EFFECT OF RATE, TIME AND METHOD OF NITROGEN FERTILIZER APPLICATION ON THE GROWTH AND YIELD OF COTTON (Gossypium hirsutum L.) VARIETY SAMCOT-9 AT SAMARU, NIGERIA

BY

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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The above declaration is confirmed.

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CERTIFICATION

This thesis entitled "Effect of rate, time and method of nitrogen fertilizer application on the growth and yield of cotton (Gossypium hirsutum L.) variety SAMCOT-9 at Samaru, Nigeria" by Lallai Duniya meets the regulations governing the award of the degree of Master of Science in Agronomy of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my wife Mary and children, Mandela and Caleb, for their patience, loneliness, moral and financial support to see to the completion of this thesis.

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ABSTRACT

A field experiment was conducted at Samaru - Zaria, during the 1996 wet season to study the effect of rate, time and method of nitrogen application on the growth and yield of upland cotton (Gossypium hirsutum L.) variety SAMCOT-9. The treatments comprised factorial combinations of four nitrogen rates (30,60,90 and 120kg N/ha), three nitrogen application times (3, 3 and 8, and 8 weeks after sowing) and two methods of nitrogen application (side dressing and single band placement) using the split plot design.

Application of nitrogen fertilizer at the rate of 60kg N/ha significantly increased growth characters of cotton such as plant height, plant dry weight, leaf area index, number of bolls/plant, seed cotton yield, cotton seed yield, lint yield and seed index (100-seed weight) more than did any of the other nitrogen rates that were tested.

Time of nitrogen application affected the yield and yield attributes of cotton. Split application of nitrogen at 3 and 8 weeks after sowing (WAS) produced a higher cotton yield than single dose application. Eventhough other rates and time of nitrogen application produced similar results, application of 60kg N/ha in split doses at 3 and 8 WAS appeared to be the more appropriate treatment for the cotton variety tested. Both methods of nitrogen application appeared to produce

similar results although the side dressing method produced slightly higher values than the single band placement.

A significant nitrogen time x method interaction on cotton seed yield showed that the combined application of 60kg N/ha at 3 and 8 WAS gave the highest cotton seed yield. The nitrogen method x rate interaction also supported this same conclusion.

Positive correlation between cotton seed yield and each of the parameters tested, with the exception of number of nodes/plant, number of leaves/plant, plant dry weight, days to 50% flowering and days to 50% boll opening were observed.

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CHAPTER ONE

1.0 INTRODUCTION

Cotton (Gossypium hirsutum L.) belongs to the family Malvaceae, the genus Gossypium with about 30 species of annual sub-shrubs, perennial shrubs or trees distributed in the tropical and sub-tropical regions of Africa, Asia, Australia and America (Purseglove, 1974). The genus includes both wild and cultivated cottons. The genus may be divided into main groups according to chromosome number, one having diploid number 26 and the other 52. The group possessing 26 diploid chromosomes may be further subdivided into 7 sub-groups, of which one is of commercial significance (Purseglove, 1974). This latter subgroup is represented by the species G. herbaceum L. and G. arboreum L., short lint cotton, which is cultivated on small scale primarily for local uses in parts of Asia, Africa and the Middle East. The commercial cotton belongs mainly to the group with 26 diploid chromosome. This group consists of G. hirsutum L., G. barbadense L. and G. tomentosum L. The origin of cotton, particularly the new world cotton, has been a subject of considerable controversy (Purseglove, 1974). However, the oldest and most authentic discoveries of cotton were reported in India or present day Pakistan between 3000 and 2700 B.C. (Muller, 1968).

Despite the extensive use of synthetic fibre, the importance of cotton as a crop of high economic value and as a source of raw material for the expanding national textile industry cannot be disputed (Martins et al., 1976). Cotton is next to cereals as the world's most important crop plant and despite increasing production of synthetic fibres, it still retains its reputation as the "queen of fibrous plants" (Muller, 1968). Cotton plays significant role in the household, industry and national economy of any country where it is grown. This significance is demonstrated not only in the numerous uses of cotton fibre itself but also in the widespread utilization of its secondary products, such as cotton-seed cake, cotton-seed oil, and the fuzz used in making felts, upholstery, carpets, mattresses, wicks, surgical cotton, photographic films, explosives, rayon, plastics, carpets, paper and sausage skin (Purseglove, 1974). Cotton is a very important cash crop and the most valuable "money" crop of the entire growing zones of the world (Muller, 1968).

Cotton has been under commercial production in Nigeria for several decades. The national annual production of cotton in Nigeria between 1996 and 1997 ranged from 979,597 bales to over 1,106,266 bales (N.U.A. Idem, personal communication). In 1969/70 cotton contributed some 2% of the total export and fetched a foreign exchange earning of 17.3 million naira

(Idem, 1984).

Many experiments have been conducted with the aim of improving cotton production in order to attain the projected national demand of about 800,000 bales of lint for the 90's (Kings, 1955; Lawes, 1963; Brown, 1971; Faulkner, 1974; Kumar and Ogunlela, 1982; Ogunlela et al., 1982; Idem, 1984; Anonymous 1985). Despite such efforts, the annual lint production which stood at 1,106,266 bales in 1996 - 1997 had fallen far below the requirement of the textile industry. The rapid decline over the years is attributable partly to a general decline in yield per unit area of land after many years of continous cultivation. This low yield has often generated the feelings of apathy among the cotton growing farmers. The ultimate consequence is that Nigeria, which was once a major cotton exporting country, is now a net importer of the commodity.

Fertilizer use is one important way of raising the production level and to reverse the unwelcome trend of decline in production, (Statou and Simomis, 1994). However, the attainment of the yield potential of this crop in northern Nigeria is often limited by poor mineral nutrition, particularly that of nitrogen (N) in savanna soils, where macronutrient status is either marginal or very low and inconsistent (Hayward, 1972). Among the major nutrients, N is

generally the most limiting in the soils of cotton growing areas of northern Nigeria (Jones and Wild, 1975).

The average total growth cycle for upland cotton under rain-fed conditions in northern Nigeria extends over a period of six to seven months (June-December). The usual observation here is for cotton to begin to flower at about nine weeks after sowing (WAS). It has been postulated by Ogunlela et al. (1982) that this crop may have a greater demand for nutrients during fruit development than at any other growth phase. The fact that N fertilizer improves seed cotton yield has already been well documented (Burhan 1971, Smithson and Heathcote, 1977; Lombin and Ogunlela, 1979; Ogunlela et al., 1982). Little or no investigation has been carried out with respect to the two new varieties recently released by the Institute for Agricultural Research, Samaru (IAR) for commercial production, namely SAMCOT-9 and SAMCOT-10.

Studies at Samaru and elsewhere in northern Nigeria have shown that the present N recommendation for early sown cotton may no longer be adequate for the varieties which are now being grown in northern Nigeria (Smithson and Heathcote, 1977; Lombin and Ogunlela, 1979; Ogunlela, et al., 1982). In such reported studies, only commercial varieties Samaru 71 and Samaru 77 (now named SAMCOT-6 and SAMCOT-8 respectively) were used.

In view of the importance of cotton in the Nigerian economy, the expanding textile industry of Nigeria and the general farming systems, there is a great need to increase seed cotton production in order to cut down on the level of lint importation.

The main objective of the present study was to determine the N requirements of one of the recently released cotton variety, SAMCOT-9 by;

i - estimating the optimum rate of N fertilizer application; and

ii - determining the appropriate time and method of N fertilizer application at Samaru - Zaria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Role of N in Morphological and Physiological Processes of Cotton

Among an array of factors that influence seed cotton yield, N supply stands out as a major factor. N has profound effects on almost all the processes of the cotton plant. The height of the plant increases with the addition of N, as do the numbers of fruiting branches, flowers and mature bolls; N also favourably affects the boll size, seed weight and lint index. Significant and positive effects of applied nitrogen rates on yields were reported by Garg (1964), Burhan (1972), Trollervey (1972), Burhan (1973), Massagni et al. (1993), and Anonymous (1974). However, a curvilinear relationship between yield and nitrogen rates was reported by Burhan (1973). Gardener and Tucker (1967) and Funderburg (1988), reported that N deficiency at early growth stages of cotton hampered the development of vegetative branches, internode elongation and fruiting, especially in 'unimodal' rainfall areas. Verma et al. (1965) reported significant increase in plant height due to N application. Reddy and Rao (1973) also observed significant effect of N on plant height and they obtained maximum plant height with the application of 134.6kg N/ha.

2.2 Nitrogen in Cotton Growth and Productivity

The significance of fluctuation in yields of seed cotton from season to season was studied by Trollervey (1972), Burhan (1973), and Burhan and Jackson (1973). This is a major problem facing the cotton industry in Nigeria and one of the controlable factors responsible for such seasonal fluctuations is soil N status. Trollervey (1972) and Burhan and Jackson (1973) observed that N application had the effect of reducing yearly yield fluctuation by improving yields in the wet seasons.

Wankede (1973) and Mamples and Frizzel (1985) concluded that higher rates of nitrogen stimulated the vegetative growth parameters such as height, branching and internodes in tall cotton varieties but not in short varieties. Althwale (1967) and Pande (1968), working separately with cotton cultivar "Buri-L-147" reported increased number of functional leaves with increase in nitrogen rates. Reddy and Rao (1973) obtained maximum number of functional leaves per plant with 134.6kg N/ha using cultivar "PRS-72". Clark (1964) in a study in Pecos Valley concluded that the number of vegetative branches per plant was increased by N application. Singh et al. (1973) reported that number of monopodia branches per plant was increased with increasing rate of nitrogen and the response to nitrogen was enhanced by early sowing (June) in the presence of high rainfall. Conversely, however, elsewhere

in India, Patil and Lande (1976) reported that nitrogen did not influence the number of monopodial branches per plant in cotton under early sowing condition.

2.3 Nitrogen Nutrition and Crop Protection in Cotton

The direct effect of N treatment on cotton growth and yield is not a simple, straight forward process. Higher rates of inorganic N treatment result in more vigorous and leafy plant growth and these in turn mean a more conducive environment for the survival and multiplication of insect pest species that are of economic importance to cotton (Mistric Jnr; 1968, Hayward, 1972, Jackson, et al., 1973). Increase in insect infestation consequently calls for a more elaborate crop protection programme. Trollervey (1972) suggested that more detailed work on nitrogen application must include work on insect control so that a recommendation that combines the best of both can be worked out for the farmer. Some other workers, Mistric Jnr. (1968); Hayward (1972) and Jackson et al., (1973) obtained similar results but in several instances, even the sprayed crop failed to respond to applied N and it was assumed that in those instances the insecticides were misapplied. Unless adequate insecticide protection is given, nitrogen application can significantly depress cotton yields because abnormal N use can cause physiological, quality, storage, and disease problems in the cotton plant.

2.4 Time of N Application

Tucker (1965) expressed the view that rates of nitrogen probably have greater influence on the growth and yield of cotton than any other single nutrient. N nutrient should be tailored to permit continued vegetative growth and fruiting, yet time the fertilizer application such that deficiencies or harmful excesses are avoided. Aside from level (rates) of N applied to cotton, the timing of application is also important. Time of N experiments have shown that significant N rate and time interactions in cotton do exist (Tucker, 1965; Anonymous, 1974). Results indicate that part of early applied N does not contribute to seed cotton yield whilst with late application there may be insufficient time before moisture stress sets in and becomes limiting for the utilization of the heavier rates of N. Thus N timing may be less important in long seasons (Tucker, 1965). High rates of N application have been shown to increase the value of seed cotton yield, ginning percentage, lint yield, boll number, dry matter yield and N yield (Mackenzie and Van Schaick, 1963; Perkins and Douglas, 1965; Gardener and Tucker 1967).

2.5 Nitrogen Uptake by Cotton at Different Growth Stages.

Olson and Bledsoe (1942) in Georgia found that the cotton crop on 0.4 ha of land contained 59.0 kg of N. The percentages of total N utilized at each of the three growth stages were

given as 44% from planting to early square, 43.3% from early square to boll formation stage and 12.7% from early boll formation stage to maturity. In a similar analysis Kumar and Ogunlela (1982) gave figures of 20% from seedling to early square stage, 45% from flowering to early boll formation stage and 35% from early boll stage to maturity. The two studies therefore suggest that about 80% of the total N uptake by cotton occurs during the reproductive phase, which was between 8 and 25 WAS.

2.6 Nitrogen Rate on Yield of Cotton.

Mackenzie and Van Shaick (1963) reported highest cotton yield at 144kg N/ha in California. Hayward (1976) reported that the application of a nitrogenous fertilizer at optimum rates may decrease yield in June sown cotton in northern Nigeria due to higher pest attack on the crop. Koli and Morrill (1976) observed a reduction in yield with the application of a nitrogen level of 90kg N/ha on cotton. In Nigeria, 50 kg N/ha and 25 kg N/ha has been recommended for early and late sown cotton respectively for the northern Guinea savanna (FMAWRRD, 1989).

Renoid and Johnson (1934) found that nitrogen application increase the number of fruiting branches per plant in cotton. Similar results were reported by Ganga and Rao (1958)

on 'Laxmi' cotton in India. Snap (1975) found that the response of dry matter accumulation to N was significant at peak periods of growth. Higher N rates favoured dry matter accumulation in the plant. Lande (1976) concluded that dry matter production was increased by N and that significant responses to 50 and 100kg N/ha were obtained during vegetative and reproductive stages, respectively.

Studies in northern Nigeria have shown that it is not likely that one would observe significant response of upland cotton to N application rates higher than 52kg N/ha. Palmer and Goldsworthy (1971), Smithson and Heathcote (1977), Lombin and Ogunlela (1979), and Lombin and Mustapha (1980), observed significant response to N rates beyond 52kg N/ha in one out of two years in Samaru. Hayward (1972) working on late sown cotton in the same region however reported that N application to July sown cotton may even decrease yield possibly as a result of increased pest attack on the crop and moisture stress. When N fertilizer application increases cotton yield it does so mainly by prolonging plant growth while also increasing the number of bolls set.

2.7 Nitrogen Rate and Yield Components of Cotton.

Increases in yield components such as number of seed/plant, seed cotton weight/boll, and number of seeds/boll with increase in N application rate have been reported.

Ogunlela et al. (1982), reported increases in yield and yield components of cotton with increased rate of N application. Seed cotton yield was mainly influenced by increase in boll number per plant. Working with normal and okra leaf types cotton in the northern and southern cotton growing zones of Nigeria, Idem (1984) obtained positive and significant influence of N application on yield and yield components such as number of bolls/plant, average boll weight and number of seeds/boll.

Anonymous (1978) reported significant yield response upto 60kg N/ha at Samaru where seed cotton yields of 2110, 2401, 2514 and 2543kg/ha were obtained with 0, 30, 60 and 90kg N/ha, respectively. Yield components such as seed cotton yield/plant, number of bolls/plant and weight/boll responded in the same manner that seed cotton yield/ha did.

A combination of high N rate, excess rainfall and high temperature results in rank growth in cotton plant with longer internodes and fewer bolls/plant (Eaten and Ergle 1957). Rank growth, according to Pearson (1965), Onu (1989), and Nikiphoroff and Whitaker (1992) is likely to encourage lodging and boll rot, and at the same time rendered pest control on the crop more difficult and less efficient in harvesting. Early sown cotton however responded considerably better to N as compared to late-sown cotton.

2.8 Time of Nitrogen Fertilizer Application in Cotton Production.

Though N application rate is an important factor in increasing cotton yield, still higher yield can be obtained by applying N fertilizer at the most optimum time, so as to result in a more efficient utilization of N by cotton plant (Statou and Simomis, 1995). There seems to be doubts as to whether or not split application of N has special advantage over single application in their effects on seed cotton yield. There is substantial evidence that a single full dose nitrogen at flowering will produce as good a yield as splitting the application (Smithson and Heathcote, 1977; Lombin and Ogunlela 1979). Lombin and Ogunlela (1979) from their study covering various savanna agroecological zones of Nigeria, observed that there was a clear tendency for cotton yields to be higher when N was applied late than when it was applied early for soils in high rainfall areas, where the likelihood of nitrogen losses through leaching is high. Faulkner et al. (1974) observed that there is no advantage in split N application over a single one. Christidis and Harrison (1955) and Funderburg (1988) have stated that field trials conducted in different parts of the world regarding the effect of nitrogenous fertilizer application at various stages of cotton plant growth vary considerably. In Nigeria, the split application recommended by Smithson and Heathcote (1977) is that N fertilizer should be applied either at flowering or in two equal splits applied

half at 3 and half at 8 weeks after sowing. This appears to be an acceptable recommendation since it has proved to be an effective and workable option for cotton growing farmers.

The response of dry matter production in cotton to time of N application differed somewhat from those of other characters. Ogunlela and Abed (1984) suggested that early applied N becomes more available for vegetative development than for reproductive development, especially at fairly low doses. Their finding corroborated the findings of Smithson and Heathcote (1977), who had earlier reported that cotton frame weights were greater when N was applied at thinning rather than at flowering period. Ogunlela and Abed (1984) concluded that early applied N must have been incorporated into vegetative growth and could not be available to the crop during the reproductive phase, a period when demand for N is expected to be greater.

2.9 Methods of Nitrogen Fertilizer Application.

Method of N fertilizer application is one important factor that could determine whether or not the crop derives a greater benefit from N application. Once the choice of fertilizer has been made for a given crop in terms of the type and rate of application, there remains the important problem of determining how and when to apply it in order to derive the best yields. This is particularly important when a limited

supply of fertilizer is to be used to obtain tangible increases in crop yields. The choice of the best method of fertilizer application depends on a number of factors, notably the kind of soil, its moisture status, its fixing power for the different nutrients, previous management, the crop to be treated, its root development and the ability of the crop species to extract nutrients from the soil as well as the kind and amount of fertilizer to be used.

Generally, the different methods of applying fertilizers may be broadly grouped into two, namely, broadcasting and placement. The main objectives of broadcasting are, firstly to distribute the fertilizer evenly and incorporate it with part of or, throughout, the plough layer. Secondly, broadcasting is done when applying large quantities of fertilizers which can be safely applied at the time of planting. In broadcasting, the fertilizer is spread over the entire land area to be treated, either before the land is ploughed or harrowed, immediately before planting or while the crop is still growing. Fertilizer placement is referred to as "side dressing" if the crop is in wide rows, or as "top dressing" if the crop is in narrow rows or not in rows (FMAWRRD, 1989). Delayed application of N can also be commonly regarded as top dressing; top dressing of P and K is ordinarily done only on pastures that occupy a piece of land for a period of several years. Foliar application using

sprays is one method of applying fertilizer, but this generally is not practiced in cotton production. Placement methods of N fertilizer have been found to affect cotton height while their effect on seed cotton yield was not significant. Sinha and Pandy (1969) and Singh et al. (1973) have found that banding the fertilizer increased seed cotton production significantly compared to broadcasting it. The placement of 80kg N + 40kg P_2O_5 15cm deep into the soil prior to sowing cotton gave a seed cotton yield of 2.0t/ha , which was much higher than the yield produced by NP fertilizer applied broadcast or that produced without NP fertilizer. Placement of this NP fertilizer rate at 30 or 45cm depth gave seed cotton yield that was not higher than placing these at a 15cm depth. The effectiveness of dibbling N as urea and P_2O_5 as superphosphate 15, 30 and 45cm deep into the soil after first irrigation was found to be similar to that of broadcasting NP.

Whatever method is used, the fertilizer should be placed sufficiently far away from the plant roots in order to avoid mechanical or chemical injury to them.

2.10 **Nitrogen Rate x Time Interaction**.

The time of N application has been reported to have significant direct effect on the pattern of response by cotton to N rate with respect to number of bolls shed, and crop

earliness (Ogunlela and Abed, 1984). In terms of lint and cotton seed yields, however, they reported that positive response to N rate was greater when it was applied at 8 weeks after than at 3 weeks after sowing. Applying 78kg N/ha at 8 weeks was as good as applying 52kg N/ha at 8 weeks with respect to yield and yield-related parameters.

The application of a high rate of N (78kg N/ha) later in the growing season (at flowering stage) was reported to result in a tendency for crop maturity to be delayed. It was then suggested that 52kg N/ha should be applied to early-sown cotton at the flowering stage in the savanna soils for best yield results as this has proved to be quite beneficial to the crop (Ogunlela and Abed, 1984).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site.

The present investigation was conducted at the experimental farm of the Institute for Agricultural Research, Samaru (lat. 11°11'N; long. 07°38'E; 686m above sea level), Nigeria during the 1996 rainy season. Samaru lies within the northern Guinea savanna zone of Nigeria. It has an average annual rainfall of about 1060mm, mostly distributed within the period of May through September, with mean monthly minimum and maximum temperature of 20°C and 30°C, respectively during this period (Kowal and Knabe, 1972). The soil is moderately deep, well-drained and characteristically ferruginous tropical sandy-loam (Kowal and Knabe, 1972). The results of analyses of the physical and chemical properties of the soil collected at 30cm depth from the experimental site are presented in Table 1. The meteorological data collected at the IAR's Samaru meteorological station during the 1996 growing season are presented in Appendix I. The field was cropped with pepper - tomato mixture during the previous year.

3.2 Experimental Design and Treatment.

The experiment was laid out in a split-plot design with methods of N fertilizer application assigned to the main plots and a combination of N rate and time of N application to the subplots. The methods of N application were:

Table 1: Physical and chemical properties of soil from experimental site taken at depth of 0-30cm, at Samaru, 1996.

Chemical property	
Soil pH in H_2O	5.6
Soil pH in (0.01 $CaCl_2$)	4.9
Organic carbon (g/kg)	7.0
Total nitrogen (g/kg)	0.2
Available phosphorus (g/kg)	14.6
Exchangeable bases (Cmol/kg)	
Na	0.07
K	0.14
Mg	0.6
Ca	1.7
CEC	4.0
Base Saturation	0.5
Physical property	
Particle size distribution (%)	
Sand	49.5%
Silt	38.1%
Clay	12.4%
Soil textural class	Sandy loam

a) **Side dressing**: where fertilizer was applied into a hole 8cm deep and about 5cm away from the seedlings and then covered with soil and

b) **Single band placement**: where fertilizer was applied in a single band at a distance of 5cm away from the seedlings.

The four nitrogen rates were 30, 60, 90 and 120kg N/ha in form of urea and the three times of application were all at 3, equal split doses at 3 and 8, and all at 8 WAS. Altogether there were 24 treatments, which were replicated three times to produce 72 plots in all.

The gross and net plot sizes were 4.5m wide (5 rows) x 8m long ($36m^2$) and 2.7m wide x 8m long ($21.6m^2$) respectively. Yield was determined from the three centre rows (net plot area), while the remaining two outer rows were considered as discards.

3.3 Field Operations

3.3.1 Soil sampling and analysis.

Soil samples were collected from randomly selected spots over the experimental area. The samples were taken from 0-30cm depth using a tubular auger before fertilizer application and planting. After bulking and air-drying the soil samples, a composite sample was taken for laboratory analysis. It was then ground, and sieved to pass through a 2mm sieve before

being subjected to physical and chemical analyses. Particle size distribution was determined the hydrometer method (Day, 1965). Soil pH was determined potentiometrically after equilibration with water and also with 0.01 $CaCl_2$ in a 1:2.5 soil solution ratio. Organic carbon was determined by the Walkley-Black method (Allison, 1965). Total nitrogen was determined by the salicylic acid method and the distillation was carried out following the modified micro-Kjeldahl method (Bremner, 1965). The Bray No. 1 method was used for the extraction of phosphate, and the ammonium molybdate-blue method was used for determining the extracted phosphate (Bray and Kurtz, 1945). Exchangeable bases of Ca, Mg, K and Na were leached with NH_4OAC, calcium and magnesium were determined by atomic absorption spectrophotometry; while sodium and potassium were determined by flame emission spectrophometry. Exchange acidity was determined by extracting the soil with 1 N KCl (McLean, 1965). Cation exchange capacity (CEC) was determined using 1 N amminonium acetate (pH 7.0) saturated followed by displacement of the adsorbed ammonia (Chapman, 1965). Base saturation was calculated as the sum of cations (Ca, Mg, K, Na) divided by CEC as determined by the two methods described above. These soil analyses values are given in Table 1.

3.3.2 Land preparation.

The land was ploughed once, harrowed twice to a fine

tilth and then ridged. Ridges were made 90cm apart. Paths of 1m across and along the plots were allowed to demarcate adjacent plots.

3.3.3 **Fertilizer application.**

The experimental area received a basal fertilizer dressing of 50kg P_2O_5 and 0.75kg of B per ha as boronated superphosphate during the planting season.

3.3.4 **Planting date and planting materials.**

The cotton was planted on 15th July, 1996. Dressed seeds of cotton variety SAMCOT-9 were obtained from the Fibre Technology Laboratory - IAR Samaru.

3.3.5 **Spacing and plant population.**

Planting was done at an intra-row spacing of 45cm and inter-row spacing of 90cm. Four to five seeds were planted per hole and the stands were later thinned down to two seedlings per stand at 3 WAS. This gave a plant population of 50,000 plants/ha.

3.3.6 **Weed and pest control.**

Weeds were controlled by means of a pre-emergence application of Gramozone at the rate of 3.5L per ha. using a knapsack sprayer. This was followed by two supplementary hoe weedings at 3 and 6 WAS and remoulding (earthening-up) at 8

WAS. Sherpa plus at the rate of 1.0L per ha was applied to control insect pests. This was done three times at two-weekly intervals from 10 WAS upto 14 WAS (a total of three sprays).

3.3.7 Harvesting.

The crop was harvested by hand-picking of seed cotton from plants within the net plot area. A total of two pickings was done to completely harvest the experimental plots.

3.4 Observations and Data Collection.

Observations on plant characters were made at 8, 12 and 16 WAS. Data for non-destructive and destructive analyses were taken from the border rows adjacent to the net plot area. The samples which consisted of five tagged plants within each net plot, were used in determining the average height of plants, number of leaves per plant, total dry weight per plant, number of nodes per plant, leaf area, leaf area index and number of bolls per.plant.

3.4.1 Plant height.

The height of five tagged plants was determined at 8, 12 and 16 WAS. This was done by measuring the plant from the ground level to the tip of the stem using a graduated metre rule. The mean of the height measurement for the five plants was taken as the mean for the plot.

3.4.2 Number of leaves per plant.

The number of fully expanded leaves on each of the five tagged stands was take at 8, 12 and 16 WAS and the mean per plant was taken to represent the average value for the plot.

3.4.3 Number of nodes per plant.

The total number of nodes per plant was taken from the five tagged stands within the plot and the average number of nodes per plant was derived.

3.4.4 Leaf area and leaf area index.

Leaf area index (LAI) was estimated using the specific leaf area (SLA) relationship reported by Evans (1972). Specific leaf area (SLA) is defined as the ratio of leaf area to that of leaf dry weight.

$$\text{Total leaf area (LA)} = \frac{a}{b} \times (b + c)$$

where;

a = area of 5 leaf discs = $2.16cm^2$

b = dry weight of 5 leaf disc in (g)

c = dry weight of remaining leaves from each sample in (g)

The leaf area index (LAI) was determined by dividing the estimated leaf area of the sample by $0.4m^2$ (the ground area).

3.4.5 **Plant dry weight.**

The leaves, stem and roots in each sample from 0.4m^2 were taken at 8, 12 and 16 WAS separated to component parts and dried to a constant weight in a ventilated oven at 60°C for 48 hours. They were then weighed with a top-loading electronic balance to obtain their dry weights.

3.4.6 **Number of open bolls.**

The total number of open bolls on the five tagged plants was determined by adding up the number of bolls picked at each picking. From this, the number of open bolls per plant was determined.

3.4.8 **Average boll weight.**

Boll weight was determined from the weight of the total number of opened bolls from five tagged plants divided by the total number of open bolls from the same plants.

3.4.9 **Seed cotton yield.**

Seed cotton yield was determined from the total seed cotton picked per net plot. Seed cotton was picked periodically as the bolls were fully opened. The total weight of picked seed cotton from each net area was used to compute yield of seed cotton in kg per ha.

3.4.10 **Cotton seed and lint yields.**

The cotton seed and lint yields were determined by weighing the cotton seed and lint derived from each of the net plots after ginning the seed cotton and using the appropriate computation.

3.4.11 **Seed index (100-seed weight).**

To estimate the seed index, 100 seeds from the ginned seed cotton were counted from each net plot and then weighed. This parameter was estimated using the average of four lots.

3.4.12 **Ginning percentage.**

Seed cotton picked from each of the net plots was ginned with a cotton ginner and ginning percentage calculated from the weights of the lint and seed cotton.

$$\text{Ginning percentage} = \frac{\text{Lint weight}}{\text{Seed cotton weight}} \times 100$$

3.4.13 **Statistical analyses of data.**

Data collected were subjected to one way analysis of variance to test for the significance of the treatment effects using the "F", test as described by Snedecor and Cochran (1967). Treatment means were compared using the Duncan's Multiple Range Test (DMRT) (Duncan, 1965) and such treatments included those of main effects and their interactions where significant.

CHAPTER FOUR

4.0 RESULTS

4.1 Effects of Rate, Time and Methods of Nitrogen Fertilizer Application on Growth Related Characters of Cotton SAMCOT-9.

4.1.1 Plant height.

Plant height was significantly influenced by different rates and times of nitrogen application at 12 and 16 WAS but not at 8 WAS (Table 2). Plant height increased with increasing rate of N fertilizer application up to 60kg N/ha, beyond this rate its effect on plant height began to decline. However, at 8WAS, plant height did not show any significant difference among the different N rates. N fertilizer application at 3 and 8WAS as split application produced the tallest plant height at 8 and 12WAS among the three different times of application. Plant height was lower with later application of N.

Comparing the different methods of N fertilizer application, it was observed that both side dressing and band placement produced similar effects on plant height. The various effects on plant height were all not statistically significant.

Table 2: Plant height (cm) of cotton at 8, 12 and 16 WAS as affected by rate, time and method of N fertilizer application at Samaru,1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)(R)			
30	37.4b	55.9b	77.8b
60	40.3a	75.1a	97.9a
90	40.5a	71.5a	90.9a
120	39.3a	61.1b	83.3b
SE±	1.42	2.22	2.52
Time of N application (T)			
3 WAS	40.4b	66.6a	89.4a
3 and 8 WAS	45.1a	70.4a	90.0a
8 WAS	32.6c	60.7b	83.1a
SE±	1.23	1.92	2.18
Method of N fertilizer application (M)			
Side dressing	38.6	64.6	87.9
Band placement	40.1	67.2	87.1
SE±	1.30	2.12	3.06
Interactions			
M x R	NS	NS	NS
M x T	NS	NS	NS
R x T	NS	NS	NS
M x R x T	NS	NS	NS

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.2 **Number of nodes per plant.**

The number of nodes per cotton plant at 8, 12 and 16 WAS was unaffected by N rate (Table 3). Time of N application significantly influenced the number of nodes per plant at the three growth stages it was measured. Split application of nitrogen at 3 and 8 WAS gave the highest number of nodes at 8, 12 and 16 WAS. Single application of N at 8WAS tended to produce the fewest nodes per plant at each stage.

When the two methods of nitrogen application were compared, it was observed that there was no statistical difference between side dressing and band placement. Also the various interaction effects on the number of nodes were all not statistically significant with the exception of number of nodes at 8 WAS, where the application method x time interaction effect on number of nodes was observed to be statistically significant.

Table 3: Number of nodes per cotton plant at 8, 12 and 16 WAS as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)			
30	3.5	10.5	14.4
60	3.9	10.2	14.5
90	3.8	10.8	14.8
120	3.7	10.7	14.9
SE±	0.18	0.30	0.33
Time of N application			
3 WAS	3.8a	10.6b	15.0a
3 and 8 WAS	4.2a	11.3a	15.1a
8 WAS	3.2b	9.8c	13.8b
SE±	0.16	0.27	0.29
Method of N fertilizer application			
Side dressing	3.7	10.4	14.3
Band placement	3.8	10.8	15.0
SE±	0.22	0.51	0.55
Interactions			
M x R	NS	NS	NS
M x T	*	NS	NS
R x T	NS	NS	NS
M x R x T	NS	NS	NS

NS = Not significant
* = Significant at 5% probability level

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.3 Effect of time x method of nitrogen application interaction on number of nodes in cotton.

Effect of time x method of N application interaction on number of nodes shows that band placement method of N fertilizer application was significantly higher than side dressing of N application, however, there was no significant difference between the two application methods at 3 and 8WAS (split application) and at 8WAS (single dose) (Table 4).

Split application of N at 3 and 8 WAS was significantly better than application at 3 or at 8 WAS (single dose) which did not differ from each other using the side dressing method of N application. However, comparing band placement and side dressing methods, it was observed that band placement produced significantly higher values at 3 WAS and at 3 and 8 WAS than at 8WAS.

Table 4: Interaction between time and method of N application on number of nodes, in cotton at 8 WAS at Samaru, 1996.

	Weeks after sowing (WAS)		
	3	3 and 8	8
Method of N application			
Side dressing	3.5b	4.0a	3.5b
Band placement	4.1a	4.4a	3.0b
SE±		0.29	

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.4 **Number of leaves per plant.**

The rate of N application was observed to have no statistically significant effect on number of leaves, eventhough this parameter appeared to have slightly increased at 12WAS, with increasing rates of nitrogen fertilizer application upto a dose of 90kg N/ha, after which the number of leaves remained unchanged (Table 5).

Time of application of nitrogen fertilizer significantly influenced the number of leaves per plant. Application of N at 3, 3 and 8 and at 8 WAS statistically differed in their effects on this parameters statistically. However, split application of nitrogen at 3 and 8 WAS gave the highest number of leaves per plant with the exception of the determination done at 16WAS.

Methods of nitrogen fertilizer application did not significantly affect the number of leaves per plant. Also none of the different interaction effects on the number of leaves per plant was significant.

Table 5: Number of leaves per cotton at 8, 12 and 16 WAS as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)			
30	16.8	36.7	59.2
60	17.0	40.2	61.5
90	17.3	41.1	62.5
120	17.4	40.0	61.6
SE±	0.74	1.50	1.58
Time of N application			
3 WAS	17.1b	39.5b	60.7b
3 and 8 WAS	19.6a	43.0a	64.1a
8 WAS	14.7bc	36.0c	58.1b
SE±	0.64	1.30	1.37
Method of N fertilizer application			
Side dressing	16.2	39.0	61.1
Band placement	18.0	40.0	61.2
SE±	1.12	2.25	2.47
Interactions			
M x R	NS	NS	NS
M x T	NS	NS	NS
R x T	NS	NS	NS
M x R x T	NS	NS	NS

NS = Not significant

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.5 **Dry weight per plant.**

Dry weight production at 16WAS was significantly influenced by rates of nitrogen application (Table 6). Dry weight per plant was observed to have increased with increasing rate of nitrogen upto 90kg N/ha after which it declined particularly at 16WAS. There was however no significant influence on dry weight production by rate of nitrogen fertilizer at 8 and 12WAS.

Time of nitrogen fertilizer application was observed to have influenced dry weight production at 12 and 16 WAS. There was no significant influence on dry weight per plant with respect to time of nitrogen application at 8WAS. The highest dry weight production per plant occurred when fertilizer was applied either in split doses at 3 and 8 WAS or at 3WAS.

Methods of nitrogen application did not have any significant effect on dry weight production. Similarly, interaction effects on dry weight production were not statistically significant.

Table 6 Dry weight per plant (g), as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)			
30	16.7	30.9	37.2c
60	15.9	29.4	47.6b
90	19.7	36.0	59.3a
120	18.4	33.1	38.0c
SE±	1.70	3.28	2.36
Time of N application			
3 WAS	19.1	35.6a	48.5a
3 and 8 WAS	18.7	34.5ab	47.5ab
8 WAS	15.0	26.1b	40.2b
SE±	1.47	2.85	2.04
Method of N fertilizer application			
Side dressing	16.1	29.5	46.2
Band placement	19.0	35.1	44.9
SE±	1.67	3.23	3.72
Interactions			
M x R	NS	NS	NS
M x T	NS	NS	NS
R x T	NS	NS	NS
M x R x T	NS	NS	NS

NS = Not significant

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.6 **Leaf area per cotton plant.**

Rate, time and method of N fertilizer application all had no significant effect on leaf area per plant in cotton (Table 7). However, application of 90kg N/ha produced the largest leaf area at 12 WAS and so did the split application of N for the same time of leaf area measurement.

The interaction of rate x time of N fertilizer application at 16 WAS was statistically significant. All other interactions were not significant statistically.

Table 7: Leaf area of cotton in cm^2 as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)			
30	69.7	120.1	174.0
60	74.5	127.3	180.2
90	108.1	201.8	185.0
120	67.3	112.9	144.2
SE±	43.24	43.2	45.7
Time of N application			
3 WAS	76.9	177.7	135.6
3 and 8 WAS	98.5	120.1	139.4
8 WAS	84.1	122.5	98.5
SE±	48.1	7.20	43.2
Method of N fertilizer application			
Side dressing	67.3	112.9	120.1
Band placement	55.3	112.9	115.3
SE±	16.2	9.61	7.21
Interactions			
M x R	NS	NS	NS
M x T	NS	NS	NS
R x T	NS	NS	*
M x R x T	NS	NS	NS

NS = Not significant
* = Significant at 5% level

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

Table 8: Interaction bètween rate and time of N fertilizer application on leaf area (cm^2) in cotton at 16 WAS at Samaru, 1996

	Time of N application (WAS)		
N rate kg/ha	127.0b	112.6c	125.5b
30	124.6b	123.7b	122.8b
60	121.6b	130.3a	120.8b
90	111.5c	120.4b	100.9c
120			
SE		0.72	

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.7 Effect of time x rate of N application interaction on leaf area of cotton.

Effect of time x rate of N fertilizer application on leaf area at 16 WAS shows that a full dose application of 30, 60 and 90kg N/ha at 3WAS did not produce statistically significant different sizes of leaf area. However, they gave statistically larger leaf area than applying 120kg N/ha (Table 8). Split application of N at 3 and 8 WAS gave the smallest leaf area with exception of 4.07 when 90kg N/ha was applied. When N was applied at 8 WAS (full dose), at rate of 30, 60 or 90kg N/ha was observed to be significantly better than the application of 120kg N/ha in their effects on leaf area, although these were not significantly different from each other statistically.

Application of 30kg N/ha at 3 and 8 WAS (full dose) produced a significantly larger leaf area than split

application at 3 and 8 WAS. Application of 60kg N/ha produced the same effects at all the different times of N application. While the application rate of 90kg N/ha produced significantly larger leaf area when applied in split doses at 3 and 8 WAS compared to applying it all at 3 WAS and all at 8 WAS (full dose) both of which were not significantly different in their effects.

4.1.8 Leaf area index (LAI).

Rate of N showed significant effect on leaf area index (LAI) at 12 and 16WAS (Table 9). Superior leaf area index was produced at 90kg N/ha. Rate of N application did not influenced leaf area index at 8 WAS.

Time of N application significantly affected leaf area index at 12WAS. Application of N fertilizer at 3 and 8WAS gave the largest leaf area index of 6.43.

Methods of N application had no statistical difference on leaf area index when compared.

Interaction between rate and time of N application on leaf area index were observed to be statistically significant at 8 and 16WAS. All other interactions were not statistically significant.

Table 9: Leaf area index (LAI) as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	Weeks after sowing 8	12	16
N rate (kg/ha)			
30	0.73	1.25b	1.80b
60	0.78	1.33b	1.88b
90	1.13	2.1a	1.93a
120	0.70	1.18b	1.50b
SE±	0.44	0.6	0.04
Time of N application			
3 WAS	0.80	1.23c	1.40
3 and 8 WAS	1.03	1.25a	1.45
8 WAS	0.87	1.27b	1.23
SE±	0.25	0.1	0.24
Method of N fertilizer application			
Side dressing	0.70	1.18	1.25
Band placement	0.50	1.23	1.20
SE±	0.4	0.06	0.05
Interactions			
M x R	NS	NS	NS
M x T	NS	NS	NS
R x T	*	NS	*
M x R x T	NS	NS	NS

NS = Not singnificant
* = Significant at 5% probability level

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

Table 10: Interaction of rate and time of N fertilizer application on leaf area index (LAI) at 8 weeks after sowing.

	Times of N application (WAS)		
	3	3 and 8	8
Nitrogen rate (kg/ha)			
30	1.58f	1.52g	1.70d
60	1.80d	1.57f	1.63e
90	2.03c	2.30b	2.63a
120	1.47h	1.45h	1.40i
SE±		0.03	

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

Table 11: Intecration of rate x time of N fertilizer application on leaf area index (LAI) at 16 WAS at Samaru, 1996.

	Time of N application (WAS)		
N rate (kg/ha)	3	3 and 8	8
30	1.94b	1.61e	1.69a
60	1.86b	1.89b	1.90b
90	1.76c	1.87b	1.98aa
120	1.52f	2.01a	1.50f
SE±		0.08	

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.1.9 **Effect of rate and time of N application on leaf area index (LAI).**

The interaction of rate and time of N application on leaf area index at 8 WAS shows that application of N at 3WAS, 3 and 8 WAS split application and at 8 WAS full dose both at the rates of 30 and 60kg N/ha did not differ in their effects (Table 10). However, the leaf area index for application of 90kg N/ha was observed to be significantly higher at 8WAS than split application at 3 and 8 WAS, which in turn was significantly higher than full dose application at 3 WAS. Application of N at 3 WAS was significantly higher at 90kg N/ha than all the other rates tested. All the other rates tested were not significantly different from each other at 3 WAS.

At 3 and 8 weeks after sowing, split application of 90kg N/ha also gave significantly largest leaf area index than all the other rates. Applying 30, 60 and 120kg N/ha at 3 and 8 WAS split application did not produce significantly different leaf area index from each other.

Similar results were also observed when N fertilizer was applied at 8 WAS, because 90kg N/ha again produce significantly larger values of leaf area index than 30 and 60kg N/ha, which in turn were significantly larger than application of 120kg N/ha.

4.1.10 **Interaction between rate and time of N application on leaf area index (LAI).**

Comparing the interactions effects of rate and time of N application on leaf area of cotton at 16 WAS, it was observed that 30 and 60kg N/ha applied at 3 WAS produce significantly higher but similar values of leaf area than at 90 and 120kg N/ha. However, application of 90kg N/ha produced significantly larger leaf area than 120kg N/ha when applied as single dose at 3 WAS (Table 11).

Application of 90kg N/ha produced significantly larger leaf area than at 30, 60kg and 120 N/ha, applied at 8WAS. Application of 120kg N/ha produced the smallest leaf area.

With respect to time, the application of 30kg N/ha prcduced significantly large leaf area at 3 WAS than at 3 and 8 WAS (split) application and at 8 WAS. The leaf area for the single dose application of 30kg N/ha at 8 WAS was also significantly larger than at 3 and 8 WAS split application. The application of 60kg N/ha produced statistically similar result at all the three times of N fertilizer application tested. The application of 90kg N/ha produced significantly larger leaf area at 8 WAS, followed by split application at 3 and 8 WAS. The lowest value was obtained when 90kg N/ha was applied at 3 WAS.

4.1.11 **Number of days to 50% flowering and 50% boll opening.**

Rate, time and method of N application had no significant effects on days to 50% flowering and 50% boll opening (Table 12).

Interaction on days to 50% flowering and 50% boll opening were also not significant. Regardless of the rate of N application, and the time and method of its application, the cotton plant attained 50% flowering and boll opening at about 62 and 101 days after planting respectively.

Table 12: Number of days to 50% flowering and 50% boll opening of cotton as affected by rate, time and method of N fertilizer application at Samaru, 1996.

Treatment	50% flowering	50% boll opening
N rate (kg/ha)		
30	63.1	101.8
60	61.8	101.5
90	61.8	101.3
120	62.9	101.4
SE±	1.6	0.46
Time of N application		
3 WAS	61.9	101.4
3 and 8 WAS	62.6	101.9
8 WAS	62.6	101.3
SE±	0.52	0.40
Method of N fertilizer application		
Side dressing	62.2	101.3
Band placement	62.5	101.8
SE±	1.5	0.35
Interactions		
M x R	NS	NS
M x T	NS	NS
R x T	NS	NS
M x R x T	NS	NS

NS = Not significant

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.2 Effect of rate, time and method of N application on yield and yield components of cotton SAMCOT-9.

4.2.1 Number of bolls per plants.

Rate of N application had significant effect on the number of bolls per plant. Results showed that number of bolls per plant increased with increasing rates of N upto a rate of 60kg N/ha, after which this parameter remained unaffected by increasing rate of N application (Table 13).

Time and method of N application all had no significant effect on the number of bolls per plant.

Interaction effects on number of bolls also were not significant statistically.

4.2.2 Seed cotton yield.

Rates of N application had significant effect on seed cotton yield (Table 13). Result showed increase in seed cotton yield as rates of N were increased upto 60kgN/ha. Seed cotton yield was however not statistically different among N rates of 60, 90 and 120kg N/ha. A nitrogen application rate of 30kgN/ha clearly produced the lowest seed cotton yield per hectare.

Time and methods of N application and their interactions had no significant effect on seed cotton yield.

4.2.3 **Cotton seed yield.**

The rate of N application had significant effect on cotton seed yield (Table 13). Seed cotton yield, cotton seed yield and lint yield increase with increasing N up to 60 kg N/ha thereafter the increase remain unaffected statistically. Cotton seed and seed cotton yield were however not statistically different at N rates of 60, 90 and 120kg N/ha.

Similarly, time of N application had significant effect on the cotton seed yield. The application of N at 3 and 8WAS (split application) gave the highest cotton seed yield among the three application times tested. Application of N at 3WAS and at 8 WAS were statistically the same with respect to cotton seed yield. The method of N application did not influence cotton seed yield.

4.2.4 **Lint yield.**

Rate of N application had significant effect on lint yield (Table 13). Results indicate that lint yield was increased with increasing rate of nitrogen application upto 60kg N/ha, but lint declined as N rate was increased to 120kg N/ha. Statistically the lint yield obtained at 60, 90 and 120kg N/ha did not appear to have differed from each other.

Time and methods of N application and their interactions were all not significant in their effects on lint yield.

Table 13: Number of bolls/plant, seed cotton yield, cotton seed yield, lint yield, ginning percentage and seed index (100-seed weight) in cotton as influeneced by N rate, time and method of N application at Samaaru, 1996.

Treatment	No. of bolls/plant	Seed cotton yield (kg/ha)	Cotton seed yield (kg/ha)	Lint yield (kg/ha)	Ginning percentage (kg/ha)	Seed index (g)
N rate (kg/ha)						
30	7.0b	462.0b	296.8b	172.2b	36.8	6.5c
60	7.7a	556.0a	339.8a	200.1a	36.3	8.0b
90	9.2a	598.0a	374.2a	228.0a	36.7	9.3a
120	7.9a	516.0a	320.7a	185.0ab	36.1	6.6c
SE±	0.52	30.76	18.21	12.45	0.33	0.12
Time of N application (WAS)						
3 WAS	7.7	509.0	314.5b	183.1	56.5	7.2c
3 and 8 WAS	8.1	574.0	366.6a	212.7	36.8	7.6b
8 WAS	7.9	517.0	317.6b	197.6	36.1	7.9a
SE±	0.46	26.67	20.73	10.79	0.28	0.16
Method of N application						
Side dressing	8.2	542.0	334.7	202.4	36.5	7.7
Band placement	7.7	524.0	331.1	193.3	36.4	7.5
SE±	0.27	10.1	10.32	3.70	0.14	0.03
Interactions						
M x R	NS	NS	NS	NS	NS	NS
M x T	NS	NS	NS	NS	NS	NS
R x T	NS	NS	NS	NS	NS	NS
M x R x T	NS	NS.	NS	NS	NS	NS

NS = Not significant
* = Significaant at 5% probability level

Means followed by same letter within a treatment group are not statistically different at the 5% probability level according of DMRT.

4.2.5 **Ginning percentage.**

Neither rate, time nor method of N application or the various interactions among them was observed to have significant effect on ginning percentage of cotton. Ginning percentage ranged from 36.1 to 36.8% in value (Table 13).

4.2.6 **Seed index (100-seed weight).**

Rate and time of N application and their interactions were observed to have significant effect on seed index (Table 13). Results indicate significant increase in seed index with increase rate of N application upto a rate of 90kg N/ha after which it declined. Seed index was observed to be statistically the same for N rates of 30 and 120kg N/ha.

Application of nitrogen at 8WAS gave the highest seed index while application at 3WAS gave the lowest value of seed index. N applied either as side dressing or in band placement was observed to have made no difference statistically with respect to seed index. The various interactions between rate and method of N application for this parameter were not statistically significant. The interaction of method x time of N application for seed index was statistically significant.

4.3 Correlation among seed cotton yield, growth parameters and yield components.

The results of the partial correlation analysis between yield and growth parameters as well as yield components of cotton variety SAMCOT-9 are shown in (Table 14). Seed cotton

yield was significantly and positively correlated with plant height, leaf area and leaf area index at 12 WAS (r = 0.46, 0.60 and 0.71) respectively.

Cotton seed weight, lint weight, ginning percentage and number of opened bolls per plant were also significantly and positively correlated with seed cotton yield (r = 0.42, 0.45, 0.40 and 0.43) respectively.

Number of nodes per plant, number of leaves per plant, plant dry weight, number of days to 50% flowering and number of days to 50% boll opening did not significantly correlate with seed cotton yield at 12 WAS (r = 0.13, 0.23, 0.20. 0.10, -0.19 and 0.03 respectively).

CHAPTER FIVE

5.0 DISCUSSION

Yields of cotton in northern Nigeria have been generally low because of low levels of inputs, management, especially pests and disease control, and poor mineral nutrition, particularly that of N in savanna soils. High levels of production are seldom achievable without the application of commercial fertilizers. Response to applied N by the crop is expected, as the soil of the experimental site is low in N status, compared with average nitrogen values of 0.51% (Jones, 1973) and 0.040% (Balasubramanian et al., 1982). Optimum dosage and timing of N application have been reported to differ from place to,place depending upon soil type, climatic conditions and variety (Singh and Singh, 1971; Mudholkar and Ahlawat, 1973).

5.1 Effect of rates of N on yield and yield components of cotton - SAMCOT-9.

The vegetative characters, yield and yield components of cotton variety SAMCOT-9 responded to application of nitrogen. The significant and positive response of plant height, leaf area, leaf area index, dry matter weight seed cotton yield, cotton seed yield, lint yield and seed index were no doubt as a result of the N role in plant growth,. Nitrogen being a part of plant protoplasm, is particularly associated with meristematic activities and cell differentiation in cotton (Crowther 1934; Elliot et al 1968).

Table 14: Matrix of correlation of coefficient between seed cotton yield and various parameters of cotton SAMCOT-9 at Samaru.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.00													
0.28*	1.00												
0.38*	0.60**	1.00											
0.15	0.53**	0.35**	1.00										
0.30	0.16	0.29	0.08	1.00									
0.29*	0.16	0.38	0.10	0.64**	1.00								
0.06	0.40	-0.13	0.05	-0.16	0.15	1.00							
0.60	0.07	0.20	0.03	0.11	-0.05	0.17	1.00						
0.40*	0.18	0.25	0.20	0.14	0.22	0.00	0.03	1.00					
0.27*	0.36**	0.52**	0.20	0.31*	0.40*	0.13	0.31*	0.52*	1.00				
0.19	0.33**	0.46**	0.23*	0.28*	0.44**	0.12	0.15	0.45*	0.90**	1.00			
0.01	0.01	-0.06	0.22	0.01	0.06	0.33**	0.16	0.16	0.18	0.06	1.00		
0.11	0.14	0.15	0.26*	0.15	0.26*	0.06	0.18	0.48**	0.41**	0.36**	0.03*	1.00	
0.46*	0.13	0.23	0.16	0.60**	0.71**	-0.19	0.03	0.30	0.42**	0.45**	0.40**	0.43**	1.00

* = significant at 5% level of probability (r=0.232)
** = significant at 1% level of probability (r=0.302)

1 Plant height at (12 WAS)
2 Number of nodes/plant at (12 WAS)
3 Number of leaves/plant at (12 WAS)
4 Dry matter weight at (12 WAS)
5 Leaf area at (12 WAS)
6 Leaf area index at (12 WAS)
7 Number of days to 50% flowering
8 Number of days to 50% boll opening
9 Seed cotton weight/boll (g)
10 Cotton seed weight (kg^{-1})
11 Lint weight (kg^{-1})
12 Ginning percentage (%)
13. Number of opened bolls/plant (12 WAS)
14 Seed cotton yield (kg^{-1})

Response to applied N by cotton crop is also expected with the low soil N status of the experimental site (Table 1) compared to the average N value of 0.05% for the savanna soil (Jones, 1973).

Yield and yield components such as number of bolls/plant, seed cotton/ha were significantly increased by N application. Seed cotton yield/ha increased by increasing rates of N from 30kg N/ha upto an optimum dose of 60kg N/ha for variety SAMCOT-9. Increasing nitrogen rates beyond 60kg N/ha however, gave no significant yield advantage. This could be attributed to the fact that N rates of 60kg N/ha in addition to the small amount of soil N of the experimental site was adequate to meet the N requirement for optimum seed cotton yield.

Also the increased yield of cotton with higher levels of N which resulted from significantly higher number of mature bolls/plant, boll weight and cotton seed weight may be due to availability of more nutrients for growth and development. The availability of more nutrient also prolonged the growth and increased the number of bolls set. The present findings are at par with those of Singh and Singh (1971); Singh et al (1973); Ahlawat et al (1973) and Memon et al. (1975) who found optimum doses of N to be 95kg/ha and 94kg/ha for varieties J205 and Lohit respectively.

Nitrogen rate also significantly affected plant height in the present study. This is in agreement with what was

reported by Verma et al., (1965) and Reddy and Rao (1973) who obtained significant plant height to N application. Seed index was also significantly affected by higher doses of N upto a maximum of 90kg N/ha as has been reported by Spence (1959) and Singh and Dargan (1965).

Yield and yield components such as number seeds/plant, seed cotton weight/boll and number of seed/boll have also been reported. Ogunlela et al. (1982) reported increased yield and yield components of cotton with increasing rates of N in which seed cotton yield was increased mainly through increasing boll number per plant. Also working in southern Guinea savanna of northern Nigeria, Idem (1984) obtained positive and significant influence of N application on yield and yield components of cotton such as number of bolls/plant, average boll weight and number of seed/boll.

Mackenzie and Van Shaick (1963) reported the highest cotton yield from the application of 144.0kg N/ha in California, while Koli and Morrill (1976) recorded a reduction in yield with the application of 90kg N/ha.

The present study is at par with studies earlier conducted in northern Nigeria by Palmer and Goldsworthy (1971), Smithson and Heathcote (1977), Lombin and Ogunlela (1979) and Lombin and Mustapha (1980) who observed that it was then not possible to obtain significant response of upland cotton to N application rates higher than 53kg N/ha.

The low yield values in the present study compared to expected values for cotton within this region could be attributed to late sowing as a result of which pests and disease damage as well as moisture stress decreased yield as reported by Hayward (1972) and Bland and Dugas (1989) when working on late sown cotton in Nigeria.

The significant response in growth, yield and yield components of cotton to application of N in this study and in various studies cited, further illustrate the important role of N in seed cotton yield by producing vigorous plants with better developed assimilatory surface areas as well as increase in productive and fruiting sites.

ABSTRACT

5.2 **Effect of time of N application.**

Attributes such as plant height, number of node/plant, number of leaves/plant, dry matter weight/plant, leaf area, cotton seed and seed index differ significantly due to time of N application. Leaf area index, number of days to 50% flowering and 50% boll opening, number of bolls/plant seed cotton, lint yield and ginning percentage were however observed not to differ due to time of N application.

There was highly significant difference between applying N in single dose at 3 WAS and 8 WAS after sowing and as split at 3 and 8 weeks after sowing. Application at 3 and 8 WAS as split gave the highest and statistically significant yield over application at 3 WAS and at 8 WAS, This is in agreement

with the findings of Smithson and Heathcote (1977) who found and recommended that N fertilizer should be applied either at flowering or in two splits at 3 and 8 WAS. The reason for the highly significant difference in N application as split at 3 and 8 WAS as against a full dose at 3 WAS or at 8 WAS could be attributed to the availability of the nutrient to the early stage of growth for good vegetative growth and at the later stage for a good reproductive growth as was explained by Ogunlela et al. (1982). The present study also reveals that application of N at 3 WAS and at 8 WAS as single dose produced cotton yields which were not significantly different from each other.

There was no significant difference between N application at 3WAS and at 8 WAS as full dose with respect to leaf area, leaf area index, number of bolls per plant, seed cotton yield, lint yield and ginning percentage.

Dry matter production was significant to N application only at 16 WAS. This suggests that when N is applied early to cotton the tendency is for this nutrient to be used by the plant for vegetative development rather than for reproductive development. This finding rather corroborates that of Smithson and Heathcote (1977) who had earlier reported that cotton frame weights were greater when N was applied at thinning rather than at flowering. They concluded, therefore that early applied N must have been incorporated into the vegetative growth and would therefore not be available for the

crop during the reproductive phase.

5.3 N application method.

Yield and yield attributes did not differ due to methods of N fertilizer application. Both side dressing and band placement gave similar results. Reasons for the similarity in the yield and yield attributes of cotton with respect to methods of N application could be attributed to the fact that both methods used were the same placement methods of fertilizer application only that the application differed with reference to the plants.

5.4 Interactions.

5.4.1 Time x methods of N application.

The highest values obtained for number of nodes/plant (4.4) as a result of the significant interaction between N application rates and methods of N application could be attributed to the fact that application of N at 3 and 8 WAS (split application) provided sufficient nutrient at the initial and later growth stages of the cotton plant which enabled the crop to absorb the soil N thereby producing higher nodes/plant. Side placement also allowed more of the cotton roots to come in contact with the nitrogen in the soil and consequently enhanced its absorption.

5.4.2 **Rates x time of N application.**

The highest value for leaf area (4.07cm^2) was as a result of significant interaction between rates of nitrogen application and time of N application could be due to the fact with 60kg N/ha applied as split at 3 and 8 WAS to the cotton plant was able to get a good starter dose and again when this was exhausting in the soil another was provided at the later growth stage for nourishment. The 60kg N/ha application rate appears to be the optimum dose of N for the cotton plant growth under the present study situation.

5.4.3 **Method of N application x rate of N application.**

The high values (10.0g) of seed index obtained as a result of the interaction between methods and rate of N application could be attributed to the fact that 90kg N/ha was a sufficient quantity of nitrogen using side dressing for maximum production of seed index. With this rate nitrogen could be assumed to be available for the crop in sufficient quantity throughout its life cycle in conjunction with applying it by side dressing methods.

5.5 **Correlations.**

The highly significant and positive correlations observed between seed cotton yield and plant height, leaf area, leaf area index, cotton seed weight, lint weight, ginning percentage and number of opened bolls could be attributed to the fact that all these parameters are important determinants

to photosynthetic activity and translocation of assimilates, and hence high seed cotton yield.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION.

A field experiment was conducted at the Institute for Agricultural Research Farm at Samaru, Zaria during the 1996 rainy season to investigate the effect of rate, time and methods of nitrogen fertilizer application on the yield of cotton (Gossypium hirsutum L.) variety SAMCOT-9. The treatments consisted of four N rates (30, 60, 90 and 120kg N/ha), three timings of N fertilizer application (3 WAS as full dose, equal split doses at 3 and 8 WAS and 8 WAS (full dose) and two methods of application (side dressing and single band placement). The N rate and time were factorially combined and laid out in a split-plot design with three replications.

Cotton characters, namely; plant height, dry matter weight, leaf area index, number of bolls/plant, seed cotton yield/ha, cotton seed yield/ha, lint yield and seed index were observed to increase with increasing N rate upto the highest dose of 60kg N/ha. Yield and yield components were observed to increase significantly with increase in N rate.

Number of nodes/plant, number of leaves/plant, leaf area, leaf area index and ginning percentage, however gave no statistically significant difference with the different rates of nitrogen application.

Similarly, growth chracters, yield and yield component

increased significantly with different timings of N application. Plant height number of nodes, number of leaves, dry matter weight, leaf area index, cotton seed yield and seed cotton index had significantly high values with N fertilizer application as split at 3 and 8 weeks after sowing. Leaf area, number of days to 50% flowering, 50% boll opening, number of bolls/plants seed cotton, lint yield and ginning percentage were statistically similar with respect to the different timings of N application.

Methods of N fertilizer application did not differ statistically. Both side dressing and band placement were observed to be the same in their effects on cotton yield.

Based on the findings, it can be concluded that yield benefits can be obtained from the use of 60kg N/ha as split application at 3 and 8 weeks after sowing. Application beyond 60kg N/ha gave no additional yield benefit.

7.0 APPENDIX.

Appendix 1: Total rainfall, maximum and minimum temperatures and relative humidity at ten-day intervals during the period of the experiment at Samaru, 1996

Months	Days	Total Rainfall (mm)	Maximum t^0C	Minimum t^0C	Relative humidity 10.am	4.pm
June	21 - 30	18.4	29.8	18.4	75.7	61.3
July	1 - 10	99.6	28.4	19.3	55.6	55.6
	11 - 20	65.4	27.6	16.4	74.4	57.9
	21 - 31	69.5	27.3	19.4	73.4	74.9
August	1 - 10	30.8	28.4	20.0	80.1	70.6
	11 - 20	115.6	26.9	19.0	83.4	76.6
	21 - 30	120.6	28.0	19.0	82.6	70.0
Septem.	1 - 10	79.8	29.4	21.0	81.9	69.6
	11 - 20	59.7	30.2	19.3	81.9	69.6
	21 - 31	34.2	30.4	19.7	80.3	69.6
October	1 - 10	28.7	31.6	20.0	78.7	60.2
Total		722.3mm				

Source: Meteorological Unit, IAR, Samaru

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