PERFORMANCE OF TWO SUNFLOWER (*Helianthus annuus* L.) VARIETIES UNDER VARYING PLANTING DENSITY AND NITROGEN LEVELS

BY

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DECLARATION

I declare that the work in this thesis entitled 'Performance of Two Sunflower (*Helianthus annuus* L.) Varieties under Varying Planting Density and Nitrogen Levels' has been carried out by me in the Department of Agronomy under the supervision of Professor E.B. Amans and Doctors R.A Yahaya and Y. A Sani.

Information in the text derived from literature has been duly acknowledged and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any institution.

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Chairman supervisory committee

CERTIFICATION

This thesis titled 'Performance of Two Sunflower (*Helianthus annuus* L.) Varieties under Varying Plant Density and Nitrogen Levels' meets the regulations governing the award of the degree of M. Sc. Agronomy of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This Research work is dedicated to the Almighty God and to my family.

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ABSTRACT

The performance of two sunflower (*Helianthus annuus* L.) varieties under varying plant density and nitrogen levels was investigated under field condition in 2012 rainy and dry seasons at the Institute for Agricultural Research farm and irrigation research farm in Ahmadu Bello University, Samaru Zaria (11°12`N07º37`E686 above sea level). The treatments evaluated consisted of four rates of nitrogen at (0, 50, 100 and 150 kg per hectare) three plant densities (22,222, 44,444 and 66,666 plants per hectare) and two varieties (SAMSUN 1 and SAMSUN 4). The treatments were factorially combined and laid out in a split-plot design with three replications. The combination of sunflower variety and nitrogen level constituted the main plot while plant density was assigned as sub-plot. Soils of the experimental sites were randomly sampled to depth of 30cm, bulked and analyzed for physicochemical properties before the establishment of the trials. Weather data with respect to rainfall, temperature, relative humidity and sunshine hours for the periods of experimentation was also recorded. The result showed that increase in nitrogen level from 100-150 kgNha^{-1} significantly increased number of leaves, plant height, relative growth rate, leaf area index, total dry matter, head weight, total seed weight, and 1000 seed weight in both rainy and dry seasons. SAMSUN 4 produced taller plants at 7 WAS (106.24cm) in the rainy season and 13 WAS (170.20cm) in the dry season, it also produced more yield than SAMSUN 1. Plant population density significantly influenced all parameters investigated. It was observed that plants grown at planting density of 66,666 plantsha^{-1} were taller (170.75cm) when compared to 22,222 plantsha^{-1} (161.82cm) and has more yields per hectre (1228.05 kgha^{-1} relative to 741.08 kgha^{-1}) but plots planted at 22,222 plantsha^{-1} produced plants with significantly thicker stem girth and higher leaf area index in both seasons. Based on this study, the performance of sunflower could be enhanced using nitrogen level of up to 100 kgNha^{-1} and a plant population density of up to 44,444 plantsha^{-1} and SAMSUN 4 sunflower variety was superior to SAMSUN 1 variety in both rainy and dry seasons in terms of plant height, number of days to initiation of flowering, lodging percentage, crop growth rate, head diameter, head weight, total seed weight as well as grain yield.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin and Distribution

Sunflower (*Heliantus annuus* L.) is an annual plant belonging to the family of flowering plants called '*Compositae*' or '*Asteraceae*'. The sunflower is named after its huge, fiery flower head, whose shape and image is often used to depict the sun. This aspect makes the sunflower such a remarkable eye-catching plant in any landscape. It has been stated that, if there is one annual flower that is unmistakable to anyone, it's the sunflower. It is not only pleasant to look at but also heliotropic; a phenomenon where the floral head of the plant leans towards the direction of the sun at different times of the day in accordance to the location of the sun within the day (Anon, 2012a). The crop, in history and utility is of dual economic importance; namely as an oil crop and for ornamental purposes. It is believed to have originated from Mexico or Peru (Hurt, 1949). Although, the cultivated sunflower variety Macrocarpus (DC) is not known in a truly wild state, it is believed to have come from a sub species of annuus found in dumps and vacant plots in Central and Eastern United States and Canada (Heiser, 1954).

Sunflower was introduced to Europe and Russia in the 16th and 18th centuries respectively (Hurt, 1949). It was developed as a premier oil seed crop in Russia and has been widely accepted throughout Europe (Anon, 1976). It was introduced into Europe by Spanish traders in 1510, to France in 1787 and Germany in 1925 (Purseglove, 1968).The crop was brought to Africa in the early 20th century by the Portuguese traders and European Missionaries and to Nigeria in the early sixties as an arable crop that could possibly be grown on a large scale to supplement the shortage of edible oil and meals (Ogunremi, 1979). It is today widely distributed in many parts of the tropical and temperate countries of the world (Anon, 1976).

1.2 Botanical Description

The sunflower is a single stemmed, erect usually unbranching herbaceous annual,which grows to a height of 0.6 to 3.5m depending on the cultivar. It has a rough, hairy stem, broad, coarsely toothed rough leaves and circular heads of flowers. The flower heads is a large composite of yellow florets which could be anything up to 25cm in diameter .The centre of the flower head is often dark brown in colour. The head consist of many individual flowers in their hundreds on a receptacle base which mature into seeds. The leaves and buds of young flowers do exhibit heliotropisim, a phenomenon which involves their orientation changing with the sun from East to West during the course of a day from sunrise to sunset respectively. The heliotropic response of the leaf and flower head occurs while the plants are still actively growing, but once they mature, the movement stops (Shella, 1974; Norman, 2004).

1.3 Importance and Uses of Sunflower

The sunflower is commercially cultivated principally as an oil crop. Among the numerous oil-seed crops, the sunflower oil is considered a premium one, probably comparable only to olive oil (Putnam *et al*., 1990). The oil is highly favoured for its high colour, high level of unsaturated fatty acids, good flavour and high smoke point (Putnam *et al*., 1990). It is popular as cooking and salad oil as well as for the manufacture of margarine and other food additives. The sunflower seeds are also becoming popular as roasted and salted snacks (Anon, 2012a). The meal after oil extraction is used for livestock feeds (Ogunremi, 1979). The sunflower is also a prime ornamental plant. The sheer, relatively large golden flower head and plant height makes it stand out among other annual flowers in gardens (Anon, 2012b). The sunflower was adopted as symbol of the state of Kansas (USA) because of the appreciation of its aesthetic and ornamental impact (David, 2011).

Apart from its contribution to environmental beauty, sunflower has been identified as one of the most promising plants for cleaning-up soils contaminated with heavy metals such as lead as it harvests these toxic elements from the soil, resultant sunflower plants are later destroyed, before planting delicate food crops (Dushenkov *et al*., 1995).

1.4 Soil and Climatic Requirement

Sunflower is a warm –season crop and therefore grows well in the tropics. Growth is best with full sun and temperatures between 18 to 24^0C (Schuster, 1985), however, cooler temperatures increase stem length for cut flower production (Cavins *et al*., 2000). It adapts relatively well to a wide range of soil types, it however grows best on medium –textured soils such as loams. Good soil drainage is essential for optimum sunflower production, but it does not differ substantially from other field crops in flood tolerance (Putman *et al*., 1990).

1.5 Production of Sunflower

Sunflower is a cosmopolitan, versatile crop which adapts to a wide range of environmental conditions. FAO, (2004) reported that the current world area under sunflower cultivation is 22.3 million hectare while seed production and average yield stands at 27.7 million tonnes and 1.2 tonnes per hectares respectively. However, Miller and Flick (1997) reported that Eastern European countries, Russia, Argentina and Spain accounted for over 80% total world production. South Africa, Kenya, Nigeria, Ghana, Uganda and Sudan are African countries that produce substancial quantity of the crop (Agele 2003; FAO, 2010; Showemimo *et al*., 2010). Although statistical data on production figure and hectarage in Nigeria are not available, seed yield above 1 tonne per hectare has been reported depending on cultivars planted (Aduayi *et al*., 2002 ; Toner, 2006).

1.6 Justification and Objective for the Study

Sunflower is increasingly becoming a more popular and preferred source of vegetable oil globally because of its superior quality and low cholesterol level (Ogunremi, 1979; Robbelen, 1989). However, despite the increasing acceptance and demand for this oil, the level of its production has remained very low. There is need to increase production and popularity of the crop in Nigeria through the development of improved varieties and appropriate production practices. To satisfy this need, recently, the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria released four new improved sunflower cultivars (Showemimo *et al*., 2010). However, there has not been much of research on the cultural practices needed to support the potentials of these new varieties. It is generally known that low level of soil fertility especially with respect to nitrogen supply, is one of the major limitations to crop production in the Nigerian savannah. Other notable factors inhibiting high crop yields include inappropriate planting density, weed challenge and other biotic stress. The work of Showemimo *et al*. (2010), showed that sunflower was grown at planting density of about 44,440 plantsha^{-1} and supplied with 100 kgNha^{-1}, there has not been any comprehensive study on the nutrient and plant density requirements of the new varieties. In view of the foregoing, this research was designed to achieve the following objectives:

1. To study the growth and yield responses of two sunflower varieties.

2. To assess the appropriate planting density and nitrogen level for maximizing crop yield and quality of sunflower.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of Nitrogen on Sunflower Growth and Yield

Nitrogen is the principal essential nutrient that is required by plants in large amounts and it is an indispensible component of the organic content of amino acids, chlorophyll, nucleic acids, proteins, nucleotides, co-enzymes and even enzymes. As a component of chlorophyll; a substance that gives plants their green colour, it is the site of carbohydrate formation (photosynthesis), yet this nutrient N is most commonly limiting in many soils, particularly in tropical savannah soils (Belamey and Chapman 1989; Mohammed, 1989; Hassan and Muktar, 2000; Tisdale *et al*., 2003). Tanimu *et al*. (1986a); Putnam *et al*. (1990); Khokani *et al*. (1993); Legha and Giri (1999); Tomar *et al*. (1999); Zubillaga *et al*. (2002); Wajid and Asghari (2012) reported that nitrogen is the first limiting factor for yield in many soils, although the demand for the nutrient by sunflower is not as high as that of maize.

Sunflower has an extensive rooting system which may help in uptake of residual soil nutrients. However, yield response to increasing nitrogen rate would vary with different environmental variables such as weather, soil type, residual fertility, soil moisture and cultivar. The application of nitrogen fertilizers was found to increase growth parameters such as; head diameter, 1000-seed weight, seed yield per head, seed yieldha^{-1}, seed yield per plant, straw and biological yield (Faizani *et al*., 1990; Wagh *et al*., 1991; El-Naggar and Allam, 1991; Sarmah *et al*., 1992). Putman *et al*. (1990) and Al-thabet (2006) reported that increasing nitrogen level reduced seed oil content but oil yieldha^{-1} increased. Nitrogen increases the aesthetic quality of sunflower due to its contribution in sunflower metabolism which requires protein (Wajid and Asghari, 2012). The application of nitrogen was reported to enhance the green colouration of foliage, prolong vegetativeness and increase the diameter of flower head (Wagh *et al.*, 1991).

2.2 Effect of Plant Density on Sunflower Growth and Yield

The number of plants per unit area of land or plant density directly influences the degree of competition for essential resources such as water, nutrients and space, needed among individual plants. More number of plants per unit area translates to greater degree of competition and possible limitation of resource supply which may hamper proper growth and development of such crops (Fick *et al*., 1985). Numerous research results have shown that plant density influences growth, seed yield, and quality of sunflower (Sterjo, 1989; Getmanets *et al*., 1991; Harmati, 1992; Patil *et al*., 1992). Ado *et al.* (1996); Wabekwa (2002); Olowe (2005); Al-thabet (2006), observed that increase in plant population density of sunflower resulted in an increase in plant height, total dry matter and stem diameter. An increase in plant density was found to decrease head diameter, number of seeds per head, 1000-seed weight, while seed yieldha^{-1} increased Narwal and Malik, (1985); Olowe (2005); Al-thabet (2006). Kene *et al*. (1992) also suggested that increased plant density resulted in a significant increase in seed yield as opposed to Holt and Campbell, (1984) who observed that plant density had no effect on yield. Similarly, Killi and Ozdemir (2001) reported that sowing at high plant population density resulted in higher yields in hybrid sunflower than lower plant densities. Killi and Ozdemir (2001) reported that, as plant populations increased, the seed oil content also increased. However, Narwal and Malik (1985); Villalobos *et al*. (1992) and Kene *et al*. (1992) found that plant density had no effect on seed oil content. Sedghi *et al*. (2008) studied the response of sunflower to planting density between 60,000-10,000 plantsha^{-1}. The results showed that the maximum seed weight, number of grains/head, head diameter, yield/plant and harvest index where obtained at the lowest plant density of 60,000 plantsha^{-1}. Although the highest grain yield per hectare was obtained at the density of 80,000 plantsha^{-1} but the seed size was reduced. At the highest plant density of 100,000 plantsha^{-1}, the yield parameters were significantly reduced and the proportion of empty seeds increased (Sedghi *et al*., 2008).

2.3 Response of Sunflower Varieties on Growth and Yield

There is wide variation among sunflower varieties and cultivars in respect of growth, development and morphology (Schnieter and Miller, 1981; Anon, 2012a). Crop responses to the environmental and cultural practices have been found to differ among cultivars. Significant differences have been reported among sunflower varieties in response to soil fertility levels and rates of fertilizers (Narwal and Malik, 1985; Sarmah *et al*., 1992; Oad *et al.*, 2001; Suzer, 2010; Bakhat *et al*., 2010).

Similarly cultivar reactions to variation in plant density have been reported by many workers (Narwal and Malik 1985; Sharmah *et al*., 1992; Olowe, 2005; Suzer, 2010; Ali *et al*., 2011). Tanimu *et al*. (1991) observed a significant variation in the performance of sunflower cultivars as measured in the following characters/attributes; seed yield, head weight, 100-seed weight and lodging percentage.

The interaction between sunflower variety and Nitrogen rates, plant population, were often significant (Scheiner *et al.*, 2002; Killi , 2004; Bakhat *et al*., 2010).

2.4 Interaction between Plant Population and Nitrogen Application

Plant density is linked with yield, the more the plant stands to certain limit the higher the expected production (Bertoria *et al*., 1998). Increasing sunflower population density generally increases the achene's yield to a certain level. Optimum population depends on cultural, environmental and field management factors (Robinson *et.al*., 1980; Prunty, 1981; Blamey *et.al*., 1997). Planting densities and nitrogen application rates are the major production factors contributing to final yield of crops especially for sunflower, being non branching plant. Interaction between sunflower hybrids and planting densities, sunflower hybrids and nitrogen was significant for growth and yield attributes such as plant height, head diameter, achene's yieldha^{-1} (Ado *et al*., 1988; Bakhat *et al*., 2006; Ali *et al*., 2012) but other studies (Heather *et al*., 2011) showed a non significant response on these attributes. Ali *et al*. (2012) reported a non significant interaction of nitrogen rates and plant density on 1000 seed weight of sunflower plant.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted during the 2012 rainy and 2012/2013 dry seasons in the Institute for Agricultural Research and Irrigation Farms in Samaru. Samaru is located on Latitude 11º 12N 07º 37`E 686 meters above sea level in the northern Guinea savannah ecological zone of Nigeria. The soils of the experimental sites were loam.

3.2 Treatment and Experimental Design

The treatment evaluated consisted of four rates of nitrogen (0, 50, 100 and 150 kg per hectare) three plant densities (22,222, 44,444 and 66,666 plants per hectare) and two varieties (SAMSUN 1 and SAMSUN 4). The treatments were factorially combined and laid out in a split-plot design with three replications. The combination of sunflower variety and nitrogen constituted the main plot while plant density was assigned to sub-plot. Each sub-plot consisted of five ridges (75cm apart) or 3.75m width of 4.0m length (15m^2 area). The inner three ridges (11.25m^2) constituted the net plot (Appendix II).

3.3 Crop Varieties

The two sunflower varieties selected for this study, namely SAMSUN 1 and SAMSUN 4 are both recommended for production in the Northern Guinea, Sudan and Sahel Savannah agro-ecological zones of Nigeria . The major features of the varieties are as follows:

SAMSUN 1; It is an open pollinating variety (OPV), photoperiodically neutral, bright yellow flower colour, the seeds are light ash in colour, smooth and medium sized. It matures in 80 days with a potential yield of 2.21 tha^{-1} (Showemimo *et al.*, 2010)

SAMSUN 4; It is an open pollinating variety, photoperiodically neutral. The flower colour is light yellow with light brown coloured peduncle. The seed is cream colour, smooth and large seed sized. It matures in 72 day with a potential yield of 2.27 tha^{-1} (Showemimo *et al*., 2010).

3.4 Cultural Practices

3.4.1 Routine analysis of soil of the experimental sites

Soils in the experimental sites were randomly sampled to depth of 30cm, bulked and analysed for it physicochemical properties before the establishment of the trials. Soil pH was determined in 1:2.5 soils: water ratio and salt (0.01M $CaCl_2$) suspension with a glass electrode pH meter. Available phosphorus was determined by Bray No.1 method. The concentration of P in the extract was colorimetrically determined using a spectrometer (Bray and Kurtz, 1945). Exchangeable bases were extracted using ammonium saturation method (1N NH_4OAC). The readings of sodium (Na) and Potassium (K) were obtained using the flame photometer/emission while calcium (Ca) and magnesium (Mg) were determined with the use of atomic absorption spectrophotometer (Kundsen *et al*., 1982). Walkley and Black wet oxidation method was used in determining the organic carbon (Nelson and Summer, 1982). Total nitrogen in the soil was determined by the Kjedahl method (Bremner and Mulvaney, 1982). Particle size analysis was determined using the hydrometer method (Day, 1965).

3.4.2 Weather data

Weather data with respect to rainfall, temperature, relative humidity and sunshine hours for the periods of experimentation was recorded (Appendix I).

3.4.3 Land preparation

Land was prepared by harrowing, followed by ridging at 75cm apart. Main plot and sub-plot were marked out according to the field plan.

3.4.4 Planting

Sowing was done immediately after land preparation on the 24th of July and the 7th of December 2012 for the rainy and dry season trials respectively. The seeds were sown at 2-3 seeds per hole and seedlings were thinned to one plant /stand at two weeks after emergence at an intra-row spacing of 60, 30 and 20cm to attain plant population of 22,222, 44,444 and 66,666 plants ha^{-1} planting density treatments respectively.

3.4.5 Fertilizer application

All plots received a uniform supply of 22.7kg P (SSP18%) + 24.9kg K (MOP24%) per hectare (in form of single super phosphate + Muriate of potash) at planting. Nitrogen in form of urea (46%N) was applied as per treatment in two split applications: the first half at 2 WAS and the remainder at 6WAS by band placement.

3.4.6 Weed control

Pre and post-emergent application of a mixture of paraquat (Gramazone) and metolachlor + metobromuron (Galex 500 EC) and Pendimentalin 500EC at the rate of 1.0 kg a.iha^{-1} were applied to control any existing weeds and emerging ones immediately after sowing. Supplementary hoe- weeding was done at 4 and 6 WAS, followed by earthen-up at 9 WAS.

3.4.7 Crop protection measures

Appropriate pest and disease control measures were applied when the need arose, in the course of the experiment. Uppercott (EC) (30g cypermethrine + 250 dimethoate/litre) was applied at the rate of 0.2 a.iha^{-1} to control insect pest (*Sphaerocoris annulus* F.) during the heading of sunflower in the dry season.

3.4.8 Harvesting

Harvesting was done when foliage and flower heads had dried up and the seeds were hardened. The heads was cut with knife, air dried, beaten gently in a sack after which seeds were separated from the chaff and winnowed to obtain clean seeds which were weighed to obtain seed yield per plot which was later extrapolated to yieldha^{-1}.

3.5 Data Collection

Four plants per plot were tagged randomly within the net plot for the purpose of assessing the following growth parameters.

3.5.1 Plant height (cm):

Height of tagged plants were measured at 4,7,10 and 13 WAS from the ground level to the terminal end using metre rule and the average height per plant computed for each plot and recorded.

3.5.2 Stem girth (cm):

The stem girth was measured from ground level in centimeter at 4,7,10 and 13 WAS using a venier caliper (Chidananda, 1974) and recorded on plot basis.

3.5.3 Number of leaves per plant:

The numbers of fully open leaves of the tagged plants were counted at 4,7,10 and 13WAS and the average number of leaves per plant recorded on per plot basis.

3.5.4 Number of days to initiation of flowering (DIF)

The number of days to appearance of flower bud on the tagged plant was taken and the average duration per plot recorded.

3.5.5 Number of days to 50% flowering (D50%)

The experimental field was inspected regularly after the initiation of flowering to observe the number of days it took each plot to attain 50% flowering. The number was recorded.

3.5.6 Fresh weight of shoot (FW) (g):

Sampled plants were taken randomly from each plot and cut at the base and were separated into leaves, stems, and floral parts and weighed using a metler balance. The mean fresh weight was recorded as fresh weight per plant and expressed as g fresh weight per plant on per plot basis.

3.5.7 Dry weight of shoot (DW) (g):

The sampled plants were separated into leaves, stems and floral parts, each weighed fresh and then weighed after oven drying at 70 ^{0}C for three days to attain constant weight. The mean dry weight was recorded as dry weight per plant, and expressed as g dry weight/plant on per plot basis.

3.5.8 Lodging %:

The number of lodged plants (leaning by more than 45 degree from the vertical or on the ground) was counted, the average worked out, expressed in percentage and expressed on per plot basis.

$$Lodging\ \% = \frac{Number\ of\ plants\ lodged}{Total\ number\ of\ plants} \times 100$$

3.5.9 Leaf area and leaf area index

Sample of four plants outside the net plot were cut from ground level for the purpose of the Leaf Area and Leaf Area Index determination.The leaf area of four sampled plants was determined using the disc and weight relationship as described by Rhodes and Bloodworth (1964); using the following formula:

$$Leaf\ Area = \frac{(Wt\ of\ Discs + Wt\ of\ leaves) \times Area of\ Disc}{Wt\ of\ Disc}\ \text{cm}^3$$

The leaf area index (LAI) is then calculated as:

$$LAI = \frac{Total\ leaf\ area\ /\ plant}{Area\ of\ ground\ /\ plant}$$

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

Crop growth rate (CGR) is the measure of the rate of dry matter production per unit of time or dry matter increment per unit area of land per time, calculated from the formula described by Radford (1967).

$$CGR = \frac{dW}{dt} \cdot \frac{1}{P} = \frac{W_2 - W_1}{t_2 - t_1} \cdot \frac{1}{P}$$

Where;

W_1 = Dry weight of plant (g) at time t_1

W_2= Dry weight of plant (g) at time t_2

$t_2 - t_1$= Time interval in days

P=ground area covered by plants

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

Relative growth rate (RGR) is the ratio of increase in dry weight per unit dry weight and it's expressed in g per gram dry weight per day. Relative growth rate at various stages was calculated as suggested by Radford (1967).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where;

W_1 = Dry weight of plant (g) at time t_1

W_2= Dry weight of plant (g) at time t_2

t_1 - t_2 = Time interval in days

3.5.12 Net assimilation rate ($g^{-1}cm^{-2}wk^{-1}$)**:**

The net assimilation (NAR) is the increase of plant material per unit of the assimilating material per unit of time. It was calculated for each interval between two samplings by the formula described by Watson (1952) and Radford (1967).

$$NAR = \frac{W_2 - W_1}{A_2 - A_1} . \frac{(\log_e A_2 - \log_e A_1)}{t_2 - t_1}$$

Where;

W_1 = Initial dry weight

W_2 = Dry weight after t_1 and t_2 days

$t_2 - t_1$= Time interval in days

A_2 = Leaf area at time, t_2

A_1= Initial leaf area

3.5.13 Head diameter (cm)

The Head diameter was determined from four plants from net plot at maturity using a measuring tape. The head diameter per plant was obtained from the average of four heads for each plot and was recorded.

3.5.14 Head dry weight (g):

Four dried heads were selected randomly from each net plot at maturity, oven dried at 70^0C to constant weight and weighed on a metler balance. The dry weight per plant was computed and recorded on per plot basis.

3.5.15 Total seed weight/head (g):

Seeds from four dried heads were threshed, winnowed and weighed using a metler balance. The total seed weight/head was obtained by calculating the average for each plot

3.5.16 1000 -seed weight (g):

One thousand seeds (1000seeds) from each plot were counted and weighed on a sensitive metler balance then the weight was recorded on per plot basis.

3.5.17 Harvest index:

Harvest index is the ratio of economic yield to total biological yield as described by (Donald, 1962) and expressed in percentage. The harvest index of sunflower was worked out using the following formula.

$$Harvest\ index(\%) = \frac{Economic\ Yeild}{Total\ Biological\ Yield} \times 100$$

3.5.18 Grain yield per hectare:

Heads from the net plot were harvested at maturity, air-dried, threshed and winnowed. The seeds were weighed using metler balance to obtain seed yield per plot. The values obtained were later converted to yield per hectare and recorded as per treatment.

3.5.19 Oil content:

The oil content was determined by soxhlet extraction method using the tecator HT extraction unit and expressed as a percentage by weight and recorded on per plot basis as described by (Pomeranz and Meloan, 1987).

3.6 Data Analysis

The data collected was subjected to statistical analysis of variance (ANOVA) to determine the level of significance of the treatment means as described by Snedecor and Cochran (1980). Duncan's Multiple Range Test- DMRT was used to test the difference between the treatment means (Duncans, 1955). Correlation and Regression coefficient analysis were also carried out to determine the relationship between the growth and yield components and their quantitative contributions to seed yield (Wright, 1921).

CHAPTER FOUR

4.0 RESULTS

4.1. Soil Sample Analysis of the Experimental Sites

Physicochemical properties of the soils of the experimental plots for both trials are presented in Table 1. The results showed that the soils in the experimental sites were loam while pH of the soils was slightly acidic. The organic carbon and total nitrogen concentrations were low (0.42; 0.75 gkg^{-1} and 1.14; 0.78 gkg^{-1}) in both the rainy and dry seasons; however available phosphorus was (10.68 gkg^{-1}) in the rainy season and low (8.75 gkg^{-1}) in the dry season. The concentration of the exchangeable bases showed that; calcium (Ca) was medium (5.0 $cmolkg^{-1}$) in the wet season and low (0.19 $cmolkg^{-1}$)in the dry season; Magnesium (Mg) was high (1.50 $cmolkg^{-1}$) in the rainy season and medium (0.40 $cmolkg^{-1}$) in the dry season while the opposite was the case for potassium (K). Sodium (Na) concentration in the soils was high (1.40 and1.52 $cmolkg^{-1}$) in both the rainy and dry seasons. Cation exchange capacity (CEC) was medium (6.25 $cmolkg^{-1}$) in the rainy season and low (5.60 $cmolkg^{-1}$) in the dry season.

Table1: Physicochemical characteristics of soil taken from experimental sites in Samaru at 0-30cm depth in 2012 rainy and dry seasons.

	Rainy Season	Dry Season
Physical properties		
Clay	17.8	8
Silt	38	44
Sand	44.2	48
Textural class	Loam	Loam
Chemical properties		
pH (1.25) in H_2O	6.40	6.37
Organic Carbon (g kg^{-1})	0.42	0.75
Total Nitrogen (g kg^{-1})	1.14	0.78
Available phosphorus (g/kg)	10.68	8.75
Exchangeable bases		
Ca (cmol kg^{-1})	5.00	0.91
Mg (cmol kg^{-1})	1.50	0.40
K (cmol kg^{-1})	0.19	0.34
Na (cmol kg^{-1})	1.40	1.52
CEC (cmol kg^{-1})	6.25	5.60

4.2. Growth and Yield Parameters

4.2.1 Number of leaves per plant

Influence of nitrogen rates and planting density on number of leaves per plant of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented in Table 2. It was observed that at 4 and 7 WAS in the rainy season 150 $kgNha^{-1}$ produced sunflower plants with significantly higher number of leaves than 50 $kgNha^{-1}$ and the control but was statistically comparable with 100 $kgNha^{-1}$, but at 13 WAS it was statistically comparable with 50 and 100 $kgNha^{-1}$ but higher than the control. At 13 WAS during the dry season, 150 $kgNha^{-1}$ produced sunflower plants with significantly higher number of leaves than the lower nitrogen rates, however, $100kgNha^{-1}$ was statistically comparable with $50kgNha^{-1}$ but higher than the control. At 10 WAS during the rainy season, and at 4, 7 and 10 WAS during the dry season number of leaves was not affected by nitrogen application.

Sunflower varieties showed significant difference in the number of leaves at 10 and 13 WAS of the rainy season (Table 2). It was observed that SAMSUN 4 variety produced more leaves compared with SAMSUN 1 at 10 and 13 WAS while at 4 and 7 WAS and at all the sampling periods in the dry season, variety had no significant effect on the number of leaves per plant.

At 4 and 10 WAS during the rainy season, and at 10 and 13 WAS during the dry season, 22,222 and 44,444 $plantsha^{-1}$ produced sunflower plants with number of leaves which were statistically comparable but higher than 66,666 $plantsha^{-1}$. However, planting density had no significant effect on the number of leaves per plant at 7 and 13 WAS during the rainy season and at 4 and 7 WAS during the dry season (Table 2).

Table 2: Influence of nitrogen and planting density on number of leaves per plant of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Number of Leaves per plant							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	8.78b	16.94c	24.28	17.28b	11.39	19.50	25.67	15.50c
50	9.00b	18.11bc	24.44	18.11ab	11.39	20.23	25.78	17.61b
100	9.61ab	18.67ab	24.78	19.72a	12.33	20.33	27.17	18.83b
150	10.00a	19.50a	25.44	20.00a	11.44	20.61	27.67	20.72a
SE±	0.315	0.746	0.710	0.490	0.481	0.302	1.023	0.372
Variety								
SAMSUN 1	9.53	18.58	23.97b	17.89b	11.47	20.33	26.94	16.17
SAMSUN 4	9.17	18.03	25.50a	19.67a	11.81	20.03	26.19	16.17
SE±	0.205	0.310	0.438	0.530	0.253	0.451	0.570	0.242
Density (plantsha^{-1})								
22,222	9.88a	18.29	25.33a	19.50	11.79	19.71	27.75a	17.63a
44,444	9.75a	18.63	25.38a	18.25	11.25	20.25	27.17a	16.00ab
66,666	8.42b	18.00	23.50b	18.58	11.88	20.58	24.79b	16.88b
SE±	0.251	0.380	0.536	0.650	0.310	0.552	0.698	0.546
Interactions								
NXV	NS	NS	NS	NS	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

4.2.2 Plant height

Influence of nitrogen rates and planting density on plant height of sunflower varieties during 2012 rainy and dry seasons at Samaru is presented in Table 3. Application of nitrogen resulted in significant increase in sunflower height during 2012 rainy and dry seasons. It was observed that at 4 WAS in both seasons application of 50, 100, and 150 $kgNha^{-1}$ produced statistically similar but taller plants than the control while at 7 and 13 WAS of the rainy season and 13 WAS of the dry season, application of 150 $kgNha^{-1}$ produced sunflower plants that were taller than when 50 and 100 $kgNha^{-1}$ were applied which were statistically similar but taller than sunflower plants in the control. However at 10 WAS during the rainy season, application of 100 and 150 $kgNha^{-1}$ produced sunflower plants that had comparable plant height but were taller than those observed when 50 $kgNha^{-1}$ was applied. The control produced shorter plants. At 7 and 10 WAS during the dry season plant height was not affected by nitrogen application.

Sunflower varieties showed significant difference in plant height at 4, 7 WAS of the rainy season and 13 WAS during the dry season (Table3). It was observed that SAMSUN 4 variety produced taller plants than SAMSUN 1. Sunflower plants with statistically comparable heights was recorded for both varieties at 10 and 13 WAS of the rainy season and 4, 7, and 10 WAS of the dry season.

66,666 $plantsha^{-1}$ produced significantly taller plants at 4, 7, and 10 WAS during the rainy season compared with 44,444 and 22,222 $plantsha^{-1}$. At 13 WAS during the rainy and dry season, 44,444 and 66,666 $plantsha^{-1}$ recorded plant height that where statistically similar but taller than 22,222 $plantsha^{-1}$ planting density.

Table 3: Influence of nitrogen and planting density on plant height (cm) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Plant height (cm)							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	13.79b	61.12c	76.97c	150.48c	12.63b	57.28	132.55	151.91c
50	14.29ab	82.29b	149.90b	164.56b	13.42ab	57.83	140.05	164.98b
100	15.59a	88.18b	163.56a	168.89b	13.75ab	63.14	141.72	170.16b
150	14.04ab	179.66a	168.02a	180.76a	14.46a	58.00	141.91	180.76a
SE±	0.268	4.258	4.198	2.391	0.431	2.191	4.623	1.773
Variety								
SAMSUN 1	13.81b	99.39b	137.25	163.12	13.80	60.17	140.10	163.71b
SAMSUN 4	15.04a	106.24a	141.97	169.21	13.33	57.96	138.02	170.20a
SE±	0.395	1.98	2.160	2.257	0.369	2.476	3.374	2.196
Density (plantsha^{-1})								
22,222	13.47b	97.86b	131.01b	161.82b	13.98	60.02	143.02	163.19b
44,444	13.96b	101.52b	141.98b	165.94ab	13.55	59.54	133.48	165.94ab
66,666	15.85a	109.07a	145.84a	170.75a	13.16	57.63	140.68	171.73a
SE±	0.484	2.426	2.646	2.764	0.452	3.032	4.133	2.689
Interactions								
NXV	NS	NS	NS	NS	*	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant, *= significant at 5% level of probability.

Table 4: Interaction between nitrogen and sunflower varieties at 4 weeks after sowing on plant height in 2012 dry season at Samaru.

	Nitrogen Rate ($kgNha^{-1}$)			
Treatment	0	50	100	150
Variety				
SAMSUN 1	11.12b	15.13a	14.53a	14.42a
SAMSUN4	11.70b	14.13a	14.39a	13.08ab
SE±	0.737			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Significant interaction between nitrogen and sunflower varieties at 4 weeks after sowing on plant height occurred in 2012 dry season and is shown in table 4. Holding variety constant, while varying nitrogen; SAMSUN 1 and SAMSUN 4, increase in nitrogen from 0-50 kgNha^{-1} increased plant height at 4 WAS, further increase beyond 50 kgNha^{-1} did not have significant effect on plant height. Holding nitrogen rates constant while varying variety; 0, 50, 100 and 150 kgNha^{-1} showed no significant effect among the sunflower varieties (Table 4).

4.2.3 Stem girth (cm)

Influence of nitrogen and planting density on the stem diameter of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 5. Application of nitrogen showed significant increase in sunflower stem girth during the 2012 rainy and dry seasons. Stem girth was not determined at 4 WAS, in the rainy season however, at 7 WAS stem girth was significantly increased when nitrogen was applied at 150 kgNha^{-1} but statistically similar to 100 kgNha^{-1} but higher than 50 kgNha^{-1} the control. However, application of 50 kgNha^{-1} had statistically similar stem girth as the control. At 10 WAS application of 150 kgNha^{-1} significantly increased stem girth of sunflower plant which was similar to 100 kgNha^{-1} but higher than the control. Nitrogen application had no significant effect on stem girth of sunflower plants during the dry season at all sampling periods.

Variety did not differ significantly on stem girth of sunflower plant in both rainy and dry seasons (Table 5).

The response of sunflower planting density was significant only at 10 WAS in the rainy season, and at 10 and13 WAS during the dry season (Table 5). At 10 WAS in the rainy.

Table 5: Influence of nitrogen and planting density on stem girth (cm) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Stem girth (cm)							
	Rainy season				Dry season			
Treatment	4	7	10	13WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	ND	2.36c	2.24c	2.35	1.68	2.19	2.52	2.93
50	ND	2.26c	2.54b	2.45	1.68	2.23	2.56	2.99
100	ND	2.38ab	2.66ab	2.46	1.71	2.23	2.54	3.00
150	ND	2.54a	2.82a	2.50	1.74	2.27	2.63	3.03
SE±		0.059	0.077	0.081	0.069	0.055	0.072	0.152
Variety								
SAMSUN 1	ND	2.35	2.60	2.40	1.73	2.19	2.56	3.05
SAMSUN 4	ND	2.36	2.59	2.48	1.67	2.27	2.57	2.92
SE±		0.065	0.059	0.047	0.056	0.053	0.047	0.050
Density (plantsha^{-1})								
22,222	ND	2.56	3.00a	3.11	1.76	2.31	2.65a	3.11a
44,444	ND	2.60	2.61b	3.00	1.75	2.15	2.58ab	3.00ab
66,666	ND	2.53	2.55b	2.93	1.59	2.23	2.46b	2.85b
SE±		0.072	0.080	0.055	0.069	0.066	0.057	0.061
Interactions								
NXV	ND	NS	NS	NS	NS	NS	NS	NS
NXD	ND	NS	*	NS	NS	NS	NS	NS
VXD	ND	NS	NS	*	NS	NS	NS	NS
NXVXD	ND	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant, *= significant at 5% level of probability ND= Not determined.

Table 6: Interaction between nitrogen and planting density at 10 WAS on stem girth in 2012 rainy season at Samaru.

	Nitrogen Rate (KgNha^{-1})			
Treatment	0	50	100	150
Density (plantsha^{-1})				
22,222	2.33bc	2.30bc	2.40bc	3.05a
44,444	2.27bc	2.23c	2.48b	2.25c
66,666	2.12c	2.25c	2.27bc	2.32bc
SE± 0.107				

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 7: Interaction between sunflower varieties and planting density on stem girth at 13 weeks after sowing in 2012 rainy season at Samaru.

	Variety	
Treatment	SAMSUN 1	SAMSUN 4
Density (plantsha^{-1})		
22,222	2.33b	2.68a
44,444	2.45b	2.39b
66,666	2.43b	2.36b
SE± 0.0773		

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

season, planting at 22,222 plantsha^{-1} resulted in significantly thicker stem girth than the higher planting densities. At 10 and 13 WAS in the dry season, 22,222 plantsha^{-1} produced significantly higher stem girth than 66,666 plantsha^{-1} but statistically comparable with 44,444 plantsha^{-1} however, 66,666 and 44,444 plantsha^{-1} produced sunflower plants with comparable stem girth. At 7 and 13 WAS during the rainy season and at 4 and 7 WAS during the dry season planting density had no significant effect on stem girth of sunflower plants.

Interaction between nitrogen and planting density on stem girth at 10 weeks after during the 2012 rainy season was significant (Table 6). Holding planting density constant, while varying nitrogen; at 22,222 plantsha^{-1} increasing nitrogen rates from 0 to 100 kgNha^{-1} produced statistically similar stem girth further increase to 150 kgNha^{-1} increased stem girth. At 44,444 plantsha^{-1}, increase in nitrogen application from 0 to 50 kgNha^{-1} there was no significant effect on stem girth further increase to 100 kgNha^{-1} showed an increase in stem girth. Further increase to 150 kgNha^{-1} showed a decline in stem girth. At 66,666 plantsha^{-1} increasing nitrogen from 0 to 150 kgha^{-1} showed no significant difference in stem girth. Holding nitrogen constant while varying planting density; at 0 kgNha^{-1} there was no significant response in stem girth when planting density increased from 22,222 to 66,666 plantsha^{-1} a similar trend was observed when 50 kgNha^{-1} was used. At 100 kgNha^{-1} increasing planting density from 22,222 plantsha^{-1} to 44,444 plantsha^{-1}, there was no significant increase in stem girth, futher increase to 66,666 plantsha^{-1} showed no significant effect on stem girth. At 150 kgNha^{-1} there was increase in stem girth for planting density of 22,222 plantsha^{-1}, however increase in planting density to 44,444 plantsha^{-1} showed a decline in stem girth , a similar trend was observed when planting density was increased to 66,666 plantsha^{-1}.

Interaction between sunflower varieties and planting density on stem girth at 13 WAS in 2012 rainy season is presented on Table 7. Holding planting density constant while varying variety; at 22,222 plantsha^{-1}, SAMUN 4 showed an increase in stem girth compared to SAMSUN 1, further increase in planting density to 44,444 and 66,666 plantsha^{-1} there showed no significant effect on stem girth between the two varieties. Holding variety constant while varying plant density; for SAMSUN 1 there was no significant response in stem girth when planting density was increased from 22,222 to 66,666 plantsha^{-1}. For SAMSUN 4, increase in planting density from 22,222 to 44,444 plantsha^{-1} showed a decline in stem girth further increase to 66,666 plantsha^{-1} also did not increase stem girth.

4.2.4 Fresh weight of shoot per plant (g)

Influence of nitrogen rates and planting density on fresh weight of shoot of sunflower varieties during the 2012 rainy and dry seasons at Samaru is presented on Table 8. It was observed that at 4 WAS in both seasons application of 150 kgNha^{-1} significantly increased fresh weight of shoot per plant and was statistically at par with 100 kgNha^{-1} but higher than 50 kgNha^{-1} and the control which were both comparable statistically. At 7 WAS during the rainy season however, application of 50, 100 and 150 kgNha^{-1} produced sunflower plants which were statistically comparable but weighed higher than the control a similar trend was observed at 10 WAS except that 50kgN was statistically comparable with the control. At 13 WAS during the rainy season, and 7, 10

Table 8: Influence of nitrogen and planting density on fresh weight (g) of shoot per plant of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Fresh Weight(g)							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13WAS
Nitrogen (kgNha^{-1})								
0	10.68c	174.86b	503.03b	515.39	13.56c	112.13	318.02	815.39
50	12.07bc	298.77a	556.12b	867.99	15.09bc	123.82	378.14	868.21
100	14.53ab	265.24a	634.56a	910.29	19.37ab	146.28	384.92	910.29
150	17.46a	260.56a	694.39a	917.55	21.91a	133.98	387.78	917.55
SE±	0.653	28.420	35.122	88.126	1.272	14.333	20.751	88.082
Variety								
SAMSUN 1	14.32	234.21	605.02	848.76	18.26	142.96	334.90	848.87
SAMSUN 4	13.05	265.51	589.03	906.85	16.71	115.14	399.52	906.85
SE±	0.834	18.063	32.442	44.763	1.109	7.883	23.416	141.428
Density (plantsha^{-1})								
22,222	16.86a	243.13	733.28a	910.65	19.59a	155.72a	402.34	910.65
44,444	13.90b	258.29	577.63b	886.62	18.44a	116.42b	351.57	886.78
66,666	10.30c	248.15	480.16b	836.15	14.42b	115.02b	347.73	836.78
SE±	1.022	22.122	39.733	54.823	1.359	9.654	28.679	54.710
Interactions								
NXV	NS	NS	NS	NS	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

and 13 WAS during the dry season, nitrogen application had no significant effect on the fresh weight of shoot per plant.

Variety had no significant effect on fresh weight of shoot per plant in both rainy and dry seasons. The response of sunflower planting density on fresh weight of shoot per plant was significant at 4 and 10 WAS in the rainy season and at 4 and 7 WAS in the dry season. At 4 WAS in the rainy season 22,222 $plantsha^{-1}$ produced significantly higher fresh weight of shoot per plant compared with 44,444 and 66,666 $plantsha^{-1}$ but at 10 WAS during the rainy season and 7 WAS during the dry season, 22,222 $plantsha^{-1}$ was significantly higher compared to 44,444 and 66,666 $plantsha^{-1}$ which were statistically comparable. At 4 WAS during the dry season 22,222 and 44,444 $plantsha^{-1}$ were statistically similar but higher than 66,666 $plantsha^{-1}$. However, at 7 and 13 WAS during the rainy season and at 10 and 13 WAS during the dry season, there was no significant difference in fresh weight of shoot per plant between plant densities.

4.2.5 Dry Weight of shoot per plant (g)

Influence of nitrogen and planting density on dry weight of shoot of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 9. Nitrogen application had no significant effect on dry weight of shoot per plant at 4 WAS during the rainy season and at 4 and 7 WAS during the dry season. At 7, 10 and 13 WAS in the rainy season and at 7 and 13 WAS in the dry season application of 150 $kgNha^{-1}$ was statistically comparable with 50 and 100 $kgNha^{-1}$ but higher than the control.

Sunflower varieties showed no significant difference in dry weight except at 10 WAS during the dry season when SAMSUN 4 produced significantly higher dry weight compared to SAMSUN 1 (Table 9).

Table 9: Influence of nitrogen and planting density on dry weight (g) of shoot of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Dry Weight(g)							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	4.48	17.32b	63.74b	134.68b	3.77	19.58b	63.72	135.65b
50	4.54	25.78a	95.74a	173.94ab	4.88	22.93ab	67.39	173.94ab
100	5.12	25.94a	97.34a	183.45a	4.44	23.54ab	64.23	186.35a
150	5.77	26.04a	106.61a	186.59a	4.01	25.76a	67.46	186.59a
SE±	0.301	2.643	7.144	15.653	0.241	2.521	5.150	14.949
Variety								
SAMSUN 1	5.08	24.03	88.13	166.99	4.24	22.95	57.97b	168.92
SAMSUN 4	4.88	23.51	93.25	172.34	4.31	22.95	73.53a	172.34
SE±	0.930	1.540	7.451	10.581	0.257	1.372	4.068	10.342
Density (plantsha^{-1})								
22,222	5.81a	23.93	101.30	177.50	4.93a	25.40	68.20	177.80
44,444	4.98ab	23.93	86.52	175.63	4.29ab	25.40	64.55	177.50
66,666	4.13b	23.46	84.26	155.86	3.60b	21.67	64.51	156.59
SE±	0.360	3.557	9.125	12.959	0.315	1.680	4.982	12.666
Interactions								
NXV	NS	NS	NS	NS	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant at 5% level of probability.

At 4 WAS in both seasons, planting at 22,222 plantsha^{-1} produced significantly heavier dry weight of shoot per plant compared with 66,666 plantsha^{-1} but statistically at par with 44,444 plantsha^{-1}. However, 44,444 plantsha^{-1} was statistically comparable with 66,666 plantsha^{-1}. There was no significant difference in dry weights of shoot among the planting densities at 7, 10, and 13 WAS in both rainy and dry seasons respectively.

4.2.6 Leaf area (cm^2)

Influence of nitrogen and planting density on leaf area of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table10. At 4 WAS in both the rainy and dry seasons application of 150 kgNha^{-1} produced sunflower plants with statistically comparable leaf area with 100 kgNha^{-1} but higher than 50 kgNha^{-1} and the control. At 7 and 10 WAS during the rainy season, and at 13 WAS in both seasons, application of 50 kgNha^{-1} produced significantly higher leaf area compared with the control. Increasing the rate of applied nitrogen form 50 to 100 and 100 to 150 kgNha^{-1} produced no further significant increase in leaf area. At 7 and 10 WAS in the dry season, application of 150 kgNha^{-1} produced significantly higher leaf area compared to other rates of applied nitrogen.

At 4 WAS in the rainy season, SAMSUN 4 produced plants with significantly higher leaf area compared to SAMSUN 1. At 4 WAS in the dry season and at 7, 10 and 13 WAS in both seasons, variety had no significant effect on leaf area per plaant.

At 4 WAS in both seasons and at 10 WAS during the rainy season, 22,222 plantsha^{-1} produced sunflower plants with significantly higher leaf area than 66,666plantsha-1 but statistically comparable with 44,444 plantsha^{-1}. At 7 WAS in the

Table 10: Influence of nitrogen and planting density on leaf area (cm^2) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Leaf Area (cm^2)							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	133.69b	180.53b	213.51b	276.58b	100.76b	144.21b	173.33b	280.69b
50	145.96b	202.80a	237.35a	289.98ab	110.76b	150.41b	188.16b	291.06ab
100	183.28a	220.20a	249.53a	291.06ab	133.30a	150.60b	195.79b	291.06ab
150	169.91a	207.60a	249.89a	318.81a	136.80a	186.43a	220.24a	318.81a
SE±	8.197	8.916	10.576	13.407	1.985	4.614	11.741	11.785
Variety								
SAMSUN 1	167.62a	203.33	236.19	286.38	117.32	156.28	198.29	289.18
SAMSUN 4	148.80b	202.24	238.95	301.84	123.53	159.55	190.47	302.40
SE±	3.494	4.861	5.679	7.473	3.867	4.736	5.778	7.336
Density (plantsha^{-1})								
22,222	168.02a	206.69	251.60a	288.94	129.40a	170.69a	207.56	301.94
44,444	158.14ab	204.70	236.38ab	298.86	122.90a	152.46b	189.18	296.05
66,666	148.46b	196.96	225.73b	294.53	108.97b	150.59b	186.41	289.38
SE±	4.279	5.953	6.956	9.153	4.737	5.800	7.076	8.985
Interactions								
NXV	*	NS	NS	NS	*	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant, *= significant at 5% level of probability.

dry season however, 22,222 plantsha^{-1} was significantly higher than 66,666 and 44,444 plantsha^{-1}. It was also observed that at 7 and13 WAS in the rainy season and at 10 and 13 WAS in the dry season, planting densities had no significant effect on leaf area per plant.

Significant interaction occurred between nitrogen and sunflower varieties on the leaf area at 4 WAS in 2012 rainy season (Table 11). The results obtained showed that; holding variety constant while varying nitrogen, for SAMSUN 1, increasing the rate of applied nitrogen from 0 to 50 and 50 to 100 kgNha^{-1}, significantly increased leaf area. Further increase from 100 to 150 kgNha^{-1} showed a decrease in leaf area. For SAMSUN 4, increase in nitrogen rate from 0 to 50 kgNha^{-1} did not have a significant influence on leaf area further increase beyond 50 kgNha^{-1} increased leaf area. Holding nitrogen constant while varying variety; at 0 and 50 kgNha^{-1}, SAMSUN 1 had higher leaf are compared with SAMSUN 4. At 100 and 150 kgNha^{-1}, both varieties had statistically similar in leaf area.

Significant interaction occurred between nitrogen and sunflower varieties on the leaf area at 4 WAS in 2012 dry season (Table12). Holding variety constant while varying nitrogen rates; for SAMSUN 1, increase in nitrogen rates from 0 to 50 kgNha^{-1} increased leaf area. Increasing nitrogen rate from 100 to 150 kgNha^{-1} did not have a significant influence on leaf area. For SAMSUN 4, increase in nitrogen rate from 0 to 50 kgNha^{-1} increased leaf area further increase to 100 kgNha^{-1} did not have any significant influence on leaf area. Further increase to 150 kgNha^{-1} showed a decrease in leaf area. Holding nitrogen rates constant while varying variety; at 0 kgNha^{-1} there was no significant

Table 11: Interaction between nitrogen and sunflower varieties on leaf area at 4 weeks after sowing in 2012 rainy season.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	145.96c	166.17b	191.40a	166.93b
SAMSUN4	121.41d	125.75d	175.17ab	172.88ab
SE±	7.000			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 12: Interaction between nitrogen and sunflower varieties on leaf area at 4 weeks after sowing in 2012 dry season.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	98.76e	128.08abc	118.88cde	123.54bcd
SAMSUN 4	102.76de	145.53ab	147.73a	98.13e
SE±	7.735			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

influence in leaf area between the two varieties. Similar trend was observed at 50 kgNha^{-1}. At 100 kgNha^{-1} there was increase in leaf area for SAMSUN 4 while at 150 kgNha^{-1} there was a decline.

4.2.7 Number days to initiation of flowering and 50% flowering

Influence of nitrogen and planting density on number of days to initiation of flowering and days to 50% flowering of sunflower varieties in 2012 rainy and dry seasons at Samaru is shown on Table13. In the rainy and dry seasons, It was observed that control plots and the plots that received 50 kgNha^{-1} produced sunflower plants delayed flower initiation compared to plots to which 100 and 150 kgNha^{-1} were applied. Application of nitrogen had no significant effect on the number of days to 50% flowering in both the rainy and dry seasons.

SAMSUN 4 produced plants that flowered earlier compared with SAMSUN 1 in both rainy and dry seasons. Days to 50% flowering was not affected by variety.

Planting density had no significant effect on the number of days to initiation of flowering and days to 50% flowering in both rainy and dry seasons (Table13).

4.2.8 Lodging percentage (%)

Influence of nitrogen and planting density on lodging percentage of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 14. Increasing nitrogen rate increased lodging % during the 2012 rainy and dry seasons. It was observed that in both seasons, application of I50 kgNha^{-1} produced sunflower plants with significantly higher lodging percentage than100, 50 kgNha^{-1} and the control. 100 and 50 kgNha^{-1} were statistically comparable but higher the control.

Table 13: Influence of nitrogen and planting density on days to initiation of flowering (DIF) and days to 50% flowering (D50%) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Rainy Season		Dry Season	
Treatment	DIF	D50%	DIF	D50%
Nitrogen (kgNha^{-1})				
0	54.33a	67.20	52.33a	64.20
50	53.22ab	438.80	51.22ab	435.80
100	51.56c	65.90	49.25c	63.90
150	52.25bc	66.70	50.25bc	63.70
SE±	0.490	186.042	0.490	186.042
Variety(V)				
SAMSUN 1	52.56b	252.40	50.13b	249.40
SAMSUN 4	53.56a	66.90	51.56a	63.90
SE±	0.311	131.567	0.311	131.567
Density (plantsha^{-1})				
22,222	53.33	345.10	50.98	64.30
44,444	52.21	66.50	51.21	63.50
66,666	52.98	67.30	51.33	342.10
SE±	0.380	161.136	0.380	161.136
Interactions				
NXV	NS	NS	NS	NS
NXD	NS	NS	NS	NS
VXD	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

Table 14: Influence of nitrogen and planting density on lodging percentage of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Rainy season	Dry season
Treatment	Lodging Percentage	
Nitrogen (kgNha^{-1})		
0	3.44c	3.56c
50	6.06b	4.89bc
100	7.17b	6.17b
150	9.44a	8.28a
SE±	0.442	0.948
Variety		
SAMSUN 1	6.16	7.06a
SAMSUN 4	6.44	4.39b
SE±	0.486	0.494
Density (plantsha^{-1})		
22,222	2.79c	3.17b
44,444	7.21b	6.92a
66,666	9.58a	7.08a
SE±	0.595	0.606
Interactions		
NXV	NS	NS
NXD	NS	NS
VXD	NS	NS
NXVXD	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

Sunflower varieties had no significant effect on lodging % during the rainy season but, in the dry season, significant amount of the SAMSUN 1 lodged relative to SAMSUN 4. In the rainy season, planting at 66,666 plantsha^{-1} produced plants which lodged than those planted at 44,444 and 22,222 plantsha^{-1} however, in the dry season, plots with population of 66,666 and 44,444 plantsha^{-1} were statistically comparable but higher than those of 22,222 plantsha^{-1} (Table 14).

4.2.9 Crop growth rate (CGR) (gwk^{-1})

Influence of nitrogen and planting density on crop growth rate of sunflower varieties in 2012 rainy and dry seasons at Samaru are shown in Table 15. At 4-7, 7-10 WAS during the rainy season and at 10-13WAS during the dry season, application of 150 kgNha^{-1} resulted in statistically comparable CGR with plots receiving 100 and 50 kgNha^{-1} but higher than the control. However, at 7-10 WAS during the rainy season, 100 and 50 kgNha^{-1} were statistically comparable with the control but at 10-13 WAS during the dry season only 50 kgNha^{-1} was statistically similar with the control. Application of nitrogen induced no significant effect on crop growth rate at 10-13 WAS during the rainy season and at 4-7 and 7-10 WAS during the dry season.

It was observed that variety had no significant effect on CGR throughout the sampling periods except at 7-10 WAS during the dry season where SAMSUN 4 had significantly higher crop growth rate compared with SAMSUN 1.

Crop growth rate did not differ significantly with different planting density throughout the sampling periods.

Table 15: Influence of nitrogen and planting density on crop growth rate (gwk^{-1}) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Crop Growth Rate (gwk^{-1})					
	Rainy season			Dry season		
Treatment	4-7	7-10	10-13 WAS	4-7	7-10	10-13 WAS
Nitrogen (kgNha^{-1})						
0	4.28b	15.25b	23.87	5.27	12.89	23.98b
50	6.76a	23.77ab	25.61	6.02	14.64	35.50ab
100	6.89a	23.32ab	26.07	6.51	14.71	39.65a
150	7.14a	26.89a	29.74	7.11	14.82	40.72a
SE±	0.824	3.082	6.766	0.879	1.943	5.296
Variety						
SAMSUN 1	6.32	21.365	26.29	6.24	11.67b	36.98
SAMSUN 4	6.21	23.248	26.36	6.21	16.86a	32.94
SE±	0.509	6.634	4.733	0.472	1.507	3.375
Density (plantsha^{-1})						
22,222	6.60	25.79	24.78	5.62	14.26	29.47
44,444	6.16	20.23	23.87	6.02	14.27	37.65
66,666	6.04	20.86	30.33	7.04	14.28	37.77
SE±	0.624	3.155	5.796	0.581	1.845	4.133
Interactions						
NXV	NS	NS	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

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

Influence of nitrogen and planting density on relative growth rate of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 16. At 4-7, 7-10 WAS during the rainy season and at 10-13 WAS during the dry season, 150 $kgNha^{-1}$ produced sunflower plants with statistically comparable RGR with 100 and 50 $kgNha^{-1}$ but higher than the control. However, at 7-10 WAS during the rainy season, 100 and 50 $kgNha^{-1}$ were statistically comparable with the control but at 10-13 WAS during the dry season only 50 $kgNha^{-1}$ was statistically similar with the control. Application of nitrogen had no significant effect on relative growth rate at 10-13 WAS during the rainy season and at 4-7 and 7-10 WAS during the dry season.

Sunflower varieties had no significant effect on relative growth rate during the 2012 rainy season and at 4-7 and 10-13 WAS during the dry season. However, at 7-10 WAS SAMSUN 4 produced significantly higher relative growth rate compared with SAMSUN 1.

Planting density did not differ significantly in relative growth rate throughout the sampling periods.

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

Influence of nitrogen and planting density on net assimilation rate of sunflower varieties in 2012 rainy and dry seasons at Samaru is shown in Table 17. The result obtained showed that at 4-7 WAS in both rainy and dry seasons, 150 $kgNha^{-1}$ produced sunflower plants with significantly higher NAR than the control but statistically comparable with 100 and 50 $kgNha^{-1}$ which were both at par with 0 $kgNha^{-1}$. At 7-10 and 10-13 WAS in both rainy and dry seasons, there was no significant difference in net assimilation rate due to nitrogen application.

Table 16: Influence of nitrogen and planting density on relative growth rate ($g^{-1}g^{-1}wk^{-1}$) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Relative Growth Rate ($g^{-1}g^{-1}wk^{-1}$)					
	Rainy season			Dry season		
Treatment	4-7	7-10	10-13WAS	4-7	7-10	10-13WAS
Nitrogen (kgNha^{-1})						
0	2.32b	3.17b	3.47	2.48	3.11	3.49b
50	2.66a	3.37ab	3.67	2.49	3.07	3.72ab
100	2.68a	3.43ab	3.61	2.67	3.14	3.78a
150	2.65a	3.58a	3.60	2.69	3.12	3.80a
SE±	0.090	0.084	0.010	0.113	0.082	0.084
Variety						
SAMSUN 1	2.60	3.37	3.57	2.56	3.01b	3.73
SAMSUN 4	2.56	3.41	3.60	2.60	3.21a	3.67
SE±	0.062	0.071	0.071	0.393	0.066	0.058
Density (plantsha^{-1})						
22,222	2.66	3.51	3.57	2.50	3.14	3.75
44,444	2.55	3.35	3.51	2.69	3.09	3.60
66,666	2.52	3.30	3.68	2.56	3.11	3.75
SE±	0.076	0.087	0.087	0.080	0.080	0.071
Interactions						
NXV	NS	NS	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant at 5% level of probability.

Table 17: Influence of nitrogen and planting density on net assimilation rate ($g^{-1}cm^{-2}wk^{-1}$) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Net Assimilation Rate ($g^{-1}cm^{-2}wk^{-1}$)					
	Rainy season			Dry season		
Treatment	4-7	7-10	10-13WAS	4-7	7-10	10-13 WAS
Nitrogen (kgNha^{-1})						
0	0.027b	0.079	0.098	0.038b	0.074	0.015
50	0.036ab	0.101	0.121	0.043ab	0.092	0.015
100	0.035ab	0.103	0.092	0.050ab	0.075	0.016
150	0.041a	0.122	0.089	0.053a	0.095	0.016
SE±	0.0041	0.0154	0.0240	0.0064	0.0112	0.0007
Variety						
SAMSUN 1	0.034	0.099b	0.010	0.047	0.068b	0.016
SAMSUN 4	0.036	0.104a	0.010	0.045	0.100a	0.015
SE±	0.0030	0.0010	0.017	0.0034	0.0095	0.0004
Density (plantsha^{-1})						
22,222	0.038a	0.122	0.119	0.042	0.086	0.169a
44,444	0.035ab	0.089	0.086	0.049	0.079	0.016a
66,666	0.032b	0.093	0.095	0.047	0.087	0.015b
SE±	0.0036	0.0122	0.0210	0.0041	0.0120	0.0005
Interactions						
NXV	NS	*	NS	NS	NS	NS
NXD	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant, *= significant at 5% level of probability.

There was no significant difference in net assimilation rate between the two varieties at all the sampling periods in both season except at 7-10 WAS during the dry season where it was observed that SAMSUN 4 1 produced significantly higher net assimilation rate compared to SAMSUN 1.

Planting at 22,222 plantsha^{-1} produced significantly higher NAR at 4-7 WAS during the rainy season and at 10-13 WAS during the dry season compared to 66,666 plantsha^{-1} but was statistically at par with 44,444 plantsha^{-1}. At 7-10 an 10-13 WAS in both seasons, planting density had no significant effect on NAR.

Interaction between nitrogen levels and sunflower varieties on net assimilation rate at 7-10 WAS in 2012 rainy season was found to be significant and it is presented on Table18. Holding variety constant while varying nitrogen rates, for SAMSUN 1, increase in nitrogen from 0-50 and from 50-100 kgNha^{-1} produced similar but higher NAR than the control. Further increase to 150 kgNha^{-1} showed an increase in net assimilation rate. Holding nitrogen constant while varying variety; at 0 kgNha^{-1} SAMSUN 1 showed an increase in net assimilation rate compared to SAMSUN 4 at 50 and 100 kgNha^{-1} there was no significant influence in net assimilation rate. At 150 kgNha^{-1} however SAMSUN 1 was significantly higher in net assimilation rate compared with SAMSUN 4 (Table 18).

Table 18: Interaction between nitrogen and sunflower varieties on net assimilation rate ($g^{-1}cm^{-2}wk^{-1}$) at 7-10 weeks after sowing in 2012 rainy season.

	Nitrogen Rate ($kgNha^{-1}$)			
Treatment	0	50	100	150
Variety				
SAMSUN 1	0.065c	0.080b	0.097b	0.155a
SAMSUN 4	0.094b	0.123ab	0.109ab	0.089b
SE±	0.0197			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

4.2.12 Leaf Area index (LAI)

Influence of nitrogen and planting density on leaf area index of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 19. It was observed that at 4 WAS during the rainy season 150 kgNha^{-1} produced sunflower plants with leaf area index which were significantly higher compared to the other levels of applied nitrogen. A similar trend was observed throughout the sampling periods as well as during the dry season

Sunflower variety showed significant difference in leaf area index. At 4, 10 and 13 WAS in the rainy season and at 4, 7 and 13 WAS in the dry season SAMSUN 4 produced sunflower plants with leaf area index which were significantly higher compared with SAMSUN 1. But at 7 WAS during the rainy season and at 10 WAS during the dry season SAMSUN 1 had significantly higher leaf area index compared with SAMSUN 4.

Each increase in planting density significantly increased the leaf area index at all the sampling periods in both seasons.

Significant interaction occurred between nitrogen and sunflower varieties on leaf area index at 4 WAS in 2012 rainy season, is shown in Table 20. Holding variety constant while varying nitrogen rates, for SAMSUN 1 increase in nitrogen rate from 0-50 kgNha^{-1} increases leaf area index further increase to 100 kgNha^{-1} showed a decline in leaf area index a similar trend was observed when nitrogen rate was further increased to 150 kgNha^{-1}. For SAMSUN 4, increase in nitrogen rate from 0-50 kgNha^{-1} showed a decline in leaf area index while further increase to 100 kgNha^{-1} increases leaf area index. There was a decline in Leaf area index when applied nitrogen was further increased to 150 kgNha^{-1}. Holding nitrogen rates constant while varying variety, at 0 kgNha^{-1} there was

Table 19: Influence of nitrogen and planting density on leaf area index of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Leaf Area Index							
	Rainy season				Dry season			
Treatment	4	7	10	13 WAS	4	7	10	13 WAS
Nitrogen (kgNha^{-1})								
0	0.053 d	1.337d	2.263b	2.119d	0.513d	1.268d	1.977d	1.860d
50	0.614 c	1.650c	2.615a	2.284c	0.592c	1.335c	2.191c	2.109c
100	0.719 b	1.748b	2.817a	2.558b	0.715b	1.342b	2.364b	2.188b
150	0.850 a	1.944a	2.844a	2.858a	0.721a	1.711a	2.656a	2.677a
SE±	0.0013	0.0030	0.0038	0.0025	0.0006	0.0007	0.0063	0.0106
Variety								
SAMSUN 1	0.637 b	1.706a	2.529 b	2.275 b	0.619 b	1.403 b	2.344 a	2.070 b
SAMSUN 4	0.703 a	1.621 b	2.739 a	2.625a	0.650 a	1.422 a	2.226 b	2.167a
SE±	0.0003	0.0008	0.0013	0.0019	0.0050	0.0010	0.0017	0.0079
Density (plantsha^{-1})								
22,222	1.107a	2.520a	3.992a	3.756a	0.967a	1.971a	3.441a	3.403a
44,444	0.684b	1.695b	2.837b	2.519b	0.653b	1.539b	2.500b	1.968b
66,666	0.278c	0.788c	1.173c	1.217c	0.974c	0.700c	1.041c	1.114c
SE±	0.0005	0.0011	0.0019	0.0029	0.0007	0.0016	0.0026	0.0119
Interactions								
NXV	*	NS	NS	NS	NS	NS	NS	*
NXD	NS	NS	NS	NS	NS	NS	NS	NS
VXD	NS	NS	NS	NS	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant, *= significant at 5% level of probability.

an increase in leaf area index for SAMSUN 4, at 50 $kgNha^{-1}$ SAMSUN 1 showed an increase in leaf area index. At 100 $kgNha^{-1}$, SAMSUN 4 showed an increase in leaf area index but at 150 $kgNha^{-1}$ SAMSUN 4 showed an increase in leaf area index.

Significant interaction occurred between nitrogen and sunflower varieties on leaf area index at 13 weeks after sowing in 2012 dry season, is presented on Table 21. Holding variety constant while varying nitrogen rates, for SAMSUN 1 increasing nitrogen rate from 0-50 $kgNha^{-1}$ showed no significant response in leaf area index further increase beyond 100 $kgNha^{-1}$ showed a similar trend. For SAMSUN 4, increasing nitrogen rate from 0-50 $kgNha^{-1}$ showed no significant response in leaf area index. Similar trend was observed when nitrogen rate was increased beyond 100 $kgNha^{-1}$. Holding nitrogen rates constant while varying variety, at 0 $kgNha^{-1}$ there was increase in leaf area index for SAMSUN 4, however at 50 to 150 $kgNha^{-1}$ there was no significant response on leaf area index between SAMSUN 1 and SAMSUN 4.

Table 20: Interaction between nitrogen and sunflower varieties on leaf area index at 4 weeks after sowing in 2012 rainy season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	33.45f	56.56b	35.04e	32.05g
SAMSUN4	52.14c	50.77d	59.36a	50.86d
SE±	0.00326			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 21: Interaction between nitrogen and sunflower varieties on leaf area index at 13 weeks after sowing in 2012 dry season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	0.11b	0.12ab	0.14a	0.14a
SAMSUN 4	0.14a	0.14a	0.12ab	0.14a
SE±	0.00705			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

4.2.13 Head diameter (cm) and Head weight (g)

Influence of nitrogen rates and planting density on head diameter and head weight of sunflower varieties in 2012 rainy and dry season at Samaru is presented on Table 22. It was observed that application of nitrogen resulted in significant increase in head diameter and head weight in both seasons. In the rainy season, 150 $kgNha^{-1}$ produced sunflower plants with significantly wider and heavier head than 50 $kgNha^{-1}$ and the control. Nitrogen application had no significant effect on the head weight of sunflower during the dry season.

It was observed that SAMSUN 4 produced plants with significantly wider and heavier heads compared with SAMSUN 1. However, in the dry season, variety had no significant effect on the head weight and head diameter.

In the rainy season, 22,222 $plantsha^{-1}$ produced plants with significantly higher head diameter and head weight compared with 44,444 and 66,666 $plantsha^{-1}$ both of which were statistically comparable, a similar trend was observed on head weight in the dry season. However, there was no significant difference in head diameter among the planting densities in the dry season.

Significant interaction occurred between nitrogen levels and sunflower varieties on the head diameter in 2012 rainy season is presented on Table 23. Holding variety constant while varying nitrogen rates, for SAMSUN 1, increasing nitrogen rate from 0-50 $kgNha^{-1}$ increased head diameter, further increase to 100 $kgNha^{-1}$ reduces head diameter however, further increase in nitrogen rate to 150 $kgNha^{-1}$ increased head diameter. For SAMSUN 4, increase in nitrogen rate from 0-50 $kgNha^{-1}$ showed no significant influence on head diameter, further increase to 100 $kgNha^{-1}$ increased head diameter however, further increase to 150 $kgNha^{-1}$ showed no significant influence on head diameter. Holding nitrogen rates constant while varying variety, at 0, 50 and 150 $kgNha^{-1}$ it was found that variety had no significant influence on head diameter however, at 100 kgNha^{-1} SAMSUN 4 was higher in head diameter than SAMSUN 1.

Interaction between nitrogen and planting density on head weight was also found to be significant in 2012 dry season and it is presented on Table 24. Holding planting density constant while varying nitrogen rates; at 22,222 plantsha^{-1} increasing nitrogen rate from 0-50 kgNha^{-1} decreased head weight. When nitrogen rate was increased from 50 to 100 kgNha^{-1} there was significant increase in the head weight however, further increase from 100 to 150 kgNha^{-1} showed a decline in head weight. Similar trend was observed at 44,444 plantsha^{-1}. At 66,666 plantsha^{-1}, increasing nitrogen from 0-100 kgNha^{-1} decreased head weight further increase from 50 to 100 kgNha^{-1} decreased the head weight but increasing nitrogen rate from 100 to 150 kgNha^{-1} significantly increased the head weight. Holding nitrogen rate constant while varying density; at 0 kgNha^{-1} when plant density was increased from 22,222 to 44,444 plantsha^{-1}, there was a decline in head weight a similar trend was observed when it was further increased to 66,666plantsha-1.At 50 kgNha^{-1}, increasing planting density from 22,222 to 44,444 plantsha^{-1} reduced head weight but further increase to 66,666 plantsha^{-1} significantly increased head weight. At 100 kgNha^{-1}, 22,222 plantsha^{-1} significantly increased head weight, increasing planting density to 44,444 plantsha^{-1} reduced head weight further increase to 66,666 plantsha^{-1} head weight. At 150 kgNha^{-1}, increasing planting density from 22,222 to 44,444 plantsha^{-1} increased head weight significantly further increase to 66,666 plantsha^{-1} increased head weight.

Table 22: Influence of nitrogen and planting density on head diameter (cm) and head weight (g) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Rainy Season		Dry Season	
Treatment	Head Diameter(cm)	Head Weight(g)	Head Diameter(cm)	Head weight(g)
Nitrogen (kgNha^{-1})				
0	16.15c	76.12b	19.85b	215.84
50	17.93b	79.32b	21.53ab	233.70
100	18.85ab	88.38ab	21.19ab	236.62
150	19.98a	98.41a	26.80a	243.97
SE±	0.622	9.421	3.115	10.834
Variety				
SAMSUN 1	17.43b	74.38b	22.10	229.08
SAMSUN 4	19.03a	96.73a	20.25	235.98
SE±	0.383	4.448	1.469	10.757
Density (plantsha^{-1})				
22,222	20.82a	107.74a	23.92	256.28a
44,444	17.57b	79.13b	22.87	229.08ab
66,666	16.29b	69.79b	20.25	212.25b
SE±	0.469	5.448	1.799	13.174
Interactions				
NXV	*	NS	NS	NS
NXD	NS	NS	NS	*
VXD	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant, *= significant at 5% level of probability.

Table 23: Interaction between nitrogen and sunflower varieties on head diameter in 2012 rainy season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	15.11d	19.29abc	16.15d	19.15abc
SAMSUN4	17.18cd	18.41bc	19.70ab	20.81a
SE±	0.766			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 24: Interaction between nitrogen and planting density on head weight in 2012 dry season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Density (plantsha^{-1})				
22,222	246.56c	202.67f	282.53b	184.57h
44,444	205.08f	219.05e	230.28d	194.58g
66,666	195.83g	279.42b	219.08e	330.72a
SE±	1.389			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

4.2.14 Total seed weight (g) per head and 1000 seed weight (g)

Effects of nitrogen and planting density on total seed weight per head and 1000 seed weight of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented on Table 25. Application of nitrogen resulted in increase in total seed weight per head and 1000 seed weight. In the rainy season, it was observed that application of 150 $kgNha^{-1}$ produced significantly heavier seed weight than 50 $kgNha^{-1}$ and the control but was statistically comparable with 100 $kgNha^{-}$1 whereas, 1000 seed weight was not affected by nitrogen application. In the dry season, total seed weight per head was not affected by all the nitrogen application however, 150 $kgNha^{-1}$ was observed to produce plants with statistically comparable 1000 test seed weight with 50 and 100 $kgNha^{-1}$ than the control. The control was however, comparable with 50 and 100 $kgNha^{-1}$.

It was observed that during the rainy season, SAMSUN 4 produced plants with significantly heavier total seed weight per head compared with SAMSUN 1 but there was no significant difference in 1000 seed weight between the two varieties. During the dry season, variety had no significant effect on total seed weight per head and 1000 seed weight.

In the rainy season, 22,222 $plantsha^{-1}$ produced plants with significantly higher total seed weight per head than 44,444 and 66,666 $plantsha^{-1}$ which were both statistically comparable. In the dry season, 22,222 $plantsha^{-1}$ produced plants with significantly higher seed weight and 1000seed weight than 66,666 $plantsha^{-1}$ but was comparable with 44,444 $plantsha^{-1}$ statistically a similar trend was observed on 1000 seed weight in the rainy season (Table 25).

Table 25: Influence of nitrogen and planting density on total seed weight (g) and 1000seed weight (g) of sunflower varieties in 2012 rainy and dry seasons at Samaru.

Treatment	Rainy Season		Dry Season	
	Seed weight (g)	1000Seedweight (g)	Seed weight (g)	1000Seedweight (g)
Nitrogen (kgNha^{-1})				
0	115.07c	56.85	107.09	62.63b
50	132.32bc	67.43	107.56	66.84ab
100	151.52ab	65.61	117.57	63.81ab
150	171.70a	60.46	131.34	68.39a
SE±	18.508	7.773	6.450	1.994
Variety				
SAMSUN 1	125.37b	65.03	115.04	65.35
SAMSUN 4	159.94a	59.14	116.74	65.48
SE±	8.374	3.483	7.115	1.254
Density (plantsha^{-1})				
22,222	181.74a	70.05a	129.53a	67.84a
44,444	136.15b	59.21ab	115.83ab	66.40a
66,666	110.07b	57.01b	102.31b	62.01b
SE±	10.256	4.266	8.714	1.535
Interactions				
NXV	NS	NS	NS	NS
NXD	NS	NS	NS	NS
VXD	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.
NS = Not significant at 5% level of probability.

4.2.15 Grain yield (kgha^{-1})

Influence of nitrogen and planting density on grain yield of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented in Table 26. In the rainy season, increasing nitrogen from 0-100 kgNha^{-1} had no significant effect on sunflower grain yield, however, further increase from 100 -150 kgNha^{-1} resulted in significant increase in grain yield while in the dry season, application of 50 kgNha^{-1} resulted in significantly high yield. Increasing nitrogen rate from 50-100 kgNha^{-1} had no significant effect, further increase to 150 kgNha^{-1} however resulted in significant increase in grain yield.

Sunflower varieties showed significant difference in grain yield in both rainy and dry seasons. It was observed that SAMSUN 4 out yielded SAMSUN 1 in both seasons.

Planting density was observed to significantly increase grain yield in both seasons. 66,666 plantsha^{-1} produced significantly higher grain yield than 22,222 plantsha^{-1} however, it was statistically comparable with 44,444 plantsha^{-1}.

Significant interaction occurred between nitrogen and variety on grain yield in 2012 dry season is shown in Table 27. Holding variety constant while varying nitrogen rates, for SAMSUN 1, increasing nitrogen rate from 0-50 kgNha^{-1} there was decline in grain yield further increase to 100 kgNha^{-1} increased yield, however, further increase to 150 kgNha^{-1} did not affect yield significantly. For SAMSUN 4, increasing nitrogen rate from 0-100 kgNha^{-1} there was increase in grain yield further increase to 150 kgNha^{-1} showed no significant response on grain yield. Holding nitrogen rate constant while varying variety, at 0kgNha-1 there was no significant difference in grain yield between SAMSUN 1 and SAMSUN 4 however at 50 kgNha^{-1} SAMSUN 4 showed a higher grain yield compared to SAMSUN 1. At 100 kgNha^{-1}, there was no significant response on grain yield between the two varieties. At 150 kgNha^{-1}, SAMSUN 1 produced significantly higher grain yield compared with SAMSUN 4.

Table 26: Influence of nitrogen rates and planting density on grain yield (kgha^{-1}), in 2012 rainy and dry season at Samaru.

	Rainy season	Dry season
Treatment	Grain yield (kgha^{-1})	
Nitrogen (kgNha^{-1})		
0	1007.90b	628.26c
50	1052.95b	958.31b
100	1097.98b	1081.21ab
150	1296.80a	1094.66a
SE±	70.012	80.803
Variety		
SAMSUN 1	1051.91b	682.29b
SAMSUN 4	1175.90a	773.51a
SE±	39.244	29.867
Density (plantsha^{-1})		
22,222	946.86b	574.18b
44,444	1166.81a	669.52ab
66,666	1228.05a	741.08a
SE±	48.064	36.579
Interactions		
NXV	NS	*
NXD	NS	NS
VXD	NS	NS
NXVXD	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant. *= significant at 5% level of probability.

Table 27: Interaction between nitrogen and variety on grain yield in 2012 dry season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Variety				
SAMSUN 1	712.51ab	541.94c	668.74abc	805.96a
SAMSUN4	544.00bc	774.67a	682.67abc	562.37bc
SE±	59.734			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

4.2.16 Total dry matter at harvest (g) and Harvest index

Influence of and planting density on total dry matter at harvest and harvest index of sunflower varieties in 2012 rainy and dry seasons at Samaru is shown in Table 28. Application of nitrogen resulted in significant increase in total dry matter at harvest and harvest index in both seasons. It was observed that in both rainy and dry season, application of 150 $kgNha^{-1}$ produced significantly heavier dry matter compared with the control. Increasing the rate of applied nitrogen from 50 to 100 $kgNha^{-1}$ and from 100 to 150 $kgNha^{-1}$ produced no further increase in total dry matter at harvest. Applied nitrogen of 100 $kgNha^{-1}$ increased harvest index significantly compared with the control but was statistically at par with 150 and 50 $kgNha^{-1}$ in the rainy season but in the dry season, application of nitrogen at different rates had no significant effect on harvest index.

Variety had no significant effect on total dry matter at harvest in both seasons but SAMSUN4 had significantly higher harvest index than SAMSUN 1 during the rainy season, while variety had no significant effect on harvest index in the dry season.

Plant density was observed to significantly increase total dry matter at harvest and harvest index. In the rainy, 66,666 $plantsha^{-1}$ had significantly higher total dry matter compared with the other planting densities tested while 22,222 $plantsha^{-1}$ was observed to produce significantly higher harvest index compared with other planting densities. In the dry season however, planting density had no significant effect on harvest index.

Interaction between nitrogen and planting density on total dry matter in 2012 rainy season was found to be significant, it is presented in Table 29. Holding planting density constant while varying nitrogen rates; at 22,222 $plantsha^{-1}$, increasing nitrogen rate from 0-50 $kgNha^{-1}$ increased total dry matter, further increase to 100 and from 100 to 150 $kgNha^{-1}$ showed a decline in total dry matter. At 44,444 $plantsha^{-1}$, increasing nitrogen rate from 0-50 $kgNha^{-1}$ there was no significant influence on total dry matter a similar trend was observed when nitrogen rate was increased to 100kgNha^{-1} but on increasing nitrogen rate further to 150 kgNha^{-1} showed a decline in total dry matter. At 66,666 plantsha^{-1}, increasing nitrogen rate from 0-50 kgNha^{-1} increases total dry matter, further increase to 100 kgNha^{-1} showed a decline in total dry matter while further increase to 150 kgNha^{-1} did not have a significant influence on total dry matter. Holding nitrogen rate constant while varying density, at 0kgNha-1, there was no significant effect on total dry matter. At 50 kgNha^{-1}, increasing density from 22,222-44,444 plantsha^{-1} showed no significant response to total dry matter while further increase to 66,666 plantsha^{-1} increased total dry matter. At 100 kgNha^{-1} increasing density from 22,222-44,444plantsha-1 there was a decline in total dry matter further increase to 66,666plantsha-1 showed no significant response on total dry matter. At 150 kgNha^{-1}, increasing density from 22,222-44,444 plantsha^{-1} there was an increase in total dry matter, further increase to 66,666 plantsha^{-1} did not have significant response on total dry matter.

4.2.17 Oil percentage

Influence of nitrogen and planting density on oil percentage of sunflower varieties in 2012 rainy and dry seasons at Samaru is presented in table 30. The results obtained showed that nitrogen application, variety and planting density had no significant effect on the oil content.

Table 28: Influence of nitrogen and planting density on total dry matter at harvest and harvest index of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Rainy season		Dry season	
Treatment	Total dry matter (g)	Harvest index	Total dry matter (g)	Harvest index
Nitrogen (kgNha^{-1})				
0	1.70b	96.62b	1.93b	22.79
50	2.48a	96.96ab	2.19ab	23.91
100	2.22a	97.53a	2.53a	24.98
150	1.83a	97.61a	2.27ab	25.04
SE±	0.143	0.249	0.169	1.760
Variety				
SAMSUN 1	2.13	96.72b	2.08	22.32
SAMSUN 4	1.99	97.64a	2.38	26.03
SE±	0.069	0.184	0.128	1.313
Density (plantsha^{-1})				
22,222	1.70c	98.37a	2.07	25.30
44,444	2.03b	96.94b	2.30	25.03
66,666	2.45a	96.22c	2.33	22.21
SE±	0.085	0.225	0.145	1.608
Interactions				
NXV	NS	NS	NS	NS
NXD	*	NS	NS	NS
VXD	NS	NS	NS	NS
NXVXD	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.NS = Not significant. *= significant at 5% level of probability.

Table 29: Interaction between nitrogen and planting density on total dry matter (g) in 2012 rainy season at Samaru.

	Nitrogen Rate (kgNha^{-1})			
Treatment	0	50	100	150
Density (plantsha^{-1})				
22,222	1.48fg	2.28bcd	1.75efg	1.28g
44,444	1.68efg	2.03bcde	2.43bc	1.95def
66,666	1.93ef	3.13a	2.48b	2.27bcd
SE±	0.169			

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 30: Influence of nitrogen and planting density on oil percentage of sunflower varieties in 2012 rainy and dry seasons at Samaru.

	Rainy season	Dry season
Treatment	Oil %	
Nitrogen (kgNha^{-1})		
0	40.59	32.85
50	41.22	32.94
100	41.41	33.29
150	42.23	34.03
SE±	0.724	0.840
Variety		
SAMSUN 1	41.45	33.09
SAMSUN 4	41.27	33.46
SE±	0.728	1.159
Density (plantsha^{-1})		
22,222	41.36	33.28
44,444	41.36	33.28
66,666	41.36	33.28
SE±	0.892	1.419
Interactions		
NXV	NS	NS
NXD	NS	NS
VXD	NS	NS
NXVXD	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not significant, *= significant at 5% level of probability.

4.3 Correlation Analysis

The result of correlation analysis between grain yield, growth and yield components of sunflower in 2012 rainy and dry seasons at Samaru is shown in table 30 and 31. Grain yield was found to significantly and positively correlate with leaf area index at 10WAS (0.373*), head weight (0.277*), seed weight (0.420*)while grain yield did not significantly correlated with plant height, number of leaves, stem diameter, fresh weight, dry weight,1000seed weight, total dry matter and oil%.

In the dry season, grain yield was found to significantly and positively correlate with leaf area index at 10WAS (0.373*), head weight (0.277*), total dry matter(0.237*) while grain yield did not significantly correlated with plant height, number of leaves, stem diameter, fresh weight, dry weight, seed weight,1000seed weight and oil%.

Table 31: Correlation analysis between grain yield, growth and yield components of sunflower in 2012 rainy season at Samaru

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	-0.193	1.00										
3	-0.084	0.106	1.00									
4	0.017	-0.361	0.093	1.00								
5	0.291	0.326	0.174	0.774**	1.00							
6	0.068	-0.119	0.102	0.372*	0.428*	1.00						
7	0.373*	0.129	-0.132	-0.228	-0.358	-0.105	1.00					
8	0.277*	-0.239	0.248	0.142	0.178	0.086	0.377	1.00				
9	0.420*	-0.253	0.274	0.191	0.212	0.124	-0.369*	0.954**	1.00			
10	0.148	0.050	0.275	-0.095	0.051	0.114	-0.203	0.214	0.219	1.00		
11	0.229	0.378*	-0.167	-0.159	-0.189	0.047	0.486**	-0.223	-0.160	0.004	1.00	
12	0.019	-0.038	0.101	-0.115	-0.116	0.092	0.035	-0.122	-0.166	-0.113	-0.012	1.00

Df=N-2=70
Where: 1:Grain Yield ,2:Plant Height 10WAS,3:Number of leaves10WAS, 4:Stem Diameter 10WAS 5:Fresh Weight 19WAS, 6:Dry Weight10WAS, 7:Leaf Area Index 10WAS 8:Head weight 9:Seed Weight 10:1000seed Weight 11:Total Dry matter12:oil%, *= significant at 5% level of probability, **=significant at 1% level of probability.

Table 32: Correlation analysis between grain yield, growth and yield components of sunflower in 2012 dry season at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.136	1.00										
3	-0.084	0.280*	1.00									
4	-0.185	0.102	0.201	1.00								
5	0.155	-0.044	-0.023	-0.08	1.00							
6	0.056	-0.183	0.031	-0.084	0.630**	1.00						
7	0.230*	0.162	-0.008	0.114	0.010	0.010	1.00					
8	-0.291*	0.248*	0.229	0.248*	-0.010	-0.092	-0.082	1.00				
9	-0.078	0.167	0.288*	0.146	0.153	0.096	-0.034	0.195	1.00			
10	-0.160	0.130	-0.070	0.117	-0.013	-0.148	-0.066	0.462*	0.131	1.00		
11	0.237*	0.018	0.018	-0.213	0.591	0.254*	0.153	-0.219	0.057	-0.030	1.00	
12	0.154	0.009	-0.018	-0.014	-0.092	0.025	-0.007	0.039	-0.079	-0.026	-0.205	1.00

Df=N-2=70

Where: 1:Grain Yield ,2:Plant Height 10WAS,3:Number of leaves10WAS, 4:Stem Diameter 10WAS 5:Fresh Weight 19WAS, 6:Dry Weight10WAS, 7:Leaf Area Index 10WAS 8:Head weight 9:Seed Weight 10:1000seed Weight 11:Total Dry matter 12:oil%,*= significant at 5% level of probability, **=significant at 1% level of probability.

4.4 Regression Analysis

Several polynomial models were fitted to find the best model to explain the yield response to Nitrogen levels and plant density of sunflower in both 2012 rainy and dry seasons. It was observed that, grain yield increased as nitrogen rate increases from the control to 150 $kgha^{-1}$ (Figures 1 & 3). There was consistency in both seasons. However the situation was not the same in terms of plant density; it was observed that grain yield increased as planting density increased from 22,222 to 44,444 $plantsha^{-1}$ beyond which a decline in yield was observed in both seasons (Figures 2 & 4).

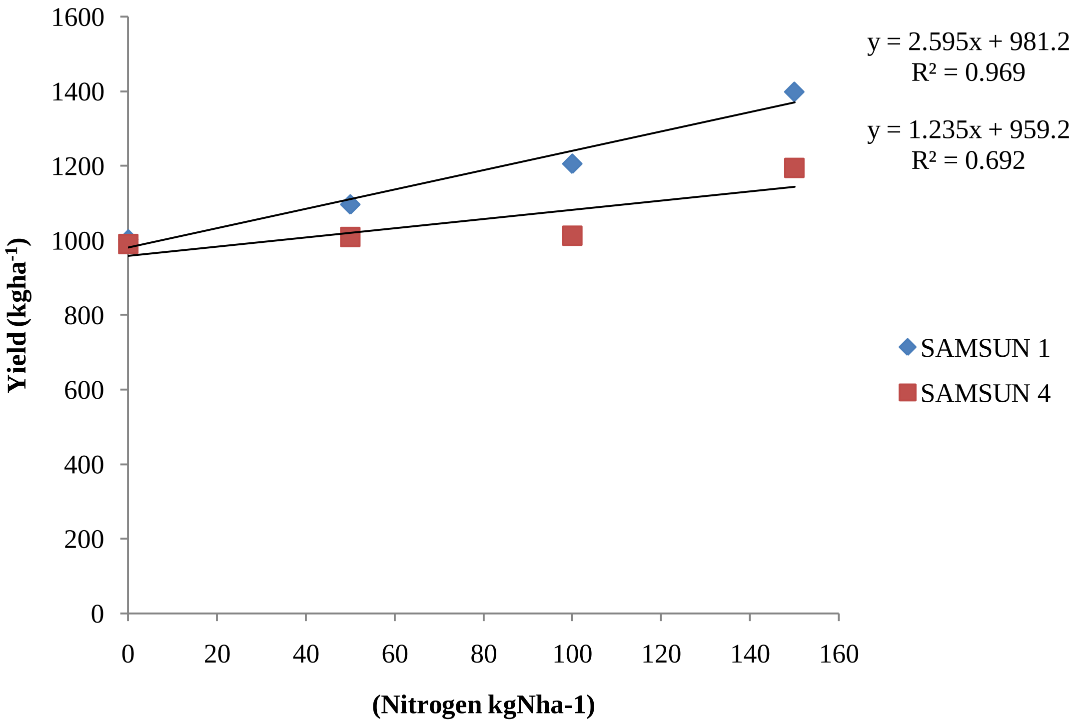

Figure1: Regression response curve of Sunflower variety to yield (Kg ha^{-1}) against Nitrogen rates ($kgha^{-1}$) during 2012 rainy season in Samaru

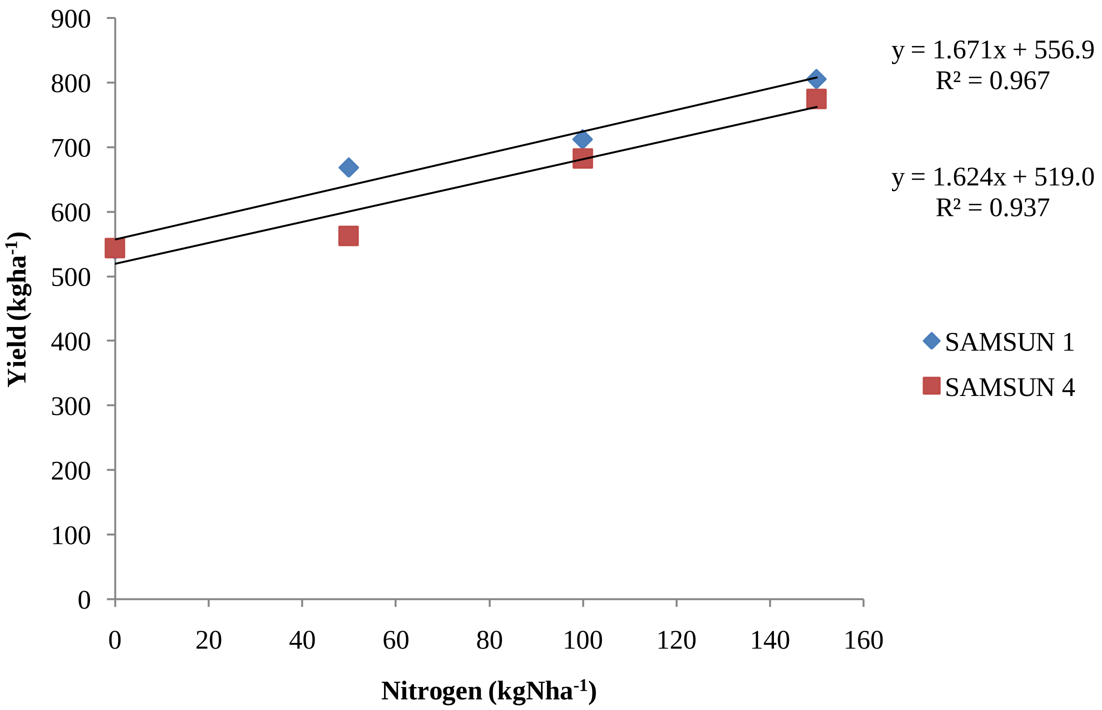

Figure 2: Regression response curve of Sunflower variety to yield (Kg ha^{-1}) against Nitrogen rates ($kgha^{-1}$) during 2012 dry season in Samaru

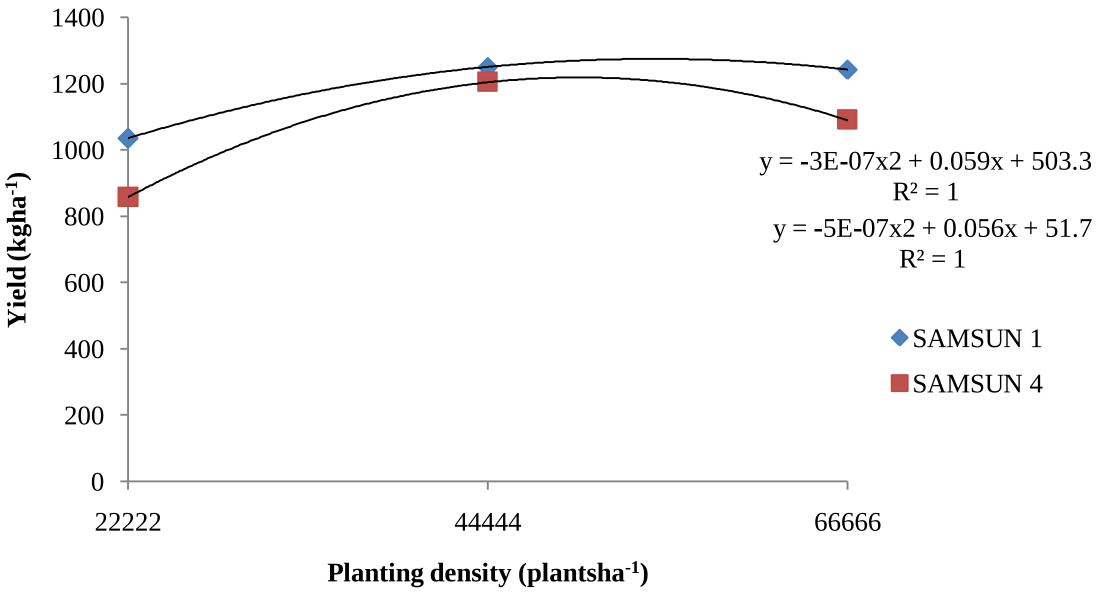

Figure 3: Regression response curve of Sunflower variety to yield (kgha^{-1}) against plant Density (plantsha^{-1}) during 2012 rainy season in Samaru

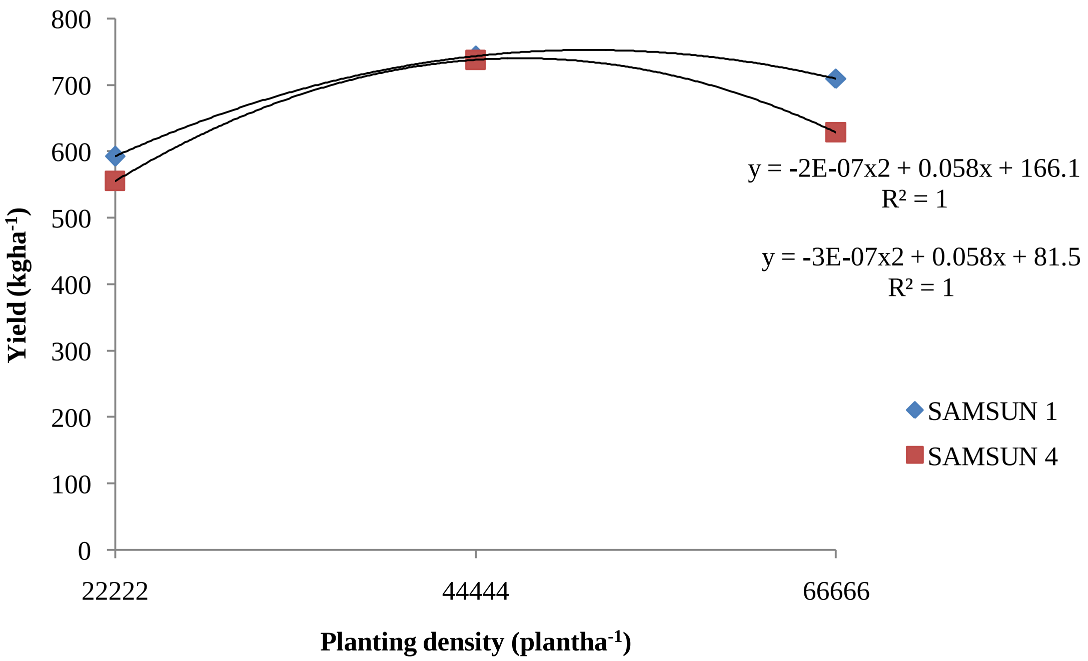

Figure 4: Regression response curve of Sunflower variety to yield (kgha^{-1}) against plant Density (plantsha^{-1}) during 2012 dry season in Samaru

CHAPTER FIVE

5.0 DISCUSSION

5.1 General

The performance of sunflower crop during the 2012 rainy and dry seasons was good however yield ha^{-1}was better in the raining season than the dry season as shown in Table 26. Although sowing was done a bit late in the rainy season but it did not affect the performance of the crop. There was difference in environmental conditions during both seasons. All the weather data (minimum and maximum temperatures, relative humidity, rainfall, solar radiation) were obtained from the Institute for Agricultural Research (IAR) meteorological station and is presented in appendix I. The season was characterised by a higher relative humidity and rainfall while the dry season had low relative humidity with no rainfall recorded during the course of the experiment. Soil characteristics are important for root distribution and performance. The effect of soil profile characteristics on plant water and nutrient uptake have been demonstrated by Graecen and Giandron (1982). The soils of the experimental sites in the rainy season was 17.8% clay, 38% silt and 44% sand while in the dry season , it was 8% clay, 44% silt and 48% both were classified as loam. Nitrogen fertilization increased yield in both seasons, this is shown in table 26.

5.2 Effect of Nitrogen on Growth and Yield of Sunflower

Application of nitrogen at higher rates increased growth parameters like crop growth rate, relative growth rate, net assimilation rate and number of leaves in both the wet and dry season trials. This is explained by the importance of nitrogen as an essential element necessary for vegetative growth and chlorophyll formation as well as promoting root development which in turn resulted in efficient assimilate production and translocation to sink (Brady, 1974). Similar observations were reported by Prasad *et al*. (2002), Moujiri and Arzani (2003), Cechin and Fumis (2004), Sadras (2006). Leaf area index was significantly increased with an increased fertilizer levels for both trials which could be attributed to stimulation of cell division and cell growth by nitrogen which in turn resulted in leaf growth. This result is in conformity with those reported by Kho (2002), Aleman *et al* (2002), Ozer *et al*. (2004) Nasim *et al.* (2012). The number of leaves, plant height as well as stem diameter increased significantly which could be due to luxury consumption with increase in fertilizer levels which resulted in delayed anthesis. This result is in conformity with Mujiri (2003), Sadras (2006) and Oyinlola *et al*. (2010). Higher nitrogen treatments levels significantly increased head diameter, head weight, 1000seed weight, which could be attributed to remobilization and partitioning of dry matter produced by sunflower crop during its vegetative stage of growth for grain filling thereby reducing the incidence of empty seeds. These results are in line with those of Tanimu *et al*. (1986a), Kene *et al*. (1992), Fatih (2004) Wabekwa *et al*. (2012). There was significant increase in lodging percentage which was associated with high nitrogen application that resulted in heavy heads that the stems could not hold. This result is similar to those reported by Tanimu *et al*. (1991); Javier *et al.* (2002). Dry matter accumulation was increased with increased in fertilizer levels in both seasons which could be attributed to the role of nitrogen in plant growth as well as increase in photosynthesis efficiency arising from increased crop canopy. These results are also in agreement with those reported by Legha and Gajeendra (2001); Bikas and Gajenda (2002); Wabegwa *et al.* (2010). Grain yield was much influenced positively by nitrogen fertilization which clearly suggests the importance of nitrogen for high seed production in sunflower. This result is as those suggested by Faizani *et al*. (1990), El-Naggar and Allam (1992), Sarmah *et al*. (1992), Wabegwa *et al.* (2010).

5.3 Effect of Density on Growth and Yield of sunflower

There was significant increase in plant height with increasing plant density, the increase in plant height with increasing plant density could be attributed to competition among plants for resources such as available light, water and nutrients as well as increased shading leading to stem etiolation. Similar observations were reported by Tanimu (1986), Baba (1994) and Ado (1996). This response is associated with the phenomenon of competition for light among individual plants at high population densities resulting in etiolation. However, this result contradicts that of Olowe (2005) who reported no significant increase in plant height at higher population density but partially in accordance to the findings of Xiao *et al*., (2006) who observed that the mean plant height increased and then decreased with increasing population density. Increasing plant population density significantly reduced stem diameter and increased lodging percentage in both trials. This report is in line with those recorded by Olowe (2005) Beg *et al*. (2007). Head weight, head diameter, seed weight and 1000seed weight where significantly reduced by increasing population density. Increasing population density from 22,222 plants ha^{-1} to 66,666 plants ha^{-1} reduced head weight, seed weight, and number of seeds per head , this could be attributed to increase competition of plants for nutrients, closer root foraging area, inadequate sunlight penetration (diffuse light or poor sunlight quality or intensity) for more efficient photosynthesis in plants grown at high population density resulting in smaller flower heads with few seeds as well as the incidence of empty seeds (Robinson *et al*., 1980; Yousaf *et al*., 1986 ; Olowe, 2005). Low grain yields were produced by plants grown under the lowest population density. This could be attributed to lower crop stand compared with the intermediate and highest population densities. This findings are in agreement with the reports of Zubriski and Zimmerman (1974); Robinson *et al.* (1980); Janegoudar *et al*. (1986) and Yousaf *et al*. (1986).

5.4. Response of Sunflower Variety on Growth and Yield

Significant varietal differences were recorded for some parameters. SAMSUN 4 produced significantly taller plants in both the rainy season and dry season trials. This might be due to different varietal behaviour and it is also in accordance with Abdel-motagally and Osman (2010) who reported that sunflower cultivars significantly differed in height. SAMSUN4 flowered and matured earlier than SAMSUN 1 in both trials irrespective of the contrasting weather conditions (rainy and dry seasons) which is line with the works of Showemimo *et al.*, 2010 that reported that SAMSUN 1 matures in 80 days with a potential yield of 2.21 tha^{-1} while SAMSUN 4 matures 72 day with a potential yield of 2.27 tha^{-1}. A similar trend of superior vegetative growth of these varieties has been reported by Ado *et al*. (1996). SAMSUN 4 produced significantly higher yield, this considerable difference in yield in the same ecological zone might be attributed to varietal differences, as well as differences in weather conditions during the growing seasons.

5.5. Interactions

Investigating the interactions among the parameters taken, result obtained revealed that there was significant ($P \leq 0.05$) interactions between nitrogen levels X variety with respect to plant height, net assimilation rate, leaf area, leaf area index, head diameter and grain yield which could be attributed to genetic difference and also to the role of nitrogen in promoting vegetative growth and chlorophyll formation which is in line with the works of Faizani *et al*., 1990; Wagh *et al*., 1991; El-Naggar and Allam, 1991; Sarmah *et al*., 1992. There was also significant interaction between nitrogen levels X planting density with respect to stem diameter, head weight, and total dry matter which be attributed to translocation of assimilates to seeds resulting in heavy heads at the expense of stem growth at higher population density (Narwal and Malik, 1985). Furthermore, there was interaction between variety X density with respect to stem diameter which could be attributed to genetic difference between the varieties and also varietal response to environmental factors on the adaptability and stability of sunflower crop, Yan and Hunt, (2003).

5.6. Correlation Studies

The significant and positive correlation between some of the growth and yield components in both the wet and dry season trials indicated the interdependence among the characters. Leaf area index, head weight, seed weight were significantly and positively correlated with the yield of sunflower indicating that there was significant association between the size of the floral head and the number of seeds.These results were supported by the results of many authors (Ahmad *et al*., 1991; Marinkovic, 1992; Danbaki, 2002; Chikkadevaiah *et al*., 2002; Satjawattana, 2005; Hladni *et al*., 2006; Srimuenwai, 2006; Kaya *et al*., 2007). Significant positive correlation was also shown between stem diameter and fresh weight, stem diameter and dry weight, fresh weight and dry weight, plant height and total dry matter, leaf area index and seed weight, head weight and seed weight, and leaf area index and total dry matter indicating that a unit increase in one character will result to a significant increase of the other character and a unit decrease in one character will decrease the other character significantly.

5.7 Regression Studies

The regression analysis showed a linear response of yield on Nitrogen levels in both seasons which indicated that the optimum nitrogen requirement for the crop was not reached thus, the additional nitrogen could increase yield. However, a quadratic response was recorded on plant density on yield of sunflower plant indicating that the optimum plant density for sunflower was reached. The optimum planting densities for both varieties was calculated. The optimum planting density for SAMSUN 1 and SAMSUN 4 in the rainy season trial were 42,142.9 and 40,000 plantsha^{-1} and for the dry season trial, the optimum planting densities were 41,428.57 and 41.428.57plantsha^{-1}; beyond this values, yield significantly declined indicating that further increase in planting density could not significantly increase the yield of sunflower crop. These results are in line with those reported by Suzer (2010).

CHAPTER SIX

6.0. SUMMARY AND CONCLUSION

A study was carried out during the 2012 wet and dry seasons at the Institute for Agricultural Research Farm at Samaru, Zaria (11º11`;07º38`E and 686m above sea level) to study the performance of two sunflower varieties under varying plant population density and nitrogen levels. The treatments consisted of four rates of nitrogen (0, 50, 100 and 150 kgha^{-1}e) three plant densities (22,222, 44,444 and 66,666 plantsha^{-1}) and two varieties (SAMSUN 1 and 4). The treatments were factorially combined and laid out in a split-plot design with three replications. The combination of sunflower cultivar and nitrogen constituted the main plot while plant density was assigned as sub-treatment. Each sub-plot consisted of five ridges (75cm apart) or 3.75m width of 4.0m length (15m^2). The inner three ridges (11.25m^2) constituted the net plot. All cultural practices including land preparation, weed control, fertilizer application, and insect control were carried out. The nutrient status of the soil before each planting season was determined. Data on growth and yield characteristics were measured and collected. The percentage oil content was also determined.

Analysis of soil before each planting season showed that the textural class of the soil for the rainy season trail was loam with moderate levels of total nitrogen and available phosphorus.

Nitrogen levels significantly affected the growth and yield parameters of sunflower. 100 kgNha^{-1} and 150 kgNha^{-1} produced sunflower crops which were taller, higher in crop growth rate and relative growth rate as well as higher in grain yield compared to the control and 50 kgNha^{-1}. Growing sunflower at an intermediate plant density of about 44,444 plants ha^{-1} produced taller plants, plants with high crop growth rate, relative growth rate, higher grain yield, total dry matter and harvest index. SAMSUN 4 had significant edge over SAMSUN 1.

Based on the findings in this study, it could therefore be concluded that the performance of sunflower would be enhanced using nitrogen levels of up to 100 $kgNha^{-1}$ and a plant population density of 44,444 $plantsha^{-1}$ and SAMSUN 4 variety in both rainy and dry seasons.

REFERENCES

Abdel-motagally, F., M., F., and Osman E. A., (2010). Effect of Nitrogen and potassium fertilization conbinations on productivity of two sunflower cultivars under east of Elewinate condition. *American Eurasian Journal of Agriculture and Environmental Science,* 8(4): 397.

Ado, S. G., Tanimu B., and Kaigama B. K., (1988). Relationships between seed yield, oil content and other agronomic traits in sunflower (*Helianthus annuus* L.). *Journal of Food and Agriculture,* 2(3): 192-197.

Ado, S. G., Kaigama B. K. and Tanimu B. (1996). Effect of Location and Population Densityon theperformanceof twosunflower(*Helianthus annus* L.) varieties. *Journal of Agricultural Technology,* 4: 65-69.

Aduayi, E. A., Chude, V. O., Adebusuyi, B. A. and Olayiwola, S.O. (2002). Fertilizer use and management practices for crops in Nigeria. Federal Ministry of Agriculture and Rural Development Abuja, Nigeria P: 63-65.

Agele, S. O. (2003). Sunflower responses to weather variations in rainy and dry cropping seasons in a tropical rain forest zone. *International Journal of Biotronics.* 32:17-33.

Ahmad, Q., Rana, M. A., and Siddiqui, S. U. H. (1991). Sunflower seed yield as influenced by some agronomic and seed characters. *Euphytica,* 56(2): 137-142.

Aleman, P. R., Cholaky, S. L. Giayetto, O. Machado, A. J. and Fundora, H. O. (2002). Nitrogen fertilizer application in sunflower in carbonate soil in the central region of cuba. *Centro Agricola,* 29: 56-63.

Ali, A., Ahmad, A., Khaliq, and Akhtar, J. (2012). Planting density and nitrogen rate optimization for growth and yield of sunflower (*Helianthus annuus* L.) hybrids. *The Journal of Animal & Plant Sciences*, 22(4): 1070-1075.

Ali, A., M. Afzal, I . Rasool, S. Hussain and M. Ahmad (2011). Sunflower (*Helianthus annus* L.) hybrids performance at different plant spacing under agro-ecological conditions of Sargodha, Pakistan. International conference on food engineering and Biotechnology, 9:317-322 *IACSIT Press,* Singapore.

Al-thabet S. S. (2006). Effect of plant spacing and nitrogen levels on growth and yield of sunflower (*Helianthus annuus* L.). *Journal of Kingdom of Saudi University, vol.* 19, *Agricultural Science.*, 1:1-11.

Anon. (2012a). Guide to sunflowers. Retrieved June 20, 2012, from http://www.sunflowerguide.com.

Anon. (2012b).Sunflowers.Floristcompare.com. Retrieved June 20, 2012, from http://www.floristguide.com.au/sunflower How long do sunflower live 5-7days clean vase or container clean look-warm or room temperature water in couple of tea spoon of sugar, change water daily. keep in cool condition with indirect sunlight .

Anonymous, (1976). Guide to field crops in the tropics and subtropics edited by Samuel L. Litzerberger. 22p.

Arnold , M. A., Lesikar, B. J. McDonald, G.V., Bryan, D. L. and Gross, A. (2003). Irrigation landscape bedding plants and cut flowers with recycled nursery runoff and constructed wetland treated water. *Journal of Environmental Horticulture* 21:89-98.

Baba, M. I. (1994). Effect of plant density and row spacing on the growth and yield of sunflower (*Helianthus annuus* L.). MSc. Thesis Department of Agronomy Ahmadu Bello University Zaria.

Bakhat, J., Ahmad, S., Tariq, M., Akbar, H. and Shafi, M. (2006). Performance of various hybrids of sunflower in Peshawar valley. *Journal of Agricultural Science*, 1(3): 25-29.

Bakhat, J., Shafi, M., Yousaf, M. and Shah, H. U. (2010). Physiology, phenology and yield of sunflower (Autumn) as affected by N.P.K fertilizer and hybrids. *Pakistan Journal of Botany,* 42(3):1909-1922.

Beg, A., Pourdad, S. S. and Alipour, S. (2007). Row and plant spacing effects on agronomic performance of sunflower in warm and semi-cold area of Iran. *Helia*, 30(47): 99-104.

Belamey, F. C. and Chapman, J. (1989). Protein ,oil and energy yields of sunflower as affected by nitrogen and phosphorus fertilization. *Agronomy Journal*, 73:583-587.

Bertoria L., Burak, R. and Nivio, A. (1998). Effect of plant densities on yield and quality of forage maize. Maize growers co-operative news letter Santa Catarina, Brazil.

Bikas, M. and Gajendra, G. (2002). Dry matter accumulation, nutrient uptake and water use efficiency of sunflower as affected by application irrigation and nutrients *Annual Agricultural Resources,* 23:238-243.

Blamey, F.P.C., Zollinger, R.K., Scneiter, A.A. (1997). Sunflower production and culture. In: SCNEITER, A.A. *Sunflower Science and Technology*. Madison: American Society of Agronomy, pp. 595-670.

Brady, N. C., (1974). The nature and property of soils. 8th Ed Macmillan Publishing company, Inc. New York, N. Y. United states of America. pp. 524-526.

Bray, R. J. and Kurtz, L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Science,* 59: 39-45.

Bremner, J. M. and Mulvaney C. S. (1982). Nitrogen-total In: methods of soil analysis. Part 2. Chemical and microbiological properties ed page, A. L. Muller, R. H. and Keeney, D. R. American society of Agronomy, Madison, W. I. U.S.A pp. 595-541.

Cavins, T. J. Dole M., and Stamback V. (2000). Unheated and minimally heated winter green house production of specialty cut flowers. *Horticulture Technology,* 19:793-799.

Cechin, I., Fumis, T. F. (2004). Effect of nitrogen supply on growth and photosynthesis of sunflower plants grown in the greenhouse. *Plant Science* 166:1379–1385.

Chikkadevaiah, Sujatha, H. L., and Nandini, R. (2002). Correlation and path analysis in sunflower, *Helia*, 25(27): 109-118.

Chindananda, G., (1974), Agronomic investigation in sunflower (*Helianthus aunus* L.) M.Sc. (Agri) Thesis, Univ. Agric. Sci., Bangalaore.

Danbaki, J. T. (2002). Productivity of soybean (*Glycine max* merr)/ Sunflower (*Helianthis annuus* L.) as influenced by plant arrangement and population. MSc. Thesis Department of Agronomy, Ahmadu Bello University, Zaria.

Day, P. R. (1965). Particle fraction and particle size analysis. In: Black C. A. Methods of soil analysis part 1. pp. 545-566. Agronomy monograph no. 9, American society of Agronomy, Madison, Wisconsin.

David, J. Wishart (Ed) 2011. Encylopedia of the Great Plains.

Donald, C. M. (1962). In search of yield. *Journal of Australian Institute. Agricultural Sci*ence, 28:171-178

Duncan, D.B (1955). Multiple Ranges and Multiple F. test *Biometrics* II: 1-42

Dushenkov, V., Kumar, P. B. A. N., Motto, H. and Raskin, I. (1995). Rhizofitration: The use of plant to remove heavy metals from aqueous streams. *Environmental Science and Technology*, 29: 1239-1245.

El Naim, A. M. (1992). Watering intervals and plant population effectnon growth and yield of two sunflower hybrids. Msc. Thesis, Faculty of Agricultural science, University of Khartoum.

El-Naggar, H. M. M. and Allam, S. A. H. (1991). Effect of nitrogen, phosphorus and potassium fertilizer levels on sunflower. *Annual Agricultural Science*, 29: 77-87.

Faizani, K. G. M., Satyanarayana, V., Latchanna, A. Shaik, M. and Ramaiah, N. V. (1990). Response of sunflower genotype to nitrogen levels. *Journal of Res. APAU*, 18: 57-9

Fatih, K. (2004). Influence of different Nitrogen levels on productivity of oilseed and confection sunflowers (*Helianthus annuus* L.) under varying plant populations. *International Journal of Agriculture and Biology* 6(4):594-598.

Fick, G. N., Caroline, J. J., Auvartir, G. E., and Duhing, P. M., (1985). Agronomic characteristics and field performance of dwarf sunflower hybrids. In: XI International Sunflower. Conference,10-13 March 1985. Mardelplata, Argentina. S 379-742.

Food and Agricultural Organization of United Nations. (2004). FAOSTAT Database Retrieved June, 20, 2012, from http:/apps.fao.org/default.htm

Food and Agricultural Organization of United Nations. FAO, (2010). Sunflower production data. Retrieved June 11, 2012 from http://faostat.fao.org/.

Gajendra, G. (2001). Effect of irrigation and nitrogen on performance of Indian mustard (*Brassicajuncea*) and sunflower (*Helianthus annuus*) under two dates of sowing. *Indian Journal of Agronomy*. 46(2): 304- 308.

Getmanets, A. Y. A., Kramarev S. M., Kharchenko, N. I. (1991). Fertilizer, plant density and productivity of sunflower. *Khimizatsiya Sel'skogokhozyaistva*, 9:93-97.

Graecen, E.L. and Giandron, E.A. (1982). Crop behaviour on claysoil. *Tropical Agriculture* (Trinidad) 59 (2): 123-132.

Harmati, I. (1992). Effect of fertilizer application on achene yield, oil content and oil yield of sunflower hybrids. No um ve ac nytermole ac s 40(6): 543-51.

Hassan, M. K. and Mukhtar, N. O. (2000). Response of sunflower hybrid variety to N and P. *Annual Report* (2000-01). Oil seed crops Research program, Wad Medani, Sudan.

Heather, D., Hannah, H., Erica, C., Rosalie, M., Susan M. and Amanda G. (2011) Vermont Sunflower Seeding Rate x Nitrogen Rate Trial, University of Vermont Extension 802:524-6501 Visit us on the web at Retrieved October 20, 2013 from http://www.uvm.edu/extension/cropsoil.

Heiser, C. B. (1954). Variation and subspeciation in the common sunflower, *Helianthus annuus* L. *American Midland Naturalist* 51: 287-305.

Hladni, N., Skoric, D., Kraljevic-Balalic, K., Sakac, Z., and Jovanovic, D. (2006). Combining ability for oil content and its correlation with other yield components in sunflower (*Helianthus. annuus* L.). *Helia*, 29(44):101-110.

Holt, H. W. and Campbell, S. J. (1984). Effect of plant density on the agronomic performance of sunflower on dryland. *Canadian Journal of Plant Science*. 64:599-605.

Hurt, E. F. (1949). Sunflower for food, fodder and fertilizer. Faber and Faber Ltd. 24 pussell square, London, p: 175.

Janegoudar, B. S., Patil, C. V and Munirajappa, R. (1986). Productivityofsunflower hybrids in relation to plant density and irrigation. *Helia*, 9:57-60.

Javier D. S., Flavio H. G., Raul S. L. (2002). Sunflower nitrogen requirement and ^{15}N fertilizer recovery in Western Pampas, Argentina. *European Journal of Agronomy* 17:73 – 79.

Kaya, Y., Evci, G., Durak, S., Pekcan, V., and Gucer, T. (2007). Determining the relationships between yield and yield attributes in sunflower. *Turkey Journal of Agriculture and Forestry*, 31:237-244.

Kene, H. K. Thosar, V. R. and Ulemale R. B. (1992).Optimum sowing time of sunflower Varieties in summer season *Journal Maharashtra* Agri. Univ. 17:411-2.

Kho, R. M., (2002). Crop Production and the balance of available resources. *Agriculture, Ecosystem and Environment*, 80:71-85.

Khokani, M. G., Ahlawat, R. P. S., Trivedi, S. J. (1993): Effect of nitrogen and phosphorus on growth and yield of sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, *38*: 507–509.

Killi, F. and Ozdemir, G. (2001). Response of hybrid oil seed sunflower cultivars to plant density. In: *Proceedings of the Third field crops congress* (industrial crops) 2:29-32. Tekirdag, Turkey.

Killi, F. (2004). Influence of different nitrogen levels on productivity of oil seed and confection sunflowers (*Helianthus annuus* L.) under varying plant populations. *International journal of Agriculture and Biology*, 6(4):594-598.

Kundsen, D., Peterson, G. A. and Prette, P. F. (1982). Lithium, sodium, potassium. In: methods of soil analysis (page, A. L. ed.)

Legha, P. K. and Giri, G. (1999): Influence of nitrogen and sulphur on growth, yield and oil content of sunflower (*Helianthus annuus*) grown in spring season. *Indian Journal of Agronomy*, 44: 408–412.

Legha, P. K. and Gajendra, G. (2001). Dry matter accumulation and nutrient uptake by spring season sunflower as affected by H and S fertilization. *Fertilizer News,* 46:57-58.

Majid, H. R. and Schnieter A. A, (1988). Semi-dwarf and conventional height sunflower performance at five plant populations. *Agronomy Journal,* 80(50):821-824.

Marinkovic, R. (1992). Path-coefficient analysis of some yield components of sunflower (*Helianthus annuus* L.). *Euphytica*, 60(3): 201-205.

Massey, J. H. (1971). Effects of nitrogen rates and plant spacing on sunflower yields *Agronomy Journal*, 63:137-138.

Miller, J. F. and Fick, G. N. (1997). Sunflower genetics. In: Schneiter, A. A. (ed) *Sunflower Technology and Production*. Agronomy Monogram, 35. Society of American Agronomy, Crop Science Society of America and Soil Science Society of America, Madison, WI, USA, p. 441-495.

Mohamed, F. M. (1989). Effect of N and P on Sunflower. Annual Report (1988-89). Gezira Research Station, Wad Medani, Sudan.

Moujiri, A. and Arzani, A. (2003). Effects of nitrogen rate and plant density on yield and yield components of sunflower. *Journal of Science Technology Agriculture and National Resources*, 7: 115-125.

Narwal, S. S. and Malik, D. S. (1985). Response of sunflower cultivars to plant density and nitrogen *Journal of Agricultural Science,* 104: 95-7.

Nasim, W., Ahmad, A., Bano, A., Olatinwo, R., Usman, M., Khaliq, T. Wajid, A. Hammad, H. Mubeen, M. and Hussain, M. (2012). Effect of nitrogen on yield and oil quality of sunflower (*Helianthus Annuus* L.) Hybrids under Sub Humid Conditions of Pakistan," *American Journal of Plant Sciences*, 3(2): 243-251.

Nelson, D. W. and Summers, L. E. (1982). Total carbon, organic carbon and organic matter. In: methods of soil analysis. Part 2 (A. L. page, Miller R. H. and Keeny D. R. Eds.). *Agronomy 9*, pp. 539-579. American society of agronomy. Maidson.

Norman, J. C. (2004). Tropical Floriculture. National Science and Technology press, Accra, Ghana pp. 216.

Oad, F. C., Sohu, G. N., Qayyum, S. M., Gandahi, A.W., Chandio G. Q. and Oad, N. I. (2001). Comparative performance of sunflower varieties in response to different fertility regimes. *Journal of Applied Sciences*, 1(3):397-399.

Ogunremi, E. A. (1979). Effect of sowing date on sunflower performance in south western Nigeria. *International Sunflower Newsletter,* 3(4):15-19.

Olowe, V. I. O. (2005). Effect of plant population on growth and yield of sunflower (*Helianthus annus* L) in the transition zone of south west Nigeria. *Tropical Agriculture Research and Extension,* 8:37-44.

Oyinlola, E. Y., Ogunwole, J. O. and Amapu, I. Y. (2010) Response of sunflower (*helianthus annuus* l.) to Nitrogen application in a savanna Alfisol. *Helia*, **33(**52):115-126.

Ozer, H. T., Polat and Ozturk, E. (2004). Response of irrigated sunflower (*Helianthus annuus* L) hybrids to nitrogen fertilization- growth, yield and yield components. *Plant Soil Environment*, 50:205-211.

Pomeranz, Y. and Meloan, Clifton, E. (1987). Food Analysis: theory and practice 2nd edition, Van Nostrad Reinhold (New York).

Prasad P. V. V., Satyanarayama, V., Murthy, V. R. K. and Boote, K. J. (2002). Maximizing yields in rice-ground cropping sequence through integrated nutrient management. *Field Crop Research*, 75: 9-21.

Prunty, L. (1981). Sunflower cultivar performance as influenced by soil water and plant population. *Agronomy Journal* 73: 257-260.

Purseglove, J. W. (1968). Tropical Crops. Dicotylodons volume 1, Longman pp. 264-273

Putnam, D. H, Oplinger, E. S., Hicks, D. R., Durgan, B. R., Noetzel, D. M., Meronuck, R.A, Doll, J. D. and Schulte, E. E. (1990). Sunflower Alternative field crop manual. University of Minnesota, pp. 9.

Radford, D. J., (1967). Growth analysis formulae: Their use and abuse. *Crop Science*, 7: 171-175.

Rhoads, F. M. and Bloodworth, M. E. (1964). Area management of cotton leaves by dry weight method. *Agronomy Journal*, 56: 520-552.

Robbelen G., Downey P. K., Ashri, A.: (eds) (1989). Oil crops of the World, their breeding and utilization. McGrewHill, N.Y., pp. 55.

Robinson, R. G., Ford, J. H., Lueschen, W. E., Rabas, D. L., Smith, L. J., Warnes, D. D. and Wiersma, J. V. (1980). Response of sunflower to plant Population. *Agronomy Journal*, 72: 869-871.

Sadras, V. O. (2006). The N:P Stiochiometry of cereal, grain legume and oilseed crops. *Field crop Resources*, 95: 13-29.

Sarmah, P. C., Katyal S. K. and Verma, O. P. S. (1992). Growth and yield of sunflower varieties in relation to fertility level and plant population. *Indian Journal of Agronomy*, 37: 285-9.

Satjawattana, K. (2005). Development of single crosses of sunflower for high yield and oil percentage, [Ph.D. thesis]. School of Crop Production Technology, Institute of Agriculture, Suranaree University of Technology, Nakhon Ratchasima, Thailand, pp. 106.

Schneiter, A. A. (ed) (2002). Agronomy Monogram, 35. Society of American Agronomy, Crop Science Society of America and Soil Science Society of America, Madison, WI, USA, pp. 441-495.

Schneiter, A. A. and Miller, J. F. (1981). Description of sunflower Growth Stages. *Crop Science*, 21: 901-903.

Schuster, W. H. (1985). *Helianthus annuus*, pp, 98-121 In: Handbook of flowering, Volume III, Halevy, A. H. Editor. Cf C press, Boca Faton, Florida.

Sedghi, M., Sharifi, R. S., Namvar A., Kharidan-e-Bejandi, T. and Melaci, P. (2008). Response of sunflower yield and grain filling period to plant density and weed interference. *Research Journal of Biology Sciences*, 3:1048-1053.

Shella, G. S. G., Langa, A. R. G., Salea, P. J. M. (1974). Quantitative measures of leaf orientation and heliotropic response in sunflower, bean, pepper and cucumber. Retrieved June 20, 2012 from www.sciencedirect.com

Showemino, F. A., Orakwue, F. C., Ado, S. E., Yeye, M. Y., Tanimu, B., Mahmud, M., Misari, S., Akpa, A. D., Egurube, E. A., Omage, J. J. and Ndirika, V. I. O. (2010). Recommendation for registration and release of four sunflower4 varieties. SAMSUN 1 (vniimk 8883), SAMSUN 2 (CHERNEANKA 66), S ASMSUN 3 (Record) and SAMSUN 4 (funtua).

Snedecor, G. W. and Cochran W. G. (1980). Statistical methods. 7th edition, Iowa State University Press, Ames, Iowa.

Srimuenwai, P. (2006). Improvement of agronomic characters, oil content and yield of synthetic varieties of sunflower. Unpublished M.Sc. thesis. School of Crop Production Technology, Institute of Agriculture, Suranaree University of Technology, Nakhon Ratchasima, Thailand, p. 80.sunflower. *Helia*, 25(37): 109-118.

Sterjo, (1989). Data on the sowing time and density of plants of sunflower hybrid. Buletini shkencave Bujqsore, 28(1): 27-46.

Suzer, S. (2010). Effect of nitrogen and plant density on dwarf sunflower hybrids . *Helia*, 33(53): 207-214.

Tanimu, B., Ado, S. G. and Tilde, A. U. (1991). Correlation between Morphological Characters of Sunflower Varieties and Seed Yield. *Journal of Agricultural Resources* 29(3).

Tanimu B., Kaigama, B.K., and Hassan, M. G. (1986a). Effect of fertilizer application on stand establishment, growth and yield of sunflower (*Helianthus annuus* L.) at Samaru. Paper at 22nd annual conference of Agricultural society of Nigeria.

Tanimu, B., Kaigama, B. K., and Hassan, M. G., (1986). Effect of time of planting and intra-row spacing on sunflower performance at Samaru. Paper at 22nd annual conference of Agricultural society of Nigeria.

Tisdale, S. L., Nelson, W. L., Beaton, J. D. and Havlin, J. L., (2003). Soil Fertility and Fertilizers. (5th edition). Prentice-Hall of India. Prt Ltd. New Delhi.

Tomar, H. P. S., Dadhwal, K. S., Sing, H. P. (1999). Effect of irrigation, N, and P on yield and yield attributes of spring sunflower (*Helianthus annuus* L.). *Tropical Agriculture*, 76: 228-231.

Toner, B., Fakra, S., Villalobos, M., Warwick, T. and Sposito, G., (2006). Spatially resolvedcharacterization of biogenic manganese oxide production within a bacterial biofilm. Appl. *Environment and Microbiology,* 71:1300-13

Villalobolos, F. J., Sadras, V. O., Soriano, A. and Fereres, E. (1992). Effects of plant population and genotype on sunflower dry matter partitioning and yield. In: *Proceedings of the 2nd Congress of the European Society for Agronomy*, Warwick University, 23-28 August 1992, 9(2): 144-149.

Wabekwa, J. W. (2002). Effect of nitrogen fertilizer and poultry manure rates on growth, yield and yield characters of sunflower (*Helianthus annuus* L.). Unbublished Msc. in Agronomy thesis. Ahmadu Bello University, Zaria .

Wabekwa, J. W., Odion, E. C. and Idem, N. U. A. (2010). Effects of nitrogen fertilizer rates on yield and yield components of sunflower *(Helianthus annuus L.)* at Samaru, Nigeria. *Journal of Arid Agriculture.* 19:159-164.

Wabekwa, J. W., Degri, M. M., Dangari, L. C. (2012). The Effects of Nitrogen Mineral on Yield Performance of Sunflower *(Helianthus Annuus L.)* in Bauchi State, Nigeria. *Journal of Environmental Issues and Agriculture in Developing Countries*, 4: 3.

Wagh, R. G., Therat, S. T. and Mane, M. J. (1991). A role of nitrogen fertilization on quality of sunflower. *Journal*. Maharashtra Agri. Univ. 16:136-7

Wajid, N. and Asghari, B. (2012). Impact of nitrogen and Plant growth promoting rhizobacteria on yield and yield components of sunflower in a glasshouse. *Environment Journal of Crop Science and Biotechnology*, 15(4): 319-324.

Watson, D. J., (1952). The physiological basis of variation in yield. *Advance Agronomy*, 4**:** 101-145.

Wright, S. (1921). Correlation and causation. *Journal of Agricultural Research.* 20: 557-585.

Xiao, S., Chen, S., Zhao, L. and Wang, G. (2006). Density effects on plant height, growth and inequality in sunflower population. *Journal of Integrative Plant Biology*, 48 (5): 513-519.

Yan, W., Hunt, L. A. (2003): Bi plot analysis of multi-environment trial data. In: Kang, MS. (Ed.), Quantitative genetics, genomics and plant breeding. CAB Inter., Wallingsford, Oxon, UK, pp. 289-303.

Yousaf, M., Akhtar, B. and Shakoor, A. (1986). Effect of spacing and nitrogen on the yield and yield components of sunflower under rain-fed conditions. *Helia*, 9:53-56.

Zubillaga, M. M., Aristi, J. P., Lavado, R. S. (2002): Effect of phosphorus and nitrogen fertilization on sunflower (*Helianthus annuus* L.) nitrogen uptake and yield. *Journal of Agronomy and Crop Science*, 188: 267-274.

Zubriski, J. C. and Zimmerman, D. C. (1974). Effects of nitrogen, phosphorus, and plant density on sunflower. *Agronomy Journal*, 66: 798-801.

Appendix I: Weather data /Mean Monthly temperatures, relative humidity, sunshine hours, evaporation and rainfall in 2012 rainy season and 2012/2013 dry season at Samaru.

SAMARU WEATHER
MOTHLY MEAN 2012

MONTH	% RELATIVE HUMIDITY 10 a.m	4 p.m	AIR TEMPERATURE (0C) Max	Min	EARTH TEMP (30cm) 10 a.m (0C)	EARTH TEMP (30cm) 4 p.m (0C)	SUNSHINE HOURS	WIND SPD (km/day) Average	TOTAL RAINFALL (mm)	OPEN PAN EVAPORATION (mm/day)
July	82.61	67.74	30.29	20.06	25.81	26.35	5.26	160.01	165.30	5.82
August	82.32	73.97	29.06	19.45	24.95	25.43	4.48	135.16	426.70	3.25
September	77.23	73.77	30.37	19.80	25.55	25.99	5.02	93.96	270.30	4.70
October	70.23	55.26	33.81	20.80	26.46	27.33	7.32	95.59	79.60	5.31
November	32.90	28.23	34.30	17.43	32.39	26.36	8.59	89.34		5.11
December	20.26	15.65	32.32	16.53	22.36	23.41	8.58	139.94		7.30
January	21.74	17.00	32.48	17.74	23.61	24.93	8.01	142.66		6.82
February	14.93	12.11	35.50	18.79	25.51	26.88	7.49	131.44		8.56
March	38.13	14.61	39.29	22.77	29.48	30.93	7.63	118.24		9.14
April	52.93	24.77	37.47	24.77	30.49	31.72	7.09	143.03	73.80	7.89
May	64.65	50.87	35.39	24.87	29.28	30.33	7.74	188.98	66.50	7.03

Source: IAR Meteorological station, Institute for Agricultural Research, samaru, zaria.

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