PERFORMANCE OF SESAME VARIETIES (*Sesamum indicum* L*)* AS INFLUENCED BY NITROGEN FERTILIZER LEVEL AND INTRA ROW SPACING

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DECLARATION

I hereby declared that, this thesis tittled " Performance of Sesame Varieties as Influenced by levels of Nitrogen Fertilizer and Intra Row Spacing" has been written by me and that it is a record of my research work in the Department of Agronomy under the supervision of Prof. M. Mahmud, Prof. I.U Abubakar and Dr. B.A Babaji.

UMAR, Umar Abdullahi (Student)	Signature	Date

The above declaration is comfirmed by

Prof. M. Mahmud (Chaiman)	Signature	Date

CERTIFICATION

This thesis titled "PERFORMANCE OF SESAME VARIETIES AS INFLUENCED BY LEVELS OF NITROGEN FERTILIZER AND INTRA ROW SPACING" 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 literary presentation.

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Prof. I.U. Abubakar Member. Supervisory Commitee	Signature	Date
Dr. B.A. Babaji Member. Supervisory Commitee	Signature	Date
Dr. B.A.Babaji Ag. Head of Department	Signature	Date
Prof. A.A. Joshua Dean, School of Postgraduate Studies	Signature	Date

DEDICATION

This work was dedicated to my supervisors namely Prof. M. Mahmud, Prof. I.U.Abubakar and Dr. B.A Babaji and to the entire staff of Agronomy Department, Ahmadu Bello University Zaria.

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ABSTRACT

A field trial was conducted to evaluate the performance of two sesame varieties (*Sesamum indicum* L) in response to levels of nitrogen fertilizer and intra row spacing at the research farm of Institute for Agricultural Research, Samaru in the Northern Guinea Savanna of Nigeria, during the wet seasons of 2009 and 2010. The treatments consisted of two sesame varieties (NCRIBen001M and NCRIBen002M), four nitrogen levels (20, 40, 60 and 80 kgN/ha) and three intra row spacing (5, 10 and 15cm). The treatments were arranged in a split plot design with the factorial combinations of nitrogen and variety assigned to the main plot and the intra row spacing placed at the sub plot. Increasing nitrogen level from 20 to 80kgN/ha resulted in significant increase in the number of leaves, plant height, number of secondary branches, total dry matter, number of capsules, weight of capsules and seed yield, but number of primary branches showed no significant response to nitrogen level above 60kgN/ha. The leaf area, leaf area index at 4WAS and crop growth rate at 6WAS showed no significant response to increased nitrogen. However, subsequent sampling periods produced significant response to increased nitrogen level up to 80kgN/ha. Narrow intra row spacing of 5cm significantly decreased the number of leaves, plant height, number of branches, total dry matter, leaf area, number of capsules, capsules yield and grain yield per plant, but showed increased leaf area index, crop growth rate and grain yield per hectare. The two varieties significantly differed in terms of plant height, total dry matter, leaf area, leaf area index, weight of capsules, crop growth rate and grain yield where NCRIBen001M significantly out performed NCRIBen002M, but they produced statistically the same number of leaves, number of branches and number of capsules per plant. A highly significant positive correlation was observed between grain yield per hectare and leaf area index and crop growth rate. The grain yield response to nitrogen application was linear (r^2= 0.2441). However, grain yield declined beyond 40kgN/ha. Application of 80kgN/ha and 5cm intra row spacing gave highest grain yield of 727.3 kg/ha and 841.9kg/ha respectively, while variety NCRIBen001M out performed NCRIBen002M in grain yield 711kg/ha and 666.3 kg/ha respectively. Sesame variety NCRIBen001M planted at 5cm intra row spacing with application of 80kgN/ha gave the highest grain yield compared to NCRIBen002M under the same conditions.

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CHAPTER ONE

1.0 INTRODUCTION

Sesame (*Sesamum indicum* L.) has been recognized as a crop with a high economic potential in Nigeria, both as a source of raw materials for industries and a reliable foreign exchange earner (Alegbejo 2003; NCRI 2008). Sesame belongs to the family *Pedaliaceae* and is one of the oldest cultivated oilseed crops in the world (Purseglove 1974). The genus consists of about 36 species of which 19 are indigenous to Africa (Weis 1983; Uzo 1998). But only three species have been reported to be grown for different purpose in Nigeria namely *Sesamum alatum, S indicum* and *S radiatum* (Dabir 2000). The most popular specie is *S. indicum* which has hundreds of varieties and strains with considerable variations in size, form, growth pattern, colour of flowers, seed size, seed colour and composition. The crop is known as Beniseed in West Africa (Seegeler 1989). In Nigeria it is locally called Ridi, Ekuku, and Isasa by Hausas, Yorubas and Ibos, respectively.

1.1 Botany and Morphology of Sesame Crop

Many cultivars of sesame crop with varying characteristics existed. These can be distinguished by their branching habit, leaf morphology, fruit dehiscence and seed colour. Sesame plant is erect annual herb growing up to 2m tall with strongly tapering taproot up to 90 cm long that bears many lateral roots. The stem is firm, square with ribs at each corner measured up to 3 cm in diameter at base. The stem colour is bright pale green, sparsely hairy to glabrous. Leaves are opposite in lower parts but arranged spirally and 3-lobed to 3-foliolate in upper parts. Flowers appear in small fascicles in upper leaf axils, they are bisexual and zygomorphic. Fruits are oblong quadrangular capsule, 1.5–3cm long, hairy, with a short triangular beak at apex. The fruit colour is grey-brown at maturity, dehiscent and contains many seed. The Seed is flattened 2–3

mm long, 0.5–1 mm thick, narrowly ridged all round or rather smooth. The seed colour may be white, ivory, grey, beige, brown, red or black (Anon. 2007).

Germination of sesame seed is moderately slow and seedlings grow slowly until they reach a height of 10 cm; thereafter, growth is rapid. Branches develop when the plant is about 25 cm tall. The degree of branching is cultivar-specific and non-branching cultivars exist. Roots of single-stemmed cultivars generally elongate more rapidly than those of branched ones, while the latter spread more quickly. Initial growth rates of sesame roots tend to be slower than those of groundnuts, maize or sorghum. Growth habit is generally indeterminate, but determinate cultivars have been selected. Flowers arise in leaf axils on the upper stem and branches Most flowers open at 5–7 a.m., wilt after midday, and are shed at 4–6 p.m. Flowers are mostly self-pollinated, but cross-pollination is possible and may reach 50%. Depending on cultivar, the crop matures in 75–150 days after sowing (Anon. 2007).

Capsules near the stem base normally ripen first, those nearest the tip ripen last. Active dry matter accumulation and synthesis of oil occur 12–24 days after fruit set, but continue at a reduced rate up to 27 days, with a slight fall in oil content before maturity. The free fatty acid percentage is highest at the beginning of synthesis, declines rapidly around 18–22 days and then more gradually until seed maturity. In most cultivars, dry mature fruits split open and seeds are shattered (Anon. 2007).

1.2 Common Sesame Varieties in Nigeria

Several local varieties and genotypes of different characteristics existed in different ecological zones of Nigeria.and were being planted by farmers in smallholder scales for generations. Most of these varieties were low yielding dehiscent varieties with low harvest index values and

responses poorly to fertilizers and other agro inputs (Uzun and Cagirgan 2006). However, the National Cereals Research Bnstitute Badeggi developed and release some improved varieties that are high yielding with higher oil content and are white seeded. These characters are essential to attract premium price in the world market (NCRI 2002). Some of these varieties include the following

1. **E-8.** A short duration variety maturing under 90 days. The seed colour is white and contain about 50% oil. This variety is capable of yielding up to 800kg per hectare and 1000 seed of this variety weight about 3.4g.
2. **Pbtil.** A short duration variety maturing under 90 days. The seed colour is whitish to yellowand contain about 45% oil. This variety is capable of yielding up to 1000kg per hectare and 1000 seed of this variety weight about 3.0g.
3. **Ex- Sudan.** A short duration variety maturing under 90 days. The seed colour is white and contain about 50% oil. This variety is capable of yielding up to 1200kg per hectare and 1000 seed of this variety weight about 3.0g.
4. **NCRIBen001M.** A medium duration variety maturing between 102 to 125 days. The seed colour is essentially white and contain about 45% oil. This variety is capable of yielding between 800-1000kg per hectare. The 1000 seed of this variety weight about 3.3g.
5. **NCRIBen002M.** A medium duration variety maturing between 102 to 125 days. The seed colour is white and contain about 45% oil. This variety is capable of yielding up to 800kg per hectare. The 1000 seed of this variety weight about 3.0g
6. **NCRIBen003L.** A long duration variety maturing above 125 days. The seed colour is white and contain about 40% oil. This variety is capable of yielding up to

1200kg per hectare. This variety is small seeded, 1000 seed of this variety weight only about 2.5g

7. **Yandev 55.** A long duration variety maturing above 125 days. The seed colour is white which contain about 40% oil. This variety is capable of yielding up to 1100kg per hectare. it is a small seeded variety, 1000 seed of this variety weight about 2.6g

1.3 Sesame Crop Production Constrains and Prospects

Nigeria has about 3.5 million hectares suitable for sesame production but only about 300,000 hectares were being cultivated largely by small holder farmers. These small holder farmers cannot afford the ever increaasing cost for farm inputs such as fertilizers, improve varieties and chemicals, inaddition to ignorance and lack of access to information on improve farm practices that can boost thier production and yield of the crop. Ignorance on the part of the farmers on quality issues for the crop mean for trading resulted in poor commodity pricing or the crop not being able to attract premium prices in the world market (Anon. 2009). The expanding markets of sesame seed in Asia and Europe in the last decade, because the products from sesame readily meet the health requirements for food in the developed world and the popular cuisine in the oriental world. The development and release of improve varieties by National Cereals Research Institute Badaggi that are high yielding of both seed and oil content will further boost the production of the crop. The potential for commercial processing of sesame seed is also great. Sesame can be processed into a number of forms and for various uses such as oil, meal, paste, confectioneries and bakery products which can be exported to Europe and Asia where they have a ready market (Anon. 2009).

1.4 Climatic and Soil Requirements of Sesame.

Sesame is a crop of tropical, sub tropical and warm temperate regions. Optimum temperatures for growth are between 20 and 24^0C during vegetative growth and about 27^0C during flowering and fruiting. The crop is drought tolerant and can grow in areas with annual rainfall of between 500 to 1500mm and soil of medium texture that is well drained and free from salt, with neutral to alkaline P^H (Anon 2004). In Nigeria the production areas are located between latitudes 7^0 to 14^0, with a dry season that last about 4 to 5 month, and annual rainfall of about 500 to 1500mm, a vegetation of open savanna woodland and a top soil of sandy loam texture (Van Rheenen 1973).

1.5 Economic Importance of Sesame.

World production of sesame was estimated at 3.7 million tonnes in the year 2005, of which Asia and Africa produced 2.4 and 1.1 million tonnes respectively. The world export volume in the year 2000 to 2005 was estimated at about 1 million tonnes of which Africa exported an estimated 463,000 or 46% (FAO 2005). The crop production in most African countries has been increasing steadily due to the crop short duration cycle and the good liquidity in the global market (Anon. 2004). In Nigeria annual production stood at about 110,000 tonnes in the year 2007, of which about 50,000 tonnes was exported (Anon 2008). Sesame seed contains approximately 50% oil and 25% protein and is used in baking, candy making, and in other food industries. Oil from the seed, which contain about 47% oleic and 39% linoliec acid, is used in cooking, salad and in making margarine. Sesame oil and food fried in sesame oil have long shelf life because the oil contains an antioxidant called sesamol. The oil can be used in the manufacture of soap, paints, perfumes, pharmaceuticals and insecticides. Sesame meal left after oil extraction is an excellent high protein (35 to 50% crude protein) feed for poultry and livestock (Oplinger 1990).

1.6 Justification for the Study

Soils of the savanna regions are known to contain low nitrogen that are inadequate to sustained good growth and development of some crop plants. This was as aresult of their sandy nature, continuous cropping and intensive grazing by livestock that left little or no crop residues to be incorporated into these soils. The low organic carbon and low cation exchange capacities characteristics of these soils must have been responsible for their low water and nutrients holding capacities (Anon. 2010). Application of fertilizers especially nitrogen fertilizer become absolutely necessary for good growth and development of crop plants growing in these regions. However, most crop plants recover only 25-35% of the nitrogen applied as fertilizers, as losses occur by ammonia volatization, denitrification, immobilization to organic forms, leaching and run off (Anon. 2010).

Studies conducted revealed that farmers in savanna areas of Nigeria hava no definite fertilizer recommendation for sesame as a sole crop as most crops are grown in mixture with other crops mostly cereals (Olowe, 2004). Survey reports by various researchers in Nigeria have shown that fertilizers are not applied to sesame even in major sesame growing areas. (Idowu, *et al.,* 2002; Ugbani, *et al.,* 2008; Babaji *et al.,* 2005 and Hamman,1998). These coupled with the low fertility status of the savanna soils and low level of management are responsible for low yield of sesame in Nigeria. Sesame nutrition remained very controversial for long time, while some researchers are of the opinion that sesame does not require fertilization, others believe that the crop needed to be fertilized (Okpara *et al.,* 2007). However research coducted earlier have shown great yield improvement for fertilized sesame crop compared to unfertilized ones (Anon. 2006; Malik 2003).

FAO (2009) compared Nigeria's low sesame yield of 367 kg/ha with Egypt's 1323 kg/ha, Ethiopias 825 kg/ha and Uganda's 609 kg/ha and attribured this to lack of improved seed and improper agronomic practices, such as under or over planting densities and lack or low fertilizer usage by Nigerian farmers. Farmers have not adequately adopted improved recommendations on seed rate, spacing or plant population densities, which lead to under or over population that ultimately resulted in low yield. There are serious discripancies among researchers on suitable intra row spacing for sesame which were attributed to wide genetic variability of the crop and its adaptability to many soils and climatic conditions (Adebisi 2004). Some researchers recormended a narrow intra row spacing of 10cm for optimum growth and yield of sesame (Adeyemo *et al.,*1992; Olowe and Busari 1996). But, Bonsu (2003) and Delgado and Yarmanos (1975) recommended a wide intra row spacing of between 20 to 45cm for optimum growth and yield of sesame. Researchers working on sesame plant population densities reported a wide range of population densities from as low as 100,000/ha to as high as 600,000/ha (Katung 1987; Adebisi *et al.,* 2005 and Gupta 1982). In line with these inadequacies, this study was proposed to further verify the optimum nitrogen level and intra row spacing for growth and yield of sesame. Therefore the objectives of this study were to:

1. Determine the effect of nitrogen fertilizer rates on the productivity of sesame crop.
2. Determine the effect of intra row spacing on the productivity of Sesame crop.
3. Determine the best sesame variety for Samaru ecology.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of Nitrogen on the Growth and Yield of Sesame.

National Cereals Research Institute Badeggi recommended 20 to 50kgN/ha for optimum growth and yield of sesame in Nigeria depending on fertility status of the soil (NCRI 2005). However, Mkamilo and Bedigian(2007) recommended 30kgN/ha as an optimum nitrogen level for optimum growth and yield in most sesame producing countries in Asia and Africa. Hossein *et al.,* (2007) and Olowe and Busari (2000) reported a significant increase in number of capsules, weight of capsules, number of branches and grain yield with increased nitrogen up to 60kgN/ha. It has been observed by Roy *et al.,* (1995) that plant height, number of leaves, and number of branches were increased with increase in nitrogen levels up to 90kgN/ha, but the number of capsules per plant, capsule yield per plant and seed yield per plant were not increased with application of nitrogen above 60kgN/ha, while 1000 seed weight did not responded to nitrogen application. Shehu *et al.,*(2010) working in Nigeria reported an incease in the number of branches, number of leaves, total dry matter and seed yield with increased nitrogen up to 112.5kgN/ha, but plant height and number of seed per capsules were not affected by nitrogen level above 37.5kgN/ha, while the number of capsules inceases with increase in nitrogen up to 75kgN/ha. Okpara, *et al.,* (2007) reported a significant increase in seed yield per hectare and number of seed per capsule with increased nitrogen up to 75kgN/ha. It has been reported by Owuna (2006) and Mankar and Santao (1995) that, days to 50% flowering, weight of capsule per plant, seed weight per capsule, 1000 seed weight were not significantly affected by increasing nitrogen, but plant height, number of leaves, number of branches and total dry matter per plant were significantly increased with increased nitrogen level up to 60kgN/ha. Haruna *et*

al., (2009) reported a significant increase in seed yield with increased nitrogen up to 60 kgN/ha but He observed a decreased yield with application of 120 kgN/ha. It has been observed by Muhamman *et al.,* (2009) that days to 50% flowering and days to 50% maturity were not significant affected by increased nitrogen level up to 90 kgN/ha, but weight of biomass at harvest, dry weight of leaves and number of capsules per plant were increased wih increased nitrogen up to 90 kgN/ha. Osman (1993) and Roy *et al.,* (1995) reported a significant increase in seed yield, number of days to flowering and number of capsules per plant with application of 40 – 66 kgN/ha. While, Malik (2003) reported a significant increase in seed yield to 794kg with application of 80 kgN/ha. Similarly Haggai (2004) reported a significant increase in seed yield from 472kg with 0 kgN/ha to 779kg with 90 kgN/ha.

Subramanian *et al.,* (2000) who worked with two varieties (VS 9104 and VRII) in India reported positive influences on growth and yield attributes with increasing nitrogen level up to 15% above the recommended rate of 35 kgN/ha. Variety VS 9104 performed better than VRII with a yield of 857 and 895 kg/ha while VRII yielded 618 and 699 kg /ha for the two year experiment respectively. Zaidi and Khan (1981) observed varying response of sesame plants to nitrogen fertilizer while working with four sesame varieties in Pakistan. Variety 5.17 produced a significantly higher yield than varieties Calid, PV, and 37-40. A varying response of ten sesame varieties to nitrogen fertilizer was reported by (Kalita *et al.,* 1980). Varieties M 3-1 and Vinayak produced significantly higher yield (2.76t and 2.65t/ha) respectively than the other varieties. Dwivedi and Namdeo, (1992) reported increased seed yield of sesame variety JT7 with increased nitrogen level up to 45 kgN/ha.

2.2 Effect of Intra Row Spacing on Growth and Yield of Sesame

Sesame grown at wide intra row spacing are less exposed to intra specific competition and therefore tend to grow more vigorously, while narrowly spaced crop grow less vigorously with thinner stem and increased plant height, but with few branches and high incidence of lodging (Caliskan *et al.,* 2004). Adeyemo *et al.*,(2005) in a studies involving three inter and intra row spacing of 50 x 15cm (133,333 plant /ha), 60 x 10cm (166,667 plants/ha and 75 x 5cm (266,667 plants/ha) reported that, 60 x 10cm produced 40% more yield than 75 x 5cm. They also reported a decreased in number of capsules per plant, weight of capsules per plant, seed yield per plant and 1000 seed weight with increased population density. It has been reported by Adeyemo, *et al*.,(1992) that plant population of 133,333 to 266,667 plants per hectare were optimal for good gowth and yield of sesame plants. However Olowe and Busari, (1996) recommended 166667 to 333,333 plant population per hactare for optimal growth and yield of sesame in semi arid regions of northern Nigeria. Samson (2005) reported a significant increase in number of branches and number of leaves per plant at wide intra row spacing of 15cm than 10cm but observed a non significant response of plant height, total dry matter, number of capsule per plant, seed yield per plant, 1000 seed weight and seed yield per hectare at those spacings. Furthermore, it has been observed by Majumdar and Row (1992) that sesame growing at narrow intra row spacing increased yield, because close spacing ensured early canopy ground cover, captured sunlight more effectively and utilized soil moisture better as long as soil surface are moist, but suffered under drought conditions because of competition for water as a result of high population density. Chimanshette and Dhoble (1992) reported that wide intra row spacing resulted in low yield per hectare, which he attributed to poor light interception but reported a corresponding increase in yield per plant with wide intra row spacing. Varying responses of sesame plant

growth, yield and yield atributes in studies involving planting density was reported by Adeyemo *et al.,*(1992), Delgado and Yermanos(1975) and Katung(1987). They all reported significant decrease in growth, yield and yield attributes with increased population density.

Sesame population studies involving 14 genitically diverse Nigerian genotypes planted at inter and intra row spacing of 50 x 15cm (133,333 plants/ha), 60 x 10cm (166,667 plants/ha) and 75 x 5cm (266,667 plants/ha) showed that, genotypes differ susbtantially in number of capsules per plant, capsule weight per plant, seed yield per plant and 1000 seed weight and concluded that genotypes responded differently to changes in population densities Adebisi *et al.,*(2005). He also reported that genotypes 530-6-1,type A and pbtill, no. 1 generally outperformed others. Subramanian *et al.,* (2000) worked with two sesame varieties (VS 9104 and VRII) and two intra row spacing of 30cm and 20cm reported that, wide intra row spacing of 30cm has a favourable influences on growth and yield attributes of the individual plants for both varieties due to lower plant population, however, seed yield per hectare did not improve mainly because of the lower number of plants. By virtue of high population density, the seed yield under intra row spacing of 20cm was higher than that of 30cm for both varieties. In another trial involving three sesame varieties and three intra row spacing of 15cm, 20cm and 30cm varying responses of the varieties were reported by (Singh and Kaushall, 1975). Variety H92 -1 gave the highest seed yield at 15cm intra row spacing than the other two varieties who in turn produced higher seed yield at same intra row spacing than H92-1.

2.3 Correlation Between Seed Yield with Growth and Yield Characters

The relationship between seed yield of sesame crop and various growth and yield characters were reported by several researchers. Engin *et al* (2010) in a studies conducted in Australia involving 345 sesame genotypes originated from 29 different sesame producing countries worlwide reported that, plant height, number of branches and 1000 seed weight had a positive significant correlation with seed yield. While all characters related to maturity, first flowering and 50% flowering had a negative correlation with seed yield of sesame crop. In another correlation studies conducted in Nigeria by Muhamman *et al* (2010) revealed that, number of branches, plant height and leaf area had a positive significant correlation with seed yield of sesame crop, while 1000 seed weight and days to 50% flowering showed a non significant relationship with seed yield. Onginjo *et al* (2009) in a correlation studies involving 30 selected mutant lines and 2 cultivars reported that, seed yield had a strong positive and significant relationship with biomass yield, harvest index and 1000 seed weight but plant height, oil content, number of capsules and number of days to flowering had a weak positive significant correlation with seed yield. Subramanian and Subramanian (1994) reported that, seed yield had a positive significant correlation with number of capsules, number of primary branches, number of capsules, number of seed per capsule and 1000 seed weight. It has been reported by Adeyemo (1991) that seed yield had a significant correlation with number of capsules, seed yield per plant, number of seed per capsules, number of primary branches, length of capsules, 1000 seed weight and stand count of sesame plant.

2.4 Regresion

The regression analysis of grain yield against nitrogen were found to exhibit both linear and quadratic models. Shehu *et al*,.(2010) reported that grain yield of sesame followed a linear model

whereby grain yield increases with increase in nitrogen level up to 112.5 kgN/ha. However, Haruna *et al.,*(2010) reported that grain yield of sesame crop followed a quadratic model whereby grain yield declined when nitrogen application was raised beyond 60 kgN/ha.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The field trials were conducted during the rainy seasons of 2009 and 2010 at the Institute for Agricultural Research (IAR) farm Samaru (Latitude 11^0 11 ʿN, Longitude 7^0 38ʾE and 686m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria.

3.2 Treatments and Experimental Design

The treatments consisted of two sesame varieties (NCRIBen001M and NCRIBen002M), four nitrogen levels (20, 40, 60 and 80kgN/ha) and three intra row spacing (5, 10 and 15cm). The treatments were arranged in a split plot design. The factorial combination of N levels and varieties were assigned to the main plot while intra row spacing was placed at the sub plot. The treatments were replicated three times.

Varietal Description

NCRIBen001M was developed from a cross between Yandev 55, which is a long duration crop, maturing above 125 days and variety E8 which is a short duration crop, maturing under 90 days to obtained a medium maturing variety. It was released in 2002 by National Cereals Research Institute Badeggi. NCRIBen001M plants are erect, with alternate leaves, the stem is smooth with 3-5 branches and grows to a height of 100cm. The flowers are white to pink and produce one capsule per axil. The variety matures between 102-125 days. The seed colour is white to yellowish and is yield about 1000kg of seed per hectare. The seed contained about 45% oil and 1000 seed of this variety weight about 3g (Olowe *et al*., 2009; NCRI, 2005; RMRDC 2004).

NCRIBen02M is a medium maturing variety which is slightly shorter in height than NCRIBen001M at maturity. It was released together with NCRIBen001M in 2002 by the same institute. The plant is erect, with alternate leaves and produce about 3-5 branches. The flowers are essentially white and the plant produces one capsule per axil. This variety also matures between 102-125 days. The seed colour is white and it yields about 800 -1000kg/ha of seed. The seed contain about 45% oil and 1000 seed of this variety also weights about 3g. (Olowe *et al*., 2009; NCRI 2005; RMRDC 2004).

3.4 Plot Size

The gross plot size was 3.0m x 3.0m ($9m^2$), consisting of four rows, each measuring 3.0m in length and spaced 0.75m apart. The net plot size was $4.5m^2$ consisting of the 2 inner rows, while the 2 border rows were used for destructive sampling.

3.5 Cultural Practice

3.5.1 Land preparations

The experimental field was ploughed, harrowed and ridged at 75cm apart. The prepared land was then marked and sub divided into the required plots and replications in accordance with the layout of the experiment.

3.5.2 Sowing

A mixture of one part of sesame seed and two parts of river sand was sown manually at a shallow depth of about 1cm, by dibbling at an intra row spacing of 5, 10 and 15cm as per treatments on ridges spaced 75cm apart. The emerged plants were thinned to one plant per stand at two weeks after sowing. This arrangement gave population of 266,667,133,333 and 88,889 plants per hecrare for 5, 10 and 15cm intrarow spacing respectively.

3.5.3 Fertilizer application

Phosphorus and potassium fertilizer was applied at planting to all the sub plots at the rate of 19.7kgP/ha and 24kg K/ha using SSP(16%P_20_5) and MOP (60% K_2O) respectively as was recommended by National Cereals Research Institute, Badeggi (NCRI 2005). Nitrogen fertilizer was applied at two and six weeks after sowing in two equal split doses at the rates of 20, 40, 60 and 80kgN/ha as per treatments using Urea (46%N).

3.5.4 Weed and pest control

Glyphosate at the rate of 5 liters per ha was applied before land preparation to control weed in 2009. No herbicide was used during the 2010 season. Hoe weeding at three and six weeks after sowing was followed. No serious insects pest and diseases attack were encountered during the experimental periods.

3.5.5 Harvesting

The fully matured crop from the net plots were harvested manually by carefully cutting the stem at base using sharp sickle. The harvested plants were seperately placed in a sack and allowed to fully dry before threshing.

3.5.6 Threshing

The fully dried harvest from the net plots were seperately threshed manually by gently beating the sacks with stick to separate the seeds from the capsules. This was followed by winnowing to separate the grains from the chaff.

3.6 Data Collection

Data were collected from 5 randomly tagged plants within each plot during the plant growth at 4, 6, 8, 10 and 12 WAS and at harvest and used to determine the following:

3.6.1 Plant height

Plant height of five tagged plants in each plot was measured from base of the plant to its apex using meter rule and the means calculated and recorded.

3.6.2 Number of leaves per plant

The number of leaves from each of the five tagged plants in each plot were counted and the means calculated and recorded.

3.6.3 Number of primary branches per plant

The number of primary branches on the 5 tagged plants in each plot were counted at harvest and the mean was calculated and recorded.

3.6.4 Number of secondary branches per plant

The number of secondary branches were counted for the 5 sampled plants in each plot at harvest and the mean was calculated and recorded.

3.6.5 Total dry matter (TDM) per plant

Five randomly sampled plants from each plot were harvested at 4, 6, 8, 10 and 12WAS and at harvest, oven dried and weighted to determine the shoot dry matter per plant.

3.6.6 Leaf area

Leaves from the five sampled plants were detarched and weighted. These were then oven dried and weighted again. The leaf area per plant was determined using leaf area dry weight relationship as was described by Rhoads and Bloodworth (1964)..

$$LA = \frac{A + B}{C}$$

LA = Leaf Area (cm)
A = Weight of leaves in the sample
B = Weight of dried leaves
C = Disc area (cm)

3.6.7 Leaf area index (LAI)

The LAI was determined by dividing the leaf area calculated above by the area subtented by the sampled plants from each plot as described by Watson (1952). The area subtented by plants was calculated by multiplying inter and intra row spacing of each treatment.

$$LAI = \frac{\text{Leaf area per plant}}{\text{Ground Area subtented by the plant}}$$

3.6.8 Crop growth rate (CGR)

The dried weight of the 5 sampled plants from each plot were used to determined CGR per plant as suggested by Radford (1967).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \cdot \frac{1}{GA} \quad g/m^2/wk$$

CGR = Crop Growth Rate
W_1 and W_2 = Total dry weight at time t_1 and t_2.
GA = Ground Area

3.6.9 Number of capsules per plant

This was determined by counting the number of capsules on the 5 sampled plants in each plot at harvest and the mean calculated and recorded.

3.6.10 Capsules yield per plant (g)

This was obtained by weighing the harvested capsules from the 5 sampled plants in each plot after sun drying and the mean calculated and recorded.

3.6.11 Grain yield per plant (g)

This was determined by threshing the capsules harvested from the 5 sampled plants from each plot. The realized clean grains were weighted and the mean grain per plant was calculated and recorded.

3.6.12 Grain yield per hectare (kg/ha)

The grain yield was determined from the harvest of each net plot. The harvested plants were threshed and winnowed to obtained clean grains, which were then weighted and converted to per hectare basis.

3.7 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Stastical Analysis Agricultural Sciences (SAS) and the means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955). Correlations analysis among growth, yield and yield components were done as described by Gomez and Gomez (1984). Regression analysis for grain yield against nitrogen levels was also done to determined wheather grain yield regressed with increased nitrogen level.

CHAPTER 4

4.0 RESULT

4.1 Soil and Climate of the Experimental Site.

Soil samples were collected from the experimental site at a depth of 0 – 30cm because sesame crop roots were contained within 30cm of the top soil. The soil samples were analysed at IAR Soil Science labratory Samaru. The result showed that, the soils were sandy loam, slightly acidic (P^H 6.0 and 6.5), low organic carbon (1.2 and 0.98), low total nitrogen (0.21 and 0.18), low cation exchange capacity (5.2 and 6.2) and available phosphorus of (8.4 and 7.4) for 2009 and 2010 years respectively. Details of the physical and chemical composition of the soil from the experimental site are contained in Table 1.

The year 2009 is more rainy 1278mm compared to 1127.3mm in 2010. The monthly rainfall distribution during the experimental periods showed that, months of 2009 are more rainy except in September, when 2010 is more rainy than 2009. The details of rainfall from July to October are, 243.2 and 216.6ml in July, 394.4 and 313.4ml in August, 198.1 and 218.5ml in September and 151.7 and 82.3ml in October for 2009 and 2010 respectively. The details of temperature, relative humidity, sunshine and rainfall at Samaru during the period of the trials were collected from IAR meteorological unit are shown in appendixes 1 and 2.

4.2 Plant Height per Plant

The plant height response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 2. In both 2009 and 2010 and in all the sampling periods, significant increase in plant height were observed with each increase in nitrogen level up to 80kgN/ha, except at 8WAS in 2009 when plant height responses to nitrogen level at 40 and 60kgN/ha and at 60 and 80kgN/ha were the same statistically. Similar trend was also observed when plant height data

Table 1: Physico – chemical characteristics of soils of the experimental site in 2009 and 2010 wet seasons at Samaru.

Soil composition	**Soil depth 0-30cm**	
Perticle size	**2009**	**2010**
Sand g/kg	560	520
Silt g/kg	320	320
Clayg/kg	120	160
Textural class	sandy loam	sandy loam
Chemical properties		
P^H in water	5.6	6.5
P^H in 0.1ml $CaCl_2$	4.7	5.2
Organic carbon g/kg	1.2	0.98
Total nitrogen	0.21	0.18
Available P (mg/kg)	8.4	7.4
Exchangegible cation (cmol/kg)		
K	0.09	0.2
Mg	0.34	1.25
Ca	2.4	2.5
Na	0.45	0.25
CEC	5.2	6.2

Table 2. Effect of nitrogen level and intra row spacing on plant height per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.(cm).

N-Level(kgN/ha)	Weeks after sowing								
	4			8			12		
	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
20	6.70d	7.68d	7.19d	58.81c	58.82d	58.81c	84.98d	85.16d	85.07d
40	9.68c	10.66c	10.16c	61.74b	62.33c	62.04b	87.81c	87.93c	87.87c
60	11.83b	12.96b	12.39b	64.06ab	64.68b	64.43a	90.30b	90.77b	90.51b
80	12.68a	13.92a	13.30a	64.21a	66.32a	65.36a	93.03a	93.41a	93.22a
SE±	0.220	0.240	0.160	0.770	0.380	0.420	0.210	0.170	0.130
Variety									
NCRIBen001M	10.24	11.35	10.78	62.51	63.56a	63.04	89.57a	89.83a	89.70a
NCRIBen002M	10.21	11.26	10.75	61.90	62.58b	62.24	88.49b	88.78b	88.64b
SE±	0.160	0.170	0.110	0.550	0.270	0.300	0.150	0.340	0.270
Intra row Spacing									
5	10.33	11.38	10.86	59.13c	60.67c	59.85c	85.68c	85.90c	85.79c
10	10.20	11.36	10.78	61.85b	62.85b	62.35b	88.70b	89.15b	88.92b
15	10.14	11.17	10.65	65.63a	65.81a	65.72a	92.70a	92.86a	92.78a
SE±	0.580	0.180	0.130	0.250	0.330	0.210	0.090	0.120	0.071
Interactions									
N x V	NS	NS	NS	NS	NS	**	NS	NS	NS
N x S	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letters wihin collums are not statistically different at 5% level of of significance

**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

was pooled across years except at 8WAS, when plant height responses to nitogen level at 60 and 80kgN/ha were not different statistically. The two varieties did not differed significantly in their plant height at 4WAS in both years and at 8WAS in 2009. However, at 8WAS in 2010 and at 12WAS in both 2009 and 2010, NCRIBen001M significantly produced taller plants than NCRIBen002M. When plant height of the two varieties was pooled across years, NCRIBen001M produced taller plants at 12WAS only while at 4 and 8WAS plant height of the two varieties were not different statistically. Significant increase in plant height was observed with increase in intra row spacing at 8 and 12WAS in both 2009 and 2010. However at 4WAS, plant height response with increase in intra row spacing was not significant in both 2009 and 2010. Analysis on the combined data for all the sampling periods of both years also showed a similar trend.

The interaction of nitrogen level and variety on plant height per plant at 8WAS for the combined years is presented in Table 3. The two varieties produced statisticaly same height at each of the levels of nitrogen. Increase in nitrogen level from 20 to 60kgN/ha increased only the height of NCRIBen001M, further increase to 80kgN/ha did not affect plant height of this variety. Plant height of NCRIBen002M were similar with aplication of 40, 60 and 80kgN/ha, but plants that recieved 60 and 80kgN/ha were significantly taller than those that recieved 20kgN/ha, while plant heights of 20 and 40kgN/ha were statistically the same for this variety. The highest and least values of plant height were recorded for NCRIBen001M with the application of 80 and 20kgN/ha respectively.

4.3 Number of Leaves per Plant

The number of leaves response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 4. At all the sampling periods and in both 2009 and 2010, significant increase in number of leaves were observed with each increase in nitrogen level up to 80kgN/ha except at

Table 3. Interaction of nitrogen levels and variety on plant height per plant of two Sesame varieties at 8WAS of the combined 2009 and 2010 wet seasons at Samaru (cm).

N-Level(kgN/ha)	NCRIBen001M	NCRIBen002M
20	58.57d	59.05cd
40	62.70b	61.37bc
60	65.30a	63.56ab
80	65.57a	64.95ab
SE±	0.840	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

Table 4. Effect of nitrogen levels and intra row spacing on number of leaves per plant of two Sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.

N-Level(kgN/ha)	Weeks after sowing								
	4			8			12		
	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
20	4.29c	4.30d	4.29d	26.53d	26.55d	26.54d	55.16c	54.99d	55.08d
40	4.56b	4.63c	4.59c	27.77c	27.77c	27.77c	57.86b	58.32c	58.09c
60	4.84a	4,97b	4.91b	29.51b	29.67b	29.59b	62.33a	62.52b	62.43b
80	5.02a	5.19a	5.11a	30.63a	30.83a	30.73a	63.44a	63.65a	63.55a
SE±	0.071	0.058	0.045	0.220	0.170	0.045	0.420	0.270	0.250
Variety									
NCRIBen001M	4.7	4.8	4.7	28.7	28.8	28.7	60.0	60.1	60.0
NCRIBen002M	4.6	4.7	4.6	28.4	28.5	28.5	59.3	59.6	59.4
SE ±	0.052	0.041	0.032	0.160	0.120	0.097	0.290	0.180	0.170
Intra row Spacing(cm)									
5	4.53b	4.68b	4.61c	24.62c	24.90c	24.76c	47.40c	47.79c	47.60c
10	4.68ab	4.78ab	4.73b	29.20b	29.15b	29.17b	61.33b	61.46b	61.39b
15	4.81a	4.86a	4.84a	32.02a	32.07a	32.04a	70.36a	70.37a	67.60a
SE ±	0.050	0.034	0.032	0.230	0.180	0.150	0.310	0.090	0.210
Interactions									
N x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S	NS	NS	NS	**	* *	*	**	**	*
S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance

* Significant at 5%
** Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

4 and 12WAS in 2009, where number of leaves responses to nitrogen level at 60 and 80kgN/ha were not significant statistically. Analysis of the combined data at all the sampling periods of both years showed an increased number of leaves with increase in nitrogen level up to 80kgN/ha. The two varieties did not significantly differed in their number of leaves at all the sampling periods and in both 2009 and 2010. Similar trend was observed when the number of leaves data was pooled across years. Significant increase in number of leaves was observed with increase in intra row spacing at 8 and 12WAS in both 2009 and 2010. However at 4WAS in both 2009 and 2010. the number of leaves response with increase in intra row spacing was not significant at 5 and 10cm and at 10 and 15cm. Analysis on the combined data of all the sampling periods of both years showed an increased number of leaves with increase in intra row spacing.

The interaction of nitrogen level and intra row spacing on number of leaves per plant at 8 and 12WAS are presented in Tables 5 and 6. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding increase in the number of leaves per plant. When the effect of increasing nitrogen level at fixed intra row spacing on number of leaves were considered, it was observed that, increasing nitrogen level from 20 to 40kgN/ha significantly increased this character, except for 5cm intra row spacing at 8 and 12WAS in 2009 only. Further increase in nitrogen level to 60kgN/ha did not significantly affect number of leaves for 5cm intra row spacing at 8WAS and 10cm intra row spacing at 8WAS in 2009. Beyond this level, leaf production was not influenced significantly for 5cm intra row spacing at 8 and 12WAS and for 15cm at 8WAS in 2009 and 10cm at 12WAS. The highest and the least values for number of leaves were generally recorded by the interaction of 80kgN/ha and 15cm intra row spacing and 20kgN/ha and 5cm intra row spacing respectively.

Table 5. Interaction of nitrogen levels and intra row spacing on number of leaves per plant of two sesame varieties at 8WAS during rainy seasons of 2009, 2010 and the combined at Samaru.

Year	N- Level	Intra row spacing (cm)		
	(KgN/ha)	5	10	15
2009	20	24.33f	26.60e	28.66d
	40	24.60f	28.26d	30.43c
	60	24.73f	29.93cd	33.86a
	80	25.07f	32.00b	35.10a
	SE±		0.460	
2010	20	24.36f	26.53e	28.7fd
	40	24.76f	27.85d	30.70c
	60	25.13f	30.10c	32.76b
	80	25.33f	32.08b	35.06a
	SE±		0.360	
Combined	20	24.35g	26.57f	28.71e
	40	24.68g	28.06e	30.57d
	60	24.93g	30.02d	33.82b
	80	25.07g	32.04c	35.08a
	SE±		0.290	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

Table 6: Interactions of nitrogen level and intra row spacing on number of leaves per plant of two sesame varieties at 12WAS during rainy seasons of 2009, 2010 and the combined at Samaru.

Year	N- Level	Intra row spacing (cm)		
	(kg/N/ha)	5	10	15
2009	20	45.06h	55.53f	64.86d
	40	45.73h	60.16e	67.66c
	60	49.46g	64.26d	73.26b
	80	49.36g	65.33d	75.63a
	SE±		0.620	
2010	20	45.01i	55.53f	64.43d
	40	46.90h	60.26e	67.78c
	60	49.46g	64.56d	73.53b
	80	49.76g	65.48d	75.71a
	SE±		0.540	
Combined	20	45.04i	55.53f	64.65d
	40	46.31h	60.21e	67.72c
	60	49.46g	64.41d	73.40b
	80	49.56g	65.42d	75.67a
	SE±		0.410	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

4.4 Number of Primary Branches per Plant

The number of primary branches response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 7. In both 2009 and 2010 significant increase in number of primary branches were observed with each increase in nitrogen level up to 60kgN/ha, further increase to 80kgN/ha did not result in significant response on the the number of primary branches. Analysis of the combined data of both years showed a similar trend. The two varieties did not significantly differed in their number of primary branches in both 2009 and 2010 and when the combined data was pooled across years. Significant increase in number of primary branches was observed with each increase in intra row spacing in both 2009 and 2010 and when the combined data was pooled across years.

The interaction of nitrogen level and intra row spacing on number of primary branches per plant in 2009, 2010 and the combined is presented in Tables 8. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding increase in the number of primary branches per plant in both years and the combined, except at 20kgN/ha in 2009 where a non significant effect was observed at 10 and 15cm intra row spacing. When the effect of increasing nitrogen level at fixed intra row spacing on number of primary branches were considered, it was observed that increasing nitrogen level from 20 to 40kgN/ha resulted in corresponding increase in number of primary branches at each intra row spacing in both years and the combined. Further increase to 60kgN/ha did not significantly affect number of primary branches for 5cm intra row spacing in 2009 and 2010. Beyond this level, the number of primary branches were also significantly not influenced for 5 and 15cm intra row spacing in both years and the combined. The highest and the least values for number of primary branches were generally recorded at interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

Table 7. Effect of nitrogen levels and intra row spacing on number of primary branches per plant of two Sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru

N-level(kg/N/ha)	2009	2010	Combined
20	2.01c	2.07c	2.04c
40	3.07b	3.04b	3.06b
60	3.74a	3.86a	3.80a
80	3.87a	4.01a	3.94a
SE±	0.096	0.073	0.057
Variety			
NCRIBen001M	3.21	3.29	3.25
NCRIBen002M	3.13	3.20	3.17
SE±	0.068	0.047	0.040
1ntra row spacing(cm)			
5cm	2.27c	2.38c	2.32c
10cm	3.31b	3.38b	3.34b
15cm	3.93a	3.98a	3.96a
SE±	0.073	0.075	0-052
Interactions			
N x V	NS	NS	NS
N x S	*	*	**
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level oof significance.

Table 8: Interaction of nitrogen levels and intra row spacing on number of primary branches per plant of two sesame varieties during 2009 and 2010 wet seasons at Samaru.

Year	N- Level	Intra row spacing (cm)		
	(kgN/ha)	5	10	15
2009	20	1.461h	1.96g	2.63fg
	40	2.33fg	3.16d	3.70c
	60	2.63fg	3.86bc	4.73a
	80	2.70ef	4.283b	4.66a
	SE±	0.145		
2010	20	1.50 h	2.10g	2.60ef
	40	2.40f	3.03d	3.70c
	60	2.73def	4.03bc	4.80a
	80	2.86de	4.33b	4.83a
	SE±	0.150		
Combined	20	1.46 h	2.03g	2.62ef
	40	2.37fg	3.10d	3.70c
	60	2.68e	3.95c	4.77a
	80	2.78e	4.28b	4.75a
	SE±	0.104		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

4.5 Number of secondary branches

The number of secondary branches response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 9. In both 2009 and 2010 significant increase in number of secondary branches were observed with each increase in nitrogen level up to 80kgN/ha. Analysis of the combined data of both years showed a similar trend. The two varieties did not significantly differed in their number of secondary branches in both 2009 and 2010 and when the combined data was pooled across years. Significant increase in number of secondary branches was observed with each increase in intra row spacing in both 2009 and 2010 and when pooled across years.

The interaction of nitrogen level and intra row spacing on number of secondary branches per plant in 2009, 2010 and the combined are presented in Tables 10. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding increase in the number of secondary branches, except at 20kgN/ha in 2009 where non significant effect was observed at 10 and 15cm intra row spacing. When the effect of increasing nitrogen level at fixed intra row spacing on number of secondary branches were considered, it was observed that increasing nitrogen level from 20 to 40kgN/ha resulted in corresponding increase in number of secondary branches at each intra row spacing in both years and the combined, except at 5 and 10cm in 2009 and at 5cm in the combined. Further increase of N to 60 kgN/ha significantly did not affect number of secondary branches for 5cm intra row spacing in both years and the combined. Beyond this level, the number of secondary branches were not significantly influenced for 10cm intra row spacing in both years and the combined and for 5cm in 2009 and the combined. The highest and the least values for number of secondary branches were recorded in the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

Table 9. Effect of nitrogen levels variety and Intra row spacing on number of secondary branches per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru

N-Level(kgN/ha)	2009	2010	Combined
20	0.78d	0.72d	0.75d
40	1.22c	1.17c	1.44c
60	1.46b	1.69b	1.57b
80	1.80a	1.93a	1.86a
SE±	0.091	0.043	0.049
Variety			
NCRIBen001M	1.34	1.41	1.38
NCRIBen002M	1.23	1.35	1.29
SE±	0.063	0.031	0.037
Intra row spacing (cm)			
5cm	0.44c	0.68c	0.56c
10cm	1.45b	1.44b	1.45b
15cm	1.98a	2.12a	1.99a
SE±	0.065	0.460	0.042
Interactions			
N x V	NS	NS	NS
N x S	**	* *	* *
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 10. Interaction of nitrogen levels and intra row spacing on number of secondary branches per plant of two sesame varieties during wet seasons of 2009,2010 and the combined at Samaru.

Year	N- Level	Intra row spacing (cm)		
	(KgN/ha)	5	10	15
2009	20	0.23g	0.85de	1.17d
	40	0.36fg	1.10d	1.85c
	60	0.46fg	1.80c	2.27b
	80	0.70ef	2.05bc	2.70a
	SE±		0.129	
2010	20	0.26g	0.73f	1.16d
	40	0.60f	1.06de	1.83c
	60	0.83ef	1.86c	2.36b
	80	1.00d	2.10bc	2.70a
	SE±		0.085	
Combined	20	0.25 f	0.85e	1.17d
	40	0.48 f	1.10 d	1.85c
	60	0.65 ef	1.80c	2.27b
	80	0.85e	2.05bc	2.70a
	SE±		0.085	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

4.6 Total Dry Matter per Plant

The total dry matter response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 11 and 12. At all the sampling periods and in both 2009 and 2010, significant increase in total dry matter were observed with each increase in nitrogen level up to 80kgN/ha. Similar trend was observed when the combined data was pooled across years. The two varieties did not significantly differed in total dry matter at all the sampling periods and in both 2009 and 2010 except at 8 and 12WAS in 2010 where NCRIBen001M produced significantly heavier total dry matter than NCRIBen002M. Analysis of the combined data at all the sampling periods of both years showed similar trend. Significant increase in total dry matter was observed with each increase in intra row spacing at all the samling periods in both 2009 and 2010. Similar trend was observed when the combined data was pooled across all the sampling periods and years.

The interaction of nitrogen level and intra row spacing on TDM per plant at 8WAS in the combined and at harvest in 2009 and the combined are presented in Tables 13. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding increase in the TDM per plant, except at harvest for 60kgN/ha in 2009 and the combined of the same sampling period and at 80kgN/ha in the combined. When the effect of increasing nitrogen level at fixed intra row spacing on TDM per plant were considered, it was observed that increasing nitrogen level from 20 to 40kgN/ha resulted in corresponding increase in TDM per plant at each intra row spacing, except at harvest for 15cm in 2009 and the combined of the same sampling period, where a non significant effects were observed. Further increase to 60kgN/ha significantly did not affect the TDM per plant at harvest for 5cm and 15cm intra row spacing in the combined only. Beyond this level, the TDM per plant was also significantly not influenced at harvest for 10cm intra row spacing in 2009 and for 5cm in the combined only. The highest and the least values for

Table 11. Effect of nitrogen level and intra row spacing on total dry matter per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru. (g)

	Weeks after sowing								
N-Level	**4**			**8**			**12**		
KgN/ha	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**
20	0.60d	0.61d	0.61d	5.09d	5.12d	5.11d	9.48d	9.51d	9.50d
40	0.65c	0.66c	0.66c	5.17c	5.19c	5.18c	9.60c	9.63c	9.61c
60	0.68b	0.70b	0.69b	5.24b	5.26b	5.26b	9.67b	9.70b	9.68b
80	0.71a	0.73a	0.72a	5.29a	5.32a	5.32a	9.77a	9.79a	9.78a
SE±	0.004	0.005	0.004	0.007	0.006	0.005	0.013	0.010	0.007
Variety									
NCRIBen001M	0.67	0.68	0.67	5.21	5.23a	5.22a	9.64	9.66a	9.65a
NCRIBen002M	0.66	0.68	0.67	5.20	5.21b	5.21b	9.63	9.64b	9.64b
SE ±	0.004	0.005	0.030	0.005	0.004	0.0035	0.009	0.007	0.007
Intra row Spacing(cm)									
5	0.56c	0.66c	0.61c	4.82c	5.12c	4.97c	9.16c	9.38c	9.27c
10	0.61b	0.75b	0.68b	5.16b	5.34b	5.25b	9.52b	9.94b	9.68b
15	0.68a	0.84a	0.71a	5.33a	5.47a	5.40a	9.85a	10.11a	9.98a
SE ±	0.015	0.012	0.011	0.005	0.007	0.004	0.007	0.011	0.005
Interactions									
N x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S	NS	NS	NS	NS	NS	*	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x Vx S	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%

NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 12. Effect of nitrogen levels and intra row spacing on total dry matter per plant at harvest of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.(g)

N- Level (KgN/ha)	2009	2010	Combined
20	16.07d	16.15c	16.11d
40	16.23c	16.38bc	16.30c
60	16.43b	16.53b	16.47b
80	16.57a	16.86a	16.71a
SE±	0.014	0.086	0.042
Variety			
NCRIBen001M	16.33	16.50	16.42
NCRIBen002M	16.23	16.45	16.39
SE±	0.010	0.061	0.030
Intra row spacing (cm)			
5cm	15.67c	15.84c	15.75c
10cm	16.51b	16.67b	16.59b
15cm	16.8 0a	16.93a	16.87a
SE±	0.011	0.059	0.030
Interactions			
N x V	NS	NS	NS
N x S	**	NS	**
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letters wihin collums are not statistically different at 5% level of of significance.

**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 13. Interaction betweem nitrogen levels, and Intra row spacing on total dry matter per plant (TDM) of two sesame varieties during, 2009 and 2010 wet seasons at Samaru.(g)

WAS/Year	N- Level	Intra row spacing (cm)		
	(KgN/ha)	5	10	15
8WAS (Combined)	20	4.86j	5.15f	5.32d
	40	4.94i	5.23e	5.37c
	60	5.03h	5.31d	5.42b
	80	5.07g	5.35c	5.50a
	SE±	0.010		
2009 (At harvest)	20	15.38j	16.16f	16.68cd
	40	15.53i	16.39e	16.76c
	60	15.78h	16.64b	16.85b
	80	15.96g	16.82bc	16.92a
	SE±	0.020		
Combined (At harvest)	20	15.43i	16.20d	16.71b
	40	15.69gf	16.42c	16.80b
	60	15.83f	16.70b	16.91b
	80	16.06df	17.03a	17.05a
	SE±	0.060		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

TDM per plant were generally recorded by the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

4.7 Leaf Area per Plant

The leaf area response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 14. At all the sampling periods and in both 2009 and 2010 significant increase in leaf area were observed with each increase in nitrogen level up to 80kgN/ha, except at 4WAS in both 2009 and 2010 where leaf area responses to nitrogen level at 60 and 80kgN/ha did not diffrered statistically. Similar trend was observed when the combined data was pooled at all the sampling periods of the years.. The two varieties significantly differed in their leaf area at all the sampling periods in both 2009 and 2010. NCRIBen001M produced significantly higher leaf area than NCRIBen002M. Similar trend was observed when the combined data was pooled across all the sampling periods of the years. Significant increase in leaf area was observed with increase in intra row spacing at all the sampling periods in both 2009 and 2010. Similar trend was observed when the combined data at all the sampling periods of the years was analysed.

The interaction of nitrogen level and intra row spacing on leaf area per plant at 12WAS in 2009 and in 2010 are presented in Tables 15. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding increase in the leaf area per plant except at 60kgN/ha in 2009, where a non significant effect was observed at 10 and 15cm intra row spacing. When the effect of increasing nitrogen level at fixed intra row spacing on leaf area per plant was considered, it was observed that increasing nitrogen level from 20 to 80kgN/ha resulted in corresponding increase in leaf area per plant at each intra row spacing except at 10 and 15cm in 2009, where the leaf area per plant were statistically the same. The highest and the

Table 14. Effect of nitrogen levels and intra row spacing on leaf area per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru. (cm^2)

	Weeks after sowing								
N- Level	**4**			**8**			**12**		
(KgN/ha)	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**
20	162.5c	162.9c	162.7c	748.9d	737.7d	749.1d	1007.8d	1008.9d	1008.3d
40	167.4b	169.0b	168.2b	781.3c	749.3c	759.5c	1053.3c	1059.8c	1056.6c
60	173.2a	174.6a	173.9a	821.7b	922.4b	822.1b	1104.2b	1104.3b	1142.3b
80	175.2a	176.7a	175.9a	841.9a	842.5a	842.2a	1124.6a	1125.8a	1125.2a
SE ±	0.930	0.890	0.640	2.280	22.900	11.480	2.840	2.200	1.800
Variety									
NCRIBen 001M	170.7a	171.8a	171.3a	809.8a	810.3a	810.0a	1078.7a	1079.3a	1079.1a
NCRIBen 002M	168.5b	169.8b	169.1b	787.1b	765.7b	776.4b	1066.2b	1070.1b	1068.2b
SE±	0.660	0.630	0.460	1.610	16.200	11.480	0.460	1.550	1.270
Intra row Spacing(cm)									
5	154.7c	155.9c	155.3c	700.6c	701.0c	700.8c	1002.4c	1004.1c	1003.2c
10	168.7b	169.9b	169.3b	805.9b	806.7b	806.4b	1091.1b	1091.0b	1091.0b
15	185.4a	186.5a	185.9a	888.7a	856.3a	872.5a	1124.4a	1129.2a	1026.5a
SE±	1.590	1.410	1.070	3.870	20.400	11.480	3.670	3.280	2.460
interactions									
N xV	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S	NS	NS	NS	NS	NS	NS	*	*	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%

NS Non significant at 5%

N = Nitrogen level

S = Intra row spacing

V = Variety

Table 15. Interaction of nitrogen level and intra row spacing on leaf area per plant of two sesame varieties at 12WAS during 2009 and 2010 wet seasons at Samaru.(cm^2)

Year	N- Level	Intra row spacing (cm^2)		
(KgN/ha)		5	10	15
2009	20	951.30h	1007.46f	1064.60de
	40	981.68g	1073.11d	1105.26c
	60	1027.18f	1131.96b	1153.41ab
	80	1049.30e	1151.73b	1172.78a
	SE±	7.340		
2010	20	942.56i	1008.56g	1065.48de
	40	983.45h	1073.55d	1122.35c
	60	1029.91f	1128.71c	1154.28b
	80	1055.41e	1158.21b	1183.88a
	SE±	6.570		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

least values for leaf area per plant were generally recorded by the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

4.8 Leaf Area index

The leaf area index response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 16. At all the sampling periods and in both 2009 and 2010 significant increase in leaf area index were observed with each increase in nitrogen level up to 80kgN/ha, except at 4WAS in 2010 where leaf area index responses to nitrogen level at 60 and 80kgN/ha was not significant statistically. When the combined data was pooled, significant increase in leaf area index was observed with each increase in nitrogen level up to 80kgN/ha in all the sampling periods of the years. The two varieties significantly differed in their responses to leaf area index at 8 and 12WAS in both 2009 and 2010. NCRIBen001M produced significantly higher leaf area index than NCRIBen002M. However, at 4WAS the leaf area index of both varieties did not differed statistically. Similar trend was observed when the combined data was pooled across all the sampling periods of the years. Significant decrease in leaf area index of both varieties was observed with increase in intra row spacing at all the sampling periods in both 2009 and 2010. Similar trend was observed at all the sampling periods when the combined data of the two years was analysed.

The interaction of nitrogen level and intra row spacing on LAI at 8WAS in 2009,2010 and the combined of the same sampling period, and at 12WAS in 2009 and the combined of that sampling period are presented in Tables 17. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in corresponding decrease in the LAI per plant at both 8 and 12WAS in both years and the combined. When the effect of increasing nitrogen level at fixed

Table 16. Effect of nitrogen levels and intra row spacing on leaf area index per plant of two sesame varieties during 2009 and 2010 wet seasons at Samaru.

N-Level	Weeks after sowing								
	4			8			12		
KgN/ha	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
20	0.52d	0.52c	0.52d	2.34d	2.33d	2.33d	3.19d	3.21d	3.20d
40	0.55c	0.53b	0.53c	2.47c	2.43c	2.45c	3.37c	3.34 c	3.36c
60	0.57b	0.55a	0.56b	2.61b	2.57b	2.59b	3.45b	3.51b	3.49b
80	0.59a	0.56a	0.57a	2.67a	2.64a	2.65a	3.58a	3.58a	3.58a
SE±	0.004	0.0023	0.0026	0.005	0.008	0.071	0.026	0.010	0.032
Variety									
NCIRIBen001M	0.56a	0.54	0.55	2.55a	2.53a	2.54a	3.44a	3.43a	3.43a
NCRIBen002M	0.55b	0.54	0.55	2.49b	2.46b	2.47b	3.37b	3.39b	3.38b
SE±	0.003	0.002	0.0027	0.004	0.0045	0.0045	0.017	0.006	0.014
Intra row Spacing(cm)									
5cm	0.85a	0.83a	0.84a	3.77a	3.74a	3.75a	5.31a	5.33a	5.32a
10cm	0.47b	0.46b	0.46b	2.19b	2.15b	2.17b	2.90b	2.90b	2.90b
15cm	0.35c	0.33c	0.34c	1.17c	1.58c	1.59c	2.00c	2.00c	2.00c
SE±	0.004	0.006	0.0036	0.012	0.014	0.0089	0.024	0.010	0.013
Interactions									
N x V	NS	NS	NS	NS	NS	NS	NS	NS	NS
N x S	NS	NS	NS	**	**	**	**	NS	**
S x V	NS	NS	NS	NS	NS	NS	NS	NS	*
NxSxV	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%
**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 17. Interaction of nitrogen level and intra row spacing on leaf area index per plant of two sesame varieties at 8 and 12WAS during 2009 and 2010 wet seasons at Samaru.

	N- Level	Intra row spacing (cm)		
WAS/Year	**(KgN/ha)**	**5**	**10**	**15**
8WAS 2009	20	3.32d	2.00g	1.51i
	40	3.63c	2.10f	1.56i
	60	3.85b	2.22e	1.62h
	80	4.11a	2.27e	1.74h
	SE±	0.027		
8WAS 2010	20	3.52d	2.05g	1.49j
	40	3.67c	2.15f	1.58i
	60	3.91b	2.26e	1.65h
	80	4.01a	2.31e	1.68h
	SE±	0.024		
8WAS Combined	20	3.47d	2.02h	1.50ij
	40	3.65c	2.13g	1.57i
	60	3.88b	2.24e	1.64h
	80	4.06a	2.29e	1.66h
	SE±	0.018		
12WAS 2009	20	5.10c	2.66f	1.86i
	40	5,27b	2.85e	1.98hi
	60	5.32b	3.02d	2.08gh
	80	5.57a	3.09d	2.10gh
	SE±	0.047		
12WAS Combined	20	5.05d	2.67g	1.87j
	40	5.24c	2.85f	1.97i
	60	5.39b	3.01e	2.06h
	80	5.57a	3.06e	2.09h
	SE±	0.026		

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

intra row spacing on LAI were considered, it was observed that increasing nitrogen level from 20 to 40kgN/ha resulted in corresponding increase in LAI per plant at each intra row spacing except at 8WAS for 15cm in 2009 and the combined of the same sampling period, and at 12WAS in 2009 where a non significant effects were observed. Further increase to 60kgN/ha significantly did not affect the LAI per plant at 12WAS in 2009 for 5cm and 15cm intra row spacing only. Beyond this level, the LAI per plant was also significantly not influenced at 8 and 12WAS for 10 and 15cm intra row spacing in both years and the combined. The highest and the least values for LAI per plant were generally recorded by the interaction of 80kgN/ha and 5cm and 20kgN/ha and 15cm intra row spacing respectively.

The interaction of variety and intra row spacing on leaf area index per plant at 12 WAS for 2009 and 2010 years combined is presented in Table 18. At 5cm, NCRIBen001M significantly produced higher LAI per plant than NCRIBen002M. However at 10 and 15cm intra row spacing, the two varieties produced statistically the same LAI per plant. When the effect of Increasing intra row spacing from 5 to 15cm was considered, a progressive decrease of LAI per plant for both varieties was recorded.

4.9 Crop Growth Rate

The crop growth rate response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 19. At all the sampling periods in 2010 and at 10WAS in 2009 significant increase in crop growth rate was observed with each increase in nitrogen level up to 80kgN/ha. However, at 6WAS application of 20 and 40kgN/ha produced same CGR, similar trend was obseved at 40 and 60kgN/ha and at 60 and 80kgN/ha. At 8WAS in 2009, same CGR was produced for 40, 60 and 80kgN/ha but were significantly higher than the CGR at 20kgN/ha. When the combined data was pooled at all the sampling periods of the years, significant increase

Table 18. Interaction of variety and intra row spacing on leave area index (LAI) per plant of two sesame varieties at 12 WAS for 2009 and 2010 combined at Samaru.

	Intra row spacing (cm)		
Variety	**5**	**10**	**15**
NCRIBen001M	5.37a	2.92c	2.01d
NCRIBen002M	5.26b	2.88c	1.99d
SE±	0.018		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT.

Table 19. Effect of nitrogen levels and intra row spacing on crop growth rate per plant of two sesame varieties during the 2009 and 2010 wet seasons and the combined at Samaru. (g/m^2)

	Weeks after sowing								
N-Level	**6**			**8**			**10**		
KgN/ha	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**	**2009**	**2010**	**Combined**
20	24.1c	25.0c	24.5b	51.6d	50.4b	51.0d	59.7d	57.7d	59.7d
40	24.4bc	25.2c	24.8b	52.5c	52.2a	52.3c	60.4c	60.5c	60.5c
60	25.0ab	25.8b	25.4a	53.3b	53.0a	53.1b	61.3b	61.4b	61.3b
80	25.5a	26.1a	25.8a	54.3a	53.8a	54.1a	61.9a	62.0a	61.9a
SE±	0.200	0.100	0.145	0.120	0.530	0.270	0.120	0.530	0.270
Variety									
NCIRIBen001M	25.2a	25.7a	25.4a	53.2a	52.8	53.0a	60.9a	60.9	60.9a
NCRIBen002M	24.3b	25.4b	24.8b	52.7b	51.9	52.3b	60.6b	60.8	60.7b
SE±	0.140	0.071	0.140	0.090	0.370	0.270	0.094	0.110	0.010
Intra row Spacing(cm)									
5cm	37.5a	37.6a	37.5a	63.0a	63.2a	63.1a	78.7a	78.6a	78.6a
10cm	21.8b	24.0b	22.9b	52.9b	53.0b	53.0b	56.5b	56.5b	56.5b
15cm	14.9c	15.0c	14.9c	42.8c	40.9c	41.9c	47.4c	47.4c	47.4c
SE±	0.330	0.160	0.200	0.140	0.160	0.270	0.160	0.160	0.010
Interactions									
N xS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N xS	NS	NS	NS	*	NS	NS	NS	NS	**
S xV	NS	NS	NS	*	NS	*	NS	NS	NS
NxSxV	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%
**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

in crop growth rate was observed with increase in nitrogen level up to 80kgN/ha. The CGR reponses of the two varieties were the same statistically at 8 and 10WAS in 2009. However they significantly differed in their crop growth rate responses at all the sampling periods in 2010 and at 6WAS in 2009. NCRIBen001M produced significantly higher CGR than NCRIBen002M. Analysis of the combined data across all the sampling periods and years showed that, NCRIBen001M significantly produced higher CGR values than NCRIBen002M. Significant decrease in CGR was observed with increase in intra row spacing at all the sampling periods in both 2009 and 2010. Similar trend was observed at all the sampling periods when the combined data of the years was analysed.

The interaction of nitrogen level and intra row spacing on CGR per plant at 8WAS in 2009 and at 10WAS for the combined are presented in Tables 20. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm resulted in progressive decrease in the CGR per plant at both 8 and 10WAS. When the effect of increasing nitrogen level at fixed intra row spacing on CGR per plant were considered, it was observed that increasing nitrogen level from 20 to 40kgN/ha did not resulted in corresponding increase in CGR per plant at each intra row spacing except at 10WAS for 5cm intra row spacing. Further increase to 60kgN/ha significantly did not affect the CGR per plant at 8WAS for all the intra row spacing and for 15cm at 10WAS. Beyond this level, the CGR per plant was not significantly influenced at 8 and 10WAS except for 5cm intra row spacing at 10WAS. The highest and the least values for CGR per plant were generally recorded by the interaction of 80kgN/ha and 5cm and 20kgN/ha and 15cm intra row spacing respectively.

The interaction of variety and intra row spacing on crop growth rate per plant at 8WAS for 2009 and the combined of the same sampling period are presented in Table 21. At fixed intra row spacing, NCRIBen001M significantly produced higher CGR per plant than NCRIBen002M,

Table 20. Interaction of nitrogen levels and intra row spacing on crop growth rate per plant of two sesame varieties at 8 and 12WAS during 2009 and 2010 wet seasons at Samaru (g/m^2)

WAS/Year	N- Level	Intra row spacing (cm)		
	(KgN/ha)	5	10	15
8WAS 2009	20	50.2c	45.01e	40.2g
	40	50.4bc	45.5e	40.7g
	60	51.1ab	46.0de	41.0fg
	80	51.9a	46.6d	41.6f
	SE+		0.310	
10WAS Combined.	20	76.91d	55.21f	46.88i
	40	78.20c	55.96f	47.19hi
	60	79.22b	56.98e	47.61gh
	80	80.18a	57.38e	48.01g
	SE+		0.227	

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance

Table 21. Interaction of variety and intra row spacing on crop growth rate per plant of two sesame varieties at 8WAS for 2009 wet season and the combined at Samaru.(g/m^2)

		Intra row spacing (cm)		
WAS/Year	**Variety**	**5**	**10**	**15**
8WAS 2009	NCRIBen001M	62.86a	53.31b	43.27d
	NCRIBen002M	63.13a	52.61c	42.40e
	SE±		0.140	
8WAS Combined	NCRIBen001M	62.99a	53.18b	42.69c
	NCRIBen002M	63.20a	52.73b	41.09d
	SE±		0.370	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT.

except for 5cm for both 2009 and the combined and at 10cm for the combined only. When the effect of Increasing intra row spacing from 5 to 15cm was considered, a progressively decrease of CGR per plant for both the two varieties was recorded. The highest value for CGR per plant was generally similar for the two varieties at 5cm, while the least value was recorded by NCRIBen002M at 15cm intra row spacing.

4.10 Number of Capsules per Plant

The number of capsules response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 22. In both 2009 and 2010 significant increase in number of capsules were observed with each increase in nitrogen level up to 80kgN/ha. Analysis of the combined data of both years showed a similar trend. The two varieties did not significantly differed in their number of capsules in both 2009 and 2010 and when the combined data was pooled across years. Significant increase in number of capsules was observed with increase in intra row spacing in both 2009 and 2010 and when the combined data was pooled across years.

The interaction of nitrogen level and intra row spacing on number of capsules per plant for the 2010 and combined years are presented in Table 23. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm significantly increased the number of capsules per plant at all levels of nitrogen. When the effect of increasing nitrogen level at fixed intra row spacing on number of capsules per plant was considered, it was observed that, increasing nitrogen level from 20 to 80kgN/ha resulted in corresponding increase in number of capsules per plant at both 5, 10 and 15cm intra row spacing. The highest and the least values for number of capsules per plant were generally recorded by the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

Table 22. Effect of nitrogen level and intra row spacing on number of capsules per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.

N-Level(KgN/ha)	2009	2010	Combined
20	47.7d	48.1d	47.9d
40	52.8c	53.3c	53.1c
60	60.1b	60.4b	60.2b
80	62.3a	63.4a	62.7a
SE±	0.550	0.530	0.370
Variety			
NCRIBen001M	55.9	56.6	56.3
NCRIBen002M	55.5	55.9	55.7
SE±	0.390	0.380	0.260
Intra row spacing(cm)			
5cm	48.7c	49.6c	49.2c
10cm	56.6b	57.1b	56.9b
15cm	61.8a	62.2a	62.0a
SE±	0.380	0.350	0.260
Interactions			
N x V	NS	NS	NS
N x S	NS	*	**
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%
**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 23. Interaction of nitrogen levels and intra row spacing on number of capsules per plant of two sesame varieties during 2010 wet season and combined at Samaru.

Year	N- Level (KgN/ha)	Intra row spacing (cm) 5	10	15
2009	20	42.2g	47.5f	54.7de
	40	46.0f	54.3de	59.7c
	60	54.0e	61.2c	66.1b
	80	56.1d	65.4b	68.2a
	SE±	0.690		
Combined	20	41.8 i	47.3g	54.7ef
	40	45.7h	54.1ef	59.4d
	60	53.8f	61.0c	66.0b
	80	55.4e	65.1b	67.8a
	SE±	0.510		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

4.11 Capsules Yield per Plant

The capsules yield response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 24. In both 2009 and 2010 significant increase in capsules yield were observed with each increase in nitrogen level up to 80kgN/ha. Analysis of the combined data of the years showed a similar trend. The two varieties significantly differed in their capsules yield. NCRIBen001M produced significantly heavier capsules yield than NCRIBen002M in both 2009 and 2010 and when the combined data was pooled across years. Significant increase in capsules yield was observed with increase in intra row spacing in both 2009 and 2010 and when the combined data was pooled across years.

The interaction of nitrogen level and intra row spacing on capsules yield per plant for the combined years was presented in Table 25. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm significantly increased the capsules yield per plant at all levels of nitrogen. When the effect of increasing nitrogen level at fixed intra row spacing on capsules yield per plant was considered, it was observed that increasing nitrogen level from 20 to 80kgN/ha resulted in corresponding increase in the capsules yield per plant at both 5, 10 and 15cm intra row spacing. The highest and the least values for capsules yield per plant were generally recorded by the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

4.12 Grain Yield per Plant

The grain yield per plant response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 26. In 2010 significant increase in grain yield per plant was observed with each increase in nitrogen level up to 80kgN/ha. However, in 2009 such increase was only observed up to 60 kgN/ha, further increase in nitrogen level to 80kgN/ha did not resulted in

Table 24. Effect of nitrogen levels and intra row spacing on capsules yield per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.(g)

N-Level(KgN/ha)	2009	2010	Combined
20	11.8d	12.0d	11.9d
40	13.1c	13.3 c	13.2c
60	14.9b	15.2b	15.0b
80	15.6a	16.1a	15.8a
SE±	0.150	0.130	0.090
Variety			
NCRIBen001M	13.9a	14.2a	14.1a
NCRIBen002M	13.3b	13.7b	13.6b
SE±	0 .100	0.090	0 .070
1ntra row spacing(cm)			
5cm	12.1c	12.4c	12.2c
10cm	14.1b	14.3b	14.2b
15cm	15.4a	15.7a	15.6a
SE±	0.100	0.090	0.210
Interactions			
N x V	NS	NS	NS
N x V	NS	NS	**
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 25. Interaction of nitrogen levels and intra row spacing on capsules yield per plant of two sesame varieties during 2009 and 2010 wet seasons combined at Samaru.(g)

N- Level	Intra row spacing (cm)		
(KgN/ha)	5	10	15
20	10.3i	11.7g	13.7ef
40	11.2h	13.4f	14.9d
60	13.4f	15.3c	16.5b
80	13.9e	16.4b	17.2a
SE±	0.132		

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

Table 26. Effect of nitrogen levels and intra row spacing on grain yield per plant of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.(g)

N- Level (kgN/ha)	2009	2010	Combined
20	4.1c	4.1d	4.1d
40	4.2b	4.9c	4.9c
60	5.8a	5.9b	5.8b
80	6.0a	6.3a	6.1a
SE±	0.100	0.070	0.060
Variety			
NCRIBen001	5.2	5.4a	5.3a
NCRIBen002	5.1	5.2b	5.2b
SE±	0.070	0.050	0.040
Intra row spacing(cm)			
5cm	4.2c	4.4c	4.3c
10cm	5.3b	5.4b	5.4b
15cm	6.0a	6.1a	6.0a
SE±	0.070	0.070	0.050
Interactions			
N x V	NS	NS	NS
N xS	NS	NS	**
S x V	NS	NS	NS
NxSxV	NS	NS	NS

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

significant increase in grain yield per plant. Analysis of the combined data of both years showed a similar trend with the year 2010. The two varieties significantly differed in their grain yield per plant in 2010. NCRIBen001M produced significantly more grain yield per plant than NCRIBen002M in that year, however in 2009 the two varieties produced same grain yield statistically. When the combined data was pooled across years, similar trend was observed with the year 2010. Significant increase in grain yield per plant was observed with increase in intra row spacing in both 2009 and 2010 and when the combined data was pooled across years.

The interaction of nitrogen level and intra row spacing on grain yield per plant for the combined years is presented in Table 27. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm significantly increased the grain yield per plant at all levels of nitrogen. When the effect of increasing nitrogen level at fixed intra row spacing on grain yield per plant was considered, it was observed that, increasing nitrogen level from 20 to 80kgN/ha resulted in corresponding increase in grain yield per plant at 5cm. However at 10 and 15cm intra row spacing, this trend was observed up to 60kgN/ha. Increasing nitrogen to 80kgN/ha did not significantly increase grain yield per plant at those intra row spacing. The highest and the least values for grain yield per plant were generally recorded by the interaction of 80kgN/ha and 15cm and 20kgN/ha and 5cm intra row spacing respectively.

4.13 Grain Yield (kg/ha)

The grain yield per hectare response of sesame varieties to levels of nitrogen and intra row spacing is presented in Table 28. In both 2009 and 2010 significant increase in grain yield per hectare were observed with each increase in nitrogen level up to 80kgN/ha. Analysis of the combined data of the years showed a similar trend. The two varieties significantly differed in

Table 27. Interaction of nitrogen level and intra row spacing on grain yield per plant of two sesame varieties during 2009 and 2010 wet seasons combined at Samaru. (g)

N- Level	Intra row spacing(cm)		
(KgN/ha)	5	10	15
20	3.47g	4.14f	4.67e
40	3.96f	5.03d	5.67c
60	4.69e	6.05b	6.73a
80	5.13d	6.27b	6.97a
SE±		0.100	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

their grain yield per hectare. NCRIBen001M produced significantly higher grain yield per hectare than NCRIBen002M in both 2009 and 2010 and when the combined data was pooled across years. Significant decrease in grain yield per hectare was observed with increase in intra row spacing in both 2009 and 2010. Analysis of the combined data for both years showed a similar trend.

The interaction of nitrogen level and intra row spacing on grain yield for 2009 and 2010 are presented in Table 29. At fixed nitrogen level, each increase in intra row spacing from 5 to 15cm significantly decreased the grain yield at all levels of nitrogen except at 20kgN/ha in 2010 where the grain yield produced at 5 and 10cm intra row spacing were similar. When the effect of increasing nitrogen level at fixed intra row spacing on grain yield was considered, it was observed that increasing nitrogen level from 20 to 80kgN/ha resulted in corresponding increase in grain yield at 5cm, except in 2010 where application of 40 and 60kgN/ha produced the same grain yield. At 10 and 15cm intra row spacing, application of 20 to 60 kgN/ha resulted in signficant increase in grain yield. Further increase to 80 kgN/ha did not result in significant effect. The highest and the least values for grain yield per plant were generally recorded by the interaction of 80kgN/ha and 5cm and 20kgN/ha and 15cm intra row spacing respectively.

The interaction of variety and intra row spacing on grain yield for 2009 and the combined years are presented in Table 30. At fixed intra row spacing of 5, 10 and 15cm, NCRIBen001M significantly produced higher grain yield than NCRIBen002M. Likewise when intra row spacing was increased from 5 to 15cm, a corresponding decrease in grain yield was observed for each of the two varieties.

The interaction of nitrogen level, variety and intra row spacing on grain yield of two sesame varieties for the combined years is presented in Table 31. At fixed nitrogen level, increasing

Table 28. Effect of nitrogen level and intra row spacing on grain yield (kg/ha) of two sesame varieties during the 2009, 2010 wet seasons and the combined at Samaru.

N-Level(kgN/ha)	2009	2010	Combined
20	547.3d	579.2d	563.2d
40	640.6c	666.7c	653.7c
60	712.1b	742.4b	727.3b
80	736.7a	766.8a	751.8a
SE±	3.800	3.100	2.400
Variety			
NCRIBen001	684.8a	711.3a	698.1a
NCRIBen002	633.5b	666.3b	649.9b
SE±	3.600	2.700	1.700
Intra row spacing (cm)			
5cm	814.9a	844.3a	828.4a
10cm	648.6b	683.5b	666.1b
15cm	514.0c	568.0c	541.0c
SE±	4.980	5.980	3.900
Interactions			
N x V	NS	NS	NS
N x S	**	**	NS
S xV	**	NS	NS
NxSxV	NS	NS	*

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

*Significant at 5%
**Significant at 1%
NS Non significant at 5%

N = Nitrogen level
S = Intra row spacing
V = Variety

Table 29. Interaction of nitrogen level and intra row spacing on grain yield (kg/ha) of two sesame varieties during 2009 and 2010 wet seasons at Samaru.

Year	N- Level	Intra row spacing (cm)		
	(KgN/ha)	5	10	15
2009	20	601.3e	575.3f	458.3i
	40	784.2c	629.3e	498.3h
	60	912.8b	684.2d	540.0g
	80	945.3a	705.7d	559.2fg
	SE±	9.960		
2010	20	610.0e	612.6e	514.8g
	40	792.0b	654.2d	554.0f
	60	809.6b	724.0c	593.6e
	80	957.8a	743.2c	609.3e
	SE±	11.960		

Means followed with the same letter wihin collums are not statistically different at 5% level of of significance.

Table 30. Interaction of variety and intra row spacing on yield (kg/ha) of two sesame varieties during 2009 wet season and the combined at Samaru.

		Intra row spacing (cm)		
	Variety	**5**	**10**	**15**
2009	NCRIBen001M	830.5a	679.8c	534.2e
	NCRIBen002M	799.4b	607.4d	493.8f
	SE±		7.040	
Combined	NCRIBen001M	843.1a	699.8c	561.2e
	NCRIBen002M	796.7b	632.3d	520.3f
	SE±		5.500	

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

Table 31. Interaction of nitrogen level, variety and intra row spacing on grain yield (kg/ha) of two sesame varieties during 2009 and 2010 wet seasons combined at Samaru.

	Intra row spacing(cm) / variety					
N-level	**5cm**		**10cm**		**15cm**	
KgN/ha	**NCRIBen001M**	**NCRIBen002M**	**NCRIBen001M**	**NCRIBen021M**	**NCRIBen001M**	**NCRIBen002M**
20	643.3f	575.0h	615.3g	572.7h	503.2i	470.0j
40	818.3d	767.8e	669.8f	613.7g	548.7h	503.7i
60	916.3b	905.3b	743.5e	664.7f	588.3g	545.3h
80	954.5a	918.7b	770.7e	678.2f	604.7g	563.8h
SE±	11.000					

Means followed by same letter within and between rows are not statistically different at 5% level of significance using DMRT

intra row spacing from 5 to 10cm significantly decreased the grain yield of the two varieties except NCRIBen002M, whose grain yield remained significantly unaffected when given 20kgN/ha. Beyond 10cm, further declined in grain yield was recorded for both varieties at all nitrogen levels. There was no significant difference in grain yield of the two varieties when spaced 5cm and given 60kgN/ha. Increasing nitrogen from 20 to 60kgN/ha resulted in significant increase in grain yield of both varieties at each level of intra row spacing, further increase to 80kgN/ha only significantly improved the grain yield of NCRIBen001M at 5cm intra row spacing. NCRIBen001M at 5cm intra row spacing when applied of 80kgN/ha produced the highest grain yield, while NCRIBen002M at 15cm intra row spacing with application of 20kgN/ha had the least grain yield per hectare.

4.9.4 Correlation Analysis

The correlation between different growth charaters, yield components and grain yield of sesame for 2009, 2010 and for the combined years are presented in table 32,33 and 34. The grain yield significantly and positively correlated with leaf area index and crop growth rate in both years and the combined. A significant correlation but negative was observed between grain yield and number of leaves, number of secondary branches, total dry matter and leaf area per plant in both years and the combined. The relationship between grain yield and plant height, number of primary branches, number of capsules, capsules yield and grain yield per plant was not significant in both years and the combined.

4.9.5 Regression Analysis

The regression analysis of grain yield against nitrogen levels for the year 2009, 2010 and for the combined years was carried out and the result is presented in fiqure 1. The response of sesame grain yield against nitrogen levels in both years and the combined were linear and positively

Table 32: Correlation between grain yield(kg/ha) and growth and yield characters of two sesame varieties in 2009 at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.833**	1.000										
3	0.861**	0.819**	1.000									
4	0.869**	0.891**	0.882**	1.000								
5	0.717**	0.820**	0.767**	0.783**	1.000							
6	0.867**	0.902**	0.900**	0.916**	0.826**	1.000						
7	-0.517**	--0.869**	-0.537**	-0.633**	-0.713**	-0.664**	1.000					
8	-0.504**	-0.837**	-0.504**	-0.624**	-0.617**	-0.613**	0.912**	1.000				
9	0.919**	0.847**	0.925**	0.897**	0.781**	0.946**	0.551**	-0.508**	1.000			
10	0.925**	0.846**	0.912**	0.900**	0.781**	0.934**	-0.549**	-0.514**	0.987**	1.000		
11	0.908**	0.825**	0.929**	0.904**	0.751**	0.920**	-0.517**	-0.492**	0.945**	0.930**	1.000	
12	-0.067NS	-0.522**	-0.101NS	-0.242*	- 0.315*	-0.220*	0.782**	0.781**	-0.073NS	- 0.088NS	-0.023NS	1.000

NS: Non Significant at 5% * : Significant at 5% **: Highly Significant at 1%

1.Plant height per plant
2.Number of leaves per plant
3.Number of primary branches per plant
4.Number of secondary branches per plant
5.Total dry matter per plant
6.Leaf area per plant
7.Leaf area index per plant
8.Crop growth rate per plant
9.Number of capsules per plant
10.Capsules yield per plant
11.Grain yield per plant
12.Grain yield(kg/ha)

Table 33: Correlation between grain yield(kg/ha) and growth and yield characters of two sesame varieties in 2010 at Samaru.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.842**	1.000										
3	0.864**	0.819**	1.000									
4	0.807**	0.891**	0.832**	1.000								
5	0.791**	0.948**	0.817**	0.871**	1.000							
6	0.878**	0.884**	0.899**	0.870**	0.901**	1.000						
7	-0.531**	-0.876**	-0.568**	-0.734**	-0.874**	- 0.650**	1.000					
8	-0.499**	-0.837**	-0.514**	-0.675**	-0.808**	-0.590**	0.948**	1.000				
9	0.929**	0.851**	0.905**	0.826**	0.854**	0.942**	-0.572**	-0.525**	1.000			
10	0.918**	0.856**	0.902**	0.830**	0.857**	0.943**	-0.577**	-0.530**	0.997**	1.000		
11	0.887**	0.837**	0.909**	0.8847**	0.816**	0.905**	-0.572**	-0.527**	0.925**	0.927**	1.000	
12	-0.164NS	-0.598**	-0.212NS	-0.444**	-0.536**	-0.259*	0.841**	0.859**	-0.180NS	-0.191NS	-0.0952NS	1.000

NS: Non Significant at 5% * : Significant at 5% **: Highly Significant at 1%

1.Plant height per plant
2.Number of leaves per plant
3. Number of primary branches per plant
4.Number of secondary branches per plant
5. Total dry matter per plant
6.Leaf area per plant
7.Leaf area index per plant
8.Crop growth rate per plant
9.Number of capsules per plant
10 Capsules yield per plant
11. Grain yield per plant
12.Grain yield(kg/ha)

Table 34: Correlation between grain yield(kg/ha) and growth and yield characters of two sesame varieties for the combined years at Samaru.

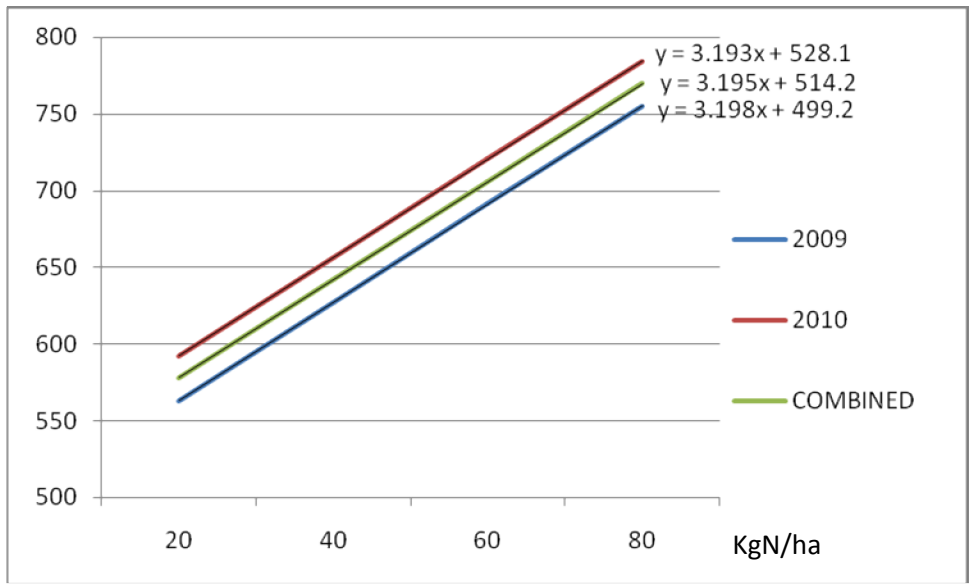
	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.837**	1.000										
3	0.863**	0.819**	1.000									
4	0.837**	0.889**	0.856**	1.000								
5	0.746**	0.870**	0.785**	0.819**	1.000							
6	0.872**	0.893**	0.899**	0.891**	0.853**	1.000						
7	-0.524**	-0.872**	- 0.559**	-0.713**	- 0.778**	- 0.657**	1.000					
8	-0.501**	-0.834**	-0.507**	-0.643**	0.690**	-0.601**	-0.561**	1.000				
9	0.919**	0.849**	0.915**	0.861**	0.809**	0.944**	-0.514**	-0.514**	1.000			
10	0.921**	0.849**	0.907**	0.864**	0.813**	0.938**	-0.562**	-0.519**	0.992**	1.000		
11	0.898**	0.831**	0.919**	0.875**	0.777**	0.912**	-0.544**	-0.506**	0.934**	0.928**	1.000	
12	-0.114NS	-0.225*	-0.155NS	- 0.344**	-0.400**	-0.229*	0.807**	0.809**	-0.126NS	-0.135NS	0.138NS	1.000

NS: Non Significant at 5% * : Significant at 5% **: Highly Significant at 1%

1. Plant height per plant
2.Number of leaves per plant
3. Number of primary branches per plant
4.Number of secondary branches per plant
5 Total dry matter per plant
6.Leaf area per plant
7. Leaf area index per plant
8.Crop growth rate per plant
9. Number of capsules per plant
10.Capsules yield per plant
11 Grain yield per plant
12.Grainyield(kg/ha

REGRESSION ANALYSIS OF GRAIN YIELD AGAINST NITROGEN LEVEL FOR 2009, 2010 AND THE COMBINED AT SAMARU

Kg/ha



significant. This showed that increasing nitrogen level from 20 to 80kgN/ha significantly increased grain yield of sesame. The linear models had an R^2 value of 0.2171, 0.2776 and 0.2441 for 2009,2010 and the combined years respectively. The linear equations were presented as folllows:

$Y = 499.277 + 3.198X$ for 2009

$Y = 529.139 + 3.193X$ for 2010

$Y = 514.208 + 3.195X$ for Combined

CHAPTER 5

5.0 DISCUSSION

5.1 Response to Nitrogen Level

The highest nitrogen level of 80 kgN/ha influenced almost all the growth, yield and yield charaters of sesame crop measured in this experiment. This may be attributed to the poor nature of the soil at the experimental site. The low organic carbon, low total nitrogen and low cation exchange capacity of this soil was responsible for its poor water and nutrient holding capacity especially for those nutrients that are subject to leaching particularly nitrogen as was earlier reported by brady (1984).

Excesssive rainfall in the last 20 days of August in 2009 (371.1mm) against 230.7mm in 2010 resulted in water logging of about two third of the experimental field, which hinders growth and development of the crop in that year. This was exhibited in low values for almost all the characters measured in 2009 compared to same characters in 2010. However good moisture regime in the month of october 2009 (151.7mm) compared to 82.3mm in 2010 allowed the 2009 crop to recover and improved its growth, thereby delaying its harvest by elevent days.

Application of 80 kgN/ha resulted in the highest values for plant height, number of leaves, number of secondary branches and total dry matter per plant, except number of primary branches per plant, plant height at 8WAS in 2009 and number of leaves at 4 and 12WAS in 2009 that were not significant beyond 60 kgN/ha . This could be attributed to the ability of nitrogen in promoting growth. It could also be attributed to the fact that N is an important constituent of chloropyl, amino acid and nucleic acid and it played important role in carbohydrates and protein metabolism, hence its essential in plant growth and development.

Nitrogen is also essential in all processes associated with protoplasm, enzymatic reactions and photosynthesis (Das, 2009). Responses of sesame crop growth to N fertilization beyond 80 kgN/ha was reported by Shehu, *et al*., (2010) and Roy *et al.,* (1995) whose result showed an increased growth with increase nitrogen level up to 112.5 and 90 kgN/ha respectively.

The leaf area, leaf area index and crop growth rate of sesame was found to have increased with increasing nitrogen level up to 80kgN/ha, exccept leaf area at 4WAS for both years, leaf area index at 4WAS in 2010 and crop grwth rate at 4WAS in 2009 and at 8WAS in 2010 which did not show response to nitrogen application beyond 60kgN/ha. Slow growth of sesame plants at the early stages was responsible for non significant values recorded for leaf area, leaf area index and crop gowth rate at 4WAS as was earlier reported by Anon. (2007). Nitrogen fertilization promoted cell division and enlargement that ultimately enhanced vegetative growth through increased number and size of leaves that resulted in increased leaf area. Large leaf area enhanced the capacity of the sesame plants to intercept adequate sunlight, which might have resulted in the production of more assimilate thereby enhancing growth and development of the crop as earlier observed by Loomis *et al.,* (1971). The increased growth was manifested in the increased values for leaf area index and crop growth rate and other growth characters earlier mentioned. Increased number of leaves with increased nitrogen level increases the potential sites for capsules to form as capsules spring from leaf axils. This couple with the increased leaf area, make available more photosynthetic surface that triggered growth through increased carbohydrate and protein metabolism that resulted in the development of more productive capsules. This in turn resulted in the increased capsules yields. The result is in line with the finding of Shehu *et al.,*(2010), Muhammam *et al.,*(2009) and and Malik *et al.,* (2003).

The significant increase in both grain yield per plant and grain yield per hectare with increased nitrogen level up to 80 kgN/ha were associated with increased sesame yield attributes or characters. Increased leaf area, leaf area index and crop growth rate with increased nitogen level may have been responsible for the increased yield of reproductive characters that ultimately resulted in increased grain yield. Similar findings were earlier reported by Shehu *et al.,* (2010) who reported a significant increase in grain yield at nitrogen level up to 75kgN/ha. However, Haruna *et al.,* (2008) and Olowe and Busari (2000) reported a non significant response in sesame grain yield at nitrogen level above 60kgN/ha. The yield increase with application of up to 80 kgN/ha as well as the linear relationship observed between grain yield and nitrogen fertilizer suggest that the optimum grain yield of the crop could be beyond 80kgN/ha. However, the grain yield increase per unit increase in nitrogen fertilizer begin to decline as nitrogen level was raised beyond 40kgN/ha. Inceasing nitrogen fertilizer from 20 to 40kgN/ha resulted in 16% increase in grain yield, further increase to 60 and 80kgN/ha increase the grain yield by 12.8 and 3.3% respectively.

5.2 Response of Varieties

The result showed that the two varieties did not differ in terms of number of leaves, number of primary and secondary branches, plant height at 4 and 8WAS, total dry matter at 4WAS for both years and at 8 and 12WAS in 2009. The non significant difference between the two varieties at 4WAS in terms of plant height and total dry matter may be atributed to the slow growth of sesame plants between emergence up to 5WAS (Anon. 2009). However, NCRIBen001M significantly out performed NCRIBen002M interms of plant height at 12WAS, total dry matter at 8 and 12WAS in 2010, leaf area, leaf area index at 8 and 12WAS and crop growth rate at 8 and 12WAS in 2009. This indicates that NCRIBen001M was better adapted to climatic

conditions of Samaru. Similar varied response of sesame varieties were earlier reported by Olowe *et al.,* 2009); Zaidi and Khan (1981) and Kalita *et al.,* (1980). The high leaf area values recorded by NCRIBen001M might have help it to intercept and convert more solar radiation through photosynthesis that resulted in the increased total dry matter, leaf area index and crop growth rate of this variety compared to NCRIBen002M.

The two varieties produced the same number of capsules in both years, and grain yield per plant in 2009. However NCRIBen001M significanly out performed NCRIBen002M on capsules yield per plant in both years, grain yield per plant in 2010 and grain yield per hectare in both years. The high grain yield of NCRIBen001M may be attributed to its superiority in larger leaf area that could have led to increased assimilate production and consequently increased its yield and yield characters compared to NCRIBen002M. Similar findings were earlier reported by (Olowe, *et al.,* 2009; NCRI, 2005 and RMRDC, 2004),

5.3 Response to Intra Row Spacing

The insignificant response of plant height to increased intra row spacing at 4WAS, and number of leaves at 5 and 10cm as well as 10 and 15cm at the same sampling period, may be attributed to slow growth of sesame plants at the early growth stages as was reported by (Anon, 2009). The increased values for number of primary and secondary branches, total dry matter and leaf area and also for plant height and number of leaves at 8 and 12WAS with increased intra row spacing, could be probably due to the fact that, sesame plants grown at wide intra row spacing are less exposed to intra specific competition for light, nutrient, moisture and space, therefore tend to grow more vigorously. High plant population associated with narrow intra row spacing tend to exert pressure on scarce growth resources such as light, space, moisture and nutrients thereby

leading to poor growth. This agreed with finding of Caliskan, (2004); Samson, (2005) and Gupta, (1982).

Despite the increased leaf area per plant and total dry matter per plant with increased intra row spacing, the leaf area index and crop growth rate were found to have decreased with increased intra row spacing from 5 to 15cm. Wide intra row spacing enhanced vigrous growth through increased plant height, number of leaves and branches, large leaf area, total dry matter, number of capsules and capsules yield because of reduced competition between individual sesame plants, but recorded low values for LAI and CGR due to wide ground area subtended by the individual plants. Therefore narrow intra row spacing of 5cm recorded higher LAI and CGR values because of its small ground area subtended by individual plant or high population density. Narrow intra row spacing enhanced LAI and CGR which promoted growth by ensuring early canopy ground cover, thus capturing sunlight more efficiently and utilizing soil moisture and nutrient more effectively. This agreed with the finding of Batera et al.,(1994), Caliskan (2004) and Majumdar and Row (1992).

Grain yield per plant was observed to have increased with increasing intra row spacing from 5 to 15cm. This was attributed to increased number of capsules and capsules yield as a result of reduced competition between individual plants due to low plant population density at 15cm intra row spacing. This agreed with the finding of Bonsu (2003); Adebisi et al.,(2005); Olowe and Busari (1994). However, grain yield per hectare was observed to have increased with decrease in intra row spacing. The high grain yield obtained at 5cm intra row spacing may be attributed to higher number of harvestable capsules per unit area observed with sesame planted at narrow intra row spacing or at high population density as compared to fewer at wide intra row spacing or low population densities. Therefore, the higher number of capsules, capsules yield and grain yield

per plant recorded at wide intra row spacing of 15cm was unable to compensate for higher number of threshed capsules obtained at higher plant density of 5cm. This agreed with the finding of Chimanshette and Dhoble (1992); Katung (1987) and Adebisi, *et al.,* (2005).

5.4 Interactions

5.4.1 Nitrogen level and variety

The significant interaction of nitrogen level and variety on plant height at 8WAS for the combined years showed that both NCRIBen001M and NCRIBen002M produced same height at every level of nirogen which indicate similarities between the varieties on plant height. However, NCRIBen001M showed an increased plant height with increase in nitrogen level up to 60kgN/ha which can be attributed to its better utilization of available nitrogen at every level compared to NCRIBen002M which produced relatively stable height at 20 and 40kgN/ha, 40 and 60kgN/ha and 60 and 80kgN/ha.

5.4.2 Nitrogen level and intra row spacing

The interaction of nitrogen level and intra row spacing was significant on number of leaves, number of primary and secondary branches, total dry matter, leaf area, leaf area index, crop growth rate , number of capsules, capsules yield, grain yield per plant and grain yield per hectare. Higher nitrogen level of 80kgN/ha and wide intra row spacing of 15cm gave significantly higher number of leaves, number of primary and secondary branches, total dry matter, leaf area, number of capsules, capsules yield and grain yeild per plant. While narrow intra row spacing of 5cm and higher nitrogen level of 80kgN/ha gave significantly higher leaf area index, crop growth rate and grain yield per hectare. Wide intra row spacing of 10 and 15cm and higher nitrogen level of 80kgN/ha enhanced the development of growth and yield attributes of

individual plants that ultimately resulted in increased grain yield of individual plants but showed a decreased grain yield per hectare due to lower plant population. In contrast sesame plants at narrow intra row spacing of 5cm with application of high nitrogen level of 80kgN/ha recorded higher LAI, CGR values and grain yield per hectare. The highest grain yield obtained here may be attributed to the combined contributions from large plant population at 5cm intra row spacing.

5.4.3 Variety and intra row spacing

The Interaction between variety and intra row spacing was significant on leaf area index, crop growth rate and grain yield per hectare. The higher leaf area index and grain yield produced by NCRIBen001M at 5cm intra row spacing signified that, it is better suited to cropping at a high plant population density than NCRIBen002M. Increasing intra row spacing to 10 and15cm lowers leaf area index, crop growth rate and grain yield of both varieties. This further showed that narrow intra row spacing of 5cm is best suited for highest grain yield of both varieties in Samaru ecology.

5.4.3 Nitrogen level, variety and intra row spacing

The only significant interaction between nitrogen level, variety and intra row spacing was observed on grain yield per hectare. NCRIBen001M significantly produced higher grain yield at all the levels of nitrogen and at all the three intra row spacing except at 5cm with aplication 60kgN/ha where the two varieties produced the same grain yield. NCRIBen001M at a narrow intra row spacing of 5cm with application of high nitrogen level of 80kgN/ha gave higher grain yield of sesame than NCRIBen002M under the same conditions. This showed that, NCRIBen001M is better suited to cropping at narrow intra row spacing of 5cm and better utilized available nitrogen fertilizer than NCRIBen002M.

5.5 Correlation

The highly significant correlation between grain yield per hectare with leaf area index and crop growth rate per plant revealed the importance of spacing generally in determining grain yield of sesame. Narrow intra row spacing of 5cm with its attendant high plant population density recorded high LAI and CGR values (0.807 and 0.809) respectively. This enhanced the photosynthetic efficiency of the crop which must have been responsible for the increased grain yield per hectare. This was in agreement with the finding of Yedava *et al.,*(1980) and Chimanshette and Dhoble (1992). The highly significant but negative correlation between grain yield per hectare and the number of leaves per plant, number of secondary branches per plant, total dry matter per plant and leaf area per plant revealed that, these are the important components and critical determinants of grain yield of individual plants which was enhanced by wide intra row spacing. However, the grain yield per hectare was found to be enhanced by the combined contributions of large plant population which was achieved through planting at closed intra row spacing. This agreed with the finding Khidir and Osman (1970) and Narayanan and Reddy (1982).

Grain yield per hectare showed a non significant relationship with plant height per plant, number of capsules per plant, capsules yield per plant, number of primary branches per plant and grain yield per plant, but in contrast, all these characters showed a strong positive and significant correlation with grain yield per plant. Wide intra row spacing with its attendant low plant population density enhanced the growth and development of individual plants through reduced competion for growth resources, this must have been responsible for these characters strong positive relationship with grain yield per plant. However, the non significant relationship of these characters with grain yield per hectare may be attibuted to the fact that, grain yield of sesame

crop was being enhanced by the combined contributions from large plant population which was achieved by sowing the crop at closed intra row spacing.

5.6 Regression

The response of grain yield against nitrogen level from the regression analysis showed that, linear model was best fit for all the years and the combined. This showed that the optimum nitrogen level for maximum grain yield of sesame crop had not been reached. However, the percentage grain yield increase with each increase in nitrogen level beyond 40kgN/ha begin to decline, (16, 12.6 and 3.3%) for 20 to 40kgN/ha, 40 to 60kgN/ha and 60 to 80kgN/ha respectively. The equations revealed that the highest grain yield of 736, 784 and 769kg/ha were obtained at the highest nitrogen level of 80kgN/ha for 2009, 2010 and the combined years respectively. The equations further showed that, grain yield of 499, 529 and 514kg/ha could be achieved without application of nitrogen fertilizer. This suspport the claims by some researchers that sesame crop does not requiare fertilization especially in areas where local varieties were being used as was earlier reported by (Okpara 2007).

CHAPTER 6

6.0 Summary and Conclusion

Trials were conducted at the research farm of the Institute for Agricultura Research Samaru in 2009 and 2010 wet seasons to determined the effect of nitrogen level and intra row spacing on two varieties of sesame. The treatments consisted of two varieties of sesame (NCRIBen001M and NCRIBen002M,) three intra row spacing (5, 10 and 15cm) and four levels of nirogen (20, 40, 60 and 80kgN/ha). The treatments were arranged in a split plot design with the factorial combination of nitrogen and variety assigned to the main plot and the intra row spacing was placed at the sub plot.

The result indicated a 16% increase in grain yield when nitrogen level was raised from 20 to 40kgN/ha. further increase to 60 and 80kgN/ha resulted in 12.6 and 3.3% increase in grain yield per hectare respectively. The performance of the varieties showed that, NCRIBen001M produced 7.5% more grain yield compared to NCRIBen002M. The result further showed that narrow intra spacing of 5cm gave 20% and 31% more yield than 10cm and 15cm respectively. Application of 60 to 80kgN/ha resulted in significant increase in plant height, number of leaves, number of primary and secondary branches branches, total dry matter, leaf area, leaf area index, crop growth rate. number of capsules, capsules yield and grain yield.

The response of the varieties was the same in plant height at 4 and 8WAS, number of leaves, number of primary and secondary branches, total dry matter at 4WAS in both years and at 4 and 8WAS in 2009, leaf area index at 4WAS, crop growth rate at 8 and 12WAS in 2010, number of capsules per plant and grain yield per plant in 2009. However, NCRIBen001M significantly outperformed NCRIBen002M at all sampling periods and years including grain yield per hectare.

The result further showed that, wide intra row spacing of 15cm significantly increase the number of leaves, plant height, number of branches, number of capsules, capsules yield, grain yield per plant, total dry matter and leaf area but showed a decreased leaf area index, crop growth rate and grain yield per hectare.

The interaction between nitrogen level and intra row spacing showed a significant interaction for number of leaves at 8 and 12WAS, number of primary and secondary branches in both years, total dry matter 2009 and the combined, leaf area at 12WAS in both years, leaf area index at 8 and 12 WAS, crop growth rate at 8 and 10WAS, number of capsules in 2010 and the combined, capsules yield in the average, and grain yield in both years.

The effect of interaction between variety and intra row spacing showed a significant interactions on leaf area index, crop growth rate and grain yield per hectare were significant. While the effect of interaction beween nitrogen level and variety showed a significant interaction for plant height at 8WAS only. The interaction between nitrogen level, variety and intra row spacing was significant only on grain yield per hectare.

Correlation anaysis showed a significant and positive correlation between grain yield per hectare with leaf area index and crop growth rate only but showed a non significant correlation with plant height, number of primary branches, number of capsules, capsules yield and grain yield per plant. The grain yield also showed a significant but negative correlation with number of leaves, number of secondary branches, total dry matter and leaf area per plant.

Regression analysis on nitrogen showed a linear pattern whereby increasing nitrogen level from 20 to 80kgN/ha significantly increases grain yield per hectare, but the increase in grain yield per unit increase in nitrogen fertilizer level declined beyond 40kgN/ha.

Based on the result obtained in this trial, it can be concluded that NCRIBen001M planted at 5cm intra row spacing with application of 80kgN/ha gave the highest grain yield of sesame, it is therefore more suited to Samaru ecology than NCRIBen002M.

REFERENCES:

Adebisi, M.A; Ajala, M.O; Ojo, D.K and Salau, A.W.(2005). Influence of population density and season on seed yield and its component in Nigerian sesame genotypes. *Journal of tropical agriculture.* **43(1-2)** 13-18.

Adedisi, M.A (2004). Variability, stability and correlation studies in seed quality and yield of sesame (*Sesamum indicum* L). An unpublished Phd thesis, university of agriculture, Abeokuta, Ogun state.

Adeyemo, M.O and Ojo,A.A.(1991). Genetic variability and associations of agronomic traits and seed of sesame (sesamum indicum L). Nigerian journal of genetics **VIII**: 39-40

Adeyemo, M.O; Ojo, A.O and Gungula, D.T (1992). Effect of population densities on some agronomic traits and seed yield of sesame (*Sesamum indicum* l) in southern guinea savanna environment. *Tropical oilseeds journal*. **1**: 35-42.

Alegbejo, M.D (2003): Sesame: a potential industrial and export oilseed crop in Nigeria. *Journal Of Sustainable Agriculture* **23(1):** 59-76

Anonymous(2004).Sesame production in Texas USDA http//nisu.edu/croppropiles/docs/ussesame.html.

Anonymous (2006). Fertilizer use by crops in Zimbabwe. FAO/UN. Rome. 55pp

Anonymous (2007); PROTA. *Sesamum indicum* L in PROTA 14: Vegetable oils/ Oleagineux. Record display.

Anonymous (2009). Small seed provides large income. USAID/MARKETS. Nigerias harvest markets. Agbiz update. October 21, 2009.

Anonymous (2010). Crop Management. Kissan Kerala. Karshaki information services and networking.on web. http: www.kissankerala.net/kissan contents/jeninfo. Assesssed on 29.9.2010.

Babaji, B.A; Haruna, I.M; Muktar, A.A. (2005) Sesame *(Sesamum indicum L); An oil Boom for Northern Nigeria.* Paper presented at the National Conference on Development of Agriculture in Northern Nigeria organized by Institute for Development Research (IDR), Ahmadu Bello University ;Zaria.

Batera, A.K; Mishra,S.K and Sha, H.S. (1994). Response of summer sesame (sesamum indicum l) to row spacing and phosphorus. Orrissa journal of agricultural research **7** (supplementary) 99-100.

Bonsu, O.K.(2003). Effect of spacing and fertilizer application on the growth, yield and yield components of sesame (sesamum indicum L). Journal of sustainable agriculture **23 (1)** 40-49

Brady, N.C. (1984). Nature and properties of soil. 7th edition. Macmillan publication. Pp. 456-475.

Caliskan, S; Arstan, M; Atiogle, H. And Isler, N. (2004). Effect of Planting Method and Plant Population on Growth and Yield of Sesame (*Sesamum indicum* L) in a Mediterranean type of Environment. *Asia journal of plant sciences* **3(5)** 610- 613.

Chimanshette, T.G and Dhoble (1992). Effect of Sowing Date and Plant Density of Seed Yield of Sesame (*Sesamum indicum* L) varieties. *Indian Journal of Agronomy*, **37**: 280-282.

Dabir, J.D. (2000) Cytogenetic studies of inter-specific hybrids between Sesamu indicum And Wild relatives. M.Sc thesis, Botany Department, University of Jos, Plateau State, Nigeria

Das, N.R. (2009). Practical Manual on Basic Agronomy with Theory. Published by scientific publishers, India. Pp 164

Dwivedi,V.D and Namdeo, K.N (1992). Response of sesame to nitrogen and phosphorus. *Indian Journal of Agronomy* **37 (3);** 606-607

Deigado, M. and Yermanos, D.I.M. (1975). Yield components of sesame (*Sesamum indicum* L) under different population densities. *Economic Botany*, **29**: 69-78 ‘

Duncan, B.D. (1955). Multiple Range and Multiple F test. Biometrics **11**: 1-42

Engin, Y, Emre, K, Seynus, F and Bulent, U. (2010). Assessment of selected criteria in sesame by using correlatio coefficient, path and factor analysis. Australian journal of crop science. **4(8)** 598-602.

FAO, (2009). Food and Agricultural Organisation of the United Nation. Faostat database available on line http;/faostat fao.org/site/567/default.aspx (05. 12. 2011)

Gomez, K.A and Gomez, A.A (1984). Statistical Procedures for Agricultural Research. 2 Ed. John Wiley and Son Inc. Singapore. pp 680.

Gupta, T.R (1982). Effect of plant density on yield and yield components in sesame (*sesamum indicum* L.) *Madras Agriculture Journal*. **69 (9);** 569-572.

Haggai, P.T (2004). Effect of nitrogen and phosporus application on yield attributes and seed yield of sesame (*Sesamum indicum* L) in northern guinea savanna of Nigeria. Proceeding of 38th annual conference of agricultural sociaty of nigeria (ASM). Lafia, Nasarawa state. PP 150-157.

Hamman, A.W (1998). Traditional production practices and utilization of beniseed: What Potential for large scale production. In. proceeding of the first National Workshop on Beniseed, March 3-5, 1998. NCRI, Badeggi. Pp 43-46

Haruna,I.M; Maude, S.M and Rahman,B.A (2009) Effect of nitrogen and phosphorus fertilizer rates on yhe yield and economic returns of sesame (*Sesamum indicum* L) in the northern guinea savanna of Nigeria. *Elctronic journal of environmental agricultural food chemistry.* ISSN-1579-4377. EJEAFche. http-ejeafche.uvigo.pdf-Adobe reader

Haruna, I.M.(2010). Productivity of sesame (*Sesamum indicum* L) as influenced by poultry manure, nitrogen and phosphorus. An unpublished Ph.d thesis submitted to the Department of Agronomy, Ahmadu Bello University Zaria, Nigeria.

Hossein, M.A; Hamid, A and Nasreen, S (2007). Effect of nitrogen and phosphorus fertilizer on and P uptake and yeild performance of sesame. Jouurnal of Agricultural Research **45(2)**: 119-127

Idowu, A.A; Iwo, G.A; Tiamiyu, S.A and Anuonye, J.C (2002). Baseline survey on Beniseed Production, Processing and Utilization in Kebbi state. In Oilseed Research Programme Report. NCRI annual review meeting 25-28 June 2002 Pp32-33.

Kalita, M.M; Chakravaty, P.B, and Paul, S.K (1980). Performance of sesamum varieties in Assam. *Indian Journal of Agronomy* **25 (3)** 522-523

Katung, P.D (1987). Effect of sowing date and plant population on yield and yield components of sesame. (sesamum indicum l). M.sc thesis,Department of Agronomy, ABU Zaria

Loomis, M.S; William, W.A and Hall, A.E (1971). Agricultural productivity. *Ann.Rev. of Plant Physiology* 22, 4311 – 468.

Majumdar, D.K and Roy, S.K (1992). Respond of sesame (*Sesamum indicum* L) to Irrigation, row spacing and plant population. *Indian Journal of Agronomy*, **37**: 758-762.

Malik,A.M; Salem, M.F; Cheema, M.A and Ahmed, S. (2003). Influence of nitrogen levels on productivity of sesame (*Sesamum indicum* L) under varying planting patterns. *International Journal of Agriculture and Biology* **4**: 490-492.

Mankar, D.D; Santao, K.K (1995). Influence of nitrogen and phosphorus on growth, yield and yield attributes of sesamum. *PKV Research journal* **19 (1**); 79-80

Mkamilo, G.S; Badigan, D. (2007) *Sesamum indicum* L. in Vegetable oils. PROTA 14: Wageningen Netherlands.

Muhamman,M.A; Gungula, D.T and Sajo, A.A (2009). Phenological and yield characteristics of sesame (*Sesamum indicum* L) as influenced by nitrogen and phosphorus rates in Mubi, Northern Guinea Savanns ecological zone of Nigeria.*Emirs: J food and agriculture*. 2009. **21(1**): 01-09. http.//cfa.uaeu.ac.ae/ejfa.shtml.

NCRI, (2002). Oilseed Research Program Report. NCRI Annual Review Meeting 22-28 June 2002.

NCRI, 2005). *Technology for Beniseed* (*Sesame) production*. 3rd edition, Oilseed Research Programme, NCRI, Badeggi (vol. 3. march 2005).

NCRI, (2008). Oilseed Research Division Report. 2008 Research Review and Planning National Cereals Research Institute Badeggi. Workshop 26-30 May 2008.

Okpara,D.A; Muoneke, C.O, and Ojifpong,T.O (2007). Effect of nitrogen and phosphorus fertilizer rates on the growth and yield of sesame (*Sesamum indicum* L) in the south eastern mainforest belt of Nigreria. *Agricultural Journal* **38:1**-8-11

Olowe,V.I.O. (2004). Production potential for sesame in savanna regions of Nigeria Nigeria. MUARIK BULLETIN **7**: 20-29

Olowe, V.I.O and Busari, L.D (1996). Evolving optimum rates of nitrogen and phosphorus application for sesame in southern guinea savanna of nigeria. *Tropical oilseed journal* pp 75-85.

Olowe,V.I.O and Busari, L.D (2000). Response of sesame (*Sesamum indicum* L) to Nitrogen and Phosphrus application in southern guinea savanna of Nigeria. *Tropical oilseed journal* pp 30-37

Olowe, V.I.O; Adeyemo, Y.A and Adeniran, O.O (2009). Sesame . The underexploited organic oil crop. Research and development centre (RESDEC). Available on line at www.unep- unctad.org/cbtf/events/sesame seed crop.

Onginjo, E.O and Ayiecho, P.O(2009). Genotypic variability in sesame mutant lines in Kenya. African crop science journal vol.**17 no.2** 2009. Pp 101-107

Oplinger, (1990). *Alternative Field Crop Manual (*Sesame*)*. Dept. of Agronomy and Soil Science, Collage of Agriculture and life Sciences and Cooperative Extension Services, University of Wisconsin-Madison W1 53706.

Osman, H.E. (1993). Response of sesame cultivars to plant density in the Sudan central Rain lands. *Arab Gulp Journal of Scientific Research* **11(3):**365-376.

Owuna, O.D (2006). The Productivity of Sesame (Sesamum *indicum*) as Influenced by Rates of Nitrogen Fertilizers and Stand Density. An unpublished PGD thesis Submitted to Department of Agronomy ABU Zaria. Nigeria.

Purseglove, J.W. (1974). *Tropical Crop Dicotyledons.* Longman London. pp 430-435

Radford, P.J. (1967). Growth Analysis formula, their uses and abuses. *Crop Science* **3**:171-173.

Rhoads, F.M & Bloodworth, M.E. (1964). Area Management of Cotton leaves by Dry Weight Method. *Agronomy Journal* **56**:520-552

RMRDC (2004) reports on survey of agro-raw materials in Nigeria. Raw materials research and development council. Abuja.

Roy, S.K; Rahaman, S.M.L; Salahudin, A.B.M. (1995). Effect of nitrogen and potassium on growth and seed yield of sesame (*Sesamum indicum* L). *Indian Journal of Agricultural Sciences.* **65 (7)** ; 509-511.

Samson, T. C (2005). Effect of Inter and Intra Row Spacing and form of Arrangement on the Productivity of Sesame (*Sesamum indicum L)*. An unpublished PGD Thesis submitted to Department of Agronomy ABU Zaria. Nigeria

Seegeler, C.J.P. (1989). *Sesamum orientale* L (Pediaceae): Sesame correct name. Taxonomy **36**: pp 657-659.

Shehu, H.E; Kwara, J.D; Sandabe, M.K (2010). Effect of NPK fertilizer on yield, content and uptake of NPK by sesame. International *journal of agriculture and biology.* ISSN print 1560-8530; ISSN on line 1814-9596. 01-060/DNK/2010/**12-6**-845-850

Singh, P.P and Kaushal, P.K (1975). Respond of rainfed sesame (Sesamum *indicum L)* to Row and plant spacings and fertilizer levels. *JNKVV Research Journal **(1/2)** 61-62.*

Subramaniyan, K; Arulmozi, N. and Mohammed, N. (2000). Fertilizer for sesame. In "*Hindu*" Tranlated on Lin edition of Indians national newspaper, Thursday sept. 07, 2000. PP 34.

Subramanian, S. and Subramanian, M.(1994). Correlation studies and path coefficient analysis in sesame (sesamum indicum l). Journal of agronomy and crop science. Vol. **173 issue 3-4**. Pg 241-248. October 1994.

Ugbani, U; Momoh, S; Ayinde A. (2008) Resources use Efficiency in Beniseed Production in Obi and Doma Local Government Areas of Nasarawa State. In Oilseed Research Division Report. NCRI Badeggi. 2008 Research Review and Planning Workshop. 26-30 may 2008. PP 29-30

Uzo, J.O (1998). Beniseed: A neglected oil wealth of Nigeria. In *Proceedings of the first National Workshop on Beniseed (Sesame), 3-5 march 1998,* Badeggi. Nigeria.

Uzun, B, and Cagirgan, M.I.(2006). Comparision of determinate and indeterminate lines of sesame for agronomic traits. Field crops research. **96**:13-18.

Watson, D.J (1952). The physiological Basis of Variation in Yield. *Advances in Agronomy* **4**:101-104.

Van Rheenen, H.A. (1973). Major Problems of Growing Sesame (*Sesame indicum* L) In Nigeria. Mededelingen Landbouhoge School, the Netherlands.

Weis, E.D (1983). *Oilseed Crops*. Longman Group, London UK.

Yadava T.P; Kumar, P; Yadav, A, K (1980). Association of Yield and its Components in Sesame. *Indian Journal of Agricultural Sciences* **50(4)** 317-319

Zaidi, S.H; Khan, A.A (1981). Performance of 4 varieties of sesame (*Sesamum indicum L)* and their response to fertilizer. *Journal of forestry **31(2)** 61-66.* Pakistani Forest Institute, Peshawar, Pakistan.

Appendix. 1

Meteorological data showing monthly rainfall, temperature, relative himidity and sunshine hours during 2009 wet season at samaru, zaria.

Month	days	Rainfall (mm)	Temperature Max.(^{O}C)	Min.(^{O}C)	Relative humidity(%) 10a.m	4p.m	Sunshine(hrs)
April	1-10	0	38.6	22.9	37.2	21.8	8.3
	11-20	8.3	38.7	23.4	50.3	36.5	8.6
	21-30	12.0	38.0	23.2	53.9	32.1	8.7
Month Total		**20.3**					
May	1-10	47.3	34.5	22.1	63.2	49.2	7.5
	11-20	13.3	36.8	22.2	56.0	41.2	9.5
	21-31	24.5	35.2	22.4	70.6	45.9	8.0
Month Total		**85.1**					
June	1-10	39.5	33.0	21.3	51.4	33.0	8.3
	11-20	15.6	33.2	21.2	57.3	33.2	8.3
	21-30	34.4	32.6	20.5	58.8	32.6	7.7
Month Total		**89.5**					
July	1-10	80.4	31.9	19.3	61.3	31.9	7.5
	11-20	43.1	31.6	20.3	64.1	31.6	8.5
	21-31	161.5	30.5	20.4	72.3	30.5	7.7
Month Total		**285.0**					
August	1-10	79.7	30.3	20.7	81.2	69.0	6.0
	11-20	232.9	29.7	19.8	79.5	68.8	5.3
	21-31	127.1	29.9	20.7	81.1	66.5	5.9
Month Total		**439.7**					
September	1-10	98.2	31.0	19.7	77.2	58.3	6.9
	11-20	92.8	32.0	19.3	77.7	65.4	6.4
	21-30	15.7	32.6	20.1	71.6	63.3	7.0
Month Total		**206.7**					
October	1-10	12.8	33.2	20.1	72.9	62.9	7.0
	11-20	121.7	32.6	20.6	74.0	63.2	6.2
	21-31	17.2	32.5	19.4	66.6	61.9	6.7
Month Total		**151.7**					
Years Total		**1278**					

Collected from meteorological unit of the Institute of Agricultural Research (IAR) Samaru. Zaria. Nigeria.

Appendix. 2

Meteorological data showing monthly rainfall, temperature, relative himidity and sunshine hours during 2010 wet season at samaru, zaria.

Month	days	Rainfall (mm)	Temperature Max.	Min.	Relative humidity 10a.m	4p.m	Sunshine
April	1-10	0	39.2	21.5	8.2	13.0	5.2
	11-20	3.3	39.6	23.7	47.6	39.6	7.6
	21-30	49.1	36.8	23.1	59.4	38.3	6.1
Month Total		**52.4**					
May	1-10	55.1	34.1	22.6	69.0	57.7	6.5
	11-20	16.7	35.9	23.0	69.5	51.5	7.6
	21-31	21.1	36.0	22.6	66.3	62.2	6.6
Month Total		**92.9**					
June	1-10	82.5	32.4	20.9	67.6	69.8	5.0
	11-20	26.6	32.3	20.7	75.6	61.1	6.3
	21-30	49.2	33.0	20.1	76.0	66.8	4.6
Month Total		**158.3**					
July	1-10	122.2	31.1	19.3	81.9	63.8	5.5
	11-20	44.1	30.5	19.5	81.9	69.2	4.5
	21-31	50.1	29.4	19.4	82.1	75.9	4.4
Month Total		**216.8**					
August	1-10	82.7	30.0	19.4	78.0	73.3	5.1
	11-20	138.2	29.9	19.5	82.0	74.2	6.2
	21-31	92.5	29.5	21.2	85.2	72.2	5.3
		313.4					
September	1-10	68.7	29.7	21.1	79.9	72.9	4.1
	11-20	108.4	31.4	21.1	81.6	64.2	5.3
	21-30	34.1	32.4	20.5	74.9	64.3	6.8
Month Total		**211.2**					
October	1-10	40.9	32.6	21.2	78.5	64.3	6.6
	11-20	9.4	33.3	20.7	76.4	65.5	6.8
	21-31	32.0	32.0	20.1	66.1	67.5	6.0
Month Total		**82.3**					
Years Total		**1127.3**					

Collected from meteorological unit of the Institute of Agricultural Research (IAR) Samaru. Zaria. Nigeria.

Biography

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Educational background

Name of Institution	Period attended	Qualification obtained
Central Primary School Gombe	1975-1981	Primary School Leaving Certificate
Government secondary school Darazo. Bauchi state.	1981-1986	GCE 'Ordinary level
School of basic sudies ABU Zaria	1986-1987	IJMB
Ahmadu Bello University Zaria	1989-1994	B. (Agriculture)
NASSI Computer School Gusau	2003	Diploma in computer studies
Ahmadu Bello University	2008- 2011	M.Sc Agronomy

Working Experience

Name of Organization	Period
NYSC Integrated Farm Iseyin Oyo state	1994-1995
Intercott Nigeria Limited Kontagora Niger State	1996-1997
Olam Nigeria limited Lagos	1997-2005
Agridimensions Commodities limited	2006-2008
Agricultural Research Council of Nigeria Abuja	2010- Date

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