PRODUCTIVITY OF SOYBEAN (*Glycine max* (L.) Merrill) AS INFLUENCED BY COW DUNG, STAND DENSITY AND PLANTING PATTERN

BY

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DECLARATION

I declare that the work in the thesis entitled "Productivity of soybean (*Glycine max* (L.) Merrill) as influenced by cow dung, stand density and planting pattern" has been performed by me in the Department of Agronomy under the supervision of Drs B.A. Babaji, R.A Yahaya and Mrs A.A. Mukhtar.

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

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Confirmed by

Dr B.A. Babaji
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CERTIFICATION

This thesis titled Productivity of soybean (*Glycine max* (L.) Merrill) as influenced by cow dung, stand density and planting pattern meets the regulations governing the award of the degree of M.Sc. Agronomy of Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This research work is dedicated to my present and future family.

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There is always a reward for a work well done, because it is often said that "No Venture, No Success." There is a price for every sacrifice. This thesis is no exemption. To achieve such an academic feats requires meaningful and substantial contributions from various people. Like any reasonable and grateful person, I cannot find words adequate to express my profound gratitude to all those who contributed tremendously to the realization of this consolidating step in my academic pursuit.I wish to first and foremost express my appreciation to God almighty for the strength given me before and during my course and research work.

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ABSTRACT

The productivity of soybean as influenced by cow dung, stand density and planting pattern was investigated under field condition at the Institute for Agricultural Research farm in Ahmadu Bello University, Samaru and at farmers field Hayin Gada Giwa Nigeria. Treatments consisted of four rates of cow dung (0, 2, 4 and 6 t ha^{-1}), two stand densities (3 and 6 plants per stand) and two planting patterns (single and double row planting). Randomized complete block design with three replications was used. The result showed that increase in cow dung to 2 t ha^{-1} 6 significantly increased total dry matter, grain weight and yield per hectare at both locations while increase up to 6 t ha^{-1} significantly increased plant height 4WAS at Samaru, number of branches 12WAS at Samaru, leaf area index 4WAS at Samaru. Generally plants grown at 6 plants per stand were taller and had larger leave area values as compared with those planted at 3 seeds per stand. Plants grown at 3 plants per stand and supplied with 6 t ha^{-1} cow dung manure on double row produced taller plants, while 3 plants per stand receiving 6 t ha^{-1} cow dung manure on single row produced more leaves. Double row planting produced taller plants, produced more branches 8WAS at Giwa, total dry matter 4WAS at Samaru and had the highest LAI value at both location. Highly significant and positive correlation (P=0.01) was observed between soybean yield and number of leaves, number of pods per plant , weight of pods per plant and grain weight per plant at both locations. In conclusion 6 plants per stand supplied with 2 t ha^{-1} gave the highest grain yield of soybean however when the regression analysis was carried out 4.5 t ha^{-1} could be recommended for high yield .

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin and Distribution

Soybean (*Glycine max* (L) Merrill) belongs to the family Fabaeceae and genus *Glycine*. Soybean also known as Chinese beans originated from China where it has been grown for over 5,000 years (Hymowitz, 1970).The distribution of soybean spread gradually from Northern China to East and South Asia countries of Korea and Japan between 2,000 BC and the third century AD (Hymonwitz and Kaizuma, 1979). Soybean was introduced Africa in 1709 but cultivation by small holder farmers was initiated in East Africa in 1908, through the trade links between Asian and East African countries (Bichi, 1982). In 1908 the crop was introduced to Moor plantation in Ibadan, Nigeria by the British (Fennel, 1966) The re-introduction of the adapted cultivars, Malayan to Samaru, Northern Nigeria in 1928 was a success (Ezedinma, 1964; Dinakin, 1986). Research work started on the crop in Samaru, Nigeria in 1930 and this led to the development and release of new cultivars – SAMSOY1 and SAMSOY 2 in 1982 (Nyiakura, 1982; Leleji and Adedzuwa, 1983).

1.2 World Production of Soybean

The potential uses of soybean have made the crop to gain popularity worldwide. World production increased from 210.9 million metric tons in 2009 to 258.4 million metric tons in 2010 (USDA, 2010). Total harvested area increased from 31.3 to 31.4 million hectares from the same period. The major producing countries are United States of America, Brazil, China and Argentina accounting

for about 90% of total world production. United States alone account for about 38% of total world produced soybean. Production in Africa was lowest at over 1 million hectare cultivated with yield of 1.5 metric tons (IITA, 2010).

1.3 Soybean Production in Nigeria

Nigeria is the leading producer of soybean in Africa with an estimated annual production of about 600 000 metric tons in (NAERLS, 2010).The growing importance of soybean led to its expansion to many parts of Nigeria. Benue is the leading producer of soybean in Nigeria with production center at Gboko and Kwande, Kastina-Ala, Gwer and Makurdi Local Government Areas (Nyiakura, 1982) .

1.4 Uses and Economic Importance of Soybean

Soybean is one of the richest food crop and industrial raw material (Dutta, 1974). This is attributed mainly to its seeds, which has a total digestible nutrient percentage of about 92%, implying that it is an excellent source of energy. It contains 40 - 42% protein and has better balanced amino acids than other vegetable protein sources. It has also become the leading source of edible oils and fats, and supplies 20% of the world's needs of these essential materials. It contains 20 - 22% oil of which 85% is unsaturated and cholesterol free (Nelson *et al*., 1978, Uwala, 1985). Its carbohydrate content is about 34% and ash constitute about 4.9% (Weingartner, 1987).

Soybean flour is useful as wheat substitute in making confectioneries, bread, pastries, breakfast food, macaroni and spaghetti. Soybean oil is used in the production of margarine, salad oil, cooking oil and butter. The dried beans can be boiled, roasted and made into coffee substitute, vegetable milk, cheese and

yogurt. It can also be made into local foods such as pap; porridge and spices such as *"daddawa"* and the ground paste is used as a substitute for melon seed for soup preparation. It is an important pre-requisite for weaning children (Koleoso and Onyekwere, 1983; Mijindadi, 1987).

Soybean is very important for industrial use. The cake obtained after oil extraction is a rich source of minerals particularly calcium, phosphorus and iron and it is good source of vitamins such as thiamin, riboflavin and niacin (Nyiakura, 1982). These properties, among others make soybean very attractive for various industrial processing and utilization in many parts of the world thereby, offering employment opportunities and manufacture of more consumable items like glycine, varnishes, enamel, water proof goods, linoleum, printing ink, rubber substitutes , paints, perfumes, soap, candle, lecithin, insecticides, celluloid etc (Delorit *et al*.,1974). The cake is also used as a constituent of fertilizer (Norman, 1978).

Soybean is used as a forage crop and feed for animals in form of hay and silage. Several agro-based industries utilize soybean cake, which is a major source of protein concentrate (about 50%) for livestock and poultry feed (Nyiakura, 1982). Soybean is valued for its improvement of soil fertility by biological fixed nitrogen through its association with *Rhizobium japonicum*, the nitrogen –fixing bacteria present in the root nodules of the plant. Soybean plant fixes 49 - 480kgs nitrogen per hectare for subsequent crops planted (Peoples and Crasswell, 1972; Rajaralnam, 1973; Hardy and Havelka. 1975; Saxena and Chandel 1992 and Wanni and Lee, 1992).This amount fixed may not meet the demand for high yield.

1.5 Constraint to Soybean Production

So many constraints have been identified for the low output of soybean. Average grain yield of soybean is low (<1 t/ha) in tropical Africa. Dual-purpose improved varieties of soybean have not reached growers to increase their production. Seed production and distribution is also a major impediment in soybean– growing countries of Africa. Pod shattering especially in the hot dry savannah environments, reduction in seed longevity, and lodging are still constraints in soybean production. (IITA, 2010)

Lack of varieties tolerant to midseason moisture stress and high yielding varieties tolerant to low phosphorus are among the abiotic constraints. In Nigeria, farmer's inability to utilize optimum plant density, unavailability of inoculums for commercial use and environmental problems are serious production constraints to the realization of good yield. Besides, equipment for processing soybean is also unavailable in many African countries. Research on seed quality such as protein, oil, carbohydrate, and anti-nutritional factors is lacking. Moreover, lack of emphasis on using molecular markers as aid to conventional breeding is also worth mentioning.

1.6 Justification

In Nigerian, Southern and Northern Guinea savanna zones constitute the major soybean producing belt within the Northern Guinea Savanna ecological zone. It's the most suitable area for soybean production because of its unimodal pattern of rainfall. However, savanna soils are generally low in native fertility, particularly carbon (0.03-0.06%), total nitrogen (0.005 - 0.03%) and available phosphorus

(0.12-0.18meq/100g) [Heathcote and Stockinger, 1970; Mokwunye, 1979 Chiezey *et al*. 1991] which invariable lead to low yields of crop including soybean.

Fertilizer use per hectare in Nigeria is very low due to problems of procurement caused by poor distribution system and high cost of fertilizer. For leguminous crops however, the problem of nitrogen availability is minimized by the ability of the crop to fix their own nitrogen from the atmosphere, even though they need some amount as starter dose. In Nigeria cow dung is readily available and affordable. It provides good source of both macro and micro nutrient that can increase soil carbon and nitrogen content, enhance soil microbial activity.

Seed has become one of the most expensive input costs for soybean growers, so the question of soybean seeding rates has taken on more importance in recent years. As a result, there is great interest from farmers in reducing soybean seeding rates and maintaining maximum yield. Therefore, it is imperative to find out the optimum planting density to obtain optimum leaf area index and to maintain it for longer period to improve yield potential of soybean

Plant population is another important factor for higher yield. If plant density is above the optimum, plant growth may be poor due to competition for nutrients, light and space. On the other hand, if it is below optimum then the nutrients, space and light will not be fully utilized, thus resulting into poor growth and yield. For exploiting the potential of high yielding varieties, the use of optimum plant population is very important.

Solar energy being unlimited, inexhaustible and non-pollutant, its efficient utilization for crop production could be a major consideration especially for a row

crop like soybean. Also for higher crop productivity, total leaf area per unit land area and light penetration to lower layers of the canopy are very important in this regard. Increasing or reducing the leaf area index from the optimum will reduce the crop growth rate due to lesser energy capture or shading of lower canopy layer. Chiezey *et al.* (2009) reported increase in grain yield of soybean and growth parameter with the application of 1t ha^{-1} of poultry manure. Olufajo (1990) also found that increase in population density increased grain yield of soybean plant up to 600,000 plants ha^{-1}.

1.7 Objective of Study

This study was therefore conducted to:

(1) To determine the productivity of soybean at different cow dung levels

(2) To determine the effect of planting pattern on soybean productivity.

(3) To determine the effect of stand density on the productivity of soybean.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of Cow Dung Manure on Soybean

The ability of soybean to utilize manure nutrients has economic and environmental impacts. Soybeans have the potential to utilize manure nitrogen (N), phosphorus (P) and potassium (K); thus increasing the potential manure application rate when comparing a corn-soybean rotation to application based only on corn and reducing the costs of commercial fertilizer for soybean production. Soybean has the potential to act as a sink for nitrogen by using inorganic nitrogen available in the soil. Varel *et al*. (1992) showed that soybean can remove up to 200 kg N/ha from the soil. Liquid manure can provide phosphorus and potassium to crops in deficient soils.

In a study conducted by Schmidt *et al*. (2000) soybean yield response was shown to increase with increasing manure nitrogen application rates for three of seven field locations. Manure was applied at seven field locations in Minnesota, to multiple soybean cultivars at zero, low, and high rates of nitrogen. Low rates ranged from 43 – 230 kg N/ha and high rates ranged from 72 – 460 kg N/ha. Soil tests for each of the sites showed that sufficient amounts of phosphorus and potassium were available for each plot. Increases in yield coincided with sites having lower available soil nitrogen in mid-June. In cases where the site had a history of white mould, the application of manure was generally unfavourable. The authors summarize that improving the ability to identify fields requiring additional nitrogen would improve soybean yield responses to manure.

McAndrews *et al*. (2006) investigated the residual effects of manure application on soybean growth and yield. Fresh or composted solid swine manure from hoop structures was applied in the fall or spring prior to corn. The residual impacts of the manure application were evaluated on the following soybean crop. For comparison, three urea treatments and a control treatment with no manure or urea were included. The manure treatment had an application rate of 340 kg N/ha and the urea treatments had application rates of 60, 120, and 180 kg N/ha. In both 2001 and 2002, the soybean plants that had composted or fresh manure applied before the previous corn crop were significantly taller than soybean plants in plots where urea was applied or where no fertilizer was applied. Additionally, they found greater potassium concentrations (27% in 2001 and 29% of 2002) in the soybeans that were grown in the manure amended plots. In both years, the soybean yield was greater in manure plots than the control or urea plots. It is speculated that soil factors not measured as part of the study such as microbial activity and concentrations of substances that mimic the effects of plant growth regulators may have contributed to the soybean responses observed. Overall, the residual effects of manure had positive effect on soybean grains.

. Killorn (1998) provided a review of data suggesting increased yields from soybean plots receiving manure. During a four-year study with a corn/soybean rotation, manure was applied at three frequencies (every year, every other year to corn and every fourth year to corn), plus a control that did not receive any manure. Manure was applied at a rate of 168 kg N ha^{-1}. When manure was applied for each year of the study, the soybean yield was 6-10kg/ha greater in the fourth year crop. However, during the second year of the study (the first soybean crop

during the rotation), no yield increase was shown. Soybean yields were 4-8kg/ha greater in the fourth year crop. Barbazan (2004) examined the effect of manure and phosphorus fertilizer application on soybeans. In the study, manure and phosphorus fertilizer were applied at rates equivalent to half (100 kg N/ha) and total (200 kg N/ha) of the expected nitrogen removal. Manure and fertilizer applications were made in the spring, four weeks prior to planting either via injection or broadcast and incorporation. Results indicated that slightly higher and more frequent early plant growth occurred with manure application as compared to phosphorus fertilizer application done even though at comparable phosphorus application rates. The control plots showed that the early plant growth was not due to soil test phosphorus already present, therefore the author suggests higher early plant growth could be the result of additional nitrogen available in the manure, or it could be the result of other nutrients and unknown growth factors in the manure. However, early growth response did not translate to a grain yield response in the study.

Rakshit (2002) conducted experiments to study the impact of manure application on soybean production and residual soil nitrogen. Liquid swine manure nitrogen rates at target levels of 0, 112, and 224 kg N/ha were applied to multiple plots. Soybean yield increases significantly three of the five sites the yield increase was statistically significant. The reasons for the increases in yield response following manure application are undetermined. Two of the five sites showed potential for a yield response with addition of phosphorus and potassium, but the increase could also be due to nitrogen or some other unknown factor in the manure. De-Jong (1995) studied the effects of liquid swine manure and urea ammonium nitrate

(UAN) application on soybean yields response and grain nitrogen content. The result was low soybean yields and reduced treatment effects in 1993. However, in 1994 growing conditions were optimal and soybean yields increased with increasing manure application. The research revealed that highest yields were shown in the plots receiving manure. It is believed that results were due to soil deficiency in phosphorus and potassium at the plots only receiving UAN. The nitrogen concentrations in the grain were greatest in the soybeans receiving the highest manure application rates.

Hati *et a*l. (2006) studied the effect of farmyard manure on soybean in a soybean-mustard cropping system. They examined the effect manure had on the soil physical properties, water-use efficiency, root growth, and soybean yield in a clayey soil. The manure contained approximately 0.48 percent, 0.17 percent, and 0.38 percent N, P, and K, respectively. The results showed that manure in combination with inorganic fertilizer improved soil physical conditions. The farmyard manure plus inorganic fertilizer amendment increased the average soybean yield by 103% over the non-amended control and by 40% over the control receiving only inorganic fertilizer.

2.2 Effect of Stand Density on Growth and Yield of Soybean

The difference in number of plants/stands is of great importance for the yield, and other yield contributing attributes of mash bean (*Vigna mungo* L.). As far as available literature is concerned, no any extensive work has been carried out about the effect of number of plants/stand on the growth, yield and yield components of mash bean with special reference to the existing climatic

conditions of tropics. Gupta and Lal (1988) stated that increase in number of plants/stand from 20 to 50 kg ha^{-1} significantly reduced branches $plant^{-1}$ and 1000 grain weight, but did not affect plant height and yield. Imtiaz *et al*. (1988) revealed that differences among number of plants/stand of mash been were statistically significant as moderate number of plants/stand (17.5-25 kg ha^{-1}) was much better than the lower (10-15.5 kg ha^{-1}) and higher (27.5-37.7 kg ha^{-1}) number of plants/stands. Singh *et al*., (1994) also reported in Pakistan greatest seed yields (1.22, 1.39 and 1.26 t ha^{-1}) produced at 20, 30 and 40 kg seeds ha^{-1}, respectively. Similarly Shah and Rahman (2009) concluded that number of plants/stand had significant influence on yield and most growth attributes of rapeseed. They also stated that the yield tended to increase with an increase in number of plants/stand up to 10 kg ha^{-1}, above which a slight decrease was noted. Majority of the researchers obtained the optimum grain yield of mash bean and other legumes by applying seed at 18-20 kg ha^{-1} (Khan and Asif, 2001; Maqsood *et al*., 2001; Ashraf *et al*., 2003; Hayat *et al*., 2008a and 2008b). Research also revealed that most of the growth and yield contributing attributes are significantly and positively correlated with the grain yield of many crop plants like., mash bean (Mahmoodul-Hassan *et al*., 2003; Khan *et al*., 2004), chickpea (Arshad *et al*., 2004), mungbean (Siddique *et al*., 2006), soybean (Malik *et al*., 2007) and sunflower (Vahedi *et al*., 2010). The optimum number of plants/stand in pulses is the most important factor for realizing good yields.(Abdulkabir *et al*., 2011).

In untreated checks in Michigan, the mean weed biomass was lowest in soybean planted with 76-cm row spacing at seeding rates of 432,000 seeds/ha compared to

308,000 and 185,000 seeds/ha. The highest soybean grain yield resulted from the highest seeding rate in both locations in 2002 (Rich and Renner, 2007). Harder *et al*. (2007) reported higher soybean yield for the weedy check plots with 76-cm row spacing with 445,000 plants/ha compared to lesser seeding densities with the same row spacing. However, weed biomass was not affected by the soybean seeding rate increase from 296,000 plants/ha to 445,000 plants/ha regardless of row spacing. Such results demonstrate that increased seeding rates may not be an effective stand-alone weed control method, but very few investigations have tested the effect of seeding rate on weed control in organic soybean systems utilizing other methods such as mechanical weed control.

2.3 Effect of Row spacing on Growth and Yield of Soybean

The greatest influence that narrow row spacing has on soybean productivity is in the reduction in the amount of light that reaches the soil surface and in the reduction in the amount of time that it takes for soybean to reach full canopy closure. Puricelli *et al*., (2003) and Steckel and Sprague (2004) independently detected significantly less radiation at the soil surface in narrow- compared to wide-row soybean throughout most of the growing season. Similarly, Dalley *et al*. (2004) and Yelverton and Coble (1991) observed greater light interception in narrow- compared to wide-row of soybean. Results from other studies also revealed that narrow row soybeans reach complete canopy closure quicker than wide-row soybeans (Shibles and Weber (1965); Wax and Pendleton 1968). For example, in one of the earliest investigations conducted on the effects of row spacing on weed control, Burnside and Colville (1964) reported that soybeans

grown on 25cm rows provided complete shading of the ground 22 days earlier than soybeans grown on 76cm spaced rows.

The available research conducted to date indicates that under most conditions narrow-row spacing will reduce the likelihood of weed resurgence in soybean (Dalley *et al*., 2004). In many studies, this response has been directly correlated with the faster rate of canopy closure and reduction in light interception at the soil surface in narrow- compared to wide-row systems. The available studies also indicate that the critical time of weed removal is most likely to occur later in narrow- compared to wide-row soybeans.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experiment Site

The experiment was carried out during the rainy season of 2011 at two sites; one at the Research Farm of the Institute for Agricultural Research (IAR) Samaru located at latitude 11^0 17' N and 007 68' E 694 above sea level Sabon-Gari Local Government Area and at Hayin Gada Giwa , located at latitude 11^0 19' N and 007^0 57' E 666m above sea level Giwa Local Government Area of Kaduna State Nigeria.

3.2 Weather Data

Information on temperature, rainfall and sunshine hours throughout the period of the experiment were collected from the IAR Meteorological Station, Samaru and were presented in Appendix I.

3.3 Soil Sampling and Analysis

Prior to land preparation, soil samples from the two depths of (0-15cm and 15-30 cm) were collected at random across the experimental fields for each of the sites using a soil auger. The composite soil samples taken after bulking for each depth were analyzed in the laboratory for physical and chemical properties. The results were presented in Table 1.

3.4 Treatments and Experimental Design

The treatments consisted of a factorial combinations of two stand densities (3 and 6 plants/stand, four cow-dung manure rates (0, 2, 4 and 6 tones ha^{-1}) and two row planting patterns (single and double rows).The single with 200,000 and 400,000

plant ha^{-1} while on the double row a population of 400,000 and 800,000 plant ha^{-1} was obtained

The treatments were laid out in a randomized complete block design with three replications. Each treatment combination was accommodated in a gross plot size of $18m^2$(3m x 4.5m). Each plot had six ridges at inter row spacing of 75cm with the first two rows from both sides forming discard. Growth parameters were estimated from the second two outer rows used as sampling plots while grain yield and other yield parameters were estimated from the two inner rows that formed the (net plot of $7.0m^2$).

3.5 Crop Varietal Description

This variety used for study is TGX1835E-10E obtained from International Institute of Tropical Agriculture Kano. It is an erect, study stem, with green base coloration and height of about 55cm.The variety is adaptable to all rust endemic areas of Nigeria and is early maturing (about 90 days), high nodulation, highly resistant to *Cercospora* leaf spot and bacterial pustule. It has a potential grain yield of 1.5 to 2.0 t/ha.

3.6 Cultural Practices

3.6.1 Land preparation

The experiment site was harrowed to a fine tilt and later ridged at 75cm apart at both locations. Plots were demarcated and marked out after measurement using pegs.

3.6.2 Sowing

Planting was done on 19th July and 27th July at Samaru and Hayin Gada respectively. The seeds were dibbled at 20cm intra- row spacing at 5 and 8 seed per stand which was later thinned a week later as per treatment requirement of 3 and 6 plants as well as double and single rows.

3.6.3 Planting pattern

The seeds were sown on the crest of the ridge for the single row and at both side of the ridge for the double row planting pattern.

3.6.4 Manure application

Cow dung manure was incorporated into the ridge as per treatment two weeks to planting at 0, 2, 4 and 6 tons per hectare.

3.6.5 Weed control

Pre- emergence herbicide (Pendimethalin) was sprayed immediately after planting at the rate of 0.5kg a.i/ha and thereafter weeds were manually controlled by hoeing once at 6 weeks after sowing (WAS) in each locations.

3.6.6 Harvesting

Harvesting of soybean for yield was done when up to 90% of the pod turned brown. Harvesting was done by uprooting the whole plant from the field, the plants were then dried and the pods threshed.

3.7 Data Collection

Sampling for measurement of growth parameters started at 4WAS and continued at 4 week intervals up to 12WAS.Five plants within the net plot were randomly

tagged for measurement of growth parameters. The following parameters were assessed.

3.7.1 Plant height

Plant height was measured (using meter ruler) from the ground level to the highest growing point and the mean was worked out for each plot.

3.7.2 Number of leaves per plant

Numbers of leaves from each of the five tagged plants in each plot was counted and later mean determined and recorded number of leaves per plant for each plot.

3.7.3 Number of branches

Numbers of branch per plant were determined by counting the branches from the five tagged plants and the mean recorded for each plot.

3.7.4 Leaf area index

Five plants from the sampling rows plot were sampled and later the leaves were removed for the purpose of determining leaf area per plant. Leaf area was measured using cork borer method, where cork borer of a known area was notched into known number of leaves. The collected leaves portion in the disc was thereafter oven dried to a constant weight at 70^0C in an oven for 48hrs. Leaf area was calculated as described by Watson (1947).

$$leaf\ area = \frac{Total\ leaf\ dry\ weight}{Dry\ weight\ of\ disc}\ Area\ of\ disc\ (cm^2)$$

$$leaf\ area\ index = \frac{leaf\ area\ m^{-2}}{land\ area\ m^{-2}}$$

3.7.5 Total dry matter

Total dry matter per plant was determined by sampling 5 plants outside the net plot .The uprooted plants was thereafter oven dried to constant weight at 70^0C in an oven for 48hrs. The oven dried samples were weighed thereafter, and the mean determined.

3.7.6 Net assimilation rate (NAR)

Weight values for dried plants from 3.7.5 above were divided by the leaf area of each plant. The mean values were worked out being the NAR as described by Watson (1958).

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{Log_e A_2 - Log_e A_2}{A_2 - A_1} \qquad gdm^{-2}\ week^{-1}$$

W_2 and W_1 are total dry matters of plant and A_2 and A_1 corresponding leaf areas at times T_2 and T_1 respectively.

3.7.7 Relative growth rate

The relative growth rate of the plant was computed using the following equation as described by Watson (1967).

$$RGR = \frac{log_e W_2 - log_e W_2}{T_2 - T_1} \quad g\ g^{-1} wk^{-1}$$

Where W_1= plant dry matter weight at time T_1

W_2= plant dry matter weight at time T_2

3.7.8 Days to 50% flowering

Days to 50% flowering was determined by counting the number of days from the time of sowing to when 50% of the plants in each plot flowered which was recorded for each plot.

3.7.9 Number of pods per plant

Five plants were harvested from the net plot. The pods picked, counted and the average taken and recorded for each plot.

3.7.10 Weight of pods per plant (g)

From five plants in 3.7.9 pods were picked and weighed, and the average was taken by dividing the total weight of pods by the number of plant sampled and the mean recorded for each plot.

3.7.11 Grain weight per plant (g)

The grain from net plot was weighed using a metler balance thereafter the mean recorded for each plot.

3.7.12 100 grain weight (g)

100 grains were counted from threshed seeds for each net plot and later weighed using a metler balance model 1210 and the values recorded for each plot.

3.7.13 Grain yield per hectare (kg)

Grain yield per hectare was computed from the weight of seeds obtained from the net plot and was thereafter converted on per hectare basis.

3.7.14 Harvest index

The harvest index (K %) was calculated by using the equation

$$K\% = \frac{Weight\ of\ grains}{Weight\ of\ Total\ Dry\ Matter} \times 100$$

3.8 Statistical Analysis

The data obtained were analyzed statistically as described by Snedecor and Cochran (1967). The means of the treatments were then compared using Duncan Multiple Range Test (Duncan 1955). Regression analysis was done to determine the optimum cow dung rate for maximum soybean grain yield (Steel and Torrie, 1994) and Correlation coefficient analysis estimated in order to determine the nature and magnitude of relationship between grain yield, growth and yield components.

CHAPTER FOUR

4.0 RESULT

4.1 Soil chemical Analysis and Cow dung Analysis

The result of chemical and physical analyses of the soil from the experimental sites and cow dung are shown in Tables 1 and 2 respectively. The result revealed that the soils were loam and clay loam in Samaru and Giwa respectively. The soil has low organic carbon (0.61- 1.43%), total nitrogen (0.06 to 0.17 %), available phosphorus (2.65 to 24.8%). Exchangeable bases were 0.26 to 1.48% Meq/100g Ca, 0.43 to 0.94 % Meq/100g Mg, 0.09 to 0.14% Meq/100g K, 2.5 to 7.46% Meq/100g Na as well as cation exchange capacity of 5.4 to 7.9 Meq/100g . While the chemical analysis of the cow dung used on the experimental site revealed higher values for nitrogen (1.79%), 1.4% potassium and 0.70% phosphorus.

4.2 Plant Height

The effect of rates of cow dung, stand density and planting pattern on plant height of soybean at Samaru and Giwa is shown in Table 3.Application of cow dung significantly influenced plant height only at 4WAS at Samaru. The applied 2 t ha-^{1} cow dung rate did not result in significant increase in plant height however further increase to 4 and 6 t ha^{-1} significantly increased height of the soybean.

The use of different number of plants/stand significantly affect plant height only at 4 and 12 WAS in both locations. At 4WAS in Samaru, sowing 3 plants per stand resulted in taller soybean plants. However, at the same sampling period at

Table 1: Physical and chemical property of the soil up to 30cm depth of the Experiment Plot at Samaru and Giwa

Soil characteristic	Samaru		Giwa	
	0-15cm	15-30cm	0-15cm	15-30cm
pH in 0.01m CaCl2	5.24	5.08	4.97	5.24
Organic carbon %	0.70	0.61	1.43	1.09
Total Nitrogen %	0.11	0.17	0.06	0.08
Available phosphorus Mg/Kg	24.8	4.1	3.82	2.65
Bases (Meq/100g)				
Ca	1.48	0.63	0.26	0.40
Mg	0.43	0.94	0.44	0.80
K	0.14	0.09	0.13	0.11
Na	25.43	7.46	6.16	3.95
C.E.C	5.5	6.8	5.4	7.9
Particle size Distribution				
Sand (%)	35	37	34	30
Silt (%)	51	45	38	32
Clay (%)	14	18	28	38
Textural class	Silt loam	Loam	Loam	clay Loam

Table 2: chemical properties of cow dung manure used in the experiment

Nitrogen %	1.79
Potassium %	1.4
Phosphate %	0.70

Table 3: Effects of cow dung, stand density and planting pattern on plant height (cm) of soybean at Samaru and Giwa

Treatment	Plant height(cm) Weeks after sowing					
	4		8		12	
	Samaru	Giwa	Samaru	Giwa	Samaru	Giwa
Cow dung(CD) t/ha						
0	15.6c	10.8	34.5	29.7	44.1	40.3
2	15.8c	11.3	35.7	31.4	42.8	38.7
4	17.0b	11.6	37.4	33.2	44.1	37.1
6	17.1a	11.8	38.3	34.3	46.0	43.1
SE+	0.5	0.3	1.5	1.5	2.2	2.6
Stand density(S)						
3	16.8a	11.0b	35.4	31.4	41.6b	37.6b
6	15.7b	11.8a	37.5	32.9	46.9a	42.3a
SE±	0.3	0.2	1.1	1.1	1.6	1.8
Planting pattern(P)						
Single	15.3b	11.5	36.8	32.0	43.2	39.9
Double	17.2a	11.3	36.2	32.3	45.2	40.0
SE±	0.3	0.2	1.1	1.1	1.6	1.8
Interactions						
CD*P	NS	NS	NS	NS	NS	NS
CD*S	NS	NS	NS	NS	NS	NS
P*S	NS	NS	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS	**	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT. **= highly significant($p \leq 0.01$); NS=Not significant

Giwa and at 12WAS in both locations sowing 6 plants per stand resulted in taller plants.

Varying the number of rows per ridge significantly influenced plant height only at 4WAS in Samaru, where sowing of soybean on double row per ridge significantly produced taller plants than for the single row planting at 4WAS at Samaru.

The interaction between cow dung, planting pattern and number of plants/stand on plant height was significant at 12WAS in Samaru. Table 4 shows the interaction of cow dung manure, number of plants/stand

Table 4. Interaction of cow dung, stand density and planting pattern on plant height (cm) of soybean 12WAS in Samaru

		Planting pattern	
Cow dung (CD)t/ha	Stand density (S)	Single	Double
0	3	36.8c	47.5b
	6	44.3b	47.7b
2	3	40.2b	43.2b
	6	39.7c	48.3b
4	3	39.7c	40.0bc
	6	52.7b	44.0b
6	3	32.2c	66.3a
	6	47.2b	38.0c
SE±		4.5	

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

and planting pattern on height of soybean at 12WAS in Samaru. Height of soybean plant was not significantly affected by planting pattern when 0 t ha^{-1} cow dung + 6 plants per stand, 2 t ha^{-1} cow dung manure and 3 plants/stand and 4t ha^{-1} cow dung manure with either 3 or 6 plants/stand planting. Double row planting of soybean resulted in taller plants when sown at 3 plants/stand with either 0 or 6 t ha^{-1} cow dung as well as 6 plants/stand with 2 t ha^{-1} cow dung manure .The situation was reversed for 6 plants/stand of soybean supplied with 6 t ha^{-1}cow dung manure, where the single row pattern resulted in taller plants. At 0,4 and 6 t ha^{-1} increasing number of plants/stand from 3 to 6 for single row soybean increased plant height while the plant height decreased with increase in number of plants along with cow dung 2 t ha^{-1}. When the double row sown soybean was considered, it was observed that varying the number of plants/stand had significant effect on height of soybean plants only when the highest manure rate of 6 t ha^{-1} was applied, where soybean sown at 3 plants/stand resulted in significantly taller plants. The tallest plants were produced by the combination of 6 t ha^{-1} cow dung manure, 3 plants/stand sown on double row. While the shortest plants were observed with 0 t ha^{-1} cow dung manure + 3 plants/stand + single row. This in turn was observed to be statistically at par with 2 t ha^{-1} + 6 plants/stand + single row, 4 t ha^{-1} cow dung manure + 3 plants/stand + either single or double row, 6 t ha^{-1} cow dung manure .

4.3 Number of Leaves

The response of number of leaves of soybean to rates of cow dung, stand density and planting pattern at Samaru and Giwa is shown on Table 5. Neither application of cow dung manure nor platting pattern had significant effects on the number of leaves at both locations throughout the sampling periods. The uses of different number of plants/stand significantly affect the number of leaves only at 4WAS and 8WAS at Samaru and Giwa, respectively. Soybean sown at 3 plants per stand produced more leaves than 6 plants per stand in both location. At 4WAS the interaction of cow dung manure, planting pattern and number of plants/stand in Samaru and that of cow dung and number of plants/stand on number of leaves of soybean in Giwa were significant.

Table 6 shows the interaction of cow dung manure, number of plants/stand and planting pattern on number of leaves of soybean at 4WAS in Samaru. Varying the number of rows per ridge at 0 t ha^{-1} + 3 or 6 number of plants/stand, 4 t ha^{-1} + 3 plants/stand and 6 t ha^{-1} + 3 number of plants/stand had no significant effect on number of leaves. Double row soybean resulted in higher number of leaves for soybean sown at 3 plants/stand and supplied with either 0 or 4 t ha^{-1} cow dung manure. The situation was reversed for 6 plants/stand of soybean when sown and supplied with 2 or 6 t ha^{-1} cow dung; where the double row pattern resulted in more leaves. Regardless of manure rate increasing number of plants/stand from 3 to 6 for single row soybean increased number of leaves. When the double row sown soybean was considered, leaf production was increased when density was increased from 3 to 6 plants for plot supplied with 2 and 6 t ha^{-1}cow dung. The highest number of leaves value was produced by the combination of 6 t ha^{-1}cow

dung manure + 6 plants/stand + single row, while plants with the least value for number of leaves were observed with 2 t ha^{-1} cow dung + 3 plants/stand.

Table 5: Effects of cow dung , stand density and planting pattern on number of leaves of soybean at Samaru and Giwa

Treatment	Number of leaves Weeks after sowing					
	4		8		12	
	Samaru	Giwa	Samaru	Giwa	Samaru	Giwa
Cowdung (CD) t/ha						
0	5.7	4.3	19.9	15.5	30.2	26.2
2	5.9	4.4	22.2	16.2	29.8	25.8
4	6.1	4.6	19.3	17.9	28.3	24.3
6	6.3	4.8	23.1	19.4	33.1	29.1
SE+	0.3	0.1	1.5	1.4	2.0	2.0
Stand density(S)						
3	6.5a	4.6	21.9	18.3a	30.2	26.4
6	5.4b	4.5	20.3	16.2b	30.5	26.3
SE±	0.2	0.1	1.1	1.0	1.4	1.4
Planting pattern(P)						
Single	5.8	4.5	20.8	16.8	30.5	7.5
Double	6.1	4.6	21.4	17.7	30.1	7.2
SE±	0.2	0.1	1.1	1.0	1.4	1.4
Interactions						
CD*P	NS	NS	NS	NS	NS	NS
CD*S	NS	**	NS	NS	NS	NS
P*S	NS	NS	NS	NS	NS	NS
CD*P*S	**	NS	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT.
**= highly significant($p \leq 0.01$); NS=Not significant

Table 6. Interaction of cow dung, stand density and planting pattern on number of leaves at Samaru during 2011 rainy season at 4 weeks after sowing.

		Planting pattern	
Cow dung (CD)t/ha	Stand density (S)	Single	Double
0	3	5.7b	6.3ab
	6	6.0b	4.7b
2	3	7.3a	4.0b
	6	5.7b	6.7a
4	3	6.3ab	6.0b
	6	7.0a	5.0b
6	3	6.3ab	4.7b
	6	8.0a	6.0b
SE±		0.7	

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

Table 7 shows the interaction of cow dung manure and number of plants/stand on the number of leaves of soybean at 4WAS in Giwa. At fixed cow dung rate of 0, 2 and 6 t ha^{-1} planting soybean at either 3 or 6 plants/stand did not result in significant production of more leaves. At 4 t ha^{-1} however, increasing the number of plants to 6 plants/stand, significantly reduced number of leaves. At fixed stand densities of 3 and 6 plants/stand, application of 2 t ha^{-1} cow dung did not result in significant improvement in leaf production. When the rate was further increased to 4 t ha^{-1}, the number of leaves significantly increased and decreased at 3 and 6 plants/ stand respectively. Further increase in cow dung manure to 6 t ha^{-1} significantly increased number of leaves only

Table 7: Interaction of cow dung and stand density on number of leaves at Giwa at 4 weeks after sowing.

Cow dung (CD) t/ha	Stand density	
	3	6
0	4.2bc	4.5b
2	4.5b	4.3b
4	5.2a	4.0c
6	4.7ab	5.0a
SE±	0.2	

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

for 6 plants/stand while it remained significantly unaffected for 3 plants/stand.The highest value for number of leaves was recorded by the combination of 4 t ha^{-1} cow dung + 3 plants/stand while the least value was by 4 t ha^{-1} cow dung + 6 plants/stand.

4.4 Number of Branches

The number of branches as influenced by rates of cow dung, stand density and planting pattern at Samaru and Giwa is presented on Table 8.Production of branches by soybean was significantly influenced by the application of cow dung only at 12WAS in Samaru. Application of 2 t ha^{-1} of cow dung manure and

Table 8. Effects of cow dung, stand density and planting pattern on number of branches of soybean at Samaru and Giwa

Treatment	Number of branches Weeks after sowing			
	8		12	
Cowdung(CD) t/ha	Samaru	Giwa	Samaru	Giwa
0	2.8	2.8	7.1b	7.1
2	3.0	2.9	6.8b	6.8
4	3.3	3.0	7.2b	7.3
6	3.2	3.4	8.3a	8.3
SE±	0.2	0.2	0.5	0.5
Stand density(S)				
3	3.1	3.0	7.1	7.5
6	3.0	3.0	7.5	7.2
SE±	0.1	0.1	0.3	0.3
Significant	NS	NS	NS	NS
Planting pattern(p)				
Single	3.0	2.9b	7.5	7.5
Double	3.1	3.2a	7.2	7.2
SE±	0.1	0.1	0.3	0.3
Significant	NS	*	NS	NS
Interactions				
CD*P	NS	NS	NS	NS
CD*S	*	NS	NS	NS
P*S	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT. *=Significant(p=0.05); NS=Not significant

further, increase to 4 t ha^{-1} did not result in significant increase in the number of branches. However further increase from 4 t ha^{-1} to 6 t ha^{-1} significantly increased the number of branches

The use of different number of plant population did not significantly affect number of branches at both locations and during all sampling periods.

Varying the row planting pattern significantly affect number of branches only at 8WAS in Giwa, where soybean sown on double row per ridge significantly produced more branches than the single row planting.

Interaction of cow dung and number of plants/stand at 8WAS in Samaru was significant. Table 9 . Varying the seed rate from 3 to 6 plants/stand did not significantly affect branching in soybean for plot supplied with either cow dung manure rate of 0 or 6 t ha^{-1}. But when 2 t ha^{-1} cow dung was supplied soybean sown at 6 plants/stand produced more branches than those sown at 3 plants/stand. However the situation was reversed for soybean that received 4 t ha^{-1} cow dung, in which when 3 plants/stand plant produced more branches than 6 plants/stand further increase to 6 t ha^{-1}cow dung increased branching only for 6 plants/stand.

Soybean, while branching for 3 plants/stand sown soybean remained significantly unaffected. Combination of 4 t ha^{-1} + 3 plants/stand, 6 t ha^{-1} cow dung manure with 3 plants/stand, 2 t ha^{-1} cow dung manure with 6 plants/stand and 6 t ha^{-1} cow dung manure with 6 plants/stand had significantly similar but higher branching than for other treatment combination.

Table 9. Interaction of cow dung and stand density on number of branches at Samaru at 8weeks after sowing.

Cow dung (CD) t/ha	Stand density	
	3	6
0	2.7b	2.8b
2	2.8b	3.2a
4	3.8a	2.7b
6	3.0ab	3.3a
SE±	3.0	

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

4.5 Number of Days to 50% Flowering

Table 10 shows the response of days to 50% flowering to cow dung, number of plants/stand and planting pattern at Samaru and Giwa. Application of cow dung manure or variation in row pattern had no significant effect on days to 50% flowering of soybean in both locations. Varying number of plants/stand significantly affected days to 50% flowering of soybean in both location. Sowing three seeds per stand significantly delayed flowering at Samaru, while it led to early flowering in Giwa. None of the interaction of factors on days to flowering was significant.

Table 10. Effects of cow dung, stand density and planting pattern on days to 50% flowering of soybean at Samaru and Giwa

Treatment	Days to 50% flowering(days) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	52.0	52.0
2	52.0	52.0
4	52.0	52.0
6	52.0	52.0
SE±	0.6	0.6
Stand density (S)		
3	52.3a	51.0b
6	51.4b	53.0a
SE±	0.4	0.4
Significance	*	*
Planting pattern (P)		
Single	52.0	52.0
Double	52.0	52.0
SE±	0.4	0.4
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT.
*=Significant($p \leq 0.05$); NS=Not significant

4.6 Total Dry Matter

The effects of rates of cow dung stand density and planting pattern on total dry matter of soybean at Samaru and Giwa is presented in Table 11. Application of cow dung significantly influenced total dry matter only at 4WAS in Giwa, where application of 2 t ha^{-1} cow dung significantly increased the total dry matter. However, further increase to 4 and 6tha-1 did not result in significant increase in total dry matter. The use of different number of plants/stand significantly affects total dry matter only at 4WAS in Samaru. Sowing 3 plants/stand resulted in heavier dry weight of soybean than for 6 plants/stand. Table 11

Planting pattern did not significantly affect total dry matter at all the sampling periods except at 4WAS in Samaru. Sowing soybean on double row per ridge significantly produced more dry matter than for single row planting. None of the factor interaction on total dry matter was significant.

4.7 Leaf Area Index

Effect of cow dung, stand density and planting pattern on leaf area index (LAI) of soybean at Samaru and Giwa during is represented on Table 12.LAI significantly responded to application of cow dung manure at all sampling periods except 8 WAS in Giwa when the response was not significant application of 2 t ha^{-1} of cow dung did not result in significant increase in LAI at 4WAS in Samaru and at 12WAS in Giwa. Further increase of cow dung to 4 and 6 t ha^{-1} significantly enhanced LAI at 4 and 12WAS in Giwa,

Table 11. Effects of cow dung, stand density and planting pattern on total dry matter of soybean at Samaru and Giwa

Treatment	Total dry matter (t/ha) Weeks after sowing					
	4		8		12	
	Samaru	Giwa	Samaru	Giwa	Samaru	Giwa
Cowdung (CD)t/ha						
0	3.0	1.1b	35.5	31.5	133.8	131.3
2	2.8	1.3a	39.1	36.6	144.3	140.5
4	3.0	1.3a	40.9	31.1	173.1	165.2
6	3.2	1.4a	48.5	45.7	177.7	169.0
SE+	0.4	0.09	5.6	4.9	20.7	20.7
Stand density(s)						
3	3.4a	1.3	41.5	37.1	158.8	155.4
6	2.5b	1.3	40.4	35.3	155.6	147.5
SE±	0.2	0.07	3.9	3.4	14.6	14.7
Planting pattern(p)						
Single	2.7b	1.3	43.0	37.1	162.1	155.0
Double	3.3a	1.3	39.0	35.3	152.3	147.9
SE±	0.2	0.07	3.9	3.4	14.6	14.7
Interactions						
CD*P	NS	NS	NS	NS	NS	NS
CD*S	NS	NS	NS	NS	NS	NS
P*S	NS	NS	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS	NS	NS

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

Table 12. Effects of cow dung, stand density and planting pattern on LAI of soybean at Samaru and Giwa

Treatment	Leave area index Weeks after sowing					
	4		8		12	
	Samaru	Giwa	Samaru	Giwa	Samaru	Giwa
Cowdung t/ha						
0	0.04b	0.02d	0.3b	0.3	0.3b	0.3b
2	0.03b	0.03c	0.4a	0.3	0.4a	0.3b
4	0.03b	0.05b	0.3b	0.3	0.4a	0.4a
6	0.14a	0.09a	0.3b	0.3	0.4a	0.4a
SE+	0.004	0.002	0.004	0.002	0.003	0.003
Stand density(s)						
3	0.04b	0.06a	0.3	0.3	0.3b	0.3b
6	0.08a	0.04b	0.3	0.3	0.4a	0.4a
SE±	0.003	0.002	0.003	0.002	0.002	0.002
Planting pattern(p)						
Single	0.06	0.05	0.3	0.3	0.3b	0.3b
Double	0.06	0.05	0.3	0.3	0.4a	0.4a
SE±	0.003	0.002	0.003	0.002	0.002	0.002
Interactions						
CD*P	NS	NS	NS	NS	NS	NS
CD*S	NS	NS	NS	NS	NS	NS
P*S	NS	NS	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS	NS	NS

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

while the magnitude of LAI was reduced the parameters at 8WAS at Samaru. The response of LAI to application of 4 t ha^{-1} was statistically comparable to 6 t ha^{-1} at 12WAS in both location Giwa, but application of 6 t ha^{-1} cow dung result in significant increase in LAI at 4WAS in Samaru and Giwa.

The use of plant population significantly affected LAI only at 4 and 12WAS were the 6 plants/stand resulted in larger LAI except at 4WAS in Giwa, where the 3 plants/stand of soybean resulted in higher LAI.

The use of different row pattern did not significantly affect LAI at early sampling period of 4 and 8WAS. In each of the locations, soybean sown on double row per ridge significantly produced higher values for LAI than for the single planting. The interactions of factors on LAI were not significant.

4.8 Relative Growth Rate (g/g/wk)

The effect of rates of cow dung, stand density and planting pattern on relative growth rate (RGR) is shown on Table 13.None of the factors used significantly influenced relative growth rate throughout the sampling periods in Samaru and Giwa. None of the interactions on RGR was significant in both locations.

4.9 Net Assimilation Rate ($g/m^2/day$)

The effect of applied cow dung, stand density and planting pattern on Net Assimilation rate (NAR) is represented on (Table 14). In most cases values recorded for Samaru and Giwa were similar. None of the interactions on NAR was significant.

Table 13: Effects of cow dung ,stand density and planting pattern on Relative Growth rate(g/g/wk) at Samaru and Giwa

Treatment	Relative growth rate (g g^{-1} wk^{-1}) Weeks after sowing			
	4-8		8-12	
	Samaru	Giwa	Samaru	Giwa
Cowdung (CD) t/ha				
0	0.66	0.82	0.33	0.36
2	0.67	0.82	0.32	0.34
4	0.65	0.78	0.36	0.40
6	0.67	0.86	0.33	0.33
SE+	0.05	0.04	0.05	0.05
Stand density(S)				
3	0.61	0.84	0.35	0.36
6	0.71	0.80	0.33	0.35
SE±	0.03	0.03	0.04	0.03
Planting pattern(P)				
Single	0.70	0.82	0.34	0.36
Double	0.63	0.82	0.33	0.35
SE±	0.03	0.03	0.04	0.03
Interactions				
CD*P	NS	NS	NS	NS
CD*S	NS	NS	NS	NS
P*S	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS

NS=Not significant

Table 14: Effect of cow dung , stand density and planting pattern on Net Assimilation Rate(g/m^2/day) at Samaru and Giwa

Treatment	Net Assimilation Rate g/m^2/day			
	Weeks after sowing			
	4-8		8-12	
	Samaru	Giwa	Samaru	Giwa
Cowdung (CD) t/ha				
0	0.05	0.05	0.06	0.05
2	0.05	0.05	0.06	0.06
4	0.05	0.05	0.06	0.06
6	0.05	0.05	0.07	0.06
SE+	0.009	0.006	0.01	0.01
Stand density(S)				
3	0.05	0.05	0.06	0.06
6	0.05	0.05	0.06	0.05
SE±	0.006	0.004	0.009	0.008
Planting pattern(P)				
Single	0.05	0.05	0.06	0.06
Double	0.05	0.05	0.06	0.06
SE±	0.006	0.004	0.009	0.008
Significance	NS	NS	NS	NS
Interactions				
CD*P	NS	NS	NS	NS
CD*S	NS	NS	NS	NS
P*S	NS	NS	NS	NS
CD*P*S	NS	NS	NS	NS

NS=Not significant

4.10 Number of Pods per Plant

The response of number of pods/ plant to rates of cow dung, stand density and planting pattern at Samaru and Giwa is shown on Table 15. Application of cow dung had no significant effect on the number of pods per plant at both locations throughout the sampling period. The use of different number of plants/stand significantly affected number of pods per plant only at Giwa, when soybean sown at 3 number of plants/stand produced more pods than for 6 plants/ stand.

Sowing soybean in different row arrangement significantly affected the crop's number of pods per plant at both locations. When soybean sown on single row/ ridge significantly produced more pods than double row sown crop in both locations. None of the factor interaction on soybean pods production was significant.

4.11 Weight of Pods per Plant

Weight of soybean pods per plant as influenced by rates of cow dung, stand density and planting pattern at Samaru and Giwa during is presented on Table 16.The response of pod to the application of cow dung was significant only at Giwa, where the application of 2 t ha^{-1} cow dung manure significantly increased pod weight that was statically comparable to those produced at 4 and 6 t ha^{-1}.The use of different number of plants/stand did not significantly affect weight of pods in both locations.

Table 15. Effect of cow dung,stand density and planting pattern on number of pods per plant of soybean at Samaru and Giwa

Treatment	Number of pods per plant Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	71.1	66.1
2	91.1	86.1
4	82.7	79.7
6	82.6	79.6
SE±	8.9	8.9
Stand density (S)		
3	87.7	88.7a
6	76.0	72.0b
SE±	6.3	6.3
Significance	NS	*
Planting pattern (P)		
Single	92.3a	83.3a
Double	71.4b	67.4b
SE±	6.3	6.3
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using DMRT.*=Significant($p \leq 0.05$); NS=Not significant

Table 16: Effect of cow dung,stand density and planting pattern on weight of pods per plant (g) of soybean at Samaru and Giwa

Treatment	Weight of pods per plant (g) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	30.5	25.5b
2	42.7	37.7a
4	44.9	42.1a
6	41.3	38.3a
SE±	4.8	4.8
Stand density(S)		
3	40.9	36.9
6	38.9	35.0
SE±	3.4	3.4
Planting pattern (P)		
Single	46.6a	42.6a
Double	33.2b	29.2b
SE±	3.4	3.4
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

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

Sowing soybean either on single or double significantly affect weight of pods per plant at both location. Soybeans sown on single row per ridge significantly produce heavier pods per plant than for the double row sown soybean. None of the factor interactions on pod weight per/plant was significant.

4.12 Grain Weight per Plant

The response of grain weight to application of cow dung manure, stand density and planting pattern at Samaru and Giwa is presented on Table 17. Application of cow dung manure significantly influenced grain weight at both locations. The application cow dung rate of 2 t ha^{-}1 significantly resulted in heavier grain weight plant that was statistically comparable to the 4 and 6 t ha^{-1} application rates in both locations. Varying number of plants/stand did not significantly affect soybean grain weight per plants; in both locations. Conversely the use of different planting patterns significantly affects the grains weight per plants. Soybean sown on single row per ridge significantly produced heavier grains than those grown on double rows in both locations. Factor interactions on grain weight per plant of soybean were not significant.

4.13 100-grain weight

Table 18 shows the effect of rate of cow dung, stand density and planting pattern on 100 grain weight at Samaru and Giwa. Application of cow dung manure significantly influenced the weight of 100 grain only at Giwa, where the application of 4t ha^{-1} cow dung manure produced the heaviest than for the least.

Table 17: Effect of cow dung, stand density and planting pattern on grain weight per plant(g) of soybean at Samaru and Giwa.

Treatment	Grain weight per plant (g) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	18.6b	17.4b
2	24.6a	23.4a
4	27.5a	26.5a
6	26.5a	25.5a
SE±	2.8	2.8
Stand density (S)		
3	25.7	24.5
6	22.9	21.7
SE±	2.0	2.0
Planting pattern (P)		
Single	27.0a	26.1a
Double	21.6b	20.7b
SE±	2.0	2.0
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT.NS=Not significant

Table 18: Effects of cow dung, stand density and planting pattern on 100seed weight(g) of soybean at Samaru and Giwa

Treatment	100 –Grain weight (g) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	15.1	15.3b
2	18.6	15.3b
4	15.1	18.8a
6	15.3	15.1b
SE±	1.7	1.7
Stand density (S)		
3	14.8	16.8
6	17.2	15.4
SE±	1.2	1.2
Planting pattern (P)		
Single	14.9	14.9
Double	17.1	17.3
SE±	1.2	1.2
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT.NS=Not significant

Neither number of plants/stand nor planting patterns significantly affected the weight of 100 seeds in both locations. None of the factor interaction on the treatment tested on the weight of 100 grain was significant

4.14 Grain yield per hectare

The effect of application of cow dung, stand density and planting pattern on grain yield per hectare of soybean at Samaru and Giwa during 2011 is shown on Table 19. Application of cow dung manure significantly influenced soybean grain yield per hectare only at Samaru. The applied cow dung rates of 2, 4 and 6 t ha^{-1} statistically produced similar but higher grain yield than for the control. The use of different number of plants/stand did not significantly affect grain yield per hectare at both location. Sowing soybean in different row pattern significantly influenced grain yield per hectare at both location. Soybeans sown on both sides of the ridge produced higher grain yield per hectare than for single row planting at both locations. The interactions of factors on grain yield per hectare were not significant in both locations

4.15 Harvest Index (%)

Table 20 shows the response of harvest indices to application of cow dung, stand density and planting pattern at Samaru and Giwa .Application of cow dung manure significantly influenced soybean harvest indices only at Samaru. The applied manure rate of 4 and 6 t ha^{-1} resulted in statistically similar and

Table 19. Effect of cow dung, stand density and planting pattern on grain yield per hectare(kg/ha) of soybean at Samaru and Giwa

Treatment	Grain yield(kg/ha) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	1925.9b	1425.9
2	2537.0a	2037.0
4	2759.2a	2459.2
6	2703.7a	2847.1
SE±	220.1	317.3
Stand density (S)		
3	2398.1	1998.1
6	2564.8	2386.3
SE±	155.7	224.3
Planting pattern (P)		
Single	2305.5b	1905.3b
Double	2657.4a	2479.6a
SE±	155.7	224.3
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

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

Table 20. Effect of cow dung, stand density and planting pattern on Harvest index (%) of soybean at Samaru and Giwa

Treatment	Harvest index (%) Location	
	Samaru	Giwa
Cow dung (CD)t/ha		
0	78.1b	71.5
2	82.4b	79.0
4	99.1a	81.0
6	97.4a	78.0
SE±	6.1	8.8
Stand density (S)		
3	90.2	78.0
6	88.3	76.8
SE±	4.3	6.2
Significance	NS	NS
Planting pattern (P)		
Single	86.3	72.6
Double	92.2	82.1
SE±	4.3	6.2
Significance	NS	NS
Interaction		
CD*P	NS	NS
CD*S	NS	NS
P*S	NS	NS
CD*P*S	NS	NS

significantly higher harvest index than for the least which was at par with the values recorded when by 0 and 2 t ha^{-1} cow dung manure was applied. The use of different number of plants/stand and planting pattern did not significantly affect harvest indices at both locations. No significant of factors on harvest was observed.

4.16 Correlation Analysis

The association between grain yield, growth and yield component of soybean at Samaru and Giwa are represented on Table 21 and 22. Positive and highly significant correlation coefficient were obtained between grain yield and number of pods per plant , weight of pods per plant, grain weight per plant and harvest index. (Table 21). Similar observations were made between number of pods per plant and weight of pods per plant and weight of pods per plant and grain weight per plant at both locations.

Also observed were positive and significant association between grain yield and number of leaves, number of pods per plant and leaf area index other variables including plant height, number of leaves, number of branches, total dry matter, leaf area index and days to 50% flowering. Highly significant but –ve correlation between grain yield and days to 50% flowering and insignificant –ve associations were observed between plant height and leaf area index, weight of pods per plant, grain weight per plant and harvest index.

Table: 21 Correlation Matrix between soybean Grain Yield and other growth and yield characters at Samaru

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0000											
2	0.0570	1.0000										
3	0.1669*	0.3301	1.0000									
4	0.1450	0.2662	0.0764	1.0000								
5	0.2083	0.1253	0.0676	0.1064	1.0000							
6	0.0077	-0.0991	0.0500	0.0689	0.1436	1.0000						
7	-0.0780**	0.0171	-0.0354	-0.0738	0.2317	-0.0185	1.0000					
8	0.0646**	0.0919*	0.0167*	0.0805*	0.0626*	0.0434*	0.3516*	1.0000				
9	0.0235**	-0.1942	-0.1466	0.1167	0.0756	0.0169	0.2003	0.7166**	1.0000			
10	0.0056**	-0.2529	-0.1704	0.1938	0.0610	0.0702	-0.1492	0.0864**	0.8994**	1.0000		
11	0.0036	0.0391	0.0697	0.0379	0.0209	-0.0662	0.1563	-0.0646	-0.1866	-0.1484	1.0000	
12	0.6096**	-0.0479	-0.1158	-0.0582	0.2616	0.0247	0.2296	-0.00746	0.0049	-0.0112	-0.19000	1.0000

1	Grain yield	7.Days to 50% flowering	Degree of freedom ( )
2	Plant height at 12 WAS	8. Number of pods per plant	*=significant at p=0.05
3	Number of leaves at 12 WAS	9. Weight of pods per plant	**=Highly significant
4	Number of branches at 12 WAS	10. Grain weight per plant	
5	Total dry matter at 12 WAS	11. 100 seed weight	
6	Leaf area index at 12 WAS	12. Harvest Index	

Table: 22 Correlation Matrix between soybean Grain Yield and other growth and yield characters at Giwa

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0000											
2	0.0678	1.0000										
3	0.2635*	0.3681	1.0000									
4	0.0840	0.0124	0.0675	1.0000								
5	0.0250	0.1826	0.0639	0.0082	1.0000							
6	0.0055	-0.1145	0.0168	0.0236	0.0685	1.0000						
7	-0.01203**	0.0712	-0.0464	-0.1272	0.2060	-0.2427	1.0000					
8	0.2069**	0.0520*	0.0001*	0.0901*	0.2004*	0.3409*	0.2219*	1.0000				
9	0.0259**	-0.0734	-0.1702	0.1327	0.2469	0.1665	0.0803	0.7116**	1.0000			
10	0.1640**	-0.1108	-0.1946	0.1995	0.1219	0.2378	-0.1028	0.6934**	0.9025**	1.0000		
11	0.1202	0.2160	0.1323	0.1637	0.0177	-0.0424	0.1035	-0.1497	-0.0259	-0.0056	1.0000	
12	0.6096**	-0.1800	-0.1747	-0.1389	0.2238	0.0991	0.1607	-0.0923	0.0465	-0.0352	-0.2128	1.0000

1	Grain yield	7.Days to 50% flowering	Degree of freedom ( )
2	Plant height at 12 WAS	8. Number of pods per plant	*=significant at p=0.05
3	Number of leaves at 12 WAS	9. Weight of pods per plant	**=Highly significant
4	Number of branches at 12 WAS	10. Grain weight per plant	
5	Total dry matter at 12 WAS	11. 100 seed weight	
6	Leaf area index at 12 WAS	12. Harvest Index	

Similar result were obtained for 3 in association with days to 50% flowering, weight of pods per plant, grain weight per plant and harvest index; number of branches with days to 50% flowering and harvest index; total dry matter with leaf area index; leaf area index with days to 50% flowering and 100-seed weight; days to 50% flowering with grain weight per plant among others. Similar observation was observed at Giwa.

4.17 Regression Analysis

Several polynomial models were fitted to find the best model to explain the yield response to cow dung manure in both locations. The results show an inconsistency among the locations. In Samaru the response was quadratic; grain yield of 4,473kg could be realized with optimum rate of 4.5 t ha^{-1}. While in Giwa the response was linear and beyond the highest cow dung manure rate of 6 t ha^{-1} grain yield increase was observed (Fig 1)

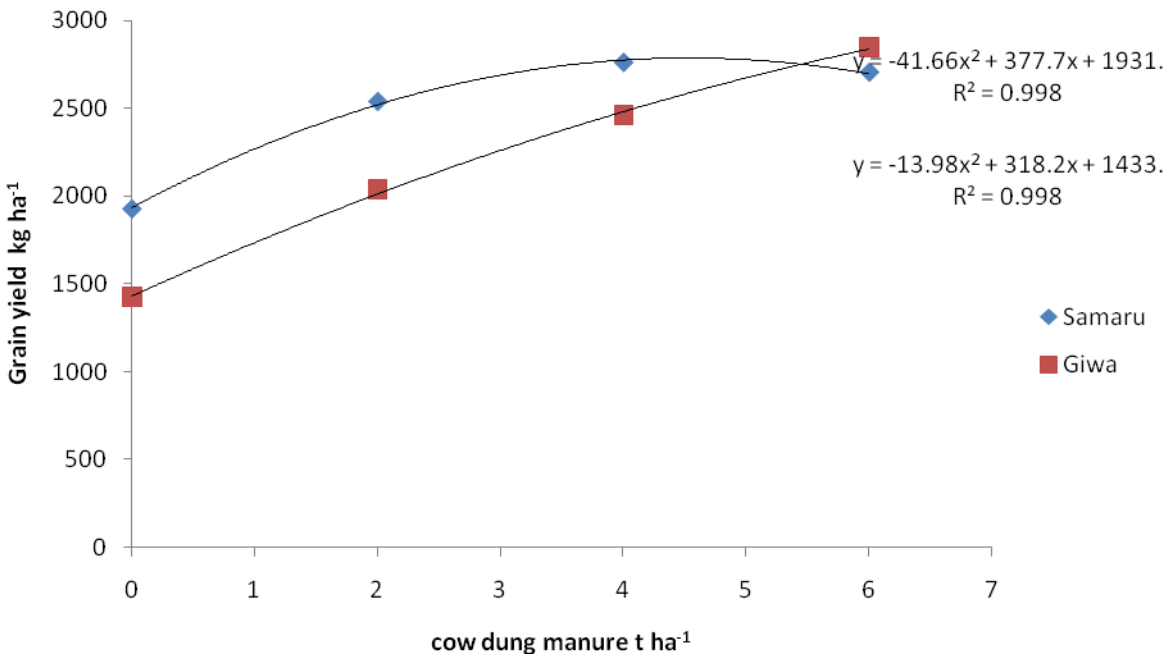


Fig: 1 Regression Analysis curve

Regression response curve of Soybean yield (Kg ha^{-1}) against cow dung rate (t ha^{-1}) during 2011 rainy in Samaru and Giwa

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of Cow dung Manure on Soybean

The result of this study had shown positive response of both growth and yield parameters of soybean to the application of cow dung manure in both locations. Growth characters such as plant height, number of branches and number of leaves/plant, leaf area index, relative growth rate, net assimilation and total dry matter were enhanced by the applied cow dung manure when compared with the control. The positive response of these to parameters to the application of cow dung manure could be attributed to improvement in the soil fertility status of the experimental field (low organic matter, and other nutrients) of the experimental fields at both locations. Hence, the addition of cow dung may have increased the amount of mineralized nutrient and organic matter which improved both the soil physical and chemical condition as well as improved availability of both macro and micro nutrients in the soil that were necessary for efficient growth and development in crops (Anon, 2007b)

Cow dung manure is known to have great role in improving water holding capacity, soil aeration , soil structure, nutrient retention and microbial activity (Anon, 2007a).Likewise, manure also enhance soil pH and decrease bulk density of soil (Anon, 2006). The resultant effects of cow dung on plant is more and larger leaf for efficient light interception and assimilates production which in turn has positive and direct effect on growth and development in plant (Varel *et al*;

1992). The increase in grain yield by the application of cow dung can be attributed to the favorable effect of the manure on growth and development of the crop in general through enhanced assimilate production from increased LAI,RGR, NAR and TDM which all have direct bearing on the final grain yield of the crop. This finding is in line with the findings of Varel *et al* (1992). The general positive response of soybean, to the application of cow dung has further proved that like other crops it also need some appreciable amounts of other nutrients apart from phosphorus and good soil condition for proper growth and development.

5.2 Effect of Stand density on Soybean

The higher values obtained for plant height and leaf area index obtained at 6 plants per stand in both locations could be as a result of competition for light and probably higher N- fixation. Contrarily the low interplant competition at lower seed rate of 3 seed per stand had resulted in the production of more branches, dry matter and increased relative growth rate. Similar observations were reported by Beaver and Johnson (1981), Cordonnier *et al*., (1982), Kanock *et al*., (1982), Piggott and Farrell (1982) and Amodu.,(2004) who reported that the proportion of seeds planted that produce matured plants with pods decrease as plant density increased from 350,000 to 650,000 plants per hectare and that plant height increased as the population increases.

This result conforms to the findings of Hicks *et a*l., (1969) and Amodu (2004) who reported that number of leaves decreased linearly as plant population increased.

Likewise, higher values for leaf area index (LAI) for soybean grown at higher plant density of 6 seeds per stand as a result of production of more leaves that could easily cover the ground thereby intercepting more light. The adequate ground cover ensured better light interception and possibly suppressed weed growth. Parvez (1989) and Chiezey *et al*. (1992) reported similar findings

The reduction in the amount of total dry matter produced per plant with increasing seed rate could be as a result of stand interplant competition for growth resources at higher plant density. Higher plant density leads to earlier canopy closure, which results in greater abscission of lower leaves. This is in conformity with Chiezey *et al.* (1993) and Amodu (2004).

The higher assimilate produced per plant as a result of low inter plant competition for soybean sown at low density might have led to production of more and heavier pods per plant, 100-grain weight and harvest index. Higher inter plant competition could result in low production of assimilate as a result of stiff inter-plant competition for space and growth factors thereby resulting in fewer pods and smaller seeds. This confirms the findings of Stroyer and Whigham (1981), Kanock *et al*. (1982); Chandel *et al*. (1987) and Amodu (2004).The 5.83% and 16.2 % respective grain yield increase recorded in Samaru and Giwa as a result of increase in plant/stand from 3 to 6 plants/stand could be attributed to higher

number of harvestable plants, pods and grain due to higher plant population . There are more plants/stand at higher plant density which in turn means more harvestable pods and grain thereby resulting in higher grain yield Lone *et al.* (2010) have reported an increased grain yield in soybean as a result of increase seed rate.

The early and late flowering of soybean at Giwa and Samaru, respectively as a result of lower seed rate of 3 seeds per stand could be attributed to differences in nutrient status between the two locations. The earlier flowering was as a result of the poor fertility status in Giwa, hence might have led to early maturity.TGX1835-10E being an early variety the low fertility status at Giwa might have led to early senescence leading to early crop. Cordonnier *et al*.(1982) and Amodu (2004) reported similar observations.

5.3 Effect of Planting Pattern on Soybean.

The taller plants with large leaf area recorded for soybean sown on double row per ridge could be attributed to the high competition for light as well as more N-fixed as a result increased plant population. The increase interplant competition for light at high density condition might lead to etiolation thereby leading to the production of taller plants. Likewise, the higher plant population in the double- row sown soybean might have led to increase areas occupied by roots thereby leading to increase N-fixation which in turn led to crop with larger LAI. It is also expected

that the area cover by leaves at high plant population will increase. Parvez (1989) and Chiezey *et al*. (1992) reported similar finding

Other growth parameters such as number of leaves and branches, TDM and RGR per plant were enhanced at lower population of one row per ridge because of the low inter-plant competition for growth factors (moisture, nutrients, light etc). Growth resources are readily available at lower population leading to more nutrients, which in addition to light resulted in production of more assimilate that were translocated to the sink. This in turn increased the rate of growth as well as increased the TDM produced. This is in conformity with Chiezey *et al.* (1993) and Amodu (2004).

The high dry matter produced due to low interplant competition of the single row sown soybean might have been the reason for higher values for high weight of pods per plant, 100-grain weight and harvest index. This confirms the findings of Stroyer and Whigham (1981), Kanock *et al*. (1982); Chandle *et al*. (1987) and Amodu, (2004). The decrease in weight of pods per plant, grain weight per plant with increasing plants per ridge number could be ascribed to increase competition for growth factors thus; affecting translocation of assimilates to the pods. Similar findings were reported by Latifi, (1980), Matheny *et al.* (1981) and Cordonnier *et al.* (1982).

Increase in the number of rows per ridge from single to double row per ridge increased grain yield per hectare by 13.2% in Samaru and 23.1% in Giwa. This could be attributed to the number of harvestable plants per unit area and grain

yield with increased number of rows resulting from more plants per unit area. This results conforms with the findings of Kure *et al*. (1984); Cheizey (1991) ; Olufajo(1990); and Amodu (2004) who reported that increased in plant population in soybean also increases grain yield. This is probably due to increase number of plants per unit area, which shows the ability for more plants to compensating for loss of the potentials of high population in yield in individual plants.

5.4 Interactions

The vegetative parameters (plant height, number of leaves, and number of branches) during the present study were observed to increase with increase in population plants/stand and planting pattern with increasing cow dung levels. These indicate that increasing population level is dependent on soil fertility levels. Taller plants and more leaves were attained at the high cow dung levels of 6 t ha^{-1} and high population of 6 plants per stand on double and single rows/ ridge respectively at the early 4WAS growth stage.

5.5 Correlation

The highly significant and positive correlation ($P \leq 0.01$) exhibited between soybean yield and growth attributes such as number of leaves, leaf area index and plant height in both location were probably due to the fact that these vegetative parameter directly determine the extent of photosynthesis and the amount of

assimilates that were available for plant growth and ultimately for grain development.

Similarly, highly significant ($p \leq 0.01$) and positive association correlations between soybean yield and yield attributes such as number of pods per plant, weight of pods per plant and grain weight per plants in both locations revealed the importance of these yield components to grain production in soybean. The result indicated that increase in any of these parameters would invariably contribute to grain yield directly or indirectly.

5.6 Regression Analysis

The regression analysis revealed that grain yield increased from the control to 3.3 t ha^{-1} beyond which a decline in yield was observed in Samaru while grain yield increase up to 6 t ha^{-1} in Giwa. The decline in yield beyond 3.3 t ha^{-1} is probably due to the fact that optimum fertilizer level has been achieved and any further increase in manure would lead to luxuriant growth at the expense of grain yield produced. Similarly, the continuous increase in grain yield might be due to the poor fertility status of the experimental site at Giwa, which was displayed on the linear graph indicating the optimum levels of manure has not been reached. Similar observations was reported by Anon (2006) who stated that increase in farmyard manure beyond the optimum rate leads to a zero point of soil charge; the point were the negative and positive charges of the soil are balanced. These usually lead to low soil Ph in which any addition of soil nutrients especially in forms of cations will not be utilized by the crop as the would leached down.

Also the application of cow dung manure exceeding the optimum rate could lead to increase incidence of soil fauna which can lead to destruction of plant roots especially at early stage of plant growth and development there by leading to lost of stands and ultimately severe yield reduction

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

Experiments was conducted at the Research Farm of Institute for Agricultural Research Samaru (11^0 17' N, 007^0 68'E 694m above sea level), Sabon-Gari LG and at Hayin Gada Shika (11^0 19' N,007^0 57'E 666m above sea level), Giwa LG of Kaduna State Nigeria during 2011 rainy season to study the effect of cow dung manure, stand density and planting pattern on growth and development of soybean. The treatments consisted of four cow dung levels (0 , 2 , 4 and 6 t ha^{-1}) and two number of plants/stand(3 and 6 seeds per stand) equivalent to (200,000 and 400,000 plant per hectare) and two planting patterns (single and double row planting). These were factorially combined and laid out in Randomized Complete block design, and replicated three times.

This result reveal that cow dung manure at 4 t ha^{-1} significantly produced high values of total dry matter, weight of pods per plant, 100-grain weight and grain yield . However, application of 2 t ha^{-1} produce heavier pods than other rates although statistically at par with 4 t ha^{-1} . This result show that sowing soybean on single row produced more pods per plant, heavier pods per plant but double row per ridge produced better grain yields. Based on the result obtained from this work, it was observed that grain yield was optimum with application of 4 t ha^{-1} cow dung at both locations.

In conclusion 6 plants per stand on double row per ridge and 2 t ha^{-1} cow dung rate could be recommended for enhancing grain yield of soybean TGX1835-10E,

however when the regression analysis was carried out 4.5 t ha^{-1} could be recommended for high yield

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Appendix I: Mean monthly temperatures, relative humidity, sunshine hours and rainfall at ten days interval during the experimental period in the wet season of year 2011

Month	Days	Max. Temp (^{o}C)	Min.Temp (^{o}c)	Rel. Hum (%) Am	Rel. Hum (%) Pm	Sunshine Hour	Rainfall (mm)
JUL	0-10	31.1	19.6	80.9	69	6.39	8.31
	11-20	30.6	19.6	85.3	67.9	5.29	10.18
	21-31	30.7	22.9	97.9	82.8	7.41	3.9

AUG	0-10	30.9	20.1	89.9	68.7	5.46	5.02
	11-20	29	19.3	80.5	77.4	3.36	17.79
	21-31	34	21.4	85.5	77.8	5.62	1.18
SEPT	0-10	31.6	19.4	80.7	69.4	6.81	3.38
	11-20	31.5	18.6	78.5	70.2	5.98	6.84
	21-30	26.4	15	55.6	45.7	5.25	1.16
OCT	0-10	33.5	20.3	73.5	60.5	6.18	3.88
	11-20	34	18.9	69.5	58	6.01	1.52
	21-31	38.1	16.9	56.8	36.9	8.35	0
NOV	0-10	35.2	12	24.8	18.3	9.19	0
	11-20	34.5	12.2	17.3	17.5	8.93	0
	21-30	32.9	11.7	13.6	12.5	8.7	0

Source : Institute for Agricultural Research Metrological data

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