YIELD AND YIELD COMPONENTS OF COTTON AS AFFECTED BY SOWING DATE, ROW SPACING AND PLANT DENSITY AT SAMARU

BY

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A thesis submitted to the Postgraduate School, Ahmadu Bello University in Partial fulfillment of the requirements for the Award of the Degree of Master of Science in Agronomy

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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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CERTIFICATION

This thesis entitled 'Yield and yield components of cotton as affected by sowing date, row spacing and plant density' by Chigbundu, Ignatius Ngozi 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 the Memory of my beloved late mother, Patricia Mberumma Chigbundu, who passed on when this research work was about to be completed and to Miss Gladys Chigbundu, who sacrificed her resources to see the completion of this thesis.

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ABSTRACT

A field experiment was conducted at Samaru, Nigeria during the 1990 wet season on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University (11^{o} 11^{1} N $07^{o}38$ 'E and 685m above sea level) in the Northern Guinea Savanna ecological zone. The main objective was to study the effect of sowing date, row spacing and plant density on yield and yield components of an elite cotton line variety 'SAMCOT-9'. Combination of two sowing dates (mid-June and mid-July) and four spacings (30,60,90 and 120cm) were used as the main plot treatment and two plant densities (50,000 and 100,000) plant ha^{-1} were assigned to the sub-plot.

Mid-July sown cotton markedly depressed seed cotton yield by a 60% margin when compared to mid-June sown cotton. The cotton variety therefore responded favourably to early sowing.

Seed cotton yield did not increase significantly with increase in plant density from 50,000 to 100,000 plants ha^{-1}; with only a marginal increase of 8% being obtained in favour of 100,000 plants ha^{-1}. The plant density of 50,000 plants ha^{-1} therefore, seems appropriate for this variety in this environment since the marginal increase in yield from additional 50,000 plants ha^{-1} cannot justify the extra time and input.

Row spacing had no significant effect on seed cotton yield. A 60cm row spacing gave a seed cotton yield that was 16.9, 18.6 and 25.3% higher than those for 30, 90 and 120cm spacings respectively.

Fibre quality of cotton in terms of length uniformity ratio, span effective length, maturity ratio, bundle strength (tenacity), micrononaire value and pressley index were significantly affected by sowing date. Significant interactions between sowing date and density were observed for yield contributing characters such as, number of fruiting points at 11 and 15 weeks after sowing, (WAS) number of mature bolls per plant, and number of shed boll per plant and plant height at 15 and 19 WAS.

Significant and positive correlations were found between cotton yield, and lint weight, seed weight and 100-seed weight. Similar trend was observed between cotton yield and number of fruiting points per plant and total dry matter per plant. Most of these yield related characters were also strongly associated.

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ABBREVIATIONS AND SYMBOLS USED

WAS	...	...	Weeks' after sowing
kg	...	...	kilogramme
g	...	...	gramme
ha^{-1}	...	...	per hectare
m^2	...	...	metre square
cm	...	...	centimetre
ppm	...	...	parts per million
%	...	...	percentage
LAI	...	...	leaf area index
NS	...	...	not significant
*	...	...	(P = 0.05) significant
r	...	...	simple correlation coefficient
LSD	...	...	Least significant difference
$SE_{\pm}$	...	...	Standard error of the mean
TDM	...	...	Total dry matter
Max.	...	...	Maximum
Min.	...	...	Minimum
hr.	...	...	hours
NB	...	...	Nota bene (Note).
D.M.R.T.		...	Duncan's multiple range test.
g/tex.	...	...	gramme per - tex.
Mgm/inch	..	...	Micro gram per-inch
U.L.V.	...	...	Ultra-low volume
I.A.R.	...	...	Institute for Agricultural Research
./'	...	...	Minutes
0^{o}.	...	...	degrees.
^{o}F.	...	...	degree Fahrenheit.
^{o}C.	...	...	Degree Centigrade.
E.	...	...	East.
N.	...	...	North.
'000,ha^{-1},		...	Thousands per hectare.
ET.	...	...	Evapotranspiration
R.H.	...	...	Relative humidity.

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Chapter 1

INTRODUCTION

1.1 Distribution and Area of Production in Nigeria

Cotton (Gossypium hirsutum L) is a major cash crop of Nigeria, where there has been cultivated three species that have been used in production. The first is the G herbaseum, which was grown in Iseyin and former kano districts for home consumption. The second group of cotton in production includes, those imported from the new world, namely, G. hirsutum and G. barbadense, which are better adapted to the savanna ecological zone. The most important type is the modern American upland cotton, whose production spread all over Nigeria after the second world war. The British cotton Growers' Association (BCGA), otherwise known as the Empire Cotton Growing Corporation; financed the first cotton project of about 20,000 hectares at Moor-plantation, Ibadan for the purpose of growing cotton for the British textile industry (Williams, 1978).

Though the Scheme failed it had tremendous impact on cotton research and production in Nigeria(Williams, 1978). Through breeding and genetic improvement however, the imported varieties gave rise to the 'Nigeria Allen'and later, the 'Samaru Allen'. Several Commerical varieties such as 'Samaru 26C', 'Samaru 70', 'Samaru 71' and 'Samaru 72' have since been developed at IAR, Samaru and distributed to farmers (Anon., 1985a).

Presently, however, the bulk of the Nigerian cotton crop is grown in the northern states (covering an approximate area of 700,000sq km) which extends from latitude 7° 30'N to latitude 13°N (Kumar and Ogunlela, 1982). This production belt is divided into three zones namely, the northern cotton zone comprising parts of Kebbi, Sokoto, Niger, Kaduna, Kano, Katsina, Jigawa, Plateau States which together contribute 60% of the total national production; the 'eastern cotton zone' which covers Bauchi, Adamawa, Taraba, Yobe and Borno States and contribute 30 - 35%. About 5 - 10% of national cotton out-put comes from the 'southern cotton zone' made up of Niger, Kwara, Kogi, Benue and Plateau States (Idem, 1984).

1.2 Economic Importance and Constraints to Production

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, despite the extensive use of synthetic fibres (Martin et al., 1976). The national annual production of cotton in Nigeria between 1969 and 1985 ranged between 150,000 bales and over 500,000 bales (1 bale = 181.4kg net weight). In 1969/70, cotton production contributed 2% of the total export and fetched a foreign exchange of 17.3 million naira (Idem 1984).

The projected national demand in the mid '80 was 800,000 to 1000,000 bales of lint (Faulkner, 1974). It was

projected that by 1990 Nigeria would be self-sufficient in cotton production (Anon., 1971). However, despite all the efforts taken to improve the production of cotton (King, 1955; Lawes, 1963; Brown, 1971; Kumar et al., 1982; Kumar and Ogunlela, 1982; Ogunlela et al., 1982; Idem, 1984; Anon., 1985a) Nigeria is yet to attain the projected estimate. Many reasons have been advanced for the failure to attain the projected estimate. These include the fact that population has increased tremendously since the last decade with the demand for cotton and its home-made products being on the increase, while the production level is on the decline. This is perhaps due to the shift in emphasis from the production of cash crops to that of food crops. Other reasons include delayed planting, vagaries of weather (rainfall, temperature etc), pest and disease outbreaks, low soil fertility, and other management problems.

These problems not withstanding, cotton is important to man because it is from it that yarns, which are utilized for the manufacture of textile fabrics, are made. In industries, it can be used in the manufacture of awning, bags, felts, belts, hose, and twine. The fuzz, when specially processed, can be used in the manufacture of carpets, photofilms and papers while the short lint is used for batting, wadding and stuffing (Martin et al., 1976). Apart from these, cotton seeds contain about (20 - 27%) of non-drying oil iodine number - 102) which

is used for food, about (7 - 8%) of the total oil is used in the production of margerine through the process of hydrogenation. It is also used in soap-making. Cotton seed cake, a by-product of oil extraction, contains a high percentage of protein, which when gossypol glucoside is removed, can be used as cotton seed meal, a component of livestock and poultry feeds. The shell of the cotton seed contains alcohol and citric acid. The leaves can also produce acids, which act as a plasticizer to control hardening of cement. Cotton seed oil is important in the paint industry and in the field of medicine, where the gossypol derivative is used to promote tissue compactibility in kidney transplant. In other words, virtually every part of the cotton plant has some economic value.

1.3 Justification and Objectives

Considering the importance of cotton in the Nigeria economy and as a result of very elaborate textile industry of Nigeria, the existing local production level of cotton is still not able to adequately meet the lint requirements of our existing textile mills. There is therefore, a great need to increase the level of production of seed cotton so as to increase the capacity of local sourcing and thus, drastically out-down on level of lint importation.

Seed cotton production is facing many problems in Nigeria. Consequently, joint efforts by experts have been made regularly in order to solve such problems but, since the release of two cotton varieties, 'Samaru 71' and 'Samaru 77'

(now renamed 'SAMCOT-6' and 'SAMCOT-8' respectively by I.A.R. Samaru) and their subsequent recommendation for cultivation in the northern and eastern cotton growing zones of Nigeria, no other new commercial variety has been released. However, only recently were two advanced lines, 'SAMCOT-9' and 'SAMCOT-10' bred at IAR have been found to be better yielding than the existing varieties and are being seriously considered for release as new commercial varieties (Anon, 1985; Echekwu and Ogunlela, 1990).

Prior to the official release of these lines to the farmers, the plant population and other cultural and management practices for optimum production would need be established. It is for this reason that the present research work was proposed with the objective of determining the effect of sowing date, spacing and density on the yield and yield components and also to run correlation analysis between yield and some components of yield of one of these elite cotton line, 'SAMCOT-9'.

Chapter 2

LITERATURE REVIEW

Extensive research work has been done on cotton in Nigeria over the years and indeed in many other Countries. However, little or no information on the agronomic aspects of this particular variety, SAMCOT-9 exist.

2.1 Sowing Date

The date at which seed is sown, to a greater extent, determines the number of flowers and bolls per plant, the ability of the crop to mature early, to survive drought in areas of low rainfall, to avert pest and disease infection and generally increase in the quality and quantity of yield. Sowing date trials conducted at the Institute for Agricultural Research, Samaru, Zaria, Nigeria and elsewhere have confirmed that yield and quality of G. hirsutum cotton declined with delay in sowing (Lawes, 1968; Brown, 1971; Ogunlela, 1981; Kumar et al., 1982; Idem, 1984; Anon, 1985b). Lawes (1968) even, observed that with late sowing, if not followed by unusual prolongation of the rainy season, the crop is likely to experience unfavourable soil moisture supply, which ultimately shortens the reproductive phase of the crop. Kumar and Ogunlela (1989a) made similar observations on cotton in the Nigerian Savanna. They observed that low yields of

cotton could result from fluctuations in local and seasonal climatic conditions, and advised that sowing be done from June to July so that crops could make use of adequate moisture. Since cotton bolls and seed cotton grade may be adversely affected by heavy rains after boll opening and/or the flowers abort during prolonged drought, care should be exercised in choosing the planting dates for cotton so that the sensitive growth phases do not coincide with extreme periods. Another sowing date trial conducted at Samaru using new cotton varieties 'SAMCOT-9' and 'SAMCOT-10' showed that mid-May sown cotton significantly out-yielded mid-June (the recommended time) and mid-July-sown cotton by 14 and 70% respectively (Anon., 1985b). However, the problem encountered by sowing in May is that there may not be adequate moisture in the soil during that month.

Sobhan (1979) observed the effect of planting date on growth and yield of upland cotton in Bangladesh and found that the highest cotton yield and ginning out-turn were obtained when cotton was planted early in the season (first week of September) than when they were planted later. Beltrao et al. (1979) made a similar observation in Brazil. Ogunlela et al. (1984) conducted research in the Southern cotton growing zone of Nigeria, and indicated that the optimum sowing date for the crop was mid-June to mid-July for Lafia and Mbatie and that for each day that

sowing was delayed, seed cotton yield was markedly reduced by 12.3 kg seed cotton ha^{-1}. Galanopoulou-sendouka et al. (1980) determined the effect of planting date and genotype on plant growth and development of cotton and reported that early sowing over-came the effect of reduced and prolonged seedling emergence, produced earliness in maturity and increased yield particularly in short seasons. In India also, studies by Misra and Malik (1980) on growth, yield and qualitative behaviour of six varieties of cotton and their response to planting date showed that all the cultivars gave high seed cotton yield average of 1.12 tonnes ha^{-1} when sown early compared with those sown later. Singh (1979) investigated the effects of advanced sowing dates in India and also observed that seeds sown in dry soils 7-15 days before the unset of monsoon rains, increased seed cotton yield by 7-10% whereas the normal sowing at the onset of rains significantly decreased yield. Furthermore, it was proved that in areas of scanty rainfall, higher yields to the tune of 31 - 39% can be obtained by advanced sowing when compared to delayed sowing 15 days after the normal sowing date. In Malawi, Seroya et al. (1980) sowed and irrigated cotton cultivars G129, 82 and 66 respectively in early March and April. Their result proved that early sowing increased the lint percent, fibre fineness and fibre strength. In Pakistan, Mitchaiwala et al. (1980) investigated the effects of sowing date over a 4 - year

period and made similar observations that late sowing of cotton led to reduced yield.

2.2 Row Spacing

Spacing of individual stands of a crop determines, more than any other single factor, the resources available to each plant and therefore affects yield. Bleasdale (1978) opined that wide spacing can delay the unset of competition and enable crops make better use of land. With widely spaced rows, neighbouring crops will compete with each other long enough before they can use the inter-row. Tupper et al. (1977) had earlier indicated that cotton seed yields were adversely affected by a 15 - inch row spacing when nitrogen level is low. El - Hattab et al. (1978) investigated the response of two Egyptian cultivars to plant density and observed that spacing per hill had no significant effect on boll weight, lint per cent, seed and leaf indices for both cultivars. Gobenberg et al. (1977) compared the sowing of cotton in wide rows with that of paired rows and found that cotton grown in paired rows gave an average seed cotton yield that was 300kg ha^{-1} higher than that grown in wide rows.

Both vegetative and fruiting branches formed have been found to respond to the amount of space available

to the plant and the number of branches formed is a function of plant height. Therefore, in order to obtain a higher yield, Idem (1984) was of the opinion that fewer branches are desirable on the cotton plant and that the bolls should be borne on the main axis with few of the branches located high up the plant. Williford et al. (1986) after evaluating a 76-cm row cotton production reported that cotton yield was influenced not only by year, irrigation and variety but, also by row spacing; although, fibre yield and quality were found not to be influenced by row spacing. Shavkievet and Karymok (1976) compared the effects of wide rows for cotton under irrigated conditions in Uzbekistan, and obtained the highest seed cotton yield of about 3.35 tonnes ha^{-1} using a 90 x 15cm spacing with 3 plants/hill, a yield that was 820kg ha^{-1} higher than the standard (60 x 50cm) with 2 - 3 plants/hill. Gerick (1981) did not find significant cultivar x row spacing interactions for the total number of flowers and bolls produced in a trial with three short-season cotton cultivars but cultivar x population interactions were significant. Abdel - Fattah et al. (1980) discovered that planting 3 plants per hill with 20cm between hills resulted in the highest seed cotton yield and highest bollworm infestation, when the effect of spacing and density of cotton as a factor affecting population of boll-worm was investigated. El-Rahman et al. (1980) in Mississippi delta reported that cotton yield was

influenced by year, irrigation and row spacing. Combination of row spacing of 76cm and irrigation resulted in a higher lint yield than in 102-cm row and irrigation. Although fibre properties were not influenced by row spacing, percentage gin turn-out was significantly higher for the 76-cm row than it was for the 102-cm row, with an average difference of one per cent.

Baker (1976) investigated the effects of narrow row spacing on yield and yield components of cotton over a 3-year period using cultivar 'Coker 310' and observed that there was no significant difference in yield, earliness in maturity, lint % and bundle strength between narrow - row and the check. Constable (1977) determined the effect of variety and row spacing on growth of cotton and found that the use of narrow (19cm) row resulted in a higher early season leaf area index than the use of 100cm row but, the difference was no longer apparent by the flowering stage. Wanjura and Bilbro (1977), using cotton cultivar 'Tamcott 788' showed that plants within row spacing in the range of 5-40cm in rows 102cm apart and date of emergence of 5-10 days, affected average plant height and number of main stem nodes, squares and bolls and the coefficient of variation of these characters. Variability was different for each character and this changed over time.

Hawkin and Peacock (1973) indicated that narrow rows could result in higher plant density thereby maximising yield of cotton. The use of narrow rows brings about increased earliness in maturity, which leads to evasion of some insects that normally appear late in the season thus increasing lint and seed cotton yields. Ahev et al. (1980) used cotton hybrid 'H - 4' to determine the effect of different spacings, nitrogen levels and times of application on yield using 60 x 60cm spacing with a density of 55, 564 plants ha^{-1} (2 plants per hill) and obtained a seed cotton yield that was higher than when 90 x 60cm spacing, 37036 plants and 80kg of N ha was applied in 3 - split doses. Malik and Malik (1986) investigated spatial response of contrasting cotton cultivars grown under semi-arid conditions and found out that number of bolls per plant increased linearly with increased spacing. A 5cm intra-row spacing produced the smallest bolls. This result further indicated that, for that environment, the optimum within-row spacing for yield is probably 17cm, if the distance between rows is one metre. Roger et al. (1976) on the other hand, studied the influence of row spacing on weed competition with cotton and observed that the highest seed cotton yield (2.75tons ha^{-1}) was obtained with a 6 - week weed-free period although a higher yield (3.2tons ha^{-1})

was achieved when crops were weed-free for the entire growing season at 76cm and 106cm row spacings respectively. Yields of about 5.3 and 5.41 tonnes/ha were obtained by Yuldershev and Ibragimov (1976) on a double row trial in Uzbek while in the Philippines, Manuel and Lingas (1973) showed that maximum yield of cotton could be obtained by planting at a spacing of 100 x 40cm.

2.3 Plant Density

Moursi (1974) indicated that the ability of plants to use environmental factors to build their tissues and convert these into economic end-products can be influenced by plant density. The recommended density for early sown cotton in Nigeria is 50,000 plants ha^{-1} (Anon, 1985b; Ogunlela, 1981). King (1955) also observed no significant yield increase when plant density of sprayed cotton was increased from 50,000 plants ha^{-1} to a higher plant density, while Lawes (1963) reported increase in yield with higher density. Increasing plant density by 100,000 plants ha^{-1} over the recommended 50,000 plants ha^{-1} gave an increase of seed cotton of 30% in late-sown cotton (Anon., 1988). Koli and Morill (1976) determined the effect of plant density on leaf area and leaf area index and reported that densities achieved through narrow rows produced large leaf areas very early in the season while Kerby and Buxton (1978) reported that leaf area per plant dropped from 32.2 to 23.4 dm^2 when plant density was increased from 11.2 to 18.5

plants per m^2 respectively in 1973 and from 35.8 to 20.8 dm^2 under 10 to 20 plants per m^2 respectively in 1974. Loomis and Williams (1963) showed that the proportion of incident light intercepted by canopy does not depend on LAR alone but, also on the architecture of the plant community. MacNamara et al. (1940) opined that leaf type and density affect normal rate of fruiting position and appearance of fruits and earliness in cotton, but changes in temperature found in the field may have little effect on plastochrons. Plastochrons however, tended to increase with increase in spacing.

Galanopoulou -Sendouka et al. (1980) determined the effect of plant density, planting date and genotype on cotton plant growth and development and found that both planting date and density of plant influenced to a large extent growth and development. The influence of density was expressed mainly on the morphological characteristics and yield components. They however, concluded that increased plant density reduced plant growth and productivity. Smith et al. (1978) found that plant population had little effect on lint per cent but plants under a lower plant density mature significantly later than did those of higher density. In other words,

a higher plant density enhances crop earliness in maturity. Brown (1971) in the northern Nigerian observed no linear relationship between yield and density with plant densities that are higher than the recommended 50,000 plants ha^{-1}. He opined that the local varieties had the ability to compensate for lower density by producing more bolls per plant. Plants growing under higher plant densities produced fewer fruiting points and bolls due to shedding. This observation was more apparent in the sympodial with the effect becoming progressively less towards the top of the plant; subsequently resulting in a smaller harvest ratio, from plants grown at higher densities (Tanner and Leon, 1962; Idem, 1984). It is therefore, conjectured that a higher plant density for adequate vegetative cover of the ground surface at flowering stage can lead to higher seed cotton yields.

In a rainfed trial which was conducted for four years with cotton grown at plant densities ranging between 250,000 and 750,000 plants ha^{-1}, 15 or 30cm wide-row spacing of at 120,000 plants per stand in 60cm rows, the control. Dushev and Nikolov (1980) reported that average seed cotton yield at 250,000 plants ha^{-1} in 15 cm rows was 8.2% higher than in the control. A higher plant density accelerated maturity in the year in which metorological factors limited length of growing period. Contrarly, Abrarov and Ibragimov (1976) reported that increase in plant density delayed maturation, but increased seed cotton yield. Furthermore Fowler and Ray (1977)

found no evidence that higher population densities in equidistant spacing patterns improve earliness in maturity or yield but reported a probable earlier maturity and higher lint yield with intermediate densities of 79,000 and 155,000 plants ha^{-1}. Studying the effect of plant density on the growth and dry matter yield of cotton, Koli and Morill (1976) reported that increased plant density reduced the volume of air and soil for individual plants and therefore, increased inter-plant competition for soil, nutrient, moisture, carbon dioxide and light. Bleasdale (1978) was also of the same opinion that increased plant density increased inter-plant competition. Koli and Morill (1976) added that in widely spaced plants, there was linear increase in dry matter production per plant as density increased due to lack of appreciable inter-plant competition. A further increase in density beyond that considered optimum, would bring about diminishing returns.

Idem (1984) reported that cotton because of its ontogeny tends to compensate for variations in stand densities in the field by reducing the production of branches and fruits in accordance with the space available, because of this characteristic, the optimum plant density is a range of densities which in the case of cotton, is dependent on environmental factors, time of planting and location.

Chapter 3

MATERIALS AND METHODS

The experiment was conducted during the 1990 wet season on the experimental farm of Institute for Agricultural Research, (IAR), Ahmadu Bello University at Samaru ($11^{o}11'N$; $07^{o}38'E$, and 685m above sea-level) in the northern Guinea Savanna of Nigeria.

3.1 Experimental design, Treatments and Plot size

The experiment was carried out using a split-plot design. Combination of two sowing dates (mid-June and mid-July) and four row spacings (30, 60, 90 and 120cm) were used as the main plot treatment while two plant density levels (50,000 and 100,000 plants ha^{-1}) achieved by using 30 x 135cm^2 or 60 x 68 cm^2 or 90 x 45cm^2 or 120 x 34 cm^2 inter-row and intra-row spacings for the 50,000 plants ha^{-1} and 30 x 68cm^2 or 60 x 34cm^2 or 90 x 22.5cm^2 or 120 x 17 cm^2 inter-row and intra-row spacings for the 100,000 plants ha^{-1} were randomised and assigned as the sub-plots treatments. There were 16 treatments which were randomised and alloted to 48 plots. The experiment was replicated three time.

The gross and net plot sizes were 48.6m^2 and 24.3m^2 respectively. The gross plots consisted of 4,6,9, and 18 rows of 9m long and 5.4m wide each for the 120, 90, 60 and 30cm spacings respectively.

3:2.1 Soil sampling and analysis

Soil samples were taken from each of the experimental plots prior to cultivation at a depth of 0 - 30 cm and bulked. The samples after drying and grinding were analysed for total N, by micro-Kjedahl method (Bremner, 1965). Phosphorous after extraction by Bray-P-1 extraction method was determined by ammonium molybdate - blue method (Bray and Kurtz, 1945). After extraction of exchangable base, calcium and magnesium were determined by atomic absorption spectrophotometry while sodium and potassium were determined by flame emission spectrophotometer. Cation exchange capacity was determined using 1N ammonium acetate (pH 7.0) saturation followed by displacement of absorbed ammonia (Chapman, 1965). The physical analysis was done by the hydrometer method (Day, 1965). The results are presented on table 1.

3.2.2. Land Preparation

The land was ploughed and harrowed but ridges were not constructed initially because the experiment was established on the flat to enable the researcher to achieve the desired row spacings and plant densities. However, ridges were later constructed, after the plants had been well established.

Table 1: Physico-chemical properties of soil from experiment site

Physical property	
Sand (%)	52.5
Silt (%)	37.0
Clay (%)	10.5
Soil textural class	Sandy loam
Chemical Property	
Soil pH (H_2O)	5.1
Soil pH (0.01, $CaCl_2$)	4.4
Organic carbon (%)	0.6
Total nitrogen (%)	0.03
Available phosphorous (ppm)	15.1
Exchangeable Sodium (Na) (meq/100g of soil)	0.07
Exchangeable Potassium (K) (meq/100g of soil)	0.15
Exchangeable Calcium (Ca) (meq/100g of soil	1.5
Exchangeable Magnesium (mg) (meq/100g of soil)	0.4
Cation exchange Capacity (ECE) (Meq/100g of soil).	3.1

3.2.3 Fertilizer application

Boronated superphosphate and muriate of potash were uniformly incorporated into the soil before planting at the rates of 25kg P_2O_5 and 50kg K_2O ha^{-1} respectively.

Nitrogen fertilizer was also applied as calcium ammonium nitrate at the rate of 60kg N ha^{-1}. Half of the quantity of the nitrogen fertilizer was applied during the pre-sowing operation while the remaining quantity was applied at the beginning of flowering i.e about 8 weeks after sowing. The N- fertilizer was uniformly placed in holes about 8cm deep and 8 to 10 cm away from the seedlings and covered with soil.

3.2.4 Stand Establishment

Stands were established on the 15 June, 1990 for June - sown cotton and 15 July, for the July planting date. Four seeds of cotton variety 'SAMCOT-9' which was supplied by the fibre Breeding Unit of I.A.R were planted per hole and later thinned down to two plants per stand at 3 weeks after sowing.
The missing stands were supplied 2 weeks after sowing.

3.2.5 Weed control

Weeds were controlled by means of pre-emergence application of diuron + alachlor at the rate of 0.8 kg 1.5 kg a.i ha^{-1} using a knapsack sprayer. This was followed by two supplementary hoe-weedings at 6 and 8 weeks after sowing. This operation was done shortly before top dressing with the nitrogen fertilizer.

3.2.6 Pest control

Cypermethrin 1.8% ULV was applied to control insect pests at the rate of 2.5 litres ha^{-1}. This was sprayed at 2-weekly interval starting from 10 weeks after sowing, till 16 weeks after sowing.

3.2.7 Harvesting

The crop was harvested by picking of seed cotton from plants in the net plots. A total of 3 pickings was done to completely harvest the experimental plots.

3.3 Observations

Observations on growth parameters were made at 7, 11, 15 and 19 weeks after sowing. Samples for non-destructive growth alalysis were taken randomly from each of the net plots whereas those for destructive analysis were taken from the border rows adjacent to the net plot. The samples consisted of 2 or 4 plants for the two plant density levels of 50,000 and 100,000 plant ha^{-1} respectively. These samples were used in determining the total dry matter, leaf area, LAI and number of fruiting points.

3.3.1 Plant height

The height of two or four plants were determined at 7, 11, 15 and 19 weeks after sowing. This was done by direct measurement with a metre rule by recording the

length of the main stem from the ground level to the apical bud of the plant. The mean of the height measurement of the four plants was taken as the mean plant height for the plot.

3.3.2 Leaf area and leaf area index

Leaf area (LA) was determined by using specific leaf area relationship (Evans, 1972). Specific leaf area (SLA) is defined here as the ratio of leaf area to that of leaf dry weight.

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

where, a = area of 5 leaf discs (m^2)

b = dry weight of 5 leaf discs (g)

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

The leaf area index (LAI) was determined by dividing the estimated leaf area of the sample by $0.8m^2$, the ground area.

3.3.3 Total dry matter

The leaves, stems, squares, flowers and bolls in each of the samples taken from $0.8m^2$ area were dried to a constant weight in an oven at a temperature of $60^{\circ}C$ for 48 hours. Dry matter per metre square was obtained by multiplying the dry matter per plant with the total number of plants per metre square.

3.3.4 Number of branches per plant

The number of branches per plant was counted and recorded from four plants at 7, 11, 15 and 19 weeks after sowing. The average number of the branches from the 4 plants was taken as the number of branches per plant.

3.3.5 Number of nodes per plant

Four plants were randomly selected from each plot and the number of their nodes counted at 7, 11, 15 and 19 weeks after sowing.

3.3.6 Days to 50% flowering

The number of days it took about 50% of the plants in each plot to flower was recorded. This was counted from the date of planting till when 50% of sample plots had flowered.

3.3.7 Number of fruiting points per plant

The number of fruiting points per plant was recorded at 7, 11, 15 and 19 weeks after sowing.

3.3.8 Days to first boll opening

The number of days it took the first boll to open in each plot was recorded. The count started from the date of planting.

3.3.9 Number of shed bolls per plant

The number of bolls shed per plant was determined from a sample of four plants per plot. The numbers of shed bolls were cumulatively added and recorded at the time of harvest.

3.3.10 Number of mature bolls per plant

The total number of mature bolls from a sample of four plants was counted and the number of the mature bolls per plant was determined.

3.3.11 Seed cotton yield

Seed cotton yield was determined from the total seed cotton picked per net plot ($24.3m^2$). A total of three pickings were made at intervals when the bolls were fully open. The seed cotton was weighed and the weight recorded.

3.3.12 Lint weight and seed weight

The seed cotton picked from the net plots was weighed and ginned. After ginning, the lint and the cotton seed were weighed separately and their weights recorded. The weight values were then used to compute lint and seed yield on an hectare basis respectively.

3.3.13 Ginning percentage (%)

Seed cotton picked from each of the net plots was ginned at the IAR ginnery and the ginning percentage determined from the following relationship.

$$\text{Ginning \%} = \frac{\text{Lint weight}}{\text{seed cotton weight}} \times \frac{100}{1}$$

3.3.14 Technological properties of cotton

Technological properties of lint, namely; length uniformity ratio, span/effective length, maturity ratio, bundle strength (tenacity), fineness (micronaire value) and pressley index were determined at the Fibre Technology laboratory.

3.4 Meteorological Data

Records of meteorological data: air temperature, rainfall, relative humidity and sunshine hours were obtained from the meteorological station at Samaru, Zaria. These are presented in Appendix Table A. 1.

3.5 Statistical Analysis

The data collected were subjected to analysis of variance as described by Steel and Torrie (1960) to test the significance of treatment effects. The least significiant difference was used to compare treatment means of the sowing date, density and row spacing and their interactions. The relationship between yield and yield components were determined by calculating correlation factors.

Chapter 4

RESULTS

4.1 Yield and Yield-related Characters

4.1.1 Seed cotton Yield

Sowing date had significant effect on the yield of seed cotton. June-sown cotton significantly out-yielded July-sown cotton by a wide margin of 60 percent.

Plant density had no significant effect on seed cotton yield except that a plant density of 100,000 plants per hectare tended to produce marginally more seed cotton than a plant density of 50,000 plants per hectare.

Row spacing did not significantly affect seed cotton yield; though a higher seed cotton yield was obtained from 60cm spacing relative to the 30, 90 or 120cm row spacings. The lowest seed cotton yield was obtained from the 120cm row spacing. The interaction effects of the various factors on seed cotton yield were however not significant (table 2).

4.1.2 Lint Yield

June-sown cotton produced significantly more lint than July-sown cotton. Of the two plant density levels tested, 50,000 plants ha^{-1} produced marginally more lint than 100,000 plants ha^{-1}.

Row spacing did not significantly affect the lint yield but more lint yield was obtained from 60cm row-spacing than from either 30,90 or 120cm row spacing.

The interaction effects on lint yield were not significant (Table 2).

Table 2: Effects of sowing date, row spacing, plant density and their interactions on seed cotton, lint, seed yield, ginning percentage and 100-seed weight of cotton cv. 'SAMCOT-9'.

Treatment	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Cotton Seed (kg ha^{-1})	Ginning Percentage (%)	100-seed weight (g)
Sowing date					
June	2867	1007	1658	35.5	8.93
July	698	247	438	34.5	6.85
SE±	151.0	125.2	100.2	0.3	0.2
LSD (0.05)	493	439.9	352.2	NS	0.6
Row spacing (cm)					
30	1693	596	1076	35.6	7.97
60	2385	809	1165	35.2	7.87
90	1636	539	1049	33.0	8.10
120	1421	504	900	36.1	7.48
SE±	571.5	198	190.4	0.6	0.5
LSD (0.05)	NS	NS	NS	NS	NS
Plant density ('000 plants ha^{-1})					
50	1624	576	1042	35.4	8.04
100	1943	672	1052	36.3	7.73
SE±	151	151.3	191.7	0.3	0.2
LSD (0.05)	NS	NS	NS	NS	0.4
Interactions:					
SD x RS	NS	NS	NS	NS	NS
SD x PD	NS	NS	NS	NS	NS
RS x PD	NS	NS	NS	NS	NS
SD x RS x PD	NS	NS	NS	NS	NS

NS = Not significant at 5% probability level.

4.1.3 Cotton seed Yield

Sowing date significantly affected the yield of cotton seed. June-sown cotton produced significantly more cotton seed than did the July-sown cotton. The cotton seed yield of June-sown crop was three times more than that of the July-sown crop.

Plant density had no significant effect on cotton seed as the quantity of seed produced from 100,000 plants ha^{-1} was about the same as that from 50,000 plant ha^{-1}.

Similarly, plant spacing had no significant effect on cotton seed yield. The interaction effects were also not significant (Table 2).

4.1.4 Ginning Percentage

Neither sowing date, plant density, nor row spacing produced any significant effect on the ginning percentage of cotton. Ginning percentage ranged from 33.0 to 36.3 percent (table 2).

4.1.5 Seed index (100-seed weight)

Sowing date and plant density had significant effects on the 100-seed weight but row spacing did not produce any significant effect. June-sown cotton produced significantly heavier seeds than did July-sown cotton. Similarly, 50,000 plants ha^{-1} level produced heavier seeds than did 100,000 plants ha^{-1}. The interaction effects were not significant (Table 2).

Table 3: Effects of sowing date, row spacing, plant density and their interactions on the number of fruiting points per plant of cotton CV. 'SAMCOT - 9'.

Treatment	Weeks after sowing		
	7	11	15
Sowing date			
June	4.9	16.3	37.7
July	6.0	16.5	24.9
SE±	0.2	0.5	0.3
LSD (0.05)	0.4	NS	0.8
Row spacing (cm)			
30	4.4	13.6	25.2
60	5.3	17.3	30.9
90	7.1	21.5	25.8
120	4.6	13.1	24.1
SE±	0.9	1.8	1.5
LSD (0.05)	1.7	3.2	2.7
Plant density ('000 plants ha^{-1})			
50	5.6	17.8	23.9
100	5.3	14.9	28.7
SE±	0.2	0.4	0.3
LSD (0.05)	NS	1.7	2.5
Interactions			
SD x RS	NS	NS	NS
SD x PD	NS	*	*
RS x PD	NS	NS	NS
SD x RS x PD	NS	NS	NS

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

4.2 Number of fruiting points per plant

There were variable effects of sowing date on the number of fruiting points per plant depending on when this was assessed. July-sown cotton tended to have more fruiting points than June-sown cotton at 7 and 11 WAS, but, the reverse was the case at 15 WAS, when the number of fruiting points for June-sown cotton was markedly higher than that for July-sown cotton. Row spacing had significant effect on the number of fruiting points throughout the period. At 7 and 11 WAS, 90cm spacing produced significantly more fruiting points than the other spacings. However, at 15 WAS, 60cm row spacing had significantly more fruiting points than the other spacings. While the effect of plant density was not observed at 7 WAS, at 11 and 15 WAS, plant density of 100,000 plants ha^{-1} produced more fruiting points than did the lower density of 50,000 plant ha^{-1}. (Table 3).

4.3.1 Cumulative number of shed bolls per plant

Sowing date had no significant effect on the cumulative number of shed bolls per plant as July-sown cotton shed about as many bolls as did June-sown cotton. It appears that most of the flowers of July-sown cotton plants did not develop into bolls before they were shed.

Table 4: Effects of sowing date, row spacing plant density and their interactions on number of mature boll/ plant: and cumulative number of shed bolls/plant of cotton cv. 'SAHCOT - 9'

Treatment	No. of shed bolls/plant.	No. of mature bolls/plant.
Sowing date		
June	10.2	27.1
July	9.9	5.8
SE±	0.5	0.4
LSD (0.05)	NS	1.8
Row spacing (cm)		
30	10.7	14.5
60	10.6	20.2
90	8.3	16.7
120	11.1	13.0
SE±	1.4	0.3
LSD (0.05)	2.4	1.1
Plant density		
('000 plant ha^{-1})		
50	10.4	13.4
100	9.9	18.7
SE±	0.7	0.1
LSD (0.05)	NS	1.1
Interactions		
SD X RS	*	*
SD X PD	NS	*
RS X PD	NS	NS
SD X RS X PD	NS	NS

* = Significant at 5% probability level

NS = Not significant at 5% probability level.

Row spacing had significant effect on shed bolls, with the 120cm row spacing having more shed bolls than did the 90cm row spacing which recorded the least number of shed bolls.

Plant density on the other hand had no significant effect on the number of shed boll. The interactions were not significant for the cumulative number of shed bolls per plant however, the interaction between sowing date and row spacing was significant for the cumulative number of shed bolls per plant (Table 4).

4.3.2 Number of mature bolls per plant

Sowing date, row spacing and plant density affected the number of mature bolls per plant positively. July-sown cotton had significantly fewer mature bolls per plant when compared to June-sown plants. The number of mature bolls per plant increased significantly with increase in plant density from 50,000 plants ha^{-1} to 100,000 plants ha^{-1}. The 60cm row spacing produced significantly more mature bolls per plant than did the 90cm row spacing.

Similarly, the 90cm row spacing had significantly more mature bolls per plant than did either the 30cm or 120cm row spacing.

There were significant interactions between sowing date and plant density on the number of mature bolls per plant but no significant interaction effect was observed between sowing date and row spacing on the number of mature bolls per plant (Table 4).

Table 5: Effects of sowing date, row spacing, plant density and their interactions on the number of days fromsowing to 50% flowering and first boll opening of cotton cv. 'SAMCOT -9'.

Treatment	No. of days to 50% flowering	No. of days to first boll opening
Sowing date		
June	59.6	110.4
July	59.6	105.0
SE±	0.3	0.2
LSD 90.05)	NS	0.6
Row spacing (cm)		
30	59.7	107.5
60	59.8	108.0
90	59.5	107.3
120	59.4	108.0
SE±	0.3	0.5
LSD (0,05)	NS	NS
Plant density ('000 plants ha^{-1})		
50	59.8	107.7
100	59.4	107.7
SE±	0.3	0.7
LSD (0.05)	NS	NS
Interactions		
SD.X RS	NS	NS
SD X PD	NS	NS
RS X PD	NS	NS
SD X RSx PD	NS	NS

NS = Not significant at 5% probability level.

4.4 Number of days to 50% flowering

The number of days from sowing to 50% flowering did not differ significantly between June and July sown-cotton (Table 5). Row spacing too, had non-significant effect on the number of days from sowing to 50% flowering as indicated on (Table 5). Similarly, plant density and the interactions were not significant for the number of days to 50% flowering (Tables 5).

4.5 Number of days from sowing to first boll opening

Sowing date had significant effect on the number of days from sowing to the first boll opening. It took July-sown cotton fewer number of days from sowing to its first boll to open than it did take the June-sown cotton.

Row spacing and plant density had no significant effect on the number of days it took the plants to open their first bolls. However, it took plants spaced 120 cm between rows approximately one day more to open their bolls when compared to the 90cm row spacing and about half-a-day more when compared to 30cm row spacing (Table 5).

Table 6: Effects of sowing date, row spacing, plant density and their interactions on the total dry matter production (g/plant) of cotton cv. 'SAMCOT -9'

Treatment	Weeks after Sowing 7	11	15
Sowing date			
June	25.0	75.2	172.0
July	21.3	57.1	127.8
SE±	1.0	2.1	3.0
LSD (0,05)	2.5	6.4	9.1
Row spacing (cm)			
30	20.5	58.7	132.6
60	23.6	79.5	140.8
90	25.6	68.9	152.3
120	22.8	58.7	162.5
SE±	1.7	2.1	3.0
LSD (0.05)	4.5	6.4	9.1
Plant density ('000 plnats ha^{-1})			
50	23.2	67.7	148.3
100	23.1	65.2	152.5
SE±	0.5	18.0	6.1
LSD (0.05)	NS	NS	NS
Interactions			
SD X RS	NS	NS	NS
SD X PD	NS	NS	NS
RS XPD	NS	NS	NS
SD X RS X PD	NS	NS	NS

NS = Not significant at 5% probability level.

4.6 Total dry matter production

Total dry matter production was significantly affected by sowing date. The total dry matter increased up to 15 WAS thereafter there was a decline in the total dry matter. However, July-sown cotton produced less total dry matter than did June-sown cotton. The highest total dry matter production was obtained at 15 WAS for June-sown cotton which was significantly higher than that of July-sown cotton.

Total dry matter production was not significantly affected by plant density. However, at a plant density higher than 50,000 plants ha^{-1}, the total dry matter was lower at 7 and 11 WAS but, at 15 WASplant density of 100,000 plants ha^{-1} produced greater dry matter (Table6). Row spacing had significant effect on total dry matter production. The least dry matter production at 11 and 15 WAS, obtained from 30 and 120cm row spacings. On the other hand, 120cm row spacing produced less total dry matter at 7 WAS than the 60 and 90cm row spacings. The 90cm row spacing produced significantly greater total dry matter than any of the other row spacings at 7 WAS but not at 15 WAS where 120cm row spacing exceeded all others although the total dry matter production at this period did not significantly differ from that of 60 and 90cm spacing. Rather, it differed significantly from production from 30cm row spacing. (Table 6).

4.7 Leaf area index

Sowing date had significant effect on the LAI of the cotton cv. SAMCOT - 9 with June-sown cotton producing superior LAI at 7, 11 and 15 WAS.

Plant density had no significant effect on LAI and the effect of row spacing on LAI was variable. At 7 WAS there was no significant effect whereas at 11 and 15 WAS a row spacing of 120cm had the highest significant effect on LAI. However, at 15 WAS the 60cm and 90cm spacings produced a moderately higher LAI, though not significantly different from the others. The interactions were not significant on the leaf area index (Table 7).

Table 7: Effects of sowing date, row spacing, plant density and their interactions on the LAI of cotton cv. 'SAMCOT - 9'

Treatment	Weeks after sowing 7	11	15
Sowing date			
June	0.38	1.28	3.27
July	0.17	0.47	1.00
$SE_{\pm}$	0.01	0.02	0.12
LSD (0.05)	0.10	0.45	0.99
Row Spacing (cm)			
30	0.22	0.90	1.73
60	0.30	0.95	2.58
90	0.29	0.57	2.51
120	0.29	1.09	1.73
$SE_{\pm}$	0.01	0.02	0.23
LSD (0.05)	NS	0.06	1.09
Plant density ('000 plants ha^{-1})			
50	0.26	0.89	2.02
100	0.29	0.86	2.25
$SE_{\pm}$	0.02	0.05	0.21
LSD (0.05)	0.07	NS	NS
Interactions			
SD x RS	NS	NS	NS
SD x PD	NS	NS	NS
RS x PD	NS	NS	NS
SD x RS x PD	NS	NS	NS

NS = Not significant at 5% probability level.

Table 8: Effects of sowing date, row spacing, plant density and their interactions on plant height (cm) of cotton cv.'SAMCOT-9'

Treatment	Weeks after sowing			
	7	11	15	19
Sowing date				
June	23.4	74.1	133.6	141.0
July	24.7	61.9	59.0	110.4
SE±	0.3	1.3	0.3	0.6
LSD (0.05)	0.5	4.3	2.91	1.1
Row Spacing (cm)				
30	23.9	67.6	125.5	125.2
60	24.3	67.7	131.6	131.6
90	24.7	70.0	124.0	124.0
120	23.3	66.5	122.9	122.9
SE±	1.2	7.7	1.3	3.0
LSD (0.05)	NS	NS	2.3	5.2
Plant density ('000 plants ha^{-1})				
50	24.0	65.2	111.9	125.0
100	24.1	70.8	115.7	126.8
SE±	0.5	1.3	0.8	0.6
LSD (0.05)	NS	4.1	1.08	NS
Interactions				
SD x RS	NS	NS	*	NS
SD x PD	*	*	*	*
RS x PD	NS	NS	NS	NS
SD x RS x PD	NS	NS	NS	NS

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

4.8 Plant height

Plant height was significantly affected by sowing date throughout the growing period. At 7 weeks after sowing, plants of July-sown cotton grew significantly taller than those of June sown-cotton. However, at 11, 15 and 19 weeks after sowing, the reverse was the case as June sown-cotton produced significantly taller plants than July sown-cotton.

Plant height was significantly affected by plant density at 11 and 15 WAS, but not at 19 WAS. Plant density of 100,000 plants per ha^{-1} produced taller plants than did 50,000 plants ha^{-1}.

The effects of row spacing on plant height as recorded at 7, 11, 15 and 19 WAS are shown in Table 8. At 7 and 11 WAS spacing did not significantly affect plant height however, at 15 and 19 WAS the 60cm row spacing produced significantly taller plants than did the 30, 90 or 120cm spacing. The interactions were not significant for the plant height apart from the interaction between sowing date and plant density that were significant through out the period and that, between sowing date and row-spacing at 15 WAS (Table 8).

4.9 Number of branches per plant

Sowing date did not affect the number of branches per plant at 7 WAS but thereafter, at 11, and 15 WAS, this was significantly affected by sowing date. June-sown cotton plants produced more branches than did those of July-sown cotton (Table 9).

Table 9: Effects of sowing date, row spacing, plant density and their interactions on the number of branches per plant of cotton cv. 'SAMCOT-9'.

Treatment	Weeks after sowing 7	11	15
Sowing date			
June	5.8	11.5	16.2
July	5.6	11.0	14.4
SE±	0.5	0.1	0.4
LSD (0.05)	NS	0.3	1.4
Row spacing (cm)			
30	5.7	10.1	15.2
60	5.4	11.8	16.8
90	5.3	12.7	15.5
120	5.6	10.4	14.2
SE±	0.7	1.2	1.0
LSD (0.05)	NS	2.16	1.72
Plant density ('000 plant ha^{-1})			
50	5.8	11.2	15.2
100	5.6	11.3	15.4
SE±	0.3	0.1	0.4
LSD	NS	NS	NS
Interactions			
SD X RS	NS	NS	NS
SD X PD	NS	NS	NS
RS XPD	NS	NS	NS
SD X RS XPD	NS	NS	NS

NS = Not significant at 5% probability level.

At 11 and 15 WAS row spacing significantly affected the number of branches per plant; unlike at 7 WAS when row spacing did not significantly affect the number of branches. At 11 WAS plants spaced 90cm between rows had more branches per plant than any of the other row spacing, followed by the 60cm row spacing. Fewer branches were however, observed on plants of rows that were 30cm apart.

The number of branches per plant was not siginficantly affected by plant density. However, 100,000 plants per hectare produced relatively fewer branches at 7 WAS than did 50,000 plants ha^{-1}, but not at 11 and 15 WAS where the branches per plant were almost at par at the two density levels. The interactions were not significant for the number of branches per plant (Table 9).

4.10 Number of nodes per plant

Plants of June-sown cotton did not produce significantly more nodes per plant than July-sown cotton except at 19 WAS.

Number of nodes per plant was not significantly affected by row spacing throughout the period.

Plant density also did not significantly affect the number of nodes produced per plant however, at 11 WAS there was a marginal difference in the number of nodes produced per plant under the 90cm row when compared with either 120, 60, or 30cm row spacing.

Table 10: Effects of sowing date, row spacing, plant density and their interactions on the number of nodes/plant of cotton cv. 'SAMCOT - 9'

Treatment	Weeks after sowing 7	11	15	19
Sowing date				
June	7.9	9.7	13.7	20.4
July	6.9	9.9	14.2	16.9
SE±	0.4	0.1	0.3	0.04
LSD (0.05)	NS	NS	NS	0.16
Row spacing (cm)				
30	7.3	9.6	13.9	18.5
60	7.3	9.9	13.8	18.7
90	7.7	10.3	14.1	18.6
120	7.3	9.6	13.7	18.7
SE±	0.5	0.3	0.3	0.2
LSD (0.05)	NS	NS	NS	NS
Plant density				
('000 plants ha^{-1})				
50	7.4	9.7	13.9	18.6
100	7.4	9.9	14.0	18.6
SE±	0.4	0.5	0.3	0.04
LSD (0.05)	NS	NS	NS	NS
Interactions				
SD x RS	NS	NS	NS	NS
SD x PD	NS	NS	NS	NS
RS x PD	NS	NS	NS	NS
SD x RS x PD	NS	NS	NS	NS

NS = Not significant at 5% probability level.

Table 11: Effects of sowing date, row spacing, plant density and their interactions on fibre length, bundle strength, maturity ratio, micronaire value (fineness) uniformity ratio and pressely index of cotton cv. 'SAMCOT - 9'

Treatment	Fibre length (cm) Span length	Bundle strength (g/tex)	Pressley index (%)	Fineness (micronaire) (value (g /inch)	Uniformity ratio (%)	Maturity ratio (%)
Sowing date						
June	24.1	14.2	6.7	2.6	36.1	85.0
July	22.5	10.2	5.0	2.8	41.0	80.8
SE±	0.1	0.3	0.6	0.05	0.21	1.3
LSD (0.05)	0.3	0.9	1.5	0.1	0.4	3.9
Row spacing (cm)						
30	23.2	12.5	5.9	2.7	38.6	83.0
60	23.5	11.9	5.6	2.7	38.5	81.8
90	23.3	12.1	5.9	2.9	38.4	84.9
120	23.2	12.4	6.0	2.6	38.5	82.3
SE±	0.1	1.1	0.6	0.05	0.2	2.6
LSD (0.05)	NS	NS	NS	NS	NS	NS
Plant density ('000 plant ha^{-1})						
50	23.1	12.3	5.9	2.7	38.6	83.0
100	23.5	12.1	5.7	2.7	38.5	82.9
SE±	0.2	0.3	0.6	0.1	0.2	2.4
LSD (0.05)	NS	NS	NS	NS	NS	NS
Interactions						
SD x RS	NS	NS	NS	NS	NS	NS
SD x PD	NS	NS	NS	NS	NS	NS
RS x PD	NS	NS	NS	NS	NS	NS
SD x RS x PD	NS	NS	NS	NS	NS	NS

NS = Not significant at 5% probability level.

4. 11 Fibre quality characters of cotton

4. 11.1 Fibre length

Sowing date significantly affected the fibre length with June-sown cotton producing longer fibres than did July-sown cotton. Row spacing on the other hand, had no significant effect on the fibre length.

Similarly, plant density had no significant effect on fibre length.

The interactions were not significant (Table 11).

4.11.2 Bundle strength

Sowing date showed a significant effect on bundle strength as June-sown cotton produced significantly higher fibre bundle strength than July-sown cotton.

There was no significant effect on the bundle strength by the plant density. However, sowing date and row spacing did not have significant effect on fibre bundle strength. The interactions were not significant (Table 11).

4.12.3 Percentage Pressley Index

Sowing date had significant effect on the percentage pressley index. There was a higher percentage Pressley index in respect of June-sown cotton than for July-sown cotton. However, plant density and row spacing had no significant effect on Pressley index. The interactions were not significant (Table 11).

4.11.4 Micronaire value (Fineness)

Sowing date had significant effect on the cotton fibre fineness; as there was statistical difference between the fibre fineness of July sown cotton and that of June-sown cotton.

Plant density and row spacing did not significantly affect fibre fineness. The interactions were not significant (Table 11).

4.11.5 Uniformity ratio

Unlike plant density and row spacing, sowing date significantly affected the uniformity ratio. July-sown cotton had a greater percentage uniformity ratio than did June-sown cotton. The interactions were not significant (Table 11).

4.11.6 Maturity ratio

Sowing date had significant effect on the maturity ratio. However, row spacing and plant density did not significantly affect the maturity ratio.

The interactions were not significant for the percentage maturity ratio (Table 11).

Table 12: Correlation between seed cotton yield and various parameters of cotton cv. SAMCOT - 9 at Samaru, 1990 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12
1.	1.00											
2.	0.87**	1.00										
3.	0.79**	0.61*	1.00									
4.	0.67**	0.67**	0.47	1.00								
5.	-0.13	-0.30	-0.30	-0.15	1.00							
6.	0.84**	0.62**	0.76**	0.65**	-0.16	1.00						
7.	0.44	0.38	0.24	0.25	-0.10	0.45	1.00					
8.	0.51*	0.50*	0.63**	0.38	-0.21	0.62**	0.08	1.00				
9.	0.88**	0.68**	0.78**	0.70**	-0.21	0.90**	0.46	0.58*	1.00			
10.	-0.11	0.11	-0.09	-0.22	-0.14	0.06	0.02	0.08	-0.54*	1.00		
11.	0.87**	0.68**	0.80**	0.69**	-0.22	0.92**	0.50*	0.59*	0.98**	-0.07	1.00	
12.	0.59*	0.43	0.60*	0.54*	-0.12	0.66**	0.37	0.38	0.71**	-0.13	0.72	1.0

* = Significant at 5% probability level. (r = 049).

** = Significant at 1% probability level. (r = 062).

n = 16

Key:

1. = Seed cotton weight (kg ha^{-1}).
2. = Lint weight (kg ha^{-1})
3. = Seed weight (kg ha^{-1})
4. = 100 - seed weight (g)
5. = Ginning Percentage (%)
6. = Plant height (15 WAS) cm.
7. = Number of branches (15 WAS).
8. = Total dry matter
9. = Fruiting points/plant (15 WAS)
10. = Shed bolls/plant (15 WAS)
11. = Mature bolls/Plant (15 WAS)
12. = Fibre length (mm).

4.13 Correlations among cotton yield, growth Parameters and yield components

Seed cotton yield significantly and positively correlated with most of the parameters evaluated. Number of fruiting points at 15 WAS and number of mature bolls per plant significantly and positively correlated with seed cotton yield (r = 0.88 and 0.87) respectively.

Seed weight, lint yiied and 100-seed weight (seed index) were also significantly and positively correlated with seed cotton yield (r = 0.79, 0.87 and 0.67 respectively). However, seed cotton yield showed a non-significant negative correlation with the ginning percentage (r =-0.13).

Other parameters that significantly positively correlated with seed cotton yield were plant height at 15 WAS (r = 0.84) and number of nodes per plant, (r = 0.80). Number of branches per plant did not significantly correlate with seed cotton yield (r = 0.44).

Fibre length and tenacity (bundle strength) significantly and positively correlated with seed cotton yield (Table 12).

Chapter 5

DISCUSSION

5.1 Effect of Sowing Dates

Sowing date affected almost all the parameters observed. Highly significant differences observed in yield and yield componnents between June and July-sown cotton as reported herein, have confirmed the earlier works of (Lawes, 1968; Brown, 1971; Ogunlela, 1981; Kumar et al., 1982 and Idem, 1984) that yield and quality of cotton tend to decline with delay in sowing.

Based on the result of the present study, it appears that sowing of this variety even in May rather than June, may still lead to a proportional increase in seed cotton yield provided soil water supply is adequate for the crop and rainfall was not prolonged so as to cause damage to the lints Ogunlela et al.(1984) had results which indicated that in the southern cotton growing zone of Nigeria, for each day sowing of cotton was delayed, seed cotton yield was markedly reduced by 12.5kg ha^{-1}. Singh (1979) also investigated the effects of advanced sowing date in India and observed that advanced sowing of seeds on dry soils, 7-17 days before the onset of monsoon rains, increased seed cotton yield by 7-10%. These reports, like the present one agreed with that of Kumar (1983) who reported that yiled and yield contributing characters of cotton namely LAI, average number of nature bolls per plant,

number of fruiting branches and total dry matter per plant were significantly affected by sowing date. The low yield obtained from late sowing of this variety, 'SAMCOT-9' cotton may also be explained in the light of reduced dry matter production, plant height and other growth parameters and consequently, about 40 - 60% reduction in number of flowers and ovaries was observed from this variety, 'SAMCOT-9'.

Number of mature bolls per plant and 100-seed weight were also affected by sowing date. More number of mature bolls per plant and increased 100-seed weight obtained from June sown-cotton could be attributed to acceleration of growth parameters and subsequent translocation of assimilates into the seeds because of high temperature during the time of boll formation.

Sowing date had significant effect on the fibre length, bundle strength, pressley index, maturity ratio uniformity ratio and micronaire value. Although the effect on these properties were significant, it appears as if these properties were genetically fixed. Much of the differences obtained however, tended to be due to the manner of handling the lint samples during the laboratory testing period and more so, due to the atmospheric conditions:

temperature and relative humidity than the sowing date. The technological properties of cotton according to Bakumovsky (1983) depend on species, varieties and cultivation conditions which invariably among other conditions include sowing date.

During the time of testing of June-sown cotton the temperature was 20.9°C (69.6°F) and the relative humidity, 25%. This low relative humidity of 25% as against the ideal or acceptable standard atmospheric conditions of temperature 20 ± 2°C and relative humidity, 65 ± 2% may be the reason for the poor bundle strength and pressley index observed during the preparation and testing period. The low relative humidity may have led to breakages hence its effect on the effective span length. Although the length was average (medium staple) and the maturity ratio and the fineness, good. Likewise for July-sown cotton, the atmospheric conditions as already mentioned above adversely affected the fibre characteristics.

Soil and atmospheric condition during the 1990 wet season also played a modifying role on the growth parameters observed. From the results obtained, mid-July sowing of cotton depressed yield of cotton by a 60% margin. The higher yield obtained from June sown-cotton in contrust to mid-July was due to favourable soil and weather conditions of rainfall, temperature, sunshine and humidity which favoured cotton yield, unlike, July sown-cotton crop which yield was depressed. The net effect of this was that reproductive structures could not fully develop before they were shed and thus, the consequent low yield obtained. The reason for the yield depression being that the July sown-cotton had its growth and reproductive phase between end of September and end of October, during that period, the squares flowers and bolls were still being formed and unfortunately, the rains ceased. The total rainfall requirement during the reproductive phase of cotton according to Bakumovsky (1983) is 1000 mm. This is in contrast with the rainfall for the 1990 wet season at Samaru during the reproductive phase of the July sown cotton which stood at about 250 mm. Although cotton is

a drought resistant plant, if the total rainfall available for its growth is less than the required and/or optimum amount particularly during the reproductive phase, the yield may be negatively affected.

Kumar et al. (1982) like Bakumovsky (1983) observed that cotton requires an optimum temperature of 25 to 32°C during flowering and boll development, during this reproductive period, a day - time temperature of 26° to 32°C may be desirable, but night temperature should be cool, about 18° to 20°C, for the translocation of photo-synthates from the source - leaves to the sink-bolls to be effective. The above conditions favoured June sown-cotton as reported here as against July sown-cotton.

Higher yield obtained from June sown-cotton may be due to abundant leaves produced per plant due to these favourable conditions and/or better interception of solar radiation which resulted into greater-total drymatter production per plant, in other words, with early sowing cotton utilized the favourable environmental conditions such as rainfall, sunshine hours and conducive evapotranspiration and transformed these into larger biomass, which resulted to higher yield. This was not so in the case of July sown-cotton, which did not experience favourable environmental conditions.

Raney and Cooper (1968) opined that cotton is particularly sensitive to water-stress during the reproductive stage which means that at this period of deficit in soil water, the yield contributing characters and yield of cotton suffer considerably. The water-holding capacity of soils vary from place to place, according to Kowal and Knabe (1972), the value is between 17.4 cm m^{-1} for loamy sandy soil of Mokwa to 31.5 cm m^{-1} for the silt Loam soil of Samaru. It is generally believed that the drying cycle of the soil water starts immediately after the cessation of the rains (3rd week of September) for 1990 wet season. Before the cessation of the rains, June sown-cotton, unlike July sown-cotton, must have made good use of the soil water during its reproductive phase. Idem (1984) worked on effect of plant density and nitrogen fertilization on growth and yield of late-sown cotton and observed that late-sown cotton developed less extensive root system when compared with early sowing. The inability of the July sown-cotton to develop extensive rooting system as reported here in may account for the low yield observed since the roots were unable to extract sufficient soil moisture during the dry period.

Cotton is known to respond favourably to relatively moderate to low humidity and prolonged sunshine hours for better retention of flowers and bolls.

During the initial growth period of July-sown cotton, the seedlings were exposed to high rainfall marked by relatively low temperature, cloudy weather and soil erosion. No wonder most of the growth parameters such as plant height, leaf area, total dry matter, number of fruiting points, and branches were not favoured by weather variables on the onset. Besides, the optimum growth and flowering phase of July-sown-cotton coincided with the dry period (end of September to end of November) and the dry atmospheric conditions were detrimental to both flowering and boll formation and their developments thereby adversely shortening the reproductive phase, which consequently resulted in the observed low seed cotton yield.

Another reason for the low yield obtained from July-sown cotton could be that of low relative humidity. High humidity favours vegetative growth and infestation of insects pest complex on crops (Pearson and Darling, 1958). Pest and insect infestation may not be considered as a major factor contributing to low yield obtained from July sown-cotton as reported herein, since adequate protection was taken against them. However, moderate relative low humidity may have adversely affected the yield contributing characters which in turn depressed the yield obtained from July-sown-cotton.

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5.2 Effects of row spacing

The overall effect of row spacing on yield was non-significant while the effect on the yield components were variable. Also, the effect of row spacing on the interactions were also variable. Spacing had a significant effect on number of branches at 11 and 15 WAS, dry matter production, and its interactions, total leaf area, number of days to 50% flowering, number of fruiting points, number of shed bolls and the number of mature bolls per plant. Since these yield components contribute to yield one can argue that row spacing affected yield positively. The 60 cm row spacing appears to be superior to the others. A yield of 2385 kg ha^{-1} of seed cotton was obtained from this row spacing as compared to 1693, 1636, and 1421 kg ha^{-1} of seed cotton obtained for 30, 90 and 120 cm row spacings respectively. The present result agrees with that of El-Hattab *et al*. (1978) who observed that spacing per hill had no significant effect on boll weight, lint percentage, seed and leaf indices for the cultivar investigated. Gerick (1981) also failed to observe significant cultivar x row-spacing interactions for total number of flowers and bolls formed. In contrast, El-Rahman *et al*. (1980) and Williford *et al*. (1986) reported that seed cotton yield was not only influenced by year alone but also by spacing. Constable (1977) determined the effect of variety and row spacing on growth of cotton and found similarly that the use of a narrow row of (19 cm)

resulted to a higher early season leaf area index than the use of 100 cm row; although that differences disappeared by the flowering stage. Wanjura and Bilbro (1977) cultivated cultivar 'Tancott 788" with within row spacing in the range of 5-40 cm in row of 102 cm apart and observed that average plant height, number of main stem nodes, square and bolls and coefficient of variation of these characters vary and change with time.

The recommended spacing for sole crop cotton cultivation in Nigeria is 0.9 x 0.45 m Idem. (1984) indicated that much more could be gained from narrow row culture but one of the limitations of this system could be the difficulty it poses with respect to manual weeding and also in the use of machines. However, narrow row culture improves rectangularity, leading to improved LAI and more efficient interception of Solar energy. Spacing determines more than any other factor, the resources available to each plant and therefore affects yield. Bleasdale (1978) opined that wide spacings can delay the onset of competition and thus enabling crops make better use of land resource.

5.3 Effect of Plant Density

The average seed cotton yield obtained for the two plant densities tested were 1624 and 1943 kg ha^{-1} for 50,000 and 100,000 plants ha^{-1} respectively. These yields appear to be normal considering the conventional recommended density for sole crop cotton of 50,000 plants ha^{-1} in Nigeria.

The non-significant effect observed for the yields derived for the plant densities is a confirmation of the findings by Lawes (1963) and Brown (1971) that 50,000 plants ha^{-1} is the appropriate plant density for sole cotton production in Nigeria.

However, a plant density up to 100,000 plants ha^{-1} increased seed cotton yield by a margin of about 8.9 per cent. The reason for this marginal increase in seed cotton yield may be due to restrictions imposed by the developing root system, which may have indirectly affected the amount of soil moisture absorbable by roots. Hearn (1972) observed that increased plant density may restrict root development and thus reduce the quantity of moisture which can be absorbed from the soil profile. Moreover, increased plant density brought about increased competition for nutrient and total nutrient absorption from the soil.

Increased plant density, according to Loomis and Williams (1963), affects the ability of the plants to intercept incoming radiation, which is influenced by leaf arrangement in the canopy and their orientation also affects the proportion of incident light that is intercepted by the crop canopy as a whole.

Chapter 6

SUMMARY AND CONCLUSION

A field experiment was conducted in 1990 wet season at Samaru in the northern Guinea Savanna to study the effect of sowing date, row spacing and plant density on the yield and yield components of an elite cotton line, SAMCOT-9.

Two sowing dates (mid-June and mid-July) and four row spacings (30, 60, 90, and 120 cm) were used as the main-plot treatment and two plant densities (50,000 and 100,000) plants ha^{-1} were randomised to form sub-plot. The experiment was laid out using split-plot design and replicated three times.

From the result obtained, June-sown cotton markedly out-yield July-sown cotton by a margin of 60%.

Increasing plant density from 50 to 100 thousand plants ha^{-1} did not significantly affect the seed cotton yield rather, some of the yield-components showed significant response to increasing density. Nevertheless, about 8% increase was noticed by increasing the density from 50,000 to 100,000 plants ha^{-1}

Row spacing had no significant effect on the yields of seed cotton lint and seed however, it had a variable effect on the yield component and some of the technological properties of cotton (SAMCOT-9).

Among the four row spacings tested (30, 60, 90, and 120 cm), the 120 cm row spacing produced the least seed cotton yield followed by 90 cm and 30 cm spacings respectively The 60 cm row spacing however, out-yielded these by 25.3 18.6 and 16.9% respectively.

The interactions between sowing date and row spacing; sowing date and plant density were significant for plant height, mature bolls per plants, and number of fruiting points at 15, WAS however, the intereactions did not result into significant effect for the yields of seed cotton, lint and cotton seed.

Significant and positive correlations observed between the yield contributing characters and seed cotton yield showed that they were highly associated and thus contribute to the total yield of the crop.

Based on the result of this experiment therefore it could be concluded that:

1. Optimum seed cotton yield could be produced from this elite line (SAMCOT-9) when the crop is sown early in the season. About 60 per cent of this crop's yield potential could be lost due to late sowing (mid-July sowing).
2. A plant density of 50,000 plants ha^{-1} seems to be optimum for this crop in this environment since there was no significant difference in seed cotton yield when the plant density was increased to 100,000 plants ha^{-1}. Availability of input, time and labour may induce the producer to increase the plant density to 100,00 plants ha^{-1} nevertherless, only 8% additional increase in seed cotton was obtained by increasing the plant density.
3. Although row spacing did not show any significant effect on seed cotton yield, the 60 cm row spacing appears to be superior to the others as it out-yielded 30, 90, and 120 cm row spacings by 16.9%, 18.6 and 25.3% respectively.

SAMCOT-9 is an advanced elite line. From this experiment, it seems that its maximum yield potential has not been fully attained therefore, if labour and finance are available it is suggested that this experiment be repeated in other locations and Cameru inclusive to ascertain this.

It is also necessary to determine the rate and/or optimum N, P and K fertilization (levels) for the production of this crop under early and late-sowings. Moreover, the possibility of advancedsowing i.e. before the onset of rains and also the effect of row orientation on the yield and yield components of this crop could also be investigated.

Since the reason for sowing cotton late in the season is because farmers give priority to food crops, which are planted first, it is also expedient that the use of this variety in mixture with food crops such as cotton/maize and/or cotton/soyabean and/or cotton/millet and/Or cotton/cowpea mixtures be also investigated.

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Appendix Table A.1.

Total rainfall, Evapotranspiration, Relative humidity and sunshine hours at 10 days interval for the 1990 wet season at Samaru*

Month	Days	Total Rainfall (mm)	ET (cm)	RH %	Sunshine hours
June	1 - 10	24.0	5.9	68.3	7.9
	11 - 20	62.0	5.4	77.8	8.8
	21 - 30	73.0	4.7	81.2	6.2
July	1 - 10	67.0	4.4	57.3	6.5
	11 - 20	84.0	4.1	59.2	5.6
	21 - 31	69.0	3.7	67.3	8.4
August	1 - 10	103.0	3.6	80.1	6.9
	11 - 20	44.0	3.1	65.2	6.8
	21 - 31	101.0	3.5	75.0	7.2
September	1 - 10	54.0	3.6	77.4	7.7
	11 - 20	14.0	3.5	74.6	6.5
	21 - 31	18.0	3.8	75.0	7.3
October	1 - 10	NIL	3.5	71.7	7.8
	11 - 20	NIL	5.1	65.7	8.0
	21 - 31	NIL	6.6	44.4	8.8
November	1 - 10	NIL	5.8	39.8	9.6
	11 - 20	NIL	5.8	30.4	9.3
	21 - 30	NIL	7.5	17.0	8.4

* Source: Samaru Meterological station.

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