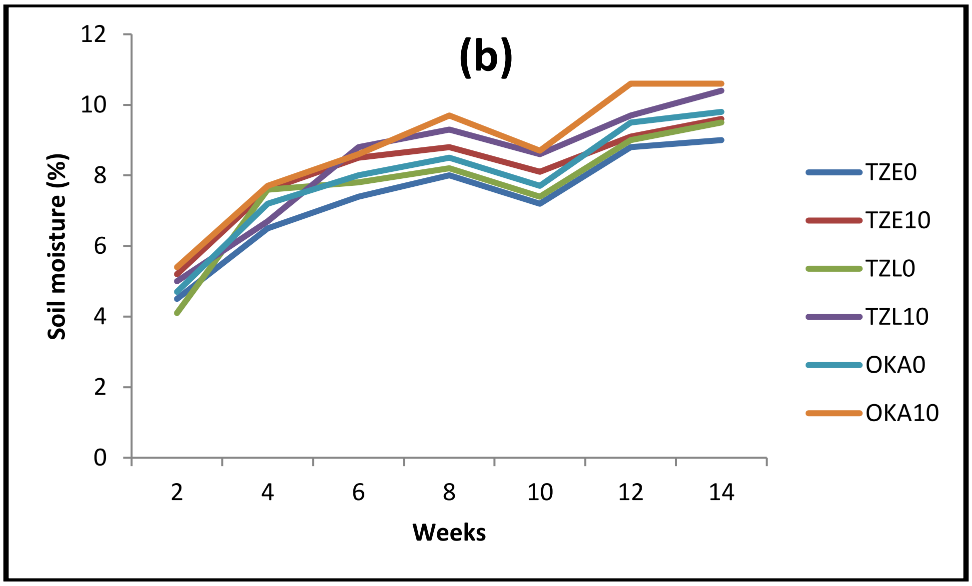


Figure 11: Soil moisture content in percentage for maize planted on March 30 (a) and April 14 (b) in 2010

TZE0=TZE COMP3 C3 WITHOUT POULTRY MANURE
TZE10= TZE COMP3 C3 WITH POULTRY MANURE
TZL0= TZL COMP4 C3 WITHOUT POULTRY MANURE
TZL10= TZL COMP34 C3 WITH POULTRY MANURE
OKAO=OKA AWAKA WITHOUT POULTRY MANURE
OKA10= OKA AWAKA WITH POULTRY MANURE

time and the occurrence of intermittent dry spells. Subsequently, soil moisture content progressively increased as the amount of rainfall increased. Moisture content of the soil in the manure plots was generally higher after the first 4-6 weeks after planting (WAP). Before this time, soil moisture content of plots which had manure treatments was not obviously more than moisture content of plots without manure treatments.

2009 TRIAL

4.1.7 Days to 50% Emergence

From the results presented on Table 3 maize seeds planted on April 14 attained 50% emergence significantly earlier (4.6 days) than seeds planted on February 28 (7.0 days) and March 30 (8.5 days). There were no significant differences in the number of days to 50% emergence due to maize variety, poultry manure and sowing date x variety x poultry manure interaction.

4.1.8 Maize Height

The effect of sowing date on maize height was significant at 2, 4 and 6 WAP. Maize planted on March 30 grew 64.2%, 51.8% and 61.6% taller than maize planted on February 28, March 15 and April 14 respectively at 2 WAP (Table 4). At 4 WAP the height of maize planted on March 30 and April 14 were not significantly different. However, they were significantly taller than maize planted on February 28 (Table 5). At 6 WAP, maize planted on March 30 grew 71.5% taller than maize planted on February 28, while maize planted on April 14 grew 91 and 58.3% taller than maize planted on February 28 and March 15 respectively (Table 6).

Significant varietal differences in height occurred only at 2 WAP when TZE COMP3C3, (7.31 cm) was significantly taller than TZL COMP4C3 (6.56 cm) and OKA AWAKA (6.10 cm). Application of 10 tons/ha of poultry manure significantly affected plant

Table 3: Effect of sowing date, variety and poultry manure on days to 50 % emergence

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		7.00	7.33	5.67	6.00	8.00	8.00
MAR 15		5.00	5.00	5.33	5.00	5.67	6.00
MAR 30		8.00	10.33	8.67	9.00	7.33	7.67
APR 14		4.33	4.67	4.33	4.33	5.00	5.00

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	7.17	5.83	8.00
MAR 15	5.00	5.17	5.83
MAR 30	9.17	8.83	7.50
APR 14	4.50	4.33	5.00

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	6.89	7.11
MAR 15	5.33	5.33
MAR 30	8.00	9.00
APR 14	4.56	4.67

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	6.08	6.83
TZL COMP4 C3	6.00	6.08
OKA AWAKA	6.50	6.67

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	7.00	5.33	8.50	4.61

LSD $_{0.05}$(sowing date) = 1.82

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	6.46	6.04	6.58

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	6.19	6.53

LSD $_{0.05}$(poultry manure) = n.s

Table 4: Effect of sowing date, variety and poultry manure on maize height at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		5.77	7.10	3.63	7.10	4.03	6.07
MAR 15		7.12	6.33	5.82	6.59	5.53	5.11
MAR 30		8.16	10.31	8.91	9.42	7.63	10.92
APR 14		3.96	9.71	3.86	7.16	3.24	6.32

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	6.43	5.37	5.05
MAR 15	6.72	6.20	5.32
MAR 30	9.24	9.17	9.27
APR 14	6.83	5.51	4.78

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	4.48	6.76
MAR 15	6.16	6.01
MAR 30	8.23	10.22
APR 14	3.69	7.73

LSD $_{0.05}$ (sowing date x manure) = 2.53

	0	10
TZE COMP3 C3	6.25	8.36
TZL COMP4 C3	5.56	7.57
OKA AWAKA	5.11	7.10

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	5.62	6.08	9.23	5.71

LSD $_{0.05}$(sowing date) = 2.45

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	7.31	6.56	6.10

LSD $_{0.05}$(variety) = 0.60

Poultry manure(tons/ha)	0	10
	5.64	7.68

LSD $_{0.05}$(poultry manure) = 0.75

Table 5: Effect of sowing date, variety and poultry manure on maize height at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		11.91	19.05	6.39	15.74	7.49	13.05
MAR 15		28.71	25.24	19.60	27.58	18.02	23.27
MAR 30		22.33	46.38	24.51	34.28	38.80	57.57
APR 14		19.32	68.42	16.05	55.47	11.73	47.09

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	15.48	11.06	10.27
MAR 15	26.98	23.59	20.64
MAR 30	34.36	29.40	48.19
APR 14	43.87	35.76	29.41

LSD $_{0.05}$ (sowing date x variety) = 15.83

	0	10
FEB 28	8.60	15.95
MAR 15	22.11	25.36
MAR 30	28.55	46.08
APR 14	15.70	56.99

LSD $_{0.05}$ (sowing date x manure) = 14.74

	0	10
TZE COMP3 C3	20.57	39.77
TZL COMP4 C3	16.64	33.27
OKA AWAKA	19.01	35.24

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	12.27	23.74	37.31	36.35

LSD $_{0.05}$(sowing date) = 14.52

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	30.17	24.95	27.13

LSD $_{0.05}$(variety) = 0.60

Poultry manure(tons/ha)	0	10
	18.74	36.09

LSD $_{0.05}$(poultry manure) = 3.51

Table 6: Effect of sowing date, variety and poultry manure on maize height at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		28.90	64.30	12.40	52.70	15.70	38.50
MAR 15		44.80	45.40	33.20	46.90	35.70	50.10
MAR 30		37.80	81.50	43.90	58.20	61.30	81.40
APR 14		44.70	112.90	34.20	99.00	28.00	87.00

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	46.60	32.60	27.10
MAR 15	45.10	40.10	42.90
MAR 30	59.60	51.00	71.30
APR 14	78.80	66.60	57.50

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	19.00	51.80
MAR 15	37.90	47.50
MAR 30	47.70	73.70
APR 14	35.60	99.60

LSD $_{0.05}$ (sowing date x manure) = 22.38

	0	10
TZE COMP3 C3	39.00	76.00
TZL COMP4 C3	30.90	64.20
OKA AWAKA	35.20	64.20

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	35.40	42.70	60.70	67.60

LSD $_{0.05}$(sowing date) = 21.99

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	57.50	47.60	49.70

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	35.00	68.20

LSD $_{0.05}$(poultry manure) = 5.58

height, resulting in 36.2, 92.6 and 94.9% increase at 2, 4 and 6 WAP respectively. The interaction of sowing date x variety x poultry manure did not significantly affect maize height at 2, 4 and 6 WAP. The effect of sowing date x variety interaction was significant on maize height at 4 WAP. Response of TZE COMP3 C3 to sowing date was between 62.6 % and 183.4 % while response of OKA AWAKA to sowing date was between 63.9 % and 369.2 %. TZL COMP4 C3 only responded (223.3 %) when planted on April 14 compared to February 28. Sowing date x poultry manure interaction significantly affected maize height at 2,4 and 6 WAP. Application of poultry manure significantly increased maize height by 109.5 % at 2 WAP when planted on April 14; by 61.4 and 263.0 % at 4 WAP when planted on March 30 and April 14 and by 172.6, 54.5 and 179.8 % at 6 WAP when planted on February 28, March 30 and April 14 respectively. Variety x poultry manure interaction did not have significant effect on maize height at 2, and 6 WAP.

4.1.9 Leaf Area Index

Sowing date did not significantly affect leaf area index (LA1) at 2 WAP (Table 7). At 4 WAP, LAI was highest (0.4) when maize was planted on April 14 and this was significantly greater than LAI when maize was planted on other dates (Table 8). LAI of maize planted on March 15 and March 30 did not differ significantly but were significantly greater than LAI of maize planted on February 28. At 6 WAP LAI of maize planted March 15, March 30 and April 14 did not differ significantly but were all significantly greater than LAI of maize planted on February 28 (Table 9). Differences in LAI due to variety were not significant at 2, 4 and 6WAP, but organic manure application resulted in 33.3 135.3 and 137.2 % increase at 2, 4 and 6 WAP respectively. As a result of interaction, increases in LAI for OKA AWAKA ranged between 36.6 and 663.2 % across sowing dates. LAI increases for TZL COMP4 C3 in response to interaction effect ranged between 45.2 and 857.1 % across sowing dates. TZE

Table 7: Effect of sowing date, variety and poultry manure on leaf area index at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		0.02	0.04	0.02	0.04	0.01	0.03
MAR 15		0.03	0.04	0.03	0.04	0.02	0.02
MAR 30		0.02	0.05	0.04	0.03	0.06	0.07
APR 14		0.03	0.04	0.02	0.04	0.02	0.04

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.03	0.03	0.02
MAR 15	0.03	0.03	0.02
MAR 30	0.04	0.04	0.07
APR 14	0.03	0.03	0.03

LSD $_{0.05}$ (sowing date x variety) = 0.02

	0	10
FEB 28	0.02	0.04
MAR 15	0.03	0.03
MAR 30	0.04	0.05
APR 14	0.02	0.04

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	0.02	0.04
TZL COMP4 C3	0.03	0.04
OKA AWAKA	0.03	0.04

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.03	0.03	0.05	0.03

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.03	0.03	0.04

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.03	0.04

LSD $_{0.05}$(poultry manure) = 0.005

Table 8: Effect of sowing date, variety and poultry manure on leaf area index at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.06	0.25	0.05	0.20	0.05	0.14
MAR 15		0.22	0.33	0.28	0.34	0.28	0.30
MAR 30		0.13	0.35	0.16	0.33	0.27	0.56
APR 14		0.28	0.73	0.15	0.55	0.14	0.74

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.16	0.12	0.10
MAR 15	0.28	0.31	0.29
MAR 30	0.24	0.25	0.42
APR 14	0.50	0.35	0.44

LSD $_{0.05}$ (sowing date x variety) = 0.13

	0	10
FEB 28	0.05	0.20
MAR 15	0.26	0.32
MAR 30	0.19	0.41
APR 14	0.19	0.67

LSD $_{0.05}$ (sowing date x manure) = 0.12

	0	10
TZE COMP3 C3	0.17	0.41
TZL COMP4 C3	0.16	0.35
OKA AWAKA	0.18	0.44

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.13	0.29	0.30	0.43

LSD $_{0.05}$(sowing date) = 0.12

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.29	0.26	0.31

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.17	0.40

LSD $_{0.05}$(poultry manure) = 0.03

Table 9: Effect of sowing date, variety and poultry manure on leaf area index at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		0.34	0.76	0.07	0.67	0.19	0.43
MAR 15		0.62	0.82	0.62	0.90	0.71	0.97
MAR 30		0.36	1.09	0.58	1.01	0.82	1.12
APR 14		0.49	1.38	0.18	1.61	0.19	1.45

LSD $_{0.05}$ (sowing date x variety x manure) = 0.24

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.55	0.37	0.31
MAR 15	0.72	0.76	0.84
MAR 30	0.72	0.79	0.97
APR 14	0.93	0.89	0.82

LSD $_{0.05}$ (sowing date x variety) = 0.19

	0	10
FEB 28	0.20	0.62
MAR 15	0.65	0.90
MAR 30	0.58	1.07
APR 14	0.29	1.48

LSD $_{0.05}$ (sowing date x manure) = 0.15

	0	10
TZE COMP3 C3	0.45	1.01
TZL COMP4 C3	0.36	1.05
OKA AWAKA	0.48	0.99

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.41	0.77	0.83	0.88

LSD $_{0.05}$(sowing date) = 0.14

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.73	0.71	0.74

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.43	1.02

LSD $_{0.05}$(poultry manure) = 0.07

COMP3 C3 did not respond to organic manure when planted on March 15 but for other dates responses ranged between 123.5 and 202.8 %. The effect of sowing date x variety interaction was significant on maize leaf area index at 2,4 and 6WAP. At 2 WAP, maize leaf area index in OKA AWAKA was significantly higher when planted on March 30 compared to February 28 (250.0 %), March 15 (250.0 %) and April 14 (133.0 %). At 4 WAP, TZE COMP3 C3 had 78.6, 108.3 and 212.5 % higher leaf area index when planted on April 14 compared to March 15, March 30 and February 28. TZL COMP4 C3 had 158.3 and 191.7 % higher leaf area index when planted on April 14 and March 15 respectively compared to February 28. Leaf area index in OKA AWAKA was 51.7 and 340.0 % higher when planted on April 14 compared to March 15 and February 28 and 44.8 and 320.0 % higher when planted on March 30 compared to March 15 and February 28. At 6 WAP, TZE COMP3 C3 had 29.2, 29.2 and 69.1 % higher leaf area index when planted on April 14 compared to March 15, March 30 and February 28. TZL COMP4 C3 had 105.4, 113.5 and 140.5 % higher leaf area index when planted on March 15, March 30 and April 14 respectively compared to February 28. Leaf area index in OKA AWAKA was 164.5, 171.0 and 212.9 % higher when planted on April 14, March 15 and March 30 respectively compared to February 28. The effect of sowing date x poultry manure interaction was significant on leaf area index at 4 and 6 WAP. Application of poultry manure significantly increased maize leaf area index at 4 WAP when planted on February 28 (300.0 %), March 30 (115.8 %) and April (252.6 %) and at 6WAP when planted on February 28 (210.0 %) March 15 (38.5 %), March 30 (84.5 %) and April 14 (410.3 %). Variety x poultry manure interaction did not have significant effect on leaf area index at 2, 4 and 6 WAP.

4.1.10 Leaf Dry Matter

The results in Table 10 show that at 2 WAP leaf dry matter in maize planted on April 14 (0.3 g) was significantly greater than in maize planted on February 28(0.18 g) and March

Table 10: Effect of sowing date, variety and poultry manure on leaf dry matter at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.13	0.23	0.15	0.26	0.11	0.18
MAR 15		0.12	0.35	0.14	0.49	0.16	0.30
MAR 30		0.14	0.20	0.18	0.33	0.14	0.36
APR 14		0.15	0.36	0.23	0.49	0.16	0.42

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.18	0.21	0.14
MAR 15	0.24	0.32	0.23
MAR 30	0.17	0.25	0.25
APR 14	0.25	0.36	0.29

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.13	0.22
MAR 15	0.14	0.38
MAR 30	0.15	0.29
APR 14	0.18	0.42

LSD $_{0.05}$ (sowing date x manure) = 0.09

	0	10
TZE COMP3 C3	0.13	0.28
TZL COMP4 C3	0.17	0.39
OKA AWAKA	0.14	0.31

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.18	0.26	0.22	0.30

LSD $_{0.05}$(sowing date) = 0.08

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.21	0.28	0.23

LSD $_{0.05}$(variety) = 0.05

Poultry manure(tons/ha)	0	10
	0.15	0.33

LSD $_{0.05}$(poultry manure) = 0.04

30 (0.22g). Maize planted on March 15 also had significantly greater leaf dry matter than maize planted on February 28. At 4 and 6 WAP sowing date effect followed the same pattern, such that leaf dry matter in maize planted on March 30 and April 14 did not differ significantly but were significantly greater than leaf dry matter in maize planted on February 28 and March 15 which also did not differ significantly (Table 11, 12). Differences due to variety was only significant at 2WAP when TZL COMP4 C3 accumulated significantly greater leaf dry matter (0.28 g) than TZE COMP3 C3 (0.21 g) and OKA AWAKA (0.23 g). Poultry manure application significantly increased leaf dry matter from 0.15 to 0.33 g (120.0 %) at 2WAP, 0.66 to 1.53 g (131.8 %) at 4WAP and 3.84 to 7.90 g (105.7 %) at 6 WAP. The effect of sowing date x variety x poultry manure interaction was not significant at 2, 4 and 6 WAP. The effect of sowing date x variety interaction was significant on maize leaf dry matter at 4 and 6 WAP. At 4 WAP, TZE COMP3 C3 accumulated 86.3 % more leaf dry matter when planted on April 14 compared to March 15. TZL COMP4 C3 accumulated 83.5 and 85.6 % more leaf dry matter when planted on April 14 compared to February 28 and March 15 respectively. Leaf dry matter accumulation was 233.9, 192.2 and 54.6 % more when planted on March 30 compared to February 28, March 15 and April 14 respectively and 116.1 % more when planted on April 14 compared to February 28. At 6WAP, TZE COMP3 C3 accumulated 273.2 and 309.8 % more leaf dry matter when planted on March 30 compared to February 28 and March 15 respectively and 266.5 and 302.5 % more leaf dry matter when planted on April 14 compared to February 28 and March 15 respectively. TZL COMP4 C3 accumulated 238.6 and 183.8 % more leaf dry matter when planted on March 30 compared to February 28 and March 15 respectively and 228.0 and 174.9 % more leaf dry matter when planted on April 14 compared to February 28 and March 15 respectively. OKA AWAKA accumulated 685.6, 461.7 and 67.2 % more leaf dry matter when planted on March 30

Table 11: Effect of sowing date, variety and poultry manure on leaf dry matter at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.55	1.55	0.28	1.54	0.26	0.87
MAR 15		0.56	0.90	0.66	1.13	0.58	0.70
MAR 30		0.86	1.23	0.81	1.64	1.44	2.30
APR 14		0.66	2.05	0.77	2.57	0.47	1.94
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		1.03	0.91	0.56			
MAR 15		0.73	0.90	0.64			
MAR 30		1.05	1.23	1.87			
APR 14		1.36	1.67	1.21			
LSD $_{0.05}$ (sowing date x variety) = 0.60							
		0	10				
FEB 28		0.37	1.30				
MAR 15		0.60	0.91				
MAR 30		1.04	1.72				
APR 14		0.64	2.19				
LSD $_{0.05}$ (sowing date x manure) = 0.48							
		0	10				
TZE COMP3 C3		0.66	1.42				
TZL COMP4 C3		0.63	1.72				
OKA AWAKA		0.69	1.45				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		0.83	0.75	1.38	1.41		
LSD $_{0.05}$(sowing date) = 0.46							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		1.04	1.18	1.07			
LSD $_{0.05}$(variety) = n.s							
Poultry manure(tons/ha)		0	10				
		0.66	1.53				
LSD $_{0.05}$(poultry manure) = 0.14							

Table 12: Effect of sowing date, variety and poultry manure on leaf dry matter at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		1.69	3.69	0.72	4.37	0.52	2.55
MAR 15		2.62	2.28	1.87	4.20	1.16	3.12
MAR 30		6.37	13.72	7.39	9.80	10.33	13.70
APR 14		5.59	14.13	4.28	12.38	3.50	10.88

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	2.69	2.54	1.53
MAR 15	2.45	3.03	2.14
MAR 30	10.04	8.60	12.02
APR 14	9.86	8.33	7.19

LSD $_{0.05}$ (sowing date x variety) = 2.80

	0	10
FEB 28	0.98	3.53
MAR 15	1.88	3.20
MAR 30	8.03	12.41
APR 14	4.46	12.46

LSD $_{0.05}$ (sowing date x manure) = 2.50

	0	10
TZE COMP3 C3	4.07	8.46
TZL COMP4 C3	3.56	7.69
OKA AWAKA	3.88	7.56

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	2.26	2.54	10.22	8.46

LSD $_{0.05}$(sowing date) = 2.43

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	6.26	5.63	5.72

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	3.84	7.90

LSD $_{0.05}$(poultry manure) = 0.72

compared to February 28, March 15 and April 14 respectively and 369.9 and 236.0 % more leaf dry matter when planted on April 14 compared to February 28 and March 15 respectively. The effect of sowing date x poultry manure interaction was significant on maize leaf dry matter at 2, 4 and 6WAP. Application of poultry manure significantly increased maize leaf dry matter by 69.2, 171.4, 93.3 and133.3 % at 2 WAP when planted on February 28, March 15, March 30 and April 14 respectively; by 251.4, 65.4 and 242.2 % at 4WAP when planted on February 28, March 30 and April 14 respectively and by 260.0, 54.6 and 179.4 % at 6 WAP when planted on February 28, March 30 and April 14 respectively. Variety x poultry manure interaction did not have significant effect on stem dry matter at 2.4 and 6 WAP.

4.1.11 Stem Dry Matter

The effect of sowing date on stem dry matter was not significant at 2 WAP (Table 13). At 4 and 6 WAP sowing date effect followed the same pattern. Stem dry matter in maize planted on March 30 and April 14 which did not differ significantly, were significantly greater than stem dry matter in maize planted on February 28 and March 15 (Tables 14, 15). There were no significant differences in stem dry matter among the maize varieties at 2,4 and 6 WAP. Poultry manure application significantly increased stem dry matter from 0.06 to 0.11 g at 2 WAP, 0.21 to 0.49 g at 4 WAP and 2.53 to 5.45 g at 6 WAP. The effect of sowing date x variety x poultry manure interaction was not significant at 2, 4 and 6 WAP. The effect of sowing date x variety interaction was significant on maize stem dry matter at 6 WAP. TZE COMP3 C3 accumulated 284.9 and 381.1 % more stem dry matter when planted on March 30 compared to February 28 and March 15 respectively and 417.6 and 547.0 % more stem dry matter when planted on April 14 compared to February 28 and March 15 respectively. TZL COMP4 C3 accumulated 413.2 and 349.6 % more stem dry matter when planted on

Table 13: Effect of sowing date, variety and poultry manure on stem dry matter at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		0.06	0.10	0.06	0.09	0.05	0.07
MAR 15		0.06	0.14	0.05	0.16	0.06	0.11
MAR 30		0.05	0.09	0.06	0.11	0.06	0.12
APR 14		0.05	0.11	0.06	0.13	0.04	0.08

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.08	0.08	0.06
MAR 15	0.10	0.10	0.09
MAR 30	0.07	0.09	0.09
APR 14	0.08	0.10	0.06

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.05	0.09
MAR 15	0.06	0.14
MAR 30	0.06	0.11
APR 14	0.05	0.11

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	0.06	0.11
TZL COMP4 C3	0.06	0.12
OKA AWAKA	0.05	0.10

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.07	0.10	0.08	0.08

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.08	0.09	0.07

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.06	0.11

LSD $_{0.05}$(poultry manure) = 0.02

Table 14: Effect of sowing date, variety and poultry manure on stem dry matter at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		0.22	0.57	0.10	0.49	0.11	0.27
MAR 15		0.20	0.28	0.21	0.36	0.17	0.20
MAR 30		0.29	0.39	0.24	0.53	0.28	0.72
APR 14		0.25	0.65	0.25	0.83	0.15	0.61

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.40	0.29	0.19
MAR 15	0.24	0.29	0.19
MAR 30	0.34	0.39	0.50
APR 14	0.45	0.54	0.38

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.14	0.44
MAR 15	0.19	0.28
MAR 30	0.27	0.55
APR 14	0.22	0.70

LSD $_{0.05}$ (sowing date x manure) = 0.12

	0	10
TZE COMP3 C3	0.24	0.47
TZL COMP4 C3	0.20	0.55
OKA AWAKA	0.18	0.45

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.29	0.24	0.41	0.46

LSD $_{0.05}$(sowing date) = 0.10

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.36	0.38	0.31

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.21	0.49

LSD $_{0.05}$(poultry manure) = 0.06

Table 15: Effect of sowing date, variety and poultry manure on stem dry matter at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.90	2.39	0.25	1.87	0.16	0.94
MAR 15		1.22	1.41	0.66	1.76	0.36	1.09
MAR 30		4.02	8.69	4.67	6.20	6.54	8.67
APR 14		4.85	12.24	3.71	10.72	3.03	9.42

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	1.65	1.06	0.55
MAR 15	1.32	1.21	0.73
MAR 30	6.35	5.44	7.60
APR 14	8.54	7.22	6.23

LSD $_{0.05}$ (sowing date x variety) = 1.87

	0	10
FEB 28	0.44	1.73
MAR 15	0.75	1.42
MAR 30	5.08	7.85
APR 14	3.86	10.79

LSD $_{0.05}$ (sowing date x manure) = 1.68

	0	10
TZE COMP3 C3	2.75	6.18
TZL COMP4 C3	2.32	5.14
OKA AWAKA	2.52	5.03

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	1.09	1.08	6.47	7.33

LSD $_{0.05}$(sowing date) = 1.63

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	4.46	3.73	3.78

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	2.53	5.45

LSD $_{0.05}$(poultry manure) = 0.49

March 30 compared to February 28 and March 15 respectively and 581.1 and 496.7 % more stem dry matter when planted on April 14 compared to February 28 and March 15 respectively. OKA AWAKA accumulated 1281.8 and 941.1 % more stem dry matter when planted on March 30 compared to February 28 and March 15 respectively and 1032.7 and 753.4 % more stem dry matter when planted on April 14 compared to February 28 and March 15 respectively. The effect of sowing date x poultry manure interaction was significant on maize stem dry matter at 4 and 6WAP. Application of poultry manure significantly increased maize stem dry matter by 214.3, 103.7 and 218.2 % at 4 WAP when planted on February 28, March 30 and April 14 and by 54.5 and 179.5 % at 6 WAP when planted on March 30 and April 14 respectively. Variety x poultry manure interaction did not have significant effect on stem dry matter at 2.4 and 6 WAP.

4.1.12 Number of Green Leaves

Sowing date did not significantly affect the number of green leaves at 2 WAP (Table 16). At 4 WAP maize planted on April 14 had significantly more leaves (6.0) than maize planted on February 28(3.5), March 15 (4.6) and March 30 (5.1). Maize planted on March 15 and March 30 also had significantly more leaves than maize planted on February 28 (Table 17). At 6 WAP maize planted on March 30 and April 14 had 6.9 and 7.5 leaves which were significantly more than the 5.5 leaves on maize planted on February 28 (Table 18). Differences in the number of leaves among maize varieties were only significant at 4 WAP when OKA AWAKA had significantly more leaves (5.0) than TZE COMP3 C3 (4.6). Poultry manure application significantly increased number of leaves from 3.3 to 3.5 at 2 WAP, 4.3 to 5.2 at 4 WAP and 6.0 to 7.3 at 6 WAP. As a result of sowing date x variety x poultry manure interaction at 6WAP, increase in number of leaves for TZE COMP3 C3 ranged between 26.4 and 69.1 % across sowing dates. TZL COMP4 C3 only increased the number of leaves in

Table 16: Effect of sowing date, variety and poultry manure on number of green leaves at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		3.27	3.67	2.87	3.53	2.40	3.20
MAR 15		2.87	3.07	3.20	2.87	3.33	3.00
MAR 30		3.93	4.20	3.87	4.13	4.07	4.40
APR 14		3.20	3.40	3.00	3.27	3.53	3.73
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		3.47	3.20	2.80			
MAR 15		2.97	3.03	3.17			
MAR 30		4.07	4.00	4.23			
APR 14		3.30	3.13	3.63			
LSD $_{0.05}$ (sowing date x variety) = 1.13							
		0	10				
FEB 28		2.84	3.47				
MAR 15		3.13	2.98				
MAR 30		3.96	4.24				
APR 14		3.24	3.47				
LSD $_{0.05}$ (sowing date x manure) = n.s							
		0	10				
TZE COMP3 C3		3.32	3.58				
TZL COMP4 C3		3.23	3.45				
OKA AWAKA		3.33	3.58				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		3.16	3.06	4.10	3.36		
LSD $_{0.05}$(sowing date) = n.s							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		3.45	3.34	3.46			
LSD $_{0.05}$(variety) = n.s							
Poultry manure(tons/ha)		0	10				
		3.29	3.54				
LSD $_{0.05}$(poultry manure) = 0.20							

Table 17: Effect of sowing date, variety and poultry manure on number of green leaves at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		3.13	4.53	2.73	4.27	2.47	3.80
MAR 15		4.60	4.67	4.33	5.00	4.33	4.67
MAR 30		4.33	5.13	4.47	5.67	5.00	5.73
APR 14		4.93	5.47	5.40	6.20	6.40	7.33
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		3.83	3.50	3.13			
MAR 15		4.63	4.67	4.50			
MAR 30		4.73	5.07	5.37			
APR 14		5.20	5.80	6.87			
LSD $_{0.05}$ (sowing date x variety) = 0.63							
		0	10				
FEB 28		2.78	4.20				
MAR 15		4.42	4.78				
MAR 30		4.60	5.51				
APR 14		5.58	6.33				
LSD $_{0.05}$ (sowing date x manure) = 0.60							
		0	10				
TZE COMP3 C3		4.25	4.95				
TZL COMP4 C3		4.23	5.28				
OKA AWAKA		4.55	5.38				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		3.49	4.60	5.06	5.96		
LSD $_{0.05}$(sowing date) = 0.56							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		4.60	4.76	4.97			
LSD $_{0.05}$(variety) = 0.23							
Poultry manure(tons/ha)		0	10				
		4.34	5.21				
LSD $_{0.05}$(poultry manure) = 0.22							

Table 18: Effect of sowing date, variety and poultry manure on number of green leaves at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		4.73	8.00	3.47	7.60	4.33	5.07
MAR 15		6.47	6.47	6.20	6.67	6.67	6.93
MAR 30		5.80	7.33	6.40	7.73	6.73	7.60
APR 14		6.07	7.87	6.93	8.00	7.67	8.33

$LSD_{0.05}$ (sowing date x variety x manure) = 1.41

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	6.37	5.53	4.70
MAR 15	6.47	6.43	6.80
MAR 30	6.57	7.07	7.17
APR 14	6.97	7.47	8.00

$LSD_{0.05}$ (sowing date x variety) = 1.30

	0	10
FEB 28	4.18	6.89
MAR 15	6.44	6.69
MAR 30	6.31	7.56
APR 14	6.89	8.07

$LSD_{0.05}$ (sowing date x manure) = 1.24

	0	10
TZE COMP3 C3	5.77	7.42
TZL COMP4 C3	5.75	7.50
OKA AWAKA	6.35	6.98

$LSD_{0.05}$ (variety x manure) = 0.50

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	5.53	6.57	6.93	7.48

$LSD_{0.05}$(sowing date) = 1.23

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	6.59	6.63	6.67

$LSD_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	5.96	7.30

$LSD_{0.05}$(poultry manure) = 0.27

response to interaction effect by 119.0 % when planted on February 28. OKA AWAKA did not respond to poultry manure across the sowing dates. The effect of sowing date x variety interaction was significant on number of green leaves at 2, 4 and 6 WAP. At 2 WAP, only OKA AWAKA responded to sowing date by 51.1 % when planted on April 14 compared to February 28. At 4 WAP, number of leaves in TZE COMP3 C3 was 20.9, 23.5 and 35.8 % more when planted on March 15, March 30 and April 14 respectively compared to February 28. TZL COMP4 C3 had 65.7, 24.2 and 14.4 % more leaves when planted on April 14 compared to February 28, March 15 and March 30 respectively and 33.4 and 44.9 % more leaves when planted on March 15 and March 30 respectively compared to February 28. OKA AWAKA had 119.5, 52.7 and 27.9 % more leaves when planted on April 14 compared to February 28, March 15 and March 30 respectively and 71.6 and 19.3 % more leaves when planted on March 30 compared to February 28 and March 15 respectively. OKA AWAKA also had 43.8 % more leaves when planted on March 15 compared to February 28. At 6 WAP, TZL COMP4 C3 had 27.9 and 35.1 % more leaves when planted on March 30 and April 14 respectively compared to February 28. OKA AWAKA had 44.7, 52.6 and 70.2 % more leaves when planted on March 15, March 30 and April 14 respectively compared to February 28. Sowing date x poultry manure interaction significantly affected number of leaves at 4 and 6WAP. Application of poultry manure significantly increased number of leaves at 4WAP when planted on February 28(51.1 %), March 30 (19.8 %) and April 14(13.4 %) and at 6WAP when planted on February 28(64.8 %) and March 30 (19.8 %). Variety x poultry manure interaction significantly affected number of leaves at 6WAP. Varietal response to poultry manure application was 28.6, 30.4 and 9.9 % for TZE COMP C3, TZL COMP4 C3 and OKA AWAKA respectively.

4.1.13 Days to 50 % Tasseling

The results presented on Table 19 show that when planted on February 28 maize tasseled significantly later (71 days) than when planted on March 30 (63 days) and April 14 (59 days). When planted on March 15 maize only tasseled significantly later (68 days) than when planted on April 14. Among the maize varieties, TZE COMP3 C3 tasseled significantly earlier (57 days) than TZL COMP4 C3 (64 days) and OKA AWAKA (76 days). TZL COMP4 C3 also tasseled significantly earlier than OKA AWAKA. Application of poultry manure significantly reduced the number of days to 50 % tasseling from about 68 to 63 days. The effect of sowing date x variety x poultry manure interaction was significant on number of days to 50 % tasseling. The maize varieties generally responded to organic manure when planted in April 14 by 10.0 % (OKA AWAKA), 14.8 % (TZE COMP3 C3) and 14.9 % (TZL COMP4 C3). Apart from this, only TZL COMP4 C3 and OKA AWAKA responded when planted on February 28(18.8 %) and March 30 (9.0 %) respectively. Tasseling occurred 7.0 and 8.0 days earlier in TZE COMP C3 when planted on April 14 compared to February 28 and March 15 respectively. TZL COMP4 C3 attained 50 % tasseling 13.0, 11.0 and 7.0 days earlier when planted on April 14 compared to February 28, March 15 and March 30 respectively. It also attained 50 % tasseling 7.0 days earlier when planted on March 30 compared to February 28. OKA AWAKA attained 50 % tasseling 16.0 and 7.0 days earlier when planted on April 14 compared to February 28 and March 15 respectively. It also attained 50 % tasseling 9.0 and 15.0 days earlier when planted on March 15 and March 30 respectively compared to February 28. Application of poultry manure reduced number of days to 50 % tasseling by 9.0 (11.3 %) ad 8.0 (13.0 %) days when planted on February 28 and April 14 respectively. In response to poultry manure application TZE COMP C3, TZL COMP4 C3 and OKA AWAKA attained 50 % tasseling 5.0, 8.0 and 4.0 days earlier respectively.

Table 19: Effect of sowing date, variety and poultry manure on number of days to 50% tasseling

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		61.67	56.00	76.33	62.00	88.33	82.67
MAR 15		60.67	59.67	70.00	64.00	75.67	78.33
MAR 30		58.33	54.67	64.00	60.67	74.33	67.67
APR 14		56.33	48.00	60.33	51.33	73.33	66.00

LSD $_{0.05}$ (sowing date x variety x manure) = 6.33

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	58.83	69.17	85.50
MAR 15	60.17	67.00	77.00
MAR 30	56.50	62.33	71.00
APR 14	52.17	55.83	69.67

LSD $_{0.05}$ (sowing date x variety) = 6.23

	0	10
FEB 28	75.44	66.89
MAR 15	68.78	67.33
MAR 30	65.56	61.00
APR 14	63.33	55.11

LSD $_{0.05}$ (sowing date x manure) = 6.01

	0	10
TZE COMP3 C3	59.25	54.58
TZL COMP4 C3	67.67	59.50
OKA AWAKA	77.92	73.67

LSD $_{0.05}$ (variety x manure) = 1.84

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	71.17	68.06	63.28	59.22

LSD $_{0.05}$(sowing date) = 6.00

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	56.92	63.58	75.79

LSD $_{0.05}$(variety) = 1.72

Poultry manure(tons/ha)	0	10
	68.28	62.58

LSD $_{0.05}$(poultry manure) = 0.61

4.1.14 Days to 50 % Silking

When planted on February 28, maize attained 50 % silking significantly, later (78 days) than when planted on March 30(68 days) and April 14(63 days) (Table 20). When planted on March 15, maize only silked si4nificantly later (74 days) than when planted on April 14. TZE COMP3 C3 silked significantly earlier (62 days) than TZL COMP4 C3 (69 days) and OKA AWAKA (81 days), while TZL COMP4 C3 silked significantly earlier than OKA AWAKA. Application of poultry manure significantly reduced the number of days to 50 % silking from about 75 to 67 days. The effect of sowing date x variety x poultry manure interaction was significant on number of days to 50 % silking. When planted on February 28, TZE COMP3 C3 and TZL COMP4 C3 silked 9.0 and 22 days earlier respectively in response to organic manure. Similarly, when planted on April 14, TZE COMP3 C3 and TZL COMP4 C3 silked 10 and 12 days earlier respectively in response to organic manure. Silking occurred 9.0 and 12.0 days earlier in TZE COMP C3 when planted on April 14 compared to February 28 and March 15 respectively. TZL COMP4 C3 attained 50 % silking 17.0 and 12.0 days earlier when planted on April 14 compared to February 28 and March 15 respectively. It also attained 50% silking 11.0 days earlier when planted on March 30 compared to February 28. OKA AWAKA attained 50 % silking 17.0 and 10.0 days earlier when planted on April 14 compared to February 28 and March 15 respectively. It also attained 50 % silking 15.0 days earlier when planted on March 30 compared to February 28. Application of poultry manure reduced number of days to 50 % silking by 12.0 (14.6 %) and 10.0 (14.6 %) days when planted on February 28 and April 14 respectively. In response to poultry manure application TZE COMP C3, TZL COMP4 C3 and OKA AWAKA attained 50 % silking 7.0, 11.0 and 5.0 days earlier respectively.

Table 20: Effect of sowing date, variety and poultry manure on number of days to 50% silking

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		69.00	60.00	88.33	66.67	94.33	88.33
MAR 15		67.67	66.33	76.00	68.67	83.33	84.33
MAR 30		64.00	57.67	68.33	64.33	79.67	72.33
APR 14		60.67	50.33	66.00	54.33	78.33	70.33

LSD $_{0.05}$ (sowing date x variety x manure) = 8.03

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	64.50	77.50	91.33
MAR 15	67.00	72.33	83.83
MAR 30	60.83	66.33	76.00
APR 14	55.50	60.17	74.33

LSD $_{0.05}$ (sowing date x variety) = 7.84

	0	10
FEB 28	83.89	71.67
MAR 15	75.67	73.11
MAR 30	70.67	64.78
APR 14	68.33	58.33

LSD $_{0.05}$ (sowing date x manure) = 7.39

	0	10
TZE COMP3 C3	65.33	58.58
TZL COMP4 C3	74.67	63.50
OKA AWAKA	83.92	78.83

LSD $_{0.05}$ (variety x manure) = 2.65

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	77.78	74.39	67.72	63.33

LSD $_{0.05}$(sowing date) = 7.38

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	61.96	69.08	81.38

LSD $_{0.05}$(variety) = 2.47

Poultry manure(tons/ha)	0	10
	74.64	66.97

LSD $_{0.05}$(poultry manure) = 0.88

4.1.15 Anthesis Silking Interval

Anthesis silking interval (ASI) was not significantly different when maize was planted on February 28 and March 15. However, ASI of maize planted on these dates was significantly greater than ASI of maize planted on March 30 and April 14 (Table 21). There were no significant differences in ASI among the maize varieties. Organic manure application significantly reduced ASI by 2 days. The effect of sowing date x variety x poultry manure interaction also affected ASI significantly. TZE COMP3 C3 responded significantly to organic manure application when planted on February 28 and March 30, while TZL COMP4 C3 responded significantly to organic manure application when planted on February 28 and April 14. The interaction of sowing date x variety did not significantly affect anthesis-silking interval. Application of poultry manure reduced anthesis-silking interval by 4.0 (43.4 %) and 2.0 (35.6 %) days when maize was planted on February 28 and April 14. Anthesis-silking interval also reduced in TZE COMP C3 and TZL COMP4 C3 by 2.0 (34.2 %) and 3.0(44.0 %) days respectively in response to poultry manure application.

4.1.16 Ear Height

The ear height of maize was significantly higher when planted on April 14 (93.8 cm) than when planted all other sowing dates (Table 22). Ear height of maize when planted on March 15 (74.9 cm) and March 30 (81.4 cm) did not differ significantly but both were significantly higher than when planted on February 28 (58.6 cm). Among the varieties, the ear height of OKA AWAKA (120.2 cm) was significantly higher than ear height of TZE COMP3 (51.6 cm) and TZL COMP4 C3 (59.8 cm). Ear height of TZL COMP4 C3 was also significantly higher than ear height of TZE COMP3 C3. Application of organic manure significantly increased ear height from 66.8 to 87.6 cm (31.1 %). There were no significant differences in ear height as a result of sowing date x variety x poultry manure interaction.

Table 21: Effect of sowing date, variety and poultry manure on anthesis-silking interval (days)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		7.33	4.00	12.00	4.67	6.00	5.67
MAR 15		7.00	6.67	6.00	4.67	7.67	6.00
MAR 30		5.67	3.00	4.33	3.33	5.33	4.67
APR 14		4.33	2.33	5.67	3.00	5.00	4.33

$LSD_{0.05}$ (sowing date x variety x manure) = 2.61

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	5.67	8.33	5.83
MAR 15	6.83	5.33	6.83
MAR 30	4.33	3.83	5.00
APR 14	3.33	4.33	4.67

$LSD_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	8.44	4.78
MAR 15	6.89	5.78
MAR 30	5.11	3.67
APR 14	5.00	3.22

$LSD_{0.05}$ (sowing date x manure) = 1.58

	0	10
TZE COMP3 C3	6.08	4.00
TZL COMP4 C3	7.00	3.92
OKA AWAKA	6.00	5.17

$LSD_{0.05}$ (variety x manure) = 1.33

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	6.61	6.33	4.39	4.11

$LSD_{0.05}$(sowing date) = 1.46

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	5.04	5.46	5.58

$LSD_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	6.36	4.36

$LSD_{0.05}$(poultry manure) = 0.60

Table 22: Effect of sowing date, variety and poultry manure on ear height (cm)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		35.30	43.40	31.40	48.90	87.30	105.30
MAR 15		43.70	52.60	46.70	72.70	108.70	125.10
MAR 30		39.30	64.80	52.5	73.3	114.60	144.10
APR 14		56.10	77.60	68.40	84.20	117.10	159.50
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		39.30	40.10	96.30			
MAR 15		48.20	59.70	116.90			
MAR 30		52.10	62.90	129.30			
APR 14		66.90	76.30	138.30			
LSD $_{0.05}$ (sowing date x variety) = n.s							
		0	10				
FEB 28		51.30	65.80				
MAR 15		66.40	83.40				
MAR 30		68.80	94.00				
APR 14		80.50	107.10				
LSD $_{0.05}$ (sowing date x manure) = n.s							
		0	10				
TZE COMP3 C3		43.60	59.60				
TZL COMP4 C3		49.80	69.80				
OKA AWAKA		106.90	133.50				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		58.60	74.90	81.40	93.80		
LSD $_{0.05}$(sowing date) = 9.33							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		51.60	59.80	120.20			
LSD $_{0.05}$(variety) = 6.45							
Poultry manure(tons/ha)		0	10				
		66.80	87.60				
LSD $_{0.05}$(poultry manure) = 4.95							

The interaction of sowing date x variety, variety x poultry manure and sowing date x poultry manure also did not have significant effect on ear height.

4.1.17 Physiological Maturity

Physiological maturity was significantly affected by sowing date, maize variety and poultry manure (Table 23). When maize was planted on April 14, it attained physiological maturity significantly earlier than when planted on February 28, March 15 and March 30 by 11, 7 and 5 days respectively. Maize planted on March 30 also attained physiological maturity significantly earlier than when planted on February 28 by 6 days. OKA AWAKA attained physiological maturity significantly later than other varieties in 116 days, while TZE COMP3 C3 attained physiological maturity significantly earlier than other varieties in 96 days. Application of poultry manure significantly depressed days to physiological maturity by 4.1 % from 108.9 to 104.5 days. The effect of sowing date x variety x poultry manure interaction was not significant on physiological maturity. Physiological maturity occurred 5.0, 7.0 and 7.0 days earlier in TZE COMP C3 when planted on April 14 compared to February 28, March 15 and March 30 respectively. TZL COMP4 C3 attained physiological maturity 15.0, 9.0 and 6.0 days earlier when planted on April 14 compared to February 28, March 15 and March 30 respectively. It also attained physiological maturity 6.0 and 9.0 days earlier when planted on March 15 and March 30 respectively compared to February 28. OKA AWAKA attained physiological maturity 12.0 and 5.0 days earlier when planted on April 14 compared to February 28 and March 15 respectively. It also attained physiological maturity 7.0 and 10.0 days earlier when planted on March 15 and March 30 respectively compared to February 28. Application of poultry manure reduced number of days to physiological maturity by 7.0 (6.5 %) and 5.0 (4.2 %) days when planted on February 28 and March 30

Table 23: Effect of sowing date, variety and poultry manure on physiological maturity

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		99.67	94.00	120.67	110.00	126.33	120.33
MAR 15		99.67	98.00	111.67	107.00	117.33	115.00
MAR 30		101.00	95.00	108.67	104.00	114.67	111.67
APR 14		92.33	90.67	102.67	98.00	112.00	110.00

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	96.83	115.33	123.33
MAR 15	98.83	109.33	116.17
MAR 30	98.00	106.33	113.17
APR 14	91.50	100.33	111.00

LSD $_{0.05}$ (sowing date x variety) = 5.08

	0	10
FEB 28	115.56	108.11
MAR 15	109.56	106.67
MAR 30	108.11	103.56
APR 14	102.33	99.56

LSD $_{0.05}$ (sowing date x manure) = 4.01

	0	10
TZE COMP3 C3	98.17	94.42
TZL COMP4 C3	110.92	104.75
OKA AWAKA	117.58	114.25

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	111.83	108.11	105.83	100.94

LSD $_{0.05}$(sowing date) = 3.88

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	96.29	107.83	115.92

LSD $_{0.05}$(variety) = 2.40

Poultry manure(tons/ha)	0	10
	108.89	104.47

LSD $_{0.05}$(poultry manure) = 1.19

respectively. Variety x poultry manure interaction did not have significant effect on physiological maturity.

4.1.18 Grain Filling Duration

Sowing date did not affect grain filling duration significantly. Grain filling duration was highest in TZL COMP4 C3 (38.8 days) and this was significantly different from the grain filling duration for TZE COMP3 C3 (34.3 days) and OKA AWAKA (34.5 days) (Table 24). Poultry manure significantly increased grain filling duration from 34.3 to 37.5 days. The effect of sowing date x variety x poultry manure interaction was significant on grain filling duration. TZE COMP3 C3 responded significantly to organic manure application by 27.3 % when planted on April 14, while TZL COMP4 C3 responded significantly to organic manure application by 34.0 and 19.1 % when planted on February 28 and April 14 respectively. The interaction of sowing date x variety and variety x poultry manure did not have significant effect on grain filling duration, but application of poultry manure significantly increased grain filling duration by 7.0 (21.2 %) days when planted on April 14.

4.1.19 Number of rows per cob

The number of maize rows per cob was not significantly affected by sowing date (Table 25). Among maize varieties, OKA AWAKA had significantly more grain rows per cob (13.8) than TZE COMP3 C3 (12.3) and TZL COMP4 C3 (12.3). Poultry manure application significantly increased number of rows per cob from 12.4 to 13.2. The effect of sowing date x variety x poultry manure interaction was not significant on number of rows per cob. The interaction of sowing x variety, variety x poultry manure and sowing date x poultry manure did not have significant effect on number of rows per cob.

Table 24: Effect of sowing date, variety and poultry manure on grain filling duration

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		30.67	34.00	32.33	43.33	32.00	32.00
MAR 15		32.00	31.67	35.67	38.33	34.00	30.67
MAR 30		37.00	37.33	40.33	39.67	35.00	39.33
APR 14		31.67	40.33	36.67	43.67	33.67	39.67

LSD $_{0.05}$ (sowing date x variety x manure) = 6.87

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	32.33	37.83	32.00
MAR 15	31.83	37.00	32.33
MAR 30	37.17	40.00	37.17
APR 14	36.00	40.17	36.67

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	31.67	36.44
MAR 15	33.89	33.56
MAR 30	37.44	38.78
APR 14	34.00	41.22

LSD $_{0.05}$ (sowing date x manure) = 5.38

	0	10
TZE COMP3 C3	32.83	35.83
TZL COMP4 C3	36.25	41.25
OKA AWAKA	33.67	35.42

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	34.06	33.72	38.11	37.61

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	34.33	38.75	34.54

LSD $_{0.05}$(variety) = 2.80

Poultry manure(tons/ha)	0	10
	34.25	37.50

LSD $_{0.05}$(poultry manure) = 1.09

Table 25: Effect of sowing date, variety and poultry manure on number of rows per cob

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		10.40	12.67	11.73	12.13	13.33	13.53
MAR 15		13.07	13.60	12.53	12.80	14.23	13.97
MAR 30		11.27	12.67	12.00	12.53	12.73	14.50
APR 14		10.87	13.00	12.40	12.53	13.47	14.27

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	11.53	11.93	13.43
MAR 15	13.33	12.67	14.10
MAR 30	12.22	12.27	13.62
APR 14	11.93	12.47	13.87

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	11.82	12.78
MAR 15	13.28	13.46
MAR 30	12.17	13.23
APR 14	12.24	13.27

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	11.53	12.98
TZL COMP4 C3	12.17	12.50
OKA AWAKA	13.44	14.07

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	12.30	13.37	12.70	12.76

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	12.25	12.33	13.75

LSD $_{0.05}$(variety) = 0.45

Poultry manure(tons/ha)	0	10
	12.38	13.18

LSD $_{0.05}$(poultry manure) = 0.43

4.1.20 Number of grains per row

The number of maize grains per row was not significantly affected by sowing date and maize variety (Table 26). However, application of poultry manure significantly increased number of grains per row from 23.2 to 25.7. The effect of sowing date x variety x poultry manure interaction was not significant on number of grains per row. The interaction of sowing x variety, variety x poultry manure and sowing date x poultry manure did not have significant effect on number of grains per row.

4.1.21 Number of grains per cob

As shown in Table 27, sowing date did not significantly affect the number of grains per cob, although maize planted on March 15 had the greatest number of grains per cob. Among the varieties, the greatest number of grains per cob was produced by OKA AWAKA (352.8) and this was significantly more than the number of grains per cob produced by TZE COMP3 C3 (286.6) and TZL COMP4 C3 (304.8). Application of organic manure significantly increased number of grains per cob by 17.7 % (289.1 to 340.4). The effect of sowing date x variety x poultry manure interaction was not significant on number of grains per cob. The interaction of sowing x variety, variety x poultry manure and sowing date x poultry manure did not have significant effect on number of grains per cob.

4.1.22 Hundred Seed Weight

Sowing date did not significantly affect the weight of hundred seeds of maize (Table 28). TZL COMP4 C3 had the greatest weight of hundred seeds (29.8 g) and this was significantly greater than weight of hundred seeds in TZE COMP3 C3 (26.7 g) and OKA AWAKA (23.4 g). The weight of hundred seeds in TZE COMP3 C3 was also significantly greater than that in OKA AWAKA. Poultry manure application significantly increased hundred seed weight

Table 26: Effect of sowing date, variety and poultry manure on number of grains per row

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		19.87	19.52	18.07	23.53	21.63	26.98
MAR 15		22.38	24.40	24.00	30.07	25.63	27.58
MAR 30		21.36	26.07	24.80	25.60	25.43	28.08
APR 14		25.43	26.73	25.07	25.77	24.07	24.47

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	19.69	20.80	24.31
MAR 15	23.39	27.03	26.61
MAR 30	23.71	25.20	26.76
APR 14	26.08	25.42	24.27

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	19.86	23.34
MAR 15	24.01	27.35
MAR 30	23.86	26.58
APR 14	24.86	25.66

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	22.26	24.18
TZL COMP4 C3	22.98	26.24
OKA AWAKA	24.19	26.78

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	21.60	25.68	25.22	25.26

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	23.22	24.61	25.49

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	23.15	25.73

LSD $_{0.05}$(poultry manure) = 1.53

Table 27: Effect of sowing date, variety and poultry manure on number of grains per cob

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		207.70	247.40	212.80	287.70	288.40	361.80
MAR 15		292.50	336.50	300.80	383.90	370.30	386.80
MAR 30		256.50	329.90	299.70	321.90	330.70	411.70
APR 14		274.50	347.90	310.80	320.90	324.40	348.70

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	227.50	250.30	325.10
MAR 15	314.50	342.40	378.50
MAR 30	293.20	310.80	371.20
APR 14	311.20	315.90	336.60

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	236.30	299.00
MAR 15	321.20	369.10
MAR 30	295.60	354.50
APR 14	303.30	339.20

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	257.80	315.40
TZL COMP4 C3	281.00	328.60
OKA AWAKA	328.40	377.30

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	267.60	345.10	325.10	321.20

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	286.60	304.80	352.80

LSD $_{0.05}$(variety) = 43.30

Poultry manure(tons/ha)	0	10
	289.10	340.40

LSD $_{0.05}$(poultry manure) = 25.19

Table 28: Effect of sowing date, variety and poultry manure on hundred seed weight (g)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		24.38	26.26	29.74	31.47	22.12	24.50
MAR 15		26.01	26.38	27.21	28.61	24.33	21.26
MAR 30		26.64	29.48	27.16	34.03	26.72	23.99
APR 14		23.43	30.92	24.74	35.15	21.01	22.98

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	25.32	30.60	23.31
MAR 15	26.19	27.91	22.79
MAR 30	28.06	30.59	25.35
APR 14	27.17	29.94	21.99

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	25.41	27.41
MAR 15	25.85	25.42
MAR 30	26.84	29.17
APR 14	23.06	29.68

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	25.11	28.26
TZL COMP4 C3	27.21	32.31
OKA AWAKA	23.54	23.18

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	26.41	25.63	28.00	26.37

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	26.69	29.76	23.36

LSD $_{0.05}$(variety) = 2.17

Poultry manure(tons/ha)	0	10
	25.29	27.92

LSD $_{0.05}$(poultry manure) = 2.15

by 10.4 % (25.29 to 27.92 g). The effect of sowing date x variety x poultry manure interaction was not significant on hundred seed weight. The interaction of sowing x variety, variety x poultry manure and sowing date x poultry manure did not have significant effect on number of weight of hundred seeds.

4.1.23 Grain Yield

Grain yield did not differ significantly across sowing dates but maize planted on March 30 had the highest yield (3.56 tons/ha) while maize planted on February 28 had the lowest yield (2.88 tons/ha) (Table 29). Varieties did not differ significantly in grain yield but OKA AWAKA had the highest yield (3.37 tons/ha) while TZE COMP3 C3 had the lowest yield (3.07 tons/ha). Poultry manure significantly increased grain yield by 33.3 %. The effect of sowing date x variety x poultry manure interaction did not significantly affect grain yield. The grain yield from TZE COMP C3 increased by 1.13 (48.7 %), 0.94 (40.5 %) and 0.9 (38.8 %) tons/ha when planted on March 15, March 30 and April 14 respectively compared to February 28. Grain yield from OKA AWAKA increased by 1.35 (52.3 %) and 0.86 (28.0 %) tons/ha when planted on March 15 compared to April 14 and February 28 respectively. Grain yield from OKA AWAKA also increased by 1.32 (51.2 %) and 0.83 (27.0 %) tons/ha when planted on March 30 compared to April 14 and February 28 respectively. Sowing date x poultry manure and variety x poultry manure interaction did not have significant effect on grain yield.

2010 TRIAL

4.1.24 Days to 50 % Emergence

The result on Table 30 shows that maize planted on March 15 and April 14 did not differ significantly in the number of days to 50 % emergence. However, they emerged significantly earlier than maize planted on February 28 and March 30. There were no significant

Table 29: Effect of sowing date, variety and poultry manure on grain yield (tons/ha)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		2.12	2.53	2.87	3.61	2.90	3.23
MAR 15		3.10	3.80	2.75	3.74	3.24	4.62
MAR 30		2.73	3.79	3.04	3.98	3.27	4.53
APR 14		2.26	4.18	2.65	3.25	2.22	2.95

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	2.32	3.24	3.07
MAR 15	3.45	3.25	3.93
MAR 30	3.26	3.51	3.90
APR 14	3.22	2.95	2.58

LSD $_{0.05}$ (sowing date x variety) = 0.83

	0	10
FEB 28	2.63	3.12
MAR 15	3.03	4.05
MAR 30	3.01	4.10
APR 14	2.38	3.46

LSD $_{0.05}$ (sowing date x manure) = 0.12

	0	10
TZE COMP3 C3	2.55	3.58
TZL COMP4 C3	2.83	3.65
OKA AWAKA	2.91	3.83

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	2.88	3.54	3.56	2.92

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	3.07	3.24	3.37

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	2.76	3.68

LSD $_{0.05}$(poultry manure) = 0.28

Table 30: Effect of sowing date, variety and poultry manure on days to 50 % emergence

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		7.33	7.33	7.33	7.33	9.00	8.33
MAR 15		4.00	5.00	4.00	4.67	4.67	4.33
MAR 30		6.33	7.00	6.00	8.00	6.67	8.67
APR 14		4.33	4.33	4.33	4.33	3.67	3.67

$LSD_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	7.33	7.33	8.67
MAR 15	4.50	4.33	4.50
MAR 30	6.67	7.00	7.67
APR 14	4.33	4.33	3.67

$LSD_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	7.89	7.67
MAR 15	4.22	4.67
MAR 30	6.33	7.89
APR 14	4.11	4.11

$LSD_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	5.50	5.92
TZL COMP4 C3	5.42	6.08
OKA AWAKA	6.00	6.25

$LSD_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	7.78	4.44	7.11	4.11

$LSD_{0.05}$(sowing date) = 1.26

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	5.71	5.75	6.12

$LSD_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	5.64	6.08

$LSD_{0.05}$(poultry manure) = n.s

differences arising from the effect of variety, poultry manure and sowing date x variety x poultry manure interaction. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on days to 50 % emergence.

4.1.25 Maize height

The effect of sowing date was significant on maize height at 4 and 6 WAP. At 4 WAP, maize planted on March 30 grew significantly taller (27.4 cm) than maize planted on all other dates (Table 32). Maize planted on March 15 (16.7 cm) and April 14 (19.6 cm) did not differ significantly but they were significantly taller than maize planted on February 28(8.1cm). At 6WAP maize planted on March 30 also grew significantly taller (72.6 cm) than maize planted on all other dates (Table 33). Maize planted on April 14 (52.3 cm) was significantly taller than maize planted on February 28(23.6 cm) and March 15 (31.1cm) which were not significantly different from each other. The effect of variety on maize height followed the same pattern at 4 and 6 WAP. At 4 WAP OKA AWAKA grew significantly taller than TZE COMP3 C3 and TZL COMP4 C3 by 36.6 and 25.9 % respectively. At 6 WAP OKA AWAKA grew significantly taller than TZE COMP3 C3 and TZL COMP4 C3 by 22 and 26.5 % respectively. Application of poultry manure significantly affected maize height and resulted in 63.8, 97.5 and 120.7 % increase at 2 (Table 31), 4 and 6 WAP respectively. The effect of sowing date x variety x poultry manure interaction was significant on maize height at 4 WAP. TZE COMP 3 C3 responded significantly to organic manure by 88.1, 141.2 and 170.5 % when planted on March 15, March 30 and April 14 respectively. TZL COMP4 C3 responded significantly to poultry manure by 98.8 % when planted on March 30. OKA AWAKA responded significantly to organic manure by 197.7 and 81.6 % when planted on March 30 and April 14 respectively. The effect of sowing date x variety interaction was significant on maize height at 2WAP.

Table 32: Effect of sowing date, variety and poultry manure on maize height at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		6.10	9.30	6.23	10.83	6.49	9.43
MAR 15		11.20	21.07	12.93	20.80	13.13	20.80
MAR 30		14.98	36.13	14.33	28.49	17.76	52.87
APR 14		7.74	20.94	16.59	23.94	17.23	31.29

LSD $_{0.05}$ (sowing date x variety x manure) = 9.15

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	7.70	8.53	7.95
MAR 15	16.13	16.87	16.97
MAR 30	25.56	21.41	35.31
APR 14	14.34	20.26	24.26

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	6.27	9.86
MAR 15	12.42	20.89
MAR 30	15.69	39.16
APR 14	13.85	25.39

LSD $_{0.05}$ (sowing date x manure) = 6.96

	0	10
TZE COMP3 C3	10.01	21.86
TZL COMP4 C3	12.52	21.02
OKA AWAKA	13.65	28.60

LSD $_{0.05}$ (variety x manure) = 4.09

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	8.06	16.66	27.43	19.62

LSD $_{0.05}$(sowing date) = 6.83

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	15.93	16.77	21.12

LSD $_{0.05}$(variety) = 3.60

Poultry manure(tons/ha)	0	10
	12.06	23.82

LSD $_{0.05}$(poultry manure) = 1.77

Table 33: Effect of sowing date, variety and poultry manure on maize height at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		17.50	26.50	12.80	26.90	19.50	38.30
MAR 15		23.10	33.20	21.90	36.90	29.80	41.80
MAR 30		42.90	106.70	29.00	89.40	41.00	126.50
APR 14		24.40	63.90	34.10	75.20	40.00	76.30

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	22.00	19.90	28.90
MAR 15	28.20	29.40	35.80
MAR 30	74.80	59.20	83.70
APR 14	44.20	54.70	58.10

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	16.60	30.60
MAR 15	25.00	37.30
MAR 30	37.60	107.50
APR 14	32.80	71.80

LSD $_{0.05}$ (sowing date x manure) = 12.52

	0	10
TZE COMP3 C3	27.00	57.60
TZL COMP4 C3	24.50	57.10
OKA AWAKA	32.50	70.70

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	23.6	31.1	72.6	52.3

LSD $_{0.05}$(sowing date) = 11.69

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	42.3	40.8	51.6

LSD $_{0.05}$(variety) = 5.99

Poultry manure(tons/ha)	0	10
	28.0	61.8

LSD $_{0.05}$(poultry manure) = 4.64

Table 31: Effect of sowing date, variety and poultry manure on maize height at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		3.17	4.83	2.60	3.57	3.07	3.87
MAR 15		2.53	4.20	2.27	3.77	2.93	3.83
MAR 30		2.63	5.37	2.43	5.43	2.30	4.87
APR 14		2.35	3.77	3.16	4.38	2.41	4.23

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	4.00	3.08	3.47
MAR 15	3.37	3.02	3.38
MAR 30	4.00	3.93	3.58
APR 14	3.06	3.77	3.32

LSD $_{0.05}$ (sowing date x variety) = 0.89

	0	10
FEB 28	2.94	4.09
MAR 15	2.58	3.93
MAR 30	2.46	5.22
APR 14	2.64	4.13

LSD $_{0.05}$ (sowing date x manure) = 0.86

	0	10
TZE COMP3 C3	2.67	4.54
TZL COMP4 C3	2.62	4.29
OKA AWAKA	2.68	4.20

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	3.52	3.26	3.84	3.38

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	3.61	3.45	3.44

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	2.65	4.34

LSD $_{0.05}$(poultry manure) = 0.22

TZE COMP3 C3 grew 30.7 % taller when planted on February 28 and March 30 compared to April 14, while TZL COMP4 C3 grew 30.1 % taller when planted on March 30 compared to March 15. Sowing date x poultry manure interaction significantly affected maize height at 2, 4 and 6 WAP. Application of poultry manure significantly increased maize height by 39.1, 52.3, 112.2 and 56.4 % at 2 WAP when planted on February 28, March 15, March 30 and April 14 ; by 68.2, 149.6 and 83.3 % at 4 WAP when planted on March 15, March 30 and April 14 and by 80.7, 185.9 and 118.9 % at 6 WAP when planted on February 28, March 30 and April 14 respectively. Variety x poultry manure interaction significantly affected maize height at 4 WAP. Varietal response to poultry manure application was 118.4, 67.9 and 109.5 % for TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA respectively.

4.1.26 Leaf Area Index

The effect of sowing date on leaf area index (LAI) was significant at 2,4 and 6 WAP. At 2 WAP, LAI of maize planted on March 30 (0.019) and April 14(0.017) did not differ significantly but they were significantly greater than LAI of maize planted on February 28 (0.014) and March 15 (0.012) (Table 34). At 4 WAP, sowing date effect followed the same pattern as at 2 WAP. LAI of maize planted on March 30(0.3) and April 14 (0.34) were significantly greater than LAI of maize planted on February 28(0.048) and March 15(0.109) (Table 35). At 6 WAP, maize planted on March 30 had significantly greater LAI (1.03) than maize planted on all other dates. Maize planted on April 14 had significantly greater LAI (0.74) than maize planted on February 28 and March 15. The LAI of maize planted on March 15 (0.36) was also significantly greater than LAI of maize planted on February 28(0.23) (Table 36). Among the varieties, TZL COMP4 C3 and OKA AWAKA had significantly greater LAI than TZE COMP3 C3 at 2 WAP, while at 4 and 6 WAP OKA AWAKA had a significantly greater LAI than TZE COMP3 C3 and TZL COMP4 C3. Application of poultry

Table 34: Effect of sowing date, variety and poultry manure on leaf area index at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.01	0.01	0.01	0.02	0.01	0.02
MAR 15		0.01	0.01	0.01	0.02	0.01	0.01
MAR 30		0.01	0.03	0.01	0.03	0.01	0.03
APR 14		0.01	0.01	0.01	0.04	0.02	0.02

LSD $_{0.05}$ (sowing date x variety x manure) = 0.006

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.01	0.02	0.02
MAR 15	0.01	0.01	0.01
MAR 30	0.02	0.02	0.02
APR 14	0.01	0.02	0.02

LSD $_{0.05}$ (sowing date x variety) = 0.005

	0	10
FEB 28	0.01	0.02
MAR 15	0.01	0.01
MAR 30	0.01	0.03
APR 14	0.01	0.02

LSD $_{0.05}$ (sowing date x manure) = 0.004

	0	10
TZE COMP3 C3	0.01	0.02
TZL COMP4 C3	0.01	0.03
OKA AWAKA	0.01	0.02

LSD $_{0.05}$ (variety x manure) = 0.003

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.01	0.01	0.02	0.02

LSD $_{0.05}$(sowing date) = 0.003

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.01	0.02	0.02

LSD $_{0.05}$(variety) = 0.002

Poultry manure(tons/ha)	0	10
	0.01	0.02

LSD $_{0.05}$(poultry manure) = 0.002

Table 35: Effect of sowing date, variety and poultry manure on leaf area index at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.03	0.06	0.03	0.63	0.03	0.07
MAR 15		0.05	0.14	0.08	0.13	0.08	0.17
MAR 30		0.07	0.40	0.14	0.33	0.14	0.78
APR 14		0.11	0.46	0.16	0.63	0.22	0.47

LSD $_{0.05}$ (sowing date x variety x manure) = 0.15

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.04	0.05	0.05
MAR 15	0.10	0.11	0.13
MAR 30	0.23	0.24	0.46
APR 14	0.29	0.39	0.34

LSD $_{0.05}$ (sowing date x variety) = 0.12

	0	10
FEB 28	0.03	0.06
MAR 15	0.07	0.15
MAR 30	0.12	0.51
APR 14	0.16	0.52

LSD $_{0.05}$ (sowing date x manure) = 0.10

	0	10
TZE COMP3 C3	0.06	0.26
TZL COMP4 C3	0.10	0.29
OKA AWAKA	0.12	0.37

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.05	0.11	0.31	0.34

LSD $_{0.05}$(sowing date) = 0.09

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.16	0.20	0.25

LSD $_{0.05}$(variety) = 0.05

Poultry manure(tons/ha)	0	10
	0.10	0.31

LSD $_{0.05}$(poultry manure) = 0.04

Table 36: Effect of sowing date, variety and poultry manure on leaf area index at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.12	0.23	0.10	0.27	0.19	0.47
MAR 15		0.21	0.30	0.20	0.33	0.27	0.85
MAR 30		0.43	1.46	0.38	1.45	0.46	1.98
APR 14		0.37	0.92	0.29	1.09	0.63	1.14

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.18	0.18	0.33
MAR 15	0.25	0.26	0.56
MAR 30	0.94	0.92	1.22
APR 14	0.65	0.69	0.89

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.13	0.32
MAR 15	0.22	0.49
MAR 30	0.42	1.63
APR 14	0.43	1.05

LSD $_{0.05}$ (sowing date x manure) = 0.18

	0	10
TZE COMP3 C3	0.28	0.73
TZL COMP4 C3	0.24	0.79
OKA AWAKA	0.39	1.11

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.23	0.36	1.03	0.74

LSD $_{0.05}$(sowing date) = 0.11

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.50	0.51	0.75

LSD $_{0.05}$(variety) = 0.12

Poultry manure(tons/ha)	0	10
	0.30	0.88

LSD $_{0.05}$(poultry manure) = 0.11

manure significantly increases LAI by 100.0, 210.0 and 193.3 % at 2, 4 and 6WAP respectively. The interaction of sowing date x variety x poultry manure significantly affected LAI at 2 and 4 WAP. At 2 WAP, TZE COMP3 C3 responded to poultry manure application only when planted on March 30, while TZL COMP4 C3 responded on all sowing dates with responses ranging between 100.0 and 300.0 %. OKA AWAKA responded by 100.0 and 200.0 % when planted on February 28 and April 14 respectively. At 4WAP, all the three varieties responded to poultry manure application when planted on March 30 and April 14. Responses were between 471.4 and 318.2 % for TZE COMP3 C3, 135.7 and 293.8 % for TZL COMP4 C3 and 457.1 and 113.6 % for OKA AWAKA. The effect of sowing date x variety interaction was significant on maize leaf area index at 2 and 4 WAP. At 2 WAP, TZE COMP3 C3 had significantly higher leaf area index when planted on March 30 compared to February 28(100.0 %), March 15(100.0 %) and April 14 (100.0 %). TZL COMP4 C3 had 100.0 % higher leaf area index when planted on February 28, March 30 and April 14 compared to March 15. OKA AWAKA also had 100.0% higher leaf area index when planted on February 28, March 30 and April 14 compared to March 15. At 4 WAP, leaf area index in TZE COMP3 C3 was 475.0 and 625.0 % higher when planted on March 30 and April 14 compared to February 28, and 130.0 and 190.0 % higher when planted on March 30 and April 14 compared to March 15. Leaf area index in TZL COMP4 C3 was 380.0 and 680.0 % higher when planted on March 30 and April 14 compared to February 28, and 118.0 and 254.5 % higher when planted on March 30 and April 14 compared to March 15. When planted on April 14 the leaf area index was 62.5 % higher compared to March 30. Leaf area index in OKA AWAKA was 820.0 and 580.0 % higher when planted on March 30 and April 14 compared to February 28, and 253.8 and 161.5 % higher when planted on March 30 and April 14 compared to March 15. When planted on March 30 the leaf area index was 35.3 % higher compared to April 14. Sowing date x poultry manure interaction significantly affected maize leaf area index at 2, 4 and 6WAP. Application of poultry manure significantly increased leaf area index at 2WAP when planted on February 28(100.0 %), March 30 (200.0 %) and April 14(100.0 %). At 4 WAP application of poultry manure increased leaf area index by 325.0 and 225.0 % when planted on March 30 and April 14, while at 6 WAP application of poultry manure significantly increased leaf area index by 146.2, 122.7, 288.1 and 144.2 % when planted on February 28, March 15, March 30 and April 14 respectively. Variety x poultry manure interaction significantly affected maize leaf area index at 2 WAP. Response of varieties to poultry manure application was 100.0, 200.0 and 100.0 % for TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA respectively.

4.1.27 Leaf Dry Matter

The results showed that at 2 WAP leaf dry matter of maize planted on March 30 (0.28 g) and April 14 (0.25 g) did not differ significantly but they were significantly greater than leaf dry matter of maize planted on February 28(0.16 g) and March 15(0.13 g) (Table 37). At 4 WAP, leaf dry matter of maize planted on March 30 (1.41g) and April 14 (1.34 g) were significantly greater than leaf dry matter of maize planted on March 15 (0.63 g) (Table 38). At 6 WAP, leaf dry matter of maize planted on March 30 (7.35 g) and April 14 (7.57 g) were significantly greater than leaf dry matter of maize planted on February 28 (2.49 g) and March 15(1.18 g) (Table 39). Differences in leaf dry matter among the varieties were significant at 4 WAP only. Leaf dry matter in TZL COMP4 C3 (1.11 g) and OKA AWAKA (1.19 g) were significantly greater than leaf dry matter in TZE COMP3 C3 (0.90 g). Poultry manure application significantly increased leaf dry matter by 73.3, 95.8 and 129.4 % at 2.4 and 6 WAP respectively. The effect of sowing date x variety x poultry manure interaction was not significant at 2.4and 6 WAP. The effect of sowing date x variety interaction was significant on maize leaf dry matter at 6 WAP. Leaf dry matter in TZE COMP3 C3 was 291.1 and

Table 37: Effect of sowing date, variety and poultry manure on leaf dry matter at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.12	0.19	0.13	0.20	0.15	0.15
MAR 15		0.10	0.13	0.13	0.17	0.10	0.15
MAR 30		0.18	0.38	0.23	0.31	0.18	0.39
APR 14		0.15	0.33	0.16	0.34	0.11	0.39

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.16	0.17	0.15
MAR 15	0.12	0.15	0.13
MAR 30	0.28	0.27	0.29
APR 14	0.24	0.25	0.25

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.13	0.18
MAR 15	0.11	0.15
MAR 30	0.20	0.36
APR 14	0.14	0.36

LSD $_{0.05}$ (sowing date x manure) = 0.07

	0	10
TZE COMP3 C3	0.14	0.26
TZL COMP4 C3	0.16	0.26
OKA AWAKA	0.14	0.27

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.16	0.13	0.28	0.25

LSD $_{0.05}$(sowing date) = 0.07

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.20	0.21	0.20

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.15	0.26

LSD $_{0.05}$(poultry manure) = 0.03

Table 38: Effect of sowing date, variety and poultry manure on leaf dry matter at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.41	0.84	0.47	1.63	0.581	1.38
MAR 15		0.46	0.65	0.49	0.86	0.48	0.81
MAR 30		0.93	1.48	1.14	1.43	1.44	2.04
APR 14		0.52	1.89	0.89	1.93	0.79	2.04

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.63	1.05	0.98
MAR 15	0.56	0.68	0.64
MAR 30	1.20	1.28	1.74
APR 14	1.20	1.41	1.41

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.49	1.28
MAR 15	0.48	0.77
MAR 30	1.17	1.65
APR 14	0.73	1.95

LSD $_{0.05}$ (sowing date x manure) = 0.56

	0	10
TZE COMP3 C3	0.58	1.22
TZL COMP4 C3	0.75	1.46
OKA AWAKA	0.82	1.57

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.89	0.63	1.41	1.34

LSD $_{0.05}$(sowing date) = 0.54

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.90	1.11	1.19

LSD $_{0.05}$(variety) = 0.17

Poultry manure(tons/ha)	0	10
	0.72	1.41

LSD $_{0.05}$(poultry manure) = 0.17

Table 39: Effect of sowing date, variety and poultry manure on leaf dry matter at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		1.17	2.42	1.02	4.08	1.74	4.50
MAR 15		0.96	1.03	0.83	1.53	1.08	1.63
MAR 30		5.25	8.84	4.60	8.93	6.62	9.85
APR 14		3.23	11.03	3.65	13.38	3.65	9.99
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		1.80	2.55	3.12			
MAR 15		0.99	1.18	1.36			
MAR 30		7.04	6.77	8.23			
APR 14		7.13	8.74	6.82			
LSD $_{0.05}$ (sowing date x variety) = 1.86							
		0	10				
FEB 28		1.31	3.67				
MAR 15		0.96	1.40				
MAR 30		5.49	9.21				
APR 14		3.51	11.62				
LSD $_{0.05}$ (sowing date x manure) = 1.91							
		0	10				
TZE COMP3 C3		2.65	5.83				
TZL COMP4 C3		2.53	7.10				
OKA AWAKA		3.27	6.49				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		2.49	1.18	7.35	7.57		
LSD $_{0.05}$(sowing date) = 1.76							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		4.24	4.81	4.88			
LSD $_{0.05}$(variety) = n.s							
Poultry manure(tons/ha)		0	10				
		2.82	6.47				
LSD $_{0.05}$(poultry manure) = 0.75							

296.1 % more when planted on March 30 and April 14 compared to February 28, and 611.1 and 620.2 % more when planted on March 30 and April 14 compared to March 15. Leaf dry matter in TZL COMP4 C3 was 165.5 and 242.7 % more when planted on March 30 and April 14 compared to February 28, and 473.7 and 640.7 % more when planted on March 30 and April 14 compared to March 15. When planted on April 14 the leaf dry matter was 29.1 % more compared to March 30. Leaf dry matter in OKA AWAKA was 163.8 and 118.6 % more when planted on March 30 and April 14 compared to February 28, and 505.1 and 401.5 % more when planted on March 30 and April 14 compared to March 15. Sowing date x poultry manure interaction significantly affected maize leaf dry matter at 2, 4 and 6 WAP. Application of poultry manure significantly increased leaf dry matter at 2 WAP by 80.0 and 157.1 % when planted on March 30 and April 14; at 4WAP by 161.2 and 167.1 % when planted on February 28 and April 14 and at 6WAP by 180.2, 67.8 and 231.1 % when planted on February 28, March 30 and April 14 respectively. Variety x poultry manure interaction did not have significant effect on leaf dry matter at 2, 4 ad 6 WAP.

4.1.28 Stem Dry Matter

The results in Table 40 showed that at 2 WAP stem dry matter of maize planted on March 30(0.08 g) and April 14 (0.08 g) were significantly greater than stem dry matter of maize planted on February 28(0.06 g) and March 15 (0.06 g). Similarly, stem dry matter of maize planted on March 30 (0.53 g) and April 14 (0.47 g) were significantly greater than stem dry matter of maize planted on February 28 (0.26 g) and March 15 (0.22 g) at 4 WAP (Table 41). At 6 WAP, stem dry matter of maize planted on March 30 (2.69 g) and April 14 (2.57 g) were also significantly greater than stem dry matter of maize planted on February 28 (0.72 g) and March 15 (0.50 g) (Table 42). Among the varieties, differences in stem dry matter were significant at 2 WAP only. Stem dry matter in TZE COMP3 C3 (0.08 g) and

Table 40: Effect of sowing date, variety and poultry manure on stem dry matter at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.06	0.08	0.05	0.07	0.05	0.06
MAR 15		0.06	0.07	0.06	0.06	0.05	0.07
MAR 30		0.06	0.13	0.07	0.10	0.05	0.08
APR 14		0.07	0.13	0.07	0.13	0.04	0.07

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.07	0.06	0.06
MAR 15	0.06	0.06	0.06
MAR 30	0.10	0.08	0.07
APR 14	0.10	0.10	0.06

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	0.05	0.07
MAR 15	0.05	0.07
MAR 30	0.06	0.10
APR 14	0.06	0.11

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	0.06	0.10
TZL COMP4 C3	0.06	0.09
OKA AWAKA	0.05	0.07

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.06	0.06	0.08	0.08

LSD $_{0.05}$(sowing date) = 0.02

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.08	0.07	0.06

LSD $_{0.05}$(variety) = 0.01

Poultry manure(tons/ha)	0	10
	0.06	0.09

LSD $_{0.05}$(poultry manure) = 0.0009

Table 41: Effect of sowing date, variety and poultry manure on stem dry matter at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.17	0.24	0.16	0.49	0.16	0.34
MAR 15		0.18	0.24	0.14	0.27	0.18	0.30
MAR 30		0.29	0.60	0.41	0.56	0.41	0.91
APR 14		0.24	0.72	0.30	0.74	0.29	0.53

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.21	0.32	0.25
MAR 15	0.21	0.20	0.24
MAR 30	0.45	0.49	0.66
APR 14	0.48	0.52	0.41

LSD $_{0.05}$ (sowing date x variety) = 0.22

	0	10
FEB 28	0.16	0.36
MAR 15	0.16	0.27
MAR 30	0.37	0.69
APR 14	0.28	0.66

LSD $_{0.05}$ (sowing date x manure) = 0.22

	0	10
TZE COMP3 C3	0.22	0.45
TZL COMP4 C3	0.25	0.51
OKA AWAKA	0.26	0.52

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.26	0.22	0.53	0.47

LSD $_{0.05}$(sowing date) = 0.21

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	0.34	0.38	0.39

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	0.24	0.50

LSD $_{0.05}$(poultry manure) = 0.06

Table 42: Effect of sowing date, variety and poultry manure on stem dry matter at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		0.49	0.69	0.34	1.23	0.47	1.11
MAR 15		0.52	0.59	0.41	0.47	0.40	0.59
MAR 30		1.68	3.23	1.67	3.30	1.89	4.37
APR 14		1.51	4.17	1.24	4.55	1.36	2.56

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	0.59	0.79	0.79
MAR 15	0.56	0.44	0.50
MAR 30	2.45	2.48	3.13
APR 14	2.84	2.90	1.96

LSD $_{0.05}$ (sowing date x variety) = 0.99

	0	10
FEB 28	0.43	1.01
MAR 15	0.44	0.55
MAR 30	1.74	3.63
APR 14	1.37	3.76

LSD $_{0.05}$ (sowing date x manure) = 0.96

	0	10
TZE COMP3 C3	1.05	2.17
TZL COMP4 C3	0.91	2.39
OKA AWAKA	1.03	2.16

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	0.72	0.50	2.69	2.57

LSD $_{0.05}$(sowing date) = 0.92

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	1.61	1.65	1.60

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	1.00	2.24

LSD $_{0.05}$(poultry manure) = 0.31

TZL COMP4 C3 (0.07g) which were not significantly different were significantly greater than stem dry matter in OKA AWAKA (0.06 g). Poultry manure application significantly increased stem dry matter by 50.0, 108.3 and 124.0 % at 2, 4 and 6 WAP respectively. The effect of sowing date x variety x poultry manure interaction was not significant at 2,4and 6 WAP. The effect of sowing date x variety interaction was significant on maize stem dry matter at 4 and 6 WAP. At 4 WAP, stem dry matter in TZE COMP3 C3 was 114.3 and 128.6 % more when planted on March 30 and April 14 compared to February 28, and 114.3 and 128.6 % more when planted on March 30 and April 14 compared to March 15, stem dry matter in TZL COMP4 C3 was 145.0 and 160.0 % more when planted on March 30 and April 14 compared to March 15. When planted on April 14 the stem dry matter was 62.5 % more compared to February 28. Stem dry matter in OKA AWAKA was 164.0 and 175.0 % more when planted on March 30 compared to February 28 and March 15 respectively. At 6 WAP, TZE COMP3 C3 accumulated 315.3 and 381.4 % more stem dry matter when planted on March 30 and April 14 respectively compared to February 28, and 337.5 and 407.1 % more stem dry matter when planted on March 30 and April 14 respectively compared to March 15. TZL COMP4 C3 accumulated 213.9 and 267.1 % more stem dry matter when planted on March 30 and April 14 respectively compared to February 28, and 463.6 and 559.1 % more stem dry matter when planted on March 30 and April 14 respectively compared to March 15. OKA AWAKA accumulated 296.2 and 148.1 % more stem dry matter when planted on March 30 and April 14 respectively compared to February 28, and 526.0 and 292.0 % more stem dry matter when planted on March 30 and April 14 respectively compared to March 15. When planted on March 30 OKA AWAKA also accumulated 59.7 % more stem dry matter compared to April 14. Sowing date x poultry manure interaction significantly affected maize stem dry matter at 2, 4 and 6 WAP. Application of poultry manure increased stem dry matter at 2 WAP by 40.0, 40.0, 66.7 and 83.3 % when planted on February 28, March 15, March 30 and April 14; at 4 WAP by 86.5 and 135.7 % when planted on March 30 and April 14 and at 6 WAP by 108.6 and 174.5 % when planted on March 30 and April 14. Variety x poultry manure interaction did not have significant effect on stem dry matter at 2, 4 ad 6 WAP.

4.1.29 Number of green leaves

Sowing date significantly affected the number of leaves at 4 and 6 WAP. At 4 WAP maize planted on April 14 had significantly more leaves (5.4) than maize planted on all other dates. The number of leaves on maize planted on March 15(4.7) and March 30(4.7) were significantly more than the number of leaves on maize planted on February 28(3.7) (Table 44). At 6 WAP, maize planted on April 14 had significantly more leaves (7.4) than maize planted on all other dates. Maize planted on March 30 had significantly more leaves (7.0) than maize planted on February 28(5.3) and March 15(5.80). The number of leaves on maize planted on March 15 was significantly more than the number of leaves on maize planted on February 28 (Table 45). Among the varieties, OKA AWAKA had significantly more leaves (4.9) than TZE COMP3 C3 (4.4) and TZL COMP4 C3 (4.6) at 4 WAP. Similarly at 6 WAP, OKA AWAKA had significantly more leaves (6.9) than TZE COMP3 C3 (6.1) and TZL COMP4 C3 (6.1). Application of poultry manure significantly increased number of leaves by 25.0, 21.4 and 24.6 % at 2 (Table 43), 4 and 6 WAP respectively. The effect of sowing date x variety x poultry manure interaction was significant on the number of leaves at 4 and 6 WAP. At 4 WAP, TZE COMP3 C3 and TZL COMP4 C3 significantly responded to poultry manure on all sowing dates while OKA AWAKA responded on all sowing dates but April 14. Reponses were between 22.2 and 43.2 % for TZE COMP3 C3, 16.3 and 24.4 % for TZL COMP4 C3 and 18.2 and 38.7 % for OKA AWAKA. Similarly at 6 WAP, TZE COMP3 C3 and TZL COMP4 C3 responded significantly to poultry manure on all sowing dates while

Table 44: Effect of sowing date, variety and poultry manure on number of green leaves at 4WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		3.27	4.07	3.47	4.07	3.13	4.33
MAR 15		4.07	5.13	4.13	5.00	4.40	5.20
MAR 30		3.67	5.27	4.13	5.13	4.60	5.47
APR 14		4.47	5.53	4.87	5.73	5.73	6.27

LSD $_{0.05}$ (sowing date x variety x manure) = 0.56

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	3.67	3.77	3.73
MAR 15	4.60	4.57	4.80
MAR 30	4.47	4.63	5.03
APR 14	5.00	5.30	6.00

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	3.29	4.16
MAR 15	4.20	5.11
MAR 30	4.13	5.29
APR 14	5.02	5.84

LSD $_{0.05}$ (sowing date x manure) = 0.38

	0	10
TZE COMP3 C3	3.87	5.00
TZL COMP4 C3	4.15	4.98
OKA AWAKA	4.47	5.32

LSD $_{0.05}$ (variety x manure) = 0.28

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	3.72	4.66	4.71	5.43

LSD $_{0.05}$(sowing date) = 0.38

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	4.43	4.57	4.89

LSD $_{0.05}$(variety) = 0.27

Poultry manure(tons/ha)	0	10
	4.16	5.10

LSD $_{0.05}$(poultry manure) = 0.08

Table 45: Effect of sowing date, variety and poultry manure on number of green leaves at 6WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		4.40	5.33	4.40	5.27	5.27	7.07
MAR 15		4.93	6.40	5.13	6.13	5.27	7.00
MAR 30		5.80	8.33	6.07	7.13	6.07	8.40
APR 14		5.93	7.67	6.67	7.93	7.87	8.20

$LSD_{0.05}$ (sowing date x variety x manure) = 0.41

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	4.87	4.83	6.17
MAR 15	5.67	5.63	6.13
MAR 30	7.07	6.60	7.23
APR 14	6.80	7.30	8.03

$LSD_{0.05}$ (sowing date x variety) = 0.32

	0	10
FEB 28	4.69	5.89
MAR 15	5.11	6.51
MAR 30	5.98	7.96
APR 14	6.82	7.93

$LSD_{0.05}$ (sowing date x manure) = 0.21

	0	10
TZE COMP3 C3	5.27	6.93
TZL COMP4 C3	5.57	6.62
OKA AWAKA	6.12	7.67

$LSD_{0.05}$ (variety x manure) = 0.22

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	5.29	5.81	6.97	7.38

$LSD_{0.05}$(sowing date) = 0.17

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	6.10	6.09	6.89

$LSD_{0.05}$(variety) = 0.18

Poultry manure(tons/ha)	0	10
	5.65	7.07

$LSD_{0.05}$(poultry manure) = 0.11

Table 43: Effect of sowing date, variety and poultry manure on number of green leaves at 2WAP

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		2.87	3.00	2.53	3.00	2.20	2.60
MAR 15		2.27	3.07	2.33	3.07	2.13	3.00
MAR 30		2.20	3.07	2.13	3.07	2.07	3.13
APR 14		2.40	3.07	2.47	3.07	2.80	3.20

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	2.93	2.77	2.40
MAR 15	2.67	2.70	2.57
MAR 30	2.63	2.60	2.60
APR 14	2.73	2.77	3.00

LSD $_{0.05}$ (sowing date x variety) = 0.28

	0	10
FEB 28	2.53	2.87
MAR 15	2.24	3.04
MAR 30	2.13	3.09
APR 14	2.56	3.11

LSD $_{0.05}$ (sowing date x manure) = 0.23

	0	10
TZE COMP3 C3	2.43	3.05
TZL COMP4 C3	2.37	3.05
OKA AWAKA	2.30	2.98

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	2.70	2.64	2.61	2.83

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	2.74	2.71	2.64

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	2.37	3.03

LSD $_{0.05}$(poultry manure) = 0.09

OKA AWAKA responded on all sowing dates but April 14. Responses were between 20.5 and 43.1 % for TZE COMP3 C3, 16.4 and 20.5% for TZL COMP4 C3 and 32.1 and 37.7 % for OKA AWAKA. The effect of sowing date x variety interaction was significant on number of leaves at 2 and 6 WAP. At 2 WAP, number of leaves in TZE COMP3 C3 was 11.4 % more when planted on February 28 compared to March 30. OKA AWAKA had 25.0, 16.7 and 15.4 % more leaves when planted on April 14 compared to February 28, March 15 and March 30 respectively. At 6WAP, TZE COMP3 C3 had 16.4, 45.2 and 39.6 % more leaves when planted on March 15, March 30 and April 14 respectively compared to February 28. This variety also had 24.7 and 19.9 % more leaves when planted on March 30 and April 14 respectively compared to March 15. TZL COMP4 C3 had 16.6, 36.6 and 51.1 % more leaves when planted on March 15, March 30 and April 14 respectively compared to February 28. The number of leaves was 17.2 and 29.7 % more when planted on March 30 and April 14 respectively compared to March 15. The number of leaves was 10.6 % more when planted on April 14 compared to March 30. OKA AWAKA had 17.2 and 30.1 % more leaves when planted on March 30 and April 14 respectively compared to February 28, and 17.9 and 31.0 % more leaves when planted on March 30 and April 14 respectively compared to March 15. When planted on April 14, number of leaves was 11.1 % more compared to March 30. Sowing date x poultry manure interaction significantly affected number of leaves at 2, 4 and 6 WAP. Application of poultry manure significantly increased number of leaves at 2 WAP by 13.4, 35.7, 45.1 and 21.5 %; at 4WAP by 26.1, 21.7, 28.1 and 16.3 % and at 6 WAP by 25.6, 27.4, 33.1 and 16.3 % when planted on February 28, March 15, March 30 and April 14 respectively. Variety x poultry manure interaction significantly affected number of leaves at 4 and 6 WAP. Varietal response to poultry application was 29.2, 20.0 and 19.0 % at 4 WAP and 31.5, 18.7 and 25.3 % at 6 WAP for TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA respectively.

4.1.30 Days to 50 % Tasseling

The number of days to 50 % tasseling was significantly affected by sowing date. Maize planted on February 28 (73 days) and March 15(70 days) did not differ significantly in number of days to 50 % tasseling (Table 46). However, they attained 50 % tasseling significantly later than maize planted in March 30 (62.0 days) and April 14 (63.0 days). Among the varieties, TZE COMP3 C3 attained 50 % tasseling significantly earlier (60 days) than other varieties. TZL COMP4 C3 also attained 50 % tasseling significantly earlier (65 days) than OKA AWAKA (75 days). Application of poultry manure significantly reduced number of days to 50 % tasseling by 11.6 % (8 days). There were no significant differences arising from sowing date x variety x poultry manure interaction. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on days to 50 % tasseling.

4.1.31 Days to 50 % Silking

Maize planted on March 30 and April 14 attained 50 % silking in 68 and 67 days respectively. Although they did not differ significantly, they attained 50 % silking significantly earlier than maize planted on February 28 (8 days) and March 15 (75 days) (Table 47). Maize planted on March 15 attained 50 % silking significantly earlier than maize planted on February 28. Among the varieties, TZE COMP3 C3 attained 50 % silking significantly earlier (66 days) than other varieties. TZL COMP4 C3 also attained 50 % silking significantly earlier (70 days) than OKA AWAKA (82 days). Number of days of 50 % silking was significantly reduced by 13.7 % (11 days) when poultry manure was applied. The analysis of sowing date x variety x poultry manure interaction showed that TZE COMP3 C3 and OKA AWAKA responded significantly to poultry manure on all sowing dates while TZL COMP 4 C3 responded significantly on all sowing dates but March 15. Responses ranged

Table 46: Effect of sowing date, variety and poultry manure on number of days to 50% tasseling

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		68.00	62.33	76.67	65.00	88.00	77.67
MAR 15		67.33	59.67	69.00	65.00	81.00	75.00
MAR 30		59.33	50.33	63.67	57.67	75.67	65.67
APR 14		62.00	51.67	67.33	55.33	73.00	66.67
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		65.17	70.83	82.83			
MAR 15		63.50	67.00	78.00			
MAR 30		54.83	60.67	70.67			
APR 14		56.83	61.33	69.83			
LSD $_{0.05}$ (sowing date x variety) = n.s							
		0	10				
FEB 28		77.56	68.33				
MAR 15		72.44	66.56				
MAR 30		66.22	57.89				
APR 14		67.44	57.89				
LSD $_{0.05}$ (sowing date x manure) = n.s							
		0	10				
TZE COMP3 C3		64.17	56.00				
TZL COMP4 C3		69.17	60.75				
OKA AWAKA		79.42	71.25				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		72.94	69.50	62.06	62.67		
LSD $_{0.05}$(sowing date) = 4.25							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		60.08	64.96	75.33			
LSD $_{0.05}$(variety) = 1.72							
Poultry manure(tons/ha)		0	10				
		70.92	62.67				
LSD $_{0.05}$(poultry manure) = 1.13							

Table 47: Effect of sowing date, variety and poultry manure on number of days to 50% silking

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		77.67	70.33	84.67	70.67	97.33	85.33
MAR 15		75.33	64.67	74.00	69.33	87.33	79.00
MAR 30		65.33	54.33	67.67	61.00	87.33	70.00
APR 14		68.67	55.00	72.33	59.00	79.33	70.33
LSD $_{0.05}$ (sowing date x variety x manure) = 6.82							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		74.00	77.67	91.33			
MAR 15		70.00	71.67	83.17			
MAR 30		59.83	64.33	78.67			
APR 14		61.83	65.67	74.83			
LSD $_{0.05}$ (sowing date x variety) = n.s							
		0	10				
FEB 28		86.56	75.44				
MAR 15		78.89	71.00				
MAR 30		73.44	61.78				
APR 14		73.44	61.44				
LSD $_{0.05}$ (sowing date x manure) = 6.01							
		0	10				
TZE COMP3 C3		71.75	61.08				
TZL COMP4 C3		74.67	65.00				
OKA AWAKA		87.83	76.17				
LSD $_{0.05}$ (variety x manure) = n.s							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		81.00	74.94	67.61	67.44		
LSD $_{0.05}$(sowing date) = 5.59							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		66.42	69.83	82.00			
LSD $_{0.05}$(variety) = 2.16							
Poultry manure(tons/ha)		0	10				
		78.08	67.42				
LSD $_{0.05}$(poultry manure) = 1.41							

between 9.5 and 19.9 % for TZE COMP3 C3, 9.9 and 18.4 % for TZL COMP4 C3 and 9.5 and 19.8 % for OKA AWAKA. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on days to 50 % silking.

4.1.32 Anthesis Silking Interval

Analysis of sowing date effect showed that the ASI when maize was planted on March 15, March 30 and April 14, did not differ significantly but were all significantly less than ASI of maize planted on February 28 (Table 48). The ASI for TZE COMP3 C3 (6 days) and OKA AWAKA (7 days) did not differ significantly but both were significantly greater than ASI for TZL COMP4 C3 (5 days). Poultry manure application resulted in a reduction of ASI from 7 to 5 days (28.6 %). TZE COMP 3 C3 responded significantly to poultry manure application when planted on March 15 (37.5 %) and April 14 (50.1 %), while OKA AWAKA responded significantly to poultry manure application when planted on March 30 (62.9 %) and April 14 (42.0 %). The interaction of sowing date x variety significantly affected anthesis-silking interval. ASI in TZE COMP4 C3 reduced by 2(26.4 %), 4(43.4 %) and 4(43.4 %) days when planted on March 15, March 30 and April 14 respectively compared to February 28. In TZL COMP4 C3 ASI reduced by 2(31.6 %), 3(46.3 %) and 3(36.6 %) days when planted on March 15, March 30 and April 14 respectively compared to February 28. In OKA AWAKA ASI reduced by 3(39.2 %) and 4(41.2 %) days when planted on March 15 and April 14 respectively compared to February 28. ASI also reduced in OKA AWAKA by 3(35.4 %) and 3(37.5 %) days when planted on March 15 and April 14 compared to March 30. In response to application of poultry manure ASI reduced by 3.0(33.0 %), 1.0(22.7 %) and 4.0(41.6 %) days in TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA respectively. Sowing date x poultry manure interaction did not have significant effect.

Table 48: Effect of sowing date, variety and poultry manure on anthesis-silking interval (days)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		9.67	8.00	8.00	5.67	9.33	7.67
MAR 15		8.00	5.00	5.00	4.33	6.33	4.00
MAR 30		6.00	4.00	4.00	3.33	11.67	4.33
APR 14		6.67	3.33	5.00	3.67	6.33	3.67

LSD $_{0.05}$ (sowing date x variety x manure) = 2.49

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	8.83	6.83	8.50
MAR 15	6.50	4.67	5.17
MAR 30	5.00	3.67	8.00
APR 14	5.00	4.33	5.00

LSD $_{0.05}$ (sowing date x variety) = 2.16

	0	10
FEB 28	9.00	7.11
MAR 15	6.44	4.44
MAR 30	7.22	3.89
APR 14	6.00	3.56

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	7.58	5.08
TZL COMP4 C3	5.50	4.25
OKA AWAKA	8.42	4.92

LSD $_{0.05}$ (variety x manure) = 1.09

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	8.06	5.44	5.56	4.78

LSD $_{0.05}$(sowing date) = 1.84

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	6.33	4.88	6.67

LSD $_{0.05}$(variety) = 0,90

Poultry manure(tons/ha)	0	10
	7.17	4.75

LSD $_{0.05}$(poultry manure) = 0.56

4.1.33 Ear Height

Maize planted on February 28 had the lowest ear height (54.3 cm) and this was significantly lower than ear height of maize planted on all other sowing dates. The ear height of maize planted on March 15 (76.2 cm) was also significantly lower than ear height of maize planted on March 30 (89.4 cm) (Table 49). Among the varieties, OKA AWAKA had the highest ear height (122.8 cm) which was significantly higher than the ear height of TZE COMP3 C3 (45.9 cm) and TZL COMP4 C3 (55.4 cm). The ear height of TZL COMP4 C3 was significantly higher than the ear height of TZE COMP3 C3. Poultry manure application significantly increased ear height from 60.0 cm to 89.4 cm (49.0 %). The effect of sowing date x variety x poultry manure interaction significantly affected ear height. OKA AWAKA responded significantly to poultry manure application when planted on all sowing dates. The responses were between 24.7 and 53.9 %. TZE COMP3 C3 responded significantly to poultry manure by 46.8, 83.4 and 126.4 % when planted on March 30, March 15 and April 14 respectively. TZL COMP4 C3 responded significantly to poultry manure by 40.9 and 165.8 % when planted on March 15 and April 14 respectively. Sowing date x variety interaction did not have significant effect on ear height. Application of poultry manure significantly increased maize ear height by 30.1, 38.5, 39.9 and 90.3 % when planted on February 28, March 15, March 30 and April 14 respectively. In response to application of poultry manure ear height increased by 25.1(75.1 %), 22.6(51.2 %) and 40.5(39.5 %) cm in TZE COMP3 C3, TZL COMP4 C3 and OKA AWAKA.

Table 49: Effect of sowing date, variety and poultry manure on ear height (cm)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		22.80	35.30	31.40	37.90	87.40	111.00
MAR 15		31.90	58.50	48.60	68.50	111.10	138.50
MAR 30		48.70	71.50	63.40	72.70	111.50	168.40
APR 14		30.30	68.60	33.00	87.70	100.10	154.10

LSD $_{0.05}$ (sowing date x variety x manure) = 16.25

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	29.00	34.60	99.20
MAR 15	45.20	58.50	124.80
MAR 30	60.10	68.00	140.00
APR 14	49.40	60.30	127.10

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	47.20	61.40
MAR 15	63.90	88.50
MAR 30	74.50	104.20
APR 14	54.40	103.50

LSD $_{0.05}$ (sowing date x manure) = 11.42

	0	10
TZE COMP3 C3	33.40	58.50
TZL COMP4 C3	44.10	66.70
OKA AWAKA	102.50	143.00

LSD $_{0.05}$ (variety x manure) = 7.54

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	58.30	76.20	89.40	79.00

LSD $_{0.05}$(sowing date) = 10.68

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	45.90	55.40	122.80

LSD $_{0.05}$(variety) = 5.83

Poultry manure(tons/ha)	0	10
	60.00	89.40

LSD $_{0.05}$(poultry manure) = 4.22

4.1.34 Physiological Maturity

Maize matured in 106 and 104 days when planted on March 30 and April 14. While these maturity times were not significantly different, both were significantly earlier when compared to maturity time of 114 days for maize planted on February 28 and March 15 (Table 50). Among the varieties, TZE COMP3 C3 matured significantly earlier (104 days) than TZL COMP4 C3 (108 days) and OKA AWAKA (117 days). TZL COMP4 C3 matured significantly earlier than OKA AWAKA. Application of poultry manure significantly reduced the number of days to physiological maturity from 111 days to 108 days (3.3 %). The effect of sowing date x variety x poultry manure interaction was significant on physiological maturity. The interaction of sowing date x variety and sowing date x poultry manure did not have significant effect on days to physiological maturity. In response to application of poultry manure TZL COMP4 C3 and OKA AWAKA attained physiological maturity 4.0(3.5 %) and 6.0(4.8 %) days earlier respectively.

4.1.35 Grain Filling Duration

Sowing date significantly affected grain filling duration. Maize planted on March 15 and March 30 had grain filling duration of 39.5 days and 38.2 days. While these did not differ significantly, they were both significantly greater than grain filling duration of 32.7 days for maize planted on February 28 (Table 51). TZL COMP4 C3 had the highest grain filling duration (38 days) among the varieties and this was significantly greater than the lowest grain filling duration of 35.1 days for OKA AWAKA. Application of poultry manure increased grain filling duration by 20.4 %. As a result of sowing date x variety x poultry manure interaction effect grain filling duration in TZE COMP3 C3 significantly increased by 18.8 to 40.2 % in response to poultry manure when planted on all sowing dates. TZL COMP4 C3 responded significantly to poultry manure by 27.3 and 29.2 % when planted on February 28

Table 50: Effect of sowing date, variety and poultry manure on physiological maturity (days)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		107.33	106.33	114.00	108.00	126.67	120.00
MAR 15		108.67	107.00	115.67	113.00	123.33	119.00
MAR 30		102.67	98.67	105.00	102.33	116.33	110.00
APR 14		99.33	98.00	104.33	100.33	113.67	108.00
LSD $_{0.05}$ (sowing date x variety x manure) = n.s							
		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
FEB 28		106.83	111.00	123.33			
MAR 15		107.83	114.33	121.17			
MAR 30		100.67	103.67	113.17			
APR 14		98.67	102.33	110.83			
LSD $_{0.05}$ (sowing date x variety) = n.s							
		0	10				
FEB 28		116.00	111.44				
MAR 15		115.89	113.00				
MAR 30		108.00	103.67				
APR 14		105.78	102.11				
LSD $_{0.05}$ (sowing date x manure) = n.s							
		0	10				
TZE COMP3 C3		104.50	102.50				
TZL COMP4 C3		109.75	105.92				
OKA AWAKA		120.00	114.25				
LSD $_{0.05}$ (variety x manure) = 2.09							
Sowing date		FEB 28	MAR 15	MAR 30	APR 14		
		113.72	114.44	105.83	103.94		
LSD $_{0.05}$(sowing date) = 3.50							
Variety		TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA			
		103.50	107.83	117.12			
LSD $_{0.05}$(variety) = 1.71							
Poultry manure(tons/ha)		0	10				
		111.42	107.56				
LSD $_{0.05}$(poultry manure) = 1.07							

Table 51: Effect of sowing date, variety and poultry manure on grain filling duration

Sowing date	Poultry manure	TZE COMP3 C3 0	TZE COMP3 C3 10	TZL COMP4 C3 0	TZL COMP4 C3 10	OKA AWAKA 0	OKA AWAKA 10
FEB 28		29.67	36.00	29.33	37.33	29.33	34.67
MAR 15		33.33	42.33	41.67	43.67	36.00	40.00
MAR 30		37.33	44.33	37.33	41.33	29.00	40.00
APR 14		30.67	43.00	32.00	41.33	34.33	37.67

LSD $_{0.05}$ (sowing date x variety x manure) = 5.63

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	32.83	33.33	32.00
MAR 15	37.83	42.67	38.00
MAR 30	40.83	39.33	34.50
APR 14	36.83	36.67	36.00

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	29.44	36.00
MAR 15	37.00	42.00
MAR 30	34.56	41.89
APR 14	32.33	40.67

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	32.75	41.42
TZL COMP4 C3	35.08	40.92
OKA AWAKA	32.17	38.08

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	32.72	39.50	38.22	36.50

LSD $_{0.05}$(sowing date) = 4.39

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	37.08	38.00	35.12

LSD $_{0.05}$(variety) = 1.99

Poultry manure(tons/ha)	0	10
	33.33	40.14

LSD $_{0.05}$(poultry manure) = 1.17

and April 14 respectively. OKA AWAKA responded significantly to poultry manure by 37.9 % only when planted on March 30. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on grain filling duration.

4.1.36 Number of rows per cob

As presented in Table 52, maize planted on March 30 had significantly more grain rows per cob (13.7) than maize planted on February 28(12.5) and April 14(13.2). Maize planted on March 15 and April 14 did not differ significantly in number of grain rows per cob but they were significantly more than the grain rows per cob in maize planted on February 28. Among the varieties, OKA AWAKA had the highest number of grain rows per cob (14.0) which was significantly more than the grain rows per cob in other varieties. Number of grain rows per cob was significantly more in TZE COMP3 C3 (13.0) than the grain rows per cob in TZL COMP4 C3 (12.4). Application of poultry manure significantly increased number of grain rows per cob by 9.4 %. The interaction of sowing date x variety, variety x poultry manure and sowing date x poultry manure did not have significant effect on number of rows per cob.

4.1.37 Number of grains per row

Sowing date did not significantly affect the number of grains per row (Table 53). Among the varieties however, OKA AWAKA had the highest number of grains per row (26.3) which was significantly more than the grains per row in the other varieties. Number of grains per row was significantly more in TZL COMP4 C3 (24.5) than the grains per row in TZE COMP3 C3 (22.4). Application of poultry manure significantly increased number of grains per row by 27.1 %. The number of grains per row in TZE COMP3 C3 increased by 20.5 %

Table 52: Effect of sowing date, variety and poultry manure on number of rows per cob

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		11.43	13.07	10.53	12.67	13.47	13.73
MAR 15		13.20	13.20	12.67	13.07	13.07	14.57
MAR 30		13.20	14.00	12.53	12.93	14.00	15.33
APR 14		11.60	14.53	12.00	13.07	13.03	14.67

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	12.25	11.60	13.60
MAR 15	13.20	12.87	13.82
MAR 30	13.60	12.73	14.67
APR 14	13.07	12.53	13.85

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	11.81	13.16
MAR 15	12.98	13.61
MAR 30	13.24	14.09
APR 14	12.21	14.09

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	12.36	13.70
TZL COMP4 C3	11.93	12.93
OKA AWAKA	13.39	14.57

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	12.48	13.29	13.67	13.15

LSD $_{0.05}$(sowing date) = 0.51

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	13.03	12.43	13.98

LSD $_{0.05}$(variety) = 0.48

Poultry manure(tons/ha)	0	10
	12.56	13.74

LSD $_{0.05}$(poultry manure) = 0.50

Table 53: Effect of sowing date, variety and poultry manure on number of grains per row

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		17.47	23.20	17.00	24.47	24.80	29.33
MAR 15		20.35	24.73	25.33	28.13	24.60	28.85
MAR 30		21.67	27.33	26.47	28.63	21.60	32.07
APR 14		18.03	26.67	18.20	27.58	22.20	26.73

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	20.33	20.73	27.07
MAR 15	22.54	26.73	26.72
MAR 30	24.50	27.55	26.83
APR 14	22.35	22.89	24.47

LSD $_{0.05}$ (sowing date x variety) = 3.70

	0	10
FEB 28	19.76	25.67
MAR 15	23.43	27.24
MAR 30	23.24	29.34
APR 14	19.48	26.99

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	19.38	25.48
TZL COMP4 C3	21.75	27.20
OKA AWAKA	23.30	29.25

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	22.71	25.33	26.29	23.24

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	22.43	24.48	26.27

LSD $_{0.05}$(variety) = 1.47

Poultry manure(tons/ha)	0	10
	21.48	27.31

LSD $_{0.05}$(poultry manure) = 1.22

when planted on March 30 compared to February 28. In TZL COMP4 C3 number of grains per row increased by 28.9 and 32.9 % when planted on March 15 and March 30 respectively compared to February 28, and 16.8 and 20.4 % when planted on March 15 and March 30 respectively compared to April 14. Interaction of sowing date x poultry manure and variety x poultry manure did not have significant effect.

4.1.38 Number of grains per cob

Maize planted on March 30 produced the greatest number of grains per cob (361.6), but this was only significantly more than the number of grains per cob produced when maize was planted on February 28(288.7) (Table 54). OKA AWAKA produced the greatest number of grains per cob (370.4) among the varieties. This was significantly more than grains per cob in TZE COMP3 C3 (296.0) and TZL COMP4 C3 (308.1). Number of grains per cob significantly increased by 38.3 % in response to poultry manure application. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on number of grains per cob.

4.1.39 Hundred Seed Weight

The weight of hundred seeds of maize was not significantly affected by sowing date (Table 55). TZL COMP4 C3 had a significantly greater weight of hundred seeds (20.5 g) than TZE COMP3 C3 (18.5 g) and OKA AWAKA (18.5 g). Poultry manure application significantly increased weight of hundred seeds from 16.7 to 21.7 g (29.8 %). The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on weight of hundred seeds.

Table 54: Effect of sowing date, variety and poultry manure on number of grains per cob

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		200.70	303.60	179.90	309.40	335.70	403.10
MAR 15		271.60	324.20	321.30	371.60	320.30	425.50
MAR 30		288.30	382.70	332.40	370.50	303.10	492.70
APR 14		208.90	387.70	218.40	361.70	290.50	392.60

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	252.20	244.70	369.40
MAR 15	297.90	346.40	372.90
MAR 30	335.50	351.40	397.90
APR 14	298.30	290.10	341.50

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	238.80	338.70
MAR 15	304.40	373.80
MAR 30	307.90	415.30
APR 14	239.30	380.70

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	242.40	349.50
TZL COMP4 C3	263.00	353.30
OKA AWAKA	312.40	428.50

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	288.70	339.10	361.60	310.00

LSD $_{0.05}$(sowing date) = 51.65

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	296.00	308.10	370.40

LSD $_{0.05}$(variety) = 27.12

Poultry manure(tons/ha)	0	10
	272.60	377.10

LSD $_{0.05}$(poultry manure) = 23.99

Table 55: Effect of sowing date, variety and poultry manure on hundred seed weight (g)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		13.76	21.16	17.01	21.74	18.10	21.52
MAR 15		15.68	21.50	18.77	25.62	16.96	19.88
MAR 30		18.43	22.24	18.03	23.77	15.35	20.02
APR 14		14.40	21.09	17.08	21.82	16.76	19.64

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	17.46	19.38	19.81
MAR 15	18.59	22.20	18.42
MAR 30	20.33	20.90	17.69
APR 14	17.75	19.45	18.20

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	16.29	21.48
MAR 15	17.14	22.34
MAR 30	17.27	22.01
APR 14	16.08	20.85

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	15.57	21.50
TZL COMP4 C3	17.72	23.24
OKA AWAKA	16.79	20.27

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	18.88	19.74	19.64	18.46

LSD $_{0.05}$(sowing date) = n.s

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	18.53	20.48	18.53

LSD $_{0.05}$(variety) = 1.31

Poultry manure(tons/ha)	0	10
	16.69	21.67

LSD $_{0.05}$(poultry manure) = 1.08

4.1.40 Grain Yield

Maize grain yield was significantly affected by sowing date. Grain yield was greatest when maize was planted on March 30 (3.19 tons/ha) but this was only significantly greater than maize planted on February 28(2.34 tons/ha) and April 14(2.69 tons/ha). Maize planted on March 15 had a significantly greater grain yield (2.86 tons/ha) than maize planted on February 28 (Table 56). Maize varieties did not differ significantly in grain yield. Application of poultry manure significantly, increased maize grain yield by 61.3 %. The interaction of sowing date x variety, sowing date x poultry manure and variety x poultry manure did not have significant effect on grain yield.

Table 56: Effect of sowing date, variety and poultry manure on grain yield (tons/ha)

Sowing date	Poultry manure	TZE COMP3 C3		TZL COMP4 C3		OKA AWAKA	
		0	10	0	10	0	10
FEB 28		1.90	2.32	1.50	2.53	2.49	3.32
MAR 15		1.97	3.34	2.61	3.87	2.08	3.29
MAR 30		2.36	3.85	2.57	4.06	2.17	4.13
APR 14		1.14	3.74	2.12	3.67	2.55	2.92

LSD $_{0.05}$ (sowing date x variety x manure) = n.s

	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
FEB 28	2.11	2.02	2.91
MAR 15	2.66	3.24	2.69
MAR 30	3.10	3.32	3.15
APR 14	2.44	2.89	2.74

LSD $_{0.05}$ (sowing date x variety) = n.s

	0	10
FEB 28	1.96	2.72
MAR 15	2.22	3.50
MAR 30	2.37	4.01
APR 14	1.94	3.44

LSD $_{0.05}$ (sowing date x manure) = n.s

	0	10
TZE COMP3 C3	1.84	3.31
TZL COMP4 C3	2.20	3.53
OKA AWAKA	2.32	3.42

LSD $_{0.05}$ (variety x manure) = n.s

Sowing date	FEB 28	MAR 15	MAR 30	APR 14
	2.34	2.86	3.19	2.69

LSD $_{0.05}$(sowing date) = 0.43

Variety	TZE COMP3 C3	TZL COMP4 C3	OKA AWAKA
	2.58	2.87	2.87

LSD $_{0.05}$(variety) = n.s

Poultry manure(tons/ha)	0	10
	2.12	3.42

LSD $_{0.05}$(poultry manure) = 0.27

4.1.41 Correlation Coefficients

The correlation coefficients of grain yield and yield components in 2009 are shown in Table 57. At 4 and 6 WAP, stem dry matter and leaf dry matter correlated positively and significantly with grain filling duration. At 6 WAP leaf area correlated positively and significantly with grain yield. Leaf area at 2, 4 and 6 WAP stem dry matter and leaf dry matter correlated negatively and significantly with anthesis-silking interval. At 4 and 6 WAP stem dry matter correlated negatively and significantly with tasseling and silking. Leaf dry matter at 4 WAP correlated negatively and significantly with silking, while leaf dry matter at 6 WAP correlated negatively and significantly with tasseling and silking. Grain yield correlated positively and significantly with number of grains per row and number of grains per cob. Tasseling and silking correlated significantly with anthesis-silking interval. Tasseling significantly with silking while grain filling duration correlated negatively and significantly with anthesis-silking interval.

The correlation coefficients of grain yield and yield components in 2010 are shown in Table 58. At 2 WAP stem dry matter correlated positively and significantly with grain filling duration and grain yield, and negatively and significantly with tasseling, silking and anthesis-silking interval. Leaf dry matter correlated positively and significantly with number of grains per row, number of grains per cob and grain yield, and negatively and significantly with tasseling, silking and anthesis-silking interval. At 4 WAP stem dry matter correlated positively and significantly with grain yield, and negatively and significantly with silk and anthesis-silking interval. Leaf dry matter correlated positively and significantly with number of grains per cob and grain yield. At 6 WAP stem dry matter correlated negatively and significantly with tasseling and silking. Leaf area at 2, 4 and 6 WAP correlated positively and

Table 57: Correlation coefficients of grain yield and yield components in 2009

	SDM4	SDM6	LDM2	LDM4	LDM6	LA2	LA4	LA6	TASS	SILK	ASI	GF	RPC	GPR	GPC	HSW	GY
SDM2	.652**	.326**	.861**	.628**	.358**	.464**	.535**	.625**	-.331**	-.344**	-.369**	.405**	0.179	.271*	.279*	.291*	.478**
SDM4		.672**	.653**	.955**	.691**	.624**	.618**	.702**	-.571**	-.625**	-.658**	.562**	0.08	.237	.231	.335**	.389**
SDM6			.446**	.719**	.971**	.556**	.609**	.616**	-.599**	-.645**	-.653**	.573**	0.023	.260*	0.228	0.215	0.198
LDM2				.645**	.440**	.424**	.585**	.595**	-.293*	-.320**	-.360**	.417**	.280*	.330**	.364**	.244*	.398**
LDM4					.752**	.695**	.691**	.744**	-.477**	-.538**	-.631**	.578**	0.146	.265*	.279*	.298*	.410**
LDM6						.601**	.615**	.657**	-.561**	-.618**	-.677**	.611**	0.026	.293*	.258*	.239*	.299*
LA2							.678**	.644**	-.345**	-.394**	-.474**	.489**	0.069	.279*	.259*	.2388	.302**
LA4								.862**	-.349**	-.392**	-.431**	.405**	.309**	.336**	.375**	0.162	.366**
LA6									-.390**	-.448**	-.558**	.483**	.317**	.395**	.449**	.2458	.557**
TASS										-.988**	.565**	-.470**	.322**	-0.103	0.032	-.369**	-0.093
SILK											.667**	-.511**	.281*	-0.158	-0.03	-.373**	-.014
ASI												-.523**	-0.01	-.339**	-.304**	-.274*	-.353**
GF													-0.126	0.153	0.112	.4468*	.303**
RPC														.361**	.640**	-.270*	.416**
GPR															.926**	-0.038	.649**
GPC																-0.066	.673**
HSW																	0.217

*correlation is significant at the 0.05 level ; **correlation is significant at the 0.01 level

SDM2 - Stem dry matter at 2 WAP
SDM4 - Stem dry matter at 4WAP
SDM6 - Stem dry matter at 6WAP
LDM2 - Leaf dry matter at 2WAP
LDM4 - Leaf dry matter at 4WAP
LDM6 - Leaf dry matter at 6WAP
LA2 - Leaf area at 2WAP
LA4 - Leaf area at 4WAP
LA6 - Leaf area at 6WAP
TASS - Days to 50% tasseling
SILK - Days to 50% silking
ASI - Anthesis –silking interval
GF - Grain filling duration
RPC - Number of rows per cob
GPR - Number of grains per row
GPC - Number of grain per cob
HSW - Weight of 100 seeds
GY - Grain yield

Table 58: Correlation coefficients of grain yield and yield components in 2010

	SDM4	SDM6	LDM2	LDM4	LDM6	LA2	LA4	LA6	TASS	SILK	ASI	GF	RPC	GPR	GPC	HSW	GY
SDM2	.607**	.612**	.674**	.533**	.543**	.534**	.502**	.533**	-.710**	-.734**	-.571**	.560**	.306**	.403**	.411**	.450**	.523**
SDM4		.875**	.744**	.932**	.848**	.594**	.769**	.798**	-.491**	-.536**	-.513**	.450**	.369**	.449**	.468**	.420**	.526**
SDM6			.750**	.820**	.946**	.558**	.745**	.821**	-.541**	-.554**	-.418**	.296**	.326**	.333**	.366**	0.231**	.404**
LDM2				.742**	.786**	.633**	.632**	.666**	-.583**	-.646**	-.603**	.471**	.421**	.515**	.538**	.431**	.521**
LDM4					862**	.609**	.703**	.743**	-.356**	-.409**	-.443**	.392**	.431**	.474**	.503**	.450**	.541**
LDM6						.612**	.709**	.809**	-.459**	-.481**	-.404**	.262**	.387**	.378**	.422**	.276**	.439**
LA2							.522**	.670**	-.423**	-.472**	-.506**	.449**	.288**	.581**	.537**	.586**	.631**
LA4								.888**	-.412**	-.501**	-.652**	.529**	.420**	.469**	.491**	.330**	.572**
LA6									-.429**	-.500**	-.579**	.508**	.515**	.526**	.568**	.384**	.601**
TASS										-.975**	-.574**	.622**	-0.108**	-.248**	-0.228**	-.437**	-.408**
SILK											-.723**	-.711**	-0.165**	-.353**	-.327**	-.511**	-.494**
ASI												-.759**	-.309**	-.585**	-.547**	-.599**	-.627**
GF													.384**	.599**	.574**	.670**	.712**
RPC														.605**	.790**	.300**	.584**
GPR															.958**	.642**	.802**
GPC																.591**	.794**
HSW																	.705**

*correlation is significant at the 0.05 level ; **correlation is significant at the 0.01 level

SDM2 - Stem dry matter at 2 WAP
SDM4 - Stem dry matter at 4WAP
SDM6 - Stem dry matter at 6WAP
LDM2 - Leaf dry matter at 2WAP
LDM4 - Leaf dry matter at 4WAP
LDM6 - Leaf dry matter at 6WAP
LA2 - Leaf area at 2WAP
LA4 - Leaf area at 4WAP
LA6 - Leaf area at 6WAP
TASS - Days to 50% tasseling
SILK - Days to 50% silking
ASI - Anthesis –silking interval
GF - Grain filling duration
RPC - Number of rows per cob
GPR - Number of grains per row
GPC - Number of grain per cob
HSW - Weight of 100 seeds
GY - Grain yield

significantly with stem dry matter and leaf dry matter. At 2 WAP leaf area correlated significantly with number of grains per row, number of grain per cob, weight of 100 seeds and grain yield. Leaf area at 4 WAP correlated positively and significantly with silking, grain filling duration and grain yield, and negatively and significantly with anthesis-silking interval. Leaf area at 6 WAP correlated significantly with grain filling duration, number of grain rows per cob, number of grains per row, number of grains per cob and grain yield. Grain yield correlated significantly with grain filling duration, number of grain rows per cob, number of grains per row, number of grains per cob and weight of 100 seeds. Grain yield also correlated negatively and significantly with anthesis-silking interval. Tasseling correlated positively and significantly with silking and anthesis-silking interval, and negatively and significantly with grain filling duration. Silking correlated positively and significantly with anthesis-silking interval and negatively and significantly with grain filling duration. Anthesis-silking interval correlated negatively and significantly with grain filling duration, number of grains per row, number of grains per cob and weight of 100 seeds.

4.2 Discussion

In this study sowing date (time of planting) had significant effects on maize vegetative and reproductive growth in 2009 and 2010, while yield and yield components were only affected significantly in 2010. In 2009, when compared to maize planted on April 14, maize planted on February 28 had 66.2 and 47.6 % reduction in height at 4 and 6WAP; 69.8 and 53.4 % reduction in leaf area index at 4 and 6 WAP; 40.0, 41.1 and 73.3 % reduction in leaf dry matter at 2,4 and 6 WAP; 37.0 and 85.1 % reduction in stem dry matter at 4 and 6 WAP and 41.4 and 26.1 % reduction in number of green leaves at 4 and 6 WAP. Maize planted on March 15, when compared to maize planted on April 14 had 36.8 % reduction in height at 6 WAP; 32.6% reduction in leaf area index at 4 WAP; 46.8 and 70.0 % reduction in leaf dry matter at 4 and 6 WAP; 47.8 and 85.3 % reduction in stem dry matter at 4 and 6

WAP and 22.8 % reduction in number of green leaves at 4 WAP. In 2010, when compared to maize planted on April 14, maize planted on February 28 had 58.9 and 54.9 % reduction in height at 4 and 6 WAP; 17.7, 85.3 and 68.9 % reduction in leaf are index at 2,4 and 6 WAP; 36.0 and 67.1 % reduction in leaf dry matter at 2 and 6 WAP; 25.0, 44.7 and 72.0 % reduction in stem dry matter at 2, 4 and 6 WAP and 31.7 and 28.3 % reduction in number of green leaves at 4and 6 WAP. Maize planted on March 15, when compared with maize planted on April 14 had 40.5 % reduction in height at 6 WAP; 29.4, 67.7 and 51.4% reduction in leaf area index at 2, 4 and 6WAP; 48.0, 53.0 and 67.1 % reduction in leaf dry matter at 2,4 and 6 WAP; 25.0, 53.2 and 80.5 % reduction in stem dry matter at 2,4 and 6 WAP and 14.2 and 21.3 % reduction in number of green leaves at 4 and 6 WAP. It is obvious therefore that maize planted on February 28 and March 15 had reduced vegetative growth compared to maize planted on March 30 and April 14 which were not significantly different from each other. This can be attributed to the variation in the amount of moisture available in the soil. Within the planting months, April had the highest rainfall (237.8 mm and 125.5 mm for 2009 and 2010 respectively) while February had the lowest rainfall (65.8 mm and 36.0 mm for 2009 and 2010 respectively). Consequently, soil moisture was highest during April 14 planting and lowest during February 28 planting. Moisture deficit reduces plant growth primarily through its effects on cell enlargement and cell division (Jones, 1992) and consequently leaf expansion (Nonami, 1998). Rahman *et al.,* (2004) reported the retardation of the seedling growth of corn cultivars by inhibition of root/shoot length and dry mass production. Reduction in leaf area and plant growth in response to water deficit is actually an attempt by the plants to increase water use efficiency through reduction in their rate of transpiration (Xu and Zhou, 2008). The high sensitivity of leaf growth to water deficits is considered to be a ‘stress avoidance’ mechanism, because it enables plants to tolerate severe drought conditions by saving soil water (Lopes *et al.,* 2011). The overall effect of moisture deficit on maize vegetative growth is the reduction in total biomass accumulation through reduction in plant height, stem diameter and leaf area (Otegui *et al.,* 1995; Khan *et al.,* 2001).

Among maize varieties significant differences occurred in plant height, leaf dry matter and number of green leaves but not in leaf area index and stem dry matter during the 2009 season. At 2 WAP, TZE COMP3 C3 attained a height of 7.31 cm which was 11.4 and 19.8 % higher than TZL COMP 4 C3 (6.56 cm) and OKA AWAKA (6.10 cm) respectively. Leaf dry matter accumulation was 33.3 % and 21.7 % greater in TZL COMP 4 C3 than in TZE COMP3 C3 and OKA AWAKA respectively at 2 WAP. Number of green leaves was 8.0 % more in OKA AWAKA than in TZE COMP3 C3 at 4 WAP. In the 2010 season, there were significant differences among maize varieties in all the parameters measured. At 2 WAP TZL COMP4 C3 performed better than TZE COMP 3 C3 and OKA AWAKA by 28.6 and 12.5 % in leaf area index. TZL COMP 4 C3 was 23.3 % better than TZE COMP3 C3 in leaf dry matter at 4WAP and 16.7 % better than OKA AWAKA in stem dry matter at 2 WAP. At 4 and 6WAP OKA AWAKA performed better than TZE COMP3 C3 and TZL COMP4 C3 in height, leaf area index and number of green leaves. OKA AWAKA also performed better than TZE COMP3 C3 in leaf area index at 2WAP and in leaf dry matter at 4WAP. These results show that the late maturing varieties were superior to the early maturing variety with regard to vegetative growth. Differences in dry matter accumulation may have resulted from differences in leaf area, height and number of green leaves which determine canopy structure and light interception (Keating and Wafula, 1991; Maddoni and Otegui, 1996; Idinobaa *et al.,* 2002; Stewart *et al.*, 2003). Adeniyi (2011) had reported the significant superiority of a late maturing maize variety (TZSR-W) to an early variety (TZESR-W) in terms of plant height and leaf area. The superiority of the late maturing varieties (TZL COMP4 C3 and OKA AWAKA) is attributed to more effective utilization of the long growing season for growth and dry matter accumulation (Sallah *et al.,* 1997).

Application of poultry manure significantly increased all vegetative growth parameters at 2, 4 and 6 WAP in 2009 and 2010. In 2009, poultry manure increased height by 36.2, 92.6 and 94.9 %; leaf area index by 33.3, 135.3 and 137.2 %; leaf dry matter by 120.0, 131.8 and 105.7 %, stem dry matter by 83.3, 133.3 and 115.4 % and number of green leaves by 7.6, 20.0 and 22.5 % at 2, 4 and 6 WAP respectively. In 2010 poultry manure application increased height by 63.8, 97.5 and 120.7 %; leaf area index by 100.0, 210.0 and 193.3 % ; leaf dry matter by 73.3, 95.8 and 129.4 %; stem dry matter by 50.0, 108.3 and 124.0 % and number of green leaves by 27.8, 22.6 and 25.1 % at 2,4 and 6 WAP respectively. The use of poultry manure as organic soil amendment and its capacity to improve growth has been reported for different crops including sweet potato (Ojeniyi and Adejobi, 2005; Okonkwo *et al.*, 2009), cocoyam (Obasi *et al.*, 2005), Okra (Ndaeyo *et al.*, 2005), and pumpkin (Cucurbita maxima) (Ibeawuchi, 2009). The effect of poultry manure on maize vegetative parameters reported in this study agrees with the findings of Uduma and Eka (2006) that poultry manure applied at the rate of 10 tons/ha significantly increased maize height, leaf number, leaf area, leaf dry weight and stem dry weight. Poultry manure improves soil fertility through the enhancement of soil organic matter (Onwuka and Asawalam, 2006) and supply of exchangeable cations (Boateng *et al.*, 2006).

In 2009, the effect of sowing date x variety x poultry manure interaction was significant on leaf area index at 6 WAP and number of green leaves at 6 WAP. In 2010 the effect of sowing date x variety x poultry manure interaction was significant on height at 4 WAP, leaf area index at 2 and 4 WAP and number of green leaves at 4 and 6 WAP. The results show that poultry manure application affected all the maize varieties on almost all the sowing dates. Since the response of maize varieties to poultry manure was not limited to the early sowing dates, the effect of poultry manure may not be attributed to moisture conservation alone. The results suggest that poultry manure could probably play a dual role of supplying nutrient and conserving water. However, this study could not determine the extent to which each role contributed to the total effect on vegetative growth. In 2009 sowing date x variety interaction had significant effect on height at 4 WAP, leaf area index at 2, 4 and 6 WAP, leaf dry matter at 4 and 6 WAP, stem dry matter at 6 WAP and number of leaves at 2, 4 and 6 WAP. In 2010 sowing date x variety interaction had significant effect on height at 2 WAP, leaf area index at 2, and 4 WAP, leaf dry matter at 6 WAP, stem dry matter at 4 and 6 WAP and number of leaves at 2, and 6 WAP. The results showed that vegetative growth was enhanced when maize varieties were planted at the later sowing dates, thus indicating that the varieties used in this experiment were all sensitive to moisture stress. However, OKA AWAKA showed the greatest sensitivity during vegetative growth considering that it showed the greatest response to sowing date in dry matter accumulation. In 2009 sowing date x poultry manure interaction had significant effect on height at 2 WAP, leaf area index at 2, and 4 WAP, leaf dry matter at 6 WAP, stem dry matter at 4 and 6 WAP and number of leaves at 2, and 6 WAP. In 2010 sowing date x poultry manure interaction had significant effect on height, leaf area index, leaf dry matter, stem dry matter and number of leaves at 2, 4 and 6 WAP. These results show that application of poultry manure improved vegetative growth on all sowing dates. However, the improvement was greater at the later sowing dates. Therefore, poultry manure application was able to cushion the effect of moisture stress on vegetative growth.

In the 2009 season, maize planted on February 28 attained 50 % tasseling 8.0 and 12.0 days later than maize planted on March 30 and April 14. Maize planted on March 15 attained 50 % tasseling 9.0 days later than maize planted on April 14. Similarly, maize planted on February 28 attained 50 % silking 10.0 and 15.0 days later than maize planted on March 30 and April 14, while maize planted on March 15 attained 50 % silking 11.0 days later than maize planted on April 14. Anthesis silking interval was 2.0 and 3.0 days more in maize planted on February 28 than in maize planted on March 30 and April 14. In maize planted on March 15 anthesis silking interval was 2.0 days more than maize planted on March 30 and April 14. Physiological maturity occurred 11.0 and 7.0 days later in maize planted on February 28 and March 15 than maize planted on April 14, while it occurred 6.0 days later in maize planted on February 28 than maize planted on March 30. Compared to maize planted on April 14 ear height was reduced by 35.2, 18.9 and 12.4 cm in maize planted on February 28, March 15 and March 30 respectively. In maize planted on February 28 ear height was reduced by 16.2 and 22.8 cm compared to maize planted on March 15 and March 30. In the 2010 season, maize planted on February 28 attained 50 % tasseling 11.0 and 10.0 days later than maize planted on March 30 and April 14, while maize planted on March 15 attained 50 % tasseling 7.0 days later than maize planted on March 30 and April 14. Maize planted on February 28 also attained 50 % silking 6.0, 13.0 and 14.0 days later than maize planted on March 15, March 30 and April 14 respectively, while maize planted on March 15 attained 50% silking 11.0 days later than maize planted on March 30 and April 14. Anthesis silking interval was 3.0 days more in maize planted on February 28 than maize planted on March 15, March 30 and April 14, while physiological maturity occurred 8.0 and 10.0 days later in maize planted on February 28 than maize planted on March 30 and April 14. In maize planted on March 15, physiological maturity occurred 9.0 and 11.0 days later than in maize planted on March 30 and April 14. Grain filling duration was 7.0 and 6.0 days less in maize planted on February 28 than in maize planted on March 15 and March 30. Compared to maize planted on March 15, March 30 and April 14, ear height was reduced in maize planted on February 28 by 28.7 % (21.9 cm), 39.3 % (35.1 cm) and 31.3 % (24.7 cm) respectively. In maize planted on March 15 ear height was reduced by 14.8 % (13.2 cm) compared to maize planted on March 30. The significant increase in days to 50 % tasseling, days to 50 % silking, anthesis-silking interval and physiological maturity when maize was planted on February 28 and March 15 indicate a delay in the attainment of maturity by maize varieties, which must have occurred in response to moisture deficit. This confirms earlier reports that moisture stress delays silking and increases anthesis-silking interval (Bolanos and Edmeades, 1996; Kamara *et al.,* 2003; Munyiri *et al.,* 2010; Ali *et al.,* 2011). Furthermore, the results showed a decreasing trend in days to 50 % tasseling, 50 % silking, anthesis silking interval and physiological maturity as the sowing date progressed from February 28 to April 14. This was an indication that time of planting affected maize phenology.

The results indicated that among maize varieties in the 2009 season, OKA AWAKA attained 50 % tasseling and 50 % silking 19.0 and 12.0 days later than TZE COMP3 C3 and TZL COMP4 C3. TZL COMP4 C3 attained 50 % tasseling and 50 % silking 7.0 days later than TZE COMP3 C3. Differences in anthesis silking interval among the maize varieties were not significant. Physiological maturity occurred 20.0 and 8.0 days later in OKA AWAKA than TZE COMP3 C3 and TZL COMP4 C3 while it occurred 12.0 days later in TZL COMP4 C3 than TZE COMP3 C3. Grain filling duration was 4.0 days more in TZL COMP4 C3 than TZE COMP3 C3 and OKA AWAKA. Maize ears were 133.0 % (68.6 cm) and 101.0 % (60.4 cm) higher in OKA AWAKA when compared to TZE COMP3 C3 and TZL COMP4 C3. Maize ears were 15.9 % (8.2 cm) higher in TZL COMP4 C3 than TZE COMP3 C3. In the 2010 season, OKA AWAKA attained 50 % tasseling 15.0 and 10.0 days later than TZE COMP3 C3 and TZL COMP4 C3. TZL COMP4 C3 attained 50 % tasseling 5.0 days later than TZE COMP3 C3. Similarly, OKA AWAKA attained 50 % silking 16.0 and 12.0 days later than TZE COMP3 C3 and TZL COMP4 C3. TZL COMP4 C3 also attained 50 % silking 3.0 days later than TZE COMP3 C3. Anthesis silking interval was 2.0 days and 1.0 day more in OKA AWAKA and TZE COMP3 C3 than TZL COMP4 C3. Physiological maturity occurred 14.0 and 9.0 days later in OKA AWAKA than TZE COMP3 C3 and TZL COMP4 C3, while it occurred 4.0 days later in TZL COMP4 C3 than TZE

COMP3 C3. Grain filling duration was 3.0 days more in TZL COMP4 C3 than OKA AWAKA. Maize ears were 167.5 % (76.9 cm) and 121.7 % (67.4 cm) higher in OKA AWAKA than TZE COMP3 C3 and TZL COMP4 C3. Compared to TZE COMP3 C3, maize ears were 20.7 % (9.5 cm) higher in TZL COMP4 C3. Differences in time of attainment of different developmental stages (tasseling, silking, physiological maturity) was a manifestation of the maturity group of the maize varieties which is a genetic factor. Thus, TZE COMP3 C3 is an early maturing variety while TZL COMP4 C3 and OKA AWAKA are late maturing varieties. TZL COMP4 C3 which had the highest grain filling duration in 2009 and 2010 as well as the lowest anthesis-silking interval is considered the most physiologically desirable among the three maize varieties. Bolanos and Edmeades (1996) reported that anthesis-silking interval correlated more strongly and more negatively with grain yield when moisture stress intensified and yield levels declined. Therefore, selection for reduced anthesis silking interval has been successfully used to increase the drought tolerance of maize (Faud-Hassan *et al.,* 2008).

Poultry manure application significantly reduced days to 50 % tasseling, days to 50 % silking, anthesis silking interval and days to physiological maturity in 2009 and 2010. The results for 2009 show that compared to when poultry manure was applied at 10 tons/ha the non application of poultry manure increased the number of days to 50 % tasseling by 6.0 days; days to 50 % silking by 8.0 days; anthesis silking interval by 2.0 days; days to physiological maturity by 4.0 days. Ear height was reduced by 20.8 cm and grain filling duration by 3.0 days. In 2010, non application of poultry manure increased the number of days to 50 % tasseling by 8.0 days; days to 50 % silking by 11.0 days; anthesis silking interval by 2.0 days; days to physiological maturity by 4.0 days. Ear height was reduced by 29.4 cm and grain filling duration by 7.0 days. This shows that application of poultry manure hastens maturity in maize. This may be attributed to the supply of plant nutrients particularly phosphorus. A good supply of phosphorus has been associated with increased root growth and hastening of maturity, particularly in cereals (Ting, 1982).

In 2009 sowing date x variety x poultry manure interaction significantly affected days to 50 % tasseling, days to 50 % silking, anthesis-silking interval and grain filling duration. In 2010 sowing date x variety x poultry manure interaction significantly affected days to 50 % silking, anthesis-silking interval, grain filling duration and ear height. The results suggest that the impact of moisture stress on maize flowering and consequently anthesis-silking interval is more dependent on the effect on silking than tasseling. Bolanos and Edmeades (1996) and Fuad-Hassan et al., (2008) reported that silk emergence out of the husks is delayed while anthesis is largely unaffected when soil moisture stress occurs before flowering. In 2009 sowing date x variety interaction had significant effect on days to 50 % tasseling, days to 50 % silking and physiological maturity. In 2010 sowing date x variety interaction had significant effect on anthesis-silking interval. This shows that maize varieties attained developmental stages earlier when planted at the later sowing dates. Thus, moisture stress affected maize reproductive growth by extending the time of maturity of maize varieties. OKA AWAKA was the most affected among the maize varieties. In 2009 sowing date x poultry manure interaction had significant effect on days to 50 % tasseling, days to 50 % silking, anthesis-silking interval, physiological maturity and grain filling duration. In 2010 sowing date x poultry manure interaction had significant effect on ear height. This result indicates that application of poultry manure cushioned the effect of moisture stress on reproductive growth and thereby hastened the time of maturity of maize varieties. However, this depended on the severity of the stress.

Sowing date did not significantly affect yield and yield components in 2009. In 2010 sowing date significantly affected number of rows cob^{-1}, number of grains cob^{-1} and grain yield. Maize planted on March 30 had the highest number of rows cob^{-1} which was 9.5 and

4.0 % more than number of rows cob^{-1} in maize planted on February 28 and April 14. Maize planted on March 15 and April 14 also had 6.5 and 5.4 % more number of rows cob^{-1} than maize planted on February 28. Maize planted on March 30 had the highest number of grains cob^{-1} which was 25.3 % higher than number of grains cob^{-1} in maize planted on February 28. Maize planted on March 30 also had the highest grain yield which was 36.3 and 18.6 % greater than grain yield in maize planted on February 28 and April 14. Maize planted on March 15 had 22.2 % more grain yield than maize planted on February 28. Considering the number of grains cob^{-1} (Kernel number) and grain yield in 2010, maize planted on March 30 produced the best performance. Maize grain yield is closely associated with kernel number (Andrade *et al.,* 2000; Adikuru, 2008). Therefore, March 30 which is close to the 9th April predicted onset of rains for Owerri (Audu *et al.,* 2009) is the optimum sowing date in this study.

Among the maize varieties there were significant differences in number of rows cob^{-1}, weight of 100 seeds and number of grains cob^{-1} in 2009. OKA AWAKA had 12.2 and 11.5 % more number of rows cob^{-1} than TZE COMP3 C3 and TZL COMP4 C3. Weight of 100 seeds was 11.5 and 27.4 % greater in TZL COMP4 C3 than in TZE COMP3 C3 and OKA AWAKA. OKA AWAKA had 23.1 and 15.7 % more number of grains cob^{-1} than TZE COMP3 C3 and TZL COMP4 C3. In 2010, OKA AWAKA had 7.3 and 12.5 % more number of rows cob^{-1} than TZE COMP3 C3 and TZL COMP4 C3; while TZE COMP3 C3 had 4.8 % more number of rows cob^{-1} than TZL COMP4 C3. OKA AWAKA also had 17.1 and 7.3 % more number of grains row^{-1} than TZE COMP3 C3 and TZL COMP4 C3, while TZL COMP4 C3 had 9.1 % more number of grains row^{-1} than TZE COMP3 C3. Weight of 100 seeds was 10.5 % greater in TZL COMP4 C3 than in TZE COMP3 C3 and OKA AWAKA. Number of grains cob^{-1} was 25.1 and 20.2 % more in OKA AWAKA than TZE COMP3 C3 and TZL COMP4 C3. From the results, OKA AWAKA had superior number of grains cob^{-1}

compared to TZL COMP4 C3 and TZE COMP3 C3, but this did not translate to significantly higher grain yield. TZL COMP4 C3 had superior weight of 100 seeds compared to TZE COMP3 C3 and OKA AWAKA. On the overall, while the yield differences among the maize varieties were not significant, the late maturing varieties consistently out yielded the early maturing variety.

Poultry manure application significantly increased number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1}, weight of 100 seeds and grain yield in 2009 and 2010. In 2009 application of poultry manure increased number of rows cob^{-1} by 6.5 %; number of grains row^{-1} by 11.1 %; number of grains cob^{-1} by 17.7 %; weight of 100 seeds by 10.4 %; grain yield by 33.3 %. In 2010 application of poultry manure increased number of rows cob^{-1} by 9.4 %; number of grains row^{-1} by 27.1 %; number of grains cob^{-1} by 38.3 %; weight of 100 seeds by 29.8 %; grain yield by 61.3 %. The improvement in vegetative and reproductive growth in response to application of poultry manure must have caused an overall improvement in yield and yield components. Thus, improvement in dry matter production led to increase in gain yield. Reserve assimilates which accumulate in the maize stem during vegetative development are usually remobilized to the kernels during grain filling (Setter and Meller, 1984). Therefore, maize stem acts as sink during vegetative growth and source during grain filling.

CHAPTER FIVE

SUMMARY CONCLUSION AND RECOMMENDATIONS

Delayed onset of rainfall as a manifestation of the climate change phenomenon affects almost every part of Nigeria. Based on the analysis of 30 years rainfall data (from Umuahia), delayed onset of rainfall in the agroecology of the study area is likely the result of an alteration in the rainfall pattern in the months of February and March. This alteration characteristically imposes drought spells which present a challenge to farmers with regard to choice of time of planting and other agronomic practices for the purpose of adaptation to climate change. This study was an attempt to identify options (practices) which farmers can adopt in order to adapt to delayed onset of rainfall for maize production.

The results revealed that moisture stress arising from delayed onset of rainfall was responsible for reduction in maize yield due to effects on both vegetative and reproductive development and growth. Maize yield reduction was significant in 2010 (the drier of the two years) but not in 2009. Within each year, the reduction was greatest when maize was planted on February 28 compared to when maize was planted on March 30. Thus, the extent of yield reduction depended on the severity of moisture stress. Maize yield reduction arising from moisture stress was as high as 26.6 %. The overall effect of moisture stress on vegetative growth was the reduction of dry matter accumulation, which was greatest at 6WAP. Accumulation of dry matter in the stem was reduced by as much 85.3 % in 2009 and 81.4 % in 2010. Consequently, the amount of dry matter available for remobilization to the grains during grain filling was reduced. Moisture stress also caused an increase in the anthesis-silking interval by 60.8 % in 2009 and 68.6 % in 2010. This resulted in the reduction of the number of grains available for filling through distortion of the synchrony between tasseling and silking. Moisture stress also resulted in delay in attainment of physiological maturity with maize planted on February 28 being the latest. Generally, maize planted on February 28 and

March 15 were the most affected by moisture stress while maize planted on March 30 and April 14 did not differ significantly in almost all parameters. Based on these observations and considering that maize planted on March 30 out yielded maize planted on April 14, the time (period) of planting recommended for maize in the study area is within the last week in March and the first week in April. Therefore, selection of time of planting is an effective strategy for adaptation to climate change in the humid rainforest zone.

Furthermore, to maximize the use of available land and abundant solar radiation at the beginning of the growing season, there is need as a matter of urgency to give consideration to the use of drought tolerant crop species and varieties as well as irrigation. This will contribute immensely to food security in the humid rainforest agroecology. To achieve this, research efforts must be directed to irrigation studies and the development and evaluation of drought tolerant crops. This has become necessary because drought is gradually becoming a challenge in humid areas and climate change does not appear to be abating.

Among the maize varieties, TZL COMP4 C3 and OKA AWAKA, which are late maturing, produced better vegetative and reproductive growth than TZE COMP3 C3 which is early maturing. These late maturing varieties had greater grain yield than the early maturing variety, although the differences were not significant. The late maturing varieties were superior in almost all yield components. This, in addition to extended grain filling duration contributed to their superiority over the early maturing variety. Therefore, varietal selection is an effective strategy for adaptation to climate change in this location and late maturing varieties are recommended.

Poultry manure application had an outstanding positive impact on maize performance irrespective of variety or sowing date. Across sowing dates, the effect of poultry manure increased as sowing dates moved from February 28 to April 14, implying an increase in moisture content. This suggests that when maize is planted before the onset of the rains, poultry manure could absorb the moderate moisture available and release same along with nutrient elements at dry moments. When the rains are established, the role of poultry manure basically becomes the supply of nutrients. Therefore poultry manure (and perhaps other organic amendments) can be useful in cushioning the effect of moisture stress, at least for mild stresses. This is also an indication that moisture conservation and enhanced nutrient supply are critical for adaptation to moisture stress resulting from climate change. There is need for further research in developing affordable moisture conservation techniques.

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