SOIL AND SOIL RELATED PROPERTIES, COVER CROPS, EFFECT OF PLANTING DATESON THE YIELD OF MAIZE (*ZEA MAYS L.)* IN SAMARU, NIGERIA

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVESITY, ZARIA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF MASTERS DEGREE IN SOIL SCIENCE

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ZARIA

DECEMBER, 2019

DECLARATION

I declare that the work in this dissertation entitled "**SOIL AND SOIL RELATED PROPERTIES, COVER CROPS, EFFECT OF PLANTING DATES ON THE YIELD OF MAIZE (*ZEA MAYS L.)* IN SAMARU, NIGERIA"** has been carried out by me in the Department of Soil Science, Ahmadu Bello University Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references is provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

AJIDE OLUWASEUN JEREMIAH _____ _____
Name of student Signature Date

CERTIFICATION

This dissertation "**SOIL AND SOIL RELATED PROPERTIES, COVER CROPS, EFFECT OF PLANTING DATES ON THE YIELD OF MAIZE (*ZEA MAYS L.)* IN SAMARU, NIGERIA**" by AJIDE Jeremiah Oluwaseun meets the regulations governing the award of the degree of Masters of Science of theAhmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this work to my God and my father Elder I.O. Ajide, my sibling, my lovely fiancé Aluko Grace Asabi and my supervisors Prof A.C Odunze and Dr H.M Lawal for their supervision and support. I will forever be grateful to God Almighty for surrounding me with such wonderful people.

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ABSTRACT

Declining soil quality is emerging as an environmental and economic issue of global concern, because degraded soils are becoming prevalent due to intensive use and poor soil management. Declining soil productivity due to poor soil quality (particularly Carbon and Phosphorus deficiency and high bulk density) has been a major limiting factor to food production in Nigeria. Also, failure in establishing rainfall onset usually affects farmers negatively in the Northern Guinea Savanna Ecological Zone (NGSEZ) for proper planning of cropping activities. This call forPrediction of optimum rainfall so as to validate effective planting dates for high maize yield in the Northern Guinea Savanna zone, two consecutive years' field trials were conducted in 2016 and 2017 rainy seasons at the Institute for Agricultural Research (IAR) farm located at Samaru (latitude $11^{o}1$'N and Longitude $7^{o}3$'E) in the NGSEZ of Nigeria to study the effect ofcover crops and planting dateson maizeyield.using Randomized Complete Block Design (RCBD)in factorial arrangement with a combination of four planting dates and two cover crop *Centrosema pascuorum* and *Cucurbitamaxima* and no cover treatment replicated three times. Data generated was analyzed using SAS statistical package. The combined Result shows, the variation in the climatic data over the 35 years and during the two year of the experiment shows that maize can be grown over a wide range of climate with an optimum yield under adequate management. Planting dates statistically influenced grain yield in both first and second weeks of planting 4.08 and 4.01 tons/hectare similar to plots with no cover crop while the value for the last planting date (3.86) ton/hectare is similar to the plot with cover 3.78 *Centrosema perscurum and 3.71Cucurbita maxima*. physical soil properties such as (moisture and hydraulic conductivity) and climate (rainfall and temperature) are relevant to determine best planting date and optimum crop germination before the start of dry spell mostly experienced in the second to third week of June in these experiment.when subjected to Principal Component Analysis (PCA) to indicate their level of contribution to the maize yield. The soil quality assessment on the four planting dates evaluated in the study indicates that no cover and the two cover crop has same ranking while planting date one and two is better than third and fourth planting dates 1=best while 5=worst, CP=*centrocema pascuroum*, CM=*cucubita maxima*,NO=no cover, A= planting 1, B=planting date 2, C=planting date 3,D=planting date 4, SQ=soil quality.

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CHAPTER ONE

1.0 Introduction

1.1 Background

Climate variability and change have direct and adverse, influence on quantity and quality of agricultural produce. The climate of an area is highly correlated to vegetation and by extension type of crop that can be cultivated. Temperature, rainfall, humidity, sunshine (day length) are important climatic elements that influence crop production. The overall predictability of these climatic elements is imperative for the day-to-day and medium term planning of farm operations (Sowunmi and Akintola, 2009). Climate plays a significant role in the distribution of vegetation and agriculture in Nigeria. According to Federal Government of Nigeria report on drought management (FGN, 1999), Nigeria landmass is divided into seven ecological zones. Muchow (1990) showed that seed growth may be directly influenced by air temperature. Also different sowing dates might have different environmental conditions; from emergence to seed filling and planting date was reported to affect growth and yield of maize significantly (Norwood, 2001). To date, the challenge for maize growers is finding the narrow window between planting too early and planting too late (Nielson, 1997; Nielson *et al*., 2002). Maize, sorghum, millet, wheat, rice, cowpea, yam, pepper and onion are the major crops that thrive in savannah (Sowunmi and Akintola, 2009).

Maize (*Zea mays* L.) is an important staple food crop and provides bulk of raw materials for livestock and many agro-allied industries in the world (Bello *et al*., 2010). Maize ranks second to wheat in the world cereal production.Among the three most important cereal crops in the world maize is the most important cereal crop in the sub-Sahara Africa, followed by rice and wheat; Maize is high yielding and easy to process, readily digested, and costs less than other cereals (Bello *et al.*, 2010). It is also a versatile crop, allowing it to grow across a range of agro-ecological zones (Jaliya *et al.*, 2008). It is one the most important cereal crop

grown in Nigeria, stretching from the coast to savanna. Production of maize in the Nigerian savanna has since been transformed from that of a minor crop status to a major commercial grain crop competing with sorghum and millet crops in the grain economy of nations (Elemo, 1993). Successful maize production requires an understanding of various management practices, as well as environmental conditions that affect crop performance (Eckert, 1995). Selection of appropriate cultivars, planting dates and plant densities are cultural practices that have been shown to affect maize yield potential and stability (Norwood, 2001). Temperature is a major environmental agent that determines the rate of plant growth and development. Different genotypes may behave differently under similar environmental conditions. Maize (*Zea mays* L.) development is primarily driven by temperature, with air temperature being theoretical to enhance maize development from emergence to physiological maturity (Cutforth and Shaykewich, 1990). Farmers who plant maize early are concerned about poor emergence and early plant growth. On the other hand, farmers who plant late worry about maturity time of hybrids and how late planting might affect the final grain yield and grain moisture (Lauer *et al*., 1999). Either early planting or late planting can result in lower yield because the probability exists that unfavorable climatic conditions can occur after planting or during the growing season. Norwood (2001) suggested that farmers should plant on more than one planting date in order to safeguard against unpredicted seasons.

1.2 Problem Statement

The vegetation of northern Nigeria is predominantly short grass savanna and this region is characterized by a relatively hot climate with short seasonal rainfall and a marked dry season. The pressures of increasing population are understood to cause increasing food demands by urban consumers and rural farmers, shrinking of areas of cultivation, reduced fallow intervals, accompanied with lack of inputs necessary for intensive cultivation and as a result,

reduced soil fertility (Elemo, 1993). This means that per capital and per hectare yields will decline and food will become scarce, especially for those in rural areas. Therefore, there is urgent need to increase staple food production such as maize grain, through complementing planting dates with adequate knowledge of climatic and soil physical conditions at optimum planting date. Intensification of agricultural practices can take place without associated soil degradation. Vulnerability of maize to adverse climatic change has become an important issue and therefore, a research priority. What should be done to mitigate effects of uncertain weather; such as erratic rainfall, and to plant maize to obtain sustainable grain yield remains a challenge and question to researchers and farmers especially in the NGSEZ. Moreover, measurement of soil physical properties both in the field and laboratory are important in determining its productivity (Lake *et al.*,2009). This study will therefore attempt to investigate the relationship between planting date and yield of maize with soil moisture content and climatic condition in the study area.

1.3 Justification of the Study

There is growing quest to protect soil quality under intensive land use and to adopt good management practices. More so inorganic fertilizer sources are becoming increasingly unavailable to small scale farmers due to poor economic policies and poor standard of living of the farmer. Therefore, the need for use of cover crop to protect soil and water loss needs to be evaluated. Kim *et al.* (1997) showed that farmers in the Northern Guinea savanna of Nigeria apply N-rate of 20 to 50 $KgNha^{-1}$ for sorghum; which is too low to improve crop productivity. Hence, other fertility enhancement sources are needed to facilitate sustainable crop production. *Cucurbita maxima* locally called “Kabewa”in hausa forage crop and *Centrosema pascuorum* a cover crop that have proven to have beneficial effect on soil fertility, soil erosion control and soil moisture conservation through provision of good ground

cover, return of crop residueswithout necessarily adding inorganic fertilizer (Kim *et al.* (1997). *Centrosema pascuorum* a leguminous plant and*Cucurbita maxima* a vegetable plant was intercropped with maize in this research to conserve soil moisture and improve soil quality. Also agricultural production in Nigeria is affected by weather, Extreme variations in rainfall, temperature and heat waves affect food production. Dry spells, floods and tropical rainstorms create food scarcity problems and mass movement/immigration of people (Ogunlela (1985). Therefore, favorable climatic condition for planting by farmers will affect quality and quantity of crops produced.

1.4 Aims and Objectives of the Study

The study was carried out to ascertain the role of soil physical properties, weather condition (Temperature, humidity and rainfall), cover crops and planting date on the yield of maize. The specific objectives are to:

1. Determine the effect of different planting dates on yield of maize
2. Determine soil hydrological properties at varying planting dates and their influence on maize yield.
3. Determine the effect of cover crop cropping on maize yield.
4. The effect of the cover crop, planting dates on soil quality.

CHAPTER TWO

LITERATURE REVIEW

2.1 The importance of Maize

Maize is an important cereal crop which ranks third after wheat and rice in the world (FAO, 1997, 2010), and is grown widely in many countries of the world (Onasanya *et al*., 2009). Nigeria is the 10th largest producer of maize in the world and the largest producer in Africa (FAO, 2013; Oyelade and Anwanane, 2013). It is one of the most important cereal crops in Nigeria where over 150 million people consume it on an average of 43 kg per year (Olayemi and Ikpi, 1995; FAOSTAT, 1999). Virtually all tribes in Nigeria consume maize, either fresh or processed. It is consumed as pap (*Ogi*) and '*Tuwo'* in virtually all parts of the country. Maize is a major ingredient in infant foods, brewery and poultry feed industries. It is also fermented to produce dextrins, sugars and syrup (Sowumi and Akintola, 2009). According to Onuk *et al*. (2010) maize is becoming the miracle seed for Nigeria's agricultural and economic development. Unfortunately, climate change is seriously reducing maize production in the country. Inter-governmental Panel on Climate Change (IPCC) (2007) predicted that by 2020, between 75 and 250 million people in Sub-Saharan Africa will be exposed to increased water stress caused by climate change, hence agricultural production and access to food in many African countries may be further threatened.

2.2 Climatic and Soil Requirements of Maize

Maize is grown over a wide range of climatic conditions. In Nigeria, maize is grown in areas where annual rainfall ranges from 500 mm to 3500 mm covering from the Sudan/Sahel savanna to the Mangrove forest ((FAO, 1997. High temperature above 32^{o}C at tasseling and pollination speeds up differentiation process of the reproductive organs, resulting in higher

kernels abortion (IITA, 1986). When many kernels are aborted, total sink size could limit yield (IITA, 1986). Maize is grown on a wide range of soils, but grows best in deep, well drained, medium to moderately heavy-textured soil, with adequate organic matter. It yields poorly on shallow, sandy soils because of higher susceptibility to moisture and nutrient stress. Maize does best on soils with pH of 5.5 - 7.0, and strongly acid soils with pH < 5.0 are unsuitable, except when limed, maize can also be grown in alkaline soils but deficiencies of iron and manganese must be corrected (William and Chew, 1980).

2.3 Climatic Conditions and Maize Yield

Evidences from literature revealed that recent global warming has influenced agricultural productivity, leading to declining food production (Kurukulasuriya and Mendelsohn, 2006; IISD, 2007; Lobell *et al.*, 2008). There is a growing concern that in the coming decades, the world will experience higher temperatures and changes in precipitation levels both in terms of distribution and patterns even in regions that rarely experience such harsh climates (Nwafor, 2007). Many countries in the tropical and sub-tropical regions; of which Nigeria is included, are expected to be more vulnerable to warming (Mendelsohn *et al*., 2000) because of the effect of climate change (Nwafor, 2007; Jagtap, 2007). Dinar *et al*. (2006) further reported that many African countries; such as Nigeria that has their economies largely based on weather sensitive agricultural production systems, are more vulnerable to climate change. Estimation by (FAO, 2005) is that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4 % due to climate change. Ayuba *et al*. (2007) observed that Nigeria is already being plagued with diverse ecological problems, which have been directly linked to on-going climate change. Agbola and Ojeleye (2007) revealed that there is decline in crop yield and food crops production due to reduction in rainfall, relative humidity and increase in temperature in Nigeria. Previous research strongly suggests that

maize growing regions of sub-Saharan Africa will encounter increased growing season temperatures and frequency of droughts (IPCC, 2007) Rainfall and temperature indices are key parameters in understanding climate variability, drought dynamics and eventual impacts on agricultural productivity (Nazrul, 2009). Dry spell and rainfall variability are some of the leading biophysical causes of food insecurity in Sub-Saharan Africa (SSA) (TSBF, 2009) and both impact significantly on fertilizer and water use efficiencies and also determine efficacy of risk-aversion strategies by smallholder farmers (Morris *et al.*, 2007).

Agricultural production in Nigeria is at the mercy of weather. Extreme variations in rainfall, temperature and heat waves affect food production. Dry spells, floods and tropical rainstorms create food scarcity problems and mass movement/migration of people Adeleke and Goh (1980). Considerable research works have been carried out on the effects of weather/climate on agricultural production, but few works have been specific on effects of climate change on maize production. These are reviewed below: according to Adeleke and Goh (1980), climate is the average atmospheric conditions of an area over a considerable time. Climate is not only average weather record and has a time line for aggregate weather data. Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO, 2011). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description of the climate system. It involves systematic observation, recording and processing of the various elements of climate; such as rainfall, air temperature, humidity, pressure, winds, clouds and sunshine before standardization of the climatic means or averages can be arrived at ((IPCC, 2001). In a study on crop yield variability influenced by climate, Chi-Chung *et al*. (2004) submitted that precipitation and

temperature have opposite effects on yield levels and variability of corn (maize). Further, they reasoned that more rainfall can cause yield levels to rise, while decreasing yield variance and temperature has a reverse effect on maize production. Bancy (2000) study on the influence of climate change on maize production in semi-humid and semi-arid areas of Kenya explained that in order to counter adverse effects of climate change on maize production, it might be necessary to use early maturing cultivars and practice early planting.

2.4 Planting Dates and maize production

Of all the management aspects of growing a maize crop (cultivar selection, plant density, amount and timing of fertilizers, etc.), planting date is probably the most prone to variation because of the great differences in weather at planting time between seasons and within the range of climates (Otegui *et al*., 1995). The year-to year variation in plant establishment, pest and disease incidence, makes it difficult to predict optimum planting dates for maize crops (Oktem, 2000). In practice, recommended dates are normally drawn from results of long-running series of agronomic experiments, which can give mean planting dates for highest yield, together with realistic estimates of expected yield penalties for each week of delay in planting (Lauer *et al*., 1999). However, in accepting such guidelines, several reservations must be appreciated in addition to the fact that the use of recommended date is not a guarantee of highest yield for that season (Oktem, 2000).

2.4.1 Effect of Plating Dates on Maize Yield

Maize planted at the onset of rainfall develops better and has higher yield potential because the vegetative period of its development occurs in the cooler part of the season when moisture stress is less likely (Aldrich *et al*., 1986). Corke & Kannenberg (1989) reported that

optimum use of limited growing period for maize is essential to maximize grain yield in short season areas. Generally, there are many benefits related to early planting date compared to late planting date and this include a long growth duration that allows a greater choice of hybrid maturities and wider window of opportunities for replant decisions. Again, earlier planting tends to place tasseling and silking periods ahead of the greatest risk of moisture stress and dry spell damage (Otegui & Melon, 1997). In addition, Sheperd *et al*. (1991) reported that early planting date could contribute significantly to higher maize yields. The authors also highlighted that higher yield is not the only advantage of early planting because other benefits can also be achieved from high plant density and high fertilizer rates. It also allows harvesting earlier in the season when conditions are usually better and field and time losses can be minimized (Hicks *et al*., 1993). In addition, early planting increases net returns without adding production costs.

On the other hand, late planting or planting after optimum period consistently resulted in lower yields. Delayed planting shortens effective growing season for maize, thus increasing the risk of exposure to lethal cold temperatures late in the season before grain maturation. According to Aldrich *et al*. (1986), yield reduction in late plantings could be attributed to a short growth duration, insect and disease pressure, heat and moisture stress during pollination. These results were in agreement with those by Otegui and Melon (1997), who reported that delayed plantings were generally be accompanied by increased temperatures during the growing season; which accelerates crop development and decrease accumulated solar radiation, resulting in less biomass production, kernel set and grain yield.

However, results of planting date experiments can be highly inconsistent between seasons and sites. For example, it is not unusual for a relatively late sown crop to out yield the control crop sown within what would be considered optimum period (Green *et al*., 1985). There are several reasons for such inconsistencies and unexpected results. First, the soil conditions at

different planting dates will inevitably be different and unfavourable conditions (excess or deficiency of soil moisture, serious incidence of disease, etc.) can occur at almost any point during the normal planting dates. Consequently, the observed differences in performance of crops sown on different dates are commonly a reflection of differences in established plant density (Green *et al*., 1985). Secondly, crops sown at different dates pass through each developmental stage at slightly different times(Green *et al*., 1985). Therefore, under different environmental conditions (especially photoperiod and temperature); any one of the developmental stages; which determine the components of yield, could occur under more or less favourable conditions in late-sown crops. For these reasons, it is not easy to carry out a critical comparison of grain yields and their components of the different crops in a sowing date experiment(Hicks *et al*., 1993). Scarsbrook and Doss (1972) reported that yield of maize is a function of many plants and environmental factors which are often interrelated.

2.4.2 Effect of Planting Date on Growth and Dry Matter Yield

Variation in maize planting date modifies the radiative and thermal conditions during growth Cirilo and Andrade (1994). The amount of incident radiation and proportion of this radiation that is intercepted by the crop directly determine crop growth rate. Cirilo and Andrade (1994), reported that delays in planting date determine important reductions in the amount of incident radiation accumulated from emergence to silking, because it hastened development. Inversely, high temperatures during early growth of late planting hastens leaf area development as shown by their high early percentage photosynthetic active radiation (PAR) interception values (Cirilo and Andrade, 1994)). Several authors reported similar temperature effects on leaf appearance rate and on leaf expansion in maize (Hesketh and Warrington, 1989). Cirilo and Andrade (1994) reported that at grain filling stage, plants exposed to low radiation and low temperature in late plantings, compared to early plantings, will result in

decreased dry matter production. Late plantings also show higher nonstructural carbohydrate concentration in stems at mid-grain filling than the early plantings. This suggests that low temperatures during grain filling in late plantings limit kernel growth, as well as crop photosynthesis (Cirilo and Andrade, 1994). Thus, the ratio between final kernel number and dry matter at silking dropped dramatically for the late plantings, indicating a predominance of vegetative growth over reproductive growth Maddonni *et al*. (2004). In general, late plantings will result in high crop growth rates during vegetative period because of high radiation use efficiency (RUE) and high percentage radiation will results in low crop rates during grain filling because of low RUE and low incident radiation. The inverse holds true for early plantings (Cirilo and Andrade, 1994). In addition, Maddonni *et al*. (2004) found that in late plantings, both solar radiation and temperature declines during grain filling. Thus, lowered solar radiation resulted in grain growth in excess of biomass production, indicating a possible source limitation. On the other hand, low temperature may have a negative effect on kernel weight through reductions in both radiation use efficiency and biomass partitioning to grains (Andrade *et al*., 1993).

2.4.3 Effect of Planting Date on Silking/Tasseling and Physiological Maturity

Tollenaar and Bruulsema (1998) found that the time from silking to physiological maturity lengthened with delay in planting dates. This was because cool temperatures late in the season of the latest planted crops prevented true maturity since grains never formed a true black layer. Daynard (1972) observed that delayed planting increased thermal time interval from planting to mid-silking, but decreased thermal interval between mid-silking and black layer formation. Sutton and Stucker (1974) reported that thermal intervals between plantings and black layer decreased as planting were delayed from early to late planting. Thus late plantings reduced cumulative intercepted photosynthetic active radiation from silking to

physiological maturity mainly because of their low values of daily incident radiation (Tollenaar and Aguilera, 1992). On the other hand, radiation use efficiency (RUE) for late planting was high in the early growing stages and low during the cool grain filling period. The opposite was true for early plantings that showed low RUE from emergence to silking and sustained during most of the grain filling period when temperatures were more favourable for photosynthetic process (Cirilo and Andrade, 1994). In addition, the period between emergence and maturity of maize hybrids planted earlier in the season can be up to two weeks longer than when the same cultivar is planted later (Sangoi, 1993). During this extra period, plants will uptake more solar radiation and store energy because lower temperatures limit their growth and consumption of this energy. As a result of this slower pattern of development, early-planted maize plants are smaller and less leafy at maturity (Sangoi *et al*., 1998; Silva *et al*., 1998). Stewart *et al*. (1997) reported that delayed planting increased growing degree days (GDDs) to black layer for three hybrids in a dry spell year but decreased GDDs to black layer for the same three hybrids in the following year under less stressful conditions. According to the Canadian studies, GDDs system provides a reliable estimate of thermal time required for vegetative development (Stewart *et al*., 1997). Estimates of thermal time required for grain filling (period between silking and maturity) vary considerably however, with GDD system frequently over-estimating thermal time required for grain filling. A better understanding of phenological response of maize to thermal time as planting is delayed is necessary to improve accuracy of hybrid maturity selection for late planting situations (Barger, 1969).

2.5. Cover Crops and it importance to the soil

Cover crops are fundamental sustainable tools used to manage soil fertility, soil quality, water, weeds, pests, diseases and diversity and wildlife in agro ecosystems (Lu *et al.*, 2000).

Cover crops are used to protect soil surface, especially during the winter and are harvested before or intermixed into the soil prior to planting the next crop (Donahue *et al.,* 1997). One crop may serve both purposes of green manure and cover crop. Both legume and non-legume crops serve the purpose of green manuring and cover cropping. Researchers have however shown that the potentials of legumes to biologically fix nitrogen and their extensive root system to contribute more organic matter to the soil is more beneficial than non-legumes. Furthermore, ecological benefits associated with longer fallows would be obtained from planted herbaceous legume fallow of cover crops with rapid growth and high dry matter productivity (Tian *et al.,* 1991).

2.5.1 Effect of Cover Crop on Soilbiological, physical and chemical Properties

Vegetative cover reduces runoff as well as concentration and size of transported sediment particles thus, reducing rate of loss of both soil and moisture (Odunze, 2003). It also influences soil moisture and temperature dynamics (Sultani *et al*., 2007). The reduction of moisture losses can be attributed to a combination of several factors (Shukla *et al*., 2004): (i) significant reduction in the rate of surface evaporation and surface runoff and (ii) increases in infiltration rate and moisture retention capacity of the soil.

Biological nitrogen fixation (BNF) is one of the most important processes for maintenance of life on earth, as it contributes about 70 % of all nitrogen required by natural and agricultural ecosystems and is environmentally friendly (Moreira, 2008). Legumes are known to improve soil fertility by adding much needed organic matter in the soils and fixing nitrogen biologically (Moreira, 2008). Use of annual legumes such as *Mucuna pruriens*, *Macrotyloma uniflorum and Centrosema pascuorum* as green manure, can improve soil fertility and can help increase productivity of succeeding crops (Odunze, 2003). Legumes are able to

accumulate soil N because they provide biological N fixation, which results in the fixation of about 15 to 40 kg N for every 1000 kg of dry matter of shoots produced (Humphreys, 1995). Several reports have shown use of accumulated N due to biological fixation to increase yield of subsequent crops.Some legumes have been found to facilitate utilization of soil P in low P soils of northern Guinea savanna of Nigeria (Kalm *et al*., 2002). Therefore, it is possible to increase yields of crops and improve soil quality by using green manure and nitrogen-fixing legumes.

Cover crops; such as legumes: *Pueraria phaseoloides, Mucuna pruriens, Centrosema pubescens, Stylosanthes guianensis,* and *Phaseolus aconitifolius* or the grasses: *Pennisetum purpureum, Brachiaria ruziziensis,* and *Paspalum notatum* are plants that grow rapidly and close (Lal 1995). Their dense canopy prevents rain drops from detaching soil particles and keeps soil loss to tolerable limits. So, cover crops play important roles in soil conservation (Okigbo and Lal 1977). Measurements conducted in Ibadan show that 3.3 t soil ha^{-1} were eroded from plots cultivated with sole maize and 1.8 t ha^{-1} from plots with the cover crop *P. phaseoloides*. Erosion was high on all plots at the beginning of rainy season due to the small canopy cover and high rainfall intensity, but differed significantly until the end of this period as the coverage of maize plots was much smaller (max. 40 %) than plots with *P. phaseoloides* (max. 100 %). Comparable results were published by Kirchhof and Salako (2000) and Odunze (2002). Cover crops positively influence physical soil properties such as infiltration rate, moisture content and bulk density

They increase organic matter content, nitrogen (N) levels by use of N_2-fixing legumes, cation exchange capacity, hence crop yields (Salako and Tian, 2003; Hulugalle *et al*., 1986). For example, Tian *et al*. (1999) estimated an amount of 84 to 202 kg N ha^{-1} fixed by P. phaseoloides within 18 months. This resulted in a higher maize grain yield (2.5 t ha^{-1}) than in

the control without a legume (1.3 t ha^{-1}). Wick *et al*. (1998) stated benefits of improved fallows on soil microbiological parameters.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Site description

The trial was conducted for two raing seasons 2016 and 2017 at the experimental farm of the Institute for Agricultural Research (IAR), Zaria. (latitude11°10'58"N and longitude 7° 37'0"E) in the Northern Guinea Savanna ecological zone of Nigeria (Fig 1). Long term mean annual rainfall (1987-2016) in the zone is 986.5 mm and is received mainly between the months of May and September, with peak rainfall received in August, mean daily air temperature of the area is 24^0C with an altitude of 686m above sea level (Oluwasemire and Alabi, 2004). Soils in the experimental area were classified as Typic Haplustalf (Ogunwole *et al*., 2001)

3.2 Test crop

Maize was the test crop for the trial and was obtained from Seed Production Unit of the Institute for Agricultural Research (IAR) Samaru. The maize variety used was late maturing SAMMAZ-14.

3.3 Design of Experiment, Treatment and Plot Layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) in factorial arrangement with each plot size 6 m long and 3 m wide replicatedthree times with 12 plot in each, and consist of two factor namely four planting dates and three cover crop Therefore, A total land area for the experiment was 858 m^2.as described below

Factor 1: planting dates

1. June/ week one /2016 and June/ week one/2017
2. June /week two/2016 and June/week two/2017

3. June/week three/2016 and June/week three/2017
4. June/week four/2016 and June/week four/2017

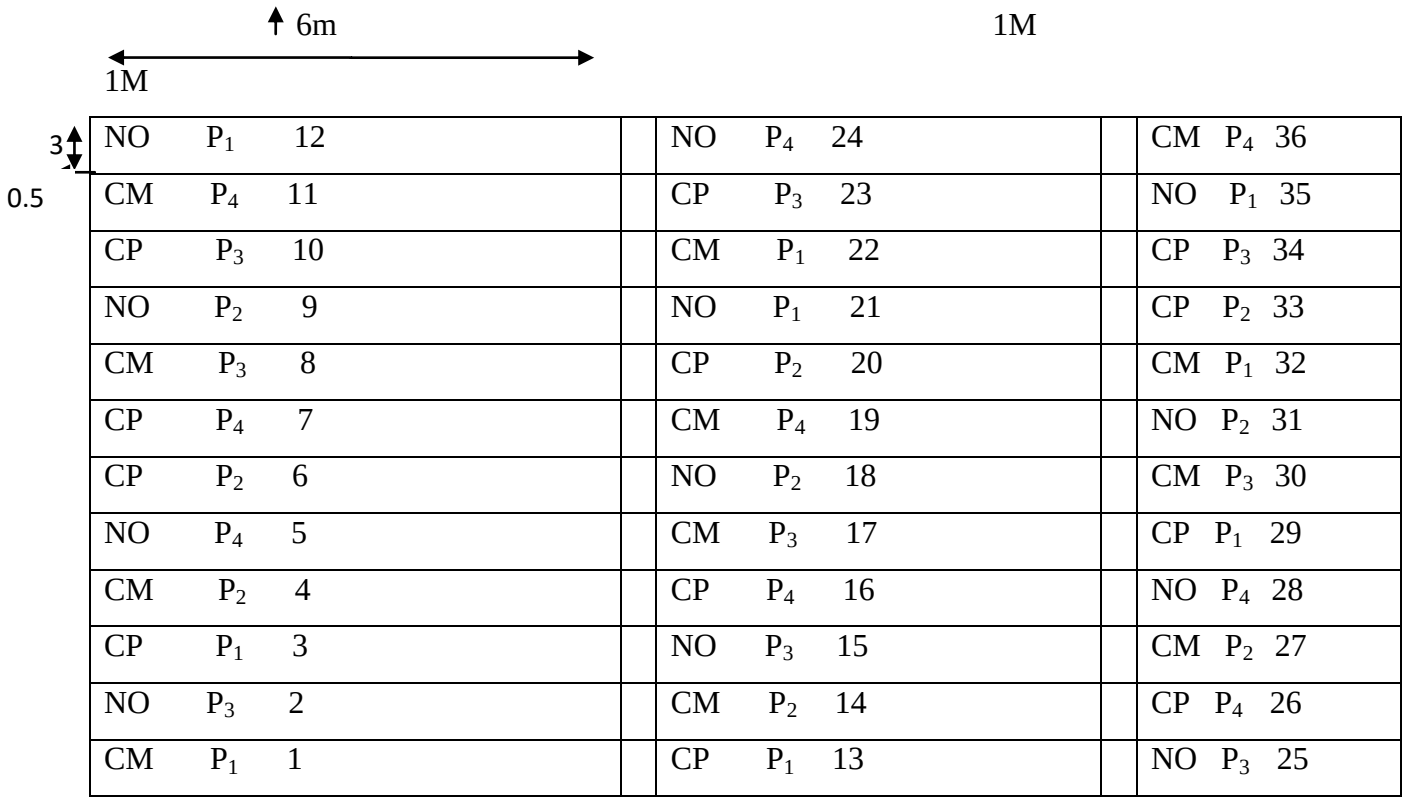
Factor 2 cover crops:

i. CM=*Cucurbita maxima*.

ii. CP=C*entrosema pascuorum.*

iii. No = no cover crop

EXPERIMENTAL DESIGN LAYOUT



NO	P_1	12		NO	P_4	24	CM	P_4 36
CM	P_4	11		CP	P_3	23	NO	P_1 35
CP	P_3	10		CM	P_1	22	CP	P_3 34
NO	P_2	9		NO	P_1	21	CP	P_2 33
CM	P_3	8		CP	P_2	20	CM	P_1 32
CP	P_4	7		CM	P_4	19	NO	P_2 31
CP	P_2	6		NO	P_2	18	CM	P_3 30
NO	P_4	5		CM	P_3	17	CP	P_1 29
CM	P_2	4		CP	P_4	16	NO	P_4 28
CP	P_1	3		NO	P_3	15	CM	P_2 27
NO	P_3	2		CM	P_2	14	CP	P_4 26
CM	P_1	1		CP	P_1	13	NO	P_3 25

P = (Planting date) NO= (no cover crop), CM = (*Cucurbita maxima*) CP= (*Centrosema pascuorum*)

3.4 Soil sampling before trial establishment.

Twelve sample were collected in polythene bags using Auger at six different points per replication at 0-15 and 15-30 cm depththe sampleair dried and crushed with pestle, then made into composite by depths to obtain three replicates, before they were taken to laboratory for routine analysis.

Soil sampling during and (weeks) after trial establishment

Core samples were collected from depths of 0 – 5 (cm surface), and 15 – 20 cm (sub surface). A hoe was use to dig the soil to obtained the second depth using meter rule, 4cm diameter and 5cm length core to determine moisture contentwas converted to volumetric unit, bulk density, using the core.Hydraulic conductivity was determined using constant head permeameter method and total porosity was determined from the bulk density and particle density.

3.5 Land Preparation and Planting Methods

The land was cleared, harrowed, after which ridges were made at inter row distance of 75 cm and maize was planted at 25 cm intra row spacing with two seed per hole. This was thinned to one seedling per stand at two weeks after germination.

3.6 Cultural Management

Weeding

Weed control was done through the use of hoes and hand pulling.

Fertilizer Application

Fertilizer (nitrogen, phosphorus as P_2O_5 and potassium as K_2O) were applied at about 5 cm depth and 5 cm away from plant roots and covered to prevent nitrogen loss to volatilization.

A First halfof the nitrogen fertilizer and all of p and k applied as (NPK15:15:15) to add 60kgN, 60kg P_2O_5 and 60kg $K_2O$the second dose was top dressed with 60 kg N applied as urea the second half of the N rate. The experiment was repeated in 2017 cropping season using the same plots and the same experimental design.

3.7 Chemical analysis

3.7.1 Determination of Soil pH

Soil pH was determined both in water and 0.01M $CaCl_2$ solution in a 1:2.5 soil: solution ratio, using a Pye Unicam model 290 MK pH meter.

2.7.2 Determination of Organic Carbon in Soil (Walkley – Black method)

One gram of the soil sample was weighed in duplicate and transferred into 250 ml Erlenmeyer flask. Five milli litre (5ml) of 1N potassium dichromate(VII) ($K_2Cr_2O_{7)}$ solution was pipetted into each flask and swirled gently to disperse the soil. Then, 10 mls of concentrated tetraoxosulphate (VI) acid (H_2SO_4) was rapidly added using an automatic pipette directing the stream into the suspension. The flask was swirled immediately and gently until soil and reagents are well mixed. It was swirled more vigorously for one minute. The flask was allowed to stand for 30 minutes on a sheet of asbestos. After the 30 minutes, 100 ml of distilled water was added. Three drops of indicator were added and titrated with 0.4N ferrous sulfate solution. As this end point is approached the solution took a greenish cast and then changed to dark green. At the point ferrous sulfate was added drop by drop and a sharp change in colour was noticed from blue to red (maroon). The blank solution was prepared in same manner but without soil. Calculation: the result was calculated as

A blank was run with no soil sample to standardize the dichromate percentage organic carbon was calculated thus;

$$\% \text{ Organic Carbon in soil} = \frac{(\text{blank} - \text{actual liter}) * 0.38 * m * f}{\text{Weight of airdry soil (g)}}$$

Where;

f = Correction factor = 1.33

m = concentration of NH_4FeSo_4

% organic matter = % org. C X 1.729. (Nelson and Sommer, 1982)

3.7.3 Determination of exchangeable Ca, Mg, K, Na (basic cations).

Thirty (30) ml of 1N ammonium acetate (NH_4OAC) was added to 5 g of soil sample and subjected to shaking in mechanical shaker for 2 hours. This was centrifuged at 2000 rpm for 10 minutes. The supernatant was carefully decanted into a 100 ml volumetric flask. Another 30 ml of NH_4OAC solution was added and shaken for 30 minutes. The supernatant was then centrifuged again and transferred into the same volumetric flask. Thirty meals of NH_4OAC solution was added and shaken for 30 minutes. The supernatant was centrifuged and transferred into the same volumetric flask. The solution was made up to mark with the NH_4OAC solution. K and Na were determined on a flame photometer, whereas Mg, Ca were determined on an atomic absorption spectrometer. (Blacked, 1965)

3.7.5 Total N in Soil (Macro – Kjeldahl Method)

One gram of soil was weighed into 500 ml Kjeldhal flask. Little water was added and was allowed to stand for 30 minutes. Five grams of Kjeldahl catalyst mixture and then 20 mls of concentrated sulphuric acid were added. The flask was heated cautiously on digestion block

until frothing ceased. The heating was increased until the digest was apparently clear. The mixture was boiled for another 2 hours and allowed to cool. A little amount of water was then added with care before washing the content into a 100 ml volumetric flask. This was allowed to cool and then made up to mark. From the digest 10 mls was pipette into a distillation flask. 20 ml of 2% boric acid was measured into 100 ml conical flask and introduced to the bottom of the condenser. Three drops of mixed indicator was then added. Of 10N sodium hydroxide (NaOH) 10 ml was added to the 10ml digest in the distilling flask. The distilling unit was immediately introduced and the digest distilled off. About 50 ml of the distillate was collected and titrated with 0.01N tetraoxosulphate (VI) acid (H_2SO_4)for a colour change from green to purple end point (Jackson, 1963) Bremner and malvaney (1982).

Calculation

$$\%N = \frac{0.014 \text{ X } (T-B) \text{ X NA X Vol .of digest X } 100}{\text{Weight of soil X Aliquote distilled}}.$$

Where;

NA = Normality of acid

T = Titre value

B = Reading for blank

3.13 Available Phosphorus in Soils (Bray No. 1 Method)

One gram of soil was weighed into 15 ml centrifuge tube and 7 mls of the extracting solution was added. This was shaken for 1 minute on a mechanical shaker and the suspension was centrifuged at 2000 rpm for 15 minutes. Two meals (2 ml) of the clear supernatant was pipetted into a 20 mls test tube. Five meals (5 ml) distilled water and 2 ml of ammonium molybdate solution were added. The content was properly mixed and 1 ml of $SnCl_2.2H_2O$ dilute solution was added and mixed again, after 5 minutes, but not later than 20 minutes. The reading was measured on electrophotometer in mg/kg (Bray and Kurtz, 1945)

3.8 Physical analysis

3.8.1 Saturated Hydraulic Conductivity

This was determined with undisturbed soil cores by the constant head permeameter method. The soil in the cores were placed in plates containing water and were allowed to stay overnight till saturation was attained. Muslin sheath was used to cover the blunt end of the core and kept tied using rubber band. This was to avoid soil loss. The cores were then secured to a plastic container after it was held in place by a special mesh and clamped to fit the core. This was then placed into the permeameter after establishing a constant head. A small tube initially filled with water was used as a junction between the inside of the plastic holder and water in thepermeameter. A chosen volume of water collected in the burette was recorded at the time of water flow using a stopwatch. The height of water both inside the core holder and outside were measured by means of Meter Bridge as the hydraulic head difference. Hydraulic conductivity was computed:

$K = \frac{VH}{At\ \Delta H}$ Where

ΔH = Change in hydraulic head (H^+- H^-)

H^+ = Head- in

H^-= Head-out

V = Volume of water collected in burette over a period of time

A= cross section area of the soil

T= Time taken for water flow

3.8.2 Particle size distribution

Particle size analysis was determined by the standard hydrometer method (Gee and Bauder, 1986) which involved the dispersion of soil particles with sodium hexametaphosphate (Calgon). Fifty gram of sieved soil was weighed into polythene bottle, 100 mls of Calgon

solution was added into the bottle. The mixture was placed on a mechanical shaker and agitated for 15 minutes. The soil suspension was transferred into 2 litre capacity cylinder and diluted up to the 1 litre mark with water. The suspension was stirred with a plunger before inserting the hydrometer. The hydrometer readings after 40 seconds were recorded for determining silt and clay content. Reading after 2 hrs were recorded and used to determine the proportion of clay fraction alone. The temperature and hydrometer reading for the blank were recorded. Computations were carried out for the particle size fractions using a formulae below.

$$\% \text{ clay} = \frac{\text{corrected 2 hours reading}}{\text{Weight of soil}} \times \mathbf{100}$$

$$\% \text{ Slit} = \frac{\text{corrected 40 seconds reading}}{\text{Weight of soil}} \times \mathbf{100}$$

$$\% \text{ Sand} = 100 - (\% \text{ clay} + \text{silt})$$

$$\text{Corrected reading (C)} = R - B \pm (0.36T)$$

C = corrected reading

R = uncorrected reading

B = Blank

T = Temperature of suspension

(Bouyoucos, 1951) as described by (International Institute of Tropical Agriculture, (IITA), 1979) . Textural triangle was used to determine the textural classes (United State Department of Agriculture (USDA), 1951)

3.8.3Bulk Density (ρb)

Bulk density was determined by core method as described by Blake and Hartge (1986a). The undisturbed cores obtained from the treatment plots were taken to the laboratory where moist weights were immediately taken before placing in the oven. The oven dried weights were taken at 105^{o}C after 24 hours. The oven dry weights obtained were used in the calculation of dry bulk density, i.e. mass of soil per unit bulk volume of soil.

$$\rho b = \frac{MS}{VS} \qquad (5)$$

Where:

ρb = bulk density

Ms = mass of oven dry soil, g

Vs = volume of soil, equivalent to volume of core ring, cm^3

For the bulk density determination, soils were sampled at four depths; 0 - 5 cm, 15 - 20 cm, during the growing period at 2, 4 and 6, weeks after sowing (WAS) and; at two depths during using core samplers of 5cm in diameter and 5 cm depth.

3.8.4 Total porosity

A total pore space was calculated by the equation below. Total porosity (f)

$$\equiv \frac{\text{total pore volume}}{\text{Bulk soil volume}} \times 100$$

Where: pore volume= $\frac{mass\ of\ water\ (weight\ at\ saturation\ -oven\ dried\ weight)g}{Density\ of\ water\ (1g/cm^3)}$

3.8.5 Dry Aggregate Stability

Dry aggregate size distribution was determined by dry sieving. Two hundred grams of soil was passed through a set of sieves with diameter of 2 mm, 0.25 mm and 0.05 mm mounted on a CSC scientific sieve shaker. The sieves were arranged in descending order of diameter. The <0.05 mm soil aggregates was collected in the collecting pan placed below the sieves. The set was shaken for 60 seconds and the soil aggregate retained in each sieve was collected and weighed. The aggregate size stability characterized by mean weight diameter (MWD) is defined according to Van Bavel, (1950) as $=\sum= x_i\omega i$

Where x_i = Mean diameter of successive size separated by sieve.

ωi = weight of soil porpotional aggregate in the size range as fraction of the total dry weight of sample.

3.8.6 Gravimetric soil moisture determination

water content of the soil was determined by oven drying sample at 105^{o}C until there was no further change of weight for about 24 hrs. The weight of the moist soil was taken on the farm before oven drying, soil sample were collected from each plot (0-5 cm depth, 15-20 cm depth) was taken making a total of 72 soil samples atthe different planting dates.

3.8.7 Soil quality determination

Soil quality was assessed by using the Parr *et al*. (1992) equation; i.e.

SQ=F (SP, P, E, H, ER, BD, FO, MI)

Where SQ =soil quality, SP =soil properties, P= potential productivity= environmental factors, H=health (human/animals) ER= erodibility, BD= biodiversity, FQ= food quality and

MI=management input. A score scale of 1to 5 will be used in the assessment of parameters in the model: where 1 is the best and 5 is the worst condition. The land for the experiment has been on long term research use (1922 till date) and has been equally managed to satisfy optimal environmental condition for sustainability, health factor for human and livestock, optimal food quality obtain, biodiversity and input management (Odunze, 2013). Therefore, SQ=F (SP, P) was used to assess quality of Alfisols in the Nigeria Guinea Savanna Zone

3.8.8Germination percentage count

3.8.9 Germination count was determine as given in the equation

The equation: Germination Percentage = Seeds germinated x 100
Total seeds sown.

Grain Yield Each net plot (3 m by 1.5 m) was harvested, shelled, winnowed, weighed and the yield was expressed in tons per hectare basis.

3.9.0 Weather data

Rainfall and temperature data for the period of 35 years to the experiment (2016 and 2017) were obtained from the meteorological station of the Institute for Agricultural Research (IAR) and used to assess the climatic condition of Samaru area for the purpose of this study. Climatic condition for 35 years before the experiment and the data for the two years during the experiment were analyzed using and weather graph to compare with long term weather information for climate change occurrence in the study area.

3.9.1 Statistical Analysis

To determine the influence of planting dates and cover crops on soil quality indicators and performance of maize yield, all data obtained were subjected to Analysis of Variance (ANOVA) using SAS (Statistical Analysis System) software version 9.3 (2011) difference between treatments means were derived from DMRT (Duncan multiple range test) at 5% probability. To address objective 1, 2, and 3, the data were subjected to ANOVA to establish the relationship between maize yield and planting date. A Multivariate statistical analysis involving principal component analysis was performed to determine indicator that significantly contribute to the outcome of the experiment**.**

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: Initial Physical and Chemical Properties of Soil in the study area

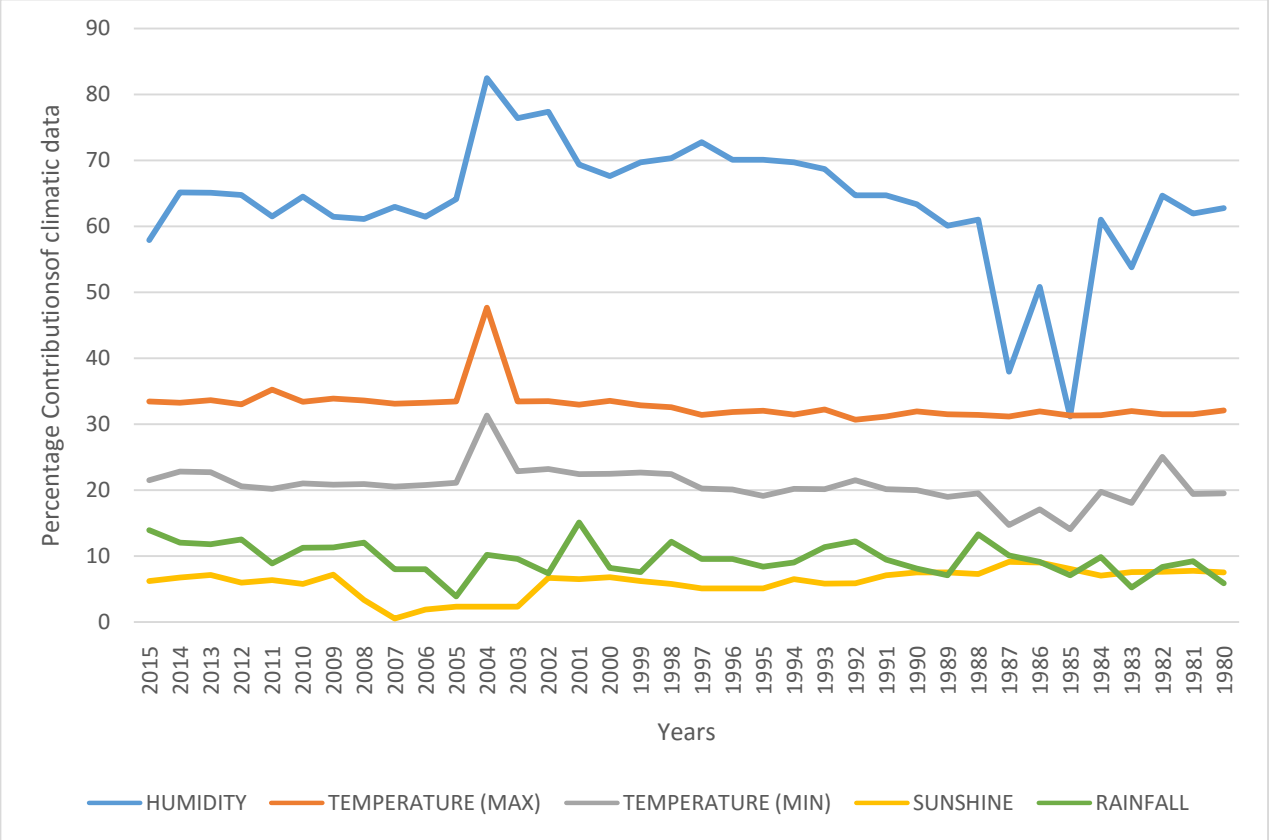
Table 4.1 show the result of soil physical and chemical properties before trial was initiated at 0-15 and 15-30 cm depth. Particle size distribution showed that sand fraction was 66% and 70% at depth 0-15 and 15-30 respectively, and dominated soil separate it was followed by silt (20% and 18%) and clay separate was the least (14% and 12%) the soil textural class was Sandy loam at both depth. Soil saturated hydraulic conductivity was (2.37- 4.99 cm/sec) and (2.09 to 5.01 cm/sec) at 0-15 and 15-30 cm depths respectively. The bulk density was found to be moderate at (1.55-1.63Mg/m^3)and (1.82-1.67 Mg/m^3) while porosity was (29.0%) and(22.0%) respectively. Soil pH in water was in was 6.4 at the surface soil and 6.8 in the subsurface soil while soil pH in $cacl_2$at the surface was 5.8 at the subsurface was 5.9. Soil Organic carbon values were higher at the surface 0-15 cm layer (3.62g kg^{-1}) than at 15-30 cm layer (3.1N gkg^{-1}). Total nitrogen of the soil was 0.99(N gkg-1) at the surface layer and 0.81(g kg-1) at the subsurface layer. Available phosphorus of the surface soil (0-15cm) was (5.34mg kg^{-1} and 5.995.34mg kg^{-1}) at the subsurface. Cation exchange capacity CEC of the soil were (7.76 cmol kg^{-1}) at surface and (7.44 cmol kg^{-1}) at subsurface layer. Generally, CEC of the experimental area was low (<10 cmol kg^{-1}) and Organic carbon (3.09 g kg^{-1})and total nitrogen (0.89 g kg^{-1})are generally poor.

Table 4.1: initial physical and chemical properties of the soil of the study area.

Soil properties	Depth (cm)	
	0-15	15-30
Sand (%)	66	70
Silt (%)	20	18
Clay (%)	14	12
Textural class	sandy loam	sandy loam
Hydraulic conductivity (cm/sec)	4.99	5.01
Bulk density (Mgm^{-3})	1.55	1.63
Total porosity (%)	29	22
Organic carbon ($g\ kg^{-1}$)	3.62	3.1
Total N ($g\ kg^{-1}$)	0.99	0.81
Available. P ($mg\ kg^{-1}$)	5.34	5.99
pH (H_2O)	6.4	6.8
pH ($CaCl_2$)	5.8	5.9
CEC ($cmol\ kg^{-1}$)	7.76	7.44

4.2 Average Climatic data for thirty-five years before the experiment

Reveals that thereis uniform pattern of humidity throughout the years except in the year 2004 which was very high compared to other years.The average annual minimum temperature was moderate but high value were observed in the 2004 which may have been influenced by the humidity of that year (2004) Yearly sunshine received is relatively constant except in the year 2007 which had the lowest sunshine. The yearly rainfall was uniform during the thirty five years before the experiment the highest was in 2015 before the experiment, In Nigeria, maize is grown in areas where annual rainfall ranges from 500 mm to 3500 mm covering from the Sudan/Sahel savanna to the Mangrove forest and the corresponding mean daily air temperatures are 27^{o}C and 25^{o}C.The climatic data shows a normal trend of rainfall, relative humidity, temperature and sunshine which are necessary at optimum range to contribute as determinant for farmer to know adequate onset of rain which can be favorable planting of maize although the planting dates selected for these experiment was in first, second, third and fourth week of June in 2016 and 2017. If the relative humidity is high it will lead to low temperature and low sunshine as observed in year 2015 but if the humidity is low there will be increase in temperature and sunshine, rate of evaporation from the soil will be high thereby reducing the water in the soil so farmer need to understand changes in climate so as to maximize the planting period for good germination.



Fig, 4.1 Climatic data for 35 years showing yearlyrelative humidity, mininum/maximum temperature, sunshine hours and rainfall depth from 1980 to 2015 in samaru

4.3: Monthly climatic data for 2016 and 2017 during the period of the experiment

The relative humidity in March (23.2 %and 15.9 %) was very low in the two years of the experiment figure 4.2 and 4.3 these affect the temperature, sunshine, and rainfall therefore the amount of moisture available in the soil is very low because of low rainfall, In April 2016, the relative humidity was low between (36.4%) from the first decadal and in the third decadal (51.6). It rises through the second decadal in the month of May (68.5%) to first decadal in the month of October(68.2%) thereafter there was a decrease in the relative humidity from the second decadal in October to the third decadal (61.6%). The maximum temperature was relatively constant from the first decadal in April (36.4^0C) to third decadal in the month of October (35.3^0C) and the minimum temperature show relative constant trend from first decadal in April(25.7^0C) to the third decadal in October (18.9^0C). The mean monthly rain fall was very low in the first decadal in April (0 mm) to third decadal in April(2.2mm) there is increase in rainfall from first decadal in May (25.2mm) to second decadal in July(33.9mm) the highest rainfall was recorded in the third decadal of July(136.1mm) which was steady till August and in the first decadal in September(90.4mm). where was sharp decrease in the rain fall from second decadal (6.9mm) and third decadal in October (3.4mm).Figure 3 show that the relative humidity was low between (13.2) from the first decadal in April to the third decadal (57.3)of April. it rises through the second decadal in the month of May (70.7) to second decadal in the month of October (71.2) thereafter there was a decrease in the relative humidity in the third decadal in October (52.4) while the maximum temperature was relative constant from the first decadal in April (21^0C) to third decadal in the month of October (34^0C) and the minimum temperature show relative constant trend from first decadal in April (21.5^0C) to the third decadal in October (15.6^0C). There is low sunshine in first decadal of

April (5.7Hrs/day) to third decadal in May (7.1Hrs/day) but the sunshine increases from first decadal in June (7.23 Hrs/day) to third decadal in October (7.6 Hrs/day).

The mean monthly rainfall was (0mm) in the first decadal in April to third decadal in April(0mm) there is increase in rainfall from first decadal in May (44.4mm) to second decadal in July(63mm) the highest rainfall was recorded in the first decadal of August (489.8mm) which continue to increase till second decadal in September(139.7mm). where was sharp decrease in the rain fall from third inSeptember (37.9mm) to the third decadal in October (0mm). This finding is similar to the work such as (Kurukulasuriya and Mendelsohn,

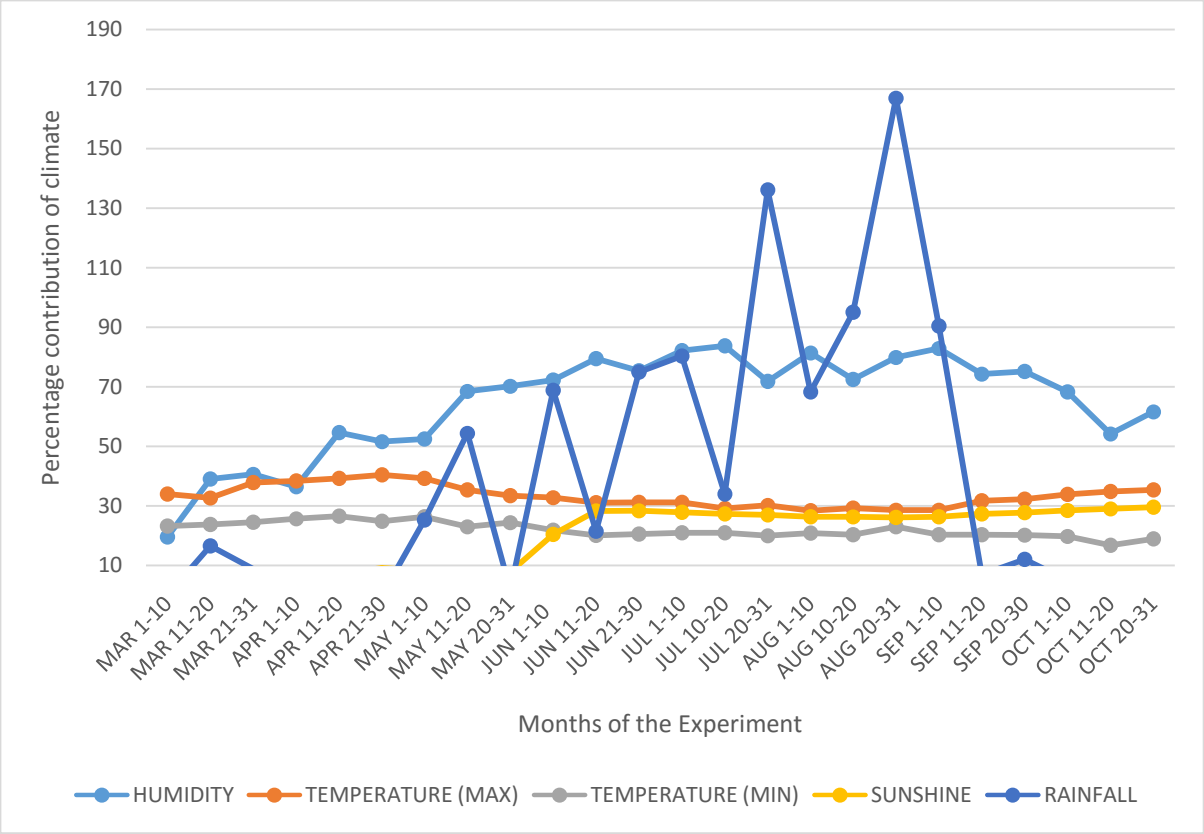


Fig 2: Climatic data for year 2016 years showing monthly humidity, minimum and maximum temperature, sunshine hours and rainfall depth in samara

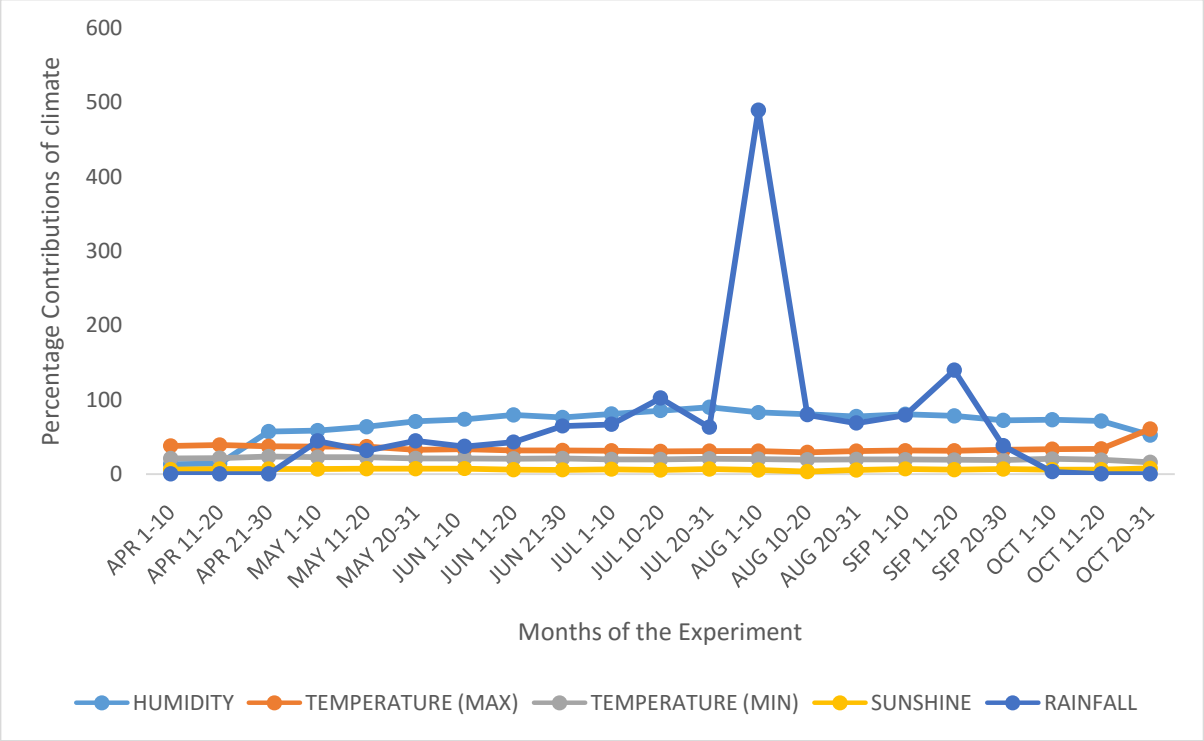


Fig 3: Climatic data for year 2017 showing relative humidity, minimum and maximum temperature, sunshine hour and rainfall depth in samara.

(2006); IISD, (2007); Lobell *et al.*, (2008) who revealed that recent global warming has influenced agricultural productivity, leading to declining food production. There is a growing concern that in the coming decades, the world will experience higher temperatures and changes in precipitation levels both in terms of distribution and patterns even in regions that rarely experience such harsh climates (Nwafor, 2007) Many countries in the tropical and sub-tropical regions; of which Nigeria is included, are expected to be more vulnerable to warming (Mendelsohn *et al.*, 2000) because of their low level of coping capacities (Nwafor, 2007; Jagtap, 2007). From the fig 2 and 3 the chosen planting date was in first to fourth week June at these period it was observed that amount of rainfall ranges between (70mm and 77mm) in the first and second decadal in June which is able to provide enough moisture to hold the germination and growth of maize seed although there was a sharp drop in the third decadal of

June in both year these lead to low (41mm) moisture in the soil due to low rainfall, relative humidity is low (34.4%) which also lead to increase in the sunshine.

Table 4.4: Total number of raining days during the trial in 2016 and 2017

The rainfall in April 2016 was (2.2mm) with just one raining day there was increase in rainfall from May, June and July but the month of August has the highest rainfall amount (330.3mm) in twenty raining days. September also has similar high rainfall but sharp decrease in rainfall was in October (8.3mm) in two raining days which was very low, therefore the total amount of rainfall in 2016 was (972.1) mm and a total of seventy rainfall days. There was (1.1mm) rainfall in April 2017 in one raining day.The month of May recorded (120.6mm) in nine raining days and increases to the month of August where there is highest rainfall amount (638.1mm) in thirteen raining days and decrease in rainfall in September (256.1) in fifteen raining days.The lowest rainfall was in October with (3mm) in one raining day. Therefore, total amount of rainfall in 2017 was (1395.3mm) and total sixty-six raining days this is in line with the report of (Odunze, 2011). Long term mean annual rainfall (1987-2016) in the zone is 986.5 mm and is received mainly between the months of May and September, with peak rainfall received in August. This implies that maize can be grown best between the months of May to October when there is rainfall starting from between the months of may to june the rainfall ranges from 81.3mm to 120.6mm the moisture available is able to enhance the germination of the crop and support the maize growth therefore the farmer can make use of these period before the month of august, September when the rainfall is high and in October when there is sharp drop in the amount of rainfall (8.3mm).

Table 4.2: Total amount of number of rainfall and rain days in mm during the mount of the trial, number of rainfall day in 2016/2017

Months	RFR/D	RF	R/D	
APRIL	2.2	1	1.1	1
MAY	81.3	6	120.6	9
JUNE	165.2	14	144.7	15
JULY	250.5	10	232.1	12
AUGUST	330.3	20	638.1	13
SEPTEMBER	109.3	12	256.7	15
OCTOBER	8.3	2	3	1
TOTAL	(972.1mm)	70	(1395.2mm)	66

RF=rainfall depth (mm), R/D raining days (days)

4.4:Effect of planting dates and cover crop on bulk density at sowing in year 2016 and 2017 at Samaru.

The highest moisture content (0.56 and 0.54 cm^3cm^{-3}) was observed in the third and fourth planting date respectively (table4.4). This implies that more water is available in the soil in the third and fourth planting dates Meanwhile the highest moisture in the cover crop was observed in C*entrosema pascuorum* and *cucubital maxima* 0.48 and 0.46**(**cm^3cm^{-3}**)** respectively. Decline in soil moisture was observed in other planting dates, which could result from decline in rainfall during the first and second week of June. This in turn may affect germination and final yield of the crop.

Soil moisture content was statistically different among cover crops. Soils under *Centrosema* retained higher moisture (0.48 cm^3cm^{-3}) than other cover crops. The planting dates effect on soil bulk density during the cropping season is presented (table4.4) in the combined analysis result shows that the least values was 1.43 Mg/m^3under *Curcubita maxima* and was not significantly different with No cover treatment (1.41 Mg/m^3. *Centrosema pascuorum* (1.45 Mgm^3) however showed statistically higher value in 2016. In 2017, the least bulk density value was obtained under *Curcubita maxima* (1.38 Mgm^3), followed by *Centrosema pascuorm* (1.47 Mgm^3) and the highest was under No cover treatment.

Fourth planting date in 2016 had least bulk density value of 1.41 Mg/m^3, followed by the third (1.46 Mgm^3) and second,Planting date (1.49 Mgm^3). First planting date had the highest bulk density value of 1.54 Mgm^3 to suggest that soils at this period were compact. In 2017, bulk density values were in the range of 1.50 to 1.58 Mgm^3 for all four planting dates; perharps because onset of rainfall was delayed and soil moisture content was relatively lower. The surface soil 0-5 cm had the least soil bulk density as compared to 5-10 cm depths in both years of study, the bulk density values are generally moderate (1.51 – 1.56 Mgm^{-3}) which

implies that the soil was slightly compacted and could restrict crop root growth and development (Evanylo and McGuinn, 2000). High bulk density values recorded in the first and second planting date agrees with the report of Abdellaty and Gamal (2009) but it is in contrary with the findings of Yusuf (2016) who reported that delay moisture has no effect on soil bulk density. The increment could also be attributed to level soil organic carbon which led to rearrangement of soil pores. Pikul and Zuzel (1994) and Franzuluebbers (2002) also reported that soil organic carbon has a direct impact on soil bulk density and/or inversely on porosity.

Table 4. 3: The effect of planting dates and cover crop on bulk density at sowing in year 2016 and 2017 at Samaru.

Treatment	2016(BD)	2017(BD)	Combined(BD)
No cover	1.41b	1.48	1.46
Centrosema pascuruom	1.45a	1.47	1.45
cucurbita maxima	1.43b	1.38	1.46
SE±	0.04	0.03	0.03
planting dates			
week1	1.54	1.54	1.53
week2	1.46	1.46	1.47
week3	1.41	1.41	1.45
week4	1.41	1.41	1.44
SE±	0.06	0.06	0.07
Depth			
0-15	1.49	1.49	1.48
15-30	1.52	1.52	1.5
SE±	0.04	0.04	0.04
cover * planting dates	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

4.5: Effect of planting dates and cover crop on total porosity at sowing in year 2016 and 2017 at samaru

The porosity of soil increased from first planting date (week one 45 %) and decreased at the fourth planting date (week four 33%) the mean of the cover crop was 25 % in both *Centrosema pascurum* and *Cucurbita maxima* but the porosity was low in treatment; with no cover having 28 %. In the year 2017 soil total porosity under the cover crops increased from no cover to *Centrosema pascurum*. While, the different planting dates also show increase in soil porosity from first date of planting to the fourth date of planting on the field. Soil porosity also increased from depth 0-5 cm and 15-20 cm. The statistical difference observed with the interaction in 2016 between the cover and planting could be ascribed to the cover crops retaining soil moisture than plot with sole maize. Result of combined analysis shows that total porosity decreased under the cover crops treatment when compared with the No Cover treatment.

Also total porosity decreased from the first planting dates to the fourth in 2016, 2017 and combined analysis, with the least porosity obtained at the fourth planting depth to suggest soil re-compaction at this planting time. Total porosity also decreased with depth in both years of study (Table 4.5). This is in agreement with report of Ogunwole (2005), who found that soil quality increases with low bulk density, aggregate strength and residue cover. Evanylo and McGuinn (2000) cited in Ecehe *et al.* (2013) observed similar trend and suggested that bulk density values of 1.55 to <1.65 Mgm^{-3} can affect root growth and development while soil bulk density of < 1.40 Mgm^{-3} are ideal for optimum root growth

Table 4.4:Effect of planting dates and cover crop on soil total porosity at sowing in year 2016 and 2017 at samara(pore volume in percentage)

TREATMENT	2016	2017	COMBINED Porosity (%)
no cover	28.0	43.0	36.0
Centrosema Pascuroum	25.0	40.0	33.0
Cucurbita Maxima	25.0	33.0	29.0
SE±	0.2	0.5	0.2
Planting Dates			
Week1	35.0	45.0	41.0
Week2	25.0	41.0	33.0
Week3	22.0	36.0	29.0
Week4	21.0	33.0	27.0
SE±	0.03	0.06	0.03
DEPTH			
0-15	29.0	41.0	35.0
15-30	22.0	37.0	29.0
SE±	0.02	0.04	0.02
INTERACTION			
COVER*Planting Dates	*	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

Table 4.6: Effect of planting dates and cover crop on hydraulic conductivity at Sowing in year 2016 and 2017 at samaru

The soil hydraulic conductivity in the study area during the year 2016 show that the mean values varied from 2.57-1.87 cm/sec in the four different planting dates, but the mean was 2.57 cm/sec in the third planting date. There was increase in soil hydraulic conductivity values in the year 2017, but decreased from the first planting to the second and third. Increased at fourth planting dates and had mean values ranging from 5.02-5.08 cm/sec. The same was evident among the cover crop in both years as seen in Table 4.6, where *Curcubita maxima* showed higher conductivity value (5.09 cm/sec) than *Centrosema pascuorum* (4.94 cm/sec), while No Cover treatment showed conductivity value of 4.89 cm/sec). These may be attributed management practice in 2016 that may have improved the soil water conductance potential in 2017. The combined analysis result shows that soils under No cover treatment and *Curcubita maxima* had highest hydraulic conductivity *than Centrosema pascuorum* (Table 4.6). Also, planting dates data shows that the third and fourth planting dates in 2016 and 2017 respectively had highest hydraulic conductivity values. Combined analysis data however shows that best hydraulic conductivity value was obtained at the third planting period (3.78 cm/sec), followed by the first planting period (3.66 cm/sec). Hydraulic conductivity decreased with depth in 2016, but increased in 2017 to present a non-discernable trend. However, combined analysis result shows that highest hydraulic conductivity under this treatment was obtained at the third top soil top (0-5 cm) than the sub soil depth of 15-20 cm. Hydraulic conductivity and water retention characteristics determine response of a soil water system to improve boundary conditions (Klute and Dirksen, 1986). Soil hydraulic conductivity among other physical properties is affected by soil compaction. Ogunwole *et al.* (2000) reported decrease in saturated hydraulic conductivity with increase in compaction. Also, saturated hydraulic conductivity increased with moisture content up to 0.22 cm^3 but declined at moisture content greater than 0.22 cm^3 in Samaru (Ogunwole *et al.*, 2000).

Table 4.5: Effect of planting dates and cover crop on hydraulic conductivity at sowing in year 2016 and 2017 at samaru

	Hydraulic conductivity at sowing (cm/sec)		
TREATMENT	2016	2017	COMBINED
No cover	2.19	4.98	3.76
Centrosema Pascuruom	2.07	4.94	3.51
Cucurbital Maxima	2.42	5.09	3.76
SE±	0.37	0.13	0.19
Planting Dates			
Week one	2.3	5.02	3.66
Week two	2. 17	4.92	3.54
Week three	2.57	4.99	3.78
Week four	1.87	5.08	3.47
SE±	0.43	0.15	0.23
DEPTH			
0-5	2.37	4.99	3.68
15-20	2.09	5.01	3.55
SE±	0.3	0.11	0.16
INTERACTION			
COVER*Planting Date	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

4.7: Effect of planting date and cover crops on moisture content (cm^3cm^{-3}), bulk density (Mg/m^3) and porosity (%) at 4 and 8weeks after planting in 2016 and 2017

Planting date and cover crop as influenced by bulk density, moisture content and porosity is presented in (table 4.7) Planting date and cover crop had no significant (NS) effect on the soil bulk density of the soils at 4 and 8 weeks after sowing. However, at six weeks, the bulk density had a significant in 2016 compared with the cover crops CP and CM which had similar means of bulk density (BD). Lower soil bulk density was observed in plots on which the cover crops were planted. Table 4.6 also show that soil bulk density at planting increased as the week of planting increased. Highest bulk density was recorded on plot with no cover. .the percentage of soil porosity as increase as the soil moisture increase there is a decrease in the mean of the porosity in the third planting date little dryness of the soil and farm operation because compaction and disturbance by use of hoes during weeding The moisture contents of the cover crops in 2016 showed no statistical difference, but in 2017 soils under *Cucubita maxima (0.73* cm^3cm^{-3}*)* and *Centrosema pascuorum (0.77* cm^3cm^{-3}*)* cover crops had statistically similar mean values greater than the No Cover treatment 0.72.Combined two year result of moisture contents under the treatments showed significantly higher values under the cover crops than under No Cover treatment.

The bulk density among soils under Centrosema *pascuorum* and *Curcubit maxima* cover crops were not significantly different in 2016, but in 2017, bulk density under the No cover was less than under the Cover crop treatments, though not significantly. Combined analysis result shows that the planting date has no statistical difference on the moisture content, bulk density and porosity, except the combine result of the bulk density which show that planting date week one, week two and week three is statistically better than week four which is the last planting date. Although soil tillage prior to planting loosens soil and temporarily reduce bulk density of the surface, it soon returns to a non-tilled state because of subsequent compaction by the action of rain drop impacts during a rainfall event (Iwuafor, 1986) and subsequent

plow runs across the field during data collection, coupled with the reducing rainfall as the crops growing season advances under rain fed crops production hence bulk density increase with weeks after the four weeks of sowing

Table 4.7: Effect of planting dates and cover crops on moisture Content (cm^3cm^{-3}), bulk density (g/cm^3) and porosity (%) at four weeks after planting in 2016 and 2017

	2016	2017		2016	2017		2016	2017	
TRT	moisture content		combined	Bulk Density		COMBINED		Porosity	COMBINED
No cover	0.88	0.29b	0.40b	1.52	1.47	1.43b	31b	37	31
Centrosema Pascuroum	0.92	0.44a	0.46a	1.51	1.53	1.55a	30b	35	32
Cucurbita Maxima	0.98	70.51a	0.49a	1.46	1.53	1.52a	35a	27	33
SE±	0.001	0.0007	0.0005	0.05	0.05	0.04	0.02	0.02	0.8
planting date									
Weekone	0.89	0.4	0.44a	1.44	1.48	1.44a	30	33	30b
Weektwo	0.88	0.36	0.41b	1.47	1.48	1.47b	33	33	33a
Weekthree	0.92	0.45	0.42a	1.54	1.37	1.54a	30	36	30b
week four	0.81	0.4	0.43a	1.54	1.36	1.54b	34	29	34a
SE±	0.0007	0.001	0.0009	0.03	0.08	0.06	0.1	0.2	0.9
DEPTH									
0-5	0.84	0.39	0.44	1.42	1.47	1.48	31	33	32
15-20	0.84	0.43	0.48	1.38	1.51	1.58	33	33	32
SE±	0.0002	0.0007	0.0005	0.03	0.06	0.06	0.01	0.01	0.6
INTERACTION									
COVER*PD	NS	NS	NS	NS	NS	NS	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

4.8: Effect of moisture content (cm^3cm^{-3}), bulk density (Mg/m^3) and porosity (%) at 8 weeks after planting in 2016 and 2017

Soil moisture contents in 2016 and 2017 were not statistically different, but the mean in all the treatments were higher 1.10 cm^3cm^{-3} in 2016 than in 2017. *Centrosema pascurum* had the highest mean of 0.77 cm^3cm^{-3}. There was statisticaldifference between bulkdensities in 2016, with No cover treatment having highest bulk density value (1.83 Mg/m^3) and the least was obtained under *Curcubita maxima* (1.53 Mg/m^3). In 2017, soils under *Curcubita maxima*, followed by *Centrosema pascuorum* had the highest bulk density values than the No cover treatment. Perhaps, following late onset of rains in 2017, the cover crops could not provide early good ground cover to moderate soil bulk density bet than the No cover treatment (Table 4.8) Following combined analysis result, the treatments showed high bulk density values, though highest value was obtained under the No cover treatment (1.75 Mg/m^3), followed by *Centrosema pascuorum* (1.73 Mg/m^3) and the least was under *Curcubit maxima*. (1.67 Mg/m^3).

The total porosity in both year ranges from 31 to 42 but the cover the mean ranges from 31, 36, and 40. Bulk density between planting dates least value of 1.62 Mgm^3 in 2016 and 1.70 Mgm^3 in 2017 at second and third planting period respectively. However, the combined analysis result reveals that the least bulk density of 1.67 Mgm^3 was obtained at the third planting period to be best among the planting periods. Bulk density between soil depths studied did not present clear trend between years but the combined analysis result shows that values decreased with depth (Table 4.8).

Table 4. 8: Effect of moisture content (cm^3cm^{-3}), bulk density (Mg/m^3) and porosity (%) at 6 weeks after planting in 2016 and 2017

	Moisture content			bulk density			porosity		combined
TRT	2016	2017	combined	2016	2017	combined	2016	2017	
No cover	1.10	0.34	0.72	1.83a	1.67	1.75a	31	37	34
Centrosema.P	0.98	0.51	0.77	1.61	1.73	1.73	39	35	36
Cucurbita. M	0.91	0.52	0.73	1.53	1.93a	1.67	42	27	35
SE±	0.0004	0.0005	0.0005	0.04	0.04	0.04	0.02	0.02	0.1
Planting Dates									
Week one	0.62	0.51	0.79	1.72a	1.78a	1.75a	35	33	34
week two	0.97	0.38	0.70	1.62	1.78	1.69	39	33	36
week three	0.98	0.47	0.73	1.65	1.7	1.67	38	36	36
week four	0.96	0.46	0.75	1.63	1.86	1.74	38	29	34
SE±	0.0009	0.0009	0.0006	0.05	0.05	0.04	0.19	0.2	0.2
DEPTH									
0-5	0.99	0.43	0.73	1.67	1.77	1.72	37	33	35
15-20	0.99	0.48	0.75	1.64	1.78	1.71	38	33	35
SE±	0.004	0.0004	0.0002	0.36	0.04	0.02	0.1	0.1	1.1
Interaction									
COVER*PD	NS	NS	NS	NS	NS	NS	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard

4.9 :Effect of Chemical properties at the different planting date during the experiment in 2016 and 2017

The pH in water and $cacl_2$ 5.76 and 6.69 but there is difference in pH of cover crop CP having the mean of 5.96, NO is 5.76 and CM 5.43 respectively. The OC in *centrosema pascuruom* and No cover was statistically higher ($5.58gkg^{-1}$, $5.13gkg^{-1}$) than *cucurbita maxima* ($4.63gkg^{-1}$) the AP in *centrosema pascuruom* was higher than in no cover and *cucurbita maxima*. The CEC in the *centrosema pascuruom* and *cucurbita maxima*were statistically higher than in No cover. Chemical properties in the planting date were similar from week one to week fourand there seems that no changes occur in the chemical properties of the soil.The same trend was observed in the second year. Total N content and exchangeable K were low. meanwhile available P was moderate (Esu, 1991) indicating poor nutrient reserve of the soil. For sustainable crop production and optimum crop yield, organic amendment should be incorporated into the soil to improve its organic carbon content and, consequently, nutrient availability (Tan, 2000: Odunze, 2006). The greatest potential for maize production can be fully realized with adequate fertilizer application (Norman *et al*, (1976).

Table 4. 9: Chemical properties at the different planting date in 2016 and 2017 seasson of croping at samaru

	2016	2017		2016	2017		2016	2017	combined	2016	2017	COMBINE
TRT	Week one		Combine	Week two		Combine	week	Three		Week	four	Combine
H20	6.71	6.71	6.71a	6.61	6.61b	6.61b	6.56	6.57b	6.56b	6.62	6.62	6.62b
pH$CaCl_2$	5.73	5.73	5.73a	5.85	5.85	5.84a	5.74	5.75	5.75a	5.55	5.55	5.54b
OC (gkg^{-1})	5.75	6.08	5.36	5.75	6.19	5.96	4.65	5.65	5.15	4.53	4.58	5.03
Total N (gkg^{-1})	1.21a	0.65	0.93	1.21	0.64	0.92	1.05	0.72	0.89	1.4	0.61	1.02
AP(mg kg^{-1})	10.4a	10.4a	10.4a	8.50	8.58a	8.58a	6.68	6.68b	6.68b	7.95b	7.95	7.95b
Ca($Cmol/Kg^{-1}$)	3.86	5.14	4.49b	5.42	6.58	6.00a	4.45	5.28	4.86b	4.94	5.33	5.14b
Mg($Cmol/Kg^{-1}$)	0.69	0.18	0.75	1.41	1.06	1.24	0.93	1.15	1.01	1.24	1.06	1.15
K($Cmol/Kg^{-1}$)	0.13b	0.53	0.033	0.28a	0.49	0.38	0.23b	0.5	0.36	0.16b	0.46	0.31
Na($Cmol/Kg^{-1}$)	0.38	0.18b	0.28	0.41	0.21b	0.31	0.42	0.23a	0.32	0.44	0.19B	0.32
Al($Cmol/Kg^{-1}$)	0.42	0.42	0.42	0.49	0.49	0.48	0.46	0.49	0.48	0.47	0.46	0.47
ECEC($Cmol/Kg^{-1}$)	5.68	7.090.	6.38b	8.21	8.82	8.52a	6.63	7.65	7.14b	7.46	7.52	7.49b
SE±	0.761	0.711	0.724	0.733	0.761	0.742	0.741	0.761	0.752	0.731	0.721	0.723

4.10: Effect of cover crop treatments and planting dates on soil aggregates in 2016 and 2017

The macro aggregates of 1mm, 0.25mm and 0.5mm was added together to calculate the mean of the treatment in the two year in the two years. The mean of the no cover is 0.76mm,CP is 0.34mm and CM is 0.34 while the aggregate of the planting date is 0.96,0.97,0.95 and 0.0.97 in planting 1-4 respectively showing no significant difference as compared with the cover crops but in the year 2016 there is statistical mean difference in CM and the two cover with CP having the similar mean with NO and However, mean generally increased across all treatments with sole *centrocema pascurum* giving significantly (2MM) higher mean than all other treatments. Implying that soil aggregate stability does not vary with management practices over the two-year study. The dry aggregate of the experimental site was found to be stable with in all the planting dates but there is the plot with no cover and *centrosemma pascurum* favors better aggregation than plot with *cucubita maxima* as seen in Table 4.9 thereby enhanced the ability of soil aggregates to resist disintegration when disruptive forces associated with farm practice and wind or water erosion are applied on the farm. The difference observed amidst the treatments in MWD could be attributed to the cover crop and planting dates. This probably resulted to the collapse of macro aggregate into micro aggregates in the other treatments with less carbon as suggested by Abu and Malgwi (2012). Suwardji and Eberbach (1998) also reported that inter annual and seasonal variability in aggregate stability results from seasonal alternate wetting and drying which interact with accumulation of plant and microbial remains associated with the growing plants.

Table 4. 10: Effect of cover crop treatments and planting dates on proportional soil aggregates in 2016 and 2017

	MWD		
	2016	2017	COMBINED
Treatment			
No cover	0.41	0.67b	0.59
Centrosema pascuruom	0.44	0.69a	0.58
cucurbita maxima	0.41	0.67b	0.58
SE±	0.02	0.02	0.02
planting dates			
week1	0.42	0.67	0.57
week2	0.42	0.67	0.57
week3	0.42	0.67	0.56
week4	0.42	0.68	0.57
SE±	0.02	0.02	0.02
Interaction			
cover * planting dates	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

4.11: Effect of planting dates and cover crops on grain yield, germination and Stover in 2016 and 2017

Generally, germination of seed (cover and test crops) were better on first and second planting dates were 3rd and fourth planting dates when bird find it easier to pick sown seeks reducing the chance for germination thereby require re-seedling especially on plots with no cover crops. There is significant interaction between the cover crop and planting dates in the two year these may be due to The various cover crops were effective in retaining the soil water than the plot with no cover for the substantial part of the cropping season in the two years (Table: 4.10). planting dates on the yields of maize in the two season is shown on (Table4.11, and 4.12), planting date did not significantly affect the maize stands per hectare, however, in 2017 the number of maize stand per hectare responded significantly to planting date ($p<0.05$) with highest stand per hectare produced in the first planting date. Planting dates significantly affected the Stover yield in both years. While in 2016 the highest response was in the third planting. In 2017 however, there was significant response to planting date with the highest in the first planting date. Harvest index was significantly affected by planting dates only in 2017 with the highest response in the first and second plantingsthe second season of 2017 had recorded better maize yield than 2016 in (table 4.16). The might be as a result of favorable agrometeological factor in the area of adequate and well distributed rainfall in the 2017 as compared to 2016. It was observed that early planting have enhanced the yield of maize in 2017. Nyakatawa and Reddy (2000) ascribed greater volumetric moisture content in cover plot similarly higher soil moisture content in cover crops soil, however, Jones et al, (1969) observed that learning crop residue on soil surface resulted in less surface runoff of water and increased soil water content hence explaining the significant relationship between cover and planting dates.

Table 4. 11: Effect of cover and planting dates on germinationcount on the in 2016 and 2017.

	Percentage germination count (%)		
Treatment	2016	2017	combine
Nocover	91.6a	92.2	92.2
Centrosema pascuruom	83.8b	83.8	83.8
cucurbita maxima	81.8b	81.8	81.8
SE±	1.61	1.61	0.009
planting dates			
week1	87.7	87.9	87.7
week2	86.4	85.4	86.4a
week3	85.7	85.7	85.7b
week4	83.8	83.8	83.8b
SE±	1.86	1.86	0.0001
Interaction			
cover * planting dates	**	*	**

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability, BD =bulk density NS = Not significant, SE = Standard Error

Table 4.12: Effect of the cover and planting dates Stover yield in 2016 and 2017

	Stover yield in kg/hectares		
Treatment	2016	2017	COMBINE
Nocover	6.25a	6.3a	6.28a
Centrosema pascuruom	4.89b	5.08b	4.98b
cucurbita maxima	4.73b	4.89b	4.81b
SE±	0.13	0.12	0.08
planting dates			
week1	5.70b	5.80a	5.76a
week2	5.07b	5.44b	5.12b
week3	5.23b	5.40b	5.32b
week4	5.17b	5.33b	5.25
SE±	0.15	0.14	0.09
Interaction			
cover * planting dates	NS	**	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability.

Table 4.13: Effect of the cover and planting dates on grain yield in 2016 and 2017

	grain yield in tones		
Treatment	2016	2017	Combine
Nocover	1.733a	2.691	4.425a
Centrosema pascuruom	1.183b	2.600	3.783b
cucurbita maxima	1.075b	2.633	3.708b
SE±	51.84	66.9	118.74
planting dates			
week1	1.477a	2.600	4.077
week2	1.400a	2.611	4.011
week3	1.200c	2.733	3.933
week4	1.244b	2.622	3.866
SE±	59.85	77.25	137.1
Interaction			
cover * planting dates	NS	NS	NS

* = significant at 0.05 level, ** = significant at 0.01, *** = significant at 0.001, **** = significant at 0.0001, NS = Not significant at 0.05 level of probability.

Principal Components Analysis

Integration of some choosen soil properties via principal components analysis as influenced by moisture and cover crops.

Factor analysis using principal component analysis (PCA) was undertaken for 11 selected soil properties which were significantly influenced by planting date or maize yield. Result obtained from the PCA revealed that only 4 factor were retained by the MENETGEN criterion or Kaiser criterion (Kaiser, 1960); By adopting this approach only components with Eigen values greater than one were retained and interpreted components with eign value greater than one accounts for greater amount of variance than had been contributed by one variable (meaningful amount of variance).

Outcome of varimax rotation, showed that bulk density and total porosity component 1 to 4 accounted for 20% of the total variance (Table 4.14) while loadings for the different variable obtained afterPCA are presented in (Table 4.15)

The magnitude of the eigenvalues was used as a criterion for interpreting the relationship between soil attributes and factors. Soil attributes were assigned to a factor for which their eigenvalues was the highest. Bulk density and total porosity have the highest communality estimate which suggest high proportion of variance was explained by the factor, therefore it would get higher performance over lower communality estimate, Available phosphorus was the least important attribute due to the lowest communality estimate.

Table 4. 14: Principal component analysis for year 2016 Eigenvalue, proportion and cumulative variance explained by factor using correlation of matrix of 11 soil properties

Component	FACTOR 1=28%	FACTOR 2=20%	FACTOR 3=13%	FACTOR 4=11%	FACTOR 5=10%	FACTOR 6=10%
OCgkg	0.117	0	-0.34	0.342	0.6	0.561*
pH(h_20)	0.229	0.254	0.319	-0.534*	0.133	0.631
pH$Cacl_2$	0.889*	0.025	0.349	0.139	0.119	-0.143
TNgkg	-0.889*	0.025	0.349	0.139	0.119	-0.143
ECEC	-0.219	-0.396	0.475*	0.657I*	0.135	-0.006
AP	0.857*	0.098	0.08	-0.211	0.02	-0.061
Mc	-0.595*	0.224	0.593*	-0.193	0.178	-0.2
Bd	-0.039	-0.951*	0.109	-0.25	0.094	0.053
POR	0.039	0.951*	-0.109	0.25	-0.094	-0.053
M/AG	-0.166	0.077	0.479*	0.243	-0.58	0.505*
YIElD	-0.546*	0.374	0.325	-0.11	0.522*	-0.117

BD = dry bulk density (Mg/m^3), GY= Grain yield (kg/ha), OC = Organic carbon ($g\ kg^{-1}$), AP= Available phosphorus ($mg\ kg^{-1}$), TN= Total nitrogen ($g\ kg^{-1}$),ECEC= effective cation exchange capacity,MC= moisture content, PH(Water), PH($CaCl_2$), TP = Total soil porosity (%).

Table 4.15 ,Soil principal component for 2017, Eigenvalue, proportion and cumulative variance explained by factor using correlation of matrix of 11 soil properties

5 factor were retained by the MENEIGEN criterion

Component	**FACTOR1 =32%**	**FACTOR2=19 %%**	**FACTOR3 =13%**	**FACTOR 4=10%**	**FACTOR5=9%**
Oc gkg	-0.082	0.288	-0.419*	0.722*	0.281
pH water	0.305	0.341	0.225	0.513*	-0.451*
$pHcacl_2$	0.802*	0.417*	-0.116	-0.212	0.293
TN gkg	0.802*	0.417*	-0.116	-0.212	0.293
ECEC	0.616*	0.258	0.456*	-0.065	-0.283
AP(ppm)	0.839*	0.233	0.173	0.042	-0.098
MOISTURE	-0.532*	0.194	0.326	-0.149	0.554*
BULK DENSITY	0.542*	-0.818*	0.014	0.024	0.055
POROSITY	-0.542*	0.818*	0.014	-0.024	-0.054
Macroagg	-0.111	0.152	0.782*	-0.014	0.028
Yield	-0.432*	0.224	-0.452*	-0.486*	-0.433*

AP= Available phosphorus (mg kg^{-1}), TN= Total nitrogen (g kg^{-1}),ECEC= effective cation exchange capacity,MC= moisture content, PH(Water), PH($CaCl_2$), TP = Total soil porosity (%).

Table 4.16 the final cumulative estimate for the cropping season in 2016 and 2017 in samaru

Component	2016	2017
OC gkg	0.96	0.87
PHwater	0.92	0.93
$PHCaCl_2$	0.97	0.96
TNgkg	0.97	0.96
ECEC	0.88	0.73
AP ppm	0.8	0.8
MC	0.86	0.8
BD	0.99	0.76
POROSITY	0.99	0.97
M/AG	0.92	0.65
YIELD	0.84	0.86

BD = dry bulk density (Mg/m^3), GY= Grain yield (kg/ha), OC = Organic carbon ($g\ kg^{-1}$), AP= Available phosphorus ($mg\ kg^{-1}$), TN= Total nitrogen ($g\ kg^{-1}$),ECEC= effective cation exchange capacity,MC= moisture content, PH(Water), PH($CaCl_2$), TP = Total soil porosity (%).

SOIL QUALITY ASSESSMENT

Soil quality assessment on 4 planting dates evaluated in the study is presented in (Table 4.16)all the cover crop are moderately good in soil conservation having ranked as 2 with the no cover but the planting date week one and week two is better than week three and four in the year 2016 but in the *Centrosema Pascuruom* is ranked best than no cover and *Cucubita Maxima* while the planting date week three is best ranked then one and two while week four is ranked least in the second year soil reaction ranged is strongly acidic in both two years of planting. Bulk density and total porosity moderate while total soil nitrogen range from moderate to low in the no cover to cover crops in both two years. Available P maize grain yield and exchangeable basis were moderate irrespective of the planting dates.

Table 4.17, soil quality and yield of maize on the different planting dates and cover crops in 2016.

TREATMENT	**CP**	**NO**	**CM**	**A**	**B**	**C**	**D**
ORG. C	3	3	3	3	3	3	3
pH water	1	2	2	1	2	3	2
pH CaCl2	3	1	4	3	3	3	4
Total.N	2	3	1	3	3	3	3
ECEC	2	2	2	2	2	2	2
Avail.P	1	2	1	2	3	3	3
Moisture.	2	2	2	2	2	3	2
bulk/D	1	2	1	1	2	1	1
Porosity	2	1	2	1	2	1	2
Yield	3	3	3	3	3	3	3
Aggregate	2	1	2	2	2	2	1
TOTAL	22	22	23	23	27	27	26
SQ ranks	2	2	2	2	4	4	3

1=best while 5=worst, CP=*centrocema pascuroum*, CM=*cucubita maxima*,NO=no cover, A=

planting 1, B=planting date 2, C=planting date 3,D=planting date 4, SQ=soil quality

CHAPTER FIVE

5.0: SUMMARY CONCLUSION AND RECOMMENDATIONS

5.1 Summary and conclusion

The variation in the climatic data over the 35 years and during the two year of the experiment have direct impact on the maize yield.

Grain and stover yield of maize were increased numerically in both year but these differences were not significant in the first year and no significant in the second year of cropping in both first and second weeks of planting 4.08 and 4.01 tons/hectare similar to plots with no cover crop while the value for the last planting date (3.86) ton/hectare is similar to the plot with cover 3.78 *Centrosema perscuroum and 3.71Cucubita maxima*.

Adequate physical soil properties such as (moisture and hydraulic conductivity) and climate (rainfall and temperature) are germane to determine best planting date, optimum crop germination before the start of dry spell mostly experienced in the second to third week of June in these experiment.Soil quality is generally low in cover crop and planting dates there is the need for farmer to incorporate plant residue into the soil to improve the soil quality.

5.2 Recommendations

Different maturity duration should be subjected to same climate for trial but the interval of planting date should be increase to determine most suitable dates and increase awareness on the effect of climate change on the soil.

Since water is a major necessity for crop production hence knowledge of soil moisture and period of dry spell to avoid seed wastage.Cover crop adoption is advantageous to the soil properties therefore the planting maize with cover should be more enhanced.

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