PERFORMANCE OF KENAF (*HIBISCUS CANNABINUS* L.) VARIETIES AS INFLUENCED BY POULTRY MANURE RATE IN THE NORTHERN GUINEA AND SUDAN SAVANNAH

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE IN AGRONOMY

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DECLARATION

I declare that the work in this Dissertation entitled "**Performance of Kenaf (*Hibiscus cannabinus* L.) Varieties as Influenced by Poultry Manure Rate in the Northern Guinea and Sudan Savannah"** has been written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree in any institution and all cited references of published and unpublished literatures have been duly acknowledged.

_________________________ ____________________

Habibu, Aminu Date

CERTIFICATION

The Dissertation entitled 'Performance of Kenaf (*Hibiscus cannabinus* L.) Varieties as Influenced by Poultry Manure Rate in the Northern guinea and Sudan Savannah' by Habibu, Aminu meets the regulations governing the award of the degree of Master of Science in Agronomy (M.Sc. Agronomy) in the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to Almighty Allah, my late father Malam Muhammad Habib Shuaibu and my entire family.

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ABSTRACT

Field trials were conducted during the 2017 wet season at the Research farms of the Institute for Agricultural Research, Samaru and Kadawa to study the "Performance of kenaf varieties as influenced by poultry manure in the Northern guinea and Sudan Savanna". Treatments consisted of three varieties (Ifeken 400, Ifeken D1 400 and Girin danani) and four rates of poultry manure (0, 2, 4 and 6 t ha^{-1}), factorially combined and laid in a Randomized Complete Block Design and replicated three times. The result showed that application of poultry manure rate at 6 t ha^{-1} significantly increase growth parameters such as plant height, number of leaves $plant^{-1}$ and shoot dry weight. Similarly, yield components such as number of seeds $capsule^{-1}$, number of capsule $plant^{-1}$, seed weight $plant^{-1}$, fibre, wood and seed yields ha^{-1} were significantly increased by the application of 6 t ha^{-1} poultry manure at Samaru and Kadawa. Girin danani significantly produced more number of leaves, wider leaf area and higher shoot dry weight than Ifeken 400 and Ifeken D1 400. However, Ifeken 400 variety took shorter days to attain 50% flowering at both locations. High and positive correlations were obtained between fibre,and seed yield and parameters such as plant height and 100 seed weight. Regression analysis showed a linear response to poultry manure rates against fibre, wood and seed yield ha^{-1} at both locations. From the study, application of 6 t ha^{-1} poultry manure resulted in better growth and higher yield in all the varieties. However, Girin danani out yielded the other two varieties in both locations. Therefore, the use of Girin danani and poultry manure at 6 t ha^{-1} can be adopted by farmers in the northern Guinea and Sudan savannah agro-ecological zones to enhance the productivity of kenaf.

CHAPTER ONE

1.0 INTRODUTION

Kenaf (*Hibiscus cannabinus* L.) is a fast growing annual crop of the malvaceae family known for both its economic and nutritional importance. Kenaf is believed to have its origin in Africa (Western Sudan), occurring as early as 4000BC, where diversified forms of its species are widely grown (Mostofa *et al*, 2013, Dempsey, 1975, Kobayashi *et al*. 2003 and Cheng *et al*., 2004). It has been grown for its edible leaves, seeds and fibre which is used in producing twine, rope and sack cloth (Wilson *et al*., 1965 and Le Malieu *et al.,* 1991). It is an erect annual shrub, 1- 4 meters in height, with well-developed tap root, leaves straight and slender stems. It has large cream-colored, flowers characterized by a reddish-purple neck. The seeds are cylindrical or kidney-shaped, pubescent, grey in colour (Purseglove, 1974 and Dempsey, 1975).

Kenaf is adapted to a wide range of soil types, but it thrives best on well drained, sandy loam soils, rich in humus with a pH of 5 to 7, and it is grown within a wide geographical range (Lat 45^0N-$30^{'}$S). It requires ample moisture at its early stage of growth and requires a rainfall of about 600mm distributed over the growing season of 4-5 months (NAERLS, 1993). Most Kenaf varieties are sensitive to photo periods, where maximum growth takes place during the long days that enables the plant to achieve greater vegetative growth before flowering. Kenaf is harvested 3-5 months after sowing, when about 50% of the plants have flowered, at which time the fiber is at its best quality and more easily separable (Baker, 1970).

1.1 Production and importance of Kenaf

Kenaf is the most economically important fiber crop after cotton and jute (USDA, 1986). However, Kenaf has attracted increasing interest from the view point of preserving the global environment and its significantly high rate of CO_2 accumulation (Alexpoulou *et al*, 2000 and Thi bacth *et al*., 2003). Bhangoo *et al*., (1994) reported that kenaf can lower soil salinity and make it more suitable for crop production due to its capacity to remove salt like boron and selenium. Kenaf is specifically grown for its fiber but some varieties have edible leaves (Webber *et a*l., 2002). Its fiber is comparable to jute in luster, although it is coarse, less supple and resistant to rottening. The cordage fiber is used in sacks, mats, carpets, ropes roofing and canvass; while the stalk is used in paper pulp production. The seeds contain about 20% oil which is extracted and used as lubricant and for illumination, soaps, paints and varnishes (Purseglove, 1968). Kenaf is rich in crude protein (14-34% in the leaf and 2-12% in the stalk) and its leaf is used for animal feeds and as human diet, similar to spinach in India, Haiti and Nigeria. As early as 30 days after planting the leaves and the scions of the plant can be consumed by humans (Prakash, 2010, Webber, 1993 and killinger, 1965). The plant is not new in Nigeria, it has been used for making ropes, erecting fence, and as leafy vegetable for human consumption (Aimin, 2006). Although kenaf originated from Africa its production is very low. For example in 2002, the total production in Africa was only 2.9% of the total global production (FAO, 2003). According to the Food and Agricultural Organization(FAO), Kenaf is now commercially cultivated in more than 20 countries, particularly China, India and Thailand, which accounted for 90% of the sown area and more than 95% of the total production in the world (FAO, 2006). However in 2015, India and China accounted for 44% and 29% of the world kenaf production (INFO, 2016). The world's average fibre yield in 1991-1993 was put at 2.02 t ha^{-1}, with Vietnam having the highest average fiber yield of 2.39 t ha^{-1}, while Africa produced only 0.82 t ha^{-1} (FAO, 2003). The potential fiber yield of Kenaf in Nigeria's savannah has been estimated at 1.50-2.50 tha^{-1} (Kumar *et al*., 1985). FAO statistics in (2016) further showed that kenaf production in Nigeria has been fluctuating since 2004 when the development of the crop started receiving attention in Nigeria's agricultural development programmes. Kenaf production peaked in 2005 and started declining between

2007 to 2010. In 2011, production started improving once more and peaked in 2012 after which it started declining gradually till 2015.

The global production and supply of kenaf bast fibre showed that China, India, Vietnam and Africa are major contributors to global production; with China producing 86.1, 86.8, 67.8, 82.3, 79.9 t ha^{-1}, India producing 144.0, 139.7, 120.0, 131.2, and 140 t ha^{-1}, while Africa produced 13.1, 11.2, 11.3, 13.3, and 12.4 t ha^{-1} of kenaf bast fibre between 2012 to 2016, respectively.

1.2 Justification and objectives

The extent to which farmers can depend on inorganic fertilizer is constrained by unavailability of the right type of inorganic fertilizer at the right time and at affordable price, as well as inadequate credit facilities for the farm inputs (Chude, 1999). Hence organic manure could be a better alternative for improved crop production, especially in the Guinea Savannah of northern Nigeria, more so for crops of economic importance (like kenaf) that are not in the limelight economically and have remained a backyard crop grown by small holder farmers in the vicinity of their homes. Poultry manure is relatively cheap, readily available and tends to be better than inorganic fertilizers in terms of good crop yield attainment and improvement of soil physical properties. Indeed, the use of poultry manure as source of nutrients for vegetable crops assuming increasing importance. Similarly, the increasing demand for poultry manure is been ascribed to its health benefits and risk-free characteristic, especially in vegetables and fruits production.

Investigations by Iken and Amusa, (2004) have indicated that Nigerian savannah soils are largely deficient in major essential nutrients like nitrogen, phosphorus and potassium, this situation makes it necessary to supply and enrich the soil with other sources of nutrients such as poultry, cow and goat manures. However, poultry manure has been found to have higher nutrients concentration than cow dung and goat manure. Nutrients elements have specific function in crop growth, development and yield but no single nutrient can give any meaningful plant growth on its own. However in terms of quantity, the amount of poultry manure required in crop production is less compared to that of cow, goat and sheep manure. This makes transportation and handling easier in addition to high nutrient concentration compared to other organic sources (Mubarak, 2014a). In addition, poultry manure is cheaper, easily obtainable and affordable. Hence, this will help poor resource farmers boost their production at less cost compared to inorganic fertilizers. However, like every other crop, kenaf production requires appropriate agronomic practices, coupled with soil nutrient amendment, to improve its productivity and biomass quality. Nitrogen, phosphorus, potassium and water are considered as the major limiting factors in the growth, development and economic yield of this important crop (Glass, 2003; Parry *et al*., 2005). Mineral fertilizers are known to be very rich in nitrogen, phosphorus and potassium that are readily available to plants, but not without detrimental effects. Organic fertilizers in general contain the entire essential nutrient elements in fairly balanced proportion. It also have the ability to release nutrients gradually and can support crops for a long time (Akanbi *et al*., 2010). In Nigeria, research work on poultry manure recommendation for kenaf Production is scanty, hence the need for more investigation on the role of poultry manure in kenaf nutrition to establish a recommended rate for higher productivity. Research conducted using improved varieties were mostly conducted in the rainforest agro-ecology and derived Savannah agro ecological zones of Nigeria. Due to environmental variations experienced across the different agro ecological zones of the country, it is necessary to evaluate the growth and yield of these improved varieties using poultry manure rates in the Savannah agro ecological zones of the country. Improved varieties such as Ifeken 100, Ifeken 400 and Ifeken D1 400 are not easily accessible to farmers in the northern guinea and sudan savannah agro ecological zones and hence, the need to conduct research work using these varieties in conjunction with poultry manure to boost the production of the crop for both small and large scale farmers.

It is in this regard that the study was conducted with the following objectives:

1. To determine the appropriate rate of poultry manure for optimum growth and yield of kenaf varieties

2. To determine the suitable kenaf variety for the northern Guinea and Sudan Savanna agro-ecology.

3. To evaluate the relationship of these factors on the growth and yield/productivity of kenaf.

CHAPTER TWO

2.0 Literature Review

2.1 Organic Manure/ Fertilizers

Organic fertilizers are materials added to the soil to supply the essential nutrients for enhanced plant growth, development and optimum productivity. Un-decomposed materials like straw, organic wastes from industrial wastes, town refuse and sewage sludge is used as organic manure. The best known organic manure is the waste from mixed arable and livestock farming called farmyard manure. Farm yard manure is partially rotted straw containing urine and faeces whereas fully rooted plant remains are usually called compost. FAO (1994) highlighted the role of organic matter in sustaining the fertility of soil for good production of vegetables by enriching the soil with essential nutrients, but best performance is obtained on well drained fertile soil with adequate organic matter content. Organic fertilizer is a very active and important component of the soil. It is the nitrogen reservoir and furnishes a large portion of the soil phosphorus and Sulphur. It protects the soil against erosion and supplies the cementing substances for desirable aggregate soil formation. It loosens the soil from all available organic fertilizer (Tindal, 1983).

In developed countries, the increase in organic farming is due to the increasing demand for organic foods. According to the United States Department of Agriculture USDA,(1986), organic farming is a production system that excludes the use of synthetic fertilizers, pesticides and growth regulators. This has enhanced the use of organic manure which is the sole nutrients source in organic farming. The use of organic source of nutrients is encouraged, even in the developed countries, because it sometimes brings a 10-30% premium in the market price, reduces input cost, improves farm safety, reduces environmental impact and gives a better-functioning agro ecosystem (Anon, 1999 and Schippers, 2000).

2.2 Poultry Manure

Poultry manure is an efficient organic fertilizer that supplies essential plant nutrients and improves the physical properties of the soil, its average nutrients contents are 3.03% N, 2.63% P_2 O_5 and 1.4% K_2O (Reddy and Reddi, 1995). It has been reported that 30% of nitrogen from poultry litter is in urea or ammonium form, and hence readily available to plants (Sunassce, 2001). Poultry manure also improves organic matter, nitrogen, pH, Phosphorus and cation exchange capacity of the soil.

Poultry manure has a fairly high nutrients content when compared with other sources of animal manure, and nutrient analysis indicated that one tonne of manure contains 30 kg ha^{-1} N, 4 kg ha^{-1} P and 24 kg ha^{-1} K, respectively (Kari, 2000). Poultry manure is a good source of major mineral elements that are capable of enhancing soil fertility (Thomas, 1997). The fertility of the soil could be maintained with the addition of poultry manure and manure application to soil may help to arrest soil organic matter decline and soil erosion (Van-camp *et-al,* 2004).To increase production farmers often use inorganic fertilizers. However, the use of these fertilizers to enhance crop production on a long term basis has often led to decline in soil organic matter content, soil acidification, soil physical degradation and consequently soil erosion (Dorey, 1976 and Robert and Robert 2003).

The shortage and high cost of fertilizers have limited their use for crop production among peasant farmers in Nigeria and other developing countries, hence the tendency for increased dependence on the use of organic manure.

Moreover the increasing cost of inorganic fertilizers and untimely supply experienced in recent years make it unaffordable to most farmers. Moreover, the health benefits of organic products are now been emphasized. Thus the use of organic manure is a viable alternative for the maintenance of soil fertility and yield, since it is relatively cheap and available (Mario, 1989). Poultry manure alone or in combination with NPK fertilizer can increase nutrient uptake and fruit yield of okra. Poultry manure also increase soluble ions, total nitrogen, available Phosphorus, manganese and zinc in soils (Ewulu *et al*., 2008). The nutrient content of poultry manure is among the highest of all animal manures and the use of poultry manure as a soil amendment for agricultural crops will provide appreciable quantities of all major macro and micro nutrients in available forms thereby improving the physical and biological properties of the soil which could enhanced crop growth and development.

Due to its sticky nature, poultry manure improves the structure of heavy soils and it neutralizes the acid soil by increasing basic salts such as calcium and magnesium (Abou El-Magd *et al* .2006, Dorey, 1976, Amanullah *et al*. 2010). Poultry manure contains higher nitrogen, calcium, magnesium and potassium than farm yard manure (FYM). Infact, poultry manure is 3-4 times stronger than farm yard manure, thus a small quantity is required compared to other forms of manures (Mario, 1989). It also improves biological activities, soil tilth and soil chemical properties.

2.3 Effect of Poultry Manure on Growth and Yield of Kenaf

The organic matter of the soil can be replenished and maintained by the application of poultry manure as the store house of plant nutrients. Nutrients contained in poultry manure and other organic sources are released more slowly and are stored for longer period in the soil, thereby ensuring longer residual effects, improved root development and higher yield of Kenaf (Sharma and Mittra 1991 and Reddy and Reddi, 1992).

Although research works on the effect of poultry manure on kenaf is scanty, investigation conducted on related crop such as jute mallow and roselle shows that fertilization with poultry manure significantly increased the growth and yield of the crops, where jute mallow plants that received 20 t ha^{-1} of poultry manure had the tallest plants, higher number of leaves per plant, leaf area and butt diameter than the lower values that were obtain from plants which did not receive poultry manure. While the application of 10 and 20 t ha^{-1} of poultry manure produced significantly higher pod, fresh and dry weight of jute mallow than lower rates applied (Atif *et al*., 2015).

Mera *et al*. (2009) reported that increasing poultry manure rate from 0 to 5 t ha^{-1} resulted in significant increase in the number of leaves of roselle but further addition of poultry manure to 7.5 t ha^{-1} did not bring about additional increase in this parameter in 1998 and 1999. The least number of leaves was observed on the untreated treatments. The poultry manure rate of 5 t ha^{-1} produced an average calyx yield of (467.0 kg ha^{-1}) in 1998, the trend was not the same in 1999 where the highest yield corresponded to 7.5 t ha^{-1} with an average calyx yield of (388.3 kg ha^{-1}). While the untreated treatment recorded the lowest calyx yield of (327.2 and 259.3 kg ha^{-1}) in 1998 and 1999 respectively. The application of 2.5 t ha^{-1} poultry manure on roselle produced significantly higher calyx yield ha^{-1} of (600.7 kg ha^{-1}) than, 0 and 5 t ha^{-1} ,which gave a calyx yield of 349.6 and 585.0 kg ha^{-1} (Haruna *et al*., 2011).

The application of poultry manure at 10 t ha^{-1} produced a higher seed yield of (359.9 kg ha^{-1}) of kenaf compared to the application of 20 t ha^{-1} which produce the least seed yield of (312.2 kg ha^{-1}). Similarly, the application of 0-10 t ha^{-1} poultry manure greatly increased the height of kenaf. However, the tallest plant was obtained with the application of 20 t ha^{-1} of poultry manure (Adekunle *et al.,* 2014).

Basri *et al*.(2013) reported that taller plants were produced when 100 g pot^{-1} of poultry manure and zeolite were applied compared to the application of 100 g pot^{-1} of poultry manure mixed with Sandy loam soils of Malaysia which produce the shortest plants of kenaf. Similarly, Akande *et al*.(2011) reported in their findings that application of Ogun rock phosphate and poultry manure at 10 t ha^{-1} gave a mean height of 267.5 and 232.0cm, respectively during the 2006 and 2007 wet seasons, while higher butt diameter of 12.8 and

9.3 cm was obtained by applying the same rate of 10 t ha^{-1} of Ogun rock phosphate and poultry manure in the same seasons.

2.4 Growth and Yield of Kenaf Varieties

Akinrotimi and Okocha (2018) reported that a local kenaf variety produce higher number of capsule per plant, number of seed per capsule and seed yield than AU 2452 (4^{A}), 2QQ (1^{3}) and EX Giwa (34^{1}). They also found out that both Cuba 108 and Tainung 1 had significantly higher 100 Seed weight compared to AU-75 (14^{4}). When several growth and yield characters were investigated in 10 varieties Adeniyan *et al*., (2014), found out that variation in certain characters could be attributed to genotype and environmental interaction among varieties and these varieties performed differently in the three environments that the trials were conducted. They found out that Ifeken D1 400 variety recorded higher values in characters that were investigated in the three environments across the growing seasons. Akande *et al*. (2011) reported that higher relative agronomic efficiency (RAE) was obtained from Cuba 108 in the 2006 and 2007 wet seasons than Tainung 1, while Cuba 108 produced significantly taller plants, higher top, middle and bottom stem diameter than Tainung 1 in both seasons. They found out that Tainung 1 produced higher seed yield than Cuba 108 in both seasons.

Adeniyan *et al*., (2014) reported higher fibre yield from Ifeken D1 400 compared with three other varieties, Ifeken D1 400 and Cuba 108 produced statistically higher wood yield than Ifeken 400 and Tainung 1. Yaghoob *et al*., (2011) reported that KK60 had taller plants than varieties V36 and G4, while variety G4 and KK60, showed greater fresh plant weight, defoliated plant weight, one meter stalk mass and dry one meter stalk mass than variety V36. The results from the trial showed that variety G4 is a more efficient variety of kenaf for biomass production compared to the other two varieties (KK60 and V36). Agbaje *et al*., (2008) tested three varieties of kenaf and found that Cuba 108 and Ifeken 400 had higher plant height, leaf biomass, total dry matter, wood and fibre yield than Ibadan local.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Samaru, (Latitude 11^0 11N Longitude 07' 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 11^0 39 N Longitude 08' 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 wet season (Kowal and Knabe, 1972).

3.2 Treatments, Experimental Design and Plot Size

The treatments consisted of four rate of poultry manure (0, 2, 4 and 6 tons ha^{-1}) and three varieties of kenaf (Ifeken 400, Ifeken D1 400, and Girin danani). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 4m x 3 ($12m^2$) while the net plot was 2 x 3 ($6m^2$).

3.3 Description of Varieties

Ifeken 400 is an improve variety developed by Institute of Agricultural Research and Training Ibadan and obtained from the Cotton Research Programme of the Institute for Agricultural Research Samaru. It is an isolate mutant of Tianung 1 and Cuba 108 and a day neutral plant, and has a fibre, wood and seed yield potentials of, 183.9 kg ha^{-1} and 389.3 kg ha^{-1}, and 114.7 kg ha^{-1} respectively.

Ifeken D1 400 is an improve variety developed by Institute of Agricultural Research and Training Ibadan and obtained from the Cotton Research Programme of the Institute for Agricultural Research Samaru. It is a day length neural plant, and has a fibre, wood and seed yield potentials of 284.8 kg ha^{-1}, 433.1 kg ha^{-1}and 156.5 kg ha^{-1} respectively (Adeniyan *et al*.2014).

Girin danani is a local cultivar obtained from farmers in Kwarbai, Zaria city in Zaria Local Government Area of Kaduna State. It is a vigorously growing tall plant and is drought tolerant.

3.4 Cultural Practices

3.4.1 Land preparation and fertilizer application

The experimental field was cleared and harrowed twice, and raised seed beds were constructed according to plot size above. The poultry manure was applied 7 days before planting by mixing the manure thoroughly with the soil with a hoe in each plot as per treatment basis.

3.4.2 Sowing

Seed was sown manually on 26th July, and 2nd August, 2017 wet season at the rate of 3 seeds per hole, at an intra-row spacing of 25cm and inter-row spacing of 50cm. Sowing was done on flat land after harrowing and the plants were thinned to 2 plants per stand at 3 weeks after sowing.

3.4.3 Soil analysis

Soil samples were randomly collected from a depth of 0 -30 cm from various points at the experimental sites during 2017 wet season prior to planting using 30 cm auger. The soil samples were thoroughly mixed, air dried, and sieved using 2 mm mesh sieve and later analysed for physical and chemical properties. The soil particle size analysis was determined by a hydrometer method (Day, 1965) and the textural class determined using textural triangle (USDA, 1960). Soil pH was determined using pH meter (Black, 1965). Total nitrogen was determined by micro Kjeldahl digestion method (Bremner, 1965). Organic carbon was analysed according to the Walkley and Black method (1934). Available P was extracted according to the Bray No. 1 method (Bray and Kurtz 1945). Exchangeable bases were determined in neutral NH_4OAC extract (Black,1968) by atomic adsorption for calcium and potassium, and Cation Exchange Capacity (CEC) was estimated by summation of exchangeable bases.

3.4.4 Manure analysis

Samples of poultry manure, obtained from a farmhouse in Ahmadu Bello University staff quarters, which was used for the experiment and was analysed in the laboratory to determine the amount of total nitrogen, phosphorus, potassium, calcium and magnesium available in the poultry manure (Table 2).

3.4.5 Weed control

Pre-plant herbicide Glyphosate, at 1.4 kg a.i ha^{-1} was sprayed 2 weeks prior to land preparation using CP3 knapsack sprayer to control existing weeds. Hoe weeding was done at 3, 5 and 7 WAS in order to control weeds.

3.4.6 Pest and disease control

Kenaf plants were protected against insect pests by regular application of mixture of cypermethrin (cymbush 10 EC) plus dimethoate (Rogor 40 EC) at the rate of 1.5 kg a.i ha^{-1} at 10 days interval prior to flower bud formation. There was no serious disease outbreak throughout the growing season in both locations.

3.4.7 Harvesting

Kenaf was harvested for fibre when 50% of the plants had flowered and it was done four times at three weeks intervals. Harvesting was done by cutting the plant stalk at ground level and tied in bundles, the bundles were left on the field for 5 days to allow for complete defoliation before retting and the fibre is extracted from the wood by retting. Retting is done by immersing the bundles of the whole stalk in stagnant water for 10 days after defoliation is completed, then the fibre is separated from the wood and mass embedding it. Seed harvest was done when the plants were mature and dry. All the plants within the net plot were harvested by cutting the plant portion with capsules, which were further sundried, beaten with sticks in bags to thresh and winnowed. The seeds collected and cleaned were then weighed.

3.6 Data Collection

3.6.1 Meteorological data

Data on temperature, relative humidity and sunshine hours were obtained from IAR Meteorological Station at Samaru and Kadawa and are presented in Appendices 1 and 2.

3.6.2 Number of days to 50% flowering

The number of days it took from seed sowing to 50% of the plants to start flowering were observed and recorded in each plot.

3.6.3 Growth parameters

Growth parameters were assessed through random sampling of five plants from each net plot that were tagged. Observation and measurement of growth characters were done at intervals of three weeks beginning from 3 WAS and terminating at 12 WAS. Parameters measured include;

Plant height (cm)

Heights of five randomly tagged plants per plot were determined by measuring the height from the ground level to the main shoot apex of the plant using a meter rule, and the average thereafter recorded.

Butt diameter (cm)

The butt diameter was measured at ground level using a Vernier calliper from the five tagged plants and the average was determined and recorded per plant for each plot.

Number of leaves plant^{-1}

The number of leaves was counted per plant from the five tagged plants from each plot and the average per plot was determined and recorded.

Shoot dry matter (g)

Samples were oven dried to a constant temperature of 70^{o} C. A Metler balance (Metler Toledo, model SB16001) was then used for weight determination and the average was computed and recorded as per treatment.

3.6.4 Growth indices

Three plants from outside net plot were used for growth indices which were uprooted at three weeks interval beginning from 3 WAS and terminated at 12 WAS. Parameters measured include;

Leaf area (cm^{-2})

Three plants were removed from each gross plot and three leaves were detached from each which was inserted inside leaf area meter (LT-3100C area meter) in the laboratory to determine the leaf area and the average was determined and recorded.

Leaf area index (LAI)

The leaf area index was derived from the result of the leaf area and calculated as shown below

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Area of ground covered}}$$

Crop growth rate (CGR)

The crop growth rate expresses the dry matter increment of plant material per unit area of ground per unit time. It was computed as suggested by Watson (1958) and recorded on per plant basis.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \quad (g\ wk^{-1})$$

Where;

CGR= Crop Growth Rate

W_1= Dry matter taken at week 1(t_1)

W_2= Dry matter taken at week 2 (t_2)

T_1= Time when W_1 was taken

T_2= Time when W_2 was taken

Relative growth rate (RGR)

The dry weight increment per unit plant weight per unit time were determined using the formular as described by Radford (1967) RGR= $\frac{loge W2 - loge W1}{t2 - t1}$ where W_2 and W_1 were the total weight per plant at time t_2 and t_1.

Where w_2-w_1 = change in dry weight

$t_2 - t_1$ = change in time

Log_e = represents natural logarithm.

3.6.5 Yield parameters

Number of capsules plant^{-1}

The number of capsules borne on each of the five randomly tagged plants was counted at harvest and the mean was determined to compute the number of capsules per plant.

Number of seeds capsule^{-1}

Number of seeds produced by five randomly tagged capsules from each plot was counted and a mean for each plot was computed.

100 Seed weight (g)

This was measured by counting out 100 seed from each net plot and weighed with a meter scale model 1210 balance and the value recorded.

Seed weight Plant^{-1}

Capsules obtained from the five tagged plants were threshed, the seeds were collected, cleaned, weighed and the mean weight per plant was calculated.

Fibre yield hectare^{-1}

Fibre yield was determined by weighing the fibre obtained from the retted kenaf stalk per net plot and computed on per hectare basis.

Wood yield hectare^{-1}

Wood yield was determined by weighing the dry wood obtained after stripping the fibre of each net plot and computed on per hectare basis.

Seed yield hectare^{-1}

The seed yield was determined from the total seed harvest for each net plot. The dried kenaf seeds were weighed and the yield computed on per hectare basis.

3.7 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) as described by Snedcor and Cochran (1967). The differences between the treatment means were compared using the Duncan Multiple Range Test (Duncan 1955).

The relationship between the parameters was determined by correlation coefficient using the procedure described by Little and Hills (1978). Regression analysis was done to determine the optimum poultry manure rate for maximum fibre, seed and wood yield as described by Steel and Torrie (1994).

CHAPTER FOUR

4.0 RESULTS

4.1 Physical and Chemical Properties of the Soil of the Experimental Sites

Soil samples from the two experimental sites, Samaru and Kadawa were sandy loam and loamy sand respectively (Table 1). The soils at both locations have low levels of nitrogen and moderate available phosphorus, organic carbon, calcium, magnesium, potassium, sodium and cation exchange capacity. The pH was slightly acidic in H_2O at Samaru and moderately acidic in $CaCl_2$ in both locations.

4.2 Nutrients Content of Poultry Manure Used for the Experiment

Poultry manure analysis indicated low contents of phosphorus, potassium, calcium and magnesium and moderate content of nitrogen (Table 2).

4.3 Plant Height

The effects of varieties and poultry manure rate on plant height of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 3. The result shows a significant difference between varieties at 3 and 6 WAS at Samaru only. At 3 WAS, Girin danani significantly produced taller plants, than Ifeken D1 400 and Ifeken 400 which were statistically similar. At 6 WAS, Ifeken 400 produced significantly tall plants with Girin danani and both significantly produced taller plants than Ifeken D1 400. At Kadawa, no significant difference was observed between varieties on plant height of kenaf at all sampling periods. Application of poultry manure significantly influenced plant height of kenaf at 3 WAS and 6 WAS at Samaru and 3-12 WAS at Kadawa. At 3 WAS in Samaru, application of 2-6 t ha^{-1} poultry manure produced similar and taller plants than the untreated control being the least. At 6 WAS, application of 6 t ha^{-1} of poultry manure

Table 1: Soil Physical and Chemical Properties of the Experimental Sites with a Depth of 0 – 30cm during 2017 wet season for Samaru and Kadawa.

Physical properties	**Samaru**	**Kadawa**
clay (g kg^{-1})	160	28
silt (g kg^{-1})	60	202
sand (g kg^{-1})	780	770
Textural class	Sandy Loam	Loamy sand
Chemical properties		
pH (H_2O) 1:2:5	6.29	6.41
pH 0.01m $CaCl_2$	5.76	5.55
Total Nitrogen (g kg^{-1})	0.08	0.11
Available(P) (mg kg^{-1})	10.11	8.52
Organic carbon (g kg^{-1})	1.21	1.45
Exchangeable bases (cmol kg^{-1})		
Calcium	3.15	2.98
Magnesium	0.51	0.46
Potassium	0.18	0.18
Sodium	0.24	0.21
Exchangeable acidity(H + Al)	0.24	0.22
CEC	4.32	4.05

Source: As analysed in Agronomy Departmental Analytical laboratory, A.B.U. Zaria.

Table 2: Nutrient content of the poultry manure used in the experiment during 2017 wet season

Nutrient content	**Value (g kg^{-1})**
Total Nitrogen	11.25
Available Phosphorus	2.50
Potassium	1.21
Calcium	1.21
Magnesium	0.71

Source: As analysed in Agronomy Departmental Analytical laboratory, A.B.U. Zaria.

Table 3: Effects of varieties and poultry manure rate on the height of kenaf at Samaru and Kadawa during the 2017 wet season.

	Plant Height (cm)							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety (V)								
Ifeken 400	41.47b	140.41a	168.05	180.02	48.28	151.59	174.92	201.02
Ifeken D1 400	41.56b	137.12b	164.15	178.40	45.92	151.91	176.52	202.72
Girin danani	43.78a	138.73ab	162.88	175.55	45.03	152.71	174.68	198.11
SE±	0.681	0.980	3.375	4.490	1.231	3.983	3.888	4.463
Poultry manure ($t\ ha^{-1}$)								
0	36.57b	132.82c	160.42	172.80	39.31c	141.92b	162.73c	178.24b
2	43.87a	138.18b	161.73	174.00	45.62b	156.81a	171.22bc	186.08b
4	43.82a	140.45ab	165.42	177.74	47.97b	154.37ab	182.11ab	216.86a
6	44.82a	143.56a	172.53	187.39	52.74a	155.17ab	185.44a	221.28a
SE±	0.787	1.132	3.897	5.185	1.422	4.599	4.490	5.154
Interaction								
V x M	NS	NS	NS	NS	NS	NS	**	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after sowing
NS = Not significant
** = significant at 1%

produced taller plants than 0-2 t ha^{-1}, and was followed by 4 and 2 t ha^{-1} in the decreasing order. There was no significant difference at 9 and 12 WAS on plant height of kenaf in respect to poultry manure rates. At 3 WAS, in Kadawa, application of 6 t ha^{-1} poultry manure significantly produced taller plants, than other treatments, followed by the application of 2 and 4 t ha^{-1}, which was statistically at par and each gave taller plants than the least height by 0 t ha^{-1}. At 6 WAS, application of 2 t ha^{-1} poultry manure produced taller plants than the untreated control but was statistically at par with application of 4 and 6 t ha^{-1}. At 9 WAS, application of 6 t ha^{-1} poultry manure which was statistically the same with plots applied with 4 t ha^{-1} poultry manure; which in turn was statistically similar with plots applied with 2 t ha^{-1} of poultry manure. The least plant height was observed on plots applied with 0 t ha^{-1}. At 12 WAS, the application of 4 and 6 t ha^{-1} poultry manure produced statistically similar and taller plants, than the lower rates which were also similar.

The interaction between varieties and poultry manure rates was significant at 9 WAS in Kadawa during the 2017 wet season (Table 4). The varieties interacted differently with increasing rates of poultry manure from 0-6 t ha^{-1}. Severally, Ifeken 400 increased plant height with increasing rate of poultry manure application although the increase was not statistically significant. Ifeken D1 400 significantly recorded higher plant height on plots applied with 6 t ha^{-1} of poultry manure than all others. While Girin danani recorded the highest significant plant height on plots applied with 2 t ha^{-1} poultry manure. On the whole, Ifeken D1 400 applied with 6 t ha^{-1} of poultry manure produced significantly higher plant height than other treatment combinations.

4.3 Number Leaves

The effects of varieties and poultry manure rate on the number of leaves of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 5. Crop variety

Table 4: Interaction between varieties and poultry manure rate on the height of kenaf at 9 WAS at Kadawa during the 2017 wet season

Treatment	9WAS Poultry Manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	161.16c-e	173.06c-e	181.06c-e	184.40cd
Ifeken D1 400	168.78c-e	152.93e	186.46bc	197.93a
Girin danani	168.78c-e	187.67b	178.80c-e	174.00c-e
SE± 7.778				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

Table 5: Effects of varieties and poultry manure rate on the number of leaves of kenaf at Samaru and Kadawa during the 2017 wet season

	Number of Leaves							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety (V)								
Ifeken 400	18.76b	23.01	26.58	30.55	18.75	22.99	27.10	31.38
Ifeken D1 400	20.97a	23.17	26.28	30.78	19.20	23.09	27.25	31.48
Girin danani	20.06a	22.67	25.85	30.75	18.64	23.51	26.65	30.87
SE±	0.393	0.467	0.518	0.676	0.573	0.611	0.677	0.707
Poultry manure(tha^{1})								
0	18.69b	22.47b	26.34	30.65	17.96	22.69	26.49	30.31ab
2	19.18b	21.86b	25.01	29.31	18.91	22.54	25.69	29.87b
4	20.84a	24.13a	26.90	31.67	18.69	23.35	27.73	32.05ab
6	21.03a	23.33ab	26.70	31.16	19.91	24.21	28.11	32.73a
SE±	0.456	0.540	0.599	0.781	0.661	0.705	0.782	0.817
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
NS = Not significant

influenced leaves numbers at 3 WAS in Samaru only. At 3 WAS, Ifeken D1 400 and Girin danani significantly produced higher number of leaves than Ifeken 400. At Kadawa, no significant difference was observed between varieties on the number of leaves of kenaf at all sampling periods. Application of poultry manure had significant effect on the number of leaves of kenaf at 3 and 6 WAS in Samaru and 12 WAS in Kadawa. At 3 WAS in Samaru, application of 4 and 6 t ha^{-1} poultry manure produced similar and higher number of leaves than the lower rates, which were also similar. At 6 WAS in this location, the application of 4 t ha^{-1} poultry manure significantly produced higher number of leaves than lower rate, but was statistically at par with the application of 6 t ha^{-1}. At 12 WAS in Kadawa, application of 6 t ha^{-1} poultry manure produced higher number of leaves than 2 t ha^{-1}, but was statistically at par with application of 4 and 0 t ha^{-1} ,while the least number of leaves was by 2 t ha^{-1} and was statistically at par with 0 t ha^{-1}. The interaction between varieties and poultry manure rate on number of leaves $plant^{-1}$ of kenaf was not significant throughout the period of study.

4.4 Leaf Area

The effects of varieties and poultry manure rate on the leaf area of kenaf during the 2017 wet season at Samaru and Kadawa is shown in Table 6. A significant difference was observed on leaf area of Kenaf varieties at 9 and 12 WAS in Samaru only. At 9 WAS, Ifeken D1 400 significantly produced higher leaf area than Ifeken 400 and Girin danani, the leaf area of Ifeken 400 and Girin danani were statistically the same. At 12 WAS, Ifeken D1 400 significantly produced higher leaf area than Girin danani; but was statistically at par with Ifeken 400. The lowest leaf area was recorded with Girin danani. At Kadawa no significant difference was observed on the leaf area of Kenaf varieties at all sampling periods. Application of poultry manure had no significant effect on leaf area of Kenaf at all sampling periods in both locations except at 9 WAS at Kadawa

Table 6: Effects of varieties and poultry manure rate on the leaf area of kenaf at Samaru and Kadawa during the 2017 wet season.

	Leaf Area							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety (V)								
Ifeken 400	15.88	21.57	29.03b	38.06ab	15.45	21.74	34.74	42.47
Ifeken D1 400	15.28	22.06	36.71a	43.15a	14.20	21.15	34.62	44.50
Girin danani	16.65	23.38	30.90b	33.94b	13.08	20.35	31.71	45.92
SE±	1.034	1.189	1.729	2.254	0.914	0.591	1.943	2.880
Poultry manure(t ha^{-1})								
0	15.26	21.70	33.68	38.29	14.11	20.47	26.53b	44.46
2	15.06	21.83	32.22	38.42	13.38	20.61	37.67a	42.23
4	15.73	22.16	31.73	38.46	15.15	21.78	33.67a	45.18
6	17.68	23.66	31.23	38.37	14.33	21.48	36.91a	45.39
SE±	1.194	1.372	1.997	2.602	1.056	0.682	2.243	3.325
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks After Sowing
NS = Not significant

Where the application of 2 t ha^{-1} poultry manure significantly produced higher leaf area than plots with 0 t ha^{-1}; but statistically at par with plots applied with 4 and 6 t ha^{-1}. The least leaf area was observed on plots applied with 0 t ha^{-1}. The interaction between varieties and poultry manure rate on leaf area of Kenaf was not significant throughout the period of study.

4.5 Leaf Area Index

The effects of varieties and poultry manure rate during the 2017 wet season at Samaru and Kadawa is presented in Table 7. A significant difference was observed on leaf area index of kenaf varieties at 9 and 12 WAS in Samaru, where Ifeken D1 400 produced a higher leaf area index compared with Ifeken 400 and Girin danani varieties which were statistically similar with each other.No significant difference on the leaf area index of kenaf varieties was observed at all sampling periods in Kadawa throughout the sampling period. Application of poultry manure had no significant difference on the leaf area index of Kenaf at all sampling periods in both locations except at 9 WAS in Kadawa, where the application of 6 t ha^{-1} poultry manure produced statistically higher leaf area index than on plots applied with 0 t ha^{-1}; but was statistically at par with plots applied with 2 and 4 t ha^{-1}. The least leaf area index was observed on plots applied with 0 t ha^{-1}.

The interaction between varieties and poultry manure on leaf area index of Kenaf was not significant throughout the period of study.

4.6 Shoot Dry Weight

The effects of varieties and poultry manure rate on the shoot dry weight of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 8. No significance difference between varieties was recorded at all sampling periods at both locations.

Table 7: Effects of varieties and poultry manure rate on the leaf area index of kenaf at Samaru and Kadawa during the 2017 wet season

	Leaf area index							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety (V)								
Ifeken 400	0.290	0.997	1.304b	1.643b	0.259	0.711	1.549	2.017
Ifeken D1 400	0.195	1.548	1.633a	2.001a	0.243	0.671	1.524	2.239
Girin danani	0.225	1.891	1.308b	1.526b	0.228	0.650	1.379	2.199
SE±	0.038	0.070	0.079	0.099	0.054	0.058	0.117	0.141
Poultry manure($t\ ha^{-1}$)								
0	0.307	1.025	1.416	1.720	0.225	0.630	1.124b	2.064
2	0.225	0.967	1.358	1.725	0.218	0.695	1.521ab	2.011
4	0.206	1.135	1.428	1.766	0.257	0.632	1.513ab	2.149
6	0.209	1.061	2.451	1.677	0.273	0.752	1.779a	2.381
SE±	0.045	0.081	0.091	0.114	0.020	0.059	0.135	0.163
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
NS = Not significant

Table 8: Effects of varieties and poultry manure rate on the shoot dry weight of kenaf at Samaru and Kadawa during the 2017 wet season

	Shoot dry weight (g)							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety								
Ifeken 400	11.24	15.95	23.94	25.68	11.48	14.99	18.96	23.69
Ifeken D1 400	11.56	16.12	20.99	24.43	11.30	15.24	18.21	22.63
Girin danani	10.98	16.82	23.25	25.58	11.30	14.75	18.78	23.69
SE±	0.549	0.859	0.698	0.815	0.168	0.427	0.474	0.993
Poultry manure(t ha^{-1})								
0	10.87	14.82	20.35b	23.89	10.94b	12.47c	15.33c	20.37b
2	11.14	17.20	23.29a	26.86	11.61a	14.11bc	18.97b	22.85ab
4	11.84	17.03	23.35a	26.12	11.39ab	15.29b	19.52ab	24.38a
6	11.19	16.13	22.51ab	23.97	11.51ab	18.11a	20.72a	25.81a
SE±	0.634	0.992	0.806	0.942	0.194	0.569	0.548	1.147
Interaction								
V x M	NS	NS	**	**	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after Sowing
** = significant at 1%
NS = Not significant

Application of poultry manure significantly influenced shoot dry weight of kenaf at 9 WAS at Samaru. The application of 4 t ha^{-1} poultry manure produced a significantly higher shoot dry weight than at 0 t ha^{-1}; but statistically at par with plots applied with 2 and 6 t ha^{-1}. The least shoot dry weight was recorded on plots applied with 0 t ha^{-1}.There was a significant difference on the application of poultry manure on the shoot dry weight of kenaf at all sampling periods in Kadawa. At 3 WAS, the application of 2 t ha^{-1}poultry manure produced significantly higher shoot dry weight than plots applied with 0 t ha^{-1}; but statistically at par with plots applied with 4 and 6 t ha^{-1} poultry manure. However at 6, 9 and 12 WAS, shoot dry weight of kenaf generally increased with increasing rate of poultry manure from 0 to 6 t ha^{-1}. Shoot dry weight was significantly higher in plots applied with 6 t ha^{-1} poultry manure than on those with 0 t ha^{-1}. There was no significant difference on shoot dry weight from plots applied with 6 t ha^{-1} poultry manure and those applied with 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded on plots applied with 0 t ha^{-1}.

The interaction between varieties and poultry manure rates on shoots dry weight of Kenaf was significant at 9 and 12 WAS in Samaru is presented in Table 9. At 9 WAS, the combination of poultry manure rate and varieties, recorded a significantly higher shoot dry weight with Ifeken 400 and 2 t ha^{-1} poultry manure; and was statistically similar with the variety Girin danani applied with poultry manure at 2 and 4 t ha^{-1}.The lowest shoot dry weight was recorded with Ifeken D1 400 applied with 2 t ha^{-1} poultry manure. At 12 WAS, Ifeken 400 applied with 2 t ha^{-1} poultry manure produced the highest shoot dry weight; but was statistically at par with Girin danani applied with poultry manure at 2 and 4 t ha^{-1} and Ifeken D1 400 at 0 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken 400 at 0 t ha^{-1}.

Table 9: Interaction between varieties and poultry manure rate on shoot dry weight of kenaf at 9 and 12WAS at Samaru during the 2017 wet season

	9 WAS			
Treatment	Poultry manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	19.41cd	27.35a	22.87bc	22.84bc
Ifeken D1 400	22.33bc	15.97d	23.37bc	22.29bc
Girin danani	19.31cd	26.45ab	23.92a-c	22.42bc
SE± 1.398				

	12 WAS			
Treatment	Poultry Manure (t ha^{-1})			
Variety (V)	0	2	4	6
Ifeken 400	21.39d	31.63a	26.86bc	23.59b-d
Ifeken D1 400	26.93a-c	21.92cd	25.31b-d	23.58b-d
Girin danani	23.34b-d	27.20ab	26.98ab	24.76b-d
SE± 1.631				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

4.7 Butt Diameter

The effects of varieties and poultry manure rate on butt diameter of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 10. No significant difference was recorded between varieties at both locations except at 12 WAS in Kadawa, where Ifeken 400 recorded significantly lower butt diameter than Ifeken D1 400 which was statistically at par with Girin danani.

The application of poultry manure significantly increased Kenaf butt diameter at 3 and 6 WAS in Samaru. At 3 WAS, butt diameter significantly increased with increasing from 0 to 6 t ha^{-1}. At 6 WAS the application of 6 t $ha^{-1}$of poultry manure significantly increased the butt diameter than at 0 t ha^{-1}; but statistically at par with plots applied with 4 t ha^{-1}. Also Kenaf butt diameter of plots applied with 2 and 4 t ha^{-1}were statistically the same. The application of 0 t ha^{-1} produced the least butt diameter. The interaction between varieties and poultry manure rates on butt diameter of Kenaf was not significant.

4.8 Crop Growth Rate

The effects of varieties and poultry manure rates on crop growth rate of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 11. There was no significant difference between varieties at all sampling periods at both locations. Application of poultry manure significantly increase the crop growth rate of kenaf at 6 WAS in Kadawa. The application of 6 t ha^{-1} of poultry manure significantly increases crop growth rate of kenaf than at 0, 2 and 4 t ha^{-1}. The crop growth rate on plots applied with 2 and 4 t ha^{-1} poultry manure was statistically similar.Theleast crop growth rate was observed on plots applied with 0 t ha^{-1}. The interaction between varieties and poultry manure rates on crop growth rate of kenaf was not significant.

Table 10: Effects of varieties and poultry manure rate on butt diameter of kenaf at Samaru and Kadawa during the 2017 wet season

	Butt Diameter (cm)							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety								
Ifeken 400	0.80	1.00	1.21	1.30	0.67	0.98	1.25	1.29b
Ifeken D1 400	0.79	1.02	1.21	1.43	0.76	1.03	1.21	1.47a
Girin danani	0.81	1.05	1.30	1.32	0.70	1.06	1.30	1.36ab
SE±	0.033	0.030	0.032	0.045	0.082	0.063	0.047	0.054
Poultry manure(t ha^{-1})								
0	0.56d	0.89c	1.17	1.28	0.63	0.90	1.18	1.33
2	0.72c	1.00bc	1.26	1.38	0.59	0.98	1.30	1.38
4	0.88b	1.08ab	1.26	1.34	0.82	1.11	1.29	1.38
6	1.04a	1.14a	1.27	1.40	0.80	1.11	1.24	1.40
SE±	0.038	0.035	0.037	0.052	0.095	0.073	0.054	0.062
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRWAS = week after sowing NS=Not significant

Table 11: Effects of varieties and poultry manure rate on crop growth rate of kenaf at Samaru and Kadawa during the 2017 wet season

	Crop Growth Rate (gwk^{1})					
	Samaru			Kadawa		
Treatment	**6WAS**	**9WAS**	**12WAS**	**6WAS**	**9WAS**	**12WAS**
Variety						
Ifeken 400	1.57	2.38	0.86	1.17	1.43	1.57
Ifeken D1 400	1.51	1.62	1.14	0.98	1.31	1.58
Girin danani	1.94	2.05	0.84	1.14	1.33	1.71
SE±	0.307	0.323	0.214	0.152	0.188	0.279
Poultry manure(t ha^{-1})						
0	1.31	1.84	1.18	0.51c	1.02	1.86
2	2.01	2.00	1.21	0.83bc	1.62	1.32
4	1.73	2.10	0.92	1.30b	1.40	1.69
6	1.64	2.12	0.48	2.19a	0.94	1.62
SE±	0.354	0.378	0.247	0.176	0.217	0.322
Interaction						
V x M	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by difference letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after sowing
NS = Not significant

4.9 Relative Growth Rate

The effects of varieties and poultry manure rate on the relative growth rate of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 12. There was no significant difference between varieties at all sampling periods at both locations. Application of poultry manure significantly affected the relative growth rate of kenaf at 6 and 9 WAS in Kadawa. At 6 WAS the application of 6 t ha^{-1}poultry manure significantly increased the relative growth rate of kenaf overall the other treatments. The least relative growth rate was observed on plots applied with 0 t ha^{-1} which was statistically similar with plots applied with 2 t ha^{-1} poultry manure.At 9WAS, highest relative growth rate was recorded with the application of 2 t ha^{-1} poultry manure;and was significantly more than that recorded on plots applied with 6 t ha^{-1} poultry manure; but statistically similar with plots applied with 0 and 4 t ha^{-1} poultry manure. The least relative growth rate was observed on plots applied with 6 t ha^{-1}.

The interaction between varieties and poultry manure rate on relative growth rate of kenaf was not significant.

4.10 Number of Days to 50% flowering

The effects of varieties and poultry manure rate on the number of days to 50% flowering of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 13. There was a significant difference between varieties at all sampling period in both locations. Generally, Ifeken D1 400 took longer days to attain 50% flowering in both locations, while Ifeken 400 took shorter days to attain 50% flowering in both locations. While there was significant difference between varieties on number of days to 50% flowering in Samaru, at Kadawa, Ifeken 400 and Girin danani were statistically the same. There was no significant difference on days to 50% flowering when poultry manure was applied in both locations.

Table 12: Effects of varieties and poultry manure rate on the relative growth rate of kenaf at Samaru and Kadawa during the 2017 wet season.

	Relative growth rate ($gg^{-1}wk^{1}$)					
	Samaru			Kadawa		
Treatment	**6WAS**	**9WAS**	**12WAS**	**6WAS**	**9WAS**	**12WAS**
Variety						
Ifeken 400	0.048	0.054	0.015	0.036	0.038	0.031
Ifeken DI 400	0.046	0.038	0.022	0.041	0.026	0.033
Girin danani	0.072	0.049	0.016	0.036	0.034	0.035
SE±	0.015	0.007	0.005	0.004	0.005	0.006
Poultry manure ($t\ ha^{-1}$)						
0	0.042	0.046	0.023	0.018c	0.032ab	0.045
2	0.059	0.042	0.022	0.027c	0.043a	0.027
4	0.051	0.045	0.016	0.042b	0.035ab	0.033
6	0.069	0.048	0.009	0.064a	0.021b	0.027
SE±	0.017	0.009	0.005	0.004	0.005	0.006
Interaction						
V x M	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letters are significantly different 5% level using DMRT.
WAS = Weeks after sowing NS = Not significant

Table 13: Effects of varieties and poultry manure rate on the number of days to 50% flowering of kenaf at Samaru and Kadawa during the 2017 wet season.

	Number of days to 50% flowering	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	61.7c	60.0b
Ifeken D1 400	68.7a	68.0a
Girin danani	65.0b	61.0b
SE±	0.739	0.984
Poultry manure(t ha^{-1})		
0	65.5	63.0
2	64.4	63.0
4	65.0	63.0
6	65.5	63.0
SE±	0.854	1.137
Interaction		
V x M	**	NS

Means in a column of any set of treatment followed by different letters are significantly difference at 5% level using DMRT.
** = significant at 1%
NS = Not significant

The interaction between varieties and poultry manure rate on number of days to 50% flowering of Kenaf was significant at Samaru.

The interaction between varieties and poultry manure rate on number of days to 50% flowering of Kenaf at Samaru is presented in Table 14. When various rates of poultry manure were compared with varieties, it was observed that the application of 0 and 6 t ha^{-1} and Ifeken D1 400 took significantly longer days to attain 50% flowering; but was statistically similar with the application of 0 and 2 t ha^{-1} and Girin danani 4 t ha^{-1} and Ifeken D1 400. It took Ifeken 400 applied with 0 and 2 t ha^{-1} poultry manure the lowest number of days to 50% flowering; and this was statistically similar with Ifeken 400 applied with 6 t ha^{-1} and Girin danani applied with 4 t ha^{-1} poultry manure.

4.11 100 Seed Weight (g)

The effects of varieties and poultry manure rates on 100 seed weight of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 15. No significant responses were recorded at all sampling periods in both locations on both varieties and poultry manure rates.

The interaction between varieties and poultry manure rates on 100 seed weight of kenaf was not significant.

4.12 Number of Seeds per Capsule

The effects of varieties and poultry manure rate on number of seeds per capsule of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 16. Varietal difference was not significant at all sampling periods in both locations.

Application of poultry manure significantly iincreased the number of seeds per capsule at all sampling periods at both locations. Increase in poultry manure rates from 0 to 6 t ha^{-1-}generally increased number of seeds per capsule. At Samaru the application of 6 t ha^{-1}poultry manure significantly produced higher number of seeds per capsule than at 0 t ha^{-1};

Table 14: Interaction between varieties and poultry manure rate on the number of days to 50% flowering of kenaf at Samaru during the 2017 wet season.

Treatment	**Poultry manure (t ha^{-1})**			
Variety (V)	**0**	**2**	**4**	**6**
Ifeken 400	60.0d	60.0d	65.0bc	61.7cd
Ifeken D1 400	70.0a	66.7ab	68.3ab	70.0a
Girin danani	66.7ab	66.7ab	61.7cd	65.0bc
SE± 1.497				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Table 15: Effects of varieties and poultry manure rate on 100 seed weight of kenaf at Samaru and Kadawa during the 2017 wet season.

	100 Seed Weight (g)	
Treatment	**Samaru**	**Kadawa**
Variety (v)		
Ifeken 400	2.45	2.34
Ifeken D1 400	2.54	2.31
Girin danani	2.53	2.41
SE±	0.048	0.045
Poultry manure(t ha^{-1})		
0	2.42	2.38
2	2.50	2.32
4	2.57	2.36
6	2.54	2.35
SE±	0.055	0.052
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by different letters are significantly difference at 5% level using DMRT.
NS = Not significant

Table 16: Effects of varieties and poultry manure rate on the number of seeds per capsule of kenaf at Samaru and Kadawa during the 2017 wet season.

	Number of seeds per capsule	
Treatment	**Samaru**	**Kadawa**
Variety (v)		
Ifeken 400	275.26	292.90
Ifeken D1 400	268.55	282.10
Girin danani	274.63	299.63
SE±	4.932	5.989
Poultry manure(t ha^{-1})		
0	258.44c	262.67c
2	268.35bc	259.57c
4	276.17ab	310.37b
6	288.28a	333.56a
SE±	5.695	6.916
Interaction		
V x M	NS	**

Means in a column of any set of treatment and followed by different letter (s) are significantly different at 5% level using DMRT
NS = Not significant
** = Significant at 1%

which was statistically at par with the number of seeds per capsule produced at 4 t ha^{-1}.The least number of seeds per capsule was recorded when plots were applied with 0 t ha^{-1}and this was statistically similar with the application of 2 t ha^{-1}. At Kadawa, an increase in poultry manure from 0 to 2 t ha^{-1} did not significantly increase the number of seeds per capsule. However, further increase in poultry manure rates from 2 to 6 t ha^{-1} resulted in significant increase in number of seeds per capsule. The interaction between varieties and poultry manure rates on number of seeds per capsule of Kenaf was significant at Kadawa.The interaction between varieties and poultry manure rates on number of seeds per capsule at Kadawa is presented in Table 17. It was observed that for Ifeken 400 and Ifeken D1 400, an increase in poultry manure rate from 0 to 2 t ha^{-1} did not significantly increase the number of seeds per capsule. However a further increase to 4 t ha^{-1} resulted in a significant increase in the number of seeds per capsule. But for Ifeken 400, a further increase in poultry manure to 6 t ha^{-1} did not result in any significant increase; while Ifeken D1 400 recorded a significant increase in the number of seeds per capsule. For Girin danani, the highest number of seeds per capsule was recorded when plots were applied with 6 t ha^{-1}, but there was no significant difference with plots applied with 0 and 4 t ha^{-1}. The number of seeds per capsule recorded when plots were applied with 2 t ha^{-1} was significantly lower than other treatments.

4.13 Number of Capsules per Plant

The effects of varieties and poultry manure rate on number of capsule per plant of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 18. Significant difference was recorded between varieties at Kadawa only.Girin danani significantly recorded higher number of capsules per plant than Ifeken D1 400, but was statistically at par with Ifeken 400. The application of poultry manure significantly increases the number of capsule per plant at both locations. There was a significant increase in the number of capsules per plant with increasing rate of poultry manure from 0 to 6 t ha^{-1}. The interaction between

Table 17: Interaction between varieties and poultry manure rate on the number of seeds per capsule of kenaf at Kadawa during the 2017 wet season.

Treatment	**poultry manure (t ha^{-1})**			
Variety (V)	**0**	**2**	**4**	**6**
Ifeken 400	249.13e	274.06c-e	321.26ab	327.13ab
Ifeken D1 400	237.80e	258.40de	291.40b-d	340.80a
Girin danani	301.06a-c	246.26e	318.46ab	332.73a
SE± 11.979				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).

Table 18: Effects of varieties and poultry manure rate on the number of capsules per plant of kenaf at Samaru and Kadawa during the 2017 wet season.

	Number of capsules per plant	
Treatment	**Samaru**	**Kadawa**
Variety (V)		
Ifeken 400	14.67	15.72a
Ifeken D1 400	14.73	15.15b
Girin danani	14.76	16.19a
SE±	0.247	0.176
Poultry manure(t ha^{-1})		
0	10.98d	11.92d
2	13.76c	13.98c
4	16.33b	17.85b
6	17.80a	18.98a
SE±	0.285	0.204
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by difference letters are significantly difference at 5% level using DMRT.
NS = Not significant

varieties and poultry manure rate on number of capsule per plant of kenaf was not significant.

4.14 Seed Weight per Plant

The effects of varieties and poultry manure rate on seed weight per plant of Kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 19. A significant difference was recorded between varieties at both locations.At Samaru, Girin danani produced significantly higher seed weight of Kenaf than Ifeken 400, butwas statistically at par with Ifeken D1 400. Similarly, Ifeken D1 400 recorded statistically the same seed weight per plant with Ifeken 400. However at Kadawa, Girin danani significantly recorded the highest seed weight per plant over Ifeken D1 400 and Ifeken 400. Ifeken D1 400 recorded significantly higher seed weight per plant compared to Ifeken 400. The application of poultry manure significantly increased the seed weight per plant at both locations. At Samaru, the application of 6 t ha^{-1} poultry manure significantly produced the highest seed weight per plant of Kenaf. The application of 2 and 4 t ha^{-1}, recorded seed weight per plant that were statistically at par with each other; while the least seed weight per plant was observed on plots applied with 0 t ha^{-1}.

At Kadawa, seed weight per plant significantly increased with poultry manure rate from 0 to 6 t ha^{-1}.

The interaction effect between varieties and poultry manure rate on seed weight per plant of Kenaf was not significant in both locations.

4.15 Kenaf Fibre Yield

Effects of varieties and poultry manure rate on fibre yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 20. In both locations, Girin danani produced significantly higher fibre yield than Ifeken D1 400 and Ifeken 400. Similarly, Ifeken D1 400 produced significantly higher Kenaf fibre yield than Ifeken 400.

Table 19: Effect of varieties and poultry manure rate on seed weight per plant of kenaf at Samaru and Kadawa during the 2017 wet season.

	Seed weight per plant (g)	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	119.81b	125.94c
Ifeken D1 400	121.22ab	130.35b
Girin danani	125.88a	135.92a
SE±	1.764	0.663
Poultry manure(t ha^{-1})		
0	108.10c	112.25d
2	122.81b	124.17c
4	122.34b	136.50b
6	135.97a	150.02a
SE±	2.037	0.766
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by difference letters are significantly difference at 5% level using DMRT.
NS = Not significant

Table 20: Effects of varieties and poultry rate on fibre yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season.

	Fibre yield per hectare (kg ha^{-1})	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	136.9c	140.6c
Ifeken D1 400	140.9b	146.5b
Girin danani	148.1a	152.5a
SE±	2.242	1.671
Poultry manure(t ha^{-1})		
0	121.3d	121.3d
2	136.5c	139.6c
4	145.8b	154.6b
6	164.3a	170.7a
SE±	2.589	1.929
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
NS = Not significant

Also in both locations fibre yield of kenaf increased with poultry manure rate from 0 to 6 t ha^{-1}.

The interaction between varieties and poultry manure rate on fibre yield per hectare of kenaf was not significant in both locations.

4.16 Kenaf Wood Yield

Effects of varieties and poultry manure rate on wood yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 21. There was significant difference between varieties at both locations. At Samaru, Girin danani recorded a significantly higher wood yield than Ifeken 400; but was statistically at par with Ifeken D1 400. The least wood yield was obtained with Ifeken 400. While at Kadawa, Girin danani recorded significantly the highest wood yield over Ifeken D1 400 and Ifeken 400. Similarly, Ifeken D1 400 recorded significantly higher kenaf wood yield than Ifeken 400. The least wood yield was obtained by Ifeken 400. Application of poultry manure significantly influenced wood yield at both locations. At Samaru, application of 6 t ha^{-1} poultry manure significantly recorded the highest wood yield against other treatments. Poultry manure applied at 2 t ha^{-1} significantly recorded higher kenaf wood yield than plots applied with 4 t ha^{-1}. While plots applied with 2 t ha^{-1} of poultry manure recorded statistically the same kenaf core yield with those treated with 0 t ha^{-1}. At Kadawa, there was a significant increase in the wood yield of kenaf with increasing poultry manure rate from 0 to 6 t ha^{-1}. The interaction between varieties and poultry manure rates on wood yield of kenaf was highly significant in both locations.

The interaction between varieties and poultry manure rate on the wood yield of kenaf at both locations is presented in Table 22. At Samaru, the combination of poultry manure rates

Table 21: Effects of varieties and poultry manure rate on wood yield per hectare of Kenaf at Samaru and Kadawa during the 2017 wet season.

	Wood yield per hectare (kg ha^{-1})	
Treatment	**Samaru**	**Kadawa**
Variety (v)		
Ifeken 400	97.8b	134.8c
Ifeken D1 400	120.0a	142.4b
Girin danani	120.3a	151.6a
SE±	0.597	0.762
Poultry manure(t ha^{-1})		
0	101.0bc	108.5d
2	117.4b	135.9c
4	92.6c	152.1b
6	139.9a	175.3a
SE±	0.690	0.879
Interaction		
V x M	**	**

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
** = Significant at 1%

Table 22: Interaction between varieties and poultry manure rate on the wood yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season.

	Samaru			
Treatment	**Poultry manure (t ha^{-1})**			
Variety (V)	0	2	4	6
Ifeken 400	109.4b	117.4ab	40.3c	132.9ab
Ifeken D1 400	103.4b	121.5ab	117.0ab	138.2ab
Girin danani	98.6bc	113.4ab	120.7ab	148.9a
SE± 1.195				

	Kadawa			
Treatment	**Poultry manure (t ha^{-1})**			
Variety (V)	0	2	4	6
Ifeken 400	95.5e	130.5b-e	145.4a-e	168.2a-c
Ifeken D1 400	108.1de	135.8a-e	150.6a-d	175.2ab
Girin danani	122.3c-e	141.5a-e	160.4a-c	182.5a
SE± 1.524				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

and varieties recorded significantly higher wood yield with Girin danani and 6 t ha^{-1} poultry manure; but was statistically similar with 2 t ha^{-1} across all varieties, Ifeken D1 400 and Girin danani applied with poultry manure rate at 4 t ha^{-1}, Ifeken 400 and Ifeken D1 400 applied with poultry manure rate at 6 t ha^{-1}. The least wood yield was recorded by the combination of 0 t ha^{-1} with Ifeken 400 and Ifeken D1 400 and 0 t ha^{-1}. However the lowest wood yield was recorded with Ifeken 400 at 4 t ha^{-1} poultry manure but statistically similar with Girin danani applied with 0 t ha^{-1}. At Kadawa, Girin danani applied with 6 t ha^{-1} poultry manure produced the highest wood yield; but statistically similar with Ifeken D1 400 and Girin danani applied with poultry manure at 2 t ha^{-1} ,Ifeken 400 applied with poultry manure at 4 t ha^{-1} and Ifeken 400 and Ifeken D1 400 applied with poultry manure at 6 t ha^{-1}. The lowest wood yield was recorded with Ifeken 400 at 0 t ha^{-1}.

4.17 Kenaf Seed yield

Effects of varieties and poultry manure rate on seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 23. There was significant difference between varieties at both locations. At Samaru, Girin danani recorded a significantly higher seed yield than Ifeken 400, but was statistically at par with Ifeken D1 400. The lowest seed yield was recorded with Ifeken 400. At Kadawa, Girin danani recorded the highest significant seed yield over Ifeken 400 and similarly, Ifeken D1 400 significantly recorded significantly higher seed yield compared with Ifeken 400. The application of poultry manure significantly increased seed yield at both locations. At Samaru, the application of 6 tha^{-1} poultry manure recorded the highest significant seed yield over other treatments. Plots applied with 2 and 4 t ha^{-1}, significantly recorded higher seed yield over plots applied with 0 t ha^{-1}, but were statistically at par with each other. The lowest seed yield was recorded on plots applied with 0 t ha^{-1}. At Kadawa, seed yield of kenaf significantly increased with increasing poultry manure rate from 0 to 6 t ha^{-1}.

Table 23: Effects of varieties and poultry manure rate on seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season.

	Seed yield per hectare (kg ha^{-1})	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	199.6b	209.9c
Ifeken D1 400	203.2ab	217.2b
Girin danani	209.7a	226.5a
SE±	2.744	1.106
Poultry manure(t ha^{-1})		
0	180.1c	187.0d
2	204.6b	206.9c
4	205.5b	227.5b
6	226.6a	250.0a
SE±	3.169	1.277
Interaction		
V x M	NS	NS

Means followed by the same do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT).
NS = Not significant

The interaction between varieties and poultry manure rate on kenaf seed yield per hectare was not significant.

4.18 Correlation Studies

4.18.1 Correlation between kenaf seed yield and growth/yield characters

Correlations between seed yield and growth/yield characters are presented in Tables 24 and 25 for Samaru and Kadawa respectively. Strong and positive correlation was observed at Samaru between kenaf seed yield (kg ha^{-1}) and seed weight per plant. While the correlations between seed yield, plant height and 100 seed weight were moderate and positive. A moderate and positive correlation was observed between 100 seed weight and seed weight per plant. A moderate and positive correlation was observed between plant height, number of leaves and seed weight per plant, leaf area and butt diameter, crop growth rate and relative growth rate, while the correlation between leaf area and leaf area index was strong and positive.

In Kadawa, there was a strong and positive correlation between seed yield on plant height, butt diameter and seed weight per plant. While the correlation between seed yield and number of leaves was moderate and positive. The correlation between plant height, butt diameter and seed weight per plant was strong and positive and between number of leaves, butt diameter and seed weight per plant was moderate and positive. The correlation between leaf area index and number of days to 50% flowering was strong and positive, and between leaf area index and seed weight per plant was moderate and positive, and the correlation between butt diameter and seed weight per plant was strong and positive, while the correlation between butt diameter and shoot dry weight and relative growth rate was moderate and positive. The correlation between crop growth rate and relative growth rate was strong and positive.

4.18.2 Correlation between fibre yield and growth/yield characters

Correlations between fibre yield and growth/yield characters are presented in Tables 26 and 27 for Samaru and Kadawa, respectively. Moderate to high and positive correlation was observed at Samaru between kenaf fibre yield (kg ha^{-1}) and plant height, 100 seed weight and wood yield. The correlation between plant height, number of leaves and wood yield was moderate and positive. The correlation between leaf area and leaf area index was strong and positive and between leaf area and butt diameter was moderately positive, while the correlation between leaf area index and butt diameter was also moderate and positive. The correlation between crop growth rate and relative growth rate was strong and positive.

In Kadawa, there was high and positive correlations between fibre yield and plant height, shoot dry weight and wood yield (Table 27). The correlation between fibre yield and number of leaves was moderate and positive. The correlation between plant height and wood yield was strong and positive, and between plant height and shoot dry weight was moderately positive. The correlation between number of leaves on one hand and shoot dry weight and wood yield on the other hand were moderate and positive. The correlation between leaf area and leaf area index was strong and positive. The correlations between shoot dry weight and crop growth rate, relative growth rate and wood yield were strong and positive. While the correlation between crop growth rate and relative growth rate was also strong and positive.

4.19 Regression Studies

4.19.1 Regression analysis of kenaf seed yields and poultry manure rate

Kenaf Seed yield response to poultry manure rate at Samaru and Kadawa is presented in Figure 1. A linear model was found to fit the data. The Seed yield increased with each increment of poultry manure from 0-6 t ha^{-1} at both locations.

Table 24: Matrix of correlations between seed yield and growth /yield characters of kenaf as influenced by varieties and poultry manure rate at Samaru during the 2017 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.381*	1.00										
3	0.229	0.349*	1.00									
4	0.072	0.192	0.096	1.00								
5	0.026	0.192	0.180	0.927**	1.00							
6	0.291	0.240	0.180	0.373*	0.420*	1.00						
7	0.217	0.187	- 0.016	0.207	0.088	0.250	1.00					
8	0.053	- 0.009	- 0.041	0.137	0.119	0.246	0.021	1.00				
9	-0.095	- 0.297	- 0.142	0.076	- 0.014	- 0.043	0.308	0.216	1.00			
10	- 0.119	- 0.328	- 0.168	0.003	- 0.069	- 0.097	0.110	0.245	0.971**	1.00		
11	0.365*	0.100	0.195	0.137	0.064	0.029	0.002	0.129	0.037	0.0074	1.00	
12	0.992**	0.378*	0.202	0.034	0.022	0,284	0.222	0.053	- 0.071	- 0.096	0.359*	1.00

* = significant 5% level of significance ** = significant at 1% level of significance

1 = seed yield per hectare, 2 = Plant height, 3 = Number of leaves, 4 = Leaf area, 5 = leaf area index, 6 = butt diameter, 7 = shoot dry weight, 8 = number of days to 50% flowering, 9 = crop growth rate, 10 = Relative growth rate, 11 = 100 seed weight, 12 = seed weight per plant.

Table 25: Matrix of correlations between seed yield and growth/yield characters of kenaf as influenced by varieties and poultry manure rate at Kadawa during the 2017 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.689**	1.00										
3	0.406*	0.254	1.00									
4	0.183	0.101	0.038	1.00								
5	0.306	0.131	0.066	0.121	1.00							
6	0.653**	0.487**	0.302*	- 0.039	- 0.046	1.00						
7	- 0.149	- 0.073	- 0.064	0.040	0.202	- 0.339*	1.00					
8	0.127	0.032	- 0.181	0.023	0.856**	- 0.121	0.191	1.00				
9	- 0.043	0.055	0.196	0.273	0.037	- 0.190	0.121	0.021	1.00			
10	- 0.188	- 0.057	0.155	0.251	0.049	- 0.385*	0.188	0.018	0.972**	1.00		
11	0.019	0.080	- 0.090	0.052	- 0.119	- 0.253	0.209	- 0.056	0.166	0.201	1.00	
12	1.000**	0.689**	0.406*	0.183	0.306*	0.653**	-0.149	0.127	- 0.043	- 0.188	0.019	1.00

* = significant at 5% level of significance ** = significant at 1% level of significance.

1 = seed yield per hectare, 2 = Plant height, 3 = number of leaves, 4 = Leaf area, 5 = leaf area index, 6 = butt diameter, 7 = shoot dry weight, 8 = number of days to 50% flowering, 9 = crop growth rate, 10 = Relative growth rate, 11 = 100 seed weight, 12 = seed weight per plant.

Table 26: Matrix of Correlations between fibre yield and growth/yield characters of Kenaf as influenced by varieties and poultry manure rate at Samaru during the 2017 wet season

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.328*	1.00										
3	0.194	0.349*	1.00									
4	-0.032	0.192	0.096	1.00								
5	-0.062	0.192	0.180	0.927**	1.00							
6	0.219	0.240	0.180	0.373*	0.420*	1.00						
7	0.050	0.187	-0.016	0.207	0.088	0.250	1.00					
8	0.019	-0.009	-0.041	0.137	0.119	0.246	0.021	1.00				
9	-0.309	-0.297	-0.142	0.076	-0.014	-0.043	0.308	0.216	1.00			
10	-0.306	-0.332	-0.172	0.003	-0.069	-0.101	0.104	0.249	0.970**	1.00		
11	0.354*	0.100	0.195	0.137	0.064	0.029	0.002	0.129	0.037	0.071	1.00	
12	0.452**	0.328*	-0.044	-0.032	-0.062	0.219	0.014	0.019	-0.168	-0.173	0.217	1.00

*= significant at 5% level of significance **= significant at 1% level of significance

1= fibre yield per hectare, 2= plant height, 3= number of leaves, 4= leaf area, 5= leaf area index, 6= butt diameter, 7= shoot dry weight, 8= number of days to 50% flowering, 9= crop growth rate, 10= relative growth rate, 11= 100 seed weight, 12= wood yield.

Table 27: Matrix of correlations between fibre yield and growth/yield characters of kenaf as influenced by varieties and poultry manure rate at Kadawa during the 2017 wet season

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.697**	1.00										
3	0.431*	0.254	1.00									
4	0.088	0.032	-0.181	1.00								
5	0.281	0.131	0.066	0.856**	1.00							
6	0.179	0.185	0.060	0.224	0.176	1.00						
7	0.520**	0.423*	0.391*	-0.112	-0.006	0.256	1.00					
8	0.060	-0.036	0.141	-0.089	0.065	0.164	-0.147	1.00				
9	-0031	0.055	0.196	-0.022	0.037	0.294	0.645**	-0.053	1.00			
10	-0.184	-0.053	0.120	0.017	0.049	0.235	0.472**	-0.022	0.972**	1.00		
11	-0.011	0.080	-0.090	-0.056	-0.119	-0.288	-0.065	-0.120	0.166	0.199	1.00	
12	0.981**	0.653**	0.406*	0.067	0.256	0.155	0.485**	0.018	-0.060	-0.209	-0.011	1.00

* = significant at 5% level of significance **= significant at 1% level of significance
1= fibre yield per hectare, 2= plant height, 3= number of leaves, 4= leaf area, 5= leaf area index, 6= butt diameter, 7= shoot dry weight, 8= number of days to 50% flowering, 9= crop growth rate, 10= relative growth rate, 11= 100 seed weight, 12= wood yield.

14.19.2 Regression analysis of kenaf fibre yields and poultry manure rate

Kenaf fibre yield response to poultry manure rate at Samaru and Kadawa is presented in Figure 2. A linear model was found to fit the data. The fibre yield increased with each increment of poultry manure from 0-6 t ha^{-1} at both locations.

14.19.3 Regression analysis of kenaf wood yields and poultry manure rate

Kenaf wood yield response to poultry manure rate at Samaru and Kadawa is presented in Figure 3. A linear model was found to fit the data although the yield slightly decline when 4 t ha^{-1} was applied at Samaru. The wood yield increased with each increment of poultry manure from 0-6 t ha^{-1} at both locations.

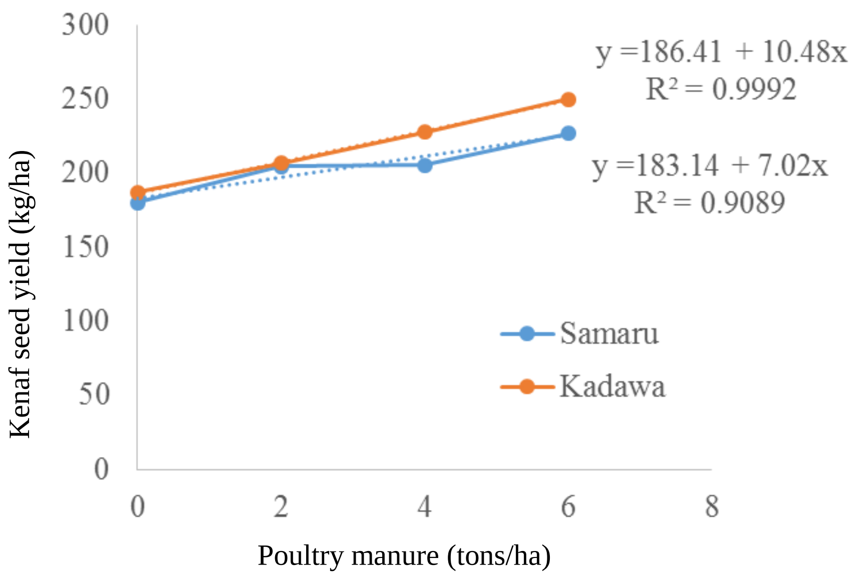

Figure 1: Seed yield of kenaf varieties as influenced by poultry manure rate during the 2017 wet season at Samaru and Kadawa.

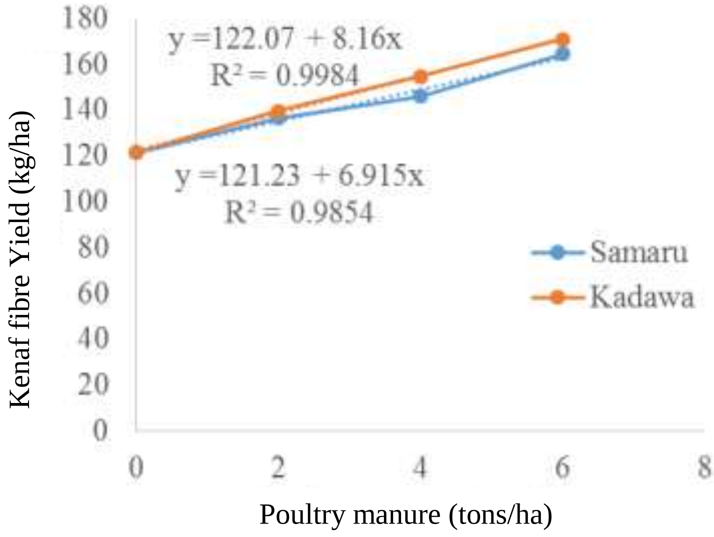

Figure 2: Fibre yield of kenaf varieties as influenced by poultry manure rate during the 2017 wet season at Samaru and Kadawa.

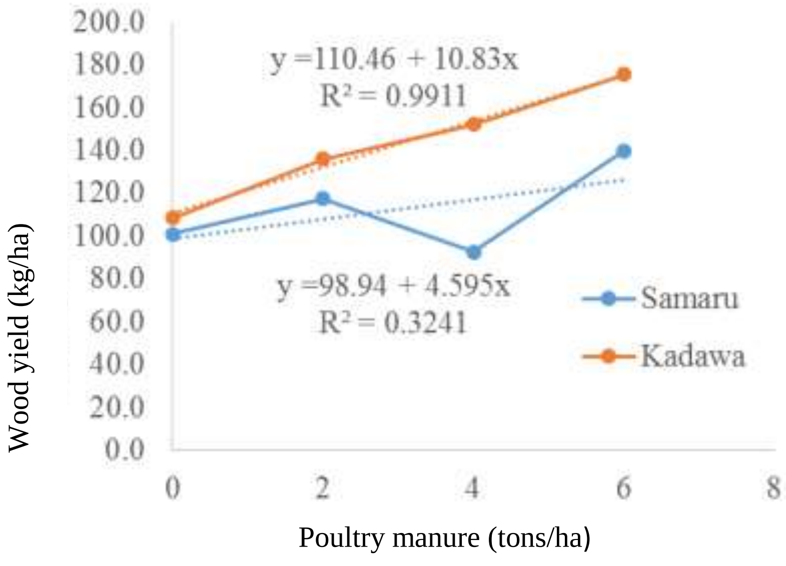

Figure 3: Wood yield of kenaf varieties as influenced by poultry manure rate during the 2017 wet season at Samaru and Kadawa.

CHAPTER FIVE

5.0 DISCUSSION

5.1 General

The soil textural class of Samaru and Kadawa were Sandy loam and loamy Sandy respectively. The pH 6.29 and 6.41 of soils at Samaru and Kadawa were within the range required for the growth of kenaf. However, higher growth and yield components of kenaf, particularly plant height, number of leaves, leaf area, leaf area index, number of seeds per capsule, fibre yield, core yield and seed yield kg ha^{-1} were observed to be significantly higher at Kadawa compared to Samaru. These could be attributed to more total nitrogen (0.11 g kg^{-1}) and organic carbon (1.45 g kg^{-1}) in the soil needed by the crop for proper growth and development. The lower growth, yield parameters and yield in Samaru could be attributed to relatively lower total nitrogen and organic carbon content (0.08 g kg^{-1} and 1.21 g kg^{-1}respectively) at this location and the low level of nutrients negatively affected the availability required for good growth and yield of the crop as reported by Adeosun (1999), who stated that low level of soil nutrients, organic matter, available phosphorus, potassium and nitrogen make crops unable to utilize them optimally for food synthesis. This is probably the reason why there was a reduction in kenaf growth and yield at Samaru. Another factor that could have attributed to the low yield observed at Samaru was the heavy rainfall and poor drainage which caused water-logging, poor soil aeration and plant metabolism, thus inducing stunted growth and development and low yield, and this is in agreement with the findings reported by Idrissa (2014), who reported that low maize yield observed in 2012 was due to heavy rainfall and poor drainage which caused water-logging, leaching of the nitrogen applied, poor soil aeration and plant metabolism thus inducing stunted growth and development and low yield.

The higher clay content of 160 g kg^{-1}at Samaru compared to 28 g kg^{-1} at Kadawa during the 2017 wet season could have increased water logging and affected growth and yield of kenaf. This result is in consonance with the findings of National Agricultural Extension Research Liaison Service (NAERLS, 1993), who reported that heavy clay soils is proned to greater water logging and kenaf does not tolerate such a condition at the seedling stage. Kenaf requires a well-drained soil for good growth and yield performance.

The physical and chemical property of the soil (Table 1) shows that the cation exchange capacity (useful indicator of soil fertility) for the soils at both locations was moderate. This is in line with the studies of Hazleton and Murphy (2007) who stated that cation exchange capacity is an essential soil property that influences nutrient availability, soil pH and soil reaction to fertilizers which are all important determinants of crop growth and development.

5.2 Influence of Poultry Manure Rate on Growth and Yield of Kenaf

The positive response of growth components such as plant height, number of leaves, leaf area, leaf area index, shoot dry weight and butt diameter to poultry manure application from 2 to 6 t ha^{-1} at both locations could be attributed to the beneficial role of manure in providing soil nitrogen, phosphorus, potassium and other essential nutrients which in turn improved growth and development of the plants during the trial. The positive effects of poultry manure to enhancing the fertility status of the soils, as the soil were low in organic carbon content. Manure when decomposed increased both micro and macro nutrients as well as enhances the physical and chemical properties of the soil. In this case, this have led to its high vegetative growth. This is in consonance with the findings of Dademel *et al*. (2004) who reported that nitrogen content in organic fertilizers has been known to enhance leaf production, flowering, seed formation and root formation, and lead to higher metabolic activities and consequently higher fruit yield in okra. The application of poultry manure greatly increased the number of leaves, leaf area and leaf area index at both locations. This shows that the manure was readily available and in best form for easy absorption by the roots, to boost the morphological growth of the plant. This finding is supported by Frank (1965) who reported that an increase in vegetative growth in treatments that receive high poultry manure rates from 6-10 t ha^{-1} could be due to high nitrogen content of the manure used. Similarly, the observed increase in plant height and stem base diameter is in agreement with the findings of Adekunle *et al*. (2014), who reported that the application of manure from 10-20 t ha^{-1} significantly increase the height and stem diameter of kenaf.

Yield components such as number of seeds per capsule, number of capsules per plant, fibre, wood and seed yield ha^{-1} were observed to increase significantly with the application of 6 t ha^{-1} of poultry manure at both locations. This could be due to the appreciable amount of essential nutrients in the poultry manure (N,P,K,Ca and Mg) and the favourable weather conditions during the wet season (appendices 1 and 2) that favoured the quick decomposition of the manure. This result conforms to earlier findings by Atif *et al*., (2015) who reported a higher yield of jute mallow when poultry manure was applied. The increase in the yield components of kenaf could be further explained in terms of the increase in leaf area and leaf area index recorded as a result of poultry manure application which enhanced light interception necessary for production of more assimilates used in the formation of seeds. In addition, the higher fibre and seed yield obtained when 6 t ha^{-1} was applied at both locations could be attributed to the fact that kenaf as a vegetable crop requires higher dose of essential nutrients especially N, P and K for growth and development; coupled with the ability of manure to improve the physical and chemical properties of the soil for good crop development and high yields. This observation agrees with the findings of Sendur Kunaran *et al*., (1998) who reported that an increase in yield could be attributed to the solubilisation effect of the major essential nutrients with addition of poultry manure thereby resulting to increased uptake of N, P and K.

5.3 Varietal Response to Growth and Yield of Kenaf

The significant differences recorded among the three kenaf varieties in terms of their growth and yield such as plant height, number of days to 50% flowering and leaf area index, seed weight per plant, fibre, wood and seed yield of kenaf is attributed to differences in the genetic composition of the varieties used. This is in line with the study of Akinfasoye *et al*., (1997) who reported that the differences in yield parameters of crops are attributed to the cultivars grown and their genetic make-up.

Girin danani produced higher fibre, wood and seed yield than Ifeken 400 and Ifeken D1 400 at both locations. Apart from the genetic composition of the variety which plays an important role in the potential yield of the crop, the differences in the rate of nutrient absorption and utilization among the three varieties and environmental variations could greatly influenced the yield of kenaf. This result agrees with the finding of Williams (2004) who observed differences in yield of kenaf varieties due to different genetic make-up of these varieties; and Adeniyan *et al*.,(2014) who stated that variation in characters investigated in varieties (plant height, butt diameter, wood and fibre yield) were due to genetic and environmental variations. The effect of climatic conditions (rainfall and temperature) and soil factors may affect the growth and yield characters (Mader *et al*.,2002).

5.4 Interaction between Varieties and Poultry Manure Rate

The interactions between varieties and poultry manure was significant on plant height, shoot dry weight, number of days to 50% flowering, number of seeds per capsule and wood yield per hectare. Taller plants were observed when 6 t ha^{-1} of poultry manure was applied to

Ifeken D1 400 at 9 WAS at kadawa than Ifeken 400 and Girin danani; while Ifeken 400 produce higher shoot dry weight at 9 and 12 WAS in Samaru than Ifeken D1 400 and Girin danani when 2 t ha^{-1} poultry manure was applied. This is in agreement with the findings of Mubarak (2014b) who reported that higher shoot dry weight obtained in clemson spineless variety of Okra may be as a result of the morphology of the variety which was taller than variety Ex-Samaru-4 and this contributes to the weight of the plant. Ifeken 400 produced flowers early at Samaru when 6 t ha^{-1} poultry manure was applied and this could be attributed to rich nutrients composition of the manure and the ability of the variety to utilize this nutrients supplied by the manure for rapid growth and development, and consequent attainment of early flowering. The earliness in attaining 50% flowering in kenaf through manure application is in conformity with the findings of Eguchi *et al.*,(1958) who reported a delay in flower initiation in plots with nitrogen deficiency. Ifeken D1 400 and produced higher number of seeds per capsule than Ifeken 400 and Girin danani in Kadawa when 6 t ha^{-1} of Poultry manure was applied and this confirmed the findings of Akinrotimi and Okocha (2018) who reported that local varieties produced the highest number of seeds per capsule . Girin danani gave higher wood yield at both locations than the two varieties when 6 t ha^{-1} of poultry manure was applied. This could be attributed to the genetic makeup of the variety which aids in its ability to adapt to the environmental conditions and enhanced light interception necessary for production of assimilates used in the growth and development of the plant. This result is corroborated by the findings of Williams (2004) who observed differences in the yield of kenaf varieties due to their different genetic makeup.

5.5 Correlation Studies

The positive and significant correlations observed between fibre yield and parameters such as plant height, 100 seed weight, and wood yield signify that they are important attributes to fibre yield. It was observed that significant increase in each of these parameters would lead to an increase in the fibre yield in both locations. The correlation study also showed a positive and significant association between seed yield, 100 seed weight and seed weight per plant, which signifies the importance of these parameters to seed yield of kenaf varieties. This is in agreement with the finding of Akinrotimi and Okocha (2018), who reported positive and significant relationship between growth parameters (plant height and leaf area index) and yield components (100 seed weight and seed weight per plant) of kenaf.

5.6 Regression Analysis

The regression analysis showed a positive linear response of kenaf fibre, wood and seed yields to poultry manure rate at both locations, which indicates that the optimum rate of poultry manure was not attained. This means that for optimum yields of fibre, wood and seed to be attained, the manure rate should further be investigated.

CHAPTER SIX

6.0 Summary and Conclusion

Field trials were conducted to determine the performance of kenaf varieties as influenced by poultry manure application. The experiments were carried out during the 2017 wet season at the Institute for Agricultural Research Farm at Samaru, Kaduna State and Kadawa, Kano State. The treatments evaluated were three varieties (Ifeken 400, Ifeken D1 400 and Girin Danani) and four poultry manure rates (0,2,4 and 6 t ha^{-1}) which were factorially combined and laid in a randomized complete block design (RCBD), replicated three times. Parameters measured were plant height (cm), number of leaves, butt diameter (cm), leaf area (cm^2), leaf area index, crop growth rate (g wk^{-1}), relative growth rate (g g wk^{-1}), shoot dry weight (g), number of days to 50% flowering, 100 seed weight (g), number of seeds per capsule, number of capsule per plant, seed weight per plant (g), fibre yield (kg ha^{-1}), wood yield (kg ha^{-1}), and seed yield (kg ha^{-1}). In both locations, the trend of growth and yield components examined were consistent and showed increase with increased application of poultry manure. At Samaru and Kadawa, the application of 6 t ha^{-1} poultry manure gave the highest fibre yield of (164.3 and 170.7 kg ha^{-1}), wood yield of (139.9 and 175.3 kg ha^{-1}) and seed yield of (226.6 and 250.0 kg ha^{-1}) respectively at both locations. A significant increase on number of seeds per capsule, number of capsule per plant and seed weight per plant was recorded by the application of 6 t ha^{-1} poultry manure, which gave the highest number of seeds per capsule (288.28 and 333.56 $kgha^{-1}$), number of capsule per plant (17.80 and 18.98) and seed weight per plant (135.97 and 150.02 g) in Samaru and Kadawa respectively. Girin danani produced more number of leaves, wider leaf area and higher shoot dry weight than Ifeken 400 and Ifeken D1 400. However Ifeken 400 took shorter days to attain 50% flowering. Girin danani produced higher fibre, wood and seed yield than the other varieties in both locations. A positive and significant correlation was recorded between fibre and seed yield and parameters such as plant height and 100 seed weight. The regression analysis for both locations were linear indicating that the optimum poultry manure rate was not achieved

Based on the results obtained from this trail, the application of 6 t ha^{-1} poultry manure resulted in better growth and higher yield with all the varieties. Girin Danani out yielded the other two varieties in both locations. Therefore, the use of Girin Danani variety and 6 t ha^{-1} poultry manure can be adopted by farmers in the Northern guinea and Sudan Savanna agro ecological zones to enhance the productivity of kenaf.

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APPENDIX 1 Samaru Meteorological Observation in 2017 wet season

	% relative humidity		temperature (^{0}c)		earth temp (30cm)		sunshine hours	rainfall (mm)	Evaporation (mm/day)
MONTH	**10 a.m**	**4 p.m**	**Max**	**Min**	**10am (^{0}C)**	**4p.m (^{0}C)**			
JUNE	76.5	61.1	32.33	20.87	26.58	27.07	6.21	4.82	7.07
JULY	85.2	70.9	30.87	20.03	25.96	26.41	6.16	7.49	5.85
AUGUST	80.1	72.2	30.29	19.61	25.77	26.28	4.66	7.72	5.86
SEPTEMBER	76.7	68.4	31.93	18.97	26.49	27.15	6.43	6.52	5.54
OCTOBER	64.5	50.1	44.10	18.10	26.21	26.88	6.63	NA	NA
NOVEMBER	NA	NA	34.20	11.97	NA	NA	NA	NA	NA
DECEMBER	NA	NA	31.36	12.48	NA	NA	NA	NA	NA

Source: IAR Meteorological Unit, Samaru- Zaria. Kaduna.

NA: Not Available

APPENDIX 2: Kadawa Meteorological Observation in 2017 wet season

	SOILTEMPERATURE		TEMPERATURE(^{0}C)		RAINFALL (mm)	HUMIDITY (%)
MONTH	**10cm**	**20cm**	**Min**	**Max**		
JUNE	35.5	31.8	25.0	36.2	125.0	79
JULY	35.1	30.7	23.5	33.1	223.9	86
AUGUST	32.4	29.9	24.2	33.3	505.8	88
SEPTEMBER	29.2	30.1	22.8	31.4	236.8	82
OCTOBER	32.7	30.1	26.6	33.9	25.0	65
NOVEMBER	32.1	29.5	15.9	31.2	NA	35
DECEMBER	26.2	23.8	13.4	24.4	NA	45
AVERAGE	31.6	29.6	22.9	32.4	474.1	61.1

Source: Kadawa Meteorological Unit, of IAR, ABU, Zaria.

NA: Not Available.

BIOGRAPHY

HABIBU, AMINU

Born in Keffi, Nasarawa State

EDUCATION QUALIFICATION AND INSTITUTION: **YEAR**

First School Leaving Certificate	St Peters Nur/Pri School Keffi	2002
Senior Secondary School Certificate	Federal Government College Keffi	2008
B. Agric (Crop/Soil option)	Nasarawa State University Keffi	2014

WORK EXPERIENCE:

National youth service	Sokoto Agricultural Development Project, Sokoto State.	2014-2015
Npower Nagro Agric Extension Advisor	Nasarawa Agricultural Development Project, Keffi, Nasarawa State.	2017-2020
Research Officer (II)	Cocoa Research Institute of Nigeria Ibadan, Oyo State.	March-2020-Date

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