EFFECTS OF NITROGEN AND GENOTYPE ON SOME PHYSIOLOGICAL AND MORPHOLOGICAL CHARACTERS OF MAIZE (*Zea mays.L*)

BY

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DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been presented in any previous application for a higher degree references made to published and unpublished literature have been duly acknowledged.

________________________ _________________
Akubuike,Chinwe Eucharia Date

The above declaration is confirmed

_________________________________ ____________________
Date

CERTIFICATION

This thesis titled Effects of Nitrogen and genotypes on some physiological and morphological character of maize (Zea mays L.) by Akubuike, chinwe Eucharia meets the regulations governing the award of the Master of Science in Crop Physiology of Ahmadu Bello University,Zaria and is approved for its contribution to scientific knowledge literary presentation.

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DEDICATION

This work is dedicated to God the Father, the Son and the Holy Spirit.

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ABSTRACT

Three genotypes (LNTP-WC2,LNTP-Y5 and OBA 98) with seven nitrogen levels (0,20,40,60,80,100 and 120 kg N ha^{-1}) used to investigate the effects of Nitrogen and genotypes on some physiological and morphological characters of maize at Samaru, in the Northern guinea Savanna of Nigeria. The trials were conducted for two years (2007 and 2008) at the institute for Agricultural research farm at Samaru, Zaria. The objectives of the study were to find out the effect of Nitrogen on the performance of maize genotypes and also to determine the varietal differences in N-use efficiency and components of N-efficiency. Nitrogen application was found to significantly ($p<0.05$) increase growth of plant such as plant height,leaf area and leaf dry weight. Plant height increased from 0.3m under control to 1.77m with the highest nitrogen rate. Similarly, highest number of leaf area plant^{-1} of 533 and 435 cm^2 in 2007 and 2008 respectively,were obtained with the highest rate of N(120 kg N ha^{-1}) Mean grain yield from 3259 kg N ha^{-1} in 2007,4502 kg N ha^{-1} in 2008 and 4082 kg N ha^{-1} in the combined analysis.The components of N-efficiency viz :N-uptake efficiency and N-utilization efficiency were positively affected by characters of maize.However,NUE and N-utilization efficiency were seen as the most important components of N-efficiency. The correlation coefficients obtained showed that 100 seed-weight, leaf area, cob length and number of rows cob^{-1} were positively and significantly correlated with grain yield.

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CHAPTER ONE

INTRODUCTION

1.1 Origin and Distribution.

Maize (*Zea mays L.)* belongs to the grass family poaceae. It is known as corn in the Americas and Australia. A cereal grain that was domesticated in Mesoamerica and then spread through out the America continents. Later the crop spread through much of the Americans. Between 1250 - 1700 A.D. Nearly the whole continent had access to the crop. There are several theories about the specific origin of maize in Mesoamerica. Maize spread to the rest of the world after European contact with the Americans in the late 15th and early 16th centuries (EUFIC, 2009).

The crop is among the most important cereals in the world. It ranks third position among cereal crops after wheat and rice, which ranked as first and second respectively (Zeidan *et al.*, 2006). The total world production was estimated at 817 tonnes, out of which Africa produced 45 tonnes representing about 5.9 % with Nigeria producing 6.95 tonnes (0.7 %) of the world figure (FAO, 2006). According to F.A.O data west and central Africa were reported to produce 2.4 tonnes in 1961 to 10.6 tonnes in 2005 (F.A.O 2005). Maize production in Nigeria was concentrated in the rain forest and Southern guinea Savanna zones, where apart from the relatively more fertile soils, the rainfall allowed two crops to be grown in one year (F.A.O 2005). However, it has been reported that the savanna zones of northern Nigeria have the greatest potential for maize production because of the higher solar radiation (Kassam *et al.*,1975).

1.2 Botany

Maize (*Zea mays L.)* is an annual grain. The stem is erect, conventionally 2-3 meters in height. The leaves are long, with the lower leaves like broad flags 50-100cm long and 5-10cm wide. Under these leaves and close to the stem grow the ears. The growth rate is about 3cm a day until it reaches the full length.

The ears are female inflorescences, covered by several layers of leaves, and close to the stem that they are not easily revealed until the emergence of pale yellow silks from the leaf whorl at the end of the ear. The silks are elongated stigmas that look like tufts of hair at first green and later red or yellow. The apex of the stem ends in the tassel, an inflorescence of male flowers. When the tassel is mature and conditions are warm and dry, anthers on the tassel release pollen. Each silk may become pollinated to produce one kernel of corn. The kernel of corn has a pericarp of the fruit fused with the seed coat. An ear contains from 200-400 kernels, 10cm-25cm in length. They are of various colours-blackish, red, white, and yellow.

1.3 Environmental Requirements

Maize *(Zea mays L.)* grows in temperate and tropical regions. At germination, it requires a temperature of 18^{O} to 20^{O}C. Its optimum growth temperature ranges between 26^{o}-30^{O}C (Onwueme and Sinha, 1991). A higher temperature of 35^{o}C is desirable at ripening time (Watson, 1988). According to Onwueme and Sinha (1991), maize is a typical short day plant with rainfall requirement of 600 mm – 1000 mm per annum. Coupled with well drained medium textured soil with high water holding capacity and pH range of 5.5-7.0. Wind is an important climatic factor especially during tasselling to ensure efficient pollination (onwueme and Sinha,1991).

1.4 Uses (economic importance) of maize

Maize *(Zea mays L.)* or corn as it is called in USA has a multitude of uses and because of its worldwide distribution and lower price relative to other cereals, maize has a wide range of uses than any other cereal. Maize can be processed into different products for various end uses at traditional level and on industrial scale. While a large proportion of products utilized in developing countries is obtained via traditional processing. In Nigeria few commercial maize processing mills are in operation producing brewer grits, maize flour and maize meal (Watson,1988).

It is used as staple food for human consumption mainly consumed in the form of fresh cob, semolina or dried ground flour (tuwo masara).Maize is also used as raw material for industries such as corn starch, corn oil, corn syrup, high fructose syrup and stalk (Watson,1988).While the stalk is used for building, construction of fences, it is also used as fuel for cooking.

1.5 Background of the study

Recent development in production of maize and its rapid expansion to north of latitude 8 °N, which was not earlier a maize growing region, have subjected the crop to various production constraints such as pests, diseases and weeds (Ayeni,1987). The challenge of maize production can also be attributed to the adoption of poor practices such as seedbed preparation, fertilizer application, use of poor planting materials, ineffective pests and disease control management, poor harvesting and storage among methods by most farmers.

Ayeni (1987) identified the constraints to maize production as low-input, crop management practices and the use of low yielding varieties which are susceptible to attack by insects such as stem borer, endemic diseases like maize streak virus and parasitic weed especially striga species. The problem of weeds is a very serious issue because maize is very sensitive to weed competition. Greater losses may be caused by weeds such as itchgrass, sedge *(cyperus* spp), spear grass and parasitic weeds especially striga species (Ayeni,1987).

1.6 Statement of problem

The major environmental and cultural constraints to maize production are those of the rapid loss of soil fertility due to leaching of minerals, degradation of organic matter at a faster rate and lack of attention paid to the maintenance of soil health and practices of exhaustive cropping pattern without returning adequate nutrients to the soil (Sani,1991).Nitrogen (N) is known to be one of the most limiting factors in the production of maize in Nigeria with reason being that most of the savanna soils are sandy, loam and N being a very mobile nutrient can easily be leached out of the root zone. Maize which is a long season crop may suffer N deficiency due to leaching of the applied N (Carsky and Iwuafor,1995).

1.7 Justification

Maize (*Zea mays L.)* is an important crop because of its significant role in the diets of the people of Nigeria, West Africa and Africa at large. Regardless of the considerable work already done on the response of Maize to N, paucity of information on use of growth indices to determine maize genotypes that can be productive under low soil N level abounds. (Lafitte and Edmeades,1994) reported that by enhancing the higher utilization of available N either by possessing a high N-uptake capacity or a more efficient use of absorbed N in grain production. Productivity of maize by selection of genotypes that perform well under suboptimal N conditions could be achieved.

This work was conducted to establish the relationship between yields of maize and some characters that could be used in improving yield in maize. The objectives of this study were:

1.8 Objective of the study

1. To study the effect of N on the growth indices and chlorophyll content of maize.
2. To investigate the effects of N on the performance of maize genotypes and the relationship between grain yield and growth indices of maize.
3. To determine the varietal differences in N-use efficiency and components of N-efficiency in the maize.

CHAPTER TWO

LITERATURE REVIEW

2.1 Mineral N uptake and effect on Physiological Processes in Plants

N is an essential nutrient in crops because of its key role in protein formation. Among the essential macronutrients, N is one of the most important element for crop growth. It plays a pivotal role in several physiological processes in the plants. Growing plants absorb mineral N from the soil. For most plants, the N is taken into the body in the form of nitrates. The minerals in soil dissolve in soil water and enter the root hairs by diffusion or active transport. However, the uptake of N by plants could be affected by temperature, moisture content and plant growth stage. N deficiency is shown by pale green or yellowish-green color of the leaves, followed by premature necrosis of the older leaves. Generally, N application will alter plant –rooting depth and increase the root density and root growth rate (Campbell, 1978), thereby increasing water use-efficiency (WUE) of plant by increasing the volume available to plants (Christianson and Vlek, 1991).

Nitrogen is one of the major (essential) elements and have a significant role in plants, its deficiency have a deleterious effect on many physiological processes. Reddy *et al*.,(2005) conducted an experiment to determine the effects of N deficiency on sorghum growth and physiology with treatments such as 100 % N at first as control, secondly, reduced N to 20 % of the control and thirdly, withheld N from solution (0 %). Photosynthetic rate (Pr), chlorophyll (chl) and Nitrogen (N) concentrations were determined from 21-58 DAS. Plants were harvested to determine effects of N deficiency on leaf area (LA), biomass accumulation. It was observed that N deficiency significantly reduced leaf area, leaf chlorophyll content and Pr. Leaf Pr decreased because of N deficiency which was mainly associated with lower stomata conductance, rather than carboxylation capacity of leaf chemistry.

2.2 Leaf Chlorophyll Content

Leaf chlorophyll content is a key indicator of the physiological status of a plant. Leaves *contain* chlorophyll, chlorophyll a and b as essential pigments for the conversion of light energy to stored chemical energy, and the amount of solar radiation absorbed by a leaf is a function of these photosynthetic pigment content. Thus, chlorophyll content is linked directly to photosynthetic potential and primary production of food (Curran *et al*.,1990). Follet *et al.,* (1981) reported that chlorophyll coloration is related to the amount of nutrients absorbed by the plant from the soil. Additionally chlorophyll gives an indirect estimate of the nutrient status as considerable leaf N is incorporated in that pigment (Filella *et al.,* 1995). The quantity of chlorophyll in the leaf is affected directly by plant stress and senescence (Hendry et al., 1982). Alvino *et al*., (1988) on a two (2) year field experiment of N effects on senescence of maize,using four treatments{ N fertilized (180 kg N ha^{-1}) with (NI) and with (ND) irrigation; and 0 kg N ha^{-1} applied with (01) and without (OD) irrigation} With size and longevity measurements made on leaves at all nodal positions and leaves 5,11 and 15(counting) from stem base were monitored for changes in photosynthetic capacity (PC),Nitrogen (N) concentration and chlorophyll content (chl).Leaf PC was correlated with percent N during senescence in all treatments(r^2=0.86).Chlorophyll and percent N were also correlated (r^2=0.80).The initial onsets of decline in these two parameters often differed by several days.In both years,lack of applied N had an early impact and reduced longevity.N deficit were more severe in 1982 than 1983.In 1982,N deficiency caused a 50% reduction in leaf values of PC,CHL and percent N. They found that the most rapid decline and earliest complete senescence of upper leaves (11 and 15) occurred in the ND treatment and this occured when the water stress was intensified.

Amujoyegbe *et al*.,(2007) reported the effects of nutrient sources such as inorganic fertilizer (IF), IF+ poultry manure (IFPM), poultry manure (PM) and control (C) (no fertilizer or manure treatment) on chlorophyll content of maize and sorghum for two years. Each fertilizer source supplied 54 kg N plus 25 kg P and 25 kg K ha^{-1}.There were significant variability and diversity observed on the two crops due to treatments. Sorghum also had the highest leaf area LA ($2752.9cm^2plant^{-1}$) and total chlorophyll content of $3.28mg\ g^{-1}$ under PM while maize on the other hand had the highest leaf area ($1969.5cm^2plant^{-1}$) and total chlorophyll content of $2.63mg\ g^{-1}$ under IFPM. In both maize and sorghum, the lowest chlorophyll content occurred in control plot. The effects of nutrient source such as control (C),IF,IFPM and PM on the chlorophyll component of maize and sorghum was more pronounced on chlorophyll a content of sorghum (i.e larger in size).Unlike that of maize where the effects were more on chlorophyll b. Generally, chlorophyll b formed the bulk of the total chlorophyll of the two crops. The effect of IFPM was higher chlorophyll a and b components in maize .While PM affected those of sorghum and the total chlorophyll.

Quartacci and Navari-Izzo (1992), reported that water deficit alters chlorophyll a, whereas chlorophyll b remains unchanged in all the cereal plants evaluated. Nyachiro *et al.,* (2001) observed that water deficit decreased chlorophyll a, b and total chlorophyll content in all the wheat cultivars evaluated and caused a decrease in photosynthetic efficiency.

2.3 Effect of N on Growth of Maize

N has a major controlling influence on growth. However, for most plants, the N is taken into the body in the form of nitrates. It is a constituent of amino acids, proteins and nucleic acids. Nitrogenous compounds are Amino acids and amides such as aspartic acid, glutamic acid, ardenine and alanine.The concentration of nitrogenous compounds is known to change from one season to the other. These compounds are translocated in the phloem. According to Carsky and Iwuafor (1995), maize production is limited by N deficiency more often than by that of any other nutrient and it is the most important nutrient for maize. N has been shown to significantly influence the growth of maize. It plays a central role in plant biochemistry as an essential constituent of cell wall, cytoplasmic protein, nucleic acid, chl and array of cell components (Hay and Walker, 1989).Plant height and dry matter production increase with increased N application up to 100 or 150 kg N ha-^{1} (Ogunlela *et al*., 1988). Plant height and length of ear were found to be increased by increasing N from 0-200 kg N ha-^{1} in maize (Mohammed *et al.*, 1978). It was also observed that peak demand for it occurs during the period from about 3 weeks before and 2 weeks after tasselling.

N has been known to affect the period from about 50 % tasselling and silking. Rathore et al., (1976) observed that N application increased the number of days to 50 % tasselling, while Ologunde (1974) recorded a decrease in the number of days to 50 % tasselling with increasing N rates.

2.4 Effect of N on Yield and Yield Components

Grain yield of maize is directly dependent on the amount of nutrient available up to a certain optimum. Many researchers have found that N application increased grain yield and its components. Samira *et al*.,(1998) and Torbeit *et al.,(*2001) found that yield and yield component of maize were increased by increasing the rate of applied N. El-sheikh (1998), reported that applying 160 kg N ha^{-1} significantly increased ear characters and grain yield of maize.

There was an attribution to delayed silk emergence, which resulted in poor ear fill or stripped kernels to N deficiency(Ding et al.,2005) Other factors such as drought and overcrowding were observed to produce similar effect. Gupta and Gautam (1994) reported that maize gave 60 and 120 kg N ha^{-1} which resulted in increased grain yield with increasing N rate resulting in a maximum yield of 4.83 t ha^{-1}.A similar response was also reported in a multi locational study in the southern guinea savanna of Nigeria (Agbede *et al.,* 1991, Ologunde and Ogunlela, 1984) in the forest zone of Nigeria. Esechie (1987), in the Northern Guinea savanna of Nigeria (Ologunde,1983). It was reported that N increased 1000–grain weight and ears per plant of maize (Prasad and Singh 1990). Field experiment revealed that maize grain yield were highest with 60 kg N ha^{-1} increasing by 2 t ha^{-1} over the control, but water-use was not significantly changed with increase in N rate . The response of maize to N fertilization is known to be related to the level of soil organic matter, the total N content of the soil, the texture of the soil and the variety of the maize used. Generally, maize planted in sandy loam soil performs better than that planted in loamy sand at all rates of N applied (Singh and singh,1979).

2.5 Maize Varietal Responses

Varieties differ in their adaptation to new ecologies, yield potentials, maturity period and canopy architecture (Dowswell *et al.,*1996).They also differ in physical and chemical properties of the grain, which affect their suitability for various end uses (Kling, 1991).The response of low N tolerant maize varieties to N does vary. Varietal differences existed for some traits related to sink capacity of maize, number of ears at harvest, chlorophyll content and grain yield.

Elemo (1991), in his evaluation of hybrid maize cultivars for adaptation to the Northern Guinea Savanna ecology reported that there was no measurable difference in grain yield and 100-grain weight of hybrid maize tested as compared to the open pollinated variety. However, hybrids are clearly higher yield than the best open pollinated varieties in all ecological zones of Nigeria (Fakorede *et al*.,1993). Kim *et al*.,(1988) showed in his work that the performance of hybrid maize was 34 % higher than what was obtained with improved open pollinated maize varieties.

2.6 N-use efficiency

The understanding of the mechanism of N-uptake and N-utilization for grain production is essential for any program that attempts to improve N-use efficiency (NUE) in maize. In general, NUE in maize (*Zea mays L.)* has been defined as grain produced (Gw) per unit of N supplied as (Ns) and expressed as (Gw/Ns) Moll *et al.,* 1982. The underlying hypothesis is that varieties with a high NUE possess mechanism for the uptake and utilization of both forms of N, regardless of the amount of N in the soils (Moll *et al*., 1982).

Differences in N-utilization efficiency among maize genotypes have been demonstrated, not only in differential response to N fertilizer, but also in differences in absorption and utilization of absorbed N for grain production (Chevalier and Schrader,1979).

Thus the potential for developing superior N efficient cultivars do exist. Efficiency in uptake and utilization of N in the production of grain requires that all the processes associated with absorption, translocation, assimilation and redistribution of N operate effectively. The relative contribution of these processes to genotypic differences in N use efficiency may vary among genetic populations and among environments. It is therefore, important to define N-use efficiency in terms of grain produced per unit of N supplied (Moll *et al*., 1982).

Differences among maize hybrids and the variation in numerous processes involved in N use efficiency were evaluated with grain yield, N accumulation in plant at silking, N accumulated in grain and stover at harvest. Moll *et al* (1982) observed significant differences among hybrids for all traits except grain yield. At low N (56 kg N ha^{-1}) supply, differences among hybrids for N use efficiency were due largely to variation in uptake efficiency. Variation in proportion of N supply, but N accumulation after silking were not important at either fertilizer rates (56 or 224 kg N ha^{-1}).Lafitte and Edmeades (1994a,b) observed that uptake efficiency and utilization efficiency were more important in describing genotype for N tolerance. In all these studies, it was pointed out that plant with high NUE possess mechanisms for efficient use of NH_4^+ that may be associated with loss of nitrification activity of bacteria under stress condition (Machado, 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Experimental Site

The field experiments were conducted at the Research Field of Institute for Agricultural Research (IAR), Samaru, Zaria ($11^{o}11^{1}$ N, 07^{o} 38^{1} E,686m above sea level) during the 2007 and 2008 wet Seasons, respectively. Samaru lies in the Northern Guinea Savanna Zone of Nigeria.

Table 1: Sources and Description of Materials

NAME	**COLOUR**	**EAR HEIGHT(cm)**	**PLANT HEIGHT(cm)**	**STAY-GREEN SCORES**	**SOURCE**
LNTP-WC2	FLINT,WHITE	60-65	135-140	110-120	IITA
LNTP-Y5	FLINT,YELLOW	60-65	140-145	110-120	IITA
Oba-98	WHITE,FLINT DENT	110	190	105	PREMIER SEEDS

3.2 Field Experiment and Techniques

3.3 Sampling and Analysis

Before the commencement of the experiment, the topsoil (0-30cm depth) sample was collected at random across the experimental field with a soil auger. The composite soil sample taken after bulking the soil was analyzed in the laboratory for physico-chemical properties such as pH, organic carbon, total nitrogen, available P,exchangeable cation (CEC) and particle size. Soil sampling and analysis was also carried out for second year of experiment.

3.4 Experimental design

Treatments consisted seven levels of N (0,20,40,60,80,100 and 120 kg N ha^{-1}) and three maize genotypes (LNPXLNTPWC-2, LNTP-Y5 and Oba 98). The Factorial Combination of the treatments were laid out in a randomized complete block design and replicated 3 times.

3.5 Land preparation and planting

The field for the experiment was ploughed, harrowed and ridged. Each plot was made up of 4 ridges, and the inter-row spacing was 75cm, while intra-row spacing was 25cm.Sowing was manually done, when the soil was sufficiently moist. Two seeds per hill were sown and about two weeks after planting (WAP) the plants were thinned seeds was thinned to one plant per hill at 2WAS.

3.6 Land area and gross plot size

The total land area for this experiment was 0.08 hectare. The gross plot size was 4m long x3m width (12 m^2) comprising four (4) rows per plot .Each replicate was separated from the other by one metre (1m) border.The net plot comprised the two (2) inner rows, measuring 4mx1.5m (6m^2)

3.7 Fertilizer application

Nitrogen in the form of urea (46 % N) was applied at the rate of 0, 20, 40, 60, 80, 100, and 120 kg N ha^{-1} The application was done in two split doses .The first half was applied at 3 WAS,while the second half was applied at 6 WAS. However, it was applied in 5cm deep holes and buried between stands. P and K were uniformly applied in the form of single superphosphate 18 % (P_2O_5) muriate of potash, 60 % (K_2O) at 19.8 kg P $ha^{-1}$and 37.4 kg K ha^{-1}, respectively.

3.8 Harvesting

Cobs were harvested per individual plots manually at 13weeks after sowing (WAS),using hands.

3.9 Data collection

Assessment of plant characters started at 2 WAS and continued at 3 weeks interval. Data were collected on the following parameters from two central rows to remove boarder effect leaving the outside rows.

3.9.1 Observations

(a) Growth Characters

i. **Plant height (cm)**

This was carried out by measuring the height with a metre rule from the soil level to the tip of the flag leaf.

ii. Leaf area (cm^2)

This was done by measuring the length and width of each leaf from the five-tagged plants using a meter rule. The mean values of the leaf area of the 5 sample plants in each plot was taken and then multiplied by a factor of 0.75, developed by Duncan and Hesketh,(1968).

iii Leaf dry weight (g)

The leaves of the five randomly selected tagged plants were removed in each plot and averaged to get the mean number of leaf dry weight. It was oven dried at a temperature of 80^0C for 24hours and the temperature was raised to 100 ^{o}C for one hour before weighing inorder to remove bond water.

iv. Stem dry weight (g)

The stems of the five randomly selected tagged plants were cut in each plot and averaged to get the mean number of stem dry weight. It was oven dried at a temperature of 80^0C for 24hours and the temperature was raised to 100^oC for one hour before weighing.

v. Plant Dry Weight (Total Dry Matter) (g)

This was taken by adding up the mean of the leaf dry weights and stem dry weights at sampling periods of 6, 9 and 12 WAS.

(b) Yield and Yield Components

i. Number of Days to 50 % Tasselling

The number of days taken by 50% of the crops per plot to attain tasselling was observed.

ii. Number of Days to 50 % Silking

The number of days taken by 50 % of the crops per plot to attain silking was observed.

iii. Anthesis –Silking Interval (ASI)

The difference between number of days to 50 % tasselling and 50 % silking was calculated.

iv. Number of Rows Per Cob

The number of rows per cob was taken for five cobs in each plot and averages worked out and recorded.

v. Cob weight per Plant

Five plants per plot were randomly selected and their cobs were harvested and weighed, the value for each plot was then divided by the number of plants (5).

vi. Grain weight Per Cob (kg)

Five cobs were randomly taken from each net plot, threshed and weighed. The value was then divided by number of cobs threshed (i.e.5) to get grain weight/cob.

vii. Cob Length (cm)

Five plants per plot were randomly selected and their cobs were harvested and length of each cob measured with a metre–rule. The value for each plot was then divided by the number of plants.

viii. Grain Yield Per Hectare (kg ha^{-1})

Grain yield per plot was extrapolated to per hectare basis. It is the same as economic yield.

ix. Harvest Index (HI)

This was obtained as a percentage of economic yield to biological yield (Donald and Hamblin, 1976). It was estimated as:

$$HI = \frac{\text{Grain yield}}{\text{Total dry matter}} \times 100$$

C. Growth Indices

From the leaf area data,leaf and plant dry weight collected, the following growth indices were calculated using the formulae by Wilson (1966).

i. Crop growth rate (CGR): dry weight increment/area of land/unit time.

$$CGR = \frac{w_2 - w_1}{t_2 - t_1} \times \frac{1}{GA} \quad gm^{-2}wk^{-1}$$

ii. Relative growth rate (RGR): dry weight increment /plant dry weight / unit time

$$RGR = \frac{l_n w_2 - l_n w_1}{t_2 - t_1} \quad g.g^{-1}wk^{-1}$$

iii. Net assimilation rate (NAR): Also called unit leaf rate (ULR) is the dry weight increment / unit leaf area /unit time

$$NAR = \frac{w_2 - w_1}{A_2 - A_1} \frac{(l_n A_2 - l_n A_1)}{t_2 - t_1} \; g.cm^{-2}wk^{-1}$$

iv. Leaf area Ratio (LAR): The ratio of total leaf area to the whole plant dry weight

$$LAR = \frac{L_1}{W_1} + \frac{L_2}{W_2}\ cm^2 g^{-1}$$

v. **Leaf area index:** The ratio of leaf surface area/unit area of land

$$LAI = \frac{LA}{GA} \times Y$$

Where;

L_1 = Length or area at period 1

L_2 = Length or area at period 2

W_1 = Weight at period 1(3 weeks)

W_2 = Weight at period 2 (6 weeks)

t_1 = Weeks in period 1

t_2 = Weeks in period 2

GA = Ground or land area

Y = Number of leaves

0.75 = Crop factor, developed by Duncan & Hesketh, 1968

D. Chlorophyll content determination

Destructive harvest of leaf samples was done at 12 WAS, in the morning hours. A cork borer of 8 cm in diameter was used to cut 1 g from the leaves. Samples were macerated with pestle and mortar and poured into test tubes which were wrapped with aluminum foil paper. 10 mls of 80 % ethanol: water (V/V) solution was poured into each test tube to extract the chlorophyll. The test tubes were then plugged with cotton wool and small foil paper and stored for 48hours. 5ml of the sample filtrate was used to determine absorbance spectrophotometrically at 663 and 645nm, and also using 80% ethanol as blank. Two readings were taken at each wavelength and the average found.

Chlorophyll a, chlorophyll b and total chlorophyll contents were calculated according to the equation of Arnon (1949).

Chl a ($mgcm^{-2}$) = (12.7A663 – 2.7A645)5

Chl b ($mgcm^{-2}$) = (22.9A645 – 4.7A663)5

Total chl ($mgcm^{-2}$) = (8.5A663 + 20.2A645)5

Where A is the absorbance of the ethanol extract at 663 and 645nm, while 5 is the five milliliters of 80% ethanol extract used for taking readings.

E. Determination of plant Nitrogen

Five plants per plot were harvested at physiological maturity,i.e when the leaves turned yellowish brown and began to fall off and the net plots were then harvested. Samples were divided into leaves, stem, cob and tassel. The samples were dried and analysed for percent N at Nitrogen laboratory of IAR. After the determination of total percent N in various plant parts, the two primary components of N use efficiency, namely;

1) The efficiency with which the N is absorbed (uptake efficiency) and

2) The efficiency with which the absorbed N is utilized to produce grains (N utilization efficiency) were calculated using the procedure described by Moll *et.al.,* (1982) as follows:

N uptake efficiency=Nt/Ns

N utilization efficiency=Gw/Nt

N use efficiency (NUE) was calculated as Gw/Ns=(Nt/Ns)(Gw/Nt)

Where Nt=the total ground plant N

Ns=Nitrogen applied; Gw=grain yield per plant

3.10 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967).The forms of ANOVA used for the field experiments are shown. The linear additive model used for analysis in the field experiment is as follows:

$$Y_{ijk} = \mu + N_1 + G_k + R_j + (NG)_{ik} + e_{ijk}$$

Y_{IJK} = Observation of the K^{th} genotype and i^{th} Nitrogen in the J^{th} replication (R) within the y^{th} year(Y)

μ = Overall population mean

N_I = effect of the i^{th} nitrogen

R_J = Observation in the j^{th} replication

G_K = effect of the K^{th} genotype, K= 1,2,3

$(NG)_{IK}$ = Effect of Nitrogen within each Genotype (interaction)

e_{ijk} = residual error due to sampling of cultivars (0, $б^2$).

Means that differed significantly were compared using Duncan’s Multiple Range Test (Duncan ,1955).Pearson Correlations were taken to determine the types of association between some growth and yield components (Little and Hills,1978).

CHAPTER FOUR

RESULTS

4.1 Growth Characters

4.1.1 Plant Height (cm)

Nitrogen (N) significantly ($P \leq 0.05$) increased plant height (Table 2) of maize. The plant height per plant of maize was highest at 120 kg N ha^{-1} at all sampling period in the year 2007 and 2008 trials. The combined analysis showed that genotype OBA-98 produced significantly ($P \leq 0.05$) taller plants than the other genotypes at 6WAS. While genotype LNTP-Y5 produced taller plants than the other genotype at 9WAS. However, at 12WAS, both LNTP-Y5 and OBA-98 gave the tallest plants.

N x genotype interactions were significant ($P \leq 0.05$) at 6WAS in 2008 and the combined analysis. Highly significant NXG interactions were observed ($P \leq 0.05$) at 9WAS in the two years, and the combined analysis and also at 12WAS in 2007. At 6 WAS in 2008 (Fig.1), increasing N rate up to 120 kg N ha^{-1} significantly ($P \leq 0.05$) increased plant height over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest plant height (63.8cm) which was comparable to 100 kg N ha^{-1} (60.2cm). However, 0 kg N ha^{-1} gave the lowest plant height (33.8cm) followed by 40 kg N ha^{-1} (53.7cm). LNTP-Y5 gave the highest plant height (66.4cm) at 120 kg N ha^{-1}, which was comparable to 100 kg N ha^{-1} (62.5cm). However, 20 kg N ha^{-1} gave the lowest plant height (51.1cm). While for OBA 98 at 120 kg N ha^{-1} gave the highest plant height (63.6cm), when plant height was significantly increased. But increasing N rate from 20-80kg N ha^{-1} had no significant positive effect. Similarly, 120kg N ha^{-1} performed better among all the genotypes studied, with the highest height produced by genotype LNTP-Y5 (66.4cm) with no significant difference among genotype LNTP-WC2 and OBA-98.

Table 2: Effect of Nitrogen and genotype on plant height (cm) of maize during the 2007 and 2008 wet seasons at Samaru

Treatment	6 WAS			9 WAS			12 WAS		
(A) N(kg N ha^{-1})	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	32.4^{g}	42.6^{f}	37.5^{g}	91.6^{g}	111.5^{g}	101.5^{g}	113.9^{f}	110.9^{e}	112.4^{g}
20	40.8^{f}	50.9^{e}	45.9^{f}	100.2^{f}	125.0^{f}	112.6^{f}	134.7^{e}	114.8^{e}	126.4^{f}
40	45.3^{e}	53.9^{de}	49.6^{e}	104.7^{e}	135.0^{e}	119.9^{e}	147.4^{e}	127.3^{d}	137.6^{e}
60	52.4^{d}	56.5^{cd}	54.4^{d}	113.8^{d}	140.9^{d}	127.4^{d}	154.2^{d}	132.8^{cd}	144.4^{d}
80	56.8^{c}	59.0^{bc}	57.9^{c}	126.5^{c}	151.3^{c}	138.9^{c}	158.6^{c}	137.4^{bc}	148.8^{c}
100	62.1^{b}	61.0^{b}	61.6^{b}	139.8^{b}	158.4^{b}	145.1^{b}	169.0^{b}	141.8^{b}	156.6^{b}
120	73.6^{a}	64.7^{a}	69.1^{a}	149.9a	173.8^{a}	161.9^{a}	177.1^{a}	149.8^{a}	165.6^{a}
SE(±)	1.02	1.18	1.10	1.21	1.34	0.91	1.77	1.60	1.20
(B) Genotype									
LNTP-WC2	52.8^{a}	53.7^{b}	53.3^{b}	98.3^{c}	145.4^{b}	121.9^{c}	147.7^{b}	125.4^{b}	136.5^{b}
LNTP-Y5	49.3^{b}	56.5^{a}	52.9^{b}	124.3^{b}	154.4^{a}	139.4^{a}	152.5^{a}	135.7^{a}	144.1^{a}
OBA-98	53.7^{a}	56.2^{a}	55.0^{a}	128.2^{a}	127.0^{c}	127.6^{b}	152.1^{a}	136.6^{a}	144.3^{a}
SE ±	0.67	0.77	0.51	0.79	0.88	0.65	1.16	1.005	1.04
Interaction (C) (AXB)	NS	*	*	**	**	**	**	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of probability using DMRT. NS = not significant.

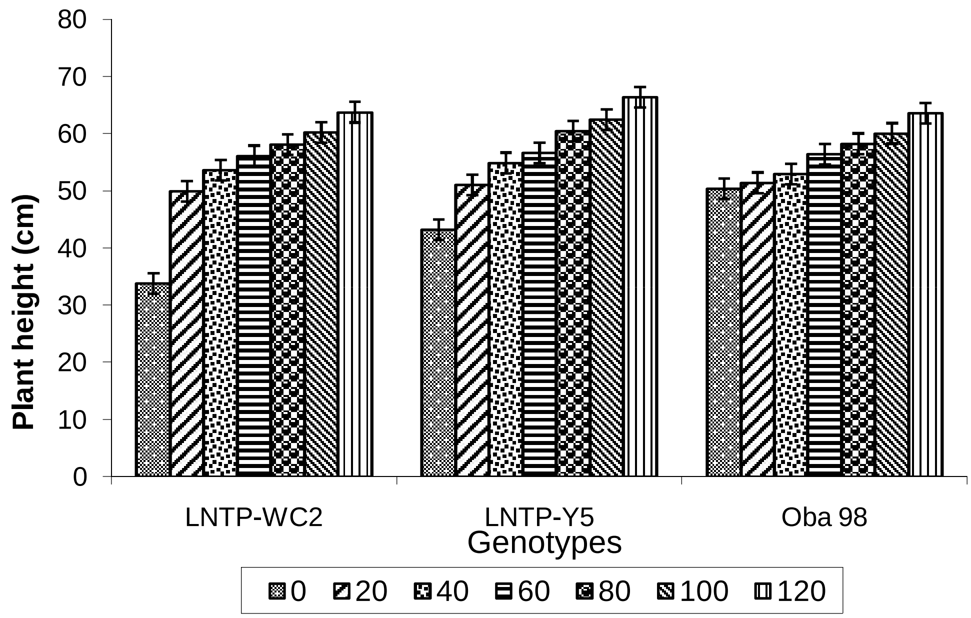

Fig. I: Plant height (cm) of maize as influenced by N x genotype interaction at 6 WAS in 2008 at Samaru

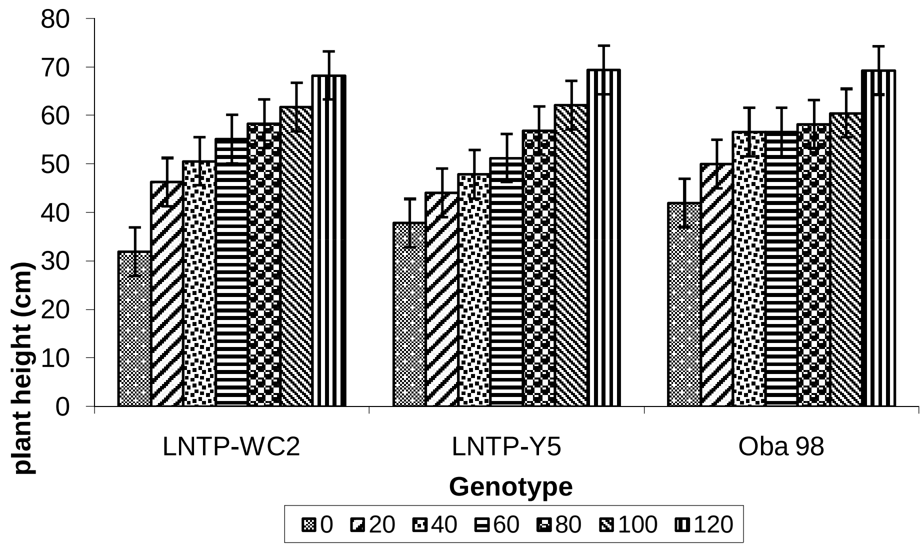

Fig. II: Plant height of maize as influenced by N x genotype interaction at 6 was (combined analysis) at samaru

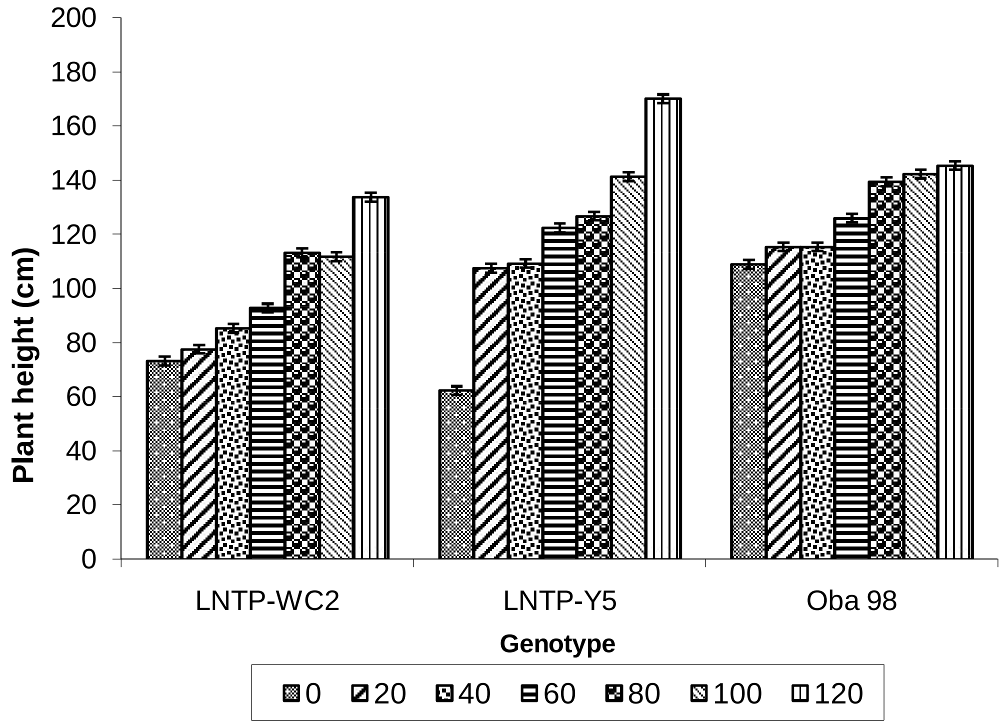

Fig. III: Plant height (cm) of maize as influenced by N x genotype interaction at 9 WAS in 2007 at Samaru

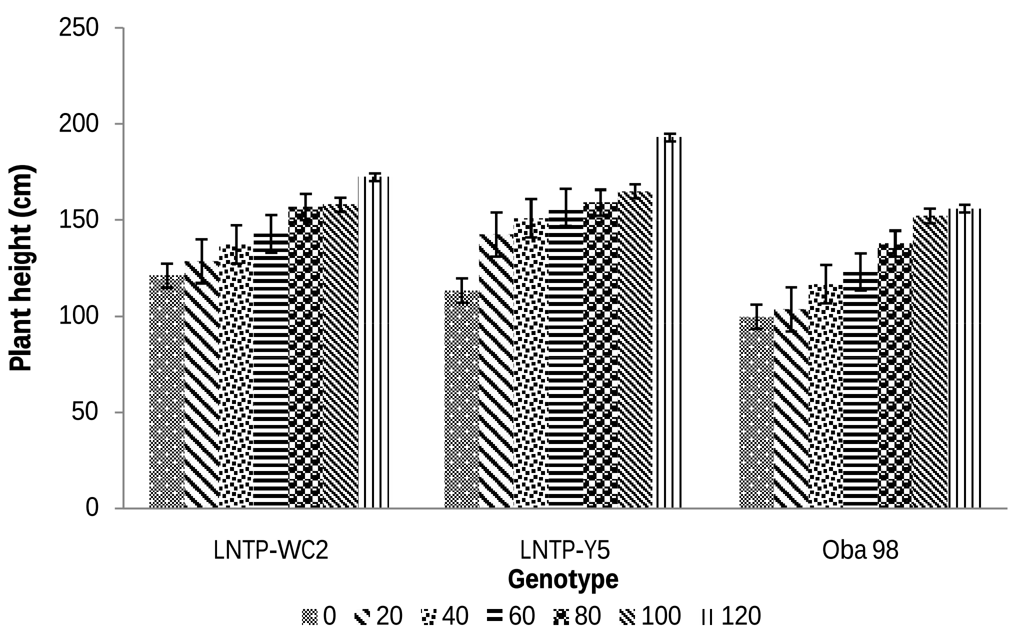

Fig. IV: Plant height (cm) of maize as influenced by N x genotype interaction at 9 WAS in 2008 at Samaru

At 6WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} increased plant height over 0kg N ha^{-1} for all the genotypes studied (fig.II). LNTP-WC2 gave the highest plant height (68.3cm) at 120kg N ha^{-1}, followed by 100kgNha^{-1-} (61.8cm). But increasing N rate from 20 to 60kg N ha^{-1} had no significant positive effect on plant height. LNTP-Y5 gave the highest plant height (69.5cm) at 120kg N ha^{-1} followed by 100kg N ha^{-1} (63.2cm). OBA-98 gave the highest plant height (69.4cm) at 120kg N ha^{-1}. But increasing, N rate from 80-100kg N had no significant positive effect on plant height.

At 9WAS in 2007 (fig.III), increasing N rate up to 120kg N ha^{-1} significantly increased plant height over 0kg N ha^{-1} for all the genotypes studied. At 120kg N ha^{-1}, LNTP-WC2 gave the highest plant height (133.8cm), followed by 80 and 100kg N ha^{-1} which had statistically similar heights. Then 60kg N ha^{-1} gave plant height of 92.8cm which is comparable to 40kg N ha^{-1} and also comparable to 20 and 0kg N ha^{-1} which gave the least plant height.

Similarly, 120kg N ha^{-1} was superior among all the genotypes studied, with the highest plant height produced by genotype LNTP-Y5 (170.1cm). Then followed by OBA-98 and LNTP-WC2. At 9WAS in 2008 (fig.IV), increasing N rate up to 120kg N ha^{-1} increased plant height over 0kg N ha^{-1} for all genotype studied. LNTP-WC2 gave the highest plant height (172.4cm) followed by 100kg N ha^{-1} which is comparable to 80kg N ha^{-1}. LNTP-Y5 gave the highest plant height (193.1cm) at 120kg N ha^{-1}. There was no significant difference at 40-80kg N ha^{-1}. While at 120kg N ha^{-1} OBA-98 gave the highest plant height (155.9cm).

Similarly, 120kg N ha^{-1} performed better among all the genotypes studied, with the highest plant height produced by genotype LNTP-Y5 (193.1cm). It was followed by LNTP-WC2 and OBA-98.

At 9WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} increased plant height over 0kg N ha^{-1} for all the genotypes studied (fig.V). LNTP-WC2 gave the highest plant height (153.1cm) at 120kg N ha^{-1}. However, at 80-100kg N ha^{-1}, the plant height are statistically similar. LNTP-Y5 gave the highest plant height (181.6cm) at 120kg N ha^{-1}. However, at 40-80kg N ha^{-1}, there is no significant difference in the plant height of the crop. While in OBA-98, 120kg N ha^{-1} gained the highest plat height (150.7cm) similarly 120 kg N ha^{-1} performed better among all the genotypes studied, with the highest plant height produced by genotype LNTP-Y5 (181.6cm). It was followed by genotype LNTP-WC2 and OBA-98.

At 12WAS in 2007 (fig.VI), increasing N rate up to 120kg N ha^{-1} increased plant height over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest plant height (133.8cm) at 120kg N ha^{-1} followed by 100kg N ha^{-1} which gave plant height of 111.8cm which is comparable to 80kg N ha^{-1}. But increasing N rate from 0 to 40kg N ha^{-1} had no significant positive effect on plant height. LNTP-Y5 at 120kg N ha^{-1} gave the highest plant height (160.1cm), followed by 100kg N ha^{-1}. While in OBA-98 at 120kg N ha^{-1} gave the highest pant height (145.5cm). It was followed by 100kg N ha^{-1} (142.4cm) which was comparable to 80kg N ha^{-1}. Similarly, 120kg N ha^{-1} performed better among all the genotypes studied, with the highest plant height produced by genotype LNTP-Y5 followed by OBA-98 and LNTP-WC2.

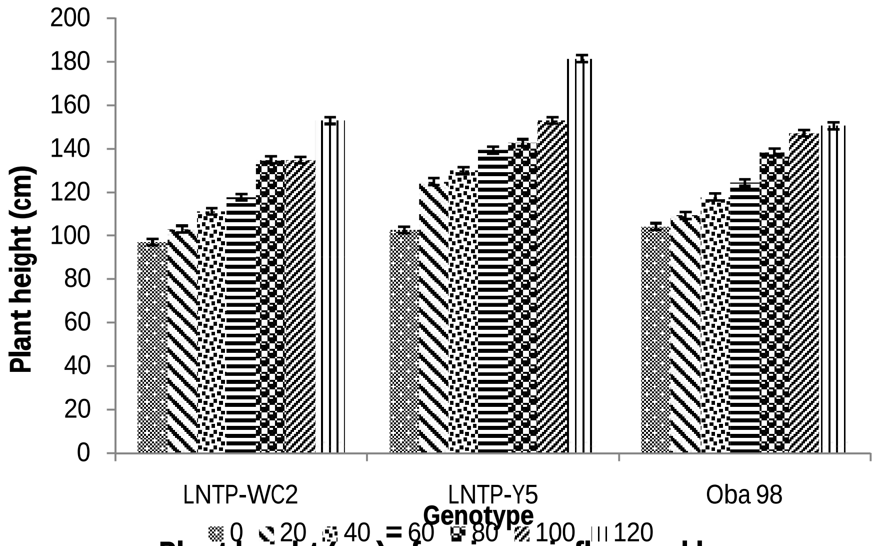

Fig. V: **Plant height (cm) of maize as influenced by N x genotype interaction at 9 WAS (combined analysis) at Samaru**

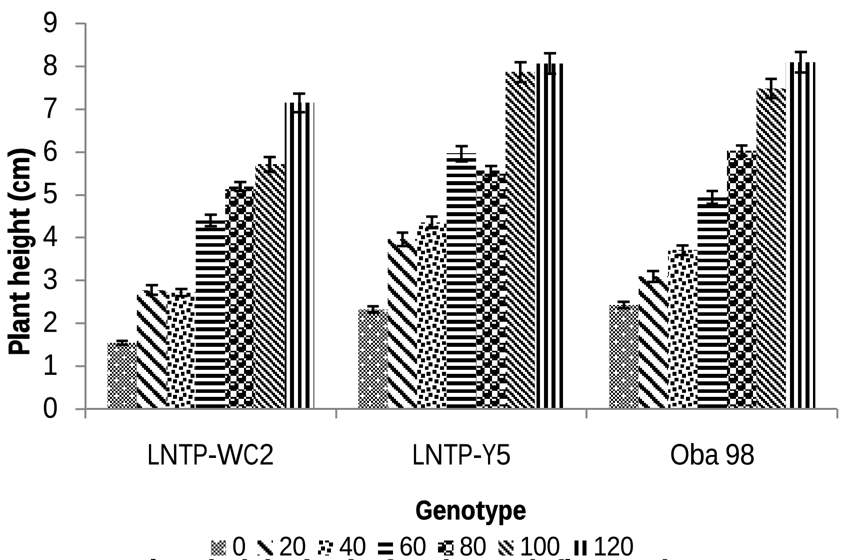

Fig. VI: **:Plant height (cm) of maize as influenced by N x genotype interaction at 12 WAS in 2007at Samaru**

4.1.2 Leaf Dry Weight (g)

Nitrogen (N) significantly ($P \leq 0.05$) increased leaf dry weight (LDW) of maize (Table 3). The LDW per plant of maize was highest at 120kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype OBA-98 produced significantly ($P \leq 0.05$) higher LDWS than the other genotypes at 6WAS. While genotype LNTP-Y5 produced higher LDWS than the other genotypes at 9WAS. However, at 12WAS, both LNTP-WC2 and LNTP-Y5 gave the highest LDWS.

N x genotype interactions were highly significant ($P \leq 0.05$) at 12WAS in 2007 (Table 3). At 12WAS in 2007 (fig.VII), increasing N rate up to 120kg N ha^{-1} increased LDW over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest LDW at 120kg N ha^{-1} (42.2cm) which is comparable to 100kg N ha^{-1}. But at 40 and 60kg N ha^{-1}, there is no significant difference on LDW. LNTP-Y5 at 120kg N ha^{-1} gave the highest LDW (47.9cm), followed by 100kg N ha^{-1} (43.5cm) which is comparable to 120kg N ha^{-1}. While for OBA-98, 120kg N ha^{-1} gave the highest LDW (42.9cm) when LDW was significantly increased. But at 80 to 100kg N ha^{-1}, the LDWS were statistically similar.

Table 3: Effect of Nitrogen and genotype on Leaf dry weight (g) of maize during the 2007 and 2008 wet seasons at Samaru

Treatment	6 WAS			9 WAS			12 WAS		
(A) N (kg N ha^{-1})	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	2.4^{g}	3.7^{g}	3.0^{g}	7.2^{g}	7.7^{g}	7.5^{g}	6.1^{g}	7.5^{f}	6.5^{g}
20	3.3^{f}	5.0^{f}	4.2^{f}	14.9^{f}	13.8^{f}	14.4^{f}	10.2^{f}	10.1^{e}	9.9^{f}
40	4.9^{e}	6.0^{e}	5.5^{e}	24.7^{e}	19.0^{e}	21.9^{e}	14.8^{e}	12.6^{de}	13.3^{e}
60	5.7^{d}	6.8^{d}	6.3^{d}	28.1^{d}	25.5^{d}	26.8^{d}	18.5^{d}	14.6^{d}	16.5^{d}
80	6.5^{c}	8.4^{c}	7.5^{c}	35.1^{c}	30.2^{c}	32.6^{c}	23.7^{c}	18.3^{c}	20.6^{c}
100	7.7^{b}	9.5^{b}	8.6^{b}	40.3^{b}	38.4^{b}	39.4^{b}	31.1^{b}	22.9^{b}	26.4^{b}
120	8.4^{a}	12.0^{a}	10.2^{a}	44.4^{a}	44.6^{a}	44.5^{a}	37.8^{a}	28.8^{a}	32.3^{a}
SE ±	0.15	0.23	0.16	0.75	0.88	0.60	0.56	0.92	0.51
(B) Genotype									
LNTP-WC2	5.5^{a}	7.3^{b}	6.4^{b}	27.4^{b}	25.9^{a}	26.6^{ab}	20.8^{b}	17.6^{a}	19.2^{a}
LNTP-Y5	5.5^{a}	7.1^{b}	6.3^{b}	29.8^{a}	24.0^{a}	27.4^{a}	23.2^{a}	15.0^{b}	19.1^{a}
OBA-98	5.7^{a}	7.8^{a}	6.7^{a}	26.2^{b}	25.0^{a}	26.1^{b}	16.9^{c}	402.4^{b}	15.4^{b}
SE ±	0.10	0.15	0.10	0.49	0.33	0.35	0.40	0.36	0.33
Interaction	NS	NS	NS	NS	NS	NS	**	NS	NS
(C) AXB									

Means followed by the same letters within a column are not significantly different at 5%level of probability using DMRT.NS=Not significant

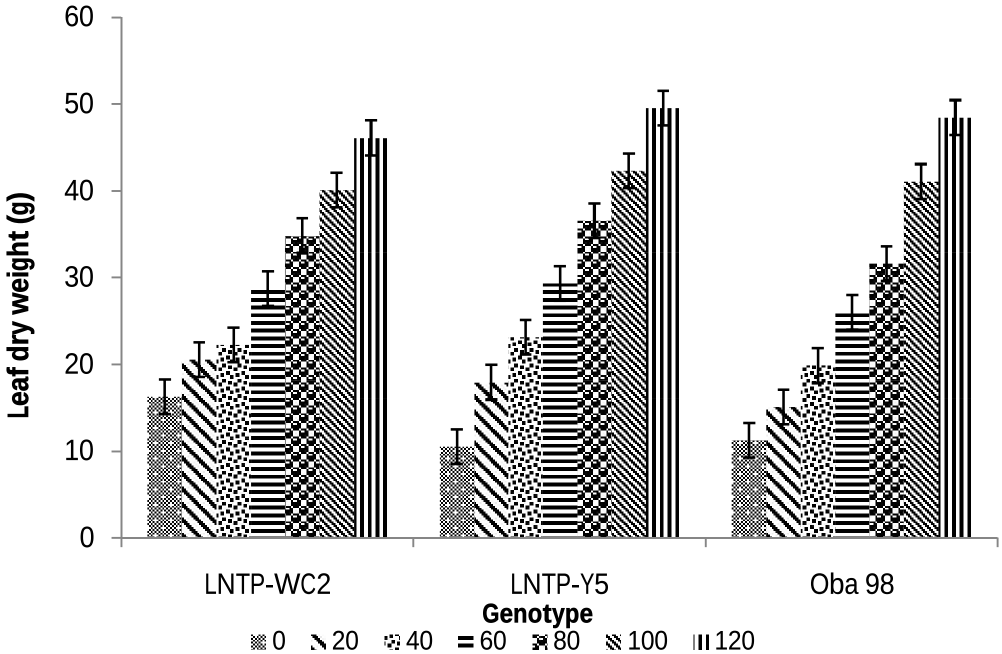

Fig vii: leaf dry weight (g) of maize as influenced N x genotype interaction at 12 WAS in 2007 at Samaru

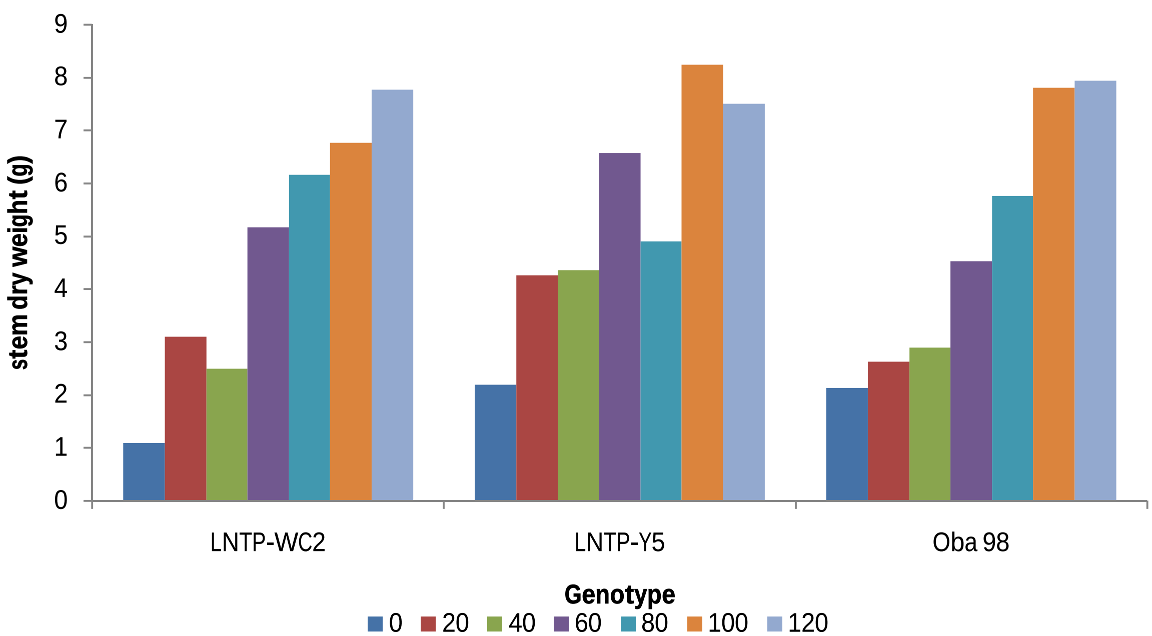

Fig. VIII: Stem dry weight (g) of maize as influenced by N and genotype interaction at 6 WAS 2007 at Samaru

4.1.3 Stem Dry Weight (g)

Nitrogen and genotype (effect) significantly ($P \leq 0.05$) increased the dry matter yield (Table 4) of maize stem. The stem dry weight (SDW) per plant of maize was highest at 120kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype LNTP-Y5 produced significantly ($P \leq 0.05$) higher SDWS than the other genotypes at 6WAS. While genotype LNTP-WC2 produced higher SDWS than the other genotypes at 9WAS. However, at 12 WAS, LNTP-Y5 gave the highest SDWS.

N x genotype interactions were highly significant ($P \leq 0.01$) at 6 WAS in 2007 and significant ($P \leq 0.05$) at combined analysis. It was highly significant ($P \leq 0.01$) at 12 WAS in 2007 and significant ($P \leq 0.05$) at its combined analysis. At 6 WAS in 2007 (fig.VIII), increasing N rate up to 120kg N ha^{-1} had no increase in the SDW over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest SDW (7.7cm), followed by 40kg N ha^{-1} (2.5cm). LNTP-Y5 gave the highest SDW at 100kg N ha^{-1} (8.2cm). But increasing N rate from 20 to 40kg N ha^{-1} had no significant positive effect on LDW. While in OBA-98, 120kg N ha^{-1} produced the highest SDW (7.9cm). But at 20 to 40kg N ha^{-1} and 100 to120kg N ha^{-1}, their SDW were statistically similar.

At 6 WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} increased SDW over 0kg N ha^{-1} for all the genotypes studied (fig.IX). LNTP-WC2 gave the highest SDW (7.1cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (5.7cm). But increasing N rate from 20 to 40kg N ha^{-1} had no significant positive effect on SDW. LNTP-Y5 gave the highest SDW (8.0cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (7.8cm). But increasing N rate from 60 to 80kg N ha^{-1} had no significant positive effect on SDW. While in OBA-98, 120kg N ha^{-1} produced the highest SDW (8.1cm). At 12WAS in 2007 (fig.X), increasing N rate up to 120kg

N ha^{-1} increased SDW over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest SDW (71.5cm) at 120kg N ha^{-1} followed by 100kg N ha^{-1} (60.2cm). LNTP-Y5 gave the highest SDW (73.8cm) at 120kg N ha^{-1} followed by 100kg N ha^{-1} (60.0cm). But increasing N rate from 20 to 40kg N ha^{-1} had no significant positive effect on SDW. While in OBA-98, 120kg N ha^{-1} produced the highest SDW (62.6cm) followed by 100kg N ha^{-1} (54.6cm).

At 12WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} increased SDW for all the genotypes studied (fig.XI). LNTP-WC2 gave the highest SDW (46.2cm) followed by 100kg N ha^{-1} (42.4cm). But increasing N rate from 20 to 40kg N ha^{-1} had no significant positive effect on SDW. LNTP-Y5 gave the highest SDW at 120kg N ha^{-1} (49.6cm) followed by 100kg N ha^{-1} (42.4cm). Also increasing N rate from 100 to 120kg N ha^{-1}, had no significant positive effect on SDW. While in OBA-98, 120kg N ha^{-1} produced the highest SDW (48.5cm). However, 0kg N ha^{-1} gave the lowest SDW (11.3cm).

Table 4: Effect of Nitrogen and genotype on Stem dry weight (g) of maize during the 2007 and 2008 wet seasons at Samaru

(A) N (kg N ha^{1})	6 WAS			9 WAS			12 WAS		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	1.8^{d}	2.4^{g}	2.1^{f}	13.8^{g}	15.8^{g}	14.8^{g}	12.9^{g}	12.7^{g}	12.8^{g}
20	3.3^{c}	3.2^{f}	3.3^{e}	26.2^{f}	23.1^{f}	24.7^{f}	18.6^{f}	17.6^{f}	17.9^{f}
40	3.3^{c}	4.0^{e}	3.6^{e}	35.5^{e}	28.5^{e}	31.9^{e}	22.1^{e}	22.1^{e}	21.8^{e}
60	5.4^{b}	4.8^{d}	5.1^{d}	42.4^{d}	33.7^{d}	38.1^{d}	29.9^{d}	27.0^{d}	28.1^{d}
80	5.6^{b}	5.6^{c}	5.6^{c}	47.7^{c}	39.9^{c}	43.8^{c}	36.9^{c}	32.9^{c}	34.4^{c}
100	7.6^{a}	6.4^{b}	7.0^{b}	58.3^{b}	47.9^{b}	53.1^{b}	45.9^{b}	37.6^{b}	41.3^{b}
120	7.7^{a}	7.8^{a}	7.8^{a}	69.3^{a}	56.3^{a}	62.8^{a}	53.1^{a}	44.3^{a}	48.1^{a}
SE ±	0.15	0.21	0.18	1.01	1.08	0.65	1.12	0.69	0.15
(B) Genotype									
LNTP-WC2	4.7^{b}	3.8^{b}	4.2^{c}	43.1^{a}	36.4^{a}	39.8^{a}	32.9^{a}	27.0^{b}	29.9^{a}
LNTP-Y5	5.4^{a}	5.5^{a}	5.5^{a}	43.4^{a}	33.7^{b}	38.5^{a}	31.5^{ab}	28.5^{a}	30.0^{a}
OBA-98	4.8^{b}	5.4^{a}	5.1^{b}	39.1^{b}	34.9^{ab}	37.0^{b}	29.6^{b}	40.4^{b}	27.7^{b}
SE ±	0.10	0.14	0.09	0.66	0.50	0.46	0.74	0.45	0.42
Interaction (C) AXB	* *	NS	*	NS	NS	NS	**	NS	*

Means followed by the same letters within a column are not significantly different at 5% level of probability using DMRT. NS = not significant

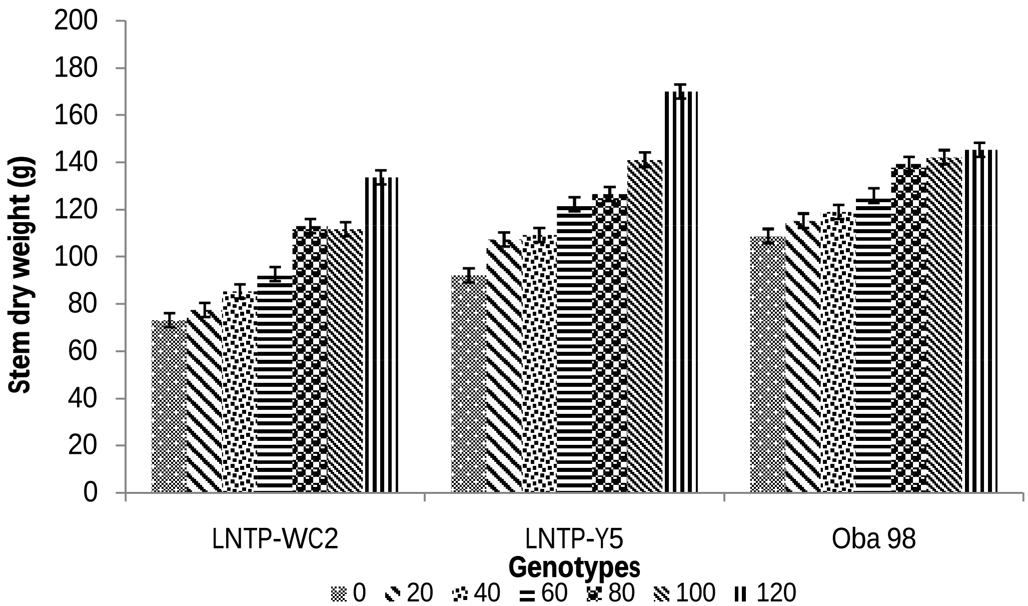

Fig. IX: Stem dry weight (g) of maize as influenced by N x Genotype interaction at 6 WAS (combined analysis) at Samaru

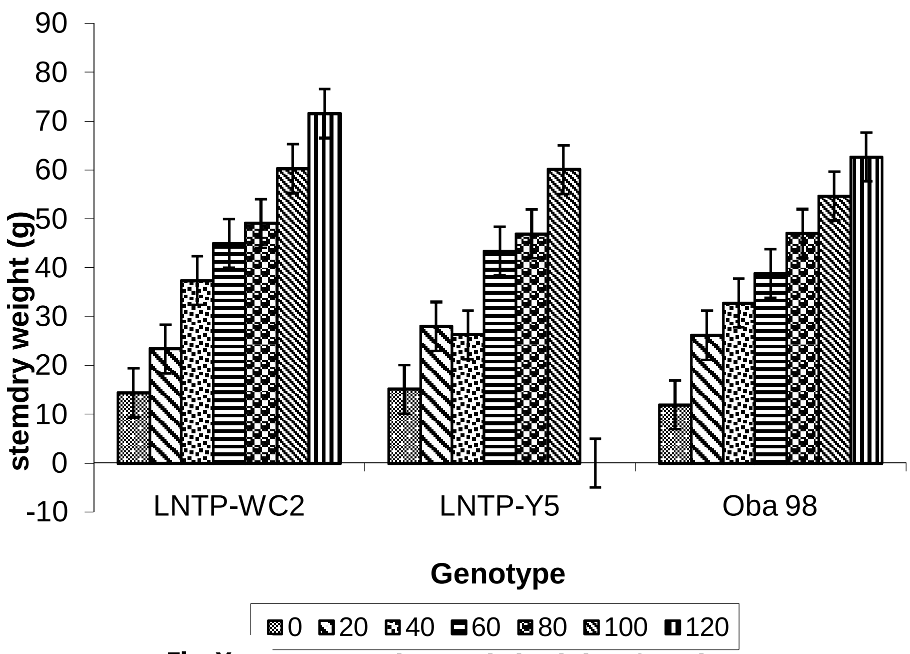

Fig. X: Stem dry weight (g) of maize as influenced by N x genotype interaction at 12 WAS in 2007 at Samaru

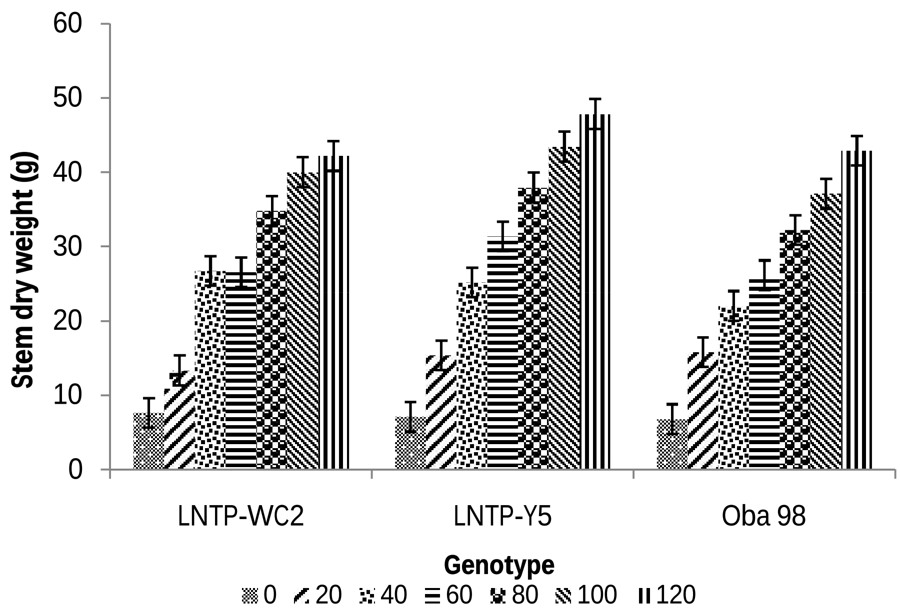

Fig. xi:Stem dry weight (g) of maize as influenced by N x genotype interaction at 12WAS (combined analysis) at Samaru

4.1.4 Total Dry Weight (g)

Nitrogen application significantly ($P \leq 0.05$) increased total dry weight (TDW) of maize (Table 5). The TDW per plant of maize was highest at 120kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that both genotype LNTP-Y5 and OBA-98 produced significantly ($P \leq 0.05$) the highest TDW. While LNTP-WC2 followed.

N x genotype interactions were highly significant ($P \leq 0.01$) at 6 WAS in 2007 and at 12 WAS in 2007. At 6 WAS in 2007 (fig.XII), increasing N rate up to 120kg N ha^{-1} increased TDW over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 produced the highest TDW (32.3cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (29.0cm) however, the control produced the lowest TDW (6.4cm). LNTP-Y5 produced the highest TDW (31.8cm) at 120kg N ha^{-1}, which is comparable to 100kg N ha^{-1} (31.5cm). While OBA-98, gave the highest TDW (32.6cm) at 120kg N ha^{-1}. At 12 WAS in 2007 (fig.XIII), increasing N rate up to 120kg N ha^{-1} increased TDW over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 produced the highest TDW (427.6cm) at 120kg N ha^{-1} followed by 100kg N ha^{-1} (200.7cm). LNTP-Y5 produced the highest TDW (243.5cm). But increasing N rate from 100 to 120kg N ha^{-1} had no significant effect on TDW. While in OBA-98, 120kg N ha^{-1}, produced the highest TDW (211.3cm). Similarly 120kg N ha^{-1} performed better among all the genotypes studied, with the highest TDW produced by genotype LNTP-Y5 (243.5cm)

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Table 5: Effect of Nitrogen and genotype on total plant dry weight (g) of maize during the 2007 and 2008 wet seasons at Samaru

(A) N (Kg N ha^{1})	6 WAS			9 WAS			12 WAS		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	7.8^{g}	9.7^{g}	8.8^{g}	42.1^{g}	46.9^{g}	44.5^{g}	334.8^{g}	333.8^{d}	315.4^{g}
20	13.3^{f}	13.3^{f}	13.3^{f}	82.2^{f}	73.9^{f}	78.1^{f}	420.8^{f}	392.5^{cd}	388.9^{f}
40	16.2^{e}	16.1^{e}	16.2^{e}	120.4^{e}	95.0^{e}	107.7^{e}	463.1^{e}	440.1^{bc}	442.9^{e}
60	22.2^{d}	18.4^{d}	20.3^{d}	140.9^{d}	118.4^{d}	129.7^{d}	539.9^{d}	518.0^{ab}	510.8^{d}
80	24.3^{c}	22.4^{c}	23.3^{e}	165.5^{c}	140.2^{c}	152.8^{c}	589.2^{c}	541.8^{a}	547.9^{c}
100	30.6^{b}	25.5^{b}	28.0^{b}	197.2^{b}	172.6^{b}	184.9^{b}	648.8^{b}	540.3^{a}	586.9^{b}
120	32.3^{a}	31.9^{a}	32.1^{a}	227.5^{a}	201.8^{a}	214.6^{a}	724.2^{a}	560.4^{a}	646.1^{a}
SE ±	0.42	0.55	0.38	3.01	3.50	2.41	13.52	13.01	12.06
(B) Genotype									
LNTP-WC2	20.3^{b}	18.3^{c}	19.3^{b}	141.1^{a}	124.6^{a}	132.8^{a}	574.9^{a}	461.0^{a}	517.9^{a}
VY LNTP-Y5	21.9^{a}	19.6^{b}	20.8^{a}	146.4^{a}	117.4^{b}	131.9^{a}	500.5^{b}	489.6^{a}	495.0^{b}
OBA-98	20.7^{b}	20.9^{a}	20.8^{a}	130.7^{b}	121.8^{ab}	126.3^{b}	519.3^{b}	402.4^{b}	460.8^{c}
SE ±	0.27	0.36	0.25	1.97	2.29	1.58	8.86	7.32	7.90
Interaction									
(C) AXB	**	NS	NS	NS	NS	NS	**	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of probability using DMRT.
NS = not significant.

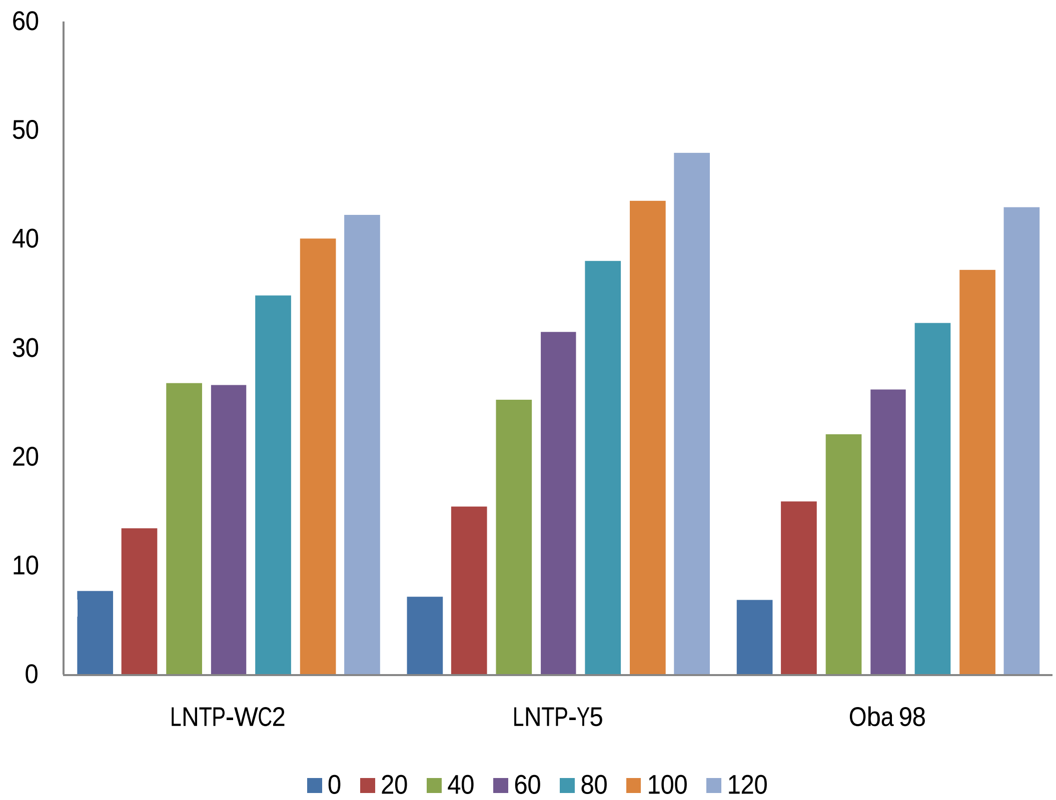

Fig xii. Total dry weight at as influenced by N x genotype interaction at 12 WAS in 2007 at samaru.

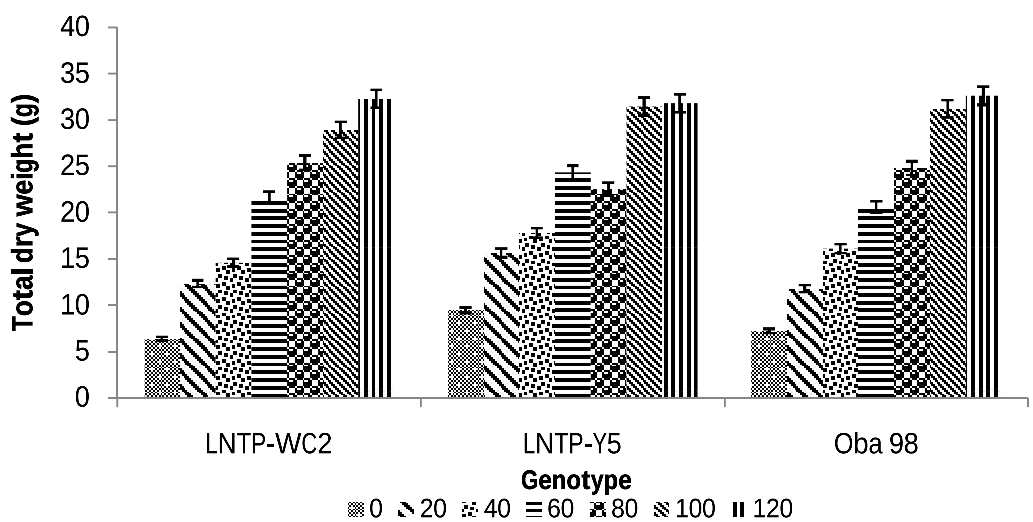

Fig. XIII: Total dry weight (g) of maize as influenced by N x genotype interaction at 6 WAS in 2007 at Samaru

4.1.5 Leaf Area (cm^2)

The number of leaf area (LA) per plant increased significantly (P≤0.05) with increase in N rates (Table 6). The LA per plant of maize was highest at 120kg N ha^{-1} at all sampling period in the year 2007 and 2008 trials. The combined analysis showed that genotype LNTP-Y5 produced significantly (P≤0.05) higher LA than the other genotypes at 6 WAS. While both LNTP-Y5 and OBA-98 produced higher LA than LNTP-WC2 at 9 WAS. However, at 12 WAS, genotype OBA-98 produces higher LA than the other genotypes.

N x genotype interactions were highly significant (P≤0.01) at 9WAS in the two years and the combined analysis and also at 12 WAS in 2007. It is significant (P≤0.05) in the combined analysis at 12 WAS (Table 6).

At 9 WAS in 2007 (fig.XIV), increasing N rate up to 120kg N ha^{-1} had no increase in the LA over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 produced the highest LA (329.4cm) at 80kg N ha^{-1}, followed by 60kg N ha^{-1} (311.5cm). But increasing N rate from 100 to 120kg N ha^{-1} had no significant positive effect on LA. LNTP-Y5 produced the highest LA (447cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (396.2cm). But increasing N rate from 60 to 80kg N ha^{-1} had no significant positive effect on LA. While OBA-98 produced the highest LA (423.2cm). Then 100kg N ha^{-1} produced LA of 390.7cm which is comparable to 80kg N ha^{-1}.

At 9WAS in 2008 (fig.XV), increasing N rate up to 120kg N ha^{-1} increased LA over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 produced the highest LA (511.9cm), followed by 100kg N ha^{-1}. LNTP-Y5 produced the highest LA (311.4cm). But increasing N rate from 40 to 60kg N ha^{-1} had no significant positive effect on LA. While OBA-98 produced the highest LA (484.4cm). Then 60kg N ha^{-1} gave plant height of 337.2cm which is comparable to 40, 20 and 0kg N ha^{-1}.

At 9WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} had increase in the LA over 0kg N ha^{-1} for all the genotypes studied (fig.XVI). LNTP-WC2 produced the highest LA (404cm), followed by 100kg N ha^{-1}. LNTP-Y5 produced the highest LA(379.2cm) at 120kg N ha^{-1}. But increasing N rate from 60 to 80kg N ha^{-1} had no significant positive effect on LA. While OBA-98 produced the highest LA (453.8cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1}.

At 12WAS in 2007 (fig.XVII), increasing N rate up to 120kg N ha^{-1} had increase in the LA over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 produced the highest LA (329.4cm) at 80kg N ha^{-1}, followed by 60kg N ha^{-1} (310.5cm). But increasing N rate from 100 to 120kg N ha^{-1} had no significant positive effect on LA. LNTP-Y5 produced the highest LA (445.0cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (396.2cm). While OBA-98 produced the highest LA (420.2cm). But increasing N rate from 80 to 100kg N ha^{-1} had no significant positive effect on LA.

At 12WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} significantly ($P \leq 0.05$) increased LA over 0kg N ha^{-1} for all the genotypes studied (fig.XVIII). LNTP-WC2 produced the highest LA (518.5cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (439.5cm). But increasing N rate from 40-60kg N ha^{-1} had no significant positive on LA. LNTP-Y5 produced the highest LA (398.4cm) at 120kg N ha^{-1}, followed by 100kg N ha^{-1} (393.6cm). But increasing N rate from 80 to 120kg N ha^{-1} also had no significant positive effect on LA. While OBA-98 produced the highest LA (476.5cm) at 120kg N ha$^{-1.}$

Table 6: Effect of Nitrogen and genotype on Leaf area (cm^2) of maize during the 2007 and 2008 wet seasons at Samaru

	6 WAS			9 WAS			12 WAS		
(A) N (kg N ha^{-1})	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	102.3^{e}	187.9^{e}	145.2^{e}	204.0^{e}	227.0^{g}	215.5^{g}	217.4^{f}	219.2^{b}	199.4^{f}
20	110.5^{e}	200.7^{de}	155.6^{e}	218.2^{e}	246.2^{f}	232.2^{f}	280.7^{e}	271.6^{b}	257.2^{e}
40	134.8^{d}	206.6^{de}	170.7^{d}	254.9^{d}	254.3^{e}	254.6^{e}	309.2^{e}	304.5^{a}	298.3^{d}
60	144.9^{cd}	216.3^{bdc}	180.6^{cd}	316.4^{c}	275.3^{d}	295.9^{d}	378.2^{d}	375.4^{a}	358.2^{c}
80	165.6^{c}	222.3^{bc}	194.0^{c}	357.6^{b}	318.2^{c}	333.9^{c}	421.2^{c}	390.9^{a}	388.5^{bc}
100	200.2^{b}	235.3^{b}	217.8^{b}	357.1^{b}	393.9^{b}	375.5^{b}	468.2^{b}	383.0^{a}	417.6^{b}
120	235.3^{a}	281.2^{a}	258.3^{a}	389.1^{a}	435.9^{a}	412.5^{a}	533.2^{a}	389.8^{a}	464.4^{a}
SE(±)	7.28	6.43	6.90	9.62	1.14	4.80	13.31	19.73	11.98
(B) Genotype									
LNTP-WC2	154.4^{b}	221.7^{b}	188.0^{b}	264.9^{c}	335.7^{b}	302.5^{a}	419.3^{a}	324.9^{a}	344.8^{a}
LNTP-Y5	180.3^{a}	219.6^{c}	199.9^{a}	326.9^{a}	227.5^{c}	303.9^{a}	340.3^{b}	342.1^{a}	328.2^{a}
OBA-98	134.0^{c}	223.2^{a}	178.6^{c}	306.8^{b}	358.6^{a}	303.9^{a}	358.2^{b}	258.4^{b}	348.2^{a}
SE ±	4.77	4.21	3.20	6.30	0.75	3.14	8.71	12.92	7.84
Interaction									
AXB	NS	NS	NS	**	**	**	**	NS	*

Means followed by the same letters within a column are not significantly different at 5% level of probability using DMRT.
NS = not significant

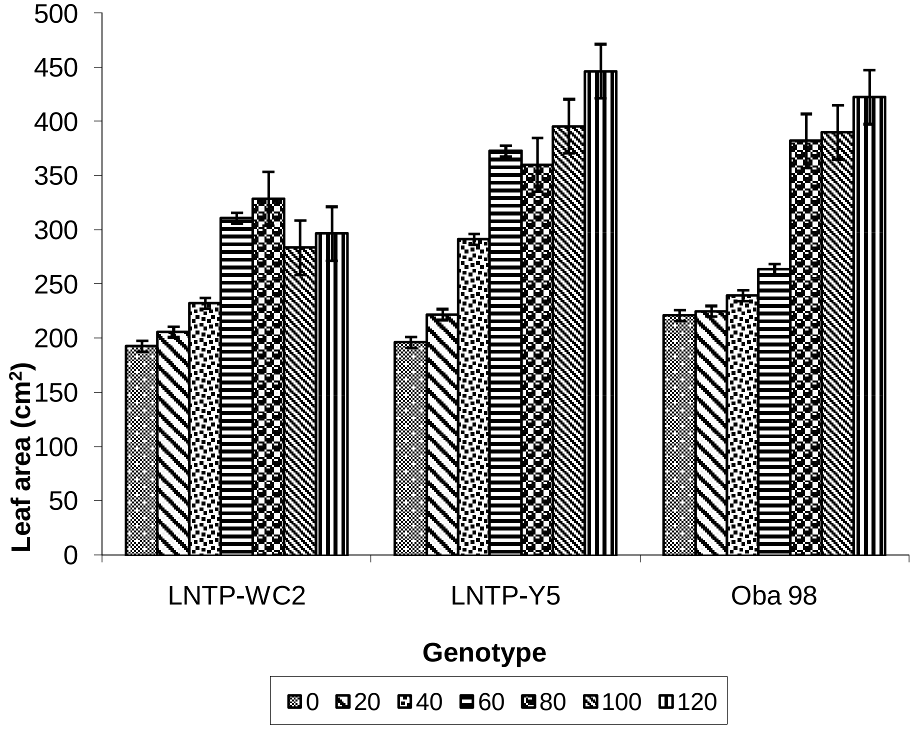

Fig. XIV: Leaf area(cm^2) of maize as influenced by N x genotype interaction at 9 WAS in 2007 at Samaru

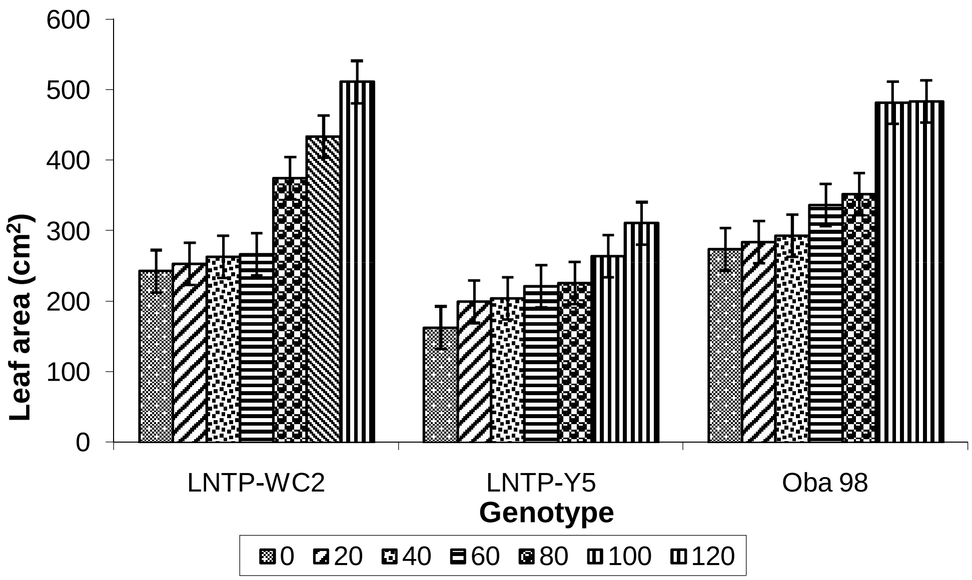

Fig xv: Leaf area of maize as influenced by N x genotyope interaction at 9 WAS in 2008 at Samaru

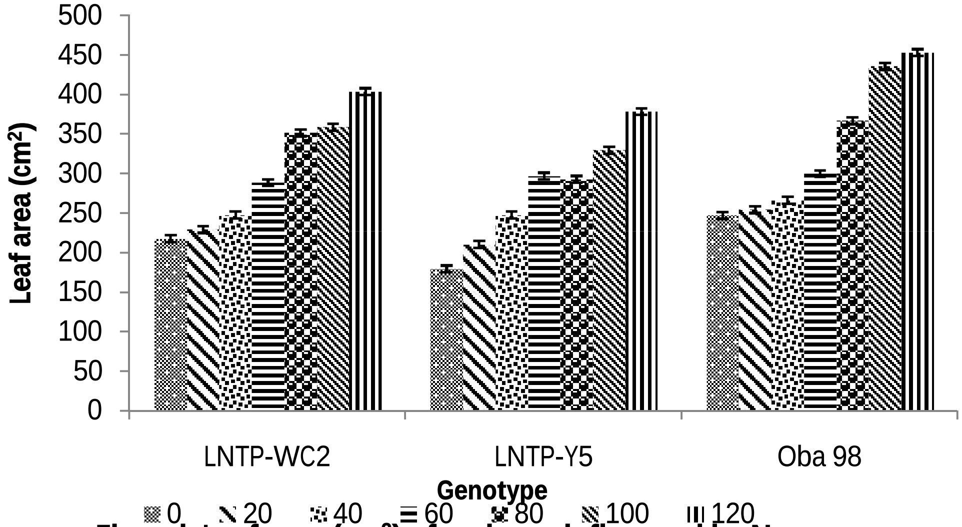

Fig. xvi: Leaf area (cm²) of maize as influenced by N x genotype interaction at 9 WAS, (combined analysis) at Samaru

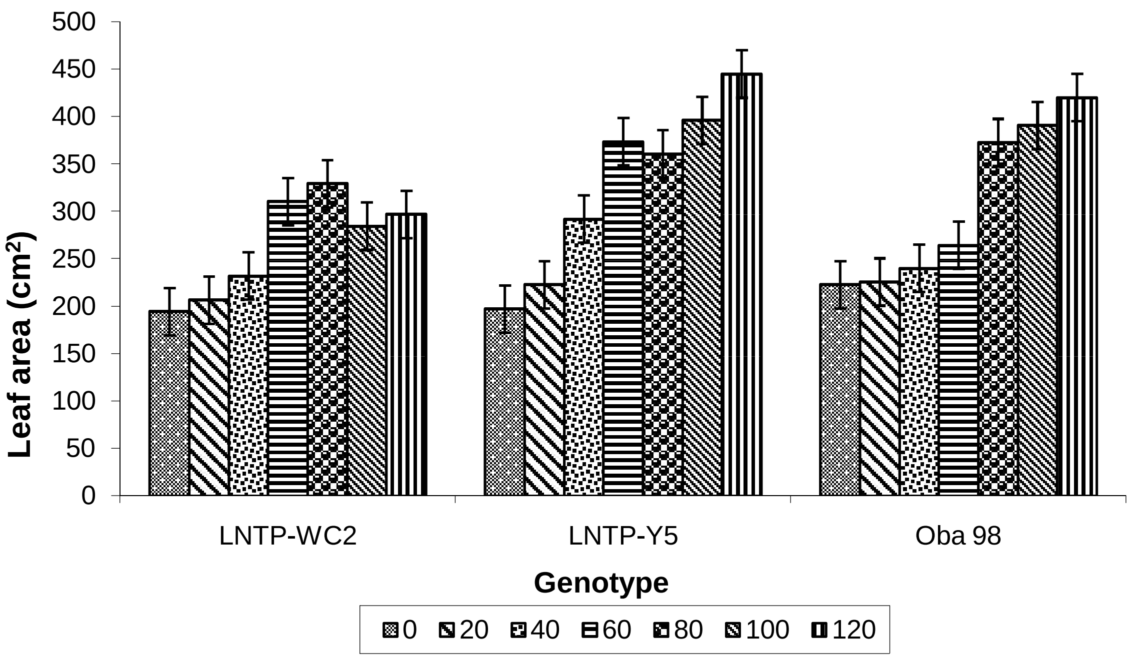

Fig. xvii: Leaf area of maize as influenced by N and genotype interaction at 12 WAS in 2007

4.1.6 Chlorophyll a, b and Total Chlorophyll Content

N significantly ($P \leq 0.05$) increased chlorophyll (Table 7), the chlorophyll per plant of maize was highest at 120kg N ha^{-1} at all sampling period in the year 2007 and 2008 trials. The combined analysis indicated that all the genotypes showed significantly ($P \leq 0.05$) high, chlorophyll at 6 WAS, 9 WAS and 12 WAS. Nx genotype interactions were highly significant ($P \leq 0.05$) at 6 WAS of the combined analysis, 9 WAS of the combined analysis and 12WAS of the combined analysis. At 6 WAS (combined analysis), for chlorophyll a, increasing N rate up to 120kg N ha^{-1} significantly ($P \leq 0.05$) increased chlorophyll a over 0 kg N ha^{-1} for all the genotypes studied. LNTP-WC-2 gave the highest plant height (52.3cm) at 120kg N ha^{-1}. LNTP-Y5 gave the highest chlorophyll a (52.5cm). The nitrogen level 60kg N ha^{-1} gave chlorophyll a (26.4cm) which is comparable to 40kg N ha^{-1}. OBA-98 gave the highest chlorophyll a (51.3cm) at 120kg Nha^{-1}. Similarly, 120kg N ha^{-1} performed better among all the genotypes studied, with the highest chlorophyll a produced by genotype LNTP-Y5. It was followed by LNTP-WC2 and OBA-98.

At 9 WAS (combined analysis) increasing N rate up to 120kg N ha^{-1} significantly ($P \leq 0.05$) increased chlorophyll.b over 0kg N ha^{-1} for all the genotypes studied. LNTP-WC2 gave the highest chorophyll.b (47.2cm) at 120kg N ha^{-1}. However, at 100 to 120kg N ha^{-1}, there is no significant difference in chlorophyll.b of the crop. While in LNTP-Y5 120kg N ha^{-1} gave the highest chlorophyll.b (58.5cm). Then 40kg N ha^{-1} is comparable to 20 and 0kg N ha^{-1}, while in OBA-98, 120kg N ha^{-1} gave the highest chlorophyll.b (58.7cm). There was no significant difference at 40 to 60kg N ha^{-1}. Similarly, 120kg N ha^{-1} performed better among all the genotypes studied, with the highest chlorophyll.b produced by genotype OBA-98. This was followed by LNTP-WC2.

At 9 WAS (combined analysis), increasing N rate up to 120kg N ha^{-1} significantly ($P \leq 0.05$) increased total chlorophyll content over 0kg N hg^{-1} for all the genotypes studied. LNTP-WC2 gave the highest chlorophyll content at 120kg N ha^{-1}. However, at 100 to 120kg N ha^{-1}, there is no significant difference in total chlorophyll content of the crop. In LNTP-Y5, the nitrogen level, 120kg N ha^{-1} , gave the highest chlorophyll content (98.1cm) At 60kg N h^{-1} gave total chlorophyll content of 56.3cm which is comparable to 40kg N ha^{-1} and also comparable to 20kg N ha^{-1}. Then in OBA-98, 120kg N ha^{-1} gave the highest total chlorophyll content (98.1cm). Then 100kg N ha^{-1} gave 95.0cm which is comparable to 80kg N ha^{-1}. Similarly 120kg N ha^{-1} was superior among all the genotype studied.

Table 7: Effect of Nitrogen and genotype on chlorophyll a, b and total chlorophyll content of three maize genotypes at 9 WAS, Samaru

	Chlorophyll a			Chlorophyll b			Chlorophyll content		
(A) N (kg N ha^{-1}	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
0	8.0^{g}	9.9^{g}	8.9^{g}	12.2^{g}	15.0^{g}	22.2^{f}	20.1^{g}	24.9^{g}	39.3^{f}
20	15.2^{f}	17.2^{f}	16.2^{f}	19.3^{f}	22.5^{f}	19.4^{f}	34.5^{g}	39.6^{f}	34.3^{f}
40	23.4^{e}	25.2^{e}	24.3^{e}	25.9^{e}	28.7^{e}	25.7^{e}	49.2^{e}	53.9^{e}	48.2^{e}
60	27.9^{d}	29.9^{d}	28.9^{d}	33.6^{d}	36.2^{d}	33.2^{d}	61.5^{d}	66.2^{d}	61.2^{d}
80	37.7^{c}	39.8^{c}	38.8^{c}	42.8^{c}	45.7^{c}	42.8^{c}	80.6^{c}	85.5^{c}	79.9^{c}
100	46.8^{b}	48.8^{b}	47.8^{b}	47.5^{b}	50.3^{b}	48.2^{b}	94.2^{b}	99.1^{b}	94.6^{b}
120	52.8^{a}	54.7^{a}	53.7^{a}	58.2^{a}	61.1^{a}	57.9^{a}	110.9^{a}	115.8^{a}	110.7^{a}
SE ±	0.48	0.50	0.55	0.39	0.43	0.46	0.72	0.77	0.65
(B) Genotype									
LNTP-WC2	30.3^{a}	32.3^{a}	31.2^{a}	34.6^{a}	37.3^{a}	35.9^{a}	64.8^{a}	69.6^{a}	66.1^{a}
LNTP-Y5	30.2^{a}	32.1^{a}	31.2^{a}	34.1^{a}	36.9^{a}	35.5^{a}	64.1^{a}	68.9^{a}	67.7^{a}
OBA-98	30.3^{a}	32.1^{a}	31.3^{a}	33.9^{a}	37.0^{a}	35.6^{a}	64.4^{a}	69.3^{a}	66.9^{a}
SE ±	0.32	0.33	0.36	0.26	0.28	0.30	0.47	0.50	0.49
Interaction	NS	NS	**	NS	NS	**	NS	NS	**
(C) AXB									

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability using DMRT.
NS = not significant.

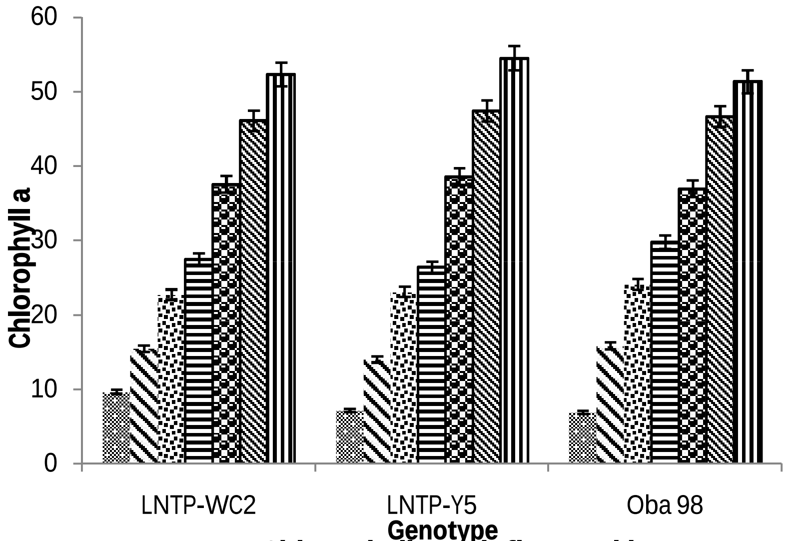

Fig. XIX: : Chlorophyll a as influenced by N x genotype interaction at 9 WAS (combined analysis) at Samaru

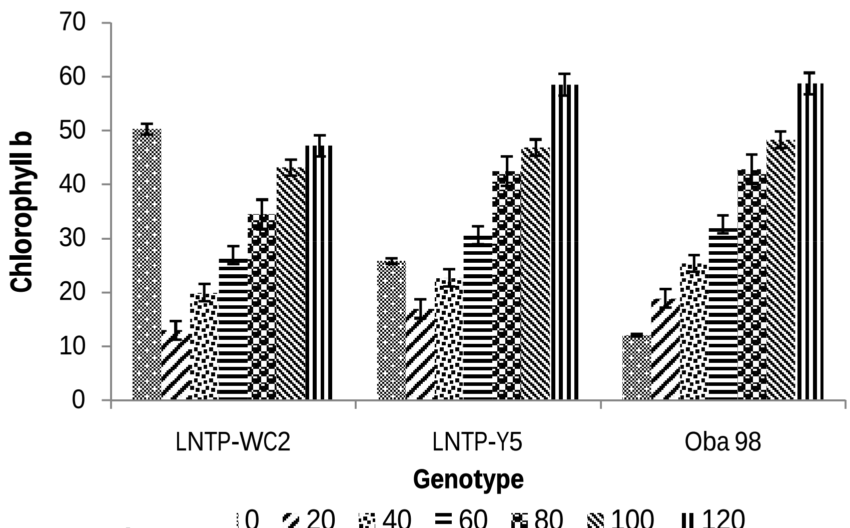

Fig. XX: : Chlorophyll b as influenced by N x genotype interaction at 9 WAS, (combined analysis) at Samuru

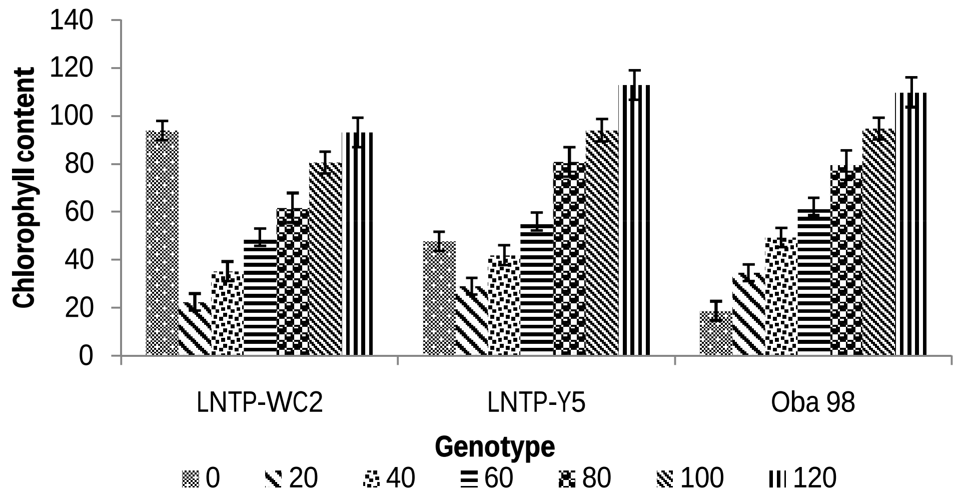

Fig. xxi: Total chlorophyll content as influenced by N x genotype interactions at 9 WAS (combined analysis) at Samaru

4.2 Yield and Yield Components

4.2.1 Days to 50% Silking

The effect of treatment on the number of days to 50% silking is shown on table8. Nitrogen (N) significantly ($P \leq 0.05$) decreased the number of days to 50% flowering (Table 8) of maize. The days to 50% flowering of maize was highest at the control at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype OBA-98 took significantly ($P \leq 0.05$) more days to reach 50% flowering than other genotypes. However, genotype LNTP-WC2 took the least days to reach 50% flowering than other genotypes.

4.2.2 Days to 50% Tasselling

The effect of treatment on the number of days to 50% tasselling is shown on Table 9. Nitrogen (N) significantly ($P \leq 0.05$) decreased the number of days to 50% tasselling (Table 9) of maize in the year 2007. While the number of days to 50% tasselling does not have effect on maize in the year 2008. The days to 50% tasselling was highest at 120kg N ha^{-1} in 2007 trial. While it was highest at 100kg N ha^{-1} in 2008 trial. The combined analysis showed that genotype OBA-98 took significantly ($P \leq 0.05$) more days to reach 50% tasselling than other genotypes. However, genotype LNTP-WC2 took the least days to reach 50% tasselling than other genotypes.

Table 8: Effect of Nitrogen and genotype on 50 % flowering of maize during the 2007 and 2008 wet seasons at Samaru

(A) N (kg N ha^{-1})	2007	2008	Mean
0	79.2^{a}	70.9^{a}	75.1^{a}
20	75.4^{b}	68.4^{b}	71.9^{b}
40	72.7^{c}	67.3^{bc}	70.0^{c}
60	70.9^{c}	66.3^{c}	68.6^{d}
80	68.2^{d}	64.4^{d}	66.3^{e}
100	63.9^{e}	63.8^{d}	63.8^{f}
120	57.0^{f}	63.7^{d}	60.3^{g}
SE (±)	0.68	0.64	0.47
(B) Genotype			
LNTP-WC2	71.5^{a}	63.3^{a}	67.2^{b}
LNTP-Y5	69.9^{b}	67.9^{c}	67.9^{c}
OBA-98	87.5^{a}	64.1^{b}	69.0^{a}
SE (±)	0.45	0.42	0.31
Interaction			
(C) AXB			
	NS	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT. NS = not significant.

Table 9: Effect of Nitrogen and genotype on 50 % tasselling of maize during the 2007 and 2008 wet seasons at Samaru

(A) N (kg N ha^{-1})	2007	2008	Mean
0	67.8^{a}	62.6^{a}	65.2^{a}
20	66.9^{ab}	63.1^{a}	65.0^{ab}
40	65.6^{bc}	62.3^{a}	63.9^{bc}
60	65.3^{cd}	61.9^{a}	63.6^{cd}
80	64.0^{de}	61.7^{a}	62.8^{cd}
100	63.1^{e}	62.0^{a}	62.6^{d}
120	56.7^{f}	61.8^{a}	59.2^{e}
SE (±)	0.52	0.55	0.38
(B) Genotype			
LNTP-WC2	66.1^{a}	63.3^{a}	62.5^{b}
LNTP-Y5	64.7^{b}	62.2^{b}	62.9^{b}
OBA-98	61.8^{c}	61.1^{c}	64.1^{a}
SE (±)	0.34	0.36	0.25
Interaction			
(C) AXB			
	NS	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT. NS = not significant.

4.2.3 Anthesis-Silking Interval (ASI)

The effect of treatment on the ASI is shown on Table 10. N significantly ($P \leq 0.05$) decreased the number of days to ASI (Table 10) of maize. The ASI per plant of maize was highest at control (0kg N ha^{-1}) at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype OBA-98 took significantly ($P \leq 0.05$) more days to reach ASI than other genotypes. However, genotypes LNTP-WC2 took the least days to reach ASI than other genotypes.

4.2.4 1000-grain Weight (g)

Nitrogen significantly ($P \leq 0.05$) have effect on 1000-grain weight of maize (Table 11). The 1000-grain weight per plant of maize was highest at 60kg N ha^{-1} in the year 2007. While it was highest at 120kg N ha^{-1} in the year 2008. The combined analysis showed that genotype LNTP-Y5 produced greater 1000-grain weight per plant than other genotypes. However, genotype LNTP-WC2 produced the least 1000-grain weight than other genotypes. Mean values of 1000-grain weight ranged from as low as 233g in 2007 to as high as 285.3g in 2008.N x genotype interaction was significant ($P \leq 0.05$) in 2008.

Table 10: Effect of N and genotype on number of days to anthesis silking interval of maize during the 2007 and 2008 wet seasons at Samaru

(A) N (kg N ha^{-1})	2007	2008	Mean
0	11.0[a]	10.9[a]	10.9[a]
20	8.6[b]	7.7[b]	8.1[b]
40	7.1[c]	6.1[c]	6.6[c]
60	5.6[d]	4.6[d]	5.1[d]
80	4.2[e]	3.8[e]	4.0[e]
100	0.8[f]	0.7[f]	0.7[f]
120	0.3[f]	0.4[f]	0.4[f]
SE (±)	0.40	0.22	0.24
(B) Genotype			
LNTP-WC2	5.2[a]	4.6[b]	4.9[b]
LNTP-Y5	5.2[a]	4.9[ab]	5.1[ab]
OBA-98	5.7[a]	5.1[a]	5.4[a]
SE (±)	0.26	0.14	0.15
Interaction			
(C) AXB			
	NS	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT. NS = not significant.

Table 11: Effect of N and Genotype on 1000-grain weight during the 2007 and 2008 wet seasons

(A) N (kg N ha^{-1})	2007	2008	Mean
0	180.00[b]	174.83[d]	182.78[b]
20	297.00[a]	225.33[c]	264.28[a]
40	300.11[a]	219.67[c]	268.78[a]
60	333.78[a]	258.00[abc]	289.56[a]
80	289.56[a]	268.50[ab]	272.17[a]
100	300.67[a]	242.17[bc]	273.89[a]
120	295.78[a]	383.17[a]	280.39[a]
SE (±)	28.81	10.41	15.56
(B) Genotype			
LNTP-WC2	286.33[a]	287.7[a]	257.57[a]
LNTP-Y5	285.43[a]	248.81[a]	267.12[a]
OBA-98	284.05[a]	228.81[b]	260.38[a]
SE (±)	18.86	6.82	10.19
Interaction			
(C) AXB			
	NS	*	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT. NS = not significant.

4.2.5 Cob Length (cm)

Nitrogen significantly ($P \leq 0.05$) increased cob length (Table 12) of maize. The cob length per plant of maize was highest at 120kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype LNTP-WC2 produced the largest cob length than other genotypes. However, genotype OBA-98 produced the least cob length than other genotypes.

4.2.6 Number of Rows Cob^{-1}

Nitrogen significantly ($P \leq 0.05$) increased the number of rows cob^{-1} of maize (Table 13). The number of rows cob^{-1} per plant of maize was highest at 120 kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that genotype LNTP-WC2 produced more number of rows cob^{-1} than other genotypes. However, genotype OBA-98 produced the least number of rows cob^{-1}.

4.2.7 Harvest Index (HI)

Nitrogen do not significantly ($P \leq 0.05$) have effect on HI of maize (Table 14). The HI per plant of maize was highest at 40kgNha^{-1} in the year 2007. While it was highest at 120kg N ha^{-1} in the year 2008. The combined analysis showed that genotype OBA-98 produced the largest HI per plant of maize than other genotypes. However, genotype LNTP-Y5 produced the least HI than other genotypes.

4.2.8 Grain Yield

Nitrogen (N) significantly ($P \leq 0.05$) increased the grain yield of maize (Table 15). The grain yield of maize was highest at 120kg N ha^{-1} at all sampling periods in the year 2007 and 2008 trials. The combined analysis showed that at 120kg N ha^{-1} we had the highest grain yield.

Genotype LNTP-WC2 had the highest grain yield in the year 2007 followed by OBA-98 and LNTP-Y5. Genotype OBA-98 had the highest yield in year 2008

Table 12: Effect of Nitrogen and Genotype on cob length (cm) of maize during the 2007 and 2008 wet seasons

(A) N (kg N ha^{-1})	2007	2008	Mean
0	9.51^{f}	10.30^{d}	9.79^{g}
20	11.52^{e}	10.93^{d}	11.15^{f}
40	12.10^{de}	12.47^{c}	12.15^{e}
60	12.77^{cd}	13.12^{bc}	12.81^{d}
80	13.50^{bc}	13.62^{ab}	13.48^{c}
100	14.02^{ab}	13.97^{ab}	14.04^{b}
120	14.42^{a}	14.78^{a}	14.64^{a}
SE (±)	0.27	0.26	0.19
(B) Genotype			
LNTP-WC2	13.29^{a}	12.95a	13.12^{a}
LNTP-Y5	12.72^{b}	12.43b	12.57^{b}
OBA-98	11.79^{c}	12.31b	12.05^{c}
SE (±)		0.17	0.13
Interaction			
(C) AXB			
	NS	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT.
NS = not significant.

Table 13: Effect of Nitrogen and Genotype on number of rows cob^{-1} of maize during the 2007 and 2008 wet seasons

(A) N (kg N ha^{-1})	2007	2008	Mean
0	10.82^{g}	10.45^{e}	10.61^{g}
20	12.01^{f}	11.60^{d}	11.78^{f}
40	12.73^{e}	12.67^{d}	12.60^{e}
60	13.50^{d}	13.18^{b}	13.30^{d}
80	14.08^{c}	13.55^{b}	13.80^{c}
100	14.56^{b}	14.18^{a}	14.26^{b}
120	15.26^{a}	14.53^{a}	14.88^{a}
SE (±)	0.14	0.21	0.13
(B) Genotype			
LNTP-WC2	12.55^{b}	12.55^{b}	13.24^{a}
LNTP-Y5	13.21^{a}	13.21^{a}	12.96^{b}
OBA-98	12.60^{b}	12.60^{b}	12.90^{b}
SE (±)	0.09	0.02	0.09
Interaction (C) AXB	NS	NS	NS

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT.
NS = not significant.

Table 14: Effect of Nitrogen and Genotype on Harvest Index of maize during the 2007 and 2008 wet seasons

(A) N (kg N ha^{-1})	2007	2008	Mean
0	2617.8[a]	2808.0[b]	2712.9bc
20	1985.1[bc]	2891.1[b]	243.1e
40	2235.5[b]	3347.7[ab]	2791.6cd
60	1989.1[bc]	3225.8[ab]	4602.4bc
80	1826.1[c]	3218.1[ab]	2522.1d
100	1775.8[c]	3517.8a	2646.8a
120	1798.9[c]	3552.39a	2675.6b
SE(±)	90.13	175.51	241.72
(B) Genotype			
LNTP-WC2	1997.31b	2685.5[c]	2341.4b
LNTP-Y5	1819.55c	3150.0b	248.77a
OBA-98	1281.01[c]	3833.4a	3057.21c
SE (±)	59.00	114.90	158.25
Interaction	NS	NS	NS
(C) AXB			

Means followed by the same letter(s) within a column are not significantly different at 5% level of significance using DMRT.
NS = not significant.

Table 15: Effect of Nitrogen and Genotype on grain yield (t ha^{-1}) during the 2007 and 2008 wet seasons

(A) N (kg N ha^{-1})	2007	2008	Mean
0	892.27^{g}	1082.4^{f}	989.4^{g}
20	1073.44^{f}	1384.1^{e}	1307.7^{f}
40	1601.71^{e}	1975.6^{d}	1902.8^{e}
60	1907.61^{d}	2585.4^{c}	2261.0^{d}
80	2171.86^{c}	3069.0^{c}	2666.3^{c}
100	2715.98^{b}	3770.6^{b}	3379.9^{b}
120	3259.02^{a}	4502.4^{a}	4082.2^{a}
SE (±)	54.51	202.17	82.05
(B) Genotype			
LNTP-WC2	2164.38^{a}	2406.4^{c}	2285.39^{b}
LNTP-Y5	1813.94^{b}	2842.0^{b}	2327.98^{b}
OBA-98	1859.63^{b}	3133.0^{a}	2496.31^{a}
SE (±)	35.69	132.32	53.72
Interaction	NS	NS	NS
(C) AXB			

Means followed by the same letters within a column are not significantly different at 5% level of significance using DMRT. NS = not significant.

Growth Indices

4.3.1 Crop growth rate (CGR) g m^2 wk^{-1}

The effects of treatments on crop growth rate (CGR) are shown in Fig.22 &23.There was significant increase in N rates from 20-120 kg N ha^{-1} in 2007 and 2008.CGR increased linearly with each increase in N level in 2007 and 2008.The CGR per plant of maize was highest at 120kg N ha^{-1} and lowest at 0 kg N ha^{-1}.The growth rate value for 2007 at 20 kg N ha^{-1} was about 110g$m^{-2}$$wk^{-1}$ and 100 g$m^{-2}$$wk^{-1}$ at same level in 2008.

4.3.2 Relative growth rate (RGR) g $g^{-1}$$wk^{-1}$

The effects of treatments on relative growth rate (RGR) are shown in Fig.24 & 25. There was an inconsistent increase in N rates from 20-120 kg N ha^{-1}in the year 2007.While in 2008,on application of 20-80 kg N ha^{-1} there was no any significant effect on RGR,(Fig 25).However, the addition of 100-120 kg N ha^{-1} produced similar RGR values but significantly higher over plants with 0-80kg N ha^{-1} which were similar.

4.3.3 Net-assimilation rate (NAR) g $cm^{-2}$$wk^{-1}$

The effect of treatments on net assimilation rate (NAR) are shown in Fig.26 & 27.There was inconsistent increase in N rates from 40-120 kg N ha^{-1} in the year 2007. In 2008, there was a linear increase in N level up to 80 kg N ha-^{1}(Fig.27).However, the addition of 100-120 kg N ha^{-1} produced about 0.17g $cm^{-2}$$wk^{-1}$ similar but significantly higher NAR values over plants with 0-80 kg N ha^{-1}.

4.3.4 Leaf area ratio (LAR) $cm^2$$g^{-1}$

The effect of treatments on leaf area ratio (LAR) are shown in Fig.28 & 29.There was a significant decrease in N level over LAR plots that did not receive any N treatment in 2007 and 2008. plants that received no N treatment had the highest LAR with about $6cm^2g^{-1}$ in 2007.In 2008,however,there was no significant effect on LAR upon the plant.The various levels of N did not however,differ significantly in LAR.

4.3.5 Leaf area index (LAI)

The effect of treatment on leaf area index (LAI) are shown in Fig.9-14.There were progressive increases in LAI with each increase in N level at 6 & 12 WAS in both years (Figs.9,11,12and 14). However, at 6 WAS in 2008 (Fig.12), only application of 120 kg N ha^{-1} significantly increased LAI over 0-100 kg N ha^{-1} which were similar. In 2008, application of 60-120 kg N ha^{-1} had similar but significantly higher LAI over 0-40 kg N ha^{-1}.Similarly, at 9 WAS in 2007 (Fig.10), plots with 60-120 kg N ha^{-1} had similar but significantly higher LAI over 0-40 kg N ha^{-1} which were statistically the same. In 2008 (Fig. 13) however, application of 0-60 kg N ha^{-1} at 9 WAS had no significant effect on LAI; while increases in N level from 60 up to 120 kg N ha^{-1} resulted in linear increases in LAI.

Key: 1=0, 2=20, 3=40, 4=60, 5=80, 6=100, 7=120 (Nitrogen levels)

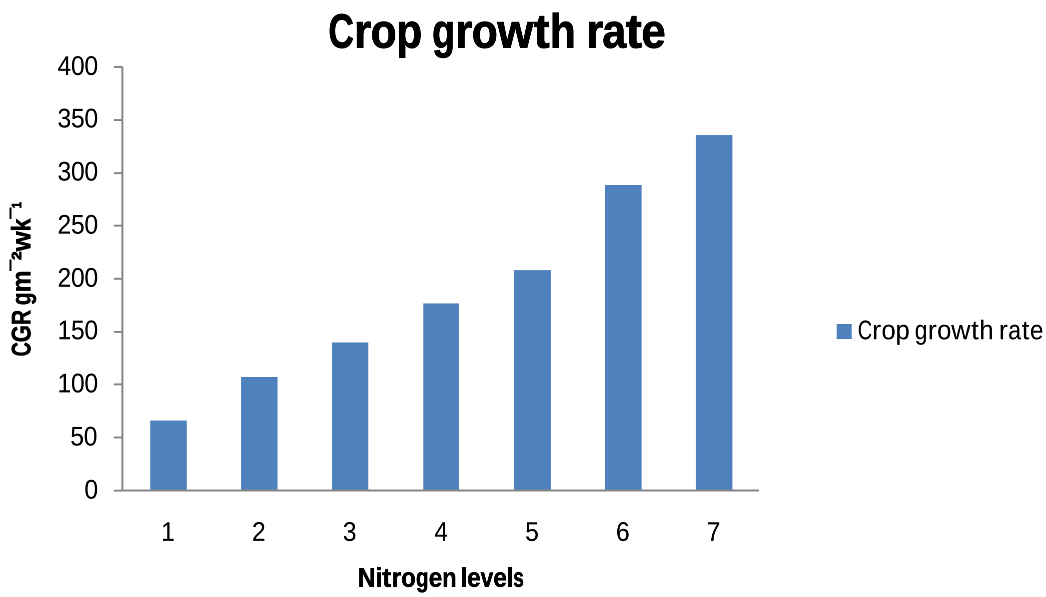

Fig. XXII Effect of N on CGR of Maize during the 2007 wet season at Samaru

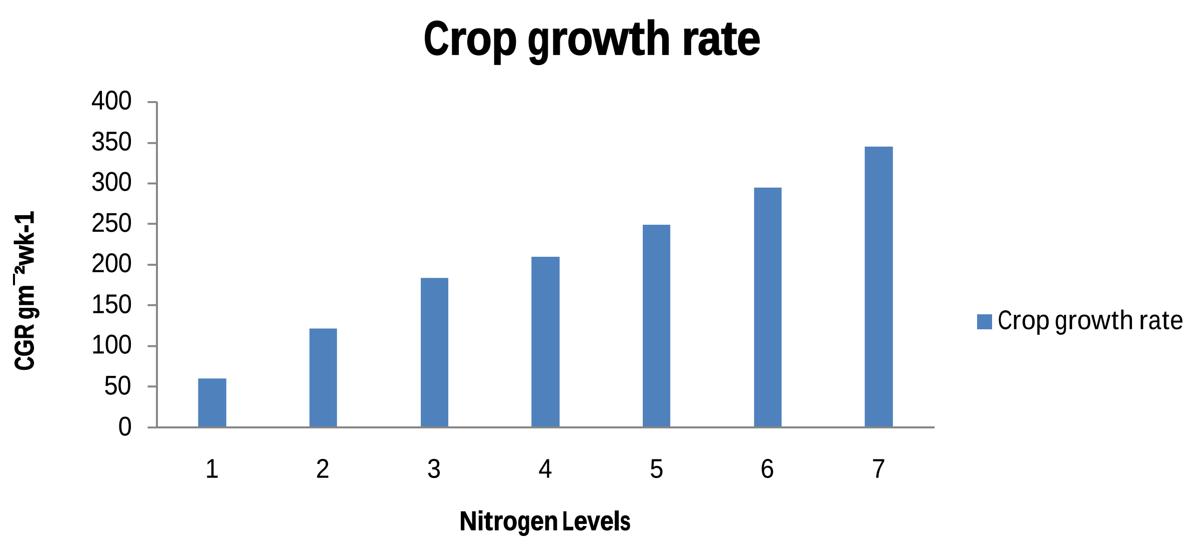

Fig.XXIII Effect of N on CGR of Maize during the 2008 wet season at Samaru

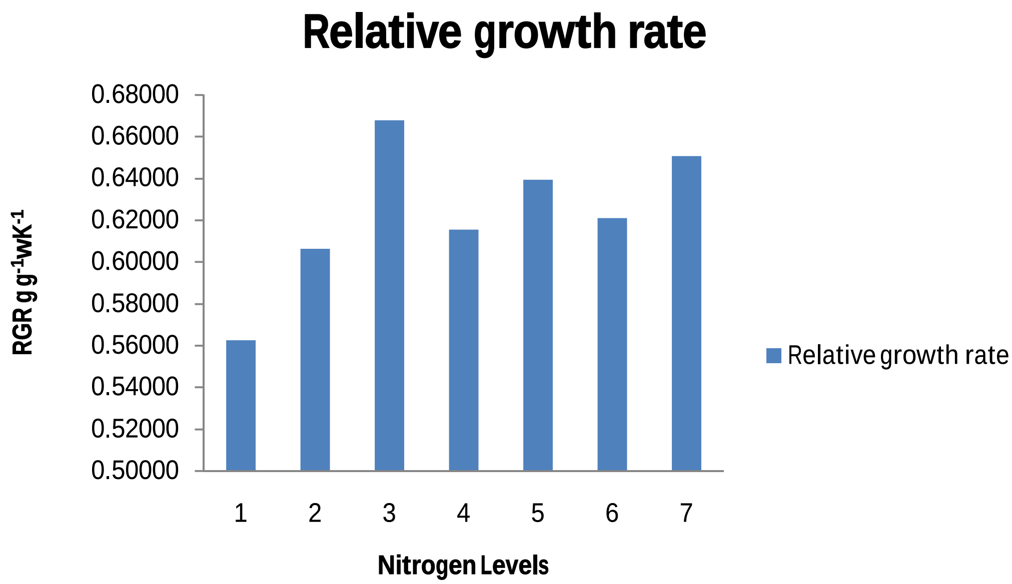

Fig.XXIV: Effect of N on RGR of maize during the 2007 wet season at Samaru

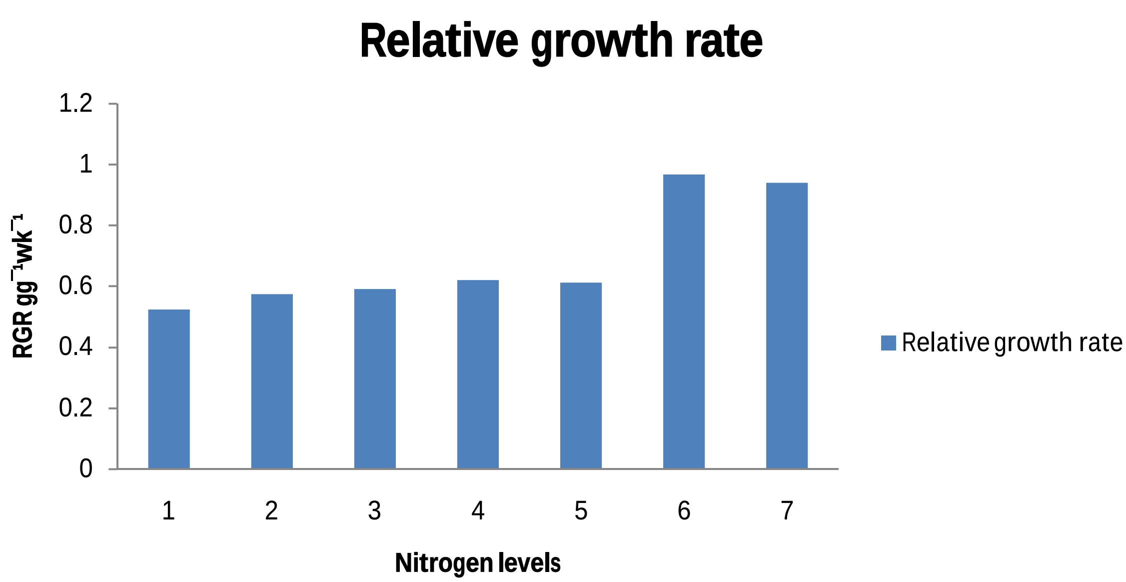

Fig.XXV: Effect of N on RGR of maize during the 2008 wet season at Samaru

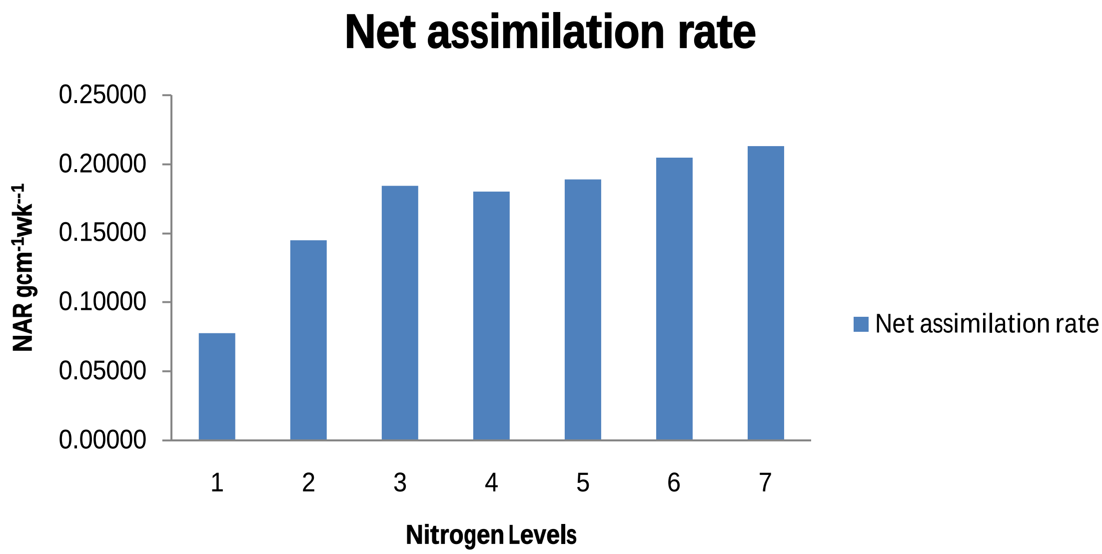

Fig.XXVI: Effect of N on NAR Of maize during the 2007 wet season at Samaru

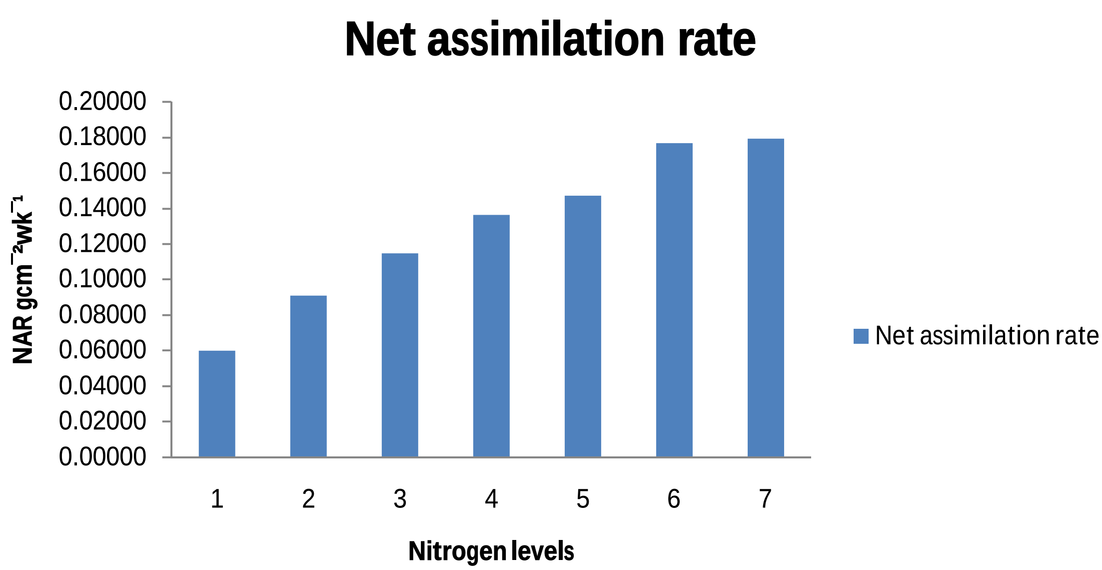

Fig.XXVII: Effect of N on NAR of maize during the 2008 wet season at Samaru

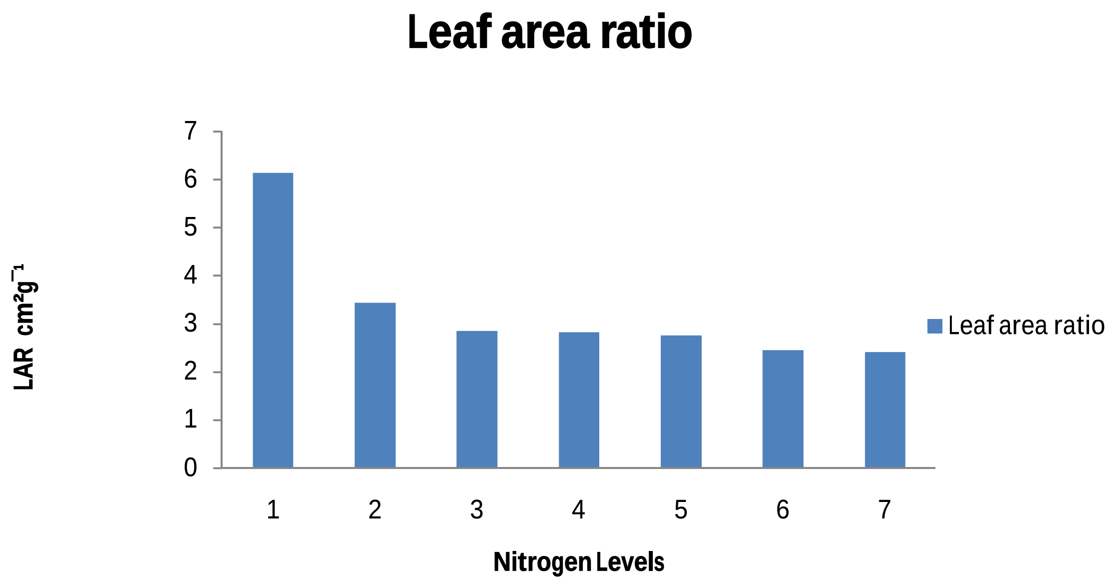

Fig.XXVIII: Effect of N on LAR of maize during the 2007 wet season at Samaru

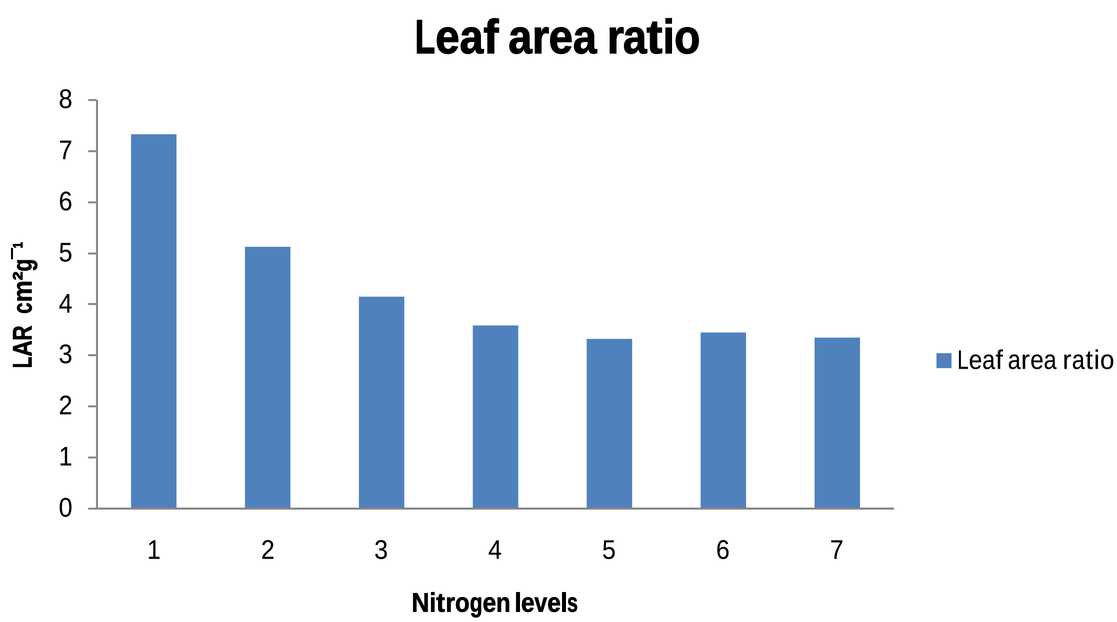

Fig.XXIX: Effect of N on LAR of maize at during the 2008 wet Season at Samaru

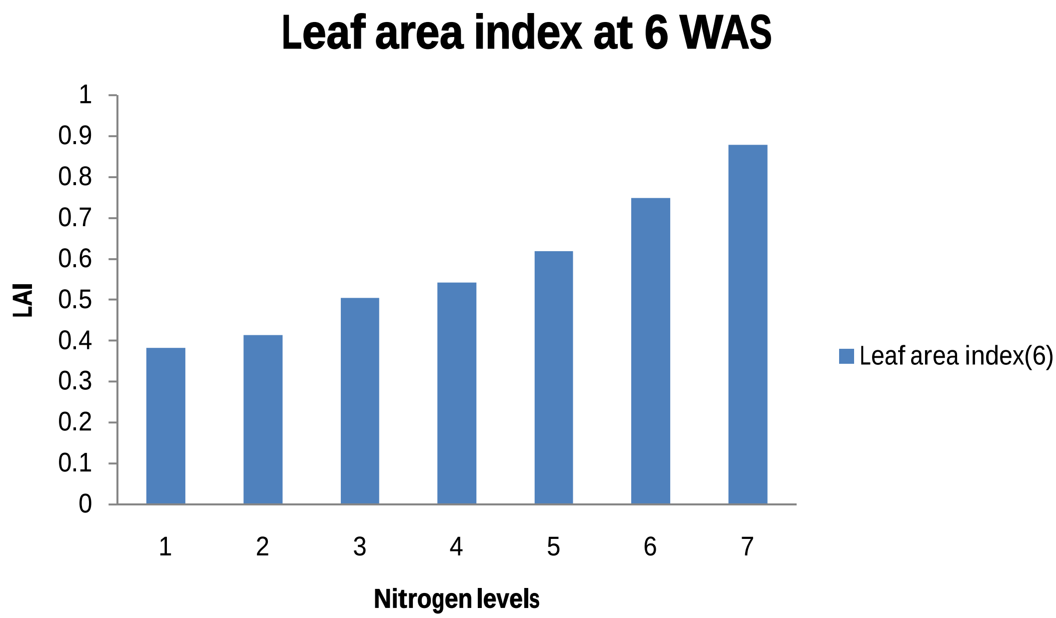

Fig.XXX: Effect of N on LAI of maize at 6WAS during the 2007 wet season at Samaru

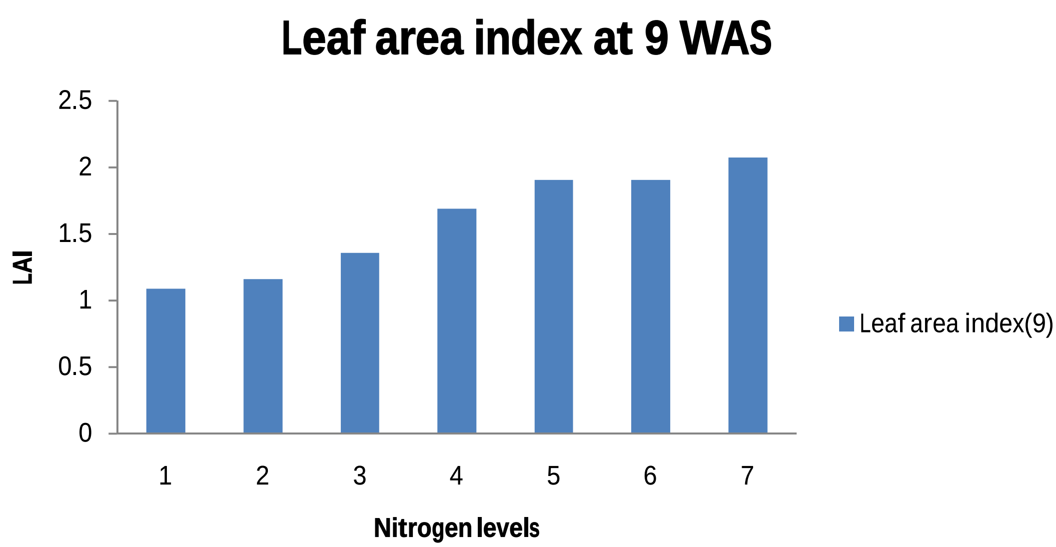

Fig.XXXI: Effect of N on LAI of maize at 9 WAS during the 2007 wet season at Samaru

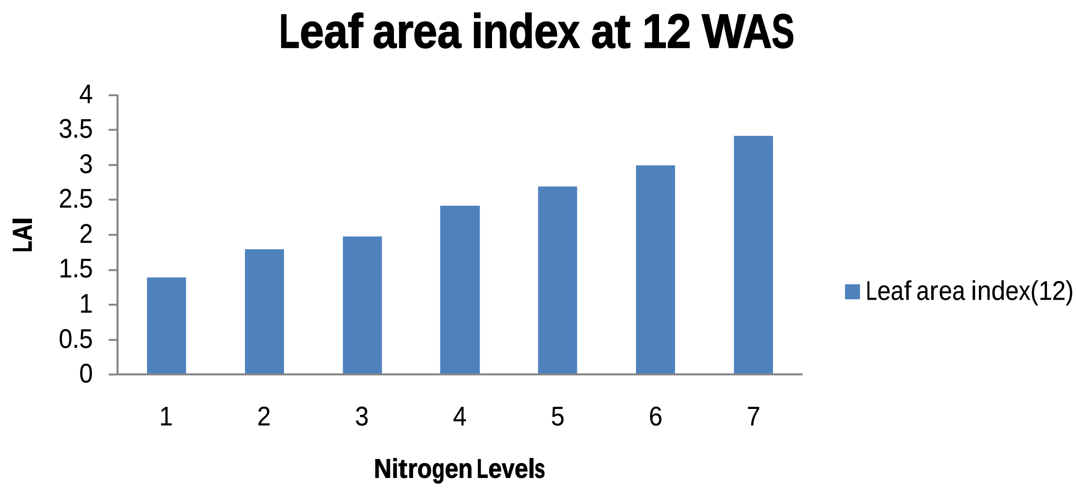

Fig.XXXII: Effect of N on LAI of maize at 12 WAS during the 2007 wet season at Samaru

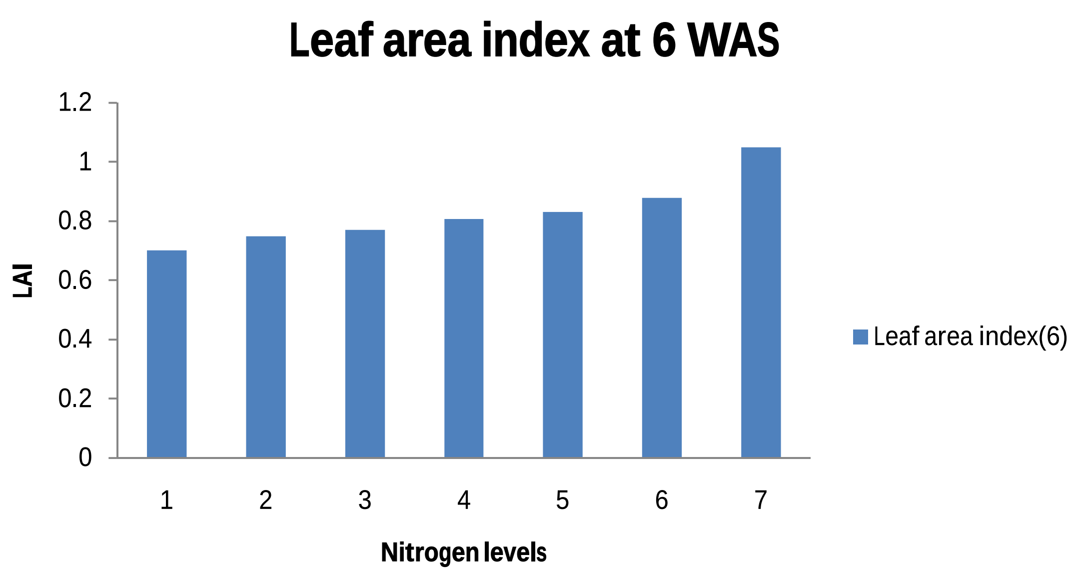

Fig.XXXIII: Effect of N on LAI of maize at 6WAS during the 2008 wet season at Samaru

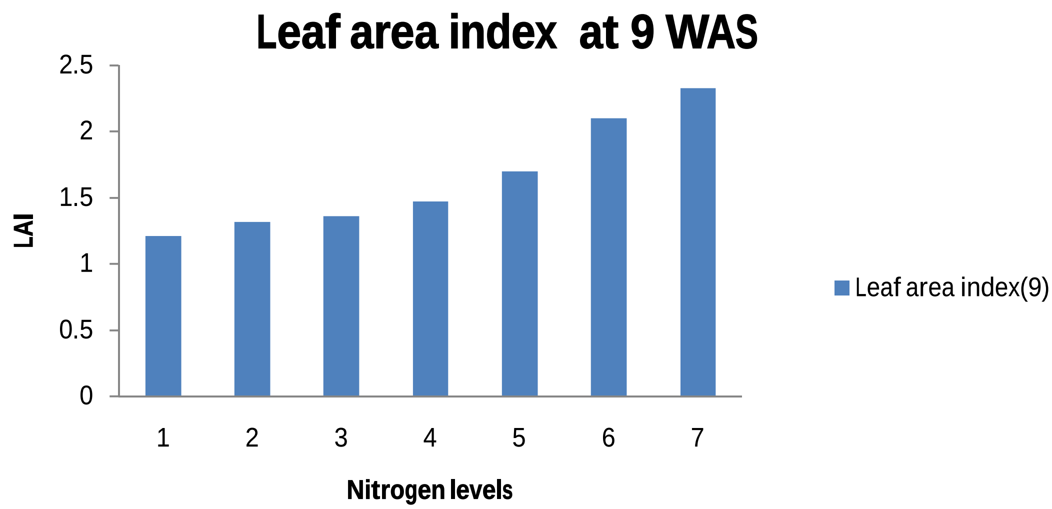

Fig.XXXIVa: Effect of N on LAI of maize at 9 WAS during the 2008 wet season at Samaru

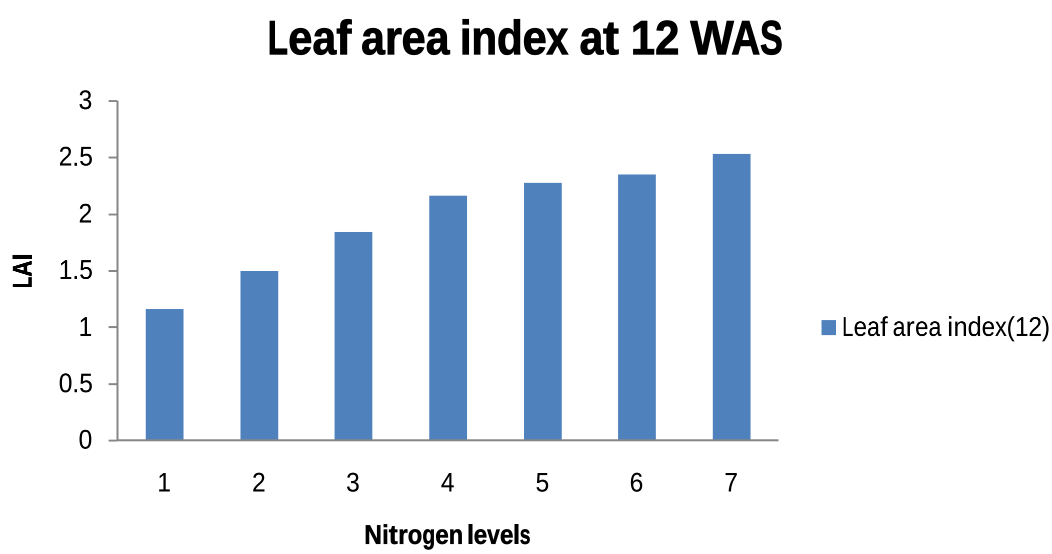

Fig.XXXIVb: Effect of N on LAI of maize at 12 WAS during the 2008 wet season at

4.4 Regression Analysis for yield parameters/components

Fig.1a: Regression of Nitrogen and Chlorophyll (2007)

i. $Y=8.031+0.348x+0.00025x^2$

$R^2=0.98$

$Y=24.535-0.130x+0.0034x^2$

$R^2=0.60$

$Y=44.44-0.236x+0.0066x^2$

$R^2=0.62$

In i, above, (chlorophyll a) x is significant at 1% level of probability,while x^2 is not significant.The value of R^2=0.98, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 98% .x is significant and positive.This means that increase in x will lead to an increase in Y. In ii, above (chlorophyll b), x is not significant, while x^2 is significant, however x^2 is positive which implies that increase in x^2 will increase the chlorophyll.The value of R^2=0.76,implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 76%.

In iii, above ,(total chlorophyll content), x is not significant,while x^2 is significant.however increase in x will increase the total chlorophyll content.The value of R^2=0.63,which implies that the combined effect of x and x^2 explain variation in Y (dependent variable) up to 63%

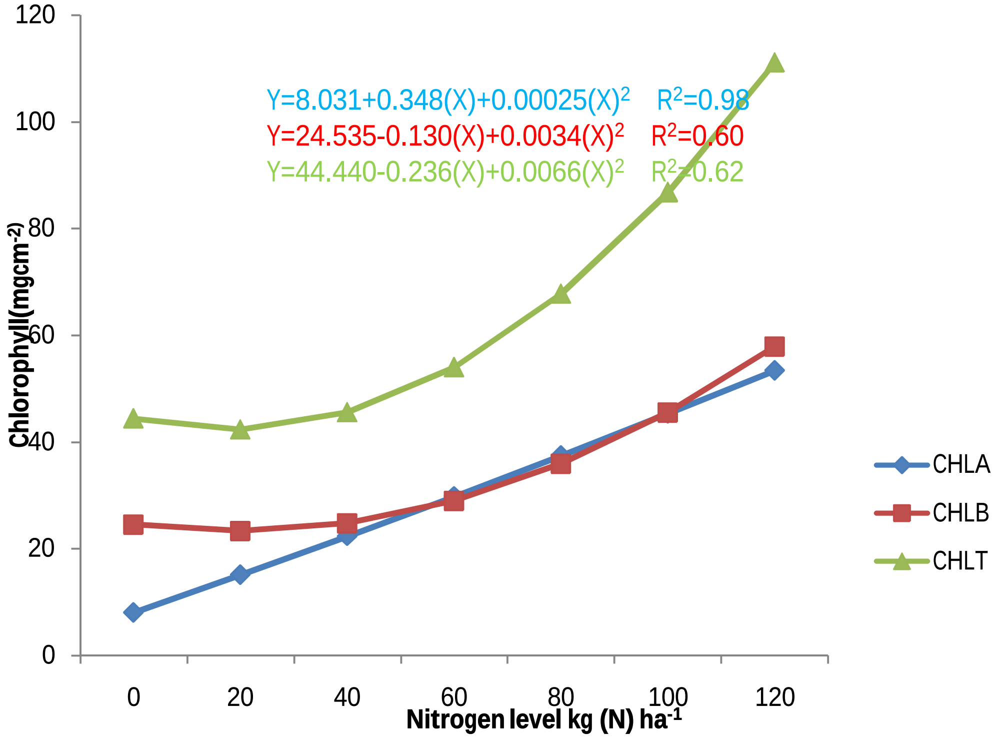

Fig. XXXV: Regression of Nitrogen and Chlorophyll (2007)

i. $Y=9.994 + 0.348\ x + 0.0026x^2$

$R^2 = 0.98$

ii. $Y= 15.222+ 0.3319x + 0.00037x^2$

$R^2 = 0.98$

iii. $Y:=25.216 + 0.6801\ x + 0.00063x^2$

$R^2 = 0.99$

In i, above, (chlorophyll a) x is significant at 1% level of probability while x^2 is not significant. The value of $R^2 = 0.98$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 98%.

In ii, (chlorophyll b), x is significant at 1% level of probability while x^2 is significant too. The value of $R^2 = 0.98$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 98%.

In iii, (total chlorophyll content) above, x is significant at 1% level of probability, while x^2 is significant too. The value of $R^2 = 0.99$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 99%.

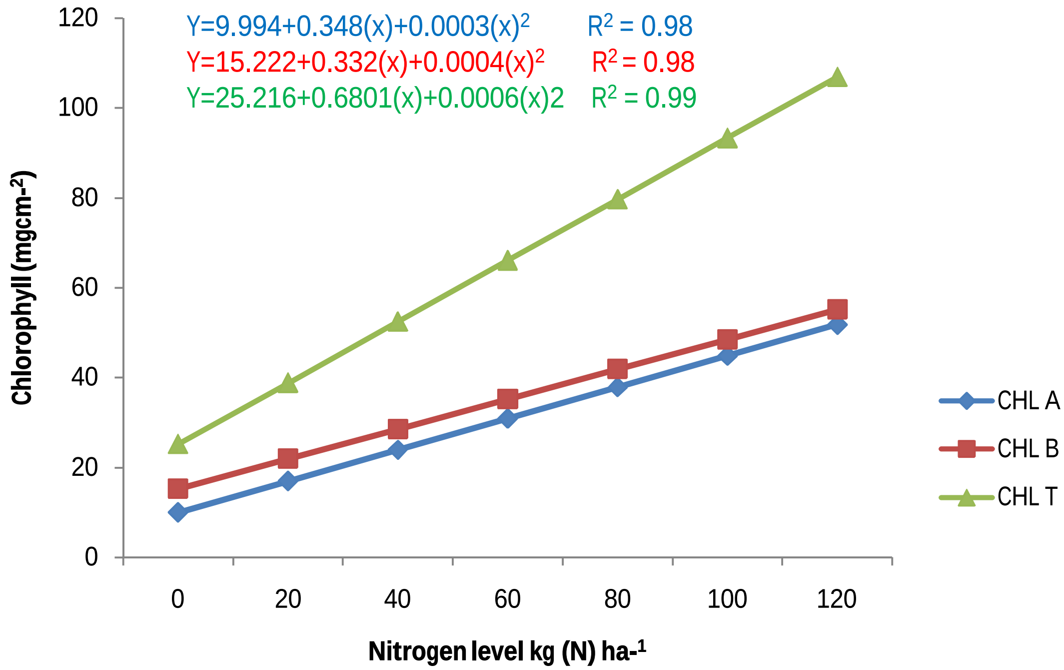

Fig. XXXVI: Regression of Nitrogen and Chlorophyll (2008)

i. $Y=19.87+ 0.100\ x + 0.0001x^2$

$R^2 = 0.76$

ii. $Y: 34.82 + 0.221x + 0.003x^2$

$R^2 = 0.77$

In (i) above, (chlorophyll a) x is significant at 1% level of probability, while x^2 is also significant. The value of $R^2 = 0.98$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 98%.

In (ii), above, (chlorophyll b), x is significant at 1% level of probability while x^2 is not significant. The value of $R^2 = 0.76$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 76%.

In iii, above, (total chlorophyll content) x is significant at 1% level of probability, while x^2 is not significant . The value of $R^2 = 0.77$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 77%.

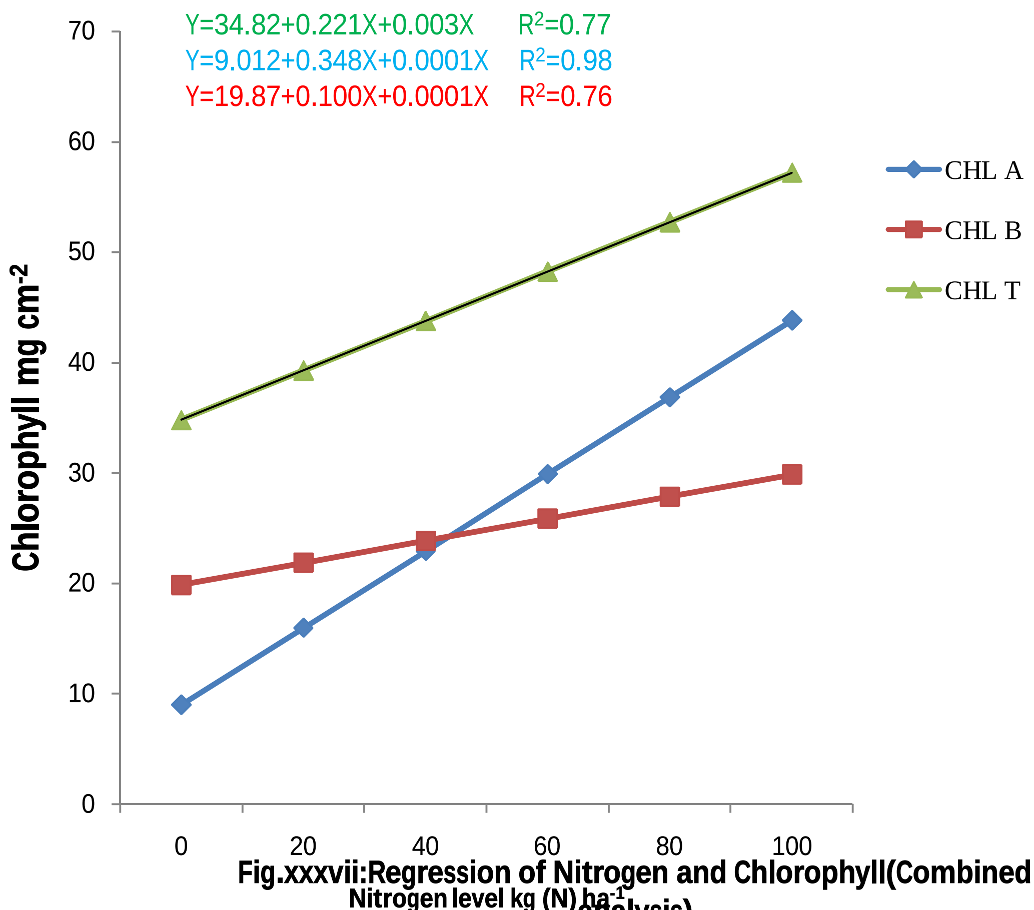

Fig.xxxvii:Regression of Nitrogen and Chlorophyll(Combined analysis)

i. $Y= 879.641+ 13.1159 x + 0.0537x^2$

$R^2 = 0.90$

ii. $Y=1130.555+ 18.9300x+ 0.1014x^2$

$R^2 = 0.82$

iii. $Y=1005 + 16.02x + 0.077x^2$

$R^2 = 0.71$

In i above, grain yield (2007), x is significant at 1% level of probability, while x^2 is not significant. The value of $R^2 = 0.90$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 90%.

In ii above, grain yield (2008), x is significant at 1% level of probability while x^2 is not significant . The value of $R^2 = 0.82$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 82%.

In iii above, grain yield (combined analysis),x is significant at 1% level of probability, while x^2 is not significant. The value of $R^2 = 0.71$, implies that the combined effect of x and x^2 can explain the variation in Y (dependent variable) up to 71%

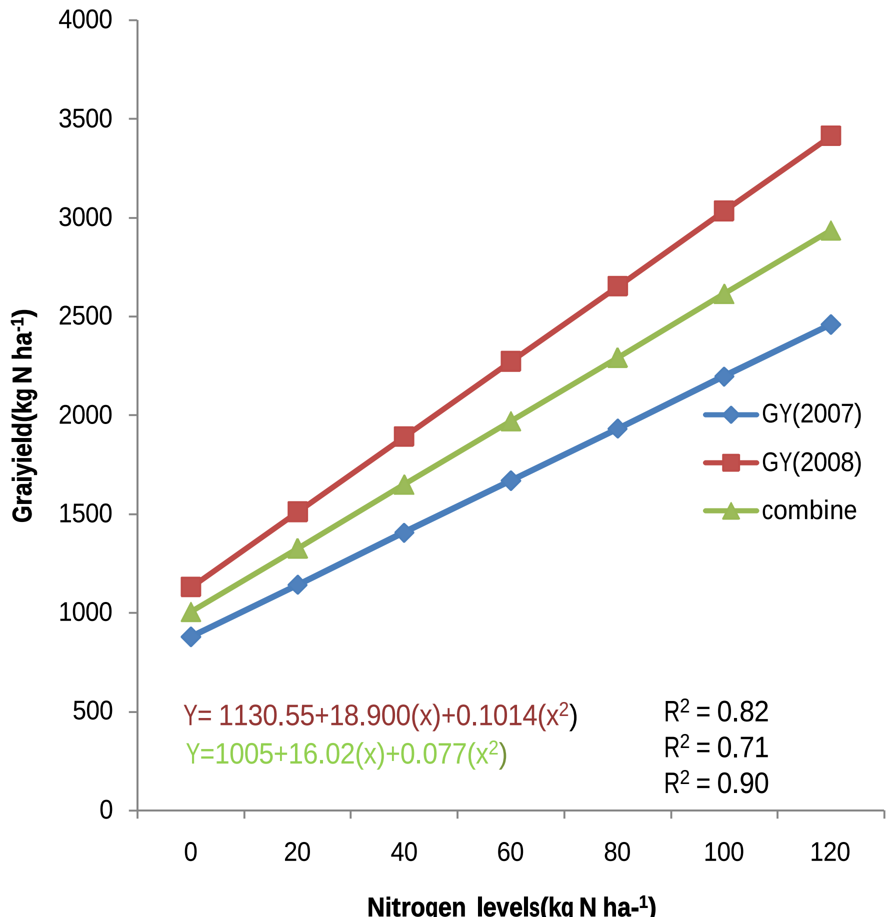

Fig. XXXVIII: Regression of Nitrogen and grainyield

4.5 Correlation Coefficient Analysis

The correlation coefficients across the two years are presented in Table 16.There were significant positive correlation between yield and leaf area per plant ,plant height and stem dry weight. The correlation obtained among other characters showed that leaf area was positively correlated with cob length. Leaf dry weight was also positively and significantly correlated with cob diameter. Plant height also showed significant positive correlation with 1000 seed-weight.

Grain yield showed significant positive correlation with 100 seed-weight (r=0.78**),leaf area (r=0.75**) and cob diameter(r=0.59**).Grain yield was also positively correlated with cob length (r=0.67**) and number of rows cob^{-1}(r=0.80**).

Table 16 : Correlation of yield , some growth and yield components of maize for 2007 and 2008 wet seasons at samaru, Nigeria.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.7475**	1.000										
3	0.8281**	0.7867**	1.000									
4	0.8360**	0.8019**	0.9259**	1.000								
5	0.8151**	0.9937**	0.8267**	0.8435**	1.000							
6	0.7787**	0.7021**	0.8005**	0.8640**	0.7483**	1.000						
7	0.4745*	0.3637	0.3355	0.3262	0.3932*	0.3423	1.000					
8	0.5909**	0.6459**	0.7316**	0.74956**	0.6697**	0.7869**	0.1887	1.000				
9	0.6749**	0.7152**	0.7857**	0.7802**	0.7413**	0.7641**	0.3103	0.7570**	1.000			
10	0.8025**	0.7923**	0.7840**	0.8756*	0.8299**	0.8202**	0.3824*	0.7574**	0.7756**	1.000		
11	0.3726*	0.2133	0.2346	0.3137	0.2174	0.3726*	-0.0385	0.4170**	0.3302	0.2504	1.00000	
12	0.7288**	0.5259**	0.6044**	0.6880**	0.5590**	0.7288**	0.1338	0.7427**	0.7294**	0.7130**	0.4797**	1.000

*= Significant at 5% level of probability
**= Significant at 1% level of probability

1= Grain yield (kg) per plant. , 2 = leaf area, 3 = leaf dry weight, 4= stem dry weight, 5 = Total dry weight,

6 = 100 seed weight, 7 = 1000 seed weight, 8 = cob diameter, 9 = cob length, 10 = Number of rows/cob

11= Ear length, 12 = Plant height

4.6 N-uptake,utilization and N-use efficiency as affected by N and genotype

Maize genotypes were more efficient in N- use at lower level of N compared to the higher rates of N in year 2007,2008 and the combined analysis (Table 17,18 and 19). However, LNTP – WC2 genotype seems to be relatively more in N utilization at higher rates of N compared to LNTP-Y5 and Oba-98 which were comparable in NUE in both years and combined analysis. This result is in conformity with the findings of Moll *et al,* (1981) and Reed *et al.*, (1980). The result also indicated that LNTP-W is likely to be preferred or recommended for cultivation in areas where N supply is limited.

Similarly, N uptake by all the genotypes decreased significantly with N rate (Table 19) and all the genotypes had statistically comparable uptake responses under various N supply levels in both seasons and the combined analysis.

On the other hand, N utilization by the various genotypes was highest at the highest level of N supply (120 kg N ha^{-1}). While the lowest N rate (20 kg N ha^{-1}) recorded the lowest N utilization for all the genotypes (Table 18,19). For LNTP-W and LNTP-Y, application of 40-80 kg N ha^{-1} led to statistically similar N utilization, while for Oba 98 plots with 80 and 100 kg N ha^{-1} had similar N utilization.

Table 17: Grain yield, N-uptake and N utilization by maize genotypes as affected by N rates at Samaru during the 2007 wet season.

	NUE(g/plant)			Uptake (g/plant)			Utilization (g/plant)		
Genotypes/	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)
kgN(ha^{-1})									
20	164.8^{a}	163.3^{a}	162.8^{a}	3.59^{b}	3.66^{b}	3.75^{a}	0.73^{a}	0.77^{a}	0.65^{a}
40	141.1^{b}	114.9^{b}	110.1^{b}	1.71^{a}	1.87^{a}	2.02^{a}	1.48^{a}	1.02^{a}	0.89^{a}
60	116.5^{c}	88.6^{c}	88.1^{c}	1.71^{a}	1.87^{a}	2.02^{a}	1.48^{a}	1.02^{a}	0.89^{a}
80	96.1^{d}	73.8^{d}	81.1^{d}	1.07^{a}	1.16^{a}	1.16^{a}	$1.^{45a}$	1.02^{a}	1.38^{a}
100	94.1^{d}	76.7^{d}	78.8^{d}	0.89^{a}	0.84^{a}	0.84^{a}	1.73^{a}	1.48^{a}	1.41^{a}
120	87.4^{e}	79.4^{d}	82.3^{e}	0.65^{a}	0.65^{a}	0.65^{a}	0.02^{a}	0.02^{a}	2.39^{b}
SE ±		13.66			0.236				0.178

Table 18: Grain yield, N-uptake and N utilization by maize genotypes as affected by N rates at Samaru during the 2008 wet season.

Genotypes/	NUE(g/plant)			Uptake (g/plant)			Utilization (g/plant)		
	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)
Kg N(ha^{-1})									
20	215.7[a]	206.3[a]	283.2[a]	3.99[a]	4.07[c]	4.16[b]	0.87[a]	0.87[a]	1.09[a]
40	142.8[b]	158.1[b]	202.8[b]	1.89[a]	2.08[a]	2.25[a]	1.33[a]	1.26[a]	1.46[a]
60	120.3[c]	144.6[c]	136.9[d]	1.51[a]	1.63[a]	1.61[a]	1.31[a]	1.44[a]	1.37[a]
80	106.6[d]	128.8[d]	128.3[e]	1.18[a]	1.28[a]	1.11[a]	1.45[a]	1.61[a]	1.84[a]
100	103.2[d]	127.9[d]	140.6[d]	0.98[a]	0.93[a]	1.03[a]	1.71[a]	2.28[a]	2.27[a]
120	101.8[d]	127.9[d]	145.7[c]	0.72[a]	0.72[a]	0.64[a]	2.33[a]	2.97[a]	3.81[b]
SE±		24.23			0.32				0.29

Table 19: Grain yield, N-uptake and N utilization by maize genotypes as affected by N rates at Samaru during the 2007 and 2008 wet seasons.

	NUE(g/plant)			Uptake (g/plant)			Utilization (g/plant)		
Genotypes/	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)	LNTP-W (VX)	LNTP-Y (VY)	Oba 98 (VZ)
kgN(ha^{-1})									
20	129.04^{a}	189.25^{a}	244.75^{a}	3.63^{c}	3.87^{b}	4.12^{b}	75.2^{d}	78.3^{d}	97.94^{d}
40	128.06^{a}	126.63^{b}	180.40^{b}	1.97^{a}	1.96^{a}	2.17^{a}	12.50^{e}	11.08^{e}	13.62^{e}
60	102.55^{b}	104.20^{c}	140.73^{c}	1.42^{a}	1.47^{a}	1.62^{a}	12.15^{e}	11.52^{e}	14.06^{e}
80	84.97^{c}	93.25^{d}	64.25^{e}	1.12^{a}	1.06^{a}	1.20^{a}	123.46^{c}	141.20^{c}	172.76^{c}
100	85.43^{c}	90.97^{d}	134.26^{d}	0.87^{a}	0.96^{a}	0.98^{a}	160.7^{b}	156.26^{b}	227.13^{b}
120	83.56^{c}	92.05^{d}	136.81^{d}	0.65^{a}	0.65^{a}	0.68^{a}	212.7^{a}	236.03^{a}	339.76^{a}
SE±		18.95			0.28			0.23	

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of N on growth Characters of maize

The results of both years (2007 and 2008) showed that N had a significant influence on growth characters such as plant height, leaf area, total dry weight, leaf and stem dry weights. Growth of maize in terms of the above characters was better in 2008 compared to 2007. Adequate moisture availability probably ensured better use of environmental resources in terms of solar energy, CO_2 and effective uptake of both soil and applied N, which resulted in increased growth of the crop.

Furthermore, N is an essential nutrient associated with cell division, expansion, synthesis of protein, chlorophyll in crops. N supply has considerable effects on plant growth, development and grain yield, as it is a fundamental constituent of many leaf cell components,particularly thosen in connection with the photosynthetic apparatus,including carboxylating enzymes and proteins of membranes (Pandey et al.,2000). Lower yield and growth attribute recorded during the year 2007 could be attributed to lower RF characterized by periodic droughts (Appendix IA) excessive high temperatures recorded at peak of pollination and fertilization (Appendix IA). Higher temperatures above 32^0C at the time of pollination may have had adverse effect on pollination and fertilization resulting in reduced seed set. This may have contributed to low yield in 2007. Similar results were reported by (Onwueme and Sinha,1991).

5.2 Effect of N on yield and yield components of maize

The significant increases observed in the yield component include cob length, 1000-grain weight, number of rows cob^{-1} with N application. N is an essential nutrient element. This could be due to involvement of N in cell division, elongation and expansion, protein synthesis and in the synthesis of chlorophyll. Increased vegetative growth, with N application means increased leaf area or the crops ability to intercept more solar energy for increased CO_2 utilization which is reflected in increased yields (Brady and Weil,2004).

Days to flowering were earlier in the year 2008 than 2007. This observed variation could be attributed to prevailing temperature in that year during the growth of maize in the field. Similarly, days to tasseling was also earlier in the year 2008 than 2007. The reduced ASI and days to flowering observed for some of the genotypes indicate that high assimilate was partitioned to growing ears, which may have caused higher ear growth rates and reduced ear abortion. This was reflected in the increased kernel number observed for those genotypes. These results are in agreement with those of Herrero and Johnson (1981) who reported that delay in silk emergence in maize results in decreased kernel number, which in turn, results in lower grain yield.

The number of 1000 grain weight was significantly increased with N application in the year 2008 than 2007. The heaviest 1000 grains was observed at 120 kg N ha^{-1} in 2008 trials. The heaviest 1000 grain weight could be due to differences in grain ear^{-1} and weight as a result of assimilate production and its partitioning (Akmal et al 2010) .

Akmal et al (2010), reported that highest 1000 grain weight (192g) was observed for 150 kg N ha^{-1} N application and lowest (172g) for 90 kg ha $^{-1}$ N. Among the genotypes evaluated, LNTP- WC2 recorded the heaviest 1000 grain weight. The number of cob length was significantly increased with N application in the year 2008 than 2007. The largest cob length could be due to differences in the genetic constituent of the crop. Also could be as a result of assimilate partitioning and production. However, cob length from LNTP – WC2 was larger than the cob length obtained from LNTP-Y5 and OBA -98. Harvest Index (HI) was significantly increased in the year 2008 than 2007. The maximum HI was recorded for OBA-98 in 2008 and minimum for OBA 98 in 2007. Rozas et al (2008) reported similar results. The grain yield of maize was significantly influenced by N. The maximum grain yield (3133 kg ha^{-1}) was recorded for OBA -98 and minimum (1813kg ha^{-1}) for LNTP – Y5. Treatment 120kg ha^{-1} yield highest (4502 kg ha $^{-1}$) and 100 kg ha^{-1} the minimum (3259 kg ha^{-1}).

5.3 Effect of N on Chlorophyll content of maize

The application of N from 0-120 kg N ha^{-1} significantly ($p<0.05$) influenced chlorophyll a,b, and total chlorophyll content of the maize plant.Highest significant effect was observed with the application of 120 kg N ha^{-1} where the highest chl a of 54.7 mg cm^{-2},chl b of 61mg cm^{-2}, and total chlorophyll content of 69.3mg cm-^{2} in 2008 respectively were obtained.According to Fillela et al.,(1995),chlorophyll gives an indirect estimate of the nutrient status as considerable leaf N is incorporated in that pigment.The result of this study showed that Oba 98 had higher chl a, while LNTP-WC2 had higher chl b in 2008 and higher total chlorophyll content in 2008. Irizar-garzar et.al.,2000 in wheat reported that the maximum chl amount per one leaf was found in the leaf number nine having the longest life span of 82d,leaf dry matter were in the third leaf (numbered from the oldest) whose average life span was 50d (Gautam,1973).

The effect of N on the chlorophyll content of maize genotypes, chl a,b and total chl. This results confirmed the findings of Amujoyegbe *et al.*, (2007) in maize and sorghum in which inorganic fertilizer + poultry manure (IFPM) had higher chl a and b components in maize. But in sorghum only PM affected chl a and b,while in maize, the effect of IF were more on chlorophyll b. Watanabe et.al.,(1994), conducted studies to determine changes in the photosynthetic properties of various Australian wheat cultivars grown over the last century. Their results suggest that chlorophyll content may be used indirectly to select cultivars for high photosynthetic capacity

5.4 Effects of N on growth Indices of maize

The application of N from 0-120 kg N ha^{-1} significantly ($p<0.05$) increased the crop growth rate (CGR) of the plant in the year 2007 and 2008 of the experiment.The effects of N during early stages of growth could be attributed to the fact that N supply promotes rapid vegetative growth of crops (Brady and weil,2004).In general,CGR did not vary significantly ($p<0.05$) during the application of 20-60 kg N ha^{-1} but increased linearly from 80-120 kg N ha^{-1}.The treatment effect is the cause of the linear response. CGR=NAR X LAI does respond very well,the greater the CGR,so the LAI increases.The increase in CGR values with N fertilization was mainly due to a larger LAI,since CGR is a product of both LAI and NAR.A higher CGR resulting from increased LAI and NAR or a combination of both usually results in high yield (Valero et.al.,2005).Similarly,an increase in CGR is commonly associated with increase in LAI than to an increase in NAR.This was because the LAI of maize indicates its photosynthetic potential or the level of its dry matter accumulation.

N application showed inconsistences on RGR in the year 2007,unlike in the year 2008.The highest RGR was 0.67g g^{-1}wk^{-1} in 2007 and 0.9g g^{-1}wk^{-1} in 2008.The inconsistences might be due to the high N status of the soil in 2007 (Appendix II) and resulted to slight or none response to N.When the N is increased to probably an optimum level (40 kg N ha^{-1}),the RGR of maize also increased which is due to increase in canopy coverage.After its optimum level,probably the rate of growth decreases,due to leaf senescence.Nevertheless,there was no significant effect on growth,on application of 20-80 kg N ha^{-1} in 2008.This might be the low N status of the soil (Appendix II).The increase in RGR value with N fertilization was mainly as a result of larger NAR since RGR is a product of both NAR and LAR (Valero et.al.,2005)

NAR is a measure of the rate of dry matter accumulation per unit leaf area. Although,there were differences in NAR in the two years of the experiment. Low NAR might be due to restricted availability of essential nutrients,decreased photosynthetic efficiency (Datta,1994) or lower rate of biomass production (Khan et.al.,2005).Our results revealed that NAR values were lower during vegetative phase than at flowering phase,unlike Valero et.al.,(2005), who reported higher values for NAR during early vegetative growth but a decline during the latter stages,a situation which the authors attributed to a general decline in photosynthetic efficiency with the occurrence of leaf senescence and also perhaps to lack of nutrients in later stages.Increase in LAR is proportional to rate of dry matter accumulation per unit leaf area.However,values recorded for vegetative growth phase in this study were significantly higher than values obtained for flowering phase.Our results however showed LAR at 0-40 kg N ha^{-1},while the highest LAR was 7.4 cm^2g^{-1}.This increase is probably due to the available N in the soil.

LAI is a measure of the ratio of leaf surface area/unit area of land.It could be associated with increase in vegetative cover,following the N application. Plots with 60-120 kg

N ha^{-1} had higher LAI over 0-40 kg N ha^{-1}.Unlike in the first year, plots with 60-120 kg N ha^{-1} had a linear increase in LAI, while plots with 0-60 kg N ha^{-1} had almost the same effect.The increase in N level brings about increase in vegetative cover, and thus maximizes the interception of solar radiation and leads to increase in total dry matter.

5.5 N – use efficiency and components of N efficiency from maize genotypes

The working hypothesis here is that a genotype with a high NUE possesses mechanism for N uptake and utilization of both forms of N (NO^{-}_3 and NH^{+}_4) in the soil either at low or high N levels.Genotypic differences among maize genotypes in respect of NUE have been reported by several workers (Moll *et al.*, 1982; Lafitte and Edmeades, 1994b), and the use of the ratio Gw/Ns as a selection criteria for NUE is widely accepted.

Similar results have been reported by Moll *et al.*, (1982), Akintoye *et al.*, 1999 and Omoigui *et al.,* (2006).The result of this study, variations in NUE in terms of its component appear to differ between levels of N supply and among genotypes. Under low N, lower utilization efficiency and NUE were observed which is the reverse to high N. LNTP–WC2 genotype is relatively higher in N utilization compared to LNTP-Y5 and Oba-98 at higher rates of N. This result is in agreement with the findings of Moll *et al,* (1981) and Reed *et.al.,*1980). The result also showed that LNTP-WC2 is likely to be preferred or recommended for cultivation in areas where N supply is limited.LNTP-WC2 under high N had higher N-utilization efficiency and NUE values than LNTP-Y5 and OBA 98 and this would help to maintain growth and productivity under low soil N.

However, each of the genotypes had more N under high N compared to low N. This was probably due to high rate of N applied, which led to having much N within the root zone and had no high uptake efficiency. Conversely, the high N–uptake efficiency under low N implies that at moderate N level, the maize plant do develop massive root system, which aids it to acquire more N from the different soil layers. Similar findings have been reported in several other maize populations by Moll *et al.,(*1982; 1987), Lafitte and Edmeades (1994b), Akintoye *et al.,* (1999) and Omoigui *et al.,* (2006).

5.6 Interactions

Interaction between N and genotypes significantly influenced plant height

6 WAS in 2008

Plant height at 0 kg N ha^{-1}, Oba-98 had significantly ($p < 0.05$) taller plants compared to LNTP-WC2 and LNTP-Y5 (El-sheikh,1998) . But when various rates of N were added, all the 3 genotypes had statistically similar heights. Each genotype, application of N from 20 kg N ha^{-1}and beyond increased the heights of LNTP-WC2 and LNTP-Y5 , while only the application of N from 80 kg N ha^{-1} increased the heights of Oba-98. Application of 120 kg N ha^{-1} to LNTP-Y5 produced the tallest plants.

9WAS in 2007

When at 0 kg N ha^{-1},Oba-98 produced the tallest plants followed by LNTP-Y5, while LNTP-WC2 had the shortest plants. But frequent applications of N to LNTP-Y5 and Oba-98 resulted in similar but significantly taller plants compared to LNTP-WC2. The tallest plants were however produced by LNTP-Y5 following the application of 120 kg N ha^{-1}

9WAS in 2008

In 2008, the reverse was the case, in the control, LNTP-WC2 had the tallest plants while LNTP-Y5 and Oba-98 had statistically similar heights. LNTP-WC2 and LNTP-Y5 produced statistically similar but significantly ($p< 0.05$) taller compared to Oba-98 at various rates of N. Oba-98 was only increased by the application of 60 kg N ha^{-1}. The tallest plants was recorded when 120 kg N $ha^{-1}$was added to LNTP-Y5.

12 WAS in 2007

In the absence of N, Oba-98 produced the tallest plants followed by LNTP-Y5 (Elsheikh,1998). When various rates of N were added, LNTP-Y5 and Oba-98 had statistically similar but significantly ($p < 0.05$) taller plants than LNTP-WC2 which had shorter plants. LNTP-WC2 and Oba-98 only responded to N following the application of 40 and 60 kg N ha^{-1} respectively, while LNTP-Y5 responded to all rate of N. The tallest plants was observed in LNTP-Y5 following the addition of 120 kg N ha^{-1}

12 WAS (Combined Analysis)

All Genotypes had statistically same heights in plots which received no N treatments. Subsequently, LNTP-Y5 and Oba-98 recorded statistically similar heights up to the highest rate of N (120 kg N ha^{-1}). The addition of 80 kg N ha^{-1} and beyond also resulted in statistically similar heights, except in Oba-98 following the application of 120 kg N ha^{-1} which resulted in the tallest plants.

Total Dry weight (6 WAS in 2007)

Total dry weight (TDW) was affected by a significant interaction between N and genotype in 2007.In plots with O and 20 kg N ha^{-1}, LNTP-Y5 had significant higher TDW than LNTP-WC2 and Oba-98 which were statistically similar up to 80 and 100 kg N ha^{-1}. LNTP-Y5 and Oba-98 were similar in TDW following the application of 80 up to 120 kg N ha^{-1}. All the genotypes had statistically similar TDW at the highest rate of N (120 kg N ha^{-1}). However, Oba-98 recorded the highest TDW following the application of 120 kg N ha^{-1}.All the genotypes responded linearly to N application (Sumi and Katayama,2000)

Leaf Area at 9 WAS (LA = leaf area)

The effect of N and genotype interaction on LA at 9 WAS in 2007 and 2008. LNTP-Y5 responded positively to all the rates of N, while genotypes LNTP-WC2 and Oba-98 only responded to N application as from 60 kg N ha^{-1} and beyond. However, Oba-98 produced the highest leaf area values with the application of 120 kg N ha^{-1}. While genotypes LNTP-WC2 and LNTP-Y5 had significantly ($p < 0.05$) lower LA compared to Oba-98 with N application. Genotypes LNTP-WC2 and LNTP-Y5 had statistically similar LA up to the addition of 100 kg N ha^{-1} (El-Gizawy,2009).

5.7 Stem dry weight as influenced by N and genotype interaction at 6 and 12 WAS in the combined analysis

All the genotypes did not differ significantly in stem dry weight at both 6 and 12WAS with the application of various rates of N and even at zero rate of N. However, application of various rates at 6 and 12 WAS, significantly ($p < 0.05$) increased stem dry weight of all the genotypes. Genotype Oba-98 had the highest stem dry weight of all the genotypes. Genotype Oba-98 had the highest stem dry weight with the application of 120 kg N ha^{-1}, even through, all genotypes recorded statistically similar stem dry weight at 12 WAS; while the highest stem dry weight at 6 WAS recorded by LNTP-Y5 after application of 120 kg N ha^{-1}.

5.8 Leaf dry weight as influenced by N and genotype interaction at 12 WAS in 2007

Varying rates of N did not seem to cause significant differences in leaf dry weight of the 3 genotypes of maize. However, though comparable with other genotypes, LNTP-Y5 recorded the highest leaf dry weight with the application of the highest rate of N (120 kg N ha^{-1}).

5.9 Chlorophyll a content as influenced by an interaction between N and genotype at 9 WAS in the combined analysis

All the genotypes seemed to have similar chlorophyll contents following application of 40-120 kg N ha^{-1} and in the plots which had no N treatments. The highest chlorophyll content was, however, observed in LNTP-Y5 following the application of 120 kg N ha^{-1}, whereas plots without N recorded very low but comparable chlorophyll contents. The lowest chlorophyll content was recorded in Oba-98 in the absence of N.

5.10 Chlorophyll b as influenced by an interaction between N and genotype at 9 WAS in the combined analysis

Shows chlorophyll b content did not vary significantly at various rates of N. chlorophyll b content of LNTP-WC2 and LNTP-Y5 did not seem to be influenced by N rates, while the chlorophyll content of Oba-98 was significantly ($p < 0.05$) increased by the application of 80-120 kg N ha^{-1} .The application of 120 kg N ha^{-1} resulted in the highest chlorophyll b in Oba-98, although all genotypes recorded statistically similar chlorophyll ‘b’ contents at the highest rate of N.Large leaf area and leaf dry weight have further confirmed the ability of Oba-98 to produce more dry matter and intercept more solar energy for increased yield of Oba-98.

5.11 Total Chlorophyll content as influenced by an interaction between N and genotype at 9 WAS in the combined analysis

Application of 20-60 kg N ha^{-1} to LNTP-WC2 significantly depressed total chlorophyll content, while similar level of N had no significant effect on total chlorophyll content in genotypes LNTP-Y5 and Oba-98. Subsequent increases in N rates had no significant effect on LNTP-WC2. Application of 100-120 kg N ha^{-1} to LNTP-Y5 and 60 - 120 kg N ha^{-1} to Oba-98 further enhanced total chlorophyll contents. Genotypes did not however vary significantly in total chlorophyll contents with N application. All the genotypes had similar total chlorophyll contents, but LNTP-Y5 had the highest total chlorophyll content (Ghosh et al.,2004).

The positive effect of N application on chlorophyll ‘a’ contents of all the genotypes indicates the need for N fertilization for improved chlorophyll ‘a’ content of maize general for improved photosynthetic capacities of the genotypes. The lack of significant response of chl ‘b’ and ‘t’ content of LNTP-WC2 and LNTP-Y5. N rates could be genetically induced. All forms of chlorophyll were significantly increased by various rates of N in Oba-98 signifying that N fertilization increased the photosynthetic ability and probably of this genotype compared to the other genotypes. At lower rates of N (20-40 kg N ha^{-1}), N depresses chlorophyll b and t contents of LNTP-WC2 while a higher rate of N restores its chl contents. This could indicate significant reduction in chl content and hence photosynthetic activities in the genotype. Larger leaf area and leaf dry weight have further confirmed the ability of Oba-98 to produce more assimilates and yields than other genotypes. It also produces the lowest chlorophyll contents in plots which had no N treatments. On the other hand, LNTP-WC2 and LNTP-Y5 responded less to N application except at higher rates of N, this indicating their ability to intercept solar energy and maintain high chlorophyll contents with less investment on N fertilization (Brady and Weil,2004)

5.12 Correlation

The significant and positive correlation shown between yield and growth parameters especially leaf area,height and TDM signifies the importance of these parameters in assimilate production. The significant and positive relationship observed between yield and leaf area index shows larger canopy cover which means greater light interception which led to increase in photosynthesis (Ubandoma,2006).Similarly, the positive and significant correlation observed between TDM and yield denotes the efficient partitioning of assimilates which was translocated to the sink for final grain yield.Yield components such as 100-grain weight, number of rows cob^{-1} and grain yield per plant which were positive and significantly correlated with yield showed their importance as yield determinants,similar findings were reported by Amoruwa (1985).

CHAPTER SIX

SUMMARY AND CONCLUSION

Field experiments were conducted at the institute for Agricultural Research farm at Samaru, Zaria during the 2007 and 2008 wet seasons to study the effects of Nitrogen and genotypes on some physiological and morphological characters of maize at samaru, in the Northern Guinea Savanna of Nigeria. Treatments consisted of three genotypes of maize {LNPXLNTPWC2 ; LNTP-YC5 and OBA 98} and seven N levels (0-120 kg N ha^{-1}) compared with the control (Zero level).The experiment was laid out in a randomized block design, with treatments arranged in factorial combination. Several growth and yield characters were determined. These included plant height, leaf area, leaf, stem and total dry weights, cob diameter, cob length, number of rows cob^{-1} and grain yield. Chlorophyll content was also determined.

Analysis of variance were conducted and treatment means were compared using DMRT at 5% level of probability. Results of this study indicated that all the growth, yield and yield components were significantly influenced by N in both years of the study. Application of various levels of N produced taller plants, while the height of the plants increased as N rate also increased.Genotype significantly influenced number of days to 50 % silking and tasselling where Oba 98 took more days to reach 50% silking and tasselling than other genotypes.While LNTP-Y5 produced taller plants. Application of N resulted in an increase of chl a, b and total chlorophyll content. There were significant impacts of N on the chl and is shown in dark green coloration of the crops. Genotype differences were observed under the N levels. LNTP-WC2 was taller than LNTP-Y5 and Oba-98. However, Oba-98 produced flower earlier than LNTP-WC2 and LNTP-Y5.A higher rate of N restores chl contents of LNTP-WC2, while a lower rate of N, depresses chl b and t, This could indicate significant reduction in chl content and hence its photosynthetic activities. Larger leaf area and leaf dry weight enhanced the ability of Oba-98 to produce more assimilates and yields than other genotypes

The growth indices of N had significant effect on the growth characters of maize. Increase in CGR values with increase in N rate and is due to a larger LAI, which resulted in high total dry matter production.RGR was inconsistent in the first year (2007), while there was no significant effect in 2008.There were differences in NAR in 2007 and 2008. Also there was an increase in LAI with each increase in N level at two growth cycles in both years. The increase in N level, which caused an increase in vegetative cover maximizing interception of solar radiation and so resulted in increase in the total dry matter, which led to high grain yield.

The correlation coefficients obtained showed that leaf area per plant,plant height and stem dry weight were positively and significantly correlated with yield.While leaf dry weight was strongly correlated with cob diameter,cob length and number of rows cob^{-1} were found to be positively and significantly correlated with yield.These characters could be used in selection index for improving the grain yield of maize under N-stress condition. All the maize genotypes were more efficient in NUE at the lower level of N compared to the higher rates of N in year 1, 2 and the combined analysis. Similarly N uptake by all the genotypes decreased significantly with N rate. Genotype Oba-98 was more efficient in N-utilization efficiency but was low in N uptake efficiency at high N level. The aim was to have a genotype with high NUE and N-utilization efficiency because it would help to maintain growth and productivity under low soil N. It could be deduced that there was a significant improvement in genotype Oba-98 compared to genotypes LNTP-WC2 and LNTP-Y5 .

Based on the above findings it was observed that the best yield of 3259,4502 and 4082 kg N ha^{-1} in 2007, 2008 and combined analysis respectively and yield components were from 120 kg N ha^{-1}.There was significant and positive correlation between grain yield and most growth and yield components which also correlated positively and significantly among themselves.The regression analysis showed that the highest rate of N produces the highest yield, no other means of deriving the optimum rate of N.

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APPENDIX 1A

Rain fall, maximum and minimum temperature relative humidity at ten days interval during the period of experiment at Samaru 2007.

Month	Decade	Rainfall (mm)	Max. (°C)	Min. (°C)	SH	RH (%)
July	1	27.4	30.8	21.4	NA	82.0
	2	32.4	29.5	20.3	NA	80.4
	3	178.8	29.2	22	NA	76.3
Aug.	1	51.1	28.9	20.5	NA	71.4
	2	177	28.8	22.1	NA	78.6
	3	146.2	28.7	21	NA	80.7
Sep.	1	16.4	29.2	20.6	NA	84.1
	2	3.5	32.3	20.4	NA	73.0
	3	12	33.5	19.9	NA	71.6
Oct.	1	4.9	34.1	18.4	NA	64.9
	2	3.4	35.2	17	NA	54.4
	3	0	35.6	18.2	NA	57.9
Nov.	1	-	35.5	15.7	NA	31.8
	2	-	35	15.7	NA	21.5
	3	-	35.4	14.2	NA	15.2
Dec.	1	-	34	13.7	NA	17.9
	2	-	33.1	13.9	NA	17
	3	-	31.72	12.8	NA	17.9

APPENDIX 1B

Rain fall, maximum and minimum temperature relative humidity at ten days interval during the period of experiment at Samaru 2008.

Month	Decade	Rain (mm)	Max.(°C)	Min.(°C)	SH	RH (%)
July	1	61	30.7	19.6	5.6	78.1
	2	7.5	30.1	20.4	6.6	78.0
	3	133	30.5	20.3	6.6	81.6
Aug.	1	124.4	29.5	19.4	4.4	81.8
	2	116.5	29.5	19.5	3.2	80.2
	3	83.2	29.6	19.4	NA	83.6
Sep.	1	144.6	31.2	24.6	NA	79.1
	2	56.6	31.0	25.0	2.2	77.3
	3	44.9	32.1	25.7	6.5	75.8
Oct.	1	68.8	31.5	20.7	6.2	77.2
	2	22.5	33.1	19.6	7.3	70.3
	3	0	34.0	15.5	9.6	40.8
Nov.	1	-	33.9	12.2	-	21.2
	2	-	33	13.6	-	24.1
	3	-	34.4	11.3	-	18.2
Dec.	1	-	34.5	13.6	-	28
	2	-	31.3	13.9	-	16.4
	3	-	30.6	16.1	-	18.3

APPENDIX 1C

Metrological data showing sunshine and wind speed at Samaru 2007 season

2007 Month	Days	Sunshine Hours	Wind speed km/hr
July	1-10	NA	197.6
	11-20	NA	171.6
	21-30	NA	185.1
Aug.	1-10	NA	141.5
	11-20	NA	132.4
	21-30	NA	118.9
Sept.	1-10	NA	89.9
	11-20	NA	102.8
	21-30	NA	98.7
Oct.	1-10	NA	93.7
	11-20	NA	91.7
	21-30	NA	93.4
Nov	1-10	NA	111.6
	11-20	NA	102.1
	21-30	NA	110.2
Dec.	1-10	NA	110.8
	11-20	NA	163.0
	21-30	NA	122.2

APPENDIX 1D

Metrological data showing sunshine and wind speed at Samaru 2008 season.

2008			
Month	Days	Sunshine Hours	Wind speed km/hr
July	1-10	5.7	189.6
	11-20	5.7	172.2
	21-30	6.0	173.5
Aug.	1-10	3.8	133.6
	11-20	1.7	133.8
	21-30	-	103.5
Sept.	1-10	-	115.6
	11-20	6.5	105.3
	21-30	5.9	90.9
Oct.	1-10	6.9	89.7
	11-20	7.8	64.0
	21-30	10.6	92.9
Nov	1-10	9.7	87.1
	11-20	9.1	121.2
	21-30	10.2	96.0
Dec.	1-10	9.0	84.5
	11-20	9.4	107.1
	21-30	9.1	187.6

APPENDIX II

Physico-chemical properties of soil taken from the experimental site at Samaru to the depth of 0-15cm and 15-30cm in both seasons.

Soil composition	0-15cm	15-30cm	0-15cm	15-30cm
Physical properties				
Particle size				
Clay (%)	16	24	130	170
Sand (%)	20	10	550	510
Silt (%)	64	66	320	320
Soil textural class (%)	Silt loam	Silt loam	Silt loam	Loam
Chemical properties				
Soil pH in water	4.95	5.02	6.7	6.10
pH in 0.01M$Cacl_2$			5.6	5.40
Organic carbon (%)	0.76	0.72	6.2	5.80
Total nitrogen (%)	0.72	0.76	0.053	0.07
Available exchangeable phosphorus (PPM)	6.24	7.13	50.16	38.25
Exchangeable bases (Meg/100g soil)				
Calcium (Ca)	0.2	0.2	1.80	2.10
Magnesium (Mg)	1.1	0.9	1.10	1.30
Potassium (K)	2.1	1.2	0.24	0.31
Sodium (Na)	-	-	0.51	0.49
Cation exchange capacity (CEC)	6.2	5.8	3.50	3.90