EFFECTS OF NITROGEN FERTILIZER AND POULTRY MANURE RATES ON GROWTH, YIELD AND YIELD CHARACTERS OF SUNFLOWER (*Helianthus annus* L.)

BY

WABEKWA, J. WASINANINDA
(MSc/Agric/32442/2001- 2002)

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF SCIENCE DEGREE IN AGRONOMY

DEPARTMENT OF AGRONOMY, FACULTY OF AGRICULTURE AND INSTITUTE FOR AGRICULTURAL RESEARCH, AHMADU BELLO UNIVERSITY, ZARIA

FEBRUARY, 2005

DECLARATION

I hereby declare that the content of this thesis are products of my imaginations, formulations and execution and extraneous source of informations have been duly acknowledged through references and citations. The subject matter herein, therefore, has not been presented in any previous application for the award of a higher degree at the Ahmadu Bello University or any other University.

-- ---------------------

Wabekwa J. Wasinaninda **Date**

The above declaration is confirmed

-- ---------------------

Dr. E.C Odion **Date**

(Major Supervisor)

CERTIFICATION

This dissertation titled “Effects of nitrogen fertilizer and poultry manure rates on growth, yield and yield characters of sunflower (*Helianthus annus L.*)” by Wabekwa .J. Wasinaninda meets the regulation governing the award of Master of Science Degree of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

-- ---------------------

Dr. E.C Odion **Date**

(Chairman, Supervisory committee)

-- ---------------------

Prof. O.O Olufajo **Date**

(Member, Supervisory committee)

-- ---------------------

Dr. E.O Asiribo **Date**

(Member, supervisory committee)

-- ---------------------

Dr. I.U Abubakar **Date**

(Head of Department)

-- ---------------------

Prof. J.U. Umoh **Date**

(Dean, post graduate school
Ahmadu Bello University, Zaria)

DEDICATION

This project is dedicated to my late Uncle, Thamwada. P. Saltiwi whose love and care for me I can never forget. May his reposed soul rest in perfect peace.

ACKNOWLEDGEMENT

I specially wish to express my deep appreciation to my project supervisor, Dr. E.C Odion, and my supervisory committee Professor O.O Olufajo and Dr. O.E Asiribo for their constructive criticism and mode of supervision which encouraged me through; and to Dr. N.U.A Idem, who inspite of his absence from A.B.U still took the pains to correct this drafts and offer some useful suggestions, may God bless them and their families. I am also grateful to Dr. Balarabe Tanimu, the Head of Agronomy Department Dr. I.U. Abubakar and all staff of Agronomy department for their numerous contributions in the course of my academic pursuits.

I am highly indebted to my special friends, Miss Hyellaglari Charles (PP), Captain Rachael and Nerat Josephine Gyang, Mr and Mrs I. M Bobbo for their advice, comfort and courage; Captain and family Isa Gadzama, Z.B Abubakar and Takana Yakubu. I can not also forget Mr Shariffai Aminu, T.K. Tabat, L.Z Dauji, Mrs Amaka, Richard Auta, Patience B. Richard, Emmanuel Fumen, David Udzai, Husseni (Ohinoyi), La'azaraus Gayus and all my classmates.

I can not also forget Miss Nanchin Ali Pollock who took her whole time and strength in typing and correcting the manuscripts. May God also reward her in abundance.

To my parents and Uncle, Mr and Mrs Wasinaninda Wabekwa, Mr and Mrs Sani Wabekwa, I express my special appreciation for their moral, financial supports and prayers. May God bless them in abundance Amen. My younger brothers and sisters, nephews and nieces, Hyellavala, Richard, Modu, Amina, Thlamwada, Ladi, Lami, Grema, Jennifer, Hyellafenda, Ndagulaya, Aliyu and Ijanada and in fact all members of my family deserve special appreciation for their prayers.

Above all I lift my hands in praise to God Almighty whose love saw me through troubled times and needs especially as I moved up and down in a seemingly endless pursuit of this academic work.

ABSTRACT

Field experiments were conducted during the wet seasons of 2002 and 2003 at the research farm of the Institute For Agricultural Research, Ahmadu Bello University, Samaru, Zaria (11^{o} 11'N, 7^{o}38'E) 686m above the sea level in the northern Guinea Savanna ecological zone of Nigeria. The aim of the experiment was to evaluate the effects of four levels of nitrogen fertilizer (0,60,120 and 180 kg ha^{-1}) and four levels of poultry manure (0,10,20 and 30 t ha^{-1}), on the growth, yield and yield characters of sunflower (var. Is'anka). The experiments were laid out in randomized complete block design (R.C.B.D) and replicated three times. Nitrogen fertilizer and poultry manure applied at higher rates of 120 kg and 20 t ha^{-1} respectively significantly increased the growth parameters, particularly plant height and total dry matter per plant over the lower rates in both years and the combined 2002 and 2003 rainy seasons. Stand count at harvest however decreased with increased nitrogen and poultry manure rates from control. The application of nitrogen fertilizer and poultry manure alone or in combination at higher rates of 120 kg N ha^{-1} and 20 t Pm ha^{-1} increased yield characters particularly, head dry weight, head diameter, number of seeds per head and seed yield per head. Poultry manure application significantly increased 100-seed weight more than nitrogen fertilizer when applied alone at 30 t ha^{-1}, while days to 50% flowering reduced with increased poultry manure rates, but was not significantly affected by nitrogen

fertilizer rates in both years and the combined analysis. The application of 20 t Pm ha^{-1} produced significantly higher seed yield per hectare of 4.2 tonnes as against 1.7 tonnes in the control and appeared to be the best nutrient requirement for optimum seed yield of sunflower at Samaru in the northern Guinea savanna agroecological zone of Nigeria. Positive and significant correlations was observed between seed yield and all other characters tested, except days to 50% flowering and stand count at harvest which negatively correlated with seed yield per hectare.

TABLE OF CONTENTS

CHAPTER FOUR: RESULTS

CHAPTER FIVE: DISCUSSION

CHAPTER SIX: SUMMARY AND CONCLUSION

LIST OF TABLES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Origin and Distribution of Sunflower.

Sunflower (*Helianthus annus L.*) belongs to the family of flowering plants called "The compositae" which are characterized by crowding together of individual flowers into a head. It was believed to have originated from Mexico or Peru though some workers traced its origin to the Great Plains of North America (Hurt, 1946). Although the cultivated sunflower (*Helianthus annus)*, variety Macrocarpus D.C was not known to have existed in a wild state, it was yet believed to have come from the Helianthus sub-species, annus which was found in dumbs and vacant plots in Central and Eastern United States and Canada (Heiser, 1954).

Sunflower seeds were found in archeological sites of American Indians dated 200 – 300 years old as food stuff, before the cultivation of corn and colonization of the new world. However, Anon (1976) in his opinion pointed out that sunflower as an economic crop has varied histories as such, dates and places of its first cultivation still remain uncertain.

Sunflower was introduced into Russia in the 18th century by Peter the great (Hurt, 1946). It was developed as a premier oil seed crop in Russia and has widely been accepted throughout Europe (Anon, 1976). It was introduced into Europe by Spanish traders in 1510, to France in 1787, and to Germany in 1925 (Purseglove, 1968). Sunflower 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 shortages of the edible oils and meals (Ogunremi, 1979). It is widely distributed to all parts of the world and has been undertaken by the new world settler as a complementary food, ornamental and as a silage crop in the late 1800 and early 1900 (Anon, 1976).

1.2 Areas of Production

The commercial production of sunflower is globally diversified. The first country to produce sunflower on commercial scale is Russia, which maintains her position with about 4-5 million tones annually (Anon, 1976). The second largest producer is Argentina, and other top producers are Bulgaria, Hungary, Yugoslavia, Turky, South Africa, and Uruguay (Purseglove, 1968, Hurt, 1946). In the tropics, Tanzania tops the production list with about 10-20,000 tonnes annually and this is followed by Kenya and Zimbabwe. Total world area sown to sunflower is about 9 million hectares and very little is grown in Nigeria but production could rise now that some farmers and companies have undertaken the production of sunflower (Tanimu *et al.*, 1988).

1.3 Economic Importance.

Most countries produce sunflower as seeds, which yield excellent light vegetable oil for human consumption and its by-product for animal consumption. Though the seeds may directly be eaten by humans, about 90% of the world total production is crushed for its edible oils (Hurt, 1946). It is relatively a new crop to most parts of the world and has been a major source of vegetable oil second only to soybeans, since its discovery (Chapman and Carter, 1975). A commercial processing of one tonne of sunflower seed for oil yielded about 400kg of oil, 350kg meal and 200kg of hull (Anon, 1976).

Sunflower protein is superior to most vegetable proteins, perhaps comparable with soybeans in terms of digestibility and other biological value, and unlike most other vegetable proteins the protein contents of sunflower is more nearly balanced in essential amino acids and low content of cholesterol. Although deficient in lysine, the net dietary value of sunflower is about 93% as high as the standard egg protein used by the nutritionist (Anon, 1976). Sunflower oil is comparable to olive oil in terms of nutritive, test, colour and keeping (preservation) qualities and has the highest best qualities for cooking, frying, canning, salad oil, margarine making and medicinal purposes. Besides, it contains the glycerides of oleic, palmetic and linoleic acids, and the meals are also rich in minerals and vitamins which are essential in human diet (Hurt, 1946).

The high oils and protein content of sunflower seeds makes it a balanced poultry feed, particularly for the laying birds and the cake containing hull is an excellent feed for the ruminants (Purseglove, 1968). Beside feed value, the heads are used as manures and the hulls which contain about 35-50% of the seeds are good source of fillers in feeds and fertilizers, best used in beddings for livestock and preparations of polishings and abrasives (Martins *et al.*, 1949). Other industrial uses of sunflower include production of soaps, paints, cosmetics and the stalks can be processed for production of pulp in paper industries (Hurt, 1946).

1.4 Fertilizer Application

Although Anon (1976) postulated that sunflower does not require as much inorganic fertilizer as the cereal crops, Putt and Urau (1963) in his opinion stated that for profitable sunflower production and in order to meet the growing demand of sunflower vegetable oil, a judicious use of inorganic fertilizer is necessary. There is great disparity among sunflower growers in various parts of the world with regards to fertilizer use and recommendation. This is largely due to soil and other environmental factors. However, organic manures like farmyard, compost, dungs, and poultry droppings are the best fertilizers for sunflower (Hurt, 1946) were it not for labour involved and insufficient supplies. The best known organic manure is a partially rotted straw containing urine and droppings (faeces) of animals (Cooke, 1967).

Manures supply both major and minor plant nutrients and improve the physical conditions of the soil, infact k, Mg and Cu supplied organically, performed better than N.P.K fertilizers (Cooke, 1967). Boy'd (1959) postulated that 10 tonnes of farmyard manures applied was found to contain N.P.K in the quantity of 17, 10 and 35kg respectively.

Farm yard manure contains all trace elements needed by plants for growth and a combined use of high level of fertilizer with farm yard manure gives a higher yield than can be obtained by fertilizers alone (Bunting, 1963). This may be due to soil physical conditions that are affected by manure application. Application of manure provides ideal environment for germination, seedling growth and nutrient uptake (Bunting 1963).

In sunflower, fertilizer and poultry manure can individually be applied or in combination. Methods of application can be side placement, broadcasting, row or foliar application; in which case the organic fertilizer is applied in liquid form. However organic manure is best applied in open furrows (row application) and allowed to decompose before planting. Also, inorganic fertilizer is better split-applied in order to derive its maximum utilization during the later development stages of the plant, and avoid wastage through leaching (Brady, 1974; Salter, 1938).

1.5 Justification and Objective of the Study

Field studies on the cultivation of sunflower started as far back as 1965 in Nigeria. Results from the preliminary trials so far conducted reveal that sunflower can do well in the derived savanna (Ogunremi, 1979), and the Guinea savanna zone (Tanimu, *et al*., 1988). Although its cultivation in Nigeria now has much promise, yet information on nutrient requirement of sunflower production is limited, despite the Federal government efforts in promoting oil seed production. With sunflower assuming a position of importance due to its high quality vegetable oil, there is the need to carryout more investigation on appropriate production practices which can take advantage of locally available nutrient sources. This work was therefore designed with the following objectives:

1. To determine the effect of nitrogen fertilizer on growth, yield and yield characters of sunflower.
2. To determine the effect of poultry manure on growth, yield and yield characters of sunflower.
3. To study the interaction between nitrogen fertilizer and poultry manure, so as to ascertain the best combination level of both nutrient sources for maximum yield of sunflower.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Effects of Nitrogen Fertilizer Rates on Growth, Yield and Yield Characters of Sunflower

Anon (1980) reported that nitrogen fertilizer is among the most needed nutrients for optimum yield of sunflower, thus he recommended 45 Kg ha^{-1} as ideal. The above recommendation is in conformity with Mahajan (1982) and Partude (1981) who also reported lower nitrogen rates of 40 and 15 kg ha^{-1} respectively for good response of sunflower. Also El-sayed *et al.* (1984) reported that 50kgNha^{-1} is the best for sunflower yield. While Chaudary and Partude (1981) recommended 75 kg N ha^{-1} as ideal for maximum yield, Bhosale *et al.* (1977) was of the opinion that nitrogen increase from 50-70 kg ha^{-1} did not increase yield significantly in sunflower. Maximum seed yield was however achieved by Suraj-Bhan (1978) using 60 kg N ha^{-1} as against higher nitrogen rate of 100 kg ha^{-1} reported by Hera and Toncea (1986). Further more Ogunremi (1979) found that 90 kg N ha^{-1} improved seed yield in sunflower, which is in conformity with Satyanarayan *et al*. (1985), who opined that nitrogen split-applied at 90 kg ha^{-1} increased seed yield. In his finding 71 kg ha^{-1}N was regarded as best by Soliman *et al*. (1981) for optimum yield, as against the recommendation of Narwal and Malik (1986) who reported 79 kg N ha^{-1} for sunflower optimum yield. In a similar report Rai (1983) also made a recommendation of 60 kg N ha^{-1}. On the other hand Tilde (1996) reported that increased nitrogen rates of 60-120 kg ha^{-1} have significantly increased yield in sunflower, which is similar to the findings of Tony (1996) and Lichev *et al.* (1973) who obtained highest seed yield with higher nitrogen rate of 120 kg ha^{-1}. Lichev *et al.* (1973) further recommended an increased nitrogen rate up to 180 kg N ha^{-1} for leached soil, and 200 kg N ha^{-1} where soil natural fertility declines. The above recommendation of 180 kg N ha^{-1} does not contradict the report of Iliev and Vangelova (1975) who confirmed a similar yield increase with increased nitrogen rates.

For yield parameters however Vannozi *et al.* (1990) was of the opinion that 100-seed weight of sunflower increased with increased nitrogen rates up to 200 kg ha^{-1}. The above recommendation contradicts the findings of Tharaprakash *et al* (2002) who reported 1000-seed weight decrease due to high nitrogen level. He further reported that 1000-seed weight increased due to increase in percentage of filled seeds at low nitrogen level. In another separate study Tharaprakash *et al.* (2002) reported 1000-seed weight increase due to good supply of phosphorus. Zibriski *et al.* (1974) however held a contrary opinion when he reported 1000-seed weight increase due to increased nitrogen level. Higher nitrogen rates of 200kgha^{-1} however improved the head diameter than lower rates (Vannozi *et al.,* 1990). Zibriski *et al*. (1974) also reported a similar increase in head size with unspecified higher nitrogen rate.

Beside head size, Tharaprakash *et al.* (2002) reported that seed weight per head depends on the head weight and seed filling. Other researchers like El Midaoui *et al*. (1999) found an increase in number of seeds per head with higher nitrogen level. Rao and Reddy (1995) made a similar recommendation of higher nitrogen rate of 120 kg ha^{-1} for significant increase in seed number per head. The above recommendation is in conformity with the finding of Mathias *et al*. (2003) who reported a positive response of number of seeds to nitrogen rate of 180 kg ha^{-1}, if top-dressed at flowering. Samuel and Werner (1975) also found an increase in number of days to flowering and further recommended a good supply of phosphorus in the presence of nitrogen to enhance early flowering.

Early doses of nitrogen promote vegetative growth in sunflower (Steer, 1983), and significant increase in vegetative growth and plant height due to increase in nitrogen supply was reported by Sarkar *et al.,* (1981), El Midaoui *et al.* (1999) was of the same opinion when he confirmed an increase stem diameter and plant height with increase nitrogen rates. In a different opinion, however, Cooke (1967) reported that high nitrogen rates cause damages to crops in field experiments especially at germination and early growth stage. Tanimu *et al*. (1986) was of the same opinion when he reported a reduction in leaf number at germination at higher nitrogen rates. Chinanda (1975) also confirmed a strong correlation between seed yield and leaf number due to increased nitrogen rates. Similarly, Schelloto (1978) reported decrease in seed yield due to reduction in leaf number especially at bud formation and flowering.

2.2 Effects of Poultry Manure Rates on Growth, Yield and Yield Characters of Sunflower

Manure refers to the dung or wastes from animals or birds that are used to improve soil fertility. It is essentially made up of organic matter that could also improve the soil physical and chemical properties. Beckman (1973) reported that application of farmyard manure increased the organic carbon content of the soil. He further reported a significant correlation between the activities of soil microorganisms, crumb structure, manures, nutrient supply and crop yield. Tinsley and Nowakowski (1959) reported that of all plant nutrients organically obtained, poultry manure gives the best result due to its manurial composition, which may not however be consistent due to many factors. Similarly, Bunting (1963) found that farmyard manure; besides supplying both major and minor plant nutrients also improved the soil physical condition, which made it ideal for germination, seedling growth and yield. Cooke (1967) made mention that poultry droppings contain twice as much nitrogen as farmyard manure and much richer in N.P.K. In their separate work, Anon (1958) and Aliyu (2002b) opined that the nutrient composition of manure depends on the breed and age of animal, the type of feed administered, the bedding material used, the environment, the handling and storage of the manure.

The use of poultry manure on sunflower has not been reported. For effective utilization however, Anon (1958) recommended 10 t ha^{-1} farmyard manure if properly mixed with soil for good crop yield. He further recommended organic manure amendments in order to supplement inorganic fertilizers and improve soil fertility. Jonnes (1973a) mention that organic matter is inherently low in savanna soils as such native nitrogen and phosphorus are equally low. He further opined that though the nutrient content of farmyard manure is relatively low, its however excellent source of organic matter and it is required in higher rates of 20-40 t ha^{-1} to compensate for the low nutrient content. He still stressed that poultry manure supports crops for longer time due to slow release. Abudullahi and Lombin (1978) reported that remarkable returns are obtained from small dressing of farmyard manure, which may largely be attributed to nitrogen and phosphorus, micronutrients or to a lesser extent nitrogen and potassium. Olson *et al.* (1971) reported that higher rates of poultry manure increased most growth parameters in vegetable crops because it contains essential nutrient elements used for photosynthesis and root development. He further made mention that higher rates depressed growth parameters at certain periods. In a similar work, Weil and Kroonje (1979) reported that higher poultry manure rates resulted in phytotoxicity released from ammonia and nitrate salts, which adversely affect soil micro-organisms and soil mineralization. In another development, the use of farmyard manure on other crops have been reported. Alam (2002) recommended 10 t ha^{-1} farmyard manure for good yield. Further more, Samuel and Werner (1975) reported that a good source of phosphorus supply in farmyard manure enhances early flowering and maturity, as well as good seed formation in plants.

2.3 Effects Of Nitrogen Fertilizer and Poultry Manure Rates on Growth, Yield and Yield Characters of Sunflower

The use of nitrogen fertilizer in combination with poultry manure on sunflower has not also been reported. Mathers and Stewart (1981) however recommended a combination of farmyard manure with 84 kg N ha^{-1} for good yield. The above recommendation is in conformity with the findings of Bunting (1963) who reported that high level of nitrogen fertilizer in combination with farmyard manure gave a higher crop yield than can be obtained with inorganic fertilizers alone. Samuel and Werner (1975) also made mention that fertilizers and farmyard manure mixtures generally increase the supply of micro-nutrient elements which can improve crop yield. Other researchers like Hera (1999) found 0.5 kg N ha^{-1} and 1.5 kg P ha^{-1} in mixture with farm yard manure as ideal for seed yield in sunflower if applied at planting. He further opined that a good response of sunflower is achieved with 25 kg N in mixture with 20 t per acre farmyard manure. Farah *et al*. (1981) also reported that 84 kg N ha^{-}

^{1} in combination with phosphorus and farm yard manure is ideal for maximum yield of sunflower.

In vegetable crops however, Ezeakunne (1985) reported that nitrogen and poultry manure increased plant height, number of leaves per plant, plant canopy, total dry matter and fruit yield. In a similar work, Aliyu (2002b) also reported that application of farmyard manure and poultry manure at 5 t ha^{-1}, supplemented with 50 kg N ha^{-1} resulted in high fruit yield. He However observed that high rate of organic manure and fertilizers reduced crop establishment and caused excessive growth. Salim *et al.* (1987) reported that adequate supply of phosphorus increased water conduction ability of the roots which enhances plant growth. Also Kaddar and Shalaby (1985) reported that potassium enhances root and shoot development in sunflower at early growth stage. In their research Mathers and Stewart (1981) reported that the combination of farmyard manure and 84 kg N ha^{-1} increased growth and canopy development in sunflower. Other researchers such as Girase *et al.* (1975) reported that nitrogen and phosphorus fertilizers applied, half at sowing and at 4 WAS increased plant height. He further reported that basal application of 60 kg P_2O_5 ha^{-1} and nitrogen as topdressing, 4 WAS increased vegetative growth and plant height. In a similar research work Johnes (1972) reported dry matter accumulation when sunflower was grown under nitrogen and phosphorus combination than when used individually. Tilde (1996) also reported increased dry matter production due to increased phosphorus application up to 60 kg ha^{-1} . He however reported insignificant increase in dry matter due to increased application of nitrogen and phosphorus in combination. Combined application of N,P and K were found to affect daily sunflower photosynthetic activity (Dorokov and Zabryan, 1981). Similarly deficiency of either Nitrogen or phosphorus was reported to decrease photosymthetic activity and respiration. Nitrogen however appears to have more pronounced effect than other macro-elements on sunflower growth (Tombesi *et al*., 1979).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location

The experiment was conducted during the wet seasons of 2002 and 2003 at the Institute for Agricultural Research Farm, Ahmadu Bello University, Samaru Zaria (11^{o}11'N, 7^{o}38'E) 686m above the sea level in Northern Guinea savanna ecological zone of Nigeria. Different plots of land that were cropped previously to cotton and cowpea in the 2001 and 2002 growing seasons respectively were used for the trial.

3.2 Sample Analysis

Soil samples from the depth of 0-15cm and 15-30cm were taken from the experimental sites at the beginning of the season, and analysed for the following physical and chemical properties: soil pH, cation exchange capacity and exchangeable bases, residual nitrogen, phosphorus and potassium, particle size distribution and textural classes Appendix I. Samples of the poultry manure used in the two years trials were also subjected to analysis to determine the important plant nutrients present and details of the analysis are presented in Appendix II.

3.3 Meteorological Data

Data on rainfall and relative humidity during the 2002 and 2003 growing seasons were obtained on ten days interval from the Institute for

Agricultural Research Meteorological Station, Ahmadu Bello University Samaru and are presented in Appendix III.

3.4 Treatments and Experimental Design

Four levels of nitrogen fertilizer (0, 60, 120 and 180 kg ha^{-1}) and four levels of poultry manure (0, 10, 20 and 30 t ha^{-1}) were applied in a factorial combination which gave a total of 16 treatments and replicated three times. The gross plot size was $18m^2$ consisting of 6 ridges, 0.75m apart and 4m long; while the net plot was the two central ridges which was $6m^2$ in area. Plots were separated by a spacing of 0.5m and blocks (replications) were separated by a discard ridge (0.75m). The treatments were laid out in a randomized complete block design (RCBD).

3.5 Cultural Practices

3.5.1 Land preparation

The experimental fields were ploughed, harrowed and ridged in order to get a fine tilth.

3.5.2 Sowing

Sowing was done on the 5^{th} of August, 2002 and 10^{th} of July, 2003 respectively. Two to three seeds were sown per hole at 25cm by 75cm and later thinned to one plant per stand at two weeks after sowing (W.A.S). This gave a total population of approximately 53,333 plants per hectare. Sunflower seed variety Is'anka was sourced from the Plant Science Department, Institute for Agricultural Research of Ahmadu Bello University Zaria. Is'anka is a shiny black seeded variety which grows to a height of about 135cm and takes about 110 days to mature. It produces fairly large floral heads with an average of about 700 seeds per head and is resistant to lodging and draught (Danbaki, 2002).

3.5.3 Application of fertilizer and manure

Nitrogen fertilizers was split-applied in two equal doses at the appropriate rates. The first application was done at 2 weeks after sowing (WAS) and the second application was done 6 week after sowing (WAS) using side placement method. Poultry manure was applied in a single dose at appropriate rates, by drilling in rows and allowed to decompose seven days before sowing.

3.5.4 Weed control

Hand weeding was done at 2 and 6 weeks after sowing (WAS) in both trials. A third weeding at 8 WAS was carried out in the second year (2003) due to weed proliferation. Remoulding of ridges was carried out as the last weeding operation at the end of September and August, 2002 and 2003, respectively.

3.5.5 Pest and disease control

In both seasons no serious disease outbreak was recorded, except for insect pests particularly crickets which reduced plant stands at the early growth stages in both years. The most serious pests were birds especially during the second year which fed on the matured seeds prior to harvest thereby reducing the seed counts per head.

3.5.6 Harvesting

The crop was harvested when it attained full maturity, but before the heads were completely dried to avoid losses to mechanical shattering. Physiological maturity in the crop was indicated by yellowing of the inner bracts and browning and withering of the outer bracts. The crop was manually harvested by the end of November and October, 2002 and 2003 respectively. This was done by cutting the heads using knife and properly sundried in order to facilitate easy threshing. The dried heads were later gathered, threshed in bags and winnowed to separate the seeds from chaff.

3.6 Observation and Recording of Data

Observation and recordings of data for the growth parameters started at 4 weeks after sowing (WAS) and continued at the intervals of 3 weeks. The following parameters were considered in the experiment.

3.6.1 Plant height

Height of five tagged plants was measured from discard ridges using metre rule and average height computed for each plot.

3.6.2 Total dry matter per plant

The total dry matter was determined by sampling 4 plants per plot from the sampling routes oven-dried at 70°C to a constant weight and weighed on a mettle balance P1210. Average total dry matter for each plot was later computed.

3.6.3 Number of days to 50% flowering

This was done by daily inspection of the plants in the field. Number of days taken by plants to attain 50% flowering from sowing were counted and recorded for each plot.

3.6.4 Stand count at harvest

Stand count at harvest was taken at maturity by counting total number of plant stands per plot.

3.6.5 Head dry weight

Ten randomly selected heads from each plot were oven-dried at 70°C to a constant weight and weighed on a mettle balance P1210. The dry weight per head was later computed from the average of ten heads.

3.6.6 Head diameter

The head diameter was determined at the crop maturity but before the head was completely dried, the diameter of ten randomly selected heads from the net plot was measured using a metre rule. Head diameter per plant was obtained from the average of the ten heads, for each plot.

3.6.7 Number of seeds per head

The seeds from the threshed head above were carefully counted, and the number of seeds per head were obtained from the average of the ten heads for each plot.

3.6.8 100 – Seed weight

One hundred seeds from each plot were selected at random and weighed on a sensitive mettle balance P1210.

3.6.9 Grain yield per head

Ten randomly selected heads from the net plot were properly sundried, threshed and winnowed. The seeds from the ten heads were then weighed and the value divided by ten to determine the grain yield per head for each plot.

3.6.10 Seed yield per hectare

Heads from the net plots were separately threshed and winnowed and the seeds were then weighed to obtain seed yield per plot. The values obtained were further extrapolated to obtain the yield per hectare for each plot.

3.7 Data Analysis

The data were subjected to statistical analysis of variance (ANOVA) in order to determine the level of significance of the treatment means as described by Snedecor and Cochran (1967), and Duncans Multiple Range Test-DMRT (Duncans, 1955), to test the differences between the significant treatment means. Correlation coefficient analysis was also carried out to determine the relationship between the growth characters, yield components and their quantitative contributions to seed yield.

CHAPTER FOUR

RESULTS

4.1 Plant Height

Mean plant height in 2002 and 2003 wet seasons was significantly influenced by nitrogen fertilizer and poultry manure rates.

In 2002, plant height generally increased with increasing nitrogen rates up to 180 kg ha^{-1} which was significantly higher than all other nitrogen rates at 7 and 10 WAS. However at 13 WAS the difference in mean plant height at 120 and 180 kg ha^{-1} was not significant and at 4 WAS there was no significant deference between all nitrogen rates, except at 180 kg N ha^{-1}. Similarly, plant height increased with increase in poultry manure rates up to 30 t ha^{-1} throughout the sampling period. The difference in plant height between 20 and 30 t ha^{-1}, at 7 and 13 WAS, and 0 and 10tha-^{1} at 4,7 and 13 WAS was however not significant (Table 1). In 2003 plant height also increased significantly with increasing nitrogen rates up to 120 kg ha^{-1} after which further increase did not increase the height of plant at 7 and 10 WAS. At 4 WAS however mean plant heights at 60 and 120 kg ha^{-1}N and control were statistically similar. The application of higher poultry manure rates (20 and 30 t ha^{-1}) increased plant height significantly compared with the control throughout the sampling period. There was no statistical difference in plant height between 20 and 30 t ha^{-1} throughout the sampling period (Table 2).

In 2002 season at 4 WAS plant height significantly increased as poultry manure rates increased at all nitrogen levels. There was also increase in plant height with increased nitrogen rates at 10 and 20 t Pm $ha^{-}1$ but the difference between other manure rates at 60-180 kg N $ha^{-}1$ were not significant (Table 3).

In 2003 season at 10 and 12WAS plant height significantly increased as poultry manure rates increased at all nitrogen levels. At 10 WAS the differences were not significant between 10-30 t pm ha^{-1} at 120 and 180 kg N ha^{-1} and control. Similarly, plant height increased with nitrogen increase at all manure rates but the difference between 60-180 kg N ha^{-1} were not significant at 20 and 30 t Pm ha^{-1} (Table 4). At 13WAS the difference between 10-30 t Pm ha^{-1} at all nitrogen rates and between 60-180 kg N ha^{-1} at 10-30 t Pm ha^{-1} were not significant (Table 5).

4.2 Dry Matter Per Plant

There were significant differences between the mean total dry matter per plant as influenced by nitrogen fertilizer and poultry manure rates throughout the sampling periods in both seasons.

In 2002 wet season, increased nitrogen rate up to 180 kg ha^{-1} significantly increased the total dry matter per plant throughout the period of sampling and least dry matter was recorded with the control. At 4WAS however the mean dry matter at 60 and 120 kg ha^{-1} nitrogen and control were statistically similar. Similarly, total dry matter increased throughout

Table 1: Effect of nitrogen fertilizer and poultry manure rates on sunflower plant height (cm) at Samaru, 2002 wet season

Treatment	**Weeks after sowing**			
Nitrogen rate (kg ha^{-1})	4	7	10	13
0	19.8 b	74.3 c	98.7c	112.4 c
60	19.5 b	75.2 c	124.4 b	142.2 b
120	19.5 b	85.5 b	126.0 b	141.1 b
180	23.0a	102.0 a	145.5 a	164.7a
SE ±	0.30	2.20	3.09	3.76
Sig	*	**	**	**
Poultry manure rate (t ha^{-1})				
0	18.8 c	75.2 b	104.9 d	120.4 b
10	19.5 c	77.3 b	117.4 c	130.5 b
20	23.5 b	89.1 a	131.2 b	153.8 a
30	24.9 a	95.5 a	141.2 a	158.6 a
SE ±	0.30	2.20	3.09	3.76
Sig	**	**	**	**
Interaction				
N x Pm	*	NS	NS	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

* = Significant at 5% ** = Significant at 1%

NS = Not significant

Table 2: Effects of nitrogen fertilizer and poultry manure rates on sunflower plant height (cm) at Samaru, 2003 wet season

Treatment	**Weeks after sowing**			
Nitrogen rate (kg ha^{-1})	4	7	10	13
0	24.1	106.6 b	140.1 c	147.4 c
60	24.7	103.1 b	157.3 b	184.3 b
120	24.4	110.7 a	179.1 a	191.6 b
180	26.6	116.8 a	184.6 a	204.7 a
SE ±	2.20	4.83	3.74	3.77
Sig	NS	*	**	**
Poultry manure rate (t ha^{-1})				
0	25.3b	89.3 b	135.4 c	155.4 b
10	26.4 ab	102.7 b	165.1 b	185.5 a
20	30.6 a	121.5 a	178.6 a	191.3 a
30	34.6 a	123.7 a	182.0 a	195.7 a
SE ±	2.20	4.83	3.74	3.77
Sig	*	**	**	**
Interaction				
N x Pm	NS	NS	*	*

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

* = Significant at 5%   ** = Significant at 1%
NS = Not significant.

Table 3: Interaction between nitrogen fertilizer and poultry manure rates on sunflower plant height (cm) at 4WAS at Samaru, 2002 wet season

	Poultry Manure rates (t ha^{-1})			
Nitrogen rates (kg ha^{-1})	0	10	20	30
0	18.0c	18.0c	22.0 b	23.3 b
60	18.6cd	18.6cd	23.0 b	25.0 a
120	18.6cd	20.0cd	24.0 a	25.3 a
180	21.0bc	22.0 b	25.3 a	26.0 a
SE ±		0.61		

Means followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

Table 4: Interaction between nitrogen fertilizer and poultry manure rates on sunflower plant height (cm) at 10WAS at Samaru, 2003 wet season

	Poultry Manure rates (t ha^{-1})			
Nitrogen rates(kg ha^{-1})	0	10	20	30
0	101.7 f	152.1 e	155.8c-e	150.8e
60	107.5 f	155.0 de	178.8ab	187.9ab
120	156.7c-e	176.6a-c	187.9ab	192.1ab
180	175.8 b-d	176.7 a-c	191.23ab	197.9a
SE ±		7.49		

Means followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

Table 5: Interaction between nitrogen fertilizer and poultry manure rates on sunflower plant height (cm) at 13WAS at Samaru, 2003 wet season

	Poultry Manure rates (t ha^{-1})			
Nitrogen rates (kg ha^{-1})	0	10	20	30
0	107.1d	152.5c	163.3c	166.6c
60	151.7c	188.8b	196.2b	200.4ab
120	166.7c	196.6ab	202.1ab	201.2ab
180	196.3b	196.7ab	207.9ab	217.9a
SE ±		7.55		

Means followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

the period of sampling with poultry manure increase up to 30 t $ha^{-1.}$ At 10 and 20 t Pm ha^{-1} however mean dry matter per plant were statistically similar at 4WAS (Table 6). In 2003 rainy season, dry matter also increased with increasing nitrogen rates up to 180 kg ha^{-1}which was significantly higher than other nitrogen rates and control, throughout the period of sampling. At 4WAS however the difference in mean dry matter between 60 and 120 kg N ha^{-1} and control were not significant. Similarly, total dry matter per plant increased significantly with increased poultry manure rates and at 30 t Pm ha^{-1} dry matter per plant were significantly higher than all other poultry manure rates and control at 4,7 and 13WAS. Mean dry matter between 10 and 20 t Pm ha^{-1} at 4WAS and between control and10 t Pm ha^{-1} at 7WAS were not significant. At 10WAS however, dry matter per plant at 20 and 30 t ha^{-1} were statistically at par, but higher than the control and 10 t Pm ha^{-1} which were not also statistically different (Table 7).

Dry matter per plant generally increased with increased interaction in both seasons. At 4 WAS in 2002 season, except at 30 t Pm h^{-1} and 180 kg N ha^{-1} the difference was not significant between 10-30 t Pm ha^{-1} at all nitrogen rates. Also the differences between all nitrogen rates at 0 t Pm $ha^{-}1$ were not significant (Table 8). At 7WAS there was no significant difference between 0-20 t Pm ha^{-1} at 0 and 60 kg N ha^{-1}. However there were significant differences between the higher and lower nitrogen rates at 30 t Pm ha^{-1} (Table 9).

At 10WAS in 2003 season however the difference between the higher and lower manure rates at 0 and 180 kg N ha^{-1} were significant. Also the difference between lower nitrogen rates at 10 and 20 t Pm ha^{-1} and between higher nitrogen rates at 20 and 30 t Pm ha^{-1} were not significant (Table 10). At 13WAS there were no significant differences between lower manure rates at all nitrogen level except at 0 kg N ha^{-1}. Similarly the difference between the lower nitrogen rates at 10 t Pm ha^{-1} and between the higher nitrogen rates at 0 t Pm ha^{-1} were not significant (Table 11).

4.3 Days to 50% Flowering

In both years nitrogen had no effect on the number of days to 50% flowering. There were significant reductions in the number of days to 50% flowering with increasing poultry manure rates in both season and the combined analysis. However, the difference between 10 and 20 t Pm ha^{-1} in both season and the combined analysis, and between 20 and 30 t Pm ha^{-1} in 2003 season was not significant (Table 12).

Days to 50% flowering reduced significantly with increased poultry manure rates in 2003 season and the difference between the highest and the lowest rates was not significant (Table 13).

There was also a significant interaction between year, fertilizer nitrogen and poultry manure rates on days to 50% flowering being reduced with increased manure rates. At 120 and 180 kg N ha^{-1} in 2002

Table 6: Effects of nitrogen fertilizer and poultry manure rates on sunflower total dry matter (g) per plant at Samaru, 2002 wet season

Treatment	**Weeks after sowing**			
Nitrogen rate (kg ha^{-1})	4	7	10	13
0	3.2	48.3 d	92.8 d	114.5 d
60	3.2	72.7 c	112.7 c	138.2 c
120	3.2	118.1 b	156.4 b	197.4 b
180	4.0	140.3 a	197.5 a	232.8 a
SE ±	0.17	4.82	5.42	5.81
Sig	NS	**	**	**
Poultry manure rate (t ha^{-1})				
0	1.7 c	63.2 d	95.3 d	117.0 d
10	2.8 b	79.8 c	122.4 c	151.9 c
20	3.0 b	104.8 b	161.3 b	197.8 b
30	3.7 a	131.6 a	180.4 a	216.2 a
SE ±	0.17	4.82	5.4	5.81
Sig	*	**	**	**
Interaction				
N x Pm	*	*	NS	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significant level using DMRT
* = Significant at 5% ** = Significant at 1%
NS = Not significant.

Table 7: Effects of nitrogen fertilizer and poultry manure rates on sunflower total dry matter (g) per plant at Samaru, 2003 wet season

Treatment	Weeks after sowing			
Nitrogen rate (kg ha^{-1})	4	7	10	13
0	3.6	49.3 d	105.8 d	141.2 d
60	3.9	89.5 c	136.8 c	181.9 c
120	3.7	120.5 b	171.6 b	234.8 b
180	4.0	148.8 a	207.0 a	254.9 a
SE ±	0.17	5.38	10.07	6.34
Sig	NS	**	**	**
Poultry manure rate (t ha^{-1})				
0	2.9 c	70.7 c	120.6 b	146.4 d
10	3.6 b	86.1 c	133.8 b	178.8 c
20	3.9 b	114.4 b	184.4 a	234.5 b
30	4.4 a	137.2 a	182.3 a	253.1 a
SE ±	0.17	5.38	10.07	6.34
Sig	**	**	**	**
Interaction				
N x Pm	NS	NS	*	**

Means, within treatment group, followed by the same letter(s) do not differ significantly at 5% significant level using DMRT
* = Significant at 5% ** = Significant at 1%
NS = Not significant.

Table 8: Interaction between nitrogen fertilizer and Poultry manure rates on sunflower total dry matter per plant at 4WAS at Samaru 2002 wet season

Treatment	Poultry manure rate (t ha^{-1})			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	0.7h	0.9h	2.2fg	2.5f
60	0.9h	2.7ef	2.9ef	3.0e
120	2.0gh	3.4bc-e	3.6b-d	3.8bc
180	2.0gh	3.8bc	4.1b	6.1a
SE ±		0.25		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 9: Interaction between nitrogen fertilizer and poultry manure rates on sunflower total dry matter per plant at 7WAS at Samaru, 2002 wet season.

Treatment	Poultry manure rate (t ha^{-1})			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	25.9h	37.9h	50.4gh	79.0de
60	57.2g	60.6fg	85.0de	88.1de
120	74.3ef	98.4d	119.7c	182.4a
180	95.2d	122.5c	161.0b	189.2a
SE ±		6.83		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 10: Interaction between nitrogen fertilizer and poultry manure rates on sunflower total dry matter per plant at 10WAS at Samaru, 2003 wet season.

Treatment	**Poultry manure rate (t ha^{-1})**			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	56.2g	76.3fg	114.4e	124.4e
60	71.6fg	81.0f	129.6e	168.4d
120	89.6f	120.4e	197.8bc	222.2a
180	154.4d	193.3c	216.6ab	221.2a
SE ±		7.67		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 11: Interaction between nitrogen fertilizer and poultry manure rates on sunflower total dry matter per plant at 13WAS at Samaru, 2003 wet season

Treatment	**Poultry manure rate (t ha^{-1})**			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	79.6h	125.4g	152.6gf	207.2f
60	129.6g	132.9g	202.9f	262.2b-d
120	141.8gf	203.4f	249.7de	282.0b
180	234.7ef	253.4c-e	278.4bc	315.6a
SE ±		8.97		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

and at 120 kg N ha^{-1} in 2003 the application of 30 t ha^{-1} poultry manure promoted early flowering than all lower manure rates.At 20 and 30 t Pm ha^{-1} no significant differences in days to 50% flowering at all nitrogen rates was observed in both years. When poultry manure was not applied 180 kg N ha^{-1}in 2002 and 120 kg N ha^{-1}in 2003 delayed flowering as compared to other manure rates (Table 14).

4.4 Stand Count at Harvest

Mean stand count at harvest was highly influenced by nitrogen fertilizer and poultry manure rates in both years and combined analysis. Stand count generally decreased with increasing nitrogen rates from 0-180 kg N ha^{-1}. At control (0kg) and 60 kg N ha^{-1}, mean stand count were at par and significantly higher than 120 and 180 kg N ha^{-1} in both seasons and combined analysis. Similarly, mean stand counts at harvest decreased with increasing poultry manure rates and was statistically higher at 0 and 10 t ha^{-1} poultry manure than other rates, which were also at par in 2003 season and combined. In 2002 wet season however each increase in poultry manure rate decreased stands count at harvest significantly (Table 15).

Stand count was significantly influenced by the interactions between nitrogen and poultry manure rates, which decreased as poultry manure rates increased at all nitrogen rates. Similarly stand count decreased as nitrogen rates increased but the difference between 180 kg

Table 12: Effects of nitrogen and poultry manure rates on days to 50% flowering on sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	72.8	72.7	72.7
60	73.0	73.5	73.2
120	72.5	73.2	72.8
180	72.9	73.0	72.9
SE ±	0.59	0.57	0.41
Sig.	NS	NS	NS
Poultry manure rate (t ha^{-1})			
0	75.7a	75.8a	75.7a
10	73.5b	73.0b	73.2b
20	72.0b	72.5bc	72.2b
30	70.0c	71.0c	70.5c
SE ±	0.59	0.57	0.41
Sig.	**	**	**
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	NS	*	NS
Y x N x Pm	-	-	*

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 13: Interaction between nitrogen fertilizer and poultry manure rates on days to 50% flowering of sunflower at Samaru, 2003 wet season

Treatment	Poultry manure rate (t ha^{-1})			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	76.3ab	74.0a-c	74.0a-c	70.0cd
60	75.3ab	74.0a-c	70.6cd	70.6cd
120	78.0a	74.0a-c	71.6cd	71.0cd
180	78.6a	73.6bc	73.6bc	69.3d
SE ±		1.14		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 14: Interaction between Year, Nitrogen fertilizer and Poultry Manure rates on days to 50% flowering on sunflower at Samaru 2002 and 2003 wet season

Treatment		Poultry manure rate (t ha^{-1})			
Y x Nitrogen rate (kg ha^{-1})		0	10	20	30
2002	0	76.3ab	74.0b-d	71.0de	70.0e
	60	73.6b-d	74.0b-d	72.0c-e	70.6de
	120	75.0ab	74.0b-d	71.6c-e	69.3e
	180	78.0a	74.0b-d	71.6c-e	69.3e
2003	0	76.3ab	74.0b-d	70.6de	70.0e
	60	75.3ab	74.0b-d	70.6de	71.0de
	120	78.0a	74.0b-d	71.6c-e	69.3e
	180	73.6b-d	74.0b-d	72.0c-e	71.0de
	SE ±		1.17		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

N ha^{-1} and other rates at 0 t Pm ha^{-1} and between lower and higher rates at 20 and 30 t Pm ha^{-1} were significant (Table 16).

4.5 Head Dry Weight

Head dry weight per plant increased with increasing nitrogen and poultry manure rates in both seasons and in the combined analysis. At higher nitrogen rates of 120 and 180 kg ha^{-1} head dry weights were statistically at par and significantly higher than the control and 60 kg N ha^{-1}. In the combine analysis however the mean head dry weight at 60 kg ha^{-1} N was statistically higher than the control. Similarly, dry weight per head increased significantly with increasing poultry manure rates up to 20 t ha^{-1} in both seasons and the combined analysis after which there was no significant increase and in the 2002 wet season head dry weight at 10 and 30 t ha^{-1} poultry manure was also at par (Table 17).

In 2002 season and the combined analysis head dry weight increased with increased poultry manure rates up to 20 t ha^{-1} at all nitrogen level but the difference between 20 and 30 t pm ha^{-1} were not significant at 60 and 180 kg N ha^{-1} in 2002 season and at 120 and 180 kg N ha^{-1} in the combined analysis. Similarly head dry weight increased with increase nitrogen rates up to 120 kg ha^{-1} at all manure rates and the difference were not significant between 120
and 180 kg N ha^{-1} except at 20 t Pm ha^{-1}in 2002 season and the combined analysis (Tables 18 and 19).

Table 15: Effects of nitrogen fertilizer and poultry manure rates on stand count of sunflower at harvest, at Samaru, 2002 and 2003 wet seasons.

Treatment Nitrogen rate (kg ha^{-1})	2002	2003	Combine
0	71.8 a	71.4 a	71.6 a
60	72.9 a	64.5 ab	68.7 a
120	61.2 b	55.5 bc	58.4 b
180	57.4 b	51.9 c	54.6 b
SE ±	1.86	3.11	1.81
Sig	**	*	**
Poultry Manure rate (t/ha)			
0	77.9 a	73.7 a	75.8 a
10	72.2 b	69.1 a	70.7 a
20	60.9 c	54.0 b	57.5 b
30	52.3 d	46.4 b	49.3 b
SE ±	1.68	3.11	1.81
Sig	**	**	**
Interactions			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	NS
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.
NS = Not significant   * = Significant at 5%   ** = significant at 1%

Table 16: Interaction between nitrogen fertilizer and poultry manure rates on stand count of sunflower at harvest at Samaru, 2002 wet season.

Treatment		**Poultry manure rate (t ha^{-1})**		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	83.3 a	77.6a-c	70.0cd	64.3 de
60	81.3 ab	73.3bc	68.6cd	64.0de
120	74.3 a-d	69.6cd	57.0f	45.3 gh
180	72.6 b-d	68.3cd	48.0fg	35.6 h
SE ±		3.73		

Means followed by the same letter(s) do not differ significantly at 5% significance level using DMRT.

There was also a significant interaction between year and nitrogen fertilizer on head dry weight in the combined analysis. In 2002 each increase in nitrogen rates increased head dry weight significantly up to 120 kg N ha^{-1}, after which there was no significant increase in head dry weight. In 2003 season on the other hand nitrogen increased head dry weight up to 60 kg N ha^{-1} only. Further increase in nitrogen rates had no significant effect on head dry weight (Table 20).

4.6 Head Diameter

Nitrogen fertilizer and poultry manure rates significantly influenced the head diameter of sunflower in both seasons and the combined analysis. All plots that received nitrogen fertilizer produced similar head diameter that was significantly wider than the control in 2002 season, while in 2003 season both 120 and 180 kg N ha^{-1} were similar and had significantly wider heads than 60 kg N ha^{-1} and the control. In the combined analysis head diameter increased significantly with increasing nitrogen rates up to 120 kg ha^{-1} which was not different from 180 kg N ha^{-1} but higher than control and 60 kg N ha^{-1}. In 2002 season, head diameter was similar for all plots that received poultry manure but was significantly higher than the control. However, in 2003 season and the combined analysis, head diameter increased significantly with increasing manure rates up to 20 t ha^{-1} after which the difference was not significant. In the combined analysis, however the difference in diameter of the

Table 17: Effects of nitrogen fertilizer and poultry manure rates on head dry weight (g) per plant of sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	216.0b	344.0b	280.0c
60	254.5b	348.3b	301.4b
120	346.7a	397.5a	372.1a
180	299.5a	393.6a	346.5a
SE ±	25.56	7.61	13.34
Sig.	*	**	**
Poultry manure rate (t ha^{-1})			
0	178.5c	289.9c	233.7c
10	257.3b	376.7b	317.0b
20	354.5a	400.2a	377.4a
30	304.1ab	417.5a	360.8a
SE ±	25.56	7.61	13.34
Sig.	*	**	**
Interaction			
Y x N	-	-	*
Y x Pm	-	-	NS
N x Pm	*	NS	**
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 18: Interaction between nitrogen fertilizer and poultry manure rates on head dry weight (g) per plant of sunflower at Samaru, 2002 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	66.6h	193.6g	343.3bc	260.3d-g
60	186.6g	211.3fg	455.6a	419.3a-c
120	223.0e-g	319.3c-e	425.3ab	275.0d-g
180	200.0g	238.0e-g	305.0d-f	275.0d-g
SE ±		36.15		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 19: Interaction between nitrogen fertilizer and poultry manure rates on head dry weight (g) per plant of sunflower at Samaru, 2002 and 2003 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	129.5g	278.1d-f	400.5ab	312.0c-e
60	231.8f	269.0ef	412.0ab	324.3c-e
120	269.0ef	352.6b-d	454.8a	426.3ab
180	270.8ef	304.8c-f	368.3bc	352.3b-d
SE ±			26.67	

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 20: Interaction between year and nitrogen fertilizer rates on head dry weight (g) per plant of sunflower at Samaru, combined 2002 and 2003 wet season

Treatment	**Year**	
Nitrogen rate (kg ha^{-1})	2002	2003
0	216.0c	274.0b
60	277.4b	348.3a
120	346.7a	397.5a
180	254.5bc	393.6a
SE±	18.86	

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

heads between 30 and 10 t ha^{-1} poultry manure was not significant (Table 21).

In the interaction, head diameter significantly increased with increase manure rates at all nitrogen level but the difference between the highest and the lowest head diameter were not significant in 2002 season and the combined analysis. Similarly head diameter increased with increased nitrogen rates at all manure rates except at 20 t Pm ha^{-1} where the difference in head diameter between all nitrogen rates in 2002 season and between 0 and 60 kg N ha^{-1} at 0-20 t Pm ha^{-1} in the combined analysis were not significant (Tables 22 and 23).

4.7 Number of Seeds Per Head

The number of seeds per head increased with increasing nitrogen rates and the difference between 120 kg N ha^{-1} and the control in 2002, and other nitrogen rates in 2003 and combined analysis were significant. The number of seeds per head increased with increasing poultry manure rates in both seasons and the difference between all the manure rates in both seasons and combined analysis were significant except between 10 t ha^{-1} poultry manure and the control in 2003 season (Table 24).

Number of seeds per head significantly increased with increase in manure rates at all nitrogen level, except at 180 kg N ha^{-1} in the 2002 season and the combined analysis. Similarly, number of seeds per head increased with increase in nitrogen rates at all manure levels but the difference between the highest and the lowest seed counts at 10 and 20 t

Table 21: Effects of nitrogen fertilizer and poultry manure rates on Head diameter (cm) of sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	15.7b	23.8b	19.7c
60	17.4a	24.4b	20.9b
120	18.5a	25.6a	22.0a
180	17.6a	25.9a	21.7a
SE ±	0.48	0.20	0.26
Sig.	*	**	**
Poultry manure rate (t ha^{-1})			
0	14.6b	22.2c	18.4c
10	17.8a	25.2b	21.5b
20	18.8a	25.9a	22.4a
30	17.9a	26.3a	22.1ab
SE ±	0.48	0.20	0.26
Sig.	**	**	**
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	**
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 22: Interaction between nitrogen fertilizer and poultry manure rates on head diameter (cm) of sunflower at Samaru, 2002 wet season

Treatment		**Poultry manure rate (t ha^{-1})**		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	10.5g	16.0d-f	19.0a-c	15.6ef
60	15.2f	17.5b-e	20.2ab	18.2b-e
120	15.8d-f	18.5a-d	18.4a-d	21.1a
180	16.9c-f	19.2a-c	17.6b-e	16.6c-f
SE ±		0.96		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 23: Interaction between nitrogen fertilizer and poultry manure rates on head diameter (cm) of sunflower at Samaru, combined 2002 and 2003 wet season

Treatment		**Poultry manure rate (t ha^{-1})**		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	14.4j	19.8f-i	23.2ab	20.2f-h
60	18.6ij	21.2d-f	23.1ab	22.0bc-e
120	19.2hi	22.2b-d	22.2b-d	24.6a
180	21.0d-f	22.9bc	21.5cd	21.4c-e
SE ±		0.52		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Pm ha^{-1} were not significant in 2002 season and the combined analysis (Table 25 and 26).

4.8 100-Seed Weights

Weight of 100 seeds was influenced by nitrogen fertilizer, which significantly decreased with increasing nitrogen rates in both seasons and the combined analysis. The application of 60 kg N ha^{-1}produced significantly heavier seeds than 180 kg N ha^{-1} and the control but were statistically similar to 120 kg N ha^{-1} in both season. The difference in weight per 100 seeds between 120 and 180 kg N ha^{-1} and the control was not significant. In the combined analysis there was no statistical difference between all nitrogen rates and the control. However, weight of 100 seeds increased significantly with increase manure rates in both seasons and the combined analysis and the differences between 20 and 30 t ha^{-1} poultry manure were similar but significantly higher than those of 10 t ha^{-1} and the control which were also similar in 2002 season and the combined analysis. In 2003 the applications of 30 t ha^{-1} poultry manure produced heavier seeds than in the control, but were similar to the lower manure rates. (Table 27)

One hundred seed weight significantly increased with increase nitrogen and poultry manure rates, but the difference between the highest and lowest seed weight at 60 kg N $ha^{-}1$ were not significant in 2002 season and the combined analysis. Similarly there were no significant differences between all nitrogen rates at 10 and 20 t Pm $ha^{-}1$

Table 24: Effects of nitrogen fertilizer and poultry manure rates on number of seeds per head of sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	563.5b	848.6b	706.0b
60	654.0ab	1050.0a	852.0a
120	765.2a	1106.3a	935.7a
180	682.0ab	1128.2a	905.1a
SE ±	39.73	65.64	38.36
Sig.	*	*	*
Poultry manure rate (t ha^{-1})			
0	441.2b	903.1b	672.2b
10	718.0a	1049.0ab	883.5a
20	773.0a	1165.0a	969.0a
30	732.5a	1016.0a	924.2a
SE ±	39.73	65.64	38.36
Sig.	**	*	**
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	*
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 25: Interaction between nitrogen fertilizer and poultry manure rates on number of seeds per head of sunflower at Samaru, 2002 wet season

Treatment s		**Poultry manure rate (t ha^{-1})**		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	166.0g	636.0b-e	801.0a-d	540.0ef
60	358.6f	716.0a-d	848.6ab	773.0a-d
120	599.0de	726.6a-d	848.6ab	934.3a
180	641.3b-e	832.0a-c	610.6b-e	682.6b-e
SE ±		79.45		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 26: Interaction between nitrogen fertilizer and poultry manure rates on number of seeds per head of sunflower at Samaru, in the combined 2002 and 2003 wet season

Treatment		**Poultry manure rate (t ha^{-1})**		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	371.1f	795.3b-e	985.0a-c	765.0de
60	655.1e	838.8b-e	995.6ab	962.0b-d
120	777.3c-e	915.0b-d	948.5b-d	1185.8a
180	885.1b-d	965.0b-d	801.8b-e	845.3b-e
SE ±		76.73		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

in 2002 season and at 10 t Pm ha-1 in the combined analysis (Tables 28and 29).

4.9 Seed Yield Per Head

Nitrogen fertilizer and poultry manure rates significantly influenced seed yield per head in both seasons and combined. Yield per head was significantly higher at 120 kg N ha^{-1} in 2002 season and the combined analysis and at 180 kg N ha^{-1} in 2003 season and the difference between 120 and 180 kg N ha^{-1} in 2003 season and combined analysis was not significant, but were higher than 60 kg N ha^{-1} and the control. In 2002 season however the difference between 120 and 180 kg N ha^{-1} was statistically significant and was higher than 60 kg N ha^{-1} and the control which was also at par. Similarly, yield per head was significantly higher at 20 t Pm ha^{-1} in 2002 and at 30 t Pm ha^{-1} in 2003 season and combined analysis and the difference between all manure rates in 2002 and between 20 and 30 t Pm ha^{-1} in 2003 season and combined was not significant (Table 30).

Seed yield per head increased with increase in nitrogen and poultry manure rates but the differences between the higher and lower manure rates at 120 and 180 kg N ha^{-1} were not significant in 2002 season and the combined analysis. However there were significant differences between the higher and lower nitrogen rates at 0 and 10 t Pm ha^{-1} in 2002 season and at 10 t Pm ha^{-1} in the combined analysis (Tables 31 and 32).

Table 27: Effects of nitrogen fertilizer and poultry manure rates on 100-seed weight (g) of sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	7.2b	7.5ab	7.3b
60	7.7a	8.1a	7.9b
120	7.5ab	7.7ab	7.6ab
180	7.0b	7.5b	7.3b
SE ±	0.17	0.20	0.13
Sig.	*	*	*
Poultry manure rate (t ha^{-1})			
0	6.9b	7.3b	7.1b
10	7.1b	7.6ab	7.4b
20	7.7a	7.8ab	7.8a
30	7.8a	8.0a	7.9a
SE ±	0.17	0.20	0.13
Sig.	*	*	*
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	**
Y x N x Pm	-	-	-

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 28: Interaction between nitrogen fertilizer and poultry manure rates on 100-seed weight (g) of sunflower at Samaru, 2002 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	5.3g	6.7d-f	8.0a-c	8.6a
60	7.6a-d	7.6a-d	7.9a-c	8.2ab
120	7.1c-f	7.3b-e	7.7a-d	7.6a-d
180	6.41f	7.3b-e	8.1a-c	6.6ef
SE ±		0.35		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 29: Interaction between nitrogen fertilizer and poultry manure rates on 100-seed weight (g) of sunflower at Samaru, in the combined 2002 and 2003 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	5.9f	7.0de	7.1de	8.4a
60	7.5c-e	7.6c-e	7.6c-e	8.0a-c
120	7.4c-e	7.6c-e	8.3ab	7.7c-e
180	6.9e	8.0a-c	8.1a-c	7.4c-e
SE ±		0.27		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 30: Effects of nitrogen fertilizer and poultry manure rate on seed yield (g) per head of sunflower at Samaru 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	41.4c	61.9b	51.6c
60	45.7c	68.1b	56.9b
120	58.5a	75.0a	66.7a
180	50.5b	76.0a	63.2a
SE ±	2.80	2.34	1.82
Sig.	*	*	**
Poultry manure rate (t ha^{-1})			
0	37.5b	52.9c	45.2c
10	47.9a	70.6b	59.2b
20	56.3a	77.3ab	66.8a
30	54.5a	80.1a	67.3a
SE ±	2.80	2.34	1.82
Sig.	*	**	**
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	**
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% **significant at 1%

Table 31: Interaction between nitrogen fertilizer and poultry manure rates on seed yield (g) per head of sunflower at Samaru, 2002 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	23.3g	40.0ef	61.3ab	41.0d-f
60	36.3g	38.0fg	56.6a-d	52.0a-d
120	44.0c-f	58.3a-c	67.6a	64.3a
180	43.0d-f	55.3a-d	57.3a-c	46.3b-e
SE ±		5.61		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 32: Interaction between nitrogen fertilizer and poultry manure rates on seed yield (g) per head of sunflower at Samaru, in the combined 2002 and 2003 wet season

Treatment		Poultry manure rate (t ha^{-1})		
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	25.9h	51.7e-g	70.5ab	58.4c-f
60	44.8g	49.7g	67.1a-c	66.0a-c
120	49.7g	68.2a-c	76.1a	73.0a
180	56.6d-f	67.4a-c	68.5a-c	60.4b-e
SE ±		3.65		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

4.10 Seed Yield Per Hectare

Nitrogen fertilizer and poultry manure rates significantly affected seed yield per hectare in both rainy seasons and the combined analysis. Yield was significantly higher at 120 kg N ha^{-1} in 2002 season and the combined analysis and at 180 kg N ha^{-1} in 2003 season. The difference between all the nitrogen rates in 2003 season and between 120 and 180 kg ha^{-1} in the combined analysis were not significant. Also there was no statistical difference between 60 kg N ha^{-1} and the control in 2002 season and the combined analysis. Similarly manure increase up to 20 t ha^{-1} in 2002 season and up to 30 t ha^{-1} in 2003 season and the combined analysis significantly increased seed yield per hectare, compared to the control. The difference between 20 and 30 t ha^{-1} manure in 2002 season and the combined analysis and between all manure rates in 2003 season were not significant (Table 33).

Yield increased with increase in poultry manure rates up to 20 t ha^{-1} at all nitrogen levels, after which there were no significant increase in the 2002 season and the combined analysis. Similarly, while there were significant differences between lower and higher nitrogen rates at 10 t Pm ha^{-1} in 2002 season and the combined analysis, there were no significant difference between 60-180 kg N ha^{-1} at 20 and 30 t Pm ha^{-1} in 2002 season and the combined analysis (Table 34 and 35).

4.11 Correlation Studies

There were some significant correlations between growth, yield

Table 33: Effects of nitrogen fertilizer and poultry manure rate on seed yield (kg) per hectare of sunflower at Samaru, 2002 and 2003 wet seasons

Treatment	2002	2003	Combine
Nitrogen rates (kg ha^{-1})			
0	2647.7b	3524.4b	3086.0b
60	2805.6b	3921.2a	3363.4b
120	3471.1a	4264.5a	3867.8a
180	3018.7b	4313.8a	3666.3a
SE ±	156.7	154.1	106.6
Sig.	*	*	**
Poultry manure rate (t ha^{-1})			
0	2126.9c	3288.8b	2707.8c
10	3002.1b	4052.8a	3527.5b
20	3493.5a	4247.8a	3870.6a
30	3320.5a	4434.6a	3877.5a
SE ±	156.2	154.1	106.6
Sig.	**	**	**
Interaction			
Y x N	-	-	NS
Y x Pm	-	-	NS
N x Pm	*	NS	*
Y x N x Pm	-	-	NS

Means, within a treatment group, followed by the same letter(s) do not differ significantly at 5% significance level using DMRT
NS = Not Significant * = Significant at 5% ** significant at 1%

Table 34: Interaction between nitrogen fertilizer and poultry manure rates on seed yield (kg) per hectare of sunflower at Samaru, 2002 wet season

Treatment	Poultry manure rate (t ha^{-1})			
Nitrogen rate(kg ha^{-1})	0	10	20	30
0	1464.6g	2663.0b-e	3892.3ab	2570.6c-f
60	2088.0fg	2400.0ef	3514.6ab	3219.6b-e
120	2409.0ef	3528.6ab	4035.6a	3911.0ab
180	2546.0d-f	3416.6a-d	3456.0a-c	2656.0b-e
SE ±		312.42		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

Table 35: Interaction between nitrogen fertilizer and poultry manure rates on seed yield (kg) per hectare of sunflower at Samaru, in the combined 2002 and 2003 wet season

Treatment	Poultry manure rate (t ha^{-1})			
Nitrogen rate (kg ha^{-1})	0	10	20	30
0	1661.3f	3161.6de	4173.6ab	3347.5cd
60	2638.0e	3181.0de	3831.8a-c	3802.6a-c
120	3074.6de	3907.8a-c	4423.8a	4064.8ab
180	3412.1cd	3859.3b-d	3936.1a-c	3457.3a-d
SE ±		213.17		

Means followed by the same letter(s) do not differ significantly at 5% significance level, using DMRT.

and yield characters in both rainy seasons and combined analysis. In 2002 wet season, there was positive and highly significant correlation ($P \leq 0.01$) between yield per hectare and all yield characters particularly, seed yield per head, head diameter, number of seeds per head and head dry weight. However seed yield per hectare did not significantly correlate with 100-seed weight. Also the correlation between yield per hectare and growth parameters particularly p1lant height and total dry matter per plant were highly significant ($P \leq 0.01$). Days to 50% flowering and stand count at harvest significantly and negatively correlated with yield per hectare, yield characters and growth, except head dry weight which recorded insignificant relationship with stand count at harvest. 100-seed weight did not also correlate significantly with yield per hectare and all other characters considered in this studies, except plat height, number of days to 50% flowering and stand count at harvest.(Table 36).

Similarly in 2003 season, there was positive and highly significant correlation ($P \leq 0.01$) between seed yield per hectare and seed yield per head, head diameter, number of seeds per head, head dry weight, total dry matter per plant and plant height. Also 100-seed weight significantly and positively correlated with yield per hectare, yield per head, head dry weight, head diameter and plant height, but was not significant with number of days to 50% flowering and stand count at harvest. However days to 50% flowering and stand count at harvest negatively correlated with seed yield per hectare and all other characters included in this studies, while there was no significant correlation between days to 50% flowering and stand count at harvest (Table 37).

In the combined 2002 and 2003 seasons there were positive and significantly high correlations ($P \leq 0.01$) between seed yield per hectare and some characters particularly yield per head, 100-seed weight, head diameter, number of seeds per head, head dry weight, total dry matter per plant and plant height. Days to 50% flowering and stand count at harvest also highly and negatively correlated with seed yield per hectare and all other characters considered in this studies, except head diameter and number of seeds per head which did not significantly correlate with days to 50% flowering (Table 38).

Table 36: Matrix of correlation coefficient between growth, yield and yield characters of sunflower in 2002 rainy season

	A	B	C	D	E	F	G	H	I	J
A	1.000									
B	0.971**	1.000								
C	0.185^{NS}	0.159^{NS}	1.000							
D	0.696**	0.634**	1.261^{NS}	1.000						
E	0.726**	0.661**	0.166^{NS}	0.848**	1.000					
F	0.682**	0.678**	0.207^{NS}	0.702**	0.621**	1.000				
G	0.623**	0.639**	0.258^{NS}	0.515**	0.488**	0.623**	1.000			
H	0.412**	0.434**	0.526**	0.458**	0.408**	0.387**	0.755**	1000		
I	-0442**	-0388**	-0.291*	-0.331*	-0.321*	-0.259^{NS}	-0.480**	-0.412**	1.000	
J	0.450**	-0.403**	0.377**	0.377**	0.370**	-0.302*	-0.696**	-0.672**	0.514**	1.000

NS = Not significant
* = Significant at 5%
** = Significant at 1%

A = seed yield per hectare
B = Seed yield per head
C =100-seed weight
D = Head diameter
E = Number of seeds per head

F = Head dry weight
G = Total dry matter per plant
H = Plant height
I = Days to 50% flowering
J= stand count at harvest

Table 37: Matrix of correlation coefficient between growth, yield and yield characters of sunflower in 2003 rainy season

	A	B	C	D	E	F	G	H	I	J
A	1.000									
B	0.881**	1.000								
C	0.391**	0.355*	1.000							
D	0.845**	0.903**	0.352*	1.000						
E	0.572**	0.639*	0.182^{NS}	0.625**	1.000					
F	0.818**	0.882**	0.325*	0.961**	0.596**	1.000				
G	0.536**	0.582**	0.322**	0.687**	0.455**	0.655**	1.000			
H	0.641**	0.695**	0.477**	0.715**	0.586**	0.654**	0.714**	1000		
I	-0.413**	-0.475**	-0.261^{NS}	-0511**	-0.321*	-0.480**	-0.380**	-0.303*	1.000	
J	-0.402**	-0.452**	-0.236^{NS}	0.440**	-0.372**	-0.427**	-0.731**	-0.592**	0.238^{NS}	1.000

NS = Not significant
* = Significant at 5%
** = Significant at 1%

A = seed yield per hectare
B = Seed yield per head
C = 100-seed weight
D = Head diameter
E = Number of seeds per head

F = Head dry weight
G = Total dry matter per plant
H = Plant height
I = Days to 50% flowering
J = stand count at harvest

Table 38: Matrix of correlation coefficient between growth, yield and yield characters of sunflower in combined 2002 and 2003 rainy seasons

	A	B	C	D	E	F	G	H	I	J
A	1.000									
B	0.939**	1.000								
C	0.331**	0.319**	1.000							
D	0.791**	0.814**	0.332**	1.000						
E	0.745**	0.461**	0.254*	0.829**	1.000					
F	0.773**	0.782**	0.302**	0.752**	0.675**	1.000				
G	0.603**	0.621**	0.317**	0.525**	0.503**	0.536**	1.000			
H	0.664**	0.711**	0.512**	0.749**	0.681**	0.597**	0.716**	1.000		
I	-0.344**	-0.336**	-0.261**	-0.199^{NS}	-0.179^{NS}	-0.284**	-0.406**	-0.259**	1000	
J	-0.443**	-0.447**	-0.326**	-o.365**	-0.390**	-0.373**	-0.723**	-0.598**	0.352**	1.000

NS = Not significant
* = Significant at 5%
** = Significant at 1%

A = seed yield per hectare
B = Seed yield per head
C = 100 -seed weight
D = Head diameter
E = Number of seeds per head

F = Head dry weight
G = Total dry matter per plant
H = Plant height
I = Days 50% flowering
J = Stand count at harvest

CHAPTER FIVE

DISCUSSION

5.1 Seasonal Effects on Yield Variation

Yield per hectare, yield characters and growths were all significantly influenced by seasonal variations. Total dry matter production was higher in 2003 than in 2002 season. This could have been due higher soil moisture build-up in 2002 (243.5mm) as against 2003 rainy season (178.2mm), which stimulated weed proliferation and possible leaching of both applied and inherent soil nutrients due to high water table (Appendix I). Also fairly distributed rainfall across the 2003 growing periods significantly influenced yield and yield characters than in 2002 season. Ceasation of rainfall from 7-9 WAS could have caused stressful flowering and impaired seed filling which resulted to hollow seededness (Appendix III). Comparatively higher total organic matter, nitrogen and phosphorus in the manure applied in 2003 wet season which could have favourably promoted plant growth and yield (Appendix II). Also the difference in the soil chemical properties which were comparatively higher in 2003 experimental site and early sowing (3.7.2) could still have favoured yield better in 2003 wet season than 2002 season (Appendix I).

5.2 Effects of Nitrogen Fertilizer Rates on Growth, Yield and Yield Characters of Sunflower

Growth characters generally increased with increase nitrogen rates at 7, 10 and 13 WAS. Plants were significantly taller at higher nitrogen rates of 120-180 kg ha^{-1} and these increases could be attributed to the role of nitrogen in growth and development of plants. The above finding agrees with Brady (1974) who reported that nitrogen is among the most needed essential elements in growth and development of plants. El Midaoui *et al.* (1999) also reported similar increase in plant heights and stem diameter with increase nitrogen rates. Similarly increase in the total dry matter per plant could physiologically be explained by increase nitrogen rates which harnessed vegetative growth and development of merismatic tissues, thereby increasing production of assimilates per unit areas which were partitioned for more growth. The above finding is also in conformity with Tilde (1996), Ilieve and Vangelova (1978) who reported increase in dry matter per plant at higher nitrogen rates of 120 kg ha^{-1}. From the physiological point of view the above finding is still in conformity with Gregory (1917) who suggested that increase in dry weight is a measure of net photosynthetic efficiency of leaves. Further more Blackman (1919) described increase in dry matter as logarithmically and as a measure of compound interest. At 4WAS however similarities in plant height and total dry matter at all nitrogen levels was presumably due to later application of nitrogen fertilizer. Higher nitrogen rates also reduced stand counts at harvest than lower rates and the control and this is due to toxicities and injuries caused by nitrogen fertilizers at early growth stages. This is also in conformity with Cooke (1967) who reported that damages to plants have often been recorded in field experiments due to higher nitrogen rates.

Yield and yield characters also increased with increased nitrogen rates. Yield per hectare was recorded at higher rate of 120 kg N ha^{-1} as against lower rates and the control. This yield increase could be attributed to increase growth and canopy development, which in turn increased the efficiency of energy interception for production of more assimilates which were partitioned to the sink. Tilde (1996) reported similar increase in yield per hectare with increased nitrogen rates of 60-120 kg ha^{-1}. Mathias (2003) and Vannozi *et al.* (1990) also reported similar yield increase with higher nitrogen rates of 180 and 200 kg N ha^{-1} respectively. Similarly, seed yield per head and head dry weight increased with increased nitrogen rates up to 120 kg ha^{-1} due to production of more assimilates at higher nitrogen rates. Tharaprakash *et al.* (2002) reported similar increases in yield per head, dry weight of head and head diameter of sunflower at higher nitrogen rates. The application of higher nitrogen rates up to 120 kg ha^{-1} also increased head diameter due to production of more assimilates which were partitioned for expansion of the floral head as reported by Vannozi *et al.* (1990) that floral heads increased with increasing nitrogen rates up to 200 kg ha^{-1}. Similarly, number of seeds per head also increased with increased nitrogen rates due to the effects of nitrogen on size of the floral heads. In this study however 100-seed weights decreased with increase in nitrogen rates above 60 kg ha^{-1} presumably due to the fact that higher nitrogen rates promoted hollow seededness and reduced the weight of individual seeds. The above finding supports the findings of Tharaprakash *et al.* (2002) who found similar decrease in weight of 1000 seeds due to increase nitrogen rates.

5.3 Effects of Poultry Manure Rates on Growth, Yield and Yield Characters of Sunflower

The application of poultry manure at higher rates increased growth parameters throughout the sampling periods. Plants were significantly taller at 20-30 t ha^{-1} poultry manure most probably due to increased supply of nutrients that are necessary for growth in the manure applied. Total dry matter also increased due to the fact that the poultry manure supplied elements necessary for vegetative growth and chlorophyll formation, as well as promoting root development which led to efficient food production and conductivity of assimilates and water. The above finding agrees with Olson (1971) who reported that poultry manure contains essential nutrient elements used for photosynthesis and root development thus the application of higher rates increased growth parameters. However increasing poultry manure rates significantly reduced the stand counts at harvest due to phytotoxic effects and injuries caused by manure at germination and at early growth stage. Weil and Krooje (1979) in a similar work reported that the application of higher rates of poultry manure affects soil mineralization and has toxic effects on plants. Olson (1971) also reported that the use of higher poultry manure rates affect growth in plants.

Yield and yield characters also increased with increase poultry manure rates. Increase in weight of 100 seeds could be attributed to the supply of phosphorus in the manure which increased seed filling and reduce hollow seededness. The above finding agrees with Tharaprakash *et al.* (2002) who reported increases in grain filling due to supply of phosphorus which improved the weight of 1000 seeds of sunflower. Number of seeds per head increased with increased poultry manure rates up to 30 t ha^{-1} and this increase could be ascribed to the enlargement of floral heads (diameter) as influenced by higher manure rates. Days to 50% flowering however decreased with increase poultry manure rates, most presumably due to supply of phosphorus, potassium and other nutrient elements associated with early flowering and maturity in plants. The above finding is also in conformity with Samuel and Werner (1975) who reported that good supply of phosphorus enhance early flowering and maturity as well as good seed formation in plants. In this study yield per hectare increased with increase poultry manure rates up to 20 – 30 t ha^{-1} than at lower rates. This yield increase could be attributed to the increased supply of both macro-and micro-nutrient elements as indicated in the analysis of the poultry manure applied. These improved the uptake of these nutrients by the plant resulting in higher growth. In addition, organic manures improved soil physical, chemical and biological conditions all to the improvement of moisture and nutrient supply to the plants resulting in higher yields (Appendix II). Bunting (1963) in a similar finding reported that organic manure supplied both major and minor plant nutrients, improves soil physical conditions and water holding capacity which makes it ideal for germination, growth and yield. Abdullahi and Lombin (1978) also reported that remarkable returns are obtained from small dressings of organic manure, which may largely be attributed to nitrogen, phosphorus, micro-nutrients or to a lesser extent nitrogen and potassium contents.

5.4 Interactions Between Nitrogen and Poultry Manure Rates on Growth, Yield and Yield Characters of Sunflower

Plant height and total dry matter per plant increased with the combination of both factors. These increases could have been attributed to increase mixtures of nutrient elements which caused growth and production of more biomass. The above finding agrees with Ezeakunne (1985) who reported that nitrogen and poultry manure mixtures increased plant height, number of leaves per plant, plant canopy and total dry matter. In these studies poultry manure treated plants increased growth parameters than nitrogen treated plants at 4WAS which could have been due to time of application of nitrogen (3.5.3). Higher levels of the factors reduced stand counts at harvest due to toxicity effects which suppressed germination and reduced plant population as reported by Hera (1999) that increase stand count of sunflower was found with lower mixture rates of 0.5 kg N ha^{-1} and organic manure. In a similar finding Aliyu (2002b) also reported that the use of higher rates of poultry manure and fertilizer mixtures reduced crop establishment due to toxicity effects.

Yield and yield characters increased with increase interactions between the two factors except days to 50% flowering which decreased with increase mixtures of nitrogen and poultry manure most presumably due to increased supply of phosphorus and potassium as reported by Samuel and Werner (1975). Increase in 100-seed weight could best be explained by the use of higher poultry manure rates than the presence of nitrogen fertilizer, which increased the percentage of filled seeds due to phosphorus supply as reported by Tharaprakash *et al.* (2002). Yield per head, head dry weight and head diameter also increased due to steady increase in yield factors and number of seeds per head increased due to increase in head diameter and expansions. Yield per hectare increased up to 4.2 tonnes as against 1.7 tonnes in the control with increased mixtures of poultry manure and nitrogen rates. This increase in yield could also be attributed to steady supply of both macro-and micro-nutrient elements which harnessed good root development and water uptake in the plants. It also provided ideal condition for conductivity of assimilates for seed formation and seed filling. Growth of plants, chlorophyll formation as well as increased plant resistance to lodging was also promoted by the increased supply of the factors, which facilitated unobstructed photosynthesis in the plants. The above findings agrees with Bunting (1963), Mathers and Stewart (1981) who recommended that higher rates of nitrogen fertilizer in combination with organic manure gave higher yield than can be obtained by nitrogen alone.

5.5 Correlation Studies Between Growth, Yield and Yield Characters of Sunflower

There were positive and significantly high correlations ($P \leq 0.01$) between yield per hectare and yield components, particularly seed yield per head, 100-seed weight, head diameter, number of seeds per head and dry weight of heads, which indicated that these parameters significantly contributed to the total yield per hectare. There was a significantly high correlation ($P \leq 0.01$) between head diameter and number of seeds per head as reported by Danbaki (2002), thus there was association between the size of floral head and number of seed per head. Similarly growth characters particularly plant height and total dry matter per plant positively and highly correlated ($P \leq 0.01$) with seed yield per hectare, thus they significantly contributed to yield through photosynthesis which were partitioned for seed production. In this studies however, days to 50% flowering and stand counts at harvest highly and positively ($P \leq 0.01$) correlated with each other, but negatively correlated ($P \leq - 0.01$) with seed yield per hectare and all other characters considered in this studies. Also days to 50% flowering did not significantly correlate with head diameter and numbers of seed per head, thus it has not influenced the expansion of floral heads and number of seeds per head.

CHAPTER SIX

SUMMARY AND CONCLUSION

Field experiments were conducted during the rainy seasons of 2002 and 2003, on the research farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria (11°11'N, 7° 38'E) 686m above sea level in the northern Guinea savanna ecological zone of Nigeria. The purpose of the experiment was to study the effects of nitrogen fertilizer and poultry manure rates on growth, yield and yield characters of sunflower (var. Is'anka) and to determine the nitrogen and poultry manure requirements and their best combination levels for optimum yield.

Four levels of nitrogen fertilizer (0,60,120 and 180 kg ha^{-1}) and four levels of poultry manure (0,10,20 and 30 t ha^{-1}) were tested in different factorial combinations in three replications and were laid out in a Randomized Complete Block Design (R.C.B.D).

Nitrogen fertilizer and poultry manure rates applied at higher rates of 120 kg and 20 t ha^{-1} respectively significantly increased growth parameters particularly plant height and total dry matter per plant. Stand count at harvest however decreased with increasing rates of nitrogen and poultry manure rates from control. Yield parameters particularly seed yield per head, head dry weight, head diameter and number of seeds per head significantly increased with increased nitrogen rates up to 120 kg ha^{-1} than other rates. Weight of

100-seeds however decreased with increased nitrogen rates above 60 Kg ha^{-1}, and days to 50% flowering was not significantly affected by nitrogen rates. Similarly the application of 120 kg N ha^{-1} significantly increased yield per hectare up to 3.9 tonnes as against 3.1 tonnes in the control. Also the application of poultry manure up to 20 t ha^{-1} significantly increased all growth and yield parameters, except stand count at harvest which decreased with increased poultry manure rates. Significant yield increase of 3.9 t ha^{-1} was recorded at higher poultry manure rate of $20tha^{-1}$ as against 2.8 t ha^{-1} yield in the control. At the higher levels of 120 kg N ha^{-1} and 20 t Pm ha-^{1} respectively growth and yield parameters also increased significantly except stand count at harvest, which significantly reduced with increased manure rates. In these studies however it was found that increase in weight of 100-seeds was significantly influenced by increased poultry manure rates than nitrogen increase. Also increased poultry manure rates up to 20 t ha^{-1} significantly increased yield up to 4.2 tonnes as against 1.7 tonnes per hectare in the control which is conclusively the best nutrient level for optimum yield of sunflower in northern Guinea savanna agro-ecological zone of Nigeria.

Correlation studies showed that except for days to 50% flowering and stand counts at harvest all other growth and yield characters considered correlated positively with yield per hectare.

Appendix I: Soil physio-chemical properties of the 2002 and 2003 experimental Sites

Soil properties	2002 rainy season		2003 rainy season	
	0-15	15-30	0-15	15-30
Particle size distribution (%)				
Clay	8	22	10	20
Silt	20	22	20	24
Sand	72	56	70	56
Textural class (U.S.D.A)	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical composition				
pH in water	6.00	5.70	5.30	5.50
pH in 0.01cacl	5.60	5.20	4.80	4.90
Organic carbon%	0.35	0.35	1.17	0.79
Total nitrogen%	0.056	0.056	0.10	0.68
Available (exch.) phosphorus (mg kg-^{1})	12.25	5.25	17.50	6.13
Exchangeable bases (cmol kg^{-1})				
Ca	1.80	2.50	2.50	1.80
Mg	0.45	0.60	0.83	0.70
K	0.27	0.18	0.40	0.52
Na	0.54	0.46	0.54	0.67
Exchangeable acidity				
H+Al	0.10	0.20	0.20	0.10
CEC	4.90	5.60	6.20	5.50

Source: Department of Soil Science, Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria.

Appendix II: Chemical composition of poultry manure used

Chemical element	2002 rainy season	2003 rainy season
Total nitrogen (%)	3.49	3.89
Available phosphorus (%)	1.36	1.47
Potassium (%)	0.986	0.863
Calcium (%)	0.68	0.76
Magnesium (%)	0.064	0.082
Iron (ppm)	2.00	2.20
Manganese (ppm)	85	85
Copper (ppm)	40	20
Zinc (ppm)	55	65

Source: Department of Soil Science, Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria.

Appendix III: Meteorological data showing rainfall and relative humidity at 10 days interval during the 2002 and 2003 growing periods

Month	2002		2003	
	Rainfall(mm)	Rel. Humidity (%)	Rainfall(mm)	Relative Humidity(%)
March	19.9	29.0	-	71.3
April	69.9	68.0	31.0	72.2
May	10.6	79.4	78.0	71.1
June	133.1	85.4	69.2	80.8
July 1-10	22.0	80.6	87.7	81.6
11-20	107.0	80.8	83.3	83.8
21-31	102.6	99.2	59.3	76.6
August 1-10	32.0	90.4	121.7	84.2
11-20	52.6	100.0	235.5	84.1
21-31	117.3	90.3	69.9	83.6
September 1-10	131.2	91.8	111.1	84.1
11-20	62.5	86.5	76.7	81.3
21-30	25.1	79.9	31.7	65.3
October 1-10	125.1	90.6	29.5	69.8
11-20	-	98.1	37.6	74.0
21-31	-	80.8	-	68.5

Source: Meteorological Unit, Department of Soil Science, Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria.

REFERENCES

Abdullahi, B and Ado, S.G (1988). The future of Sunflower as a livestock feed stuff in Nigeria. In Proceedings of the 12th International Sunflower. Yugoslavia P. 349.

Abdullahi, A and Lombin, G. (1978) Sumaru Miscellaneous papers, Institute for Agricultural Research, Ahmadu Bello University, Zaria.

Alam, S.M (2002) Organic Manuring and Agriculture. Action Plan for oil seed Production. National Institute for Agriculture. Tanjodan, Pakistan.

Aliyu, L. (2002b). The effect of organic and mineral fertilizer on growth, yield and composition of pepper (*Capsium annum L.*). *Biological Agriculture and Horticulture* 18:29-36.

Anon (1958). Suggested guide for chemical control of weeds. U.S. Agric Research Services 22-46. 55PP.

Anon (1980) Fertilizers and their application to crops in Nigeria Fertilizer use series No1. Federal Department of Agriculture. Ministry of Agriculture and Rural Development. 73PP.

Beckman, E.O (1973). Organic fertilization in vegetable farming, luxury for necessity. Technical communication on 15 Horticultural society of Nigeria. 29:247.

Bhosale, R.J, B.P Patil and S.S Idahar (1977). Effect of graded levels of nitrogen and phosphorus on yield of sunflower variety, Peredovik under irrigated conditions in Konkan region. *Indian Journal of Agric. Research 13:* 164 – 166.

Brady, N.C (1974). *The nature and properties of soils.* 8th edition. Macmillan Publishing Co inc, New York, United State of America. 524 – 526 PP.

Boy'd, D.A (1959). "Effects of Farm Yard Manure on fertilizer responses" *Journal of Agricultural Science,* Cambridge 52:384 – 391.

Bunting, A. H. (1963). Experiments on organic manure. *Journal of Agric Science* 60:121.

Chaudary, C.S and Partude, J.T (1981) Effects of nitrogen and Phosphorus on seed and oil yield of sunflower. *Indian Journal of Agricultural Science (15):* 141 – 144.

Chinanda, G. (1975). Agronomic Investigation in Sunflower. Field crops Abstract 28: No. 7625.

Cooke, G.W (1967). The Control of Soil Fertility, Macmillan Pub. Co.Inc. P143-167.

Danbaki, J.T (2002). Productivity of Soyabean/Sunflower mixtures as influenced by plant arrangement and population. Unpublished M.Sc thesis school of postgraduate studies Ahmadu Bello University, Zaria Nigeria.

Dorokov, B.L and D.P. Zabryam (1981). Daily dynamics of photosynthetic intensity in sunflower under different mineral fertilization. *Biological Abstracts*.

Duncan, D.B (1955). Multiple range and multiple 'F' test Biometrics II: 1-42.

El Midaoui, M. Benbella, M. Talouizete, A, Berrille, A (1999) Response of sunflower (*Helianthus annus .L.*) to nitrogen and potassium deficiency *International Scientific Journal 22* (30): 139-148.

El-Sayeed M.M, Mohammed L.K and El-Baid M.M (1984). Effects of Plant spacing, nitrogen and phosphorus rates on yield and yield components and oil of sunflower. *Annals of Agric Sci. Moshtohor 21(1)* 251-261.

Ezeakunne, C.D (1985). Effect of nitrogen and phosphorus and farm yard manure on the growth and yield of local garden egg (Solanum gilo) variety "Samaru Stripped". Unpublished M.Sc Thesis, school of postgraduate studies Ahmadu Bello University, Zaria Nigeria.

Farah, M.A Soliman, M.P and Bhakati, H.K (1981) Response of two sunflower varieties to nitrogen and phosphorus fertilization under saline conditions. *Agricultural Research* No. 4:143-155PP.

Girase, P D, Deokan A.B., and G.D. Patil (1975). Studies on the effect of various levels of nitrogen and phosphorus on growth, yield and yield contents of sunflower. *Indian Agriculturalist* 19 (1): 59-69

Heiser C.B (1954). Variation and sub-speciation in the common sunflower. *H. Am Midland Naturalist 51:* 287-305.

Hera, C.R and I. Toncea. (1986). The study of main elements of fertilization system in sunflower (*Helianthus annus.L.*) by means of nitrogen. Scientific Bulletin of F.A.O Research network *Australian Journal of Experimental Agriculture and Animal Husbandry No. 87:* 664-668PP.

Hera, S.G (1999) Response of sunflower to farm yard manure in India. Proceedings of the 21st Sunflower Workshop, Fargo northern Dakota, 1999. P193-197.

Hurt, E.F (1946). The sunflower for food, fodder and fertility. The economic value, worlds expansion and cultivation with particular application to great Britain. Faber and Faber, 1946: 175P.

Iliev, V and Vangelove (1978). Effect of nitrogen and photosynthetic productivity on sunflower. *Soil and Fertilizers* 14 (1): 102 – 109.

Johnes, W.K Olunber (1972). Influence of Nitrogen, phosphorus and potassium fertilizers on dry matter accumulation and distribution in sunflower (C.V Giant white). *Technical communication (2):* 1994.

Jones M.J (1973a). The organic matter content of Savanna soils of West Africa *Samaru Research Bulletin*, 186: 42-53.

Kadar. I, Shalaby, M.H (1985) Effects of Potassium and Boron fertilizer application on the nutrient content of soil and sunflower. *Field crop abstract* 40 (3): 188p.

Lichev, S, Gushevilov. J. and Kuzmanov (1973). The influence of fertilizers on sunflower yield and quality. *Agronomy Journal 63(6)* 501 -504.

Lipp, W.V. (1972). The magnitude and characteristics of damage caused by insects injurious to sunflowers. M.Sc Thesis department of entomology, North Dokota State University, Fargo.

Mahajan, A.G (1982). Effect of split application of nitrogen on yield of sunflower. *Field Corp Abstract* No. 114:1060 P.

Martins J.H, Leonard W.H and Stamp D.L (1976). Principles of field crop Production Macmillan Publishing Company Inc. New York PP 985.

Mathers, A.C. and Stewart, B.A (1981). Sunflower nutrient uptake, growth and yield as affected by nitrogen fertilization and plant population 73rd annual meeting – American society of Agronomy. 183P.

Matias, L, Fernando, O.G, German, A.B, Karina, F and Ruiz, R.A (2003). Nitrogen balance approach to sunflower fertilization. *Soil and Plant Analysis* (3): 17-18

Miller, J.F, Zimmerman, D.C, Vick, B.A and Roath, W.W (1987). Genetic control of high oleic acid content in sunflower oil. *Crop Science* 27:923-926.

Misra D.P and K. Goswani (1976). Soya bean and sunflower for North Bihar. *Indian Farming* 27 (6): 27-28.

Narwal, S.S and Malik, D.S (1986). Growth and yield response of sunflower cultivars to row spacing and nitrogen. *International Journal of Tropical Agriculture* 4:40-45.

Ogunremi, E.A (1979). Effect of sowing date on sunflower performance in south –West Nigeria. *The Sunflower news letter* 3 (4):15.

Ogunremi, E.A (1988). Sunflower in Nigeria, from planting to processing (Research Bulletin). Obafemi Awolowo University (O.A.U) Institute of Agricultural Research and Training, Ife. No. 17:1-15 pp.

Olson, R.A, Army, J.J A, Hanway, J.J and Kilner, V.J (1971). Fertilizer technology and use. Soil Science Society of America Inc. Madison, PP.217.

Partude, J.T (1981): Effects of nitrogen and Phosphorus on seed yield of sunflower. *Indian Journal of Agricultural Science* 15: 141-144.

Purseglove, J.W (1968): Tropical crops, dicotyledons. Longman group, limited, London. 68 P.

Putt, E.D and J. Urau (1963). The Influence of various cultural practices on seed and plant characters in sunflower. *Scientific Agriculture 23*: 384 – 398.

Rai, B. (1983). Strategy for increasing the production of Rabi oil seed in Bihar. *India Farming*. 33: 20-23.

Rao Y.C and Reddy, S.C. (1985). Effects of nitrogen and phosphorus levels at different plant densities on the yield attributes of sunflower. *Journal of Farming System (1)*: 44-47.

Salim M, Rahmatullah S, and A. Sultana (1987). Interactive effects of applied phosphorus and soil moisture on growth of sunflower. Helia. Food and Agricultural Organization Bulletin on Sunflower 10: 53-55 pp.

Salter, R.N (1938). Methods of applying fertilizers in soils and plants, United States Department of Agriculture. Year book of Agriculture, PP546-562.

Samuel, L.T and Werner, L.N (1975). Soil fertility and fertilizers. 3rd Edition, Macmillan Pub. co incorporation. 122-189PP.

Sarkar B.T, Coaldrake P.D Pearson C.J and Canty C.P (1981) Effect of N supply and population density on plant development and yield components of sunflower. *Field Crop Research.* 13(2): 15-19.

Satyanarayan.V. Sarma, M.V and Sentence F (1985). Studies on the level and time of nitrogen application on sunflower. *Madras Agricultural Journal 72:* 708 – 709.

Schelotto, A.L.G De (1978). Effects of artificial defoliation on yield of sunflower. *Sunflower Newsletter* 2 (1): 19-21.

Snedecor, G.W and Cochran W.G (1967) Statistical methods, 6th Edition. IOWA State University Press, IOWA, U.S.A PP. 607.

Soliman, M.E Farah, M.A and Anter, I.M (1981). Response of two sunflower varieties to nitrogen and phosphorus fertilizers under Saline condition. *Agro Chemical* 25:223 – 231.

Steer R.K. (1983). Leaf and floret production in sunflower as affected by nitrogen supply. *Annals of Botany 52* (3): 267-277.

Suraji Bhan (1978). Agronomic Practices for sunflower in Utter Pradesh. *India Farming 26* (3): 66 P.

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 presented at the 22nd annual conference of the Agricultural society of Nigeria held at Ahmadu Bello University, Zaria. PP. 1-5.

Tanimu, B. Ado, S.G and Kaigama, B.K (1988). Agronomic performance and oil content of sunflower in Nigerian savanna, in proceedings of the 12th International conference on sunflower, Yugoslavia. P. 356.

Tharaprakash, N, Sivakumar, S.D. Raja, K and Senthil, K.G (2002). Effects of nitrogen and phosphorus levels, and ratios on seed yield and nutrient uptake on sunflower hybrid DSH-I. *International Scientific Journal 25* (37): 59-68.

Tilde, A.U (1996). Effects of nitrogen and phosphorus on growth and yield of sunflower. Unpublished P.hd Thesis, school of postgraduate studies Ahmadu Bello University, Zaria Nigeria.

Tinsley, J. and Nowakowski; T.Z (1959). The composition of manurial value of poultry excreta, straw droppings, composts and deep litter. *Journal of Science Food and Agriculture* 10:145-167.

Tombesi, L. De.C. Rossi and Indiata (1979). Effect of various condition of chemical fertility on photosynthetic and respiratory processes and on composition of some plant, soils and fertilizer. *Indian Journal of Agriculture* 42 (2): 29-35.

Tony, K.T (1996). Influence of nitrogen rate in sunflower on the effect of nitrogen fertilization in subsequent winter wheat. *International Scientific Journal 19 (25):* 63-69.

Vannozi, G.P. Salera, E. Baldni, M. (1990). Sunflower yield characteristics as affected by weed control, plant density, nitrogen level and sowing date. *Scientific bulletin of the Food and agricultural organization (F.A.O) 13 (13):* 63 – 71.

Weil, R.R and Kroonje, W (1979). Physical conditions of Davidson clay loam after five years of poultry manure application. *Journal of Environmental Quality 18:* 387 – 392.

Zibriski, J.C and Zimmerman, D.C (1974). Effects of nitrogen, phosphorus and plant density on sunflower. *Agronomy Journal 66 (6):* 798 – 801.

ANOVA STRUCTURE

Source	df	ss	ms	f
Single				
r (r-1)	2			
n (n-1)	3			
p (p-1)	3			
n.p (n-1) (p-1)	9			
Error (p.n-1) (r-1)	30			
Total n.p.r-1	47			
Combined				
y (y-1)	1			
r (r-1)	2			
y.r (y-1) (r-1)	2			
n (n-1)	3			
p (p-1)	3			
y.n (y-1) (n-1)	3			
y.p (y-1) (p-1)	3			
n.p (n-1) (p-1)	9			
y.n.p (y-1) (n-1) (p-1)	9			
Error y (p.n-1) (r-1)	60			
Total y.n.p.r-1	95			

Key

* n = Nitrogen
* p = Phosphorus
* r =Replication
*y = Year

BIOGRAPHY

STUDENT'S NAME: Wabekwa, J. Wasinaninda

YEAR OF ADMISSION: 2001/2002 session

IDENFICATION No: MSc/Agric/32442/2001-2002

DATE OF BIRTH: 1st January, 1970

MARITAL STATUS: Single

L.G.A OF ORIGIN: Askira /Uba

STATE OF ORIGIN: Borno

NATIONALITY: Nigerian

PERMANENT ADRESS: Opp. Viewing Centre, Off Askira Road, Bakin Kasuwa Wamdeo, Askira/Uba Local Government Area, Borno State.

CONTACT ADRESS: Gifted School, Off Specialist Hospital Road, Gwagwalada, F.C.T- Abuja
OR G.S.M No. 08027142242

SCHOOL AND INSTITUTIONS ATTENDED, AND QUALIFICATIONS

1. Tudun Wada Primary School Wamdeo, Askira /Uba Local Government Area, Borno State (1976-1982).
   First school Leaving Certificate.
2. Comprehensive Secondary School, Uba, Askira/Uba Local Government Area, Borno State (1982-1987).
   W.A.S.C./GCE O Level Certificate.
3. Remedial programme,
   School of Remedial Studies,
   University of Maiduguri (1987-1988).
4. Part I science programme,
   Faculty of Science,
   University of Maiduguri (1988-1989).

5. Faculty of Agriculture,
   University of Maiduguri,
   B.Sc. (Hons) Agriculture (Second class lower).
   (1987 – 1994).

PREVIOUS RESEARCH WORK UNDERTAKEN

Effects of poultry manure rates on growth and yield of large pepper (*Capsicum frutosence L.*). Unpublished B.Sc Project, Department of Crop Science, Faculty of Agriculture, University of Maiduguri (1994).

POST QUALIFICATION EXPERIENCE

- National Youth Service Corps (N.Y.S.C), Federal Polytechnic Idah, Idah Local Government Area, Kogi State (1994-1995).
- Ministry of Federal Capital Territory, Education Department, Gifted School Gwagwalada, F.C.T. Abuja (1997-Date).