EFFECT OF PLANT POPULATION AND NITROGEN FERTILIZATION ON GROWTH AND YIELD OF LATE-SOWN COTTON IN NIGERIA

By

NDITOI UDO AKPAN IDEM

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FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
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DECLARATION

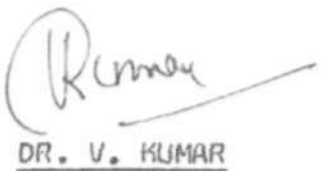
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NDITOI U. A. IDEM
(Candidate)

Date: October 2, 1984

The above declaration is confirmed.



DR. V. KUMAR
Major Supervisor

Date: Oct. 2, 1984

CERTIFICATION

This thesis entitled 'EFFECT OF PLANT POPULATION AND NITROGEN FERTILIZATION ON GROWTH AND YIELD OF LATE-SOWN COTTON IN NIGERIA' by Nditoi Udo Akpan IDEM meets the regulations governing the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

Dr. V. Kumar
Chairman, Supervisory Committee

Prof. J. Y. Yayock
Head, Agronomy Department

Prof. G. Osuide
Dean, Postgraduate School

Date 18-III-85

AHMADU BELLO UNIVERSITY
ZARIA

DEDICATION

This thesis is dedicated to my brother, Mr. E.J.A. Idem, whose foresight, scrifice and support has brought me to this academic status.

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ABSTRACT

Field experiments were conducted for a three-year (1979-81) period at Samaru (between 11°11'N and 07°38'E, 666 m above mean sea level) and Mokwo (o9°l8ˡN and 05°04'E, 152 m above mean sea level) in the northern and southern Guinea savanna zones, respectively, to study the effect of cultivar, plant population, and nitrogen fertilization on growth and yield of late-sown cotton (late July).

'Super okra' consistently outyielded 'Samaru 71' and 'Bar 14/25 throughout the three-year period at both locations, 'Super okra' which responded favourably to higher population density was also found to be more early maturing than the other two cultivars.

Seed cotton yield increased significantly with application of nitrogen. The economic optimum level of N was found to be 64.0 kg N ha^{-1} for both locations but 40 kg N ha^{-1} could be used by the hoe farmers profitably.

At Samaru, increased plant population resulted in increased seed cotton yield but the reverse was true at Mokwa location. The optimum plant population for 'Samaru 71' was 108,000 plants ha^{-1} and that of 'Super okra' was 149,500 plants ha^{-1} However, at Mokwa, the optimum population was outside the range of plant population tested.

July-sown cotton responded favourably to a row spacing of 75 cm at Mokwa as compared to the currently recommended spacing of 90 cm.

The interaction between cultivar and plant population was significant on seed cotton and lint yields at Mokwa only in 1979 growing season. Similarly the interaction between nitrogen level and plant population was significant on seed cotton yield at Samaru in 1980 growing season alone.

The major yield contributing characters were: average number of mature bolls per plant, LAI at 15 weeks after sowing (WAS) average number of fruiting branches m^{-2} at 15 WAS, average boll weight, plant height and total dry matter m^{-2}.

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ABBREVIATIONS AND SYMBOLS

Kg	Kilogram
g	gram
mg	Milligram
ha	hectare
m	metre
dm	decimetre
cm	centimetre
mm	millimetre
wk	week
ppm	part per million
%	per cent
NO_3-N	nitrate-nitrogen
LAI	leaf area index
RGR	relative growth rate
NAR	net assimilation rate
MMD	mean maturity date
PRI	production rate index
*	(p=0.05) significant
NS	not significant
p(1-p)	probability in a binomial distribution
r	simple correlation
R^2	multiple correlation
LSD	least significant difference
SED	standard error of difference
WAS	weeks after sowing
TDM	total dry matter
Max	maximum
Min	minimum

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Chapter 1

INTRODUCTION

1.1 Production

Cotton (Gossypium hirsutum L.) is a major cash crop of Nigeria. In 1969/70, a year of record cotton production, it contributed 2% of the total exports and fetched a foreign exchange of 17.3 million naira (Anonymous, 1977, 1979). Cotton production has since declined drastically. For example, whereas in 1975 Nigeria was the second largest producer in West Africa with 50,792 tonnes of lint (280,000 bales) at 167 kg ha^{-1} of mean seed cotton yield, in 1980, it produced only 22,675 tonnes of lint (125,000 bales) with an average production of 109 kg ha^{-1} of seed cotton. Nigeria now has to meet domestic demand through importation; in 1980 alone she imported 8,344 tonnes of cotton lint (46,000 bales) (Anonymous, 1981).

The ban on importation of textiles, the establishment of new textile mills and the expansion of the old ones in the country need an increased production of cotton lint to cope with the demand for textile goods. It is estimated that in order to be self sufficient in cotton, production would have to be raised to 172,333 tones of line (950,000 bales) per year by 1990 (Anonymous, 1971).

The estimated deficit (145,120 tonnes of lint or 800,000 bales) can be met through the use of improved cultivars, additional hectarages and improved management practices.

A major expansion of cotton hectarage is not envisaged at present and the breeding of substantially higher yielding cultivars relative to those in production is a long term exercise. Therefore, additional cotton lint must be obtained mainly by increasing the average yield per unit land area through the use of improved agronomic practices. The traditional production areas have relatively short rainy season and the major limitation to increased hectarage is the hoe farmers' inability to plant cotton early in the season. Together with late sowing, lack of fertilizer application and sub-optimal plant population usually result in low yields under the hoe farmers' level of management in the savanna.

1.2 Areas of Production

Cotton production areas in Nigeria is divided into three zones: the 'northern cotton zone' (between Latitudes 10^{0} and 13^{0} N) comprising parts of the present Sokoto, Niger, Kaduna, Kano and Plateau States which together contribute about 60% of the total national production; the 'eastern cotton zone' (between Latitudes 0^{0} and 11^{0} $30^{'}$ N) which covers parts of the present Bauchi, Gongola and Borno States and contribute 30 - 35% of the national cotton production. About five to ten per cent of the national cotton out-put comes from the 'southern cotton zone' (between Latitudes 7^{0} and 9^{0} 59' N), which comprises parts of the present Niger, Kwara, Benue and Plateau States (Fig. 1). The recommended cultivars for these zones are 'Samaru 71' for the 'northern cotton zone' and 'Samaru 77' for the 'eastern

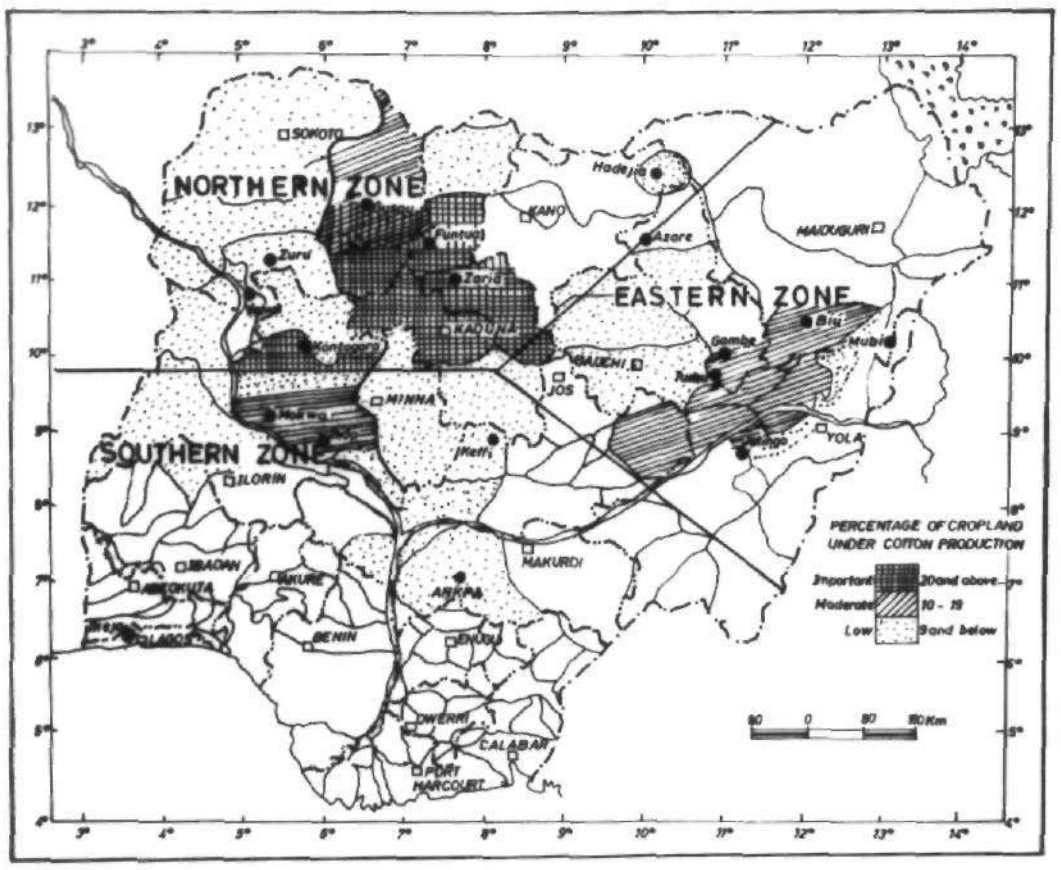


FIG.1. COTTON GROWING ZONES IN NIGERIA

(Adapted from Kumar and Ogunlela, 1982)

cotton zone'. 'Samaru 71' is also widely grown in the 'southern cotton zone'.

1.3 Climatic Requirements

Climatic factors namely, temperature sunshine and rainfall, exert great influences on cotton production. Uniformly high temperature of 22 - 32°C is required for optimum vegetative and reproductive growth during the growing season. A high annual precipitation is needed with 250 - 350 mm of it being well distributed during the period of active growth. Too high or too low a temperature or rainfall adversely affects cotton especially during the reproductive phase (McMichael and Powell, 1971).

1.4 Limitation to Yield

In the early part of the rainy season (April to June), farmers give priority to the planting of food crops such that most of the cotton is sown late, in late July or in early August. Consequently, yields of late-sown cotton are invariably poor, ranging from 150 - 300 kg ha^{-1} of seed cotton (Kumar and Ogunlela, 1982c). Cotton is an indeterminate crop and under the agro-ecological conditions of Nigeria, its life cycle and productivity are largely dependent on the soil-water stress at the reproductive phase. Cotton is particularly sensitive to water stress during flowering and boll development stages (Raney and Cooper, 1960).

During the initial seven weeks of growth, late-sown cotton

is exposed to high rainfall, marked by relatively low temperatures, cloudy weather, and severe weed infestation. The grand growth and flowering phases of late-sown cotton invariably coincides with the end of the wet season such that the crop flowers and bolls develop in the dry season thus reducing the duration of the reproductive phase. It seems probable that late-sown cotton develops a less extensive root system relative to the early-sown crop thus making the former less able to make efficient use of any stored soil moisture during the dry season.

Nitrogen plays a vital role in all living tissues of the plant, of which it constitutes upto 1 to 4% of plant dry weight. Nitrogen requirement of cotton vary considerably depending on the stage of development of the plant. Generally nitrogen requirement is minimal in the early growth stages and increases as the rate of growth accelerates, to a peak during the period between onset of flowering and early boll formation. The late-sown cotton is generally unfertilized by the savanna farmers. The leached farruginous soils of Nigerian savanna are universally deficient in nitrogen (Vine, 1966). The poor yields of the late-sown cotton is partly as a result of poor soil fertility level. Nitrogen, phosphorus, potassium and minor nutrients like boron are required for good cotton production in Nigerian savanna. The recommended level of phosphorus and boron (5kg + 0.35kg ha^{-1}) in the form of

boronated super phosphate appears sufficient. The deficiency of potash is limited to reverine areas of 'southern cotton zone' only and the research investigations on potash fertilization is in progress (Ogunlela et al., 1984).

The late-sown cotton has a small stature and the canopy can hardly cover the ground at peak flowering stage. The leaf area index (LAI) resulting from low plant density also limits the yield of late-sown cotton. There is no specific recommended spacing for the late-sown cotton, therefore, farmers adopt the plant spacing recommended for the early-sown crop. The sparse planting result in poor utilization of solar energy, soil moisture and nutrients by the late-sown cotton.

1.5 Management Practices to Improve Yields

The cotton production areas have short rainy season of 100 - 120 days, especially for late-sown cotton. In order to increase cotton production, early maturing cultivars that can mature shortly after the cessation of the rains should be used for late-planting in all the cotton growing zones of Nigeria. Okra and Super okra leaf-type cottons which are early maturing, have low incidence of boll rot, open canopy which facilitates pest control and higher photosynthetic efficiency of the lower leaves (Harrock et al., 1978) can be used to improve yield.

Cotton soils in Nigeria are deficient in nitrogen. Response to nitrogen has been reported earlier (Kumar et al.,

1982a and 1982c). To improve the yields of late-sown cotton, moderate amount of nitrogen is needed.

Another approach to increase the late-sown cotton yield is by adopting a denser plant population than that used by the farmers which is recommended for early-sown crop. The current recommendation of 90 x 44 cm spacing for the early-sown cotton, with two plants per stand gives a highly rectangular plant arrangement, and may lead to considerable under-utilization of solar radiation during the early part of the growing season of the late-sown cotton. Cotton has responded to higher plant populations elsewhere than those used in Nigeria (Brown, 1971; and Burhan and Taha, 1974).

1.6 Objectives

In an attempt to increase the yield of late-sown cotton, field experiments were carried out to:

i. compare the yield potentials of 'Super okra' 'Samaru 71' and 'Bar 14/25',

ii. determine the optimum level of nitrogen fertilization and population density for late-sown cotton,

iii. determine the optimum row spacing for late-sown cotton.

Chapter 2

LITERATURE REVIEW

There is very little information on agronomic research on late-sown cotton. Consequently most of the available information refer to timely sown cotton.

2.1 Cultivar

Two major species of cotton grown in West Africa include Gossypium hircutum L. and Gossypium barbadense L. (Berger, 1969). The latter is a longer season species and is adapted to irrigated conditions, while the former is a shorter season species grown mainly under rainfed conditions. G. hirsutum L. has a wide range of leaf types. The cultivars with entire leaves (normal leaf cotton) does not have pronounced lobes. The okra leaf cotton exhibits a much reduced leaf area with deeply cleft, narrow lobed leaves and the super okra leaf cotton has its leaf further reduced to a single strap-shaped lobe. In both okra and super okra leaf-types, the leaves tend to hand down vertically, contrasting with the horizontal orientation of the normal leaf type (McLlory, 1967 and Berger, 1969).

Until recently okra leaf-type cotton could not be used commercially because of its open canopy which is proned to severe weed infestation (Karami and Weaver, 1962; Jones and Andries, 1967; Andries et al., 1971; and Johnson and Walhood,

1972). With the advance in the use of sellective and persistant herbicides, the okra leaf-type, which allows more light penetration to the lower leaves of the plant, appears to have some practical value in reducing boll rot loss and increasing earliness. Andries et al., (1969) reported that okra leaf cotton, which has a smaller stature, higher flowering rates and less tendency for rank growth than plants with normal leaves, was better suited to denser population that are considered optimal for normal leaf cotton. Similar finding were also reported by Johnson and Walhood (1972), and Thomson (1972).

High abortion rate of young bolls of Super okra leaf-type was associated with a general reduction in leaf area index (LAI) which presumably resulted in the reduction of bolls per fruiting position (Ibrahim, 1974; Kerby and Buxton, 1976; De Olivera, 1974; and Pegelow et al., 1977). Pegelow et al., (1977) reported that the lower leaves of 'Super okra' plants were more photosynthetically active than the lower leaves of normal leaf-type cotton. Harrock et al., (1970) observed that Super okra leaf-typed translocated equivelent amount of ^{14}C-assimilates from each of the source-leaves to the sink-bolls, although its leaf area was only 42% of the normal leaf-type cotton. Leaf area of 'Super okra' plants were approximately 2.6 times more efficient than normal leaf plants in translocating ^{14}C-assimilate from source-leaves to sink-bolls.

Rao and Weaver (1976) reported that okra leaf-type cotton produced essentially the same yield as normal leaf cotton but had a slightly longer and stronger lint. They concluded that okra leaf-type cotton was more suitable in areas with short growing season and/or high risk of boll rot loss. This observation supports the suitability of Super okra leaf-type for late-planting. Andries et al. (1969) observed significant increase in lint yield and micronaire value in Super okra leaf-type cotton as compared to normal leaf-type.

Kerby et al. (1980) studied three near-isogenic lines of normal, okra and Super okra leaf-types and observed that okra and Super okra leaf-types had generally high $^{14}CO_2$ uptake per unit leaf area, but lower LAI than 'normal' leaf-type cotton. Uptake of $^{14}CO_2$ among leaf-types per unit leaf area was different only in the "top interval" during the fifth week in the order: 'normal' 'okra' 'Super okra'. During the fifth week the top height interval accounted for 81, 77 and 69% of the canopy ^{14}C-assimilation, but contained only 29, 28 and 32% of fruit dry weight for normal, okra and Super okra leaf-types, respectively. Okra and Super okra leaf-types had a larger percentage of dry fruit weight and smaller percentage of leaf and petioles than normal leaf-type cotton.

2.2 Nitrogen Fertilization

2.2.1 Growth

There are two main phases of development in the life of cotton namely, vegetative and reproductive phases. There is, however, a transitional phase when the squares, flowers and burs are formed while the vegetative phase continues (Arnon, 1972). The vegetative phase lasts from emergence till the time when the maximum leaf area is reached at approximately 10 - 12 weeks after sowing (WAS). The reproductive phase covers the period of squaring, flowering, boll formation, development and maturity (8 - 22 weeks).

Christidis and Harrison (1955) stated that nitrogen is normally concentrated in the growing points of any plant in the early growth stages, and influences both the rate and extent of growth. In young cotton plants, the demand for nitrogen, though critical, is not high. Availability of nitrogen becomes most critical during peak boll-filling stage, when the demand for nitrogen is also greatest. Gardner and Tucker (1967) reported that nitrogen deficiency at early growth stages hampered development of vegetative branches, internode elongation and fruiting especially in 'one peak' flowering regions. On soils with inadequate supply of nitrogen ($\leq$ 4 ppmNO_3-N) fertilizer nitrogen should be applied early in the season to avoid nitrogen deficiencies.

Reddy and Rao (1970) reported favourable effect of nitrogen (67 - 135kg ha^{-1}) on cotton plant height. Gopalswamy and Palaniswamy (1974) found that application of nitrogen significantly increased plant height and delayed maturity. Favourable effect of nitrogen on cotton plant height has also been reported by Narayanan et al.(1974), Sonap (1975) and Lande (1976).

According to Reddy and Rao (1970) increases in levels of nitrogen linearly increased the number of functional leaves. Patil (1975) expressed a contrary view. Koli and Morrill (1976) reported that nitrogen significantly increased the number of internodes and vegetative branches of cotton plants. Thompson et al. (1976) showed that low nitrogen levels (0 - 134 kg ha^{-1}) caused cotton plants to grow slower, flower later, and produce less fruits and seed cotton than higher (134 - 201 kg ha^{-1}) N-levels. Smithson et al. (1976) working at Samaru, Nigeria, reported that nitrogen increased the number of bolls per plant. It prolonged the growth period and enabled the later formed flowers and fruits to develop to maturity. They indicated that early application of nitrogen promoted vegetative growth while split application of nitrogen resulted in high reproductive growth.

2.2.2 Yield components, yield and quality

Since nitrogen nutrition plays an important role on the

vegetative and reproductive phases of cotton, the yield contributing characters, yield and the quality of the fibre are likely to be influenced by nitrogen application.

Renoid *et al.* (1934) observed marked increase in number of fruiting branches per plant with nitrogen application. Iftekhar *et al.* (1969) found that the mean number of branches per plant of four cotton cultivars increased with increase in nitrogen level and recorded maximum number of fruiting branches per plant with 150 kg ha^{-1} of applied nitrogen. Similar result were reported by Lande (1976). Negi and Singh (1976) observed that the application of nitrogen significantly increased dry matter accumulation per plant.

Hamilton *et al.* (1956) found that increase in nitrogen level increased the the number of bolls per plant. Lombin and Ogunlela (1979) summarising 10 field trials conducted for three years, covering the major cotton growing areas of Nigeria concluded that June-sown cotton did not respond to N beyond 50 kg ha^{-1}. Kumar *et al.* (1982b) reported no response of May-sown cotton beyond 90 kg ha^{-1} of nitrogen at Samaru, Nigeria. Favourable effects of nitrogen fertilization on boll size has been reported by Singh *et al.* (1979). However, other workers (Senap, 1975; Lande, 1976) have reported no effect of nitrogen on boll weight.

Martin and Ware (1932) and Nayak (1954) have reported

linear increase in seed index with increased nitrogen levels. Similar result was also reported by Garg (1962) but Singh and Dargon (1965) and Lande (1976) reported no effect of nitrogen on seed index of cotton.

Effect of nitrogen fertilization on ginning percentage has been variable. A marked decrease in ginning percentage with nitrogen application has been reported by Sen and Ahmed (1947), Verma et al. (1965) and Sondge (1972). Mayilswamy and Iruthayaraj (1980) working in India, reported that fibre fineness was higher at 45 kg ha^{-1}, but fibre length and bundle strength were higher at 90 kg N ha^{-1}.

Jackson and Faulkner (1962) stated that low doses of nitrogen appeared to favour early maturity, while higher doses delayed maturity. Lande (1976) reported no effect of nitrogen on earliness index of cotton. Palmer and Goldsworthy (1971) and Hayward (1972) reported minimal or negative response to N in unsprayed cotton but good response by sprayed crop. Hayward (1976) working at Samaru, Nigeria, reported that nitrogen application may decrease yield of July-sown cotton if the crop is either unsprayed or improperly sprayed. Koli and Morrill (1976) also observed a reduction in yield with 90 kg N ha^{-1} at Stillwater, U.S.A. Rao and Weaver (1976) reported a slight increase in boll rot loss with higher (100 - 160 kg ha^{-1}) nitrogen levels, with a resultant decrease in yield. They also observed no significant effect of nitrogen on the earliness

of cotton.

Burhan (1971) working at the Gezira, Sudan, reported a currilinear relationship between seed cotton yield and the rate of nitrogen application. The relationship was most adequately represented by the quadratic polynomial function:

$$Y = a + 1.37X - 0.14\ X^2$$

He recommended the use of 134.5 as against 69.7 kg N ha^{-1}. Kumar et al. (1982c) working at Samaru, Nigeria, obtained a quadratic regression between seed cotton yield and nitrogen level for July-sown cotton.

$$Y = 522.0 + 9.14\ X - 0.08\ X^2$$

They recommended the use of 26 kg N ha^{-1} for mid-July-sown cotton in the Nigerian savanna.

2.2.3 Nitrogen content

The quantity of nutrients absorbed by the root system of any plant is dependent on the quantities of these nutrients available in the active root zone. Armstrong and Albert (1931) reported that just prior to the rapid production of lower buds, about three-quarters of the total dry matter of the cotton plant and from 80 - 90% of nitrogen was present in the leaves. At the end of the fruiting period only one-fifth to one-third of the cotton dry weight and from 30 - 55% of nitrogen was present in the leaves while 40 - 60% of nitrogen was found in the bolls. The percentage of nitrogen in the stalk changed very slightly.

A small portion of the nitrogen was in the roots and it remained relatively constant throughout the growing season.

Olson and Bledsoe (1942) working in Georgia, U.S.A., found that cotton plants on one hectare contained 145 kg N ha^{-1}. Percentages of the total N utilized during vegetative and reproductive stages were 17.2 and 82.2, respectively. Garg (1962) observed that the total nitrogen content in the plant increased with increasing level of nitrogen from 20 to either 40 or 60 kg at all stages of growth.

Thompson *et al.* (1976) using 0 - 201 kg N ha^{-1} derived a model for N-concentration in the leaves from each N-treatment. N content decreased as the season progressed. They indicated that nitrogen concentration in the leaves diminished with time but not in a linear fashion. Nitrogen concentration tended to level off at the end of the season, with the minimum concentrations depending directly on the rate of nitrogen application. Early season leaves contained about six per cent nitrogen regardless of the rate of nitrogen application. The initial N-concentrations of the mid-season leaves varied from about 3.2% for unfertilized control to about 4.6% for all other N application rates. The initial N-concentrations for the late season leaves were about 2.7, 2.9, 3.5 and 3.3% for 0, 67, 134 and 201 kg N ha^{-1}, respectively.

2.3 Plant Population

Plant population should be considered not only in terms of the number of plants per unit area but also in terms of spatial arrangement or plant rectangularity. In this context, the inter- and intra-row spacings, the number of plants per hill or stand, amount of seed broadcast per drill row or the number of drills per ridge, and the row direction may exert considerable influence on the crop. Consequently, different plant distributions for the same density can be achieved. Plant size and leaf-shape may contribute to a plant ability to tolerate crowding. The length of the growing season and time of planting exert considerable influence on the ultimate crop canopy. Spatial arrangements effect the water use, water-use efficiency and efficiency of radiant energy interception (Evans, 1975).

Plant density has a marked effect on the crops capacity to utilize environmental factors and to build up plant tissues by converting solar energy into chemical energy. Because of its ontogeny, the cotton plant tends to compensate for variations in stand densities in the field, by developing branches and fruits in relation to the space available to individual plants. Donald (1963) reported that in general, the more favourable the environment for any season whatsoever, the higher the optimum population will be, a view supported by Christidis and Harrison (1955) and Hearn (1972). Hearn (1972) stated that optimum cotton density was less with bollworm infestation, infertile

soils and drought.

2.3.1 Growth and yield

Holliday (1960) reported that yield is a product of either the crop's growth in the vegetative or reproductive phase. The relationship was shown to give a typical flat-topped curve with only small decreases in yield at both sides of the optimum and can be fitted by the quadratic regression:

$$Y = a + b x - cx^2 \quad - - - - \quad (i)$$

where y = yield per unit area,

x = plant population,

and a, b and c regression constants.

The second relationship which is a symptotic in shape, can be described by the expression:

$$Y = Ax \frac{1}{1 + Abx} \quad - - - - \quad (ii)$$

where Y = yield of dry matter per unit area,

A = the "apparent" maximum yield per plant,

X = number of plants per unit area,

b = the linear regression coefficient of the reciprocal of yield per plant on population.

In equation (ii), the term $\left[\frac{1}{1 + Abx}\right]$ represents the manner in which the maximum plant yield (A) is reduced by increasing competition resulting from greater plant density and was termed

"competition factor". The expression "$\frac{1}{x}$" is a measure of the area available per plant and the environmental resources are available to the plant on an area basis. He observed that as plant density increased, yield of seed increased to a maximum. This yield level remains constant within a certain range and then declined more or less steeply as population increased still further even when moisture and nutrients were not limiting. Donald (1961) reported that the relationship of seed or fruit (economic yield) to density is different from that of "biological yield". He suggested that "the minimum density giving the ceiling biological yield may also be the density giving the maximum seed yield".

Hearn (1972) working on variable cotton population densities in Uganda, observed some contradictory evidence in the findings of Holliday (1960). Using the Bleasdale and Nelder (1960) equation on yield population relationship, Hearn (1972) derived a mathematical model for the determination of optimum densities for cotton in Uganda:

$$W^{\theta} = a + b\,(x_1\, x_2)^{-1}$$

where x_1 and x_2 are the within and between row spacings, therefore, $(x_1\, x_2)^{-1}$ is the population density,

W = yield per plant, a, b and θ are positive constants.

The assumptions were (a) that increase in total plant dry weight

followed a logistic curve, (b) that a constant biological yield is eventually attained over a range of dense population and (c) that the weight of the plant parts which formed the economic yield is allometrically related to the weight of the whole plant, when these vary in response to changes in density. The constant θ reflected the way the proportion of the total weight of a plant found in a particular part changes as plant size decreases with denser populations: $\theta < 1$, the equation fits the parabolic curve.

The recommended spacing for cotton in Nigeria is on ridges 0.9 m apart and 0.44 m between stands along the ridges with two plants per stand. This density of about 49,400 plants ha^{-1} (about 5 plants m^{-2}) has been considered optimum for the early-sown cotton, grown under high management (Lawes, 1968). Lawes (1963) obtained higher seed cotton yield from plant population greater than recommended in Nigeria but King (1955) failed to demonstrate this relationship. Hughes (1963) working in Arkansas, U.S.A. compared plant densities of 172,970; 135, 905 and 49,420 plants ha^{-1} for five years. In two out of five years, there was increased lint yield at the highest plant density as compared to the medium/low plant densities. Douglas (1964) reported that 74,130 plants ha^{-1} significantly outyielded 140,260 and 222,390 plants ha^{-1} but did not differ from 24,710 plants ha^{-1} in South-West Georgia, U.S.A. Brown (1971) concluded that response to increased plant population was likely to be minimal in these cotton varieties with dense

canopy which restricted light and insecticide penetration into the crop. He suggested further study of the effect of spacing on varieties with widely different habit, leaf shape and earliness of flowering.

Hawkins and Peacock (1970, 1971) working in Georgia, U.S.A. found that higher yields were obtained at plant populations of 96,000 to 114,000 plants ha^{-1}. Douglas and Andries (1970) obtained yield response to plant populations of 24,700; 74,000; 148,000 and 222,300 plants ha^{-1}, with the highest yield at 74,000 plants ha^{-1}. Heskinson _et al_. (1971) reported reduced yield at 494,000 plants ha^{-1} and attributed this to barren plants. They also reported increased lint percentage with increased population, a view supported by Melville and Caldwell (1972). Bridge _et al_. (1973) obtained the highest yields at 114,000 to 121,000 plants ha^{-1}. Tupper and Anderson (1973) reported that plant spacing resulting in 120,492 and 192,730 plants ha^{-1} yielded significantly more seed cotton than plants grown at densities of 49,420 or 76,607 plants ha^{-1} in Mississippi, U.S.A. Pennington and Waddle (1973) indicated that as plant population increased, fewer fruiting positions were produced and greater insect losses and/or elevated square shedding and reduction in boll size were recorded. Other workers have reported increased yield with increase in plant population in cotton (Briggs and Patterson, 1969; Niles, 1970; Ray, 1971; and Koli and Morrill, 1976).

Arnon (1972) concluded that a crop like cotton with indeterminate growth habit "in which the flowering apices do not arise directly from the major vegetative apices" respond to higher density mainly by change in the number of parts formed but crops with determinate growth habit respond mainly through changes in the size of the parts. He stated that with evenly spaced plants, dry matter yield first tends to increase linearly with increase in plant density, due to lack of appreciable inter-plant competition. Further increase in density brings dininishing returns. Inter-plant competition reduced productivity of individual plants which could be compensated for by increased number of plants per unit area. Increase in plant density reduced volume of air and soil for individual plants and increase inter-plant competition for soil nutrients, moisture, carbon dioxide and light. The conventional row spacing used in cotton production in Nigeria is about 90 cm. Considering the growth pattern of cotton and the small frame of the late-planted crop, narrow-row culture could increase the plant density, thereby maximising the yield of the late-sown cotton. Brasheers et al. (1960) and Kirk et al. (1969) reported that high canopy photosynthesis and lint yield can be obtained at relatively low plant densities in narrow-row plantings. However, higher densities are frequently recommended to reduce monopodial branding in order to facilitate finger-stripper harvesting. Similar findings have been reported by Hawkins and Peacock (1973), Baker (1976) and Pegelow et al. (1977).

Culp et al. (1974) reported extensive studies in Arkansas, U.S.A. on high plant population through increasing the number of plants within rows of conventional spacing or by the use of narrow-rows. With conventional row widths, increasing plant population from 27,675 to 110,000 plants ha^{-1} had no effect on lint yield or fibre properties. Rows spaced 50.8 cm with two plants per 30 cm outyielded two plants per 30 cm grown in conventional row width of 101.6 cm; while increasing the plant population to 250,320 plants ha^{-1} by decreasing row widths to 17.8 or 22.9 cm significantly reduced the lint yield. Plant densities of 129,164 plants ha^{-1} or higher resulted in significant decrease in boll size, seed weight, and/or fibre fineness. Heilman et al. (1975) reported no significert differences in the yield of "Tamcot SP-37" when grown at densities of 81,543; 163,086 or 244,629 plants ha^{-1} in Texas, U.S.A. Using different row spacing in Georgia, U.S.A., Baker (1976) observed that there were no difference in yield, earliness, lint percentage, fibre length or fibre strength between narrow row and the conventional check. The conventional check produced larger bolls, fewer blooms, lower potential yield and set a higher per cent of early blooms. He concluded that an indeterminate type cotton will not respond favourably to high population in narrow-row planting because of crowding and lack of light penetration resulting in higher boll shedding rates. The potential of this production method can only be fully utilized through the development of cultivars specifically suited for this

method of production. Dwarf, semi-dwarf, true determinate types and/or alteration of canopy to allow sunlight penetration and reduce boll shedding appeared to be the initial problems to be solved. Kerby and Buxton (1976) using 11.2 and 10.5 plants m^{-2} in 1973, and 10.0 and 20.0 plants m^{-2} in 1974, observed 17% and 10% more fruiting positions in 1973 and 1974, respectively in the higher than the lower population, in Arizona, U.S.A. High population, however, led to greater square abortion than the low population (23% in 1973 and 25% in 1974). A similar trend was observed in boll abortion. Koli and Morrill (1976) observed that narrow-row depressed plant height of cotton in Oklahoma, U.S.A. In two years of the trial 25 cm rows produced the shortest plants. There was a significant reduction in plant height as plant population increased from 123,550 to 173,000 plants ha^{-1}. Payne et al. (1976) reported that narrow-row culture has shown considerable promise in many parts of U.S.A. by improving earliness and reducing production cost. Saleem and Buxton (1976) reported that under the condition of delayed node of sympodial branch due to high densities excessive vegetative growth was enhanced which reduce lint yield, which confirmed an earlier work by Ray and Fowler (1971).

Buxton et al. (1977) working in Arizona, U.S.A. noted that population pressure increased plant height when plants were young, while the effect on older plants was inconsistent. The morphological measurements showed that each five plants m^{-2}

increase in population decreased the number of main stem nodes by one and each eight plants m^{-2} increase in population decreased the number of monopodial branch per plant by one. They also observed that high plant population densities increased leaf density, creating a more favourable micro-climate for insect and disease and making the defoliation more difficult, hence optimum plant density appeared to be between 10 and 15 plants m^{-2}, Samra and Salam (1970) and Sastrosupadi and Marlijindadi (1970) demonstrated the superiority of narrow-row cotton to conventional spacing in good cotton yield. Smith et al. (1970) using 32,123; 96,369 and 160,615 plants ha^{-1} with three cotton cultivars obtained 2,256; 2,562 and 2,407 kg ha^{-1} of seed cotton, respectively in 1975. The difference between the three population levels was not significant in 1976. They observed that plant population had little effect on lint percentage but that plants at lowest population matured significantly later than did at the two higher populations. Smith et al. (1979) using 96.5 cm rows and 6.1, 10.2 and 30.5 cm within rows (169,041; 101,573 and 33,969 plants ha^{-2}, respectively) obtained significant yield increase at 101,573 plants ha^{-1} population density as compared with 169,041 plants ha^{-1}, but there was no significant difference from the wider spacing of 30.5 cm (intra-row). Low density caused significantly delayed maturity, while high density (6.1 cm intra-row) resulted in significant reduction in lint percentage and boll size. Mayilswamy and Iruthayaraj (1980) using two cotton cultivars in India, grown

at 33,333, 44,444 and 66,666 plants ha^{-1} recorded highest fibre fineness with 66,666 plants ha^{-1}. Plant density had no effect on Bartletts index, seed index and maturity coefficients. Galanopoulou-Sendouka et al. (1980) using 25 cm intra-row spacing on 100, 50 and 25 cm rows corresponding to 10, 20 and 40 plants m^{-2} observed decreased productivity of individual plants and increased dry matter production m^{-2} at high densities. At very high density, plants showed lower efficiency of leaves, higher fruit shedding and smaller boll size, while at intermediate plant density, earliness and high yield were more consistant.

2.3.2 Yield components and quality

The number of plants per unit area affects leaf area per plant, LAI and light interception. Tanner and Lemon (1962) reported that when soil moisture is available and a substantial crop cover shades the ground, most of the net radiation is used for transpiration and in consequence higher water-use efficiency. It is reported that the proportion of incident light that is intercepted by the canopy does not depend on LAI alone but also on the "architecture of the plant community". Loomis and Williams (1963) indicated that the leaves are arranged in canopy and their orientation affects the proportion of incident light that is intercepted by the crop's leaf area as a whole. Donald (1963) reported that the leaf characters of importance in this respect are: - leaf angle, leaf area, continuity of

leaf layers and randomness of dispersion of the leaves.

Wilson (1969) estimated the extinction coefficients (K$_L$) which is a measure of the light interception efficiency of the leaf area of various field crops which suggest that cotton has a relatively high light interception capacity. He further reported that under limited water supply, only a relatively low plant population per unit area can be supported. The optimum LAI is thus low and a high K is advantageous in maximising the light interception. Under adequate water supply, a low K becomes beneficial because it engenders high optimum LAI. Under these conditions, efficiency of light utilization is optimal; at high LAI, a lower K ensures that the total light available is dispersed over a greater area of leaves, but the light is proportionally weaker.

Koli and Morrill (1976) reported that high population achieved through narrow-row produced a large leaf area very early in the season which is advantageous for subsequent plant development and growth. Similarly, Buxton et al. (1977) reported that increased plant density also increased leaf area index, especially in the central portion of the plant canopy. The leaf area indices were 3.25, 3.97 and 4.29 for densities of 7.4, 14.8 and 19.8 plants m^{-2}, respectively. Kerby and Buxton (1976) observed that the leaf area per plant dropped from 32.2dm^2 to 23.4dm^2 at 11.2 and 16.5 plants m^{-2}, respectively in 1973 and from 35.8dm^2 to 20.0dm^2 at 10 and 20 plants m^{-2},

respectively in 1974. These resulted in LAI of 3.61 and 4.33 at 11.2 and 10.5 plants m^{-2}, respectively in 1973 and in 1974, 3.50 and 4.00 at 10 and 20 plants m^{-2}.

The total number of fruiting points, rate of production of fruiting bodies, and the rate of maturity of the early formed bolls are affected by plant density. Douglas and Andries (1970) reported that high population in both narrow and conventional rows produced smaller bolls than low population. Melville and Caldwell (1972) working in Louisiana, U.S.A. indicated that high population produced more total blooms than low population. Buxton et al. (1977) reported that the percentage of bolls attached to sympodial branches arising from monopodial branches decreased as plant density increased. At seven plants m^{-2}, approximately 25% of the bolls developed on monopodial branches. This percentage was reduced to almost zero when the plant population approached 30 plants m^{-2}. Jackson and Faulkner (1962) also noted that a high percentage of mature bolls were located at the first position of sympodial branches when plant density was high.

Longenecker et al. (1970) obtained an average increase of 15% at first picking from narrow-row (high plant density) cotton. Close spacing (10 cm) increased earliness of determinate early maturing cultivars but not the late maturing cultivars (Koli and Morrill, 1976). Fowler and Ray (1977) using mean maturity date (MMD) and production rate index (PRI), as

measures of earliness; found that both measures were inversely related to plant density. These confirmed the findings of Ray and Richmond (1966) and Kirk et al. (1969). The optimum plant population for both yield and earliness was in the range of 79,000 to 155,000 plants ha^{-1}.

Bailey and Trought (1926) reported that monopodial plastochrons were greater near the top than the base of cotton plants and that sympodial plastochron related to the number of days between successive fruiting branches while monopodial plastochron was the number of days between the first fruiting positions of successive fruiting branches. McNamara et al. (1927) observed a tendency for plastochron to increase with close plant spacing. Kerby and Buxton (1976) reported that plants grown at high population densities generally had larger sympodial and monopodial plastochrons (longer time interval between the appearance of fruiting positions) than plants at low population.

2.3.3. Nitrogen content

Moursi and Gawad (1962) reported an increase in the total mineral (nitrogen phosphorus and potassium) uptake per unit area with increase in cotton plant population, although the total uptake per plant was low with increasing plant density. They indicated that plant density exerted a marked effect on nitrogen metabolism in that low plant population tended to increase the the concentration of total nitrogen in cotton plant tissues.

2.3.4 Late-sown cotton

Lambert and Crowther (1935) reported that spacing had little effect on early-sown cotton in the Sudan, but there was an increased response to closer spacing with late sowing. A similar finding was reported by Ferguson (1953). The explanation given by these workers was that with early-sown cotton the plants were able to compensate extensively for loss of stand and, therefore, plant density was not of great importance in determining final yield. Burhan and Taha (1974) recommended an intra-row spacing of 50 cm for the early-sown cotton in the Sudan, and 30 cm if sowing was delayed to later than mid-August.

2.4 Cultivar x Nitrogen x Plant Population

The nitrogen requirements of a particular cultivar at a definite population density is likely to differ from that of another variety at the same or different population density. Kerby and Buxton (1976) using normal, okra and super okra leaf type cottons at 10 and 20 plants m^{-2} observed higher boll retention by the normal leaf than the okra and super okra leaf type cottons at two population levels. Okra and super okra leaf type cottons, however, had higher total number of fruiting positions than the normal leaf cotton at both 10 and 20 plants m^{-2}.

Koli and Morrill (1976) observed significant interaction between nitrogen and population on plant height and seed cotton

yield. Rao and Weaver (1976) reported no significant irteraction between leaf shape, plant population, nitrogen rates and irrigation, on boll rot, lint percentage, earliness and boll size.

2.5 Correlation and Regression

Katarki and Sangaih (1966) reported that yield of seed cotton showed significant positive correlation with boll weight per plant. Other workers (Rajale and Khuspe, 1960; Ali and Chandramohan, 1973; and Lande, 1976), showed similar relationships between seed cotton yield and boll number per plant, number of sympodial branches, plant height, seed index, number of seeds per boll, number of locules per boll, boll weight, number of seeds per locule, dry matter and ginning percentage. Kurlekar and Khuspe (1980) reported that seed cotton yield per plant was positively correlated with leaf number, leaf area, total dry matter, leaf nitrogen content at seven and 13 weeks after sowing of hybrid H-4. The multiple regression analysis showed that the number of picked bolls per plant, plant height and leaf number had the greatest effect on yield followed by total dry matter, leaf nitrogen content at 50 and 90 days after sowing and leaf area.

From all indications, cultivar has specific effects on yield and yield components of cotton. In a similar manner, optimum population for maximum yield varies with environmental inputs while nitrogen plays a major role in the yield of cultivars and at different plant population levels.

Chapter 3

MATERIALS AND METHODS

Field experiments were conducted during the wet seasons of 1979, 1980 and 1981 on the experimental farms of the Institute for Agricultural Research, Ahmadu Bello University at Samaru (11^{0} 11'N; 07^{0} 30'E, 686m above mean sea level) in the northern Guinea savanna zone and at Mokwa (09^{0} 18'N; 05^{0} 04'E, 152m above mean sea level) in the southern Guinea savanna zone of northern Nigeria.

3.1 Experiment I: Cotton Cultivar x Nitrogen Level x Plant Population

An experiment consisting of variable population densities, nitrogen levels and cultivars was laid out at Samaru and Mokwa in 1979, 1980 and 1981 wet seasons. The details are described as follows.

3.1.1 Design and plot size

The experiment was laid out in a split-plot design with population levels assigned to the main plots and the combination of nitrogen and cultivar assigned to the subplots. The trial tested three population levels in the first year but in the second year, two additional levels of population were added on the basis of the first year's results.

The 24 treatments in 1979 and 40 treatments in 1980 and 1981 (all possible combinations of population x nitrogen x

cultivars) were replicated three times.

3.1.2 Treatments

Main plot

Population levels: Plant populations of 50,000; 100,000; 150,000; 200,000 and 250,000 plants ha^{-1} were used with only the first three population levels used in the 1979 season. The inter-row spacing was 90 cm and the intra-row spacings of 9, 11, 15, 22 and 44 cm used to achieve the above population levels.

Subplot

Nitrogen levels: 0 (control), 40, 80 and 120 kg N ha^{-1} were used in the three growing seasons (1979 to 1981).

Cultivars: Two cultivars of cotton were used, Samaru 71 and Super okra.

Seeds (4-10) were planted on 90 cm conventional ridges.

The subplot size consisted of six ridges each by four metres long. Yield was determined from the centre two rows (1.8 x 2.2 m). Routine samples were taken from the next rows on either side of the net plot and the extreme rows of each plot left as the discard.

3.1.3 Cultivars

Two cultivars - Samaru 71 and Super okra leaf type cotton (Gossypium hirsutum L.) were used in this investigation. A brief description of the cultivars were given below:

Samaru 71

This cultivar developed in the early 1960s as selection from a cross between the American Upland-Allen variety with a local cotton variety. This cultivar has few or no vegetative branches, which are green when young then turn brown later. It has large cordate five-lobed hairy leaves. The flowers have large pale yellow petal without a spot at the base. The bolls are large, round with five locules and a few inconspicuous oil glands, early maturity and medium staple length (25.4 - 27.0 mm). It was blight resistant but has now lost that characteristics*.

Super okra

This cultivar was imported from the Sudan in the late 1960s. The first few leaves are cordate later five-lobed, then three-lobed and finally reduced to single strap shaped smooth leaves. It has many ascending vegetative branches. The stem is green when a few weeks old, then turns brown later. The flowers have large yellow petals without a spot at the base. The bolls are five-locular, slightly pitted, oval shaped with a pointed

* Nace, L. (1979). Personal communication, IAR, ABU, Zaria.

tip. The bolls are smaller than those of 'Samaru 71'. It is a blight resistant, early-maturing and medium staple length (25.5 - 27.0 mm) cultivar*.

3.1.4 Seed source

Dressed seeds of the two cotton cultivars were obtained from the Plant Science Department of Institute for Agricultural Research, Samaru.

3.1.5 Planting

The experiment was planted at Samaru on 12, 15 and 15 July 1979, 1900 and 1901 respectively. The same trial was planted at Mokwa on 10, 22 and 22 July, 1979, 1900 and 1901, respectively. These planting dates coincided with the farmers' planting time in the northern and southern Guinea savanna zones, respectively.

Four to ten seed were planted per hill depending upon the availability of seed and thinned to two plants per stand three weeks later.

3.1.6 Fertilizer application

Phosphorus was broadcast uniformly just before ridging at the rate of 45 kg ha^{-1} (P_2O_5) in form of boronated superphosphate (10% P_2O_5 and 5% borax). Potassium was also applied prior to ridging at the rate of 90 kg ha^{-1} (K_2O)

* Nuce, L. (1979). Personal communication, I.A.R., A.B.U., Zaria.

using muriate of potash.

Nitrogen was band placed in a split application with half the dose (40, 80, 120 kg ha^{-1}) applied at four and the remaining half at eight weeks after sowing. Calcium ammonium nitrate (26% N) was used as the nitrogen source.

3.1.7 Weed control

In 1979, 1980 and 1981 a mixture of duiron and fluridone each at the rate of 0.8 kg ha^{-1} active ingredient was applied as pre-emergence and was followed by one supplemental hoe weeding at six to seven weeks after sowing at both locations.

3.1.8 Insect control

In 1979, a mixture of benzene hexachloride (BHC), dichlorodiphenyltri-chloroethane (DDT) and carbaryl at the rates of 1.5 litres per 110 litres of water per hectare, 6 litres in 200 litres of water per hectare and 1.0 kg ha^{-1} active ingredient, respectively was sprayed biweekly at Samaru from the eighth to the sixteenth week after sowing. In 1980 and 1981 cymbush 1.0 ULV at 2.5 litres ha^{-1} biweekly was used. Carbaryl at the rate of 2.2 kg ha^{-1} active ingredient was sprayed weekly beginning from the eighth to the sixteenth weeks after sowing in 1979, 1980 and 1981 at Mokwa.

3.2 Experiment II: Cotton Cultivar x Plant Population x Row Spacing

This experiment was sited at Mokwa only and consisted of row spacings, plant populations and cultivars under high fertility.

3.2.1 Design and plot size

The experiment was laid out in split-plot design with row spacings as the main plot and a combination of populations and cultivars assigned to subplots, replicated three times. The gross plot size was 6 x 4 m. The net plot was 6 m^2. The routine samples were taken from the remaining outer rows, the extreme rows at either ends of such plot being left as discard. To achieve the desired populations with varied inter- and intra-row spacings, this experiment was planted on the flat bed.

3.2.2 Treatments

Main plot

Row spacing: The row spacing consisted of 60, 75 and 90 cm rows.

Subplot

Plant population: Three population levels - 50,000; 100,000 and 150,000 plants ha^{-1} were used in 1979 to 1981 seasons.

Cultivar: Three cultivars - Samaru 71, Bar 14/25 and Super okra were tested.

Plant arrangement: The following inter- and intra-row spacings (cm) of cotton were used with variable populations.

Inter-row spacing (cm)	Plant population (000 ha ^{1})		
	50	100	150
60	67	33	22
75	54	27	18
90	44	22	15

3.2.3 Cultivar

'Samaru 71' and 'Super okra' belong to the species G. hirsutum L. whereas 'Bar 14/25' belongs to species G. barbadense L.

'Samaru 71' and 'Super okra' cultivars used in this trial have been earlier described under sections 3.1.3. A brief discription of 'Bar 14/25' is given below.

'Bar 14/25' This cultivar, derived from the Sea Island Cotton (G. barbadense L.) was imported from Israel in 1966. It has few to many ascending vegetative branches. The leaves are fairly deeply divided into three or five lobes and are usually glabrous. The flowers are large, deep yelow in colour with red spot at the base. The bracteoles are large, almost as broad as long, divided at the apex into 10 to 15 green acuminate teeth. The bolls are large, 3.5 to 6 cm long, five locular and

deeply pitted. The cultivar produces a fine lint with creamy white colour, silky and lustrous with a staple length of about 31.0 mm or more. It is stronger and firmer than the lint of 'Samaru 71' and 'Super okra'. It is a late maturing cultivar and susceptible to bacterial blight*.

3.2.4 Seed source

Dressed seeds of the three cultivars were obtained from the Plant Science Department of Institute for Agricultural Research, Samaru.

3.2.5 Time of planting

This trial was laid out and the crop planted at Mokwa on 19, 24 and 23 July, 1979, 1980 and 1981, respectively.

3.2.6 Fertilizers application

Fertilizers were applied at the rates of 00, 45 and 90 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Phosphorus and potassium were applied during land preparation and nitrogen was applied in a split application, half at four weeks and the remaining half at eight weeks after sowing.

3.2.7 Weed and insect control

These are as described earlier under section 3.1.4.

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* Nace, L. (1979). Personal communication, I.A.R., A.B.U., Zaria.

3.3 Assessment of Plant Characters

3.3.1 Routine sampling

Experiment I

About 0.40 m^2 was sampled in each plot. The plants were cut at ground level at 7, 11 and 15 weeks after sowing. The sample size consisted of 2, 4, 8, 8 and 10 plants for the five population of 50,000; 100,000; 150,000; 200,000 and 250,000 plants ha^{-1}, respectively. These were used for the determination of LAI, dry matter yield, RGR, NAR and number of fruiting branches.

Experiment II

Plants from about 0.40 m^2 were sampled in each plot. Time interval for the sampling was similar to that described under section 3.3.1. The sample sizes consisted of two, four and six plants per plot for the population levels of 50,000; 100,000 and 150,000 plants ha^{-1}, respectively.

The plants were sampled from the two rows adjoining the net plot at each sampling. Five plants were tagged within each net plot of both experiments for the determination of plant height, boll weight, harvest ratio, seed index and lint index.

3.3.2 Shoot height

Height of the five tagged plants was measured from ground level to the base of the uppermost leaf at six and nine weeks

after sowing and at maturity.

3.3.3 Leaf area and leaf area index

Leaf area (LA) was estimated using the specific leaf area (SLA) relationship as reported by Evans (1972). Specific leaf area (SLA) is defined 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)

($0.000246\ m^2$)

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 0.4 (the ground area).

3.3.4 Net assimilation rate

Net assimilation rate (NAR) is the plant's rate of increase of dry weight per unit leaf area. This is similar to the unit leaf rate (ULR) as described by Evans (1972). The NAR was determined using the following formular (Gregory, 1926).

$$\frac{(W_2 - W_1)\ (\text{Log}_e L_2 - \text{Log}_e L_1)}{(t_2 - t_1)\ (L_2 - L_1)}$$

where L_1 and L_2 are total leaf area at times t_1 and t_2

W_1 and W_2 and dry weight of the plant at times t_1 and t_2.

3.3.5 Dry matter yield

The leaves, stem, squares, flowers and bolls in each sample from 0.4 m^2 were separated and dried to constant weight in a ventilated oven at 60°C and dried to constant weight. This semple was subsequently used for calculation of various growth analyses and leaves for nitrogen content.

3.3.6 Relative growth rate

Relative growth rate (RGR) was computed using the data from the dry matter yield at the different sampling periods. This is a measure of dry matter accumulation - an efficiency index of a plant.

$$RGR = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{(t_2 - t_1)} \text{ g g}^{-1} \text{ day}^{-1}$$

where, W_1 = Weight of total dry matter in g at time t_1,

W_2 = Weight of total dry matter in g at time t_2,

$t_2 - t_1$ = time interval in days

Log_e = Natural , $\log_e = 2.71020$.

3.3.7 Number of fruiting branches

The fruiting branches were counted and recorded at 7, 11 and 15 weeks after sowing from the plants sampled for dry weight accumulation.

3.3.8 Nitrogen content in the leaf

The nitrogen content in the leaves was determined, using the standard micro-Kjeldahl procedure as described by Purvis et al. (1966).

3.3.9 Flowering dates

Dates of 50% flowering were recorded for each plot from which the number of days from planting to 50% flowering were calculated.

3.3.10 Date of boll opening

Date of opening of first boll from five tagged plants was recorded for each plot.

3.3.11 Number of mature bolls

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

3.3.12 Average boll weight

Boll weight was determined from total dry weight of seed cotton picked from five tagged plants divided by total number of open bolls from same plants.

3.3.13 Harvest ratio

The number of open bolls picked on the five tagged plants was divided by the fruiting points of the five tagged plants at 15 weeks after planting, expressed as follows:

$$G = \frac{\text{Total number of open bolls}}{\text{Total number of fruiting points}}$$

3.3.14 Earliness and maturity indices

These were determined by computing the Mean Maturity Date (MMD) and the Production Rate Index (PRI) according to Christidis and Harrison (1955) and Gilbro and Quisenbery (1973) as expressed below:

$$MMD = \frac{(W_1H_1) + (W_2H_2) + \ldots\ldots\ldots\ldots (W_nH_n)}{(W_1 + W_2 + \ldots\ldots\ldots\ldots W_n)} \text{ day}$$

For hand picking:

$$PRI = \frac{(W_1 + W_2 + \ldots\ldots\ldots\ldots W_n)^2}{(W_1H_1) + (W_2H_2) + \ldots (W_nH_n)} \text{ kg ha}^{-1} \text{ day}^{-1}$$

where, W = weight of seed cotton in kg ha^{-1},

H = number of days from sowing to

date of picking 1, 2, ... n

consecutive periodic pickings.

Where earliness and not the yield is the critical information required MMD is very sensitive but where both earliness and yield are equally important then PRI is more reliable. In this study both methods were used. In addition to these, the percentage of the first picking to the total yield was also

determined.

3.3.15 Seed cotton yield

Seed cotton yield was determined from the total seed cotton picked per net plot. Seed cotton was picked periodically and sun-dried as the bolls were fully open. The picked seed cotton was weighed.

3.3.16 Ginning percentage

Seed cotton picked from the five tagged plants in each plot was ginned with a portable cotton ginner and the ginning percentage determined from the weights of the lint and seed cotton.

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

3.3.17 Seed index

The cotton seed from the cotton ginner was treated with concentrated sulphuric acid to remove the fury. The acid effect was neutralized with sodium hydroxide solution and then rinsed thoroughly with water. The cotton seeds were dried and 1,000 seeds counted and weighed.

3.3.18 Lint index

This was computed with the use of seed index and ginning percentage as follows:

$$\text{Lint Index} = \frac{\text{Weight of 1,000 seeds} \times \text{Ginning \%}}{100 - \text{Ginning \%}}$$

3.4 Physical and Chemical Analyses of Soils

Soil samples at ten different random spots on the field to a depth of 30 cm were taken every year on the different fields before land preparation. The composite soil samples were chemically and mechanically analysed to determine the soil type and fertility level of the soils. The sand, silt and clay fractions were determined for each sample.

Extraction of the soil with 25% hydrochloric acid at room temperature provided an approximation of the total potash and phosphate present. The available phosphate was extracted by shaking two grams of soil with 40 ml of 0.002 N sulphuric acid, followed by filtering (Troug, 1930). The extracted phosphate was determined by the molybdate blue colour method (Bray and Kurtz, 1945; Murphy and Riley, 1963). Exchangeable cations (to determine the effective CEC) were extracted by shaking the soil with IN NH_4OAC for two hours and centrifuged. The potassium in the extract was determined with Flame photometer and the calcium and magnesium in the extract was determined by Atomic Absorption Spectrophotometer (Perkin Elmer, model 403).

The nitrogen in the soil was determined using the standard micro-Kjeldah procedure as described by Purvis et al. (1966) using Markham distillation apparatus (Markham, 1945). The soil characteristics of the different fields used each year for the experiments are given in Tables 3.1 and 3.2.

Table 3.1 Soil physical and chemical characteristics at Samaru determined before sowing each year.

Soil Characteristics	1979	1980	1981
Sand %	31.00	47.33	51.33
Silt %	40.50	33.33	20.67
Clay %	20.50	19.33	20.00
Type	Silt loam	Silt loam	Silt loam
pH (Water)	5.00	5.13	5.20
pH (KCl)	5.10	4.20	4.32
Organic Carbon %	0.31	0.50	0.53
Nitrogen %	0.02	0.04	0.04
Ca^{++} (mg g^{-1})	775.00	635.00	672.00
Mg^{++} " "	217.00	113.33	107.21
Na^{+} " "	39.12	50.33	42.10
K^{+} " "	110.00	55.33	61.17
Mn^{++} " "	9.21	10.33	12.32
P (available) (mg g^{-1})	1.50	4.40	5.62
Cation exchange capacity	6.46	4.75	12.77
Base Saturation %	94.50	93.09	41.00

Table 3.2. Soil physical and chemical characteristics at Mokwa determined before sowing each year.

Soil Characteristics	1979	1980	1981
Sand %	72.30	04.00	91.33
Silt %	12.50	7.33	4.67
Clay %	15.20	8.67	4.00
Type	Loamy Sand	Loamy Sand	Loamy Sand
pH (Water)	5.70	5.62	5.53
pH (KCl)	5.01	4.05	4.02
Organic Carbon %	0.30	0.40	0.02
Nitrogen %	0.05	0.04	0.13
Ca^{++} (mg g^{-1})	365.00	105.00	171.23
Mg^{++} " "	69.00	22.00	19.25
Na^{+} " "	41.25	36.00	21.22
K^{+} " "	32.30	26.00	17.32
P (available) (mg g^{-1})	5.00	7.50	4.23
Mn^{++} (mg g^{-1})	32.10	27.30	22.31
Cation exchange capacity	2.03	1.47	5.33
Base Saturation %	90.40	93.64	31.00

The pH of the fields at Samaru ranged from 5.1 to 5.0 (in H_2O) and 4.2 to 5.1 (in KCl). The nitrogen level was poor (0.02 to 0.04%). The cation exchange capacity was very low. The soil was a silt loam.

The pH of the fields at Mokwa ranged from 5.6 to 5.7 (in H_2O) and 4.9 to 5.0 (KCl). The nitrogen level was low 0.04 to 0.05%. The cation exchange capacity was very low. The base saturation % for both sites were very high. Total K was particularly low at Mokwa, but was fair at Samaru. The soil type at Mokwa was loamy sand (Tables 3.1 and 3.2).

3.5 Optimum Nitrogen

The optimum nitrogen was calculated using the formula:

$$Xo = \frac{b - q/p}{2c}$$ (Anonymous, 1966)

where Xo = optimum nitrogen level,

b and c = regression constants,

p = price per unit of seed cotton (51 kobo kg^{-1})

q = price (Unsubsidised + application cost) per unit of nitrogen (₦0.00 kg^{-1} N).

3.6 Optimum Plant Population

The optimum plant population was calculated from the formula:

$$X_o = \frac{b_2 - \quad b_2^2 - 3b_1 b_3}{3b_3}$$ (Willey and Heath, 1969)

where X_o = optimum plant population,

b_1, b_2 and b_3 are regression constants.

The above formula is derived from $Y = b_1 x - b_2 x^2 + b_3 x^3$

where Y = yield of seed cotton kg ha^{-1}

X = plant population in thousand ha^{-1}

b_1 b_2 and b_3 regression constants.

3.7 Statistical Analysis

The data collected were statistically analysed as described by Steel and Torrie (1960). The least significant difference was used to compare the treatment means.

Correlation and regression of one variable on another were computed to determine their quantitative relationships.

3.8 Meteorological Data

Records of meteorological data - temperature, rainfall, relative humidity and sunshine hours were obtained from the meteorological stations at both locations. The meteorological data are stated on Appendices 1 to 8.

Chapter 4

RESULTS

4.1 Cultivar, Nitrogen and Plant Population

4.1.1 Plant height

Plant height recorded at 24 weeks after sowing did not differ significantly between the two cultivars at Samaru (Table 4.1). At Mokwa, although cultivar Samaru 71 was not significantly taller than 'Super okra' at six weeks after sowing it tended to outgrow it uptill maturity (Table 4.2 and Plates 1a, b and c).

The application of nitrogen significantly increased plant height in two out of three years at Samaru (Table 4.1) and throughout the three years at Mokwa (Table 4.2). The application of 120 kg N ha^{-1} resulted in significantly taller plant than 40 kg N ha^{-1} in 1979 and 1901 at Samaru. A similar effect was observed at Mokwa in 1979, 1900 and 1901.

Plant population above 50,000 plants ha^{-1} had no significant effect on plant height at 24 weeks after sowing at Samaru (Table 4.1). However, at Mokwa, plant height at seven weeks after sowing increased with increase in plant population upto 100,000 plants ha^{-1} (Table 4.2). The reverse was true at nine and 24 weeks after sowing at which plant height decreased with increase in plant population (Plates 1a, b and c).

Table 4.1 Main effect of cultivar, nitrogen level and plant population on the final plant height (cm) of cotton at Samaru.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	93.9	101.0	74.5
Super okra	87.2	106.1	75.7
SED (±)	5.1	5.0	2.2
LSD (p=0.05)	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})			
0	81.6	102.1	50.9
40	90.3	104.9	76.7
80	99.5	103.4	83.5
120	110.0	103.8	89.4
SED (±)	7.1	7.0	3.2
LSD (p=0.05)	14.4	N.S.	6.4
Plant population (000 ha^{-1})			
50	94.9	99.9	71.0
100	92.0	101.7	77.5
150	84.8	100.3	76.0
200	NIL	103.0	75.5
250	NIL	104.1	74.9
SED (±)	9.9	9.0	4.5
LSD (p=0.05)	N.S.	N.S.	N.S.

Table 4.2. Main effect of cultivar, nitrogen level and plant population on the final plant height (cm) of cotton at Mokwa.

Treatment	1979			1980			1981		
	7	9	24	7	9	24	7	9	24 (WAS)
Cultivar									
Samaru 71	45.3	110.3	112.4	43.3	103.6	111.3	47.3	123.8	133.0
Super okra	43.0	107.0	110.0	30.3	100.0	107.5	43.3	121.0	129.0
SED (±)	1.25	2.00	1.97	1.49	1.73	2.00	1.34	2.10	2.10
LSD ($\bar{p}$=0.05)	2.50	N.S.	N.S.	3.0	N.S.	N.S.	2.7	N.S.	N.S.
Nitrogen level (kg ha^{-1})									
0	37.7	74.2	103.3	34.3	60.9	63.4	30.7	90.0	91.0
40	45.7	107.1	111.9	41.6	90.5	103.5	41.5	125.3	125.3
80	47.9	126.5	115.0	44.0	120.2	126.3	50.7	133.4	146.4
120	45.3	126.0	115.0	45.1	129.2	144.4	50.3	140.9	161.4
SED (±)	1.77	2.94	2.79	1.50	2.40	2.97	2.00	3.12	3.12
LSD ($\bar{p}$=0.05)	3.60	5.90	5.56	3.2	5.0	6.0	4.2	6.3	6.3
Plant population (000 ha^{-1})									
50	40.1	111.1	115.2	30.2	110.0	119.3	41.2	131.3	141.0
100	46.2	110.0	114.3	44.9	104.3	107.4	49.2	127.0	130.0
150	46.2	104.9	105.6	41.2	100.0	100.6	40.7	123.4	133.0
200	NIL	NIL	NIL	42.0	101.5	109.0	46.1	114.6	124.0
250	NIL	NIL	NIL	40.0	93.5	101.0	41.4	116.0	126.3
SED (±)	2.40	3.12	3.27	2.16	2.01	2.36	2.91	4.37	4.37
LSD ($\bar{p}$=0.05)	6.9	N.S.	9.1	5.0	4.6	5.5	6.7	10.1	10.1



Plate I a. The effect of plant population and nitrogen on the growth of cotton varieties Samaru 71 and Super okra at 9 WAS at Mokwa at 50,000 plants ha^{-1}



Plate I b. The effect of plant population and nitrogen on the growth of cotton varieties Samaru 71 and Super okra at 9 WAS at Mokwa at 100,000 plants ha^{-1}



Plate I c. The effect of plant population and nitrogen on the growth of cotton varieties Samaru 71 and Super okra at 9 WAS at Mokwa at 150,000 plants ha^{-1}.

The interaction between cultivar and nitrogen fertilization was significant on plant height at 24 weeks after sowing in 1979, and plant height at nine weeks after sowing in 1980 and 1981 seasons (Table 4.3). In 1980 and 1981 seasons, height of 'Samaru 71' at nine weeks after sowing increased significantly with N levels while that of 'Super okra' increased upto 80 kg N ha^{-1} only. 'Samaru 71' was taller than 'Super okra' at 120 kg N ha^{-1} although at 40 kg N ha^{-1} 'Super okra' was taller than 'Samaru 71' in 1979 and 1980 seasons. In 1981 season 'Samaru 71' was taller than 'Super okra'.

Plant height of 'Samaru 71' was significantly reduced by increasing population beyond 50,000 plants ha^{-1} while the height of 'Super okra' decreased at populations higher than 100,000 plants ha^{-1} at Makwa in 1979 (Table 4.4). The tallest plants were observed at 50,000 and 100,000 plants ha^{-1} in 'Samaru 71' and 'Super okra', respectively.

Interaction between nitrogen and plant population was significant on height of cotton at Makwa in 1979 season only (Table 4.5). At 50,000 plants ha^{-1}, there was significant increase in cotton plant height with application of nitrogen. However, at 100,000 plants ha^{-1}, there was no significant difference in plant height between the control and 40 kg N ha^{-1} but 80 and 120 kg N ha^{-1} resulted in significant reduction in cotton plant height. At 150,000

plants ha^{-1}, significantly taller plants were found at 40 kg N ha^{-1}.

Table 4.3. Interaction between cultivar and nitrogen on plant height of cotton at Mokwa.

Nitrogen level (kg ha^{-1})	24 WAS, 1979		9 WAS, 1980		9 WAS, 1981	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
0	109.3	97.3	59.4	62.4	07.5	94.4
40	123.3	120.4	94.9	102.5	130.7	120.0
00	101.7	110.0	124.2	116.2	150.7	143.1
120	115.3	100.3	135.0	122.6	163.4	150.5
SED (±)	3.90		3.50		4.40	
LSD (p=0.05)	7.0		7.0		0.0	

Table 4.4. Interaction between cultivar and plant population on cotton plant height at 24 weeks after sowing at Mokwa in 1979.

Plant population (000 ha^{-1})	Cultivar	
	'Samaru 71'	'Super okra'
50	110.6	111.0
100	110.0	117.0
150	107.0	103.4
SED (±)	3.40	
LSD (p=0.05)	6.90	

Table 4.5. Interaction between nitrogen level and plant population on cotton plant height at 24 weeks after sowing at Mokwa, in 1979.

Nitrogen level	Plant population (000 ha^{-1})		
(kg ha^{-1})	50	100	150
0	00.5	131.3	90.2
40	113.0	131.5	131.2
00	131.3	109.3	00.0
120	136.0	05.2	102.3
SED (±)		2.53	
LSD (p=0.05)		5.1	

4.1.2 Leaf area index

'Samaru 71' produced significantly higher LAI than 'Super okra' in 1979 and 1900 seasons at Samaru (Table 4.6) and at 15 weeks after sowing in 1979 and 1900 and at 11 weeks after sowing in 1901 at Mokwa (Table 4.7).

Nitrogen fertilization at 40 kg ha^{-1} increased LAI in 1979 and 1901 seasons at Samaru (Table 4.6) and at Mokwa (upto 00 kg ha^{-1}) throughout the three growing seasons (Table 4.7) except at seven weeks after sowing in 1979.

The effect of plant population on LAI was variable. Increased plant population upto 150,000 plants ha^{-1} significantly increased cotton LAI at Samaru and Mokwa (Tables 4.6 and 4.7). However, plant density did not

Table 4.6. Main effects of cultivar, nitrogen level and plant population on cotton LAI at Samaru.

	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	0.21	0.94	1.13	1.23	1.69	2.17	0.31	0.92	1.09
Super okra	0.15	0.64	0.83	1.13	1.47	1.69	0.32	0.93	1.09
SED (±)	0.005	0.005	0.10	0.06	0.10	0.17	0.03	0.03	0.07
LSD ($\bar{p}$=0.05)	0.01	0.01	0.21	N.S.	0.21	0.35	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})									
0	0.15	0.21	0.64	0.94	1.47	1.94	0.21	0.64	0.64
40	0.21	0.83	0.94	1.33	1.64	2.01	0.31	1.13	1.09
80	0.21	0.94	1.01	1.13	1.52	1.74	0.31	1.09	1.23
120	0.21	1.09	1.23	1.09	1.69	1.94	0.47	0.94	1.33
SED (±)	0.007	0.07	0.15	0.00	0.14	0.24	0.05	0.05	0.10
LSD ($\bar{p}$=0.05)	0.014	0.014	0.30	N.S.	N.S.	N.S.	0.10	0.10	0.21
Plant population (000 ha^{-1})									
50	0.15	0.52	0.64	0.94	1.23	1.23	0.15	0.52	0.03
100	0.21	0.74	1.09	0.03	1.33	1.69	0.21	0.74	0.9
150	0.21	1.09	1.23	1.23	1.74	1.83	0.33	1.13	1.13
200	NIL	NIL	NIL	1.47	1.47	2.47	0.33	1.13	1.13
250	NIL	NIL	NIL	1.33	2.01	2.47	0.64	1.13	1.23
SED (±)	0.01	0.01	0.19	0.11	0.20	0.33	0.07	0.07	0.14
LSD ($\bar{p}$=0.05)	0.03	0.03	0.54	0.25	0.46	0.76	0.16	0.16	N.S.

Table 4.7. Main effects of cultivar, nitrogen level and plant population on cotton LAI at Mokwa.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	0.21	1.64	1.52	1.23	2.01	1.52	0.31	2.21	1.74
Super okra	0.21	1.64	1.33	1.13	1.03	1.33	0.31	1.03	1.64
SED (±)	0.05	0.11	0.05	0.07	0.11	0.05	0.04	0.10	0.07
LSD ($\tilde{p}$=0.05)	N.S.	N.S.	0.10	N.S.	N.S.	0.10	N.S.	0.21	N.S.
Nitrogen level (kg ha^{-1})									
0	0.15	0.03	1.09	0.74	1.13	0.74	0.21	1.23	1.23
40	0.21	1.52	1.33	1.33	1.69	1.33	0.47	2.01	1.69
80	0.21	2.13	1.52	1.23	2.33	1.69	0.31	2.33	2.01
120	0.31	1.01	1.74	1.23	2.52	2.13	0.31	2.52	1.03
SED (±)	0.07	0.15	0.07	0.10	0.15	0.07	0.05	0.15	0.10
LSD ($\tilde{p}$=0.05)	N.S.	0.31	0.14	0.21	0.31	0.14	0.10	0.31	0.21
Plant population (000 ha^{-1})									
50	0.15	1.33	1.09	0.94	1.33	0.94	0.15	1.23	1.33
100	0.21	1.64	1.64	0.03	1.74	1.23	0.21	1.74	1.47
150	0.31	2.01	1.64	1.23	1.03	1.52	0.31	2.47	1.94
200	NIL	NIL	NIL	1.47	2.69	1.47	0.31	2.01	1.94
250	NIL	NIL	NIL	1.33	2.13	2.23	0.64	2.74	1.52
SED (±)	0.10	0.21	0.10	0.14	0.21	0.10	0.07	0.21	0.14
LSD ($\tilde{p}$=0.05)	N.S.	0.50	0.20	0.32	0.49	0.23	0.16	0.49	N.S.

significantly affect cotton LAI at seven and 15 weeks after sowing in 1979 and 1981 seasons at Mokwa. A similar trend was observed at Samaru at 15 weeks after sowing in 1981 season.

Interaction between cultivar and nitrogen level was significant on cotton LAI at Samaru and Mokwa in 1979 (Table 4.8). 'Samaru 71' responded to 80 and 120 kg N ha^{-1} whereas 'Super okra' did not respond beyond 40 kg N ha^{-1} Samaru. Beneficial effect of nitrogen fertilization on LAI of 'Super okra' magnified at 40 kg N ha^{-1}. 'Super okra' excelled 'Samaru 71' at all the levels of nitrogen tested at Mokwa.

The response of LAI of the two cultivars to increased plant population (interaction) was variable (Table 4.9). While 'Samaru 71' responded upto 150,000 plants ha^{-1} at Samaru in 1980 and 1981, 'Super okra' reponded upto 200,000 plants ha^{-1} at the same location. The response of 'Super okra' LAI was significant at 150,000 plant ha^{-1} and significantly superior over S.71 at Mokwa in 1979.

4.1.3 Dry matter production

Dry matter yield of the cultivars did not show consistent trend. Total dry matter produced by 'Samaru 71' was significantly higher than that of 'Super okra' at 11 and 15 weeks after sowing in 1979 (Table 4.10).

Table 4.8. Interaction between cultivar and nitrogen level on cotton LAI at Samaru and Mokwa in 1979.

Treatment	11 WAS, Samaru		11 WAS, Mokwa	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
0	0.71	0.33	0.03	0.93
40	0.71	0.04	1.24	1.72
80	1.13	0.04	1.33	1.01
120	1.24	0.93	1.33	1.01
SED (±)	0.25		0.21	
LSD (p=0.05)	0.50		0.42	

Table 4.9. Interaction between cultivar and plant population on cotton LAI at Samaru and Mokwa.

Plant population (000 ha^{-1})	7 WAS, Samaru 1900		11 WAS, Samaru 1901		15 WAS, Samaru 1901		7 WAS, Mokwa 1979	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
50	0.63	0.52	0.61	0.52	0.93	0.72	0.63	0.53
100	0.83	0.71	0.83	0.52	1.15	0.72	0.84	0.74
150	1.05	1.23	1.01	1.15	1.01	1.15	0.95	1.15
200	1.74	1.15	1.15	1.24	1.01	1.34	NIL	NIL
250	1.01	1.15	1.01	1.15	1.25	1.34	NIL	NIL
SED (±)	0.17		0.11		0.16		0.11	
LSD (p=0.05)	0.34		0.22		0.32		0.22	

The reverse was however observed at seven weeks after sowing in 1981 season at Samaru.

No significant differences were observed between the two cultivars in terms of dry matter production except at seven weeks after sowing in 1981 season when 'Super okra' produced significantly higher dry matter yield than 'Samaru 71' (Table 4.11).

Nitrogen application significantly increased dry matter yield at 11 and 15 weeks after sowing in 1979 and 1981 at Samaru (Table 4.10). Dry matter yield increased with increase in nitrogen level upto 80 kg ha^{-1}. N application significantly increased dry matter yield in 1979, 1980 and 1981 seasons at Mokwa (Table 4.11). The N response was observed upto 80 kg N ha^{-1} (Figs. 2 and 3).

Dry matter yield significantly increased with increased plant population except at seven weeks after sowing in 1979 at Samaru (Table 4.10). The crop responded upto 150,000 plants ha^{-1}. Increased plant population upto 150,000 plants ha^{-1} significantly increased the dry matter yield at Mokwa except at 15 weeks after sowing in 1981 (Table 4.11 and Figs. 4 and 5).

Significant interaction between cultivar and nitrogen on dry matter at Samaru and Mokwa (Table 4.12) confirmed that 'Samaru 71' responded upto 80 kg N ha^{-1}, while response of 'Super okra' was limited upto 40 kg N ha^{-1}.

Table 4.10. Main effects of cultivar, nitrogen level and plant population on cotton dry matter ($g\ m^{-2}$) at Samaru.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	20.4	193.9	420.9	200.6	257.0	900.4	47.3	222.5	460.6
Super okra	15.6	151.9	319.2	214.5	366.2	842.2	64.1	242.6	551.0
SED (±)	3.6	13.3	42.3	13.5	23.6	42.5	3.7	13.2	36.0
LSD ($\bar{p}$=0.05)	N.S.	26.9	85.4	N.S.	N.S.	N.S.	7.4	N.S.	72.7
Nitrogen level ($kg\ ha^{-1}$)									
0	13.4	99.4	244.0	194.2	324.7	877.0	47.3	132.0	296.6
40	19.9	160.6	340.0	205.9	361.4	884.2	56.6	236.9	400.9
80	19.0	204.0	416.6	232.1	373.0	905.0	59.3	270.5	611.3
120	19.7	220.0	494.9	214.6	309.5	854.2	59.0	252.9	620.0
SED (±)	4.3	10.9	59.0	19.3	33.7	59.5	5.2	17.6	50.0
LSD ($\bar{p}$=0.05)	N.S.	30.2	120.7	N.S.	N.S.	N.S.	N.S.	35.5	102.7
Plant population ($000\ ha^{-1}$)									
50	10.0	109.2	259.2	97.0	266.6	550.5	20.0	130.7	373.4
100	20.6	154.1	397.9	151.0	320.2	730.2	42.7	174.0	429.6
150	22.6	255.0	465.4	249.4	395.5	832.6	55.9	283.7	546.0
200	NIL	NIL	NIL	206.0	337.0	1133.3	65.0	200.0	571.9
250	NIL	NIL	NIL	273.0	491.3	1113.0	85.0	270.6	609.6
SED (±)	6.1	10.9	83.7	27.0	47.2	83.3	8.2	25.3	71.2
LSD ($\bar{p}$=0.05)	N.S.	52.6	232.7	62.4	109.0	192.4	10.9	58.4	164.5

Table 4.11. Main effect of cultivar, nitrogen level and plant population on cotton dry matter yield (g m^{-2}) at Mokwa.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	127.7	552.5	851.0	270.0	590.2	704.9	130.5	530.9	609.3
Super okra	110.3	632.4	820.2	271.0	599.5	651.0	197.0	507.4	706.6
SED (±)	6.9	40.1	59.2	13.1	35.3	40.4	7.0	21.5	64.0
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.		N.S.	N.S.	15.0	N.S.	N.S.
Nitrogen level (kg ha^{-1})									
0	83.3	311.0	534.0	156.7	320.2	329.3	107.5	311.0	551.7
40	139.4	595.7	814.3	267.6	529.9	620.3	171.0	530.9	660.7
80	134.4	715.0	1033.0	330.0	741.4	774.0	206.2	601.7	847.9
120	134.9	747.4	977.3	327.1	707.9	902.1	186.5	632.6	831.1
SED (±)	9.9	57.3	84.5	18.7	50.5	57.7	11.0	30.6	92.6
LSD ($\bar{p}$=0.05)	19.9	115.7	170.6	37.7	102.0	116.6	22.3	61.9	187.1
Plant population (000 ha^{-1})									
50	74.6	325.0	577.2	199.9	441.6	460.0	82.3	329.0	570.2
100	128.5	501.1	773.3	246.2	504.0	636.7	141.1	431.3	641.3
150	174.2	951.6	1660.0	277.7	593.3	710.0	193.4	594.5	817.2
200	NIL	NIL	NIL	310.8	779.5	853.0	185.3	514.0	806.4
250	NIL	NIL	NIL	310.0	655.2	915.4	230.3	726.0	655.0
SED (±)	13.9	80.2	118.3	26.2	70.7	80.8	15.4	44.1	132.3
LSD ($\bar{p}$=0.05)	30.5	223.0	320.9	60.5	163.3	186.6	35.8	101.9	N.S.

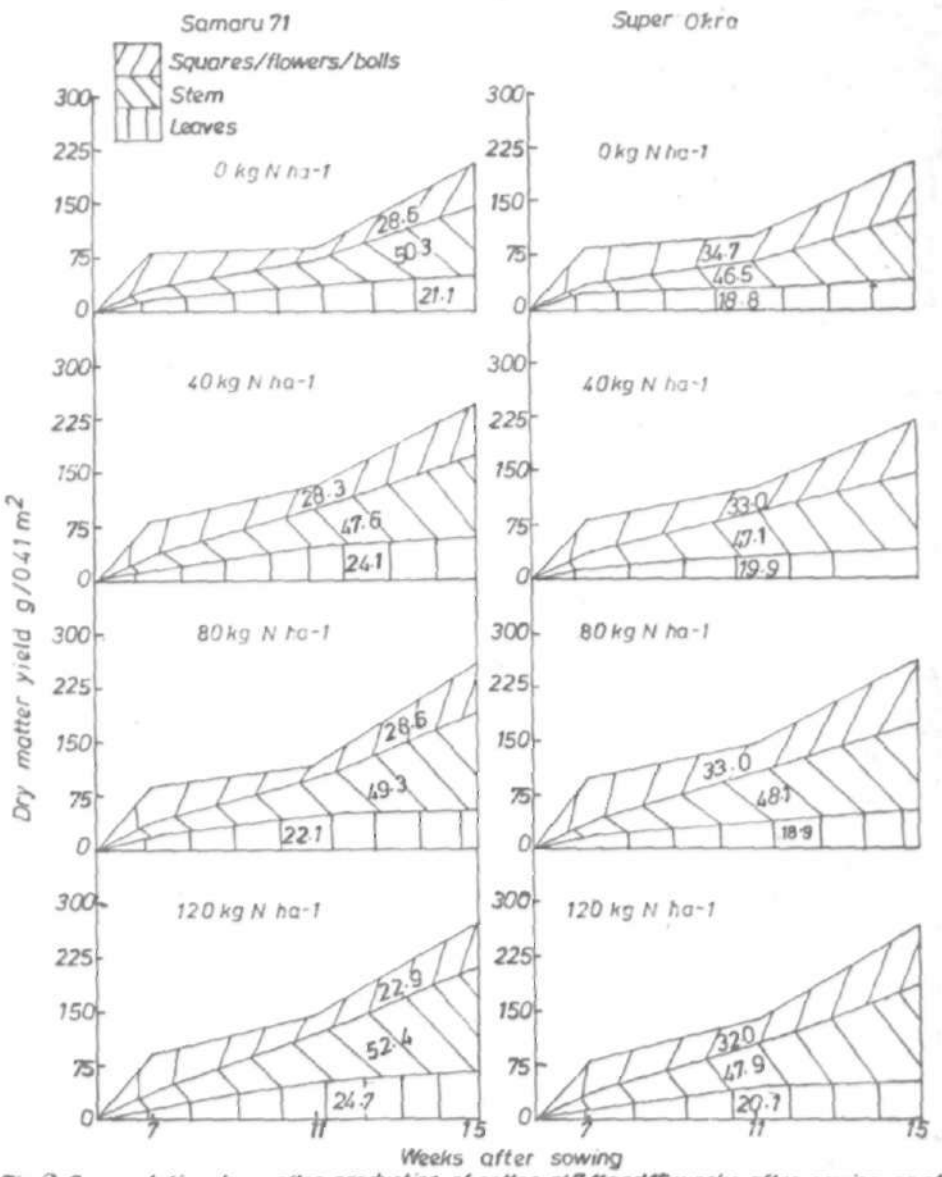


Fig 2: Cummulative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by nitrogen and leaf type. Figures indicate (%) contribution of each plant part at the LSD VAS at Samaru (3 year mean, 1979, 1980 and 1981)

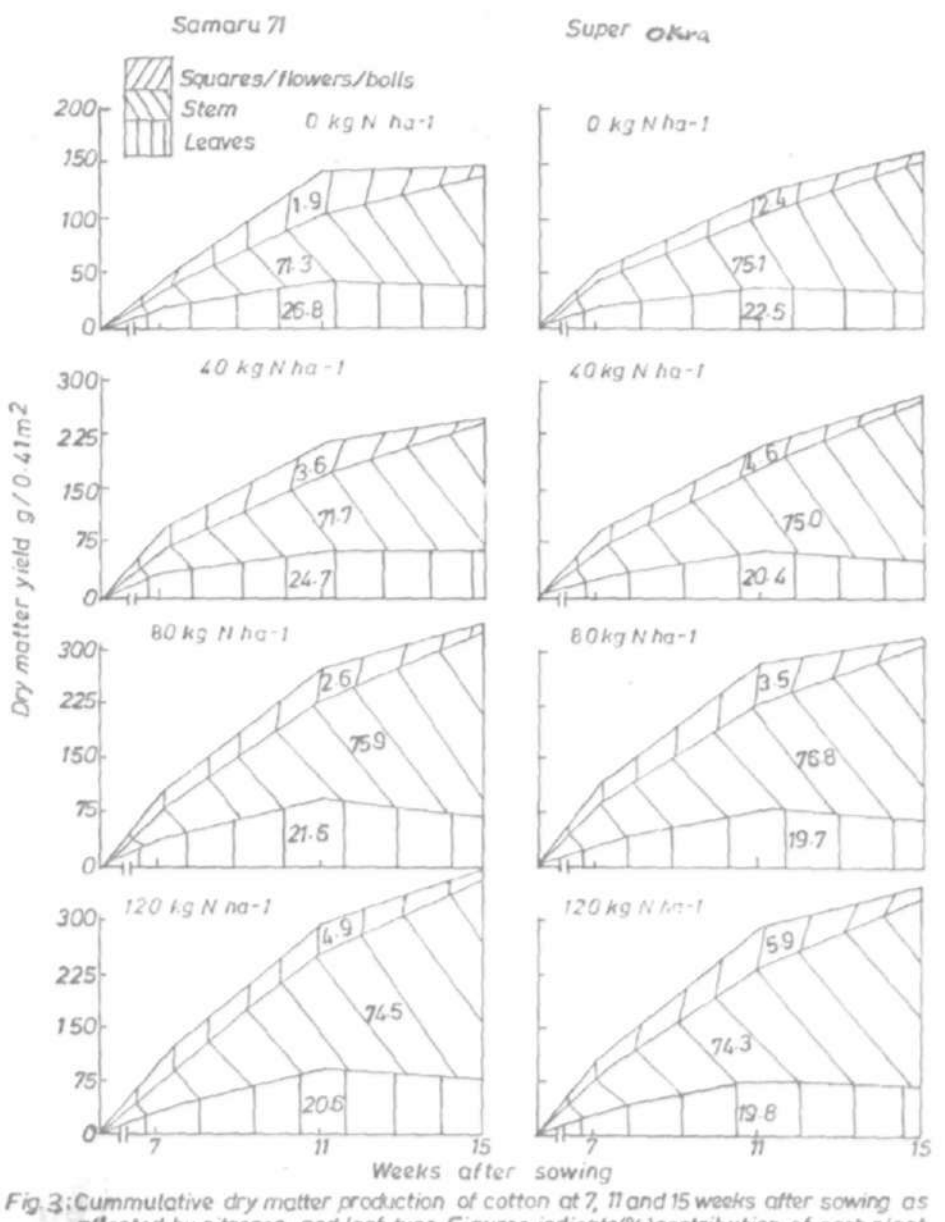


Fig.3: Cummulative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by nitrogen and leaf type. Figures indicate(%) contribution of each plant part at the LS WAS at Makwa(3year mean, 1979, 1980 and 1981).

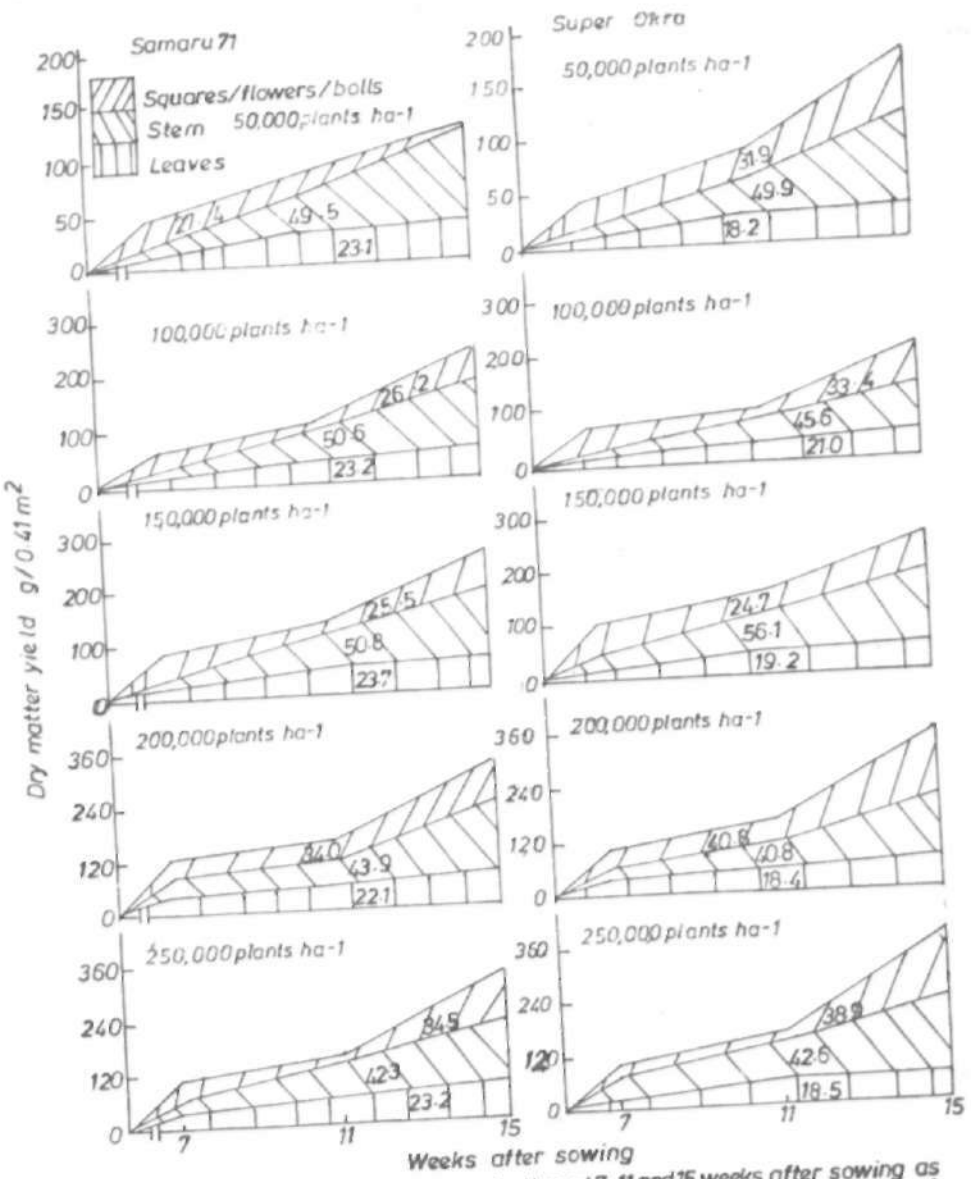


Fig.4 : Cummulative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by plant population and leaf type. Figures indicate (%) contribution of each plant part at the 15 WAS at Samaru (3 year mean, 1979, 1980 and 1981).

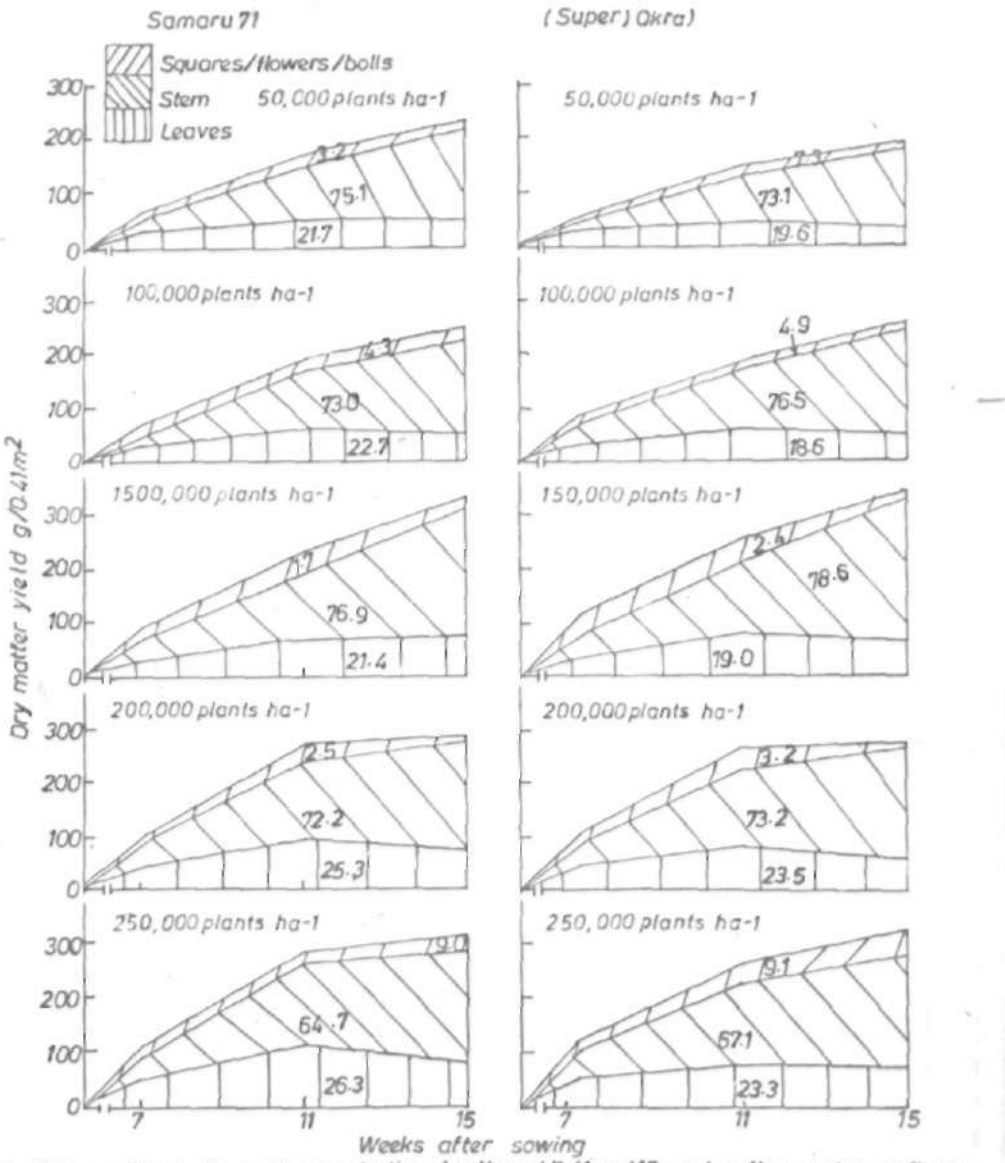


Fig.5: Cummulative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by plant population and leaf type. Figures indicate[%] contribution of each plant part at the ISHAS at Makwa(3 year mean, 1979, 1980 and 1981)

Table 4.12. Interaction between cultivar and nitrogen level on cotton dry matter production (g m^{-2}) at Samaru and Mokwa in 1979.

Nitrogen Level (kg ha^{-1})	11 WAS, Samaru		15 WAS, Mokwa	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
0	150.9	67.7	572.6	495.0
40	176.9	100.6	672.5	950.0
80	252.5	205.4	1074.5	909.3
120	203.4	237.4	1005.3	869.3
SED (±)	26.9		26.9	
LSD (p=0.05)	54.1		54.1	

Table 4.13. Interaction between cultivar and plant population on cotton dry matter production (g m^{-2}) at Samaru.

Plant population (000 ha^{-1})	7 WAS, 1980		11 WAS, 1981		15 WAS, 1981	
	'Samaru 71'	'Super okra	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
50	94.1	99.6	149.3	127.9	371.0	375.1
100	140.6	153.6	190.0	149.0	401.4	377.0
150	221.0	277.4	260.3	290.0	409.6	602.6
200	312.0	261.0	255.6	320.6	436.0	466.0
250	266.6	201.0	240.7	310.7	523.4	696.0
SED (±)	24.2		27.9		30.9	
LSD (p=0.05)	40.6		56.1		62.1	

Cultivar and plant population interaction significantly affected dry matter yield (Table 4.13). In 1980, dry matter yield of 'Samaru 71' increased with increase in plant population upto 200,000 plants ha^{-1}. The dry matter yield of 'Super okra' increased with increase in plant population only upto 150,000 plants ha^{-1}. In 1981 and at 11 weeks after sowing, the dry matter yield of both cultivars increased with increase in plant population upto 150,000 plants ha^{-1}. In 1981, dry matter yield of 'Samaru 71' at 15 weeks after sowing responded to increased plant population upto 100,000 plants ha^{-1}. However, dry matter yield of 'Super okra' responded to increased population up to 250,000 plants ha^{-1}.

Cultivar and plant population interaction significantly affected dry matter yield at Nakwa (Table 4.14). Dry matter yield of both cultivars was significantly higher at 200,000 plants ha^{-1} than at all the other population levels. In 1981 and at seven weeks after sowing dry matter yield of both cultivars responded to increased plant population upto 250,000 plants ha^{-1}.

Interaction between nitrogen and plant population was significant on dry matter yield at Nakwa in 1979 (Table 4.15). Dry matter yield did not responded to higher population density in control plots (no nitrogen). The response was observed upto 100,000 plants ha^{-1} in plants fertilized at 40 kg N ha^{-1}. While it responded upto 100,000 plants ha^{-1}

Table 4.14. Interaction between cultivar and plant population on cotton dry matter production ($g\ m^{-2}$) at Mokwa.

Plant Population ($000\ ha^{-1}$)	11 WAS, 1979 'Samaru 71'	11 WAS, 1979 'Super okra'	7 WAS, 1981 'Samaru 71'	7 WAS, 1981 'Super okra'
50	406.5	279.5	74.6	89.8
100	463.9	544.3	110.9	163.2
150	509.3	677.3	149.5	237.4
200	776.4	702.9	156.5	214.3
250	714.5	596.2	193.2	203.7
SED (±)	71.4		37.5	
LSD (p=0.05)	143.5		35.2	

Table 4.15. Interaction between nitrogen and plant population on cotton dry matter production ($g\ m^{-2}$) at Mokwa in 1979.

Nitrogen level ($kg\ ha^{-1}$)	Plant population ($000\ ha^{-1}$)		
	50	100	150
0	379.2	463.9	554.9
40	410.8	875	1101.6
80	675.6	865.4	1310.8
120	631.2	672.2	1494.2
SED (±)		146.3	
LSD (p=0.05)		294.1	

at 00 and 120 kg N ha^{-1}.

4.1.4 Relative growth rate

'Samaru 71' significantly excelled 'Super okra' in terms of RGR as recorded between 11 and 15 weeks after sowing at Samaru in the 1979 season only (Table 4.16).

The application of nitrogen significantly increased RGR between 11 and 15 weeks after sowing at Samaru in 1979 and 1901 and at Mokwa in 1979, 1900 and 1901 seasons. At Samaru, the response was at 40 and 00 kg N ha^{-1} in 1979 and 1901, respectively. However, at Mokwa, the response went up 40 kg N ha^{-1} in 1979 and 1900 and 00 kg N ha^{-1} in 1901 (Table 4.17).

The interaction between cultivar and nitrogen on RGR was significant at Mokwa in 1979. 'Samaru 71' had a significant increase in RGR at 00 kg N ha^{-1} while 'Super okra' had its increase at 40 kg N ha^{-1} compared with no nitrogen (Table 4.10).

The interaction between cultivar and plant population on RGR was significant at Mokwa in 1900 and at Samaru in 1901 (Table 4.19). A significant response was observed by increasing the plant population from 50,000 to 250,000 plants ha^{-1} (between seven and 11 weeks after sowing) at Mokwa in 1900 by 'Samaru 71'. 'Super okra' had a significant higher RGR at 200,000 plants ha^{-1} as compared with 50,000, 100,000

Table 4.16. Main effect of cultivar, nitrogen level and plant population on the relative growth rate of cotton (g g^{-1} day^{-1}) (between 11 and 15 WAS) at Samaru.

Treatment	1979	1900	1901
Cultivar			
Samaru 71	0.03	0.03	0.02
Super okra	0.01	0.03	0.02
SED (±)	0.003	0.003	0.001
LSD (p=0.05)	0.006	N.S.	N.S.
Nitrogen level (kg ha^{-1})			
0	0.01	0.03	0.01
40	0.03	0.03	0.02
00	0.03	0.03	0.03
120	0.03	0.03	0.03
SED (±)	0.005	0.004	0.001
LSD (p=0.05	0.01	N.S.	0.003
Plant population (000 ha^{-1})			
50	0.03	0.03	0.03
100	0.01	0.03	0.03
150	0.01	0.03	0.01
200	NIL	0.01	0.01
250	NIL	0.01	0.0
SED (±)	0.007	0.005	0.001
LSD (p=0.05)	0.019	0.01	0.002

Table 4.17. Main effect of cultivar, nitrogen level and plant population on relative growth rate (g g^{-1} day^{-1}) (between 11 and 15 WAS) at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	0.02	0.03	0.03
Super okra	0.02	0.03	0.02
SED (±)	0.004	0.004	0.004
LSD (p=0.05)	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})			
0	0.01	0.01	0.01
40	0.03	0.03	0.02
80	0.03	0.03	0.03
120	0.03	0.03	0.03
SED (±)	0.005	0.005	0.005
LSD (p=0.05)	0.01	0.01	0.01
Plant population (000 ha^{-1})			
50	0.03	0.02	0.02
100	0.01	0.03	0.02
150	0.01	0.03	0.03
200	NIL	0.03	0.02
250	NIL	0.03	0.03
SED (±)	0.007	0.007	0.007
LSD (p=0.05)	0.019	N.S.	N.S.

Table 4.18. Interaction between cultivar and nitrogen on cotton relative growth rate (g g^{-1} day^{-1}) between 11 and 15 WAS) at Mokwa in 1979.

Nitrogen level (kg ha^{-1})	Cultivar 'Samaru 71'	'Super okra'
0	0.01	0.01
40	0.02	0.03
80	0.03	0.03
120	0.03	0.03
SED (±)	0.005	
LSD (p=0.05)	0.01	

Table 4.19. Interaction between cultivar and plant population on cotton relative growth rate (g g^{-1} day^{-1}) at Samaru and Mokwa.

Plant population (000 ha^{-1})	Between 7 and 11 WAS at Mokwa, 1980 Samaru 71	Super okra	Between 11 and 15 WAS at Samaru, 1981 Samaru 71	Super okra
50	0.07	0.05	0.04	0.04
100	0.06	0.07	0.06	0.04
150	0.06	0.09	0.08	0.08
200	0.10	0.11	0.07	0.08
250	0.10	0.07	0.06	0.08
SED (±)	0.01		0.01	
LSD (p=0.05)	0.02		0.02	

and 250,000 plants ha^{-1}. Both cultivars had significant response to 150,000 plants ha^{-1} as compared with 50,000 and 100,000 plant ha^{-1} at Samaru in 1981 between 11 and 15 weeks after sowing (Table 4.20).

4.1.5 Net assimilation rate

'Samaru 71' had significantly higher net assimilation rate (NAR) than 'Super okra' at Samaru in 1980 (Table 4.20) and at Mokwa during the 1981 season (Table 4.21).

At Samaru, the application of 40 kg N ha^{-1} resulted in higher NAR than no nitrogen (control) in 1979 while in 1981, NAR was higher with the application of 80 and 120 kg N ha^{-1} (Table 4.20). However, at Mokwa, N application at 80 kg ha^{-1} in 1979, at 80 kg N ha^{-1} and above in 1980 and 40 kg N ha^{-1} and above in 1981 resulted in higher NAR than nitrogen control (Table 4.21).

In 1979 at Samaru, 150,000 plants ha^{-1} had the highest NAR. In 1980, higher NAR was obtained at plant population of 250,000 plants ha^{-1} compared with 50,000 plants ha^{-1} while higher values of NAR were obtained at 150,000 plants ha^{-1} and 200,000 plants ha^{-1} in 1981 (Table 4.20). However, at Mokwa significant response to increased plant population was observed at 200,000 plants ha^{-1} in 1980 and at 150,000 and and 250,000 plants ha^{-1} in 1981 (Table 4.21).

Table 4.20. Main effect of cultivar, nitrogen level and plant population on cotton net assimilation rate (g m^{-2} day^{-1}) (between seven and 11 WAS) at Samaru.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	16.5	20.3	18.4
Super okra	15.9	15.8	16.4
SED (±)	2.2	2.2	2.9
LSD (p=0.05)	N.S.	3.9	N.S.
Nitrogen level (kg ha^{-1})			
0	13.2	16.7	9.2
40	20.4	17.2	17.8
80	14.8	17.6	20.8
120	16.2	20.8	22.4
SED (±)	3.1	3.2	4.1
LSD (p=0.05)	6.3	N.S.	8.3
Plant population (000 ha^{-1})			
50	11.6	14.3	11.5
100	16.2	16.5	13.8
150	20.7	20.4	21.6
200	NIL	16.6	22.3
250	NIL	22.7	18.6
SED (±)	4.3	3.8	5.7
LSD (p=0.05)	12.1	8.8	13.2

Table 4.21. Main effect of cultivar, nitrogen level and plant population on cotton net assimilation rate (g m^{-2} day^{-1}) (between seven and 11 WAS) at Makwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	21.5	18.7	29.5
Super okra	19.6	15.7	22.1
SED (±)	1.6	3.2	2.2
LSD (p=0.05)	N.S.	N.S.	4.4
Nitrogen level (kg ha^{-1})			
0	20.2	3.6	18.1
40	23.7	18.6	26.4
80	23.1	25.1	31.7
120	15.1	24.6	36.1
SED (±)	2.3	4.6	3.0
LSD (p=0.05)	4.7	9.3	6.2
Plant population (000 ha^{-1})			
50	19.0	7.5	12.0
100	20.1	13.4	20.0
150	21.7	12.9	31.9
200	NIL	29.0	23.2
250	NIL	23.3	41.2
SED (±)	3.2	6.4	4.2
LSD (p=0.05)	N.S.	14.0	9.5

4.2 Cultivar, Nitrogen and Plant Population

4.2.1 Number of fruiting branches

'Super okra' produced significantly higher number of fruiting branches than 'Samaru 71' at Samaru (Table 4.22) and Makwa (Table 4.23) except at seven, 15 and 11 weeks after sowing in 1979, 1980 and 1981, respectively at Samaru and at 15 weeks after sowing in 1980 at Makwa (Tables 4.22 and 4.23).

The application of N had a significant effect on the number of fruiting branches at the 11 and 15 weeks after sowing in 1979 and seven and 11 weeks after sowing in 1981 at Samaru (Table 4.22). At Makwa, the application of N significantly affected the number of fruiting branches at all the steges of the crop sampled except at 15 weeks after sowing in 1980. In 1979 at Samaru, 120 kg N ha^{-1} resulted in significantly higher number of fruiting branches of cotton at 11 and 15 weeks after sowing than the no nitrogen control. While in 1980, all the N levels had higher number of fruiting branches than the no nitrogen control. At Makwa, the number of fruiting branches at seven weeks after sowing was significantly increased by all N levels compared with no nitrogen treatment. However, at 11 and 15 weeks after sowing the fruiting branches were only significantly increased by 120 kg N ha^{-1} except in 1980 at 11 weeks after sowing where 00 kg N ha^{-1} was adequate and in 1981 at 15 weeks after sowing where all N levels increased the number of fruiting branches

Table 4.22. Main effects of cultivar, nitrogen level and plant population on the number of fruiting branches of cotton m^{-2} at Samaru.

Treatment	1979			1900			1901		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	10.5	24.7	36.0	20.3	43.7	61.9	11.5	55.2	61.2
Super okra	12.5	52.6	53.3	45.1	63.4	50.1	23.5	51.6	91.7
SED (+)	6.2	6.4	0.6	7.4	4.7	2.5	2.5	3.2	4.0
LSD ($\bar{p}$=0.05)	N.S.	13.0	17.3	15.0	9.5	N.S.	5.1	N.S.	9.6
Nitrogen level (kg ha^{-1})									
0	0.9	24.2	20.1	24.2	46.6	62.9	6.7	45.4	52.3
40	13.7	30.0	44.4	41.5	50.1	63.1	19.9	56.6	77.0
00	19.2	30.4	36.4	43.4	56.4	56.9	21.6	54.2	07.1
120	20.4	61.9	66.7	36.2	53.1	57.1	21.9	56.9	00.6
SED (+)	0.9	9.2	12.0	10.6	6.7	3.5	3.6	4.5	6.0
LSD ($\bar{p}$=0.05)	N.S.	10.5	24.3	N.S.	N.S.	N.S.	7.2	N.S.	13.7
Plant population (000 ha^{-1})									
50	7.9	10.3	11.3	6.2	16.6	22.0	5.5	37.4	45.4
100	15.1	45.1	43.9	26.6	47.1	40.5	11.0	45.6	46.6
150	24.0	60.5	70.7	55.4	44.4	53.1	15.4	59.1	92.6
200	NIL	NIL	NIL	49.2	62.4	01.1	23.1	59.3	97.7
250.	NIL	NIL	NIL	46.1	97.2	07.6	32.2	65.3	100.1
SED (+)	12.5	12.9	16.0	14.0	9.4	4.9	5.0	6.3	9.4
LSD ($\bar{p}$=0.05)	N.S.	35.0	46.7	34.2	2 1.7	11.3	11.6	14.6	21.7

Table 4.23. Main effects of cultivar, nitrogen level and plant population on the number of fruiting branches of cotton m^{-2} at Mokwa.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	24.5	34.3	57.6	20.3	29.3	51.0	33.6	56.4	73.7
Super okra	59.0	62.2	62.9	54.7	55.7	53.0	50.4	65.1	93.8
SED (+)	6.6	0.4	9.2	5.0	7.6	2.9	2.2	3.0	3.5
LSD ($\bar{p}$=0.05)	13.3	17.0	N.S.	11.7	15.3	N.S.	4.4	7.7	7.1
Nitrogen level (kg ha^{-1})									
0	14.4	29.1	41.1	26.6	29.1	49.2	20.1	49.9	66.2
40	43.7	46.0	50.8	40.2	42.0	49.4	45.6	59.3	86.4
80	49.7	48.0	60.0	40.7	52.1	55.9	40.0	59.0	88.6
120	61.2	69.1	70.7	42.2	46.6	56.6	46.6	73.9	94.1
SED (+)	9.4	12.0	13.1	8.3	10.8	4.1	3.1	5.3	5.0
LSD ($\bar{p}$=0.05)	19.0	26.3	26.4	16.8	21.8	N.S.	6.2	10.8	10.1
Plant population (000 ha^{-1})									
50	5.3	12.7	24.7	11.1	12.7	14.4	22.8	52.6	46.3
100	50.3	65.3	77.8	26.6	20.6	29.5	30.2	60.7	87.9
150	63.1	66.7	70.7	60.2	61.4	87.8	45.1	78.8	73.6
200	NIL	NIL	NIL	54.8	55.9	74.6	46.8	87.2	86.2
250	NIL	NIL	NIL	50.9	53.8	79.8	57.4	52.8	124.8
SED (+)	13.2	17.1	10.3	11.6	15.1	5.7	4.3	7.4	7.8
LSD ($\bar{p}$=0.05)	36.6	47.6	51.8	26.8	34.9	13.2	9.9	N.S.	16.2

of cotton as compared with the control.

Plant population had a significant effect on the number of fruiting branches at both locations (Tables 4.22 and 4.23). In 1979, at Samaru, the number of fruiting branches at 11 and 15 weeks after sowing increased with plant population. In 1980, increased plant population significantly increased the number of fruiting branches at seven, 11 and 15 weeks after sowing at Samaru. A similar effect was observed in 1981 (Table 4.22). At Mokwa, plant population at 100,000 and 150,000 plants ha^{-1} had higher number of fruiting branches than 50,000 plants ha^{-1} in 1979, while in 1980 and 1981, significant increase in the number of fruiting branches occurred with plant population of 150,000 plants ha^{-1} and above (Table 4.23).

Interaction between cultivar and plant population was significant on the number of fruiting branches of the two cotton cultivars at seven and 11 weeks after sowing in 1979 and 1981 at Samaru, and at seven weeks after sowing at Mokwa during the 1981 season. In 1979 at Samaru, 150,000 plants ha^{-1} resulted in significantly higher number of fruiting branches at 11 weeks after sowing than 50,00 plants ha^{-1} in both cultivars of cotton. The highest number of fruiting branches was obtained with 'Super okra' at a population of 150,000 plants ha^{-1}. However, in 1981, the number of fruiting branches at seven weeks after sowing was significantly higher at 250,000 plants ha^{-1} and 150,000 plants ha^{-1} and above for

cultivars Samaru 71 and Super okra, respectively as compared with 50,000 plants ha^{-1}. At 11 weeks after sowing, both cultivars had higher number of fruiting branches at 150,000 plants ha^{-1} and above than at 50,000 plants ha^{-1} with 'Super okra' exhibiting the highest number at 150,000 plants ha^{-1} and above. In 1901 at Mokwa, both cultivars had significantly higher number of fruiting branches at seven weeks after sowing and 100,000 plants ha^{-1} and above than at 50,000 plants ha^{-1}. The highest number of fruiting branches was obtained with 'Super okra' at 250,000 plants ha^{-1} (Table 4.24).

The interaction between N and plant population was significant on the number of fruiting branches at 11 weeks after sowing in 1900 and seven weeks after sowing in 1901 at Mokwa (Table 4.25). At 11 weeks after sowing and 150,000 plants ha^{-1} increased N level resulted in significant increase in the number of fruiting branches. At both 150,000 and 250,000 plants ha^{-1} significant response was observed at 80 kg N ha^{-1}. At seven weeks after sowing in 1901, and at 100,000 plants ha^{-1} and above increased nitrogen level upto 40 kg N ha^{-1} resulted in significant increase in the number of fruiting branches (Table 4.25).

4.2.2 Number of shed bolls

'Super okra' exhibited a significantly higher boll shedding at 13 weeks after sowing than 'Samaru 71' in 1900 and

Table 4.24. Interaction between cultivar and plant population on the number of fruiting branches of cotton at Samaru and Mokwa.

Plant population (000 ha^{-1})	11 WAS, Samaru 1979		7 WAS, Samaru 1901		11 WAS, Samaru 1901		7 WAS, Mokwa 1901	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
50	36.1	67.4	13.2	16.0	39.1	46.0	19.9	25.9
100	56.5	69.1	20.4	22.3	59.3	62.9	30.0	26.3
150	07.6	114.7	10.9	30.7	00.1	130.0	34.0	55.7
200	NIL	NIL	21.0	43.7	90.7	143.0	40.0	53.0
250	NIL	NIL	31.0	53.3	101.5	146.9	42.5	72.2
SED (±)	20.4		5.7		10.5		4.9	
LSD (p=0.05)	41.0		11.5		21.1		9.0	

Table 4.25. Interaction between nitrogen and plant population on the number of fruiting branches of cotton at Mokwa.

Plant population (000 ha^{-1})	11 WAS, 1900 Nitrogen level (kg ha^{-1})				7 WAS, 1901 Nitrogen level (kg ha^{-1})			
	0	40	00	120	0	40	00	120
50	55.7	76.3	70.3	40.5	10.5	22.3	24.5	26.4
100	67.7	90.7	96.6	110.9	22.3	37.7	51.6	40.0
150	52.3	72.2	124.1	145.9	30.5	24.7	56.9	43.2
200	130.5	104.0	172.3	154.3	33.6	51.6	42.2	52.3
250	91.7	100.5	156.7	103.1	36.5	60.6	66.5	59.5
SED (±)	24.3				7.0			
LSD (p=0.05)	40.0				14.1			

1981 at Samaru and Mokwa (Table 4.26).

The application of nitrogen significantly increased the number of shed bolls, except in 1980 at Samaru (Table 4.26).

Plant density beyond 50,000 plants ha^{-1} consistently increased the number of shed bolls except in the 1980 season at Mokwa (Table 4.26). In the 1980 season at Samaru the number of boll shed increased upto 250,000 plants ha^{-1} whereas in 1981 at Samaru, the response was observed upto 150,000 plants ha^{-1}. However at Mokwa, increased boll shedding was observed upto 100,000 and 150,000 plants ha^{-1}, respectively in 1979 and 1981.

The interaction between cultivar and nitrogen on boll shedding was significant at Mokwa in 1979 (Table 4.27). Without nitrogen application, 'Samaru 71' shed a significantly higher number of bolls than 'Super okra'. However, the number of shed bolls were comparable in both cultivars with application of nitrogen.

The interaction between nitrogen and plant population was significant on boll shedding at Mokwa in 1979. At 50,000 plants ha^{-1} increase in the levels of nitrogen was not significant on the number of shed bolls. However, at increased plant population of 100,000 plants ha^{-1}, 120 kg N ha^{-1} resulted in significant increase in the number of shed bolls, while at 150,000 plants ha^{-1} all the N levels increased

Table 4.26. Main effects of cultivar, nitrogen and plant population on the number of shed bolls of cotton m^{-2} at Samaru and Mokwa.

Treatment	Samaru		Mokwa		
	1980	1981	1979	1980	1981
Cultivar					
Samaru 71	4.4	7.9	7.5	7.1	2.9
Super okra	15.6	17.0	7.4	0.6	7.1
SED (±)	0.8	0.6	0.4	0.8	0.5
LSD (p=0.05)	1.6	1.2	N.S.	1.6	0.9
Nitrogen level (kg ha^{-1})					
0	8.9	10.4	5.9	5.9	3.4
40	11.1	13.2	7.4	9.0	5.1
80	9.0	13.4	8.2	9.6	5.0
120	11.1	12.9	8.4	7.6	5.6
SED (±)	1.1	0.9	0.6	1.1	0.6
LSD (p=0.05)	N.S.	1.8	1.3	2.2	1.3
Plant population (000 ha^{-1})					
50	5.3	6.8	4.8	10.2	2.8
100	8.8	10.9	8.4	7.1	4.8
150	11.7	14.5	9.2	7.3	6.1
200	10.0	15.3	NIL	7.3	5.6
250	15.0	14.0	NIL	7.3	6.2
SED (±)	1.5	1.3	0.8	1.5	0.8
LSD (p=0.05)	3.5	3.0	2.2	N.S.	1.8

Table 4.27. Interaction between cultivar and nitrogen on the number of shed bolls of cotton m^{-2} at Mokwa in 1979.

Nitrogen level ($kg\ ha^{-1}$)	Cultivar	
	'Samaru 71'	'Super okra'
0	7.0	4.0
40	7.5	7.4
00	7.7	0.7
120	0.0	0.7
SED (±)	0.9	
LSD (p=0.05)	1.0	

the number of shed bolls (Table 4.20). In all the N treatments, plant population of 100,000 and 150,000 plants ha^{-1} had more shed boll than 50,000 plants ha^{-1}.

The interaction between cultivar and plant population was significant on the number of shed bolls at Samaru in 1900 (Table 4.29). At all the plant populations 'Super okra' shed more bolls than 'Samaru 71'. In both cultivars, plant population at 150,000 plants ha^{-1} and above resulted in greater boll shedding than 50,000 plants ha^{-1}.

4.2.3 Number of mature bolls per plant

The number of mature bolls per plant was not

Table 4.28. Interaction between nitrogen and plant population on boll shedding of cotton at Mokwa in 1979.

Nitrogen level (kg ha^{-1})	Plant Population (000 ha^{-1})		
	50	100	150
0	4.4	7.0	6.4
40	4.6	7/6	10.2
00	4.0	0.9	10.8
120	5.4	10.2	9.4
SED (±)		1.1	
LSD (p=0.05)		2.2	

Table 4.29. Interaction between cultivar and plant population on cotton boll shedding at Samaru in 1900.

Plant population (000 ha^{-1})	Cultivar	
	'Samaru 71'	'Super okra'
50	2.0	0.6
100	4.2	11.6
150	4.0	10.6
200	4.7	15.3
250	6.3	23.0
SED (±)	1.4	
LSD (p=0.05)	2.0	

significantly affected by cultivar at Samaru (Table 4.30). However, 'Super okra' recorded significantly higher number of mature bolls per plant than 'Samaru 71' in all the trials conducted at Mokwa (Table 4.31).

The application of nitrogen significantly increased the number of mature bolls per plant in 1900 and 1901 seasons at Samaru and during the 1979 season at Mokwa as compared with no nitrogen treatment (Table 4.30).

Plant population beyond 50,000 plants ha^{-1} significantly and progressively reduced the number of mature bolls per plant at both locations (Table 4.30).

The interaction between cultivar and plant population on the number of mature bolls per plant was significant at Samaru during the 1901 season (Table 4.31), thereby indicating that cultivar Samaru 71 tended to excel cultivar Super okra at 50,000 plants ha^{-1}, although non-significant, but as the plant population increased 'Super okra' produced slightly more mature bolls per plant than 'Samaru 71', and this was significant at 250,000 plants ha^{-1}. With 'Samaru 71' the number of mature bolls per plant declined significantly as plant population increased. Such decline was not consistent with population in 'Super okra', although 100,000 plants ha^{-1} and above produced fewer mature bolls than 50,000 plants ha^{-1}.

The interaction between nitrogen and plant population on

Table 4.30. Main effects of cultivar, nitrogen and plant population on the number of mature bolls per plant of cotton at Samaru and Mokwa.

Treatment	Samaru		Mokwa		
	1980	1981	1979	1980	1981
Cultivar					
Samaru 71	4.4	4.1	4.0	2.4	4.0
Super okra	5.2	4.3	6.0	3.0	5.0
SED (±)	0.4	0.3	0.4	0.2	0.3
LSD (p=0.05)	N.S.	N.S.	0.8	0.5	0.6
Nitrogen level (kg ha^{-1})					
0	3.0	3.5	4.0	2.4	4.3
40	5.0	4.7	5.7	2.8	5.0
80	5.3	4.3	6.2	3.1	4.6
120	5.0	4.4	5.7	2.5	4.0
SED (±)	0.5	0.4	0.5	0.4	0.4
LSD (p=0.05)	1.0	0.8	1.1.	N.S.	N.S.
Plant population (000 ha^{-1})					
50	6.2	7.1	6.3	5.0	6.3
100	5.3	4.0	4.6	3.5	5.0
150	4.2	3.9	3.4	2.0	3.7
200	3.3	2.6	NIL	1.7	2.9
250	3.0	2.7	NIL	1.3	2.6
SED (±)	0.7	0.	0.	0.	0.6
LSD (p=0.05)	1.6	1.4	1.7	1.4	1.4

Table 4.31. Interaction between cultivar and plant population on the number of mature bolls of cotton per plant at Samaru, 1901.

Plant population ('000 ha^{-1})	Cultivar	
	Samaru 71	Super okra
50	7.5	6.7
100	5.1	4.6
150	3.6	4.2
200	2.3	2.9
250	1.8	3.5
SED (±)	0.6	
LSD (p=0.05)	1.2	

the number of mature bolls per plant was significant at Samaru during the 1901 season only (Table 4.32). At a plant population of 50,000 plants ha^{-1}, nitrogen significantly and linearly increased the number of mature bolls per plant upto 80 kg ha^{-1}, but at 100,000 plants ha^{-1}, the number of mature bolls per plant was increased similarly by all N levels. At higher population densities (150,000 plants ha^{-1} and above) nitrogen fertilization did not affect the number of mature bolls per plant.

4.2.4 Boll weight

The boll weight of 'Super okra' was consistently

Table 4.32. Interaction between nitrogen and plant population on the number of mature bolls of cotton per plant at Samaru in 1901.

Plant population (000 ha^{-1})	Nitrogen level (kg ha^{-1})			
	0	40	00	120
50	4.7	6.7	0.4	0.6
100	3.0	5.9	5.6	6.0
150	3.4	4.3	4.1	3.7
200	2.6	3.1	2.0	2.0
250	2.9	3.4	2.5	1.0
SED (±)		0.0		
LSD (p=0.05)		1.6		

higher than that of 'Samaru 71' except at Mokwa during 1901 season (Table 4.33).

The application of nitrogen upto 00 kg ha^{-1} significantly increased the boll weight of cotton at Mokwa in 1900 and 1901. In 1900 00 kg ha^{-1} resulted in higher boll weight than no nitrogen treatment, while in 1901, 00 and 120 kg N ha^{-1} produced heavier bolls than no nitrogen treatment (Table 4.33).

Plant population from 50,000 to 250,000 poants ha^{-1} had no significant effect on the boll weight of cotton at both Samaru and Mokwa (Table 4.33).

Table 4.33. Main effect of cultivar, nitrogen level and plant population on average boll weight (g) of cotton at Mokwa and Samaru.

Treatment	Samaru		Mokwa		
	1980	1981	1979	1980	1981
Cultivar					
Samaru 71	3.1	3.1	3.2	3.4	2.8
Super okra	4.3	4.1	4.0	3.9	3.0
SED (±)	0.3	0.3	0.3	0.2	0.2
LSD (p=0.05)	0.6	0.6	0.6	0.4	N.S.
Nitrogen level (kg ha^{-1})					
0	3.0	3.1	3.4	3.5	2.4
40	3.2	3.5	3.4	3.2	2.8
80	3.5	3.8	3.9	4.6	3.0
120	3.3	4.0	3.8	3.4	3.2
SED (±)	0.4	0.4	0.4	0.3	0.3
LSD (p=0.05)	N.S.	N.S.	N.S.	0.6	0.6
Plant population (000 ha^{-1})					
50	3.0	3.3	3.0	3.9	3.5
100	3.0	3.6	3.4	4.1	2.9
150	3.4	3.5	3.7	3.6	2.6
200	3.5	4.0	NIL	3.9	2.5
250	3.6	3.6	NIL	2.8	2.8
SED (±)	0.6	0.6	0.6	0.5	0.4
LSD (p=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.

4.2.5 Harvest ratio

'Super okra' had a significantly higher harvest ratio than 'Samaru 71' during the 1980 season (Table 4.35).

The harvest ratio of cotton was significantly affected by the application of nitrogen at Mokwa in 1980 and 1981 (Table 4.34). Where application of 120 kg N ha^{-1} resulted in significant reduction in harvest ratio at Mokwa in 1980 and 1981.

Plant population at 250,000 plants ha^{-1} significantly decreased the harvest ratio of cotton at Mokwa during the 1980 season only.

The interaction between cultivar and nitrogen on harvest ratio was significant at Mokwa in 1980 (Table 4.35). With 'Samaru 71', the harvest ratio was significantly reduced by the application of N at 80 and 120 kg ha^{-1}, while no difference due to N was observed with 'Super okra'. However, non-significant higher harvest ratios were observed in 'Super okra' than 'Samaru 71' at all levels of nitrogen.

4.2.6 Earliness

Cultivar, nitrogen and plant population effected the various parameters of earliness of cotton differentially at both Samaru and Mokwa.

Table 4.34. Main effects of cultivar, nitrogen and plant population on the harvest ratio of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	0.61	0.43	0.31
Super okra	0.62	0.64	0.31
SED (±)	0.03	0.03	0.04
LSD (p=0.05)	N.S.	0.06	N.S.
Nitrogen level (kg ha^{-1})			
0	0.65	0.66	0.46
40	0.64	0.64	0.44
80	0.66	0.53	0.33
120	0.71	0.42	0.22
SED (±)	0.04	0.04	0.05
LSD (p=0.05)	N.S.	0.08	0.11
Plant population (000 ha^{-1})			
50	0.64	0.67	0.34
100	0.63	0.66	0.33
150	0.70	0.50	0.35
200	NIL	0.63	0.41
250	NIL	0.41	0.35
SED (±)	0.05	0.06	0.07
LSD (p=0.05)	N.S.	0.14	N.S.

Table 4.35. Interaction between cultivar and nitrogen on cotton harvest ratio at Mokwa in 1900.

Nitrogen level ($kg\ ha^{-1}$)	Cultivar	
	'Samaru 71'	'Super okra'
0	0.73	0.64
40	0.54	0.74
80	0.44	0.63
120	0.31	0.52
SED (±)	0.10	
LSD (p=0.05)	0.20	

Number of days to 50% flowering

As reflected in the number of days to 50% flowering 'Super okra' flowered earlier than 'Samaru 71' in 1900 and 1901 at Mokwa (Table 4.36).

Applied nitrogen had significant effect on the number of days to 50% flowering at Mokwa in 1901 season only. Nitrogen application at 40 kg ha^{-1} significantly decreased the number of days to 50% flowering as compared with 120 kg ha^{-1} (Table 4.36).

Plant population in the range tested had no significant effect on the number of days to 50% flowering of cotton at Mokwa (Table 4.36).

The interaction between cultivar and plant population

Table 4.36. Main effects of cultivar, nitrogen and plant population on the number of days to 50% flowering of cotton at Mokwa.

Treatment	50% Flowering		
	1979	1980	1981
Cultivar			
Samaru 71	59.0	62.1	65.1
Super okra	59.4	60.1	62.7
SED (±)	0.3	0.0	0.3
LSD (p=0.05)	N.S.	1.7	0.6
Nitrogen level (kg ha^{-1})			
0	59.4	62.1	64.3
40	59.5	63.5	63.4
80	59.5	60.7	63.5
120	60.1	62.0	64.3
SED (±)	0.4	1.1	0.3
LSD (p=0.05)	N.S.	N.S.	0.6
Plant population (000 ha^{-1})			
50	60.1	59.6	63.5
100	59.4	61.4	64.0
150	59.3	61.3	63.0
200	NIL	61.3	63.0
250	NIL	61.0	64.3
SED (±)	0.6	1.6	0.4
LSD (p=0.05)	N.S.	N.S.	N.S.

on the number of days to 50% flowering was significant at Nokwa in 1979 (Table 4.37). 'Super okra' exhibited significantly fewer days to 50% flowering at plant population of 100,000 and 150,000 plants ha^{-1} than at 50,000 plants ha^{-1}.

Number of days to first boll opening

As reflected in the number of days to first boll opening. 'Super okra' was significantly earlier than 'Samaru 71' in 1900 and 1901 at Nokwa. In both years, bolls of 'Super okra' opened about four days earlier than those of 'Samaru 71' (Table 4.36).

The number of days from sowing to first boll opening was significantly affected by the application of nitrogen at Nokwa in 1979, 1900 and 1901. In 1979, 120 kg N ha^{-1} resulted in significant increase in the number of days to first boll opening as compared with the no nitrogen treatment while 40 kg N ha^{-1} decreased the number of days in 1900. Both 80 and 120 kg N ha^{-1} significantly increased the number of days to first boll opening in 1901 (Table 4.36).

Plant population had significant effect on the number of days to first boll opening in 1900 and 1901. Plant population at 200,000 and 250,000 plants ha^{-1} significantly increased the number of days by seven and nine, respectively compared with 50,000 plants ha^{-1} (Table 4.36).

Table 4.37. Interaction between cultivar and plant population on the number of days to 50% flowering at Nakwa in 1979.

Plant population ('000 ha^{-1})	Cultivar	
	'Samaru 71'	'Super okra'
50	59.6	60.6
100	59.9	50.9
150	59.8	50.7
SED (±)	0.5	
LSD (p=0.05)	1.0	

Mean maturity date

The mean maturity date (MMD) was significantly earlier in plants of 'Super okra' than those of 'Samaru 71' in 1900 and 1901 at Samaru and in 1979 and 1901 at Nakwa. In all the years 'Super okra' exhibited an earlier maturity (about five days) than 'Samaru 71' (Table 4.39).

Nitrogen application significantly affected earliness in 1901 at Samaru and in 1900 at Nakwa. While 120 kg N ha^{-1} reduced the MMD at Samaru in 1901, it increased MMD at Nakwa in 1900 (Table 4.39).

Mean maturity date was significantly affected by plant population in the 1901 season at both locations (Table 4.39).

Table 4.30. Main effects of cultivar, nitrogen and plant population on the number of days from sowing to first boll opening at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	106.3	100.6	117.3
Super okra	105.6	104.2	113.3
SED (±)	0.5	1.6	0.6
LSD (p=0.05)	N.S.	3.2	1.2
Nitrogen level (kg ha^{-1})			
0	105.4	109.3	114.3
40	104.9	103.7	112.5
80	106.1	106.2	116.2
120	107.4	106.4	110.3
SED (±)	0.7	2.2	0.8
LSD (p=0.05)	1.5	4.4	1.6
Plant population (000 ha^{-1})			
50	104.8	102.0	114.8
100	106.0	103.3	114.2
150	107.1	103.4	113.3
200	NIL	110.2	116.0
250	NIL	112.3	117.6
SED (±)	1.0	3.1	1.1
LSD (p=0.05)	N.S.	7.2	2.5

Table 4.39. Main effect of cultivar, nitrogen and plant population on the mean maturity date of cotton at Samaru and Nakwa.

Treatment	Samaru		Nakwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	143.4	126.5	136.6	136.2	159.5
Super okra	130.0	123.0	134.9	136.3	154.4
SED (±)	0.8	1.3	0.4	1.3	1.1
LSD ($\bar{p}$=0.05)	1.6	2.5	0.9	N.S.	2.3
Nitrogen level (kg ha^{-1})					
0	140.3	120.2	135.6	131.4	157.0
40	140.9	124.6	135.3	132.7	157.0
80	142.1	125.2	136.1	137.0	155.6
120	141.1	121.9	136.0	143.0	150.2
SED (±)	1.1	1.8	0.6	1.9	1.6
LSD ($\bar{p}$=0.05)	N.S.	3.7	N.S.	3.8	N.S.
Plant population (000 ha^{-1})					
50	142.1	107.8	134.9	135.4	153.4
100	139.3	120.6	136.0	133.9	154.3
150	140.4	130.9	136.4	140.3	157.7
200	141.7	133.3	NIL	132.9	159.0
SED (±)	1.5	2.6	0.8	2.7	2.2
LSD ($\bar{p}$=0.05)	N.S.	6.0	N.S.	N.S.	5.1

Maturity was delayed by 13 days at Samaru and five days at Mokwa between 50,000 and 150,000 plants ha^{-1}. There was no effect of increased plant population beyond 150,000 on NHD.

Production rate index

The production rate index of 'Super okra' was significantly higher than that of 'Samaru 71' during the 1981 season, both at Samaru and Mokwa (Table 4.40). 'Super okra' produced 13.1 and 10.2 kg ha^{-1} day^{-1} of seed cotton as compared with 10.2 and 7.0 kg ha^{-1} day^{-1} from 'Samaru 71' during the 1981 season at Samaru and Mokwa, respectively.

Applied nitrogen had a significant effect on the production rate index of cotton during the 1981 season at Samaru, and during the 1979 and 1981 seasons at Mokwa (Table 4.40). At Samaru in 1981 and at Mokwa in 1979, all N levels similarly increased production rate index as compared with no nitrogen treatment, while in 1981 at Mokwa, only 40 and 80 kg N ha^{-1} significantly increased the production rate index (Table 4.40).

Plant population had significant effect on production rate index in 1980 and 1981 at Samaru, and in 1979 and 1981 at Mokwa (Table 4.40). At Mokwa, production rate index decreased with population increase upto 200,000 plants ha^{-1}, while at Samaru in 1980, plant population of 150,000 plants ha^{-1} and above similarly resulted in significant increase in production rate index (Table 4.40).

Table 4.40. Main effects of cultivar, nitrogen and plant population on the production rate index of cotton at Samaru and Makwa.

Treatment	Samaru		Makwa		
	1980	1981	1979	1980	1981
Cultivar					
Samaru 71	13.4	10.1	7.7	6.5	7.0
Super okra	13.4	13.1	7.7	7.6	10.2
SED (±)	0.2	0.2	0.1	1.3	0.1
LSD (p=0.05)	N.S.	0.4	N.S.	N.S.	0.2
Nitrogen level (kg ha^{-1})					
0	13.7	9.0	6.0	5.0	0.1
40	13.4	12.1	7.0	6.6	0.9
80	13.2	13.2	8.7	8.0	9.3
120	13.3	12.2	8.0	8.0	8.1
SED (±)	0.3	0.3	0.2	1.9	0.2
LSD (p=0.05)	N.S.	0.6	0.4	N.S.	0.4
Plant population (000 ha^{-1})					
50	12.2	11.6	8.2	7.0	10.0
100	13.4	12.6	7.7	7.7	9.1
150	13.9	11.9	7.2	5.7	8.0
200	13.0	10.4	NIL	9.2	7.5
250	13.7	11.5	NIL	5.7	7.6
SED (±)	0.4	0.4	0.3	2.7	0.3
LSD (p=0.05)	0.9	0.9	0.8	N.S.	0.7

The interaction between cultivar and plant population on production rate index was significant at Mokwa in 1979 (Table 4.41). The highest production rate index of 3.4 was recorded at 50,000 plants ha^{-1} by 'Samaru 71'. In this cultivar, populations of 100,000 and 150,000 plants ha^{-1} resulted in significantly lower production rate index than 50,000 plants ha^{-1}.

Percentage of first picking to total seed cotton yield

'Super okra' yielded a higher percentage of seed cotton at first picking than 'Samaru 71' at Samaru and Mokwa.

Application of 40 kg N ha^{-1} increased percentage of seed cotton yield at first picking (Fig. 6) while increased plant population decreased the percentage of seed cotton yield at first picking at both locations (Fig. 7).

4.3 Yield

4.3.1 Seed cotton yield

'Super okra' significantly outyielded 'Samaru 71' by 37% at Samaru in 1981 and by 35 and 40% at Mokwa in 1980 and 1981 growing seasons, respectively (Table 4.42). On the basis of pooled analysis, 'Super okra' outyielded 'Samaru 71' by 27% (Table 4.43). No seed cotton yield was recorded at Samaru in 1979 because the experiment failed.

Seed cotton yield was significantly affected by

Table 4.41. Interaction between cultivar and plant population on the production rate index of cotton at Mokwa in 1979.

Plant population ($000\ ha^{-1}$)	Cultivar	
	'Samaru 71'	'Super okra'
50	3.4	2.9
100	2.5	2.9
150	2.1	2.4
SED (±)	0.2	
LSD (p=0.05)	0.4	

nitrogen application at both locations (Tables 4.42 and 4.43). In all cases the application of nitrogen increased seed cotton yield significantly as compared with the no nitrogen treatment (Figs. 8 and 9).

Plant population significantly affected seed cotton yield at Samaru during the 1980 season and at Mokwa during the 1979 and 1981 seasons (Table 4.42). Plant population above 50,000 plants ha^{-1} had higher seed cotton yield than 50,000 plants ha^{-1} at Samaru in 1980. On the contrary increased plant population above 50,000 plants ha^{-1} resulted in decrease in the seed cotton yield at Mokwa, although there was no significant difference between 50,000 and 100,000 plants ha^{-1} in terms of seed cotton yield except during the 1979 season (Figs. 10 and 11).

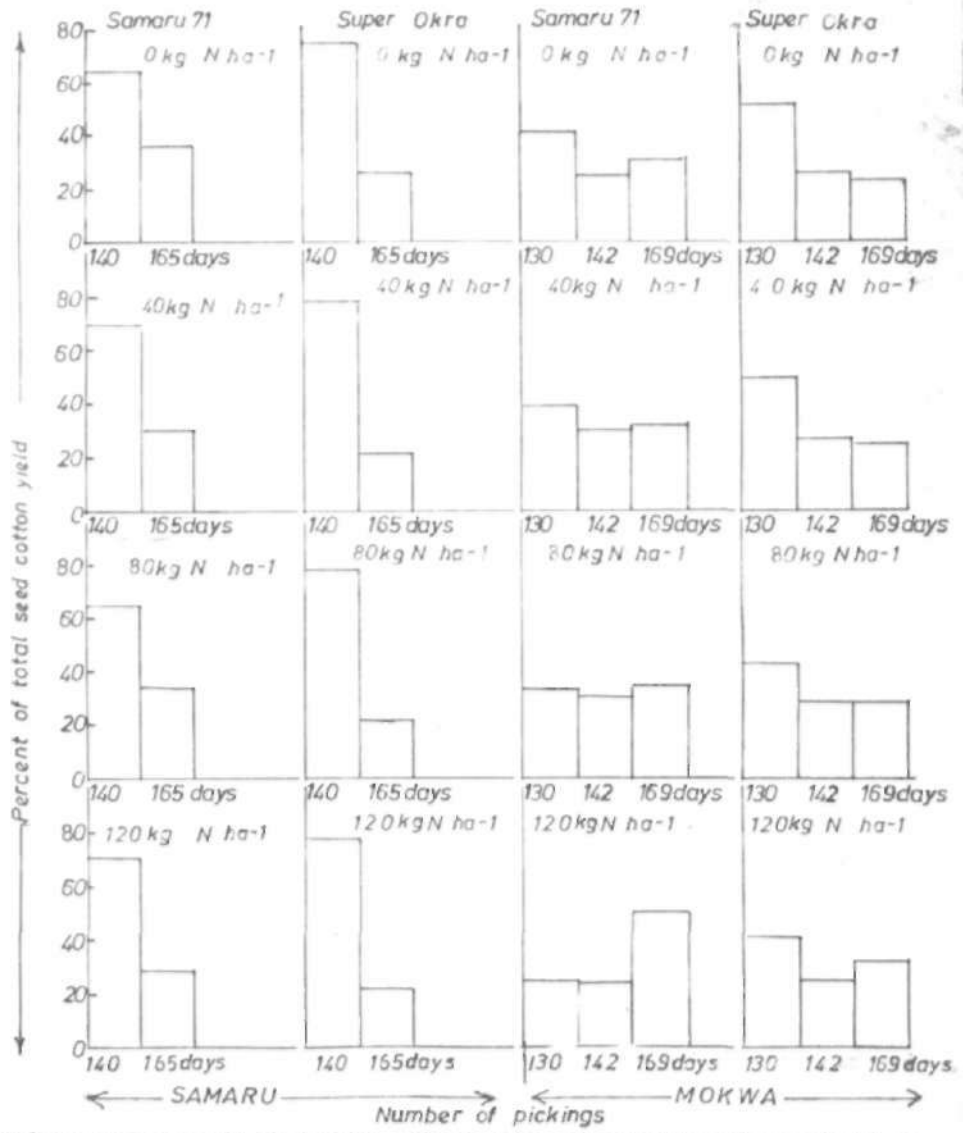


Fig 6 : First, second and third cotton pickings as percent of total seed cotton yield as affected by nitrogen levels and leaf type (2year and 3year means for Samaru and Mokwa respectively).

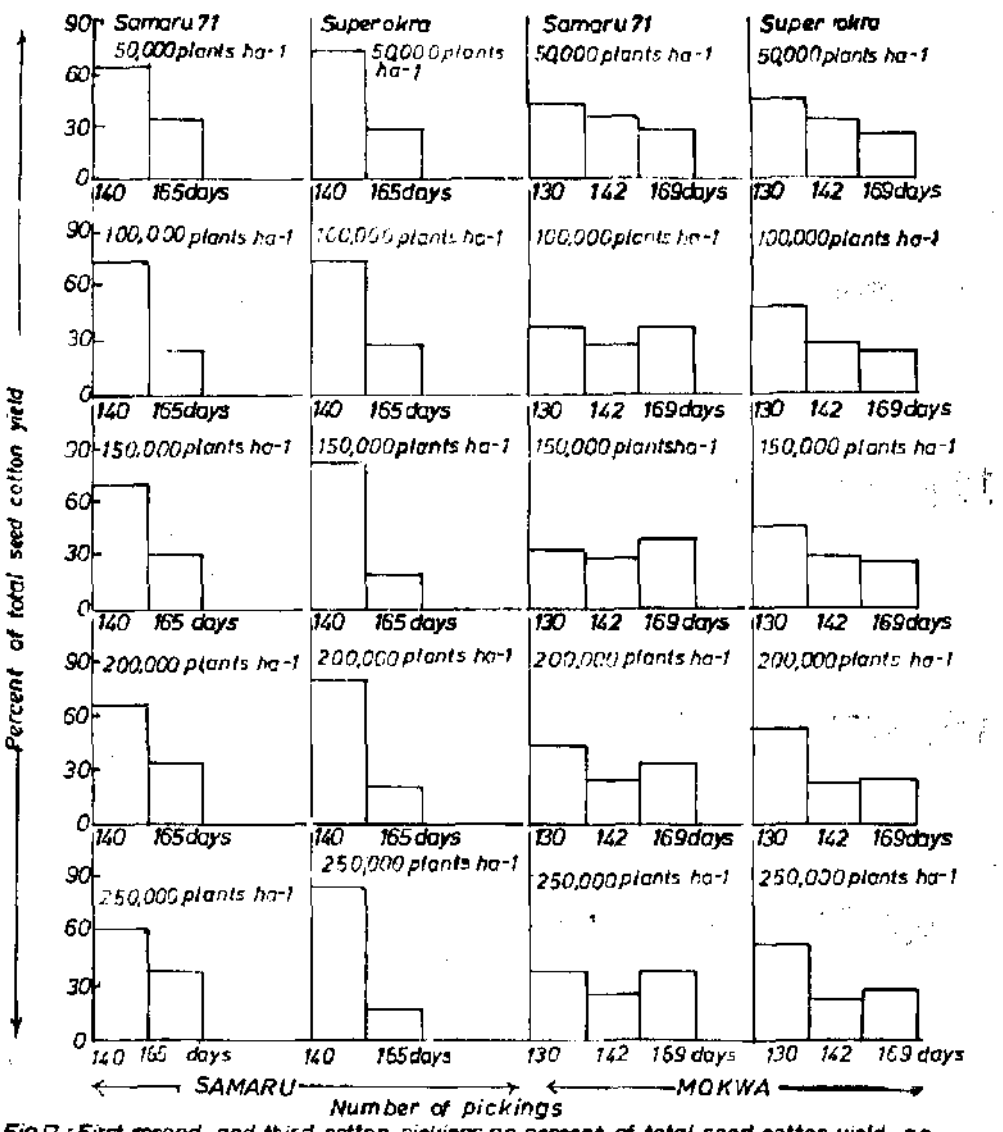


Fig.7 ; First, second and third cotton pickings as percent of total seed cotton yield as affected by plant population and leaf type (2year and 3year means for Samaru and Mokwa respectively

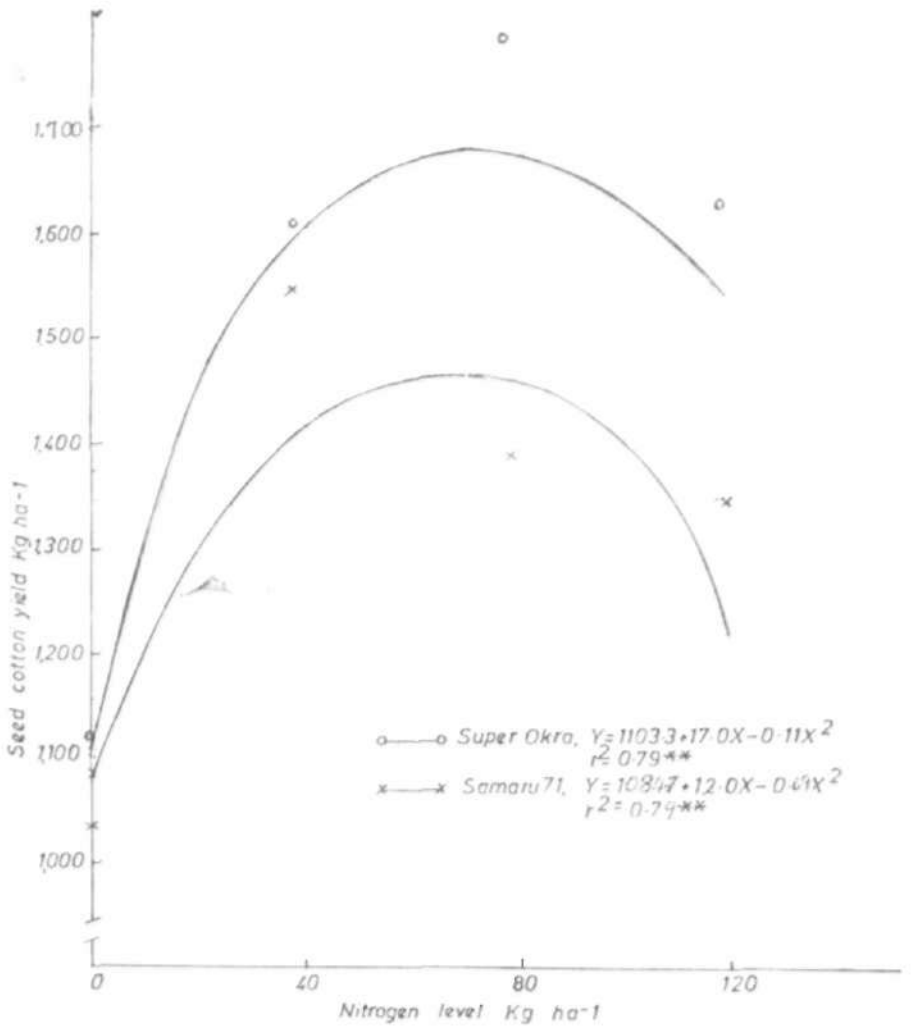


Fig. 8 : Regression of seed cotton yield on nitrogen level at Samaru (1980 and 1981 mean)

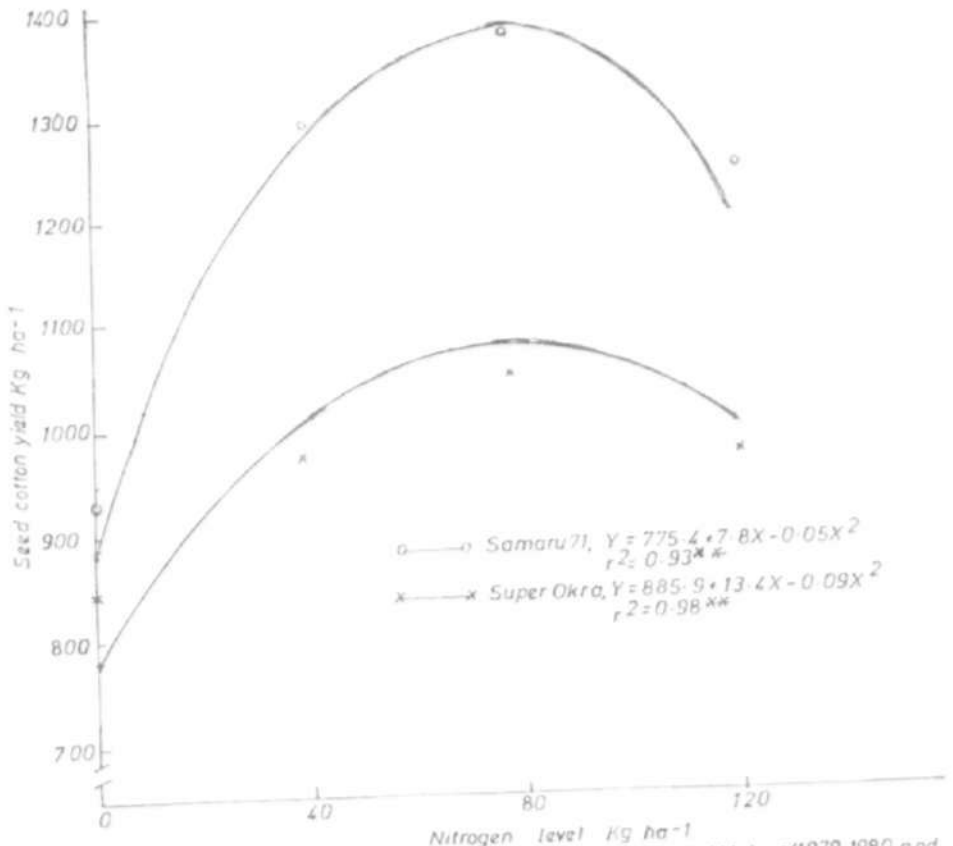


Fig. 9 : Regression of seed cotton yield on nitrogen level at Mokwa (1979, 1980 and 1981 mean)

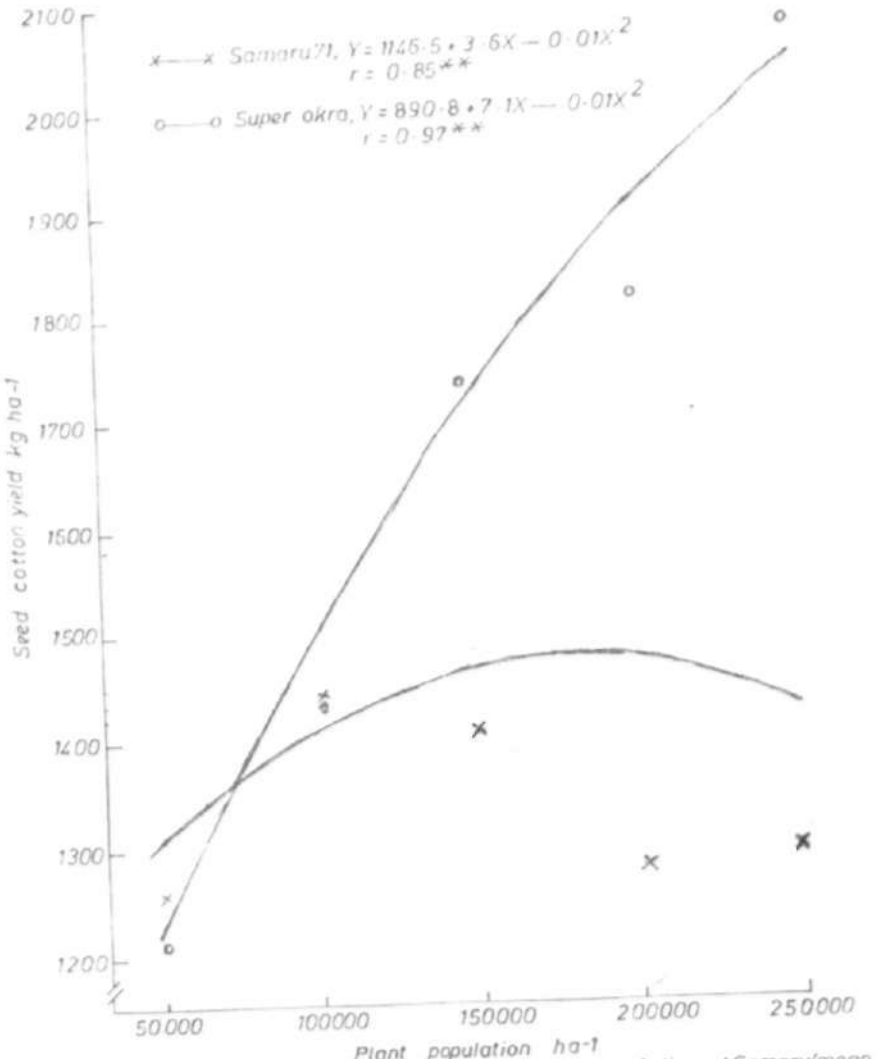


Fig.10; Regression of seed cotton yield plant population at Samaru(mean of 1980 and 1981 season)

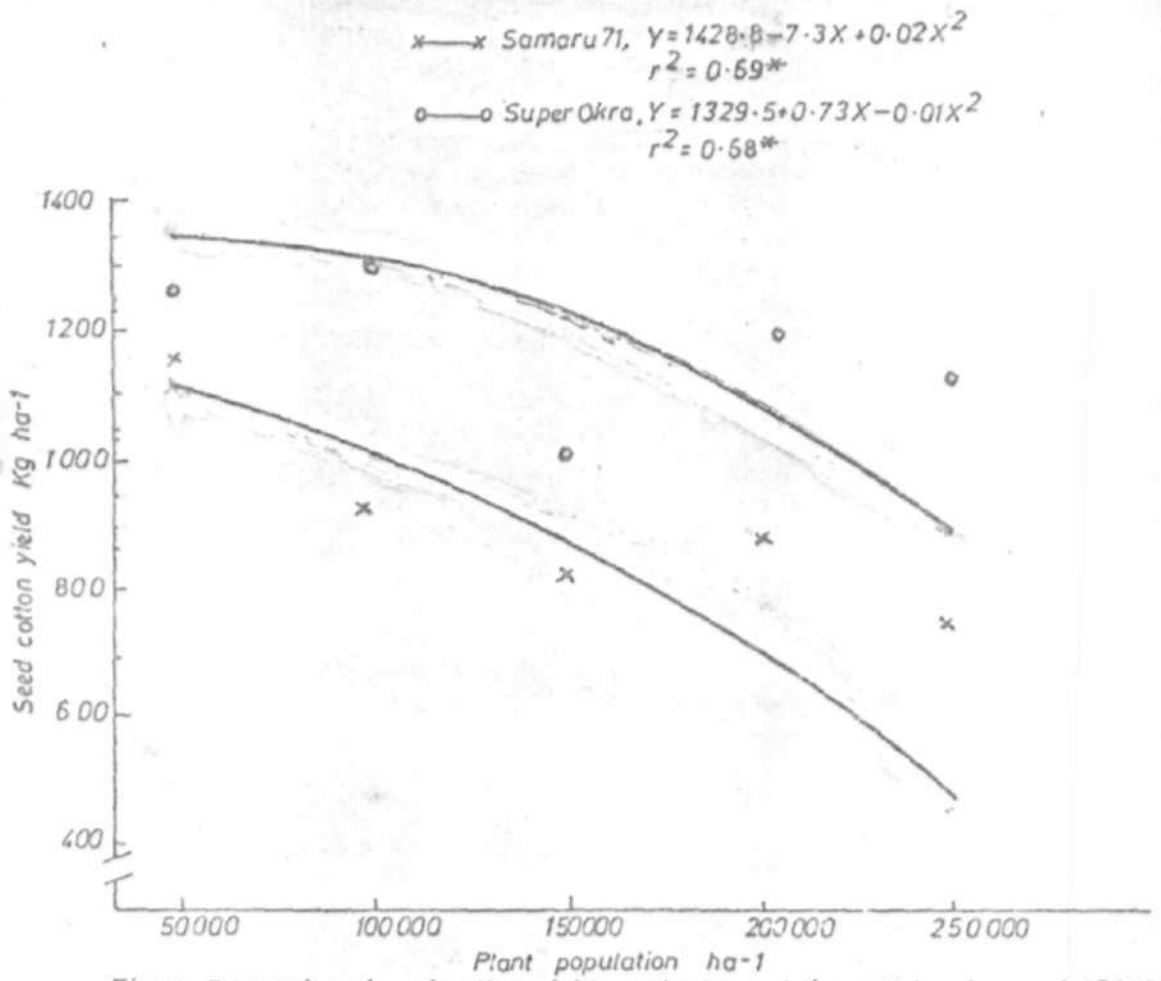


Fig.11: Regression of seed cotton yield on plant population at Mokwa (mean of 1979, 1980 and 1981 season)

Table 4.42. Main effects of cultivar, nitrogen and plant population on seed cotton yield (kg ha^{-1}).

Treatment	Samaru		Makwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	1,460.0	1,100.0	996.0	752.0	1,004.0
Super okra	1,457.0	1,623.0	1,022.0	1,017.0	1,607.0
SED (±)	42.5	90.0	54.0	64.2	64.0
LSD ($\bar{p}$=0.05)	N.S.	102.5	N.S.	129.0	130.2
Nitrogen level (kg ha^{-1})					
0	1,005.0	1,145.0	603.0	650.0	1,190.0
40	1,642.0	1,530.0	1,052.0	074.0	1,431.0
80	1,594.0	1,572.0	1,100.0	1,001.0	1,407.0
120	1,609.0	1,376.0	1,112.0	933.0	1,272.0
SED (±)	60.0	120.4	77.5	91.7	91.7
LSD ($\bar{p}$=0.05)	120.6	250.1	155.0	104.3	104.3
Plant population (000 ha^{-1})					
50	1,260.0	1,201.0	1,102.0	000.0	1,649.0
100	1,436.0	1,470.0	1,001.0	1,040.0	1,409.0
150	1,495.0	1,550.0	043.0	745.0	1,249.0
200	1,535.0	1,307.0	NIL	973.0	1,202.0
250	1,506.0	1,405.0	NIL	775.0	1,216.0
SED (±)	113.0	190.0	70.4	131.0	191.6
LSD ($\bar{p}$=0.05)	262.9	N.S.	101.1	N.S.	441.2

Table 4.43. Main effects of cultivar, nitrogen and plant population, year and location on seed cotton yield.

Treatment	Seed cotton yield kg ha^{-1}	LSD (p=0.05)	SED(±)
Cultivar			
Samaru 71	1124		74.7
Super okra	1426	140.7	
Nitrogen level (kg ha^{-1})			
0	990		
40	1370		
80	1433		
120	1297	212.5	106.0
Plant population (000 ha^{-1})			
50	1250		
100	1341		
150	1263		
200	1274	N.S.	145.5
250	1246		
Year			
1900	1174		
1901	1376	140.7	74.7
Location			
Samaru	1435	140.7	
Mokwa	1116		74.7

On the basis of the pooled analysis, there was no significant response to increased plant population within the limits tested (Table 4.43). However, the year and location had significant effects on seed cotton yield. Seed cotton yield during the 1981 season was significantly higher than that of 1980. Similarly, seed cotton yield at Samaru was significantly higher than that of Mokwa (Table 4.43).

The interaction between cultivar and plant population on seed cotton yield was significant at Mokwa during the 1979 season (Table 4.44). With 'Samaru 71' seed cotton yield was significantly reduced with increased plant population beyond 50,000 plants ha^{-1}. However, with 'Super okra' there was no significant difference in seed cotton yield at the three population levels. At 50,000 plants ha^{-1}, 'Samaru 71' outyielded 'Super okra'.

The interaction between nitrogen and plant population was significant on seed cotton yield at Samaru during the 1980 season (Table 4.45). Seed cotton yield was increased by increased N levels upto 40 kg N ha^{-1} at all the population levels. The highest seed cotton yield was obtained at 40 kg N ha^{-1} and 200,000 plants ha^{-1}.

4.3.2 Lint yield

Lint yield followed the same trend as seed cotton yield. The superiority of 'Super okra' over 'Samaru 71' was again

Table 4.44. Interaction between cultivar and plant population on seed cotton yield at Mokwa in 1979.

Plant population (000 ha^{-1})	Cultivar	
	'Samaru 71'	'Super okra'
50	1,200.0	1,077
100	916.0	1,006
150	704.0	901
SED (±)	94.9	
LSD (p=0.05)	190.7	

Table 4.45. Interaction between nitrogen and plant population on seed cotton yield at Samaru in 1980.

Plant population (000 ha^{-1})	Nitrogen level (kg ha^{-1})			
	0	40	80	120
50	1,060.0	1,352.0	1,353.0	1,269.0
100	997.0	1,614.0	1,507.0	1,627.0
150	1,024.0	1,573.0	1,660.0	1,717.0
200	963.0	1,056.0	1,692.0	1,627.0
250	971.0	1,013.0	1,752.0	1,007.0
SED (±)			136.6	
LSD (p=0.05)			271.0	

recorded at the two locations during the three growing seasons (Table 4.46).

The application of 40 kg N ha^{-1} at Samaru resulted in lint yield increases of 64 and 27% as compared with no nitrogen treatment during the 1900 and 1901 seasons, respectively. At Mokwa, increases of 45%, 34.5% and 27% in lint yield in 1979, 1900 and 1901, respectively were recorded with 40 kg N ha^{-1} compared with no nitrogen treatment at Mokwa (Table 4.46). At both sites N levels did not differ significantly in their effect on lint yield although a lint yield increase of 50% over the control was recorded at Mokwa with 60 kg N ha^{-1}.

Plant population had a significant effect on lint yield at Samaru in 1900, and all the three seasons at Mokwa. Significant yield increases of 22% and 24% were obtained with populations of 200,000 and 250,000 plants ha^{-1} over 50,000 plants ha^{-1} at Samaru in 1900 (Table 4.46). There were 10% and 17% decreases in lint yield in the 1979 and 1901 seasons, respectively between 50,000 and 100,000 plants ha^{-1} at Mokwa and decreases of 27%, 16% and 27% were recorded between 50,000 and 150,000 plants ha^{-1} during the 1979, 1900 and 1901 seasons, respectively (Table 4.46).

The interaction between cultivar and plant population on lint yield was significant at Mokwa during the 1979 season. The lint yield of 'Samaru 71' was significantly reduced at

Table 4.46. Main effects of cultivar, nitrogen and plant population on lint yield of cotton at Samaru and Mokwa.

Treatment	Samaru		Mokwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	579	400	330	225	302
Super ekee	502	653	361	305	553
SED (±)	15.4	35.4	13.3	0.5	16.5
LSD ($\bar{p}$=0.05)	N.S.	71.5	N.S.	17.1	33.2
Nitrogen level (kg ha^{-1})					
0	399	471	254	195	403
40	654	599	360	262	510
80	615	646	407	324	537
120	652	567	369	279	422
SED (±)	22.0	50.6	19.0	12.1	23.5
LSD ($\bar{p}$=0.05)	44.4	102.2	41.7	24.5	47.4
Plant population (000 ha^{-1})					
50	506	470	411	266	569
100	560	610	339	312	473
150	500	611	299	224	425
200	617	572	NIL	291	463
250	620	504	NIL	232	410
SED (±)	31.4	72.3	27.1	17.3	33.5
LSD ($\bar{p}$=0.05)	72.5	N.S.	75.3	40.0	77.4

population levels of 100,000 and 150,000 plants ha^{-1} as compered with 50,000 plants ha^{-1}, while that of 'Super okra' was no significantly affected by increase in plant population. 'Smaru 71' recorded a higher but non-significant lint yield only at the 50,000 plants ha^{-1} (Table 4.47).

Table 4.47. Interaction between cultivar and plant population on lint yield of cotton at Mokwa in 1979.

Plant population (000 ha^{-1})	Cultivar	
	'Sameru 71'	'Super okra'
50	436	305
100	303	374
150	276	323
SED (±)	36.3	
LSD (p=0,05)	73.0	

4.3.3 Number of seeds per boll

The number of seeds per boll was significantly affected by N levels only at Mokwa during the three seasons. During the three seasons application of N at 00 and 120 kg ha^{-1} resulted in more seed per boll than no nitrogen treatment (Table 4.40).

Table 4.40. Main effects of cultivar, nitrogen and plant population on the number of seeds per boll at Nakwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	28.8	28.1	31.2
Super okra	29.1	29.5	31.8
SED (±)	0.7	0.7	0.4
LSD (p=0.05)	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})			
0	26.6	26.6	30.1
40	28.4	28.4	31.3
80	30.6	29.7	32.0
120	30.0	30.6	32.6
SED (±)	1.0	1.0	0.6
LSD (p=0.05)	2.0	2.0	1.2
Plant population (000 ha^{-1})			
50	28.7	29.2	32.6
100	28.7	29.0	31.4
150	29.3	29.2	31.2
200	NIL	28.4	31.6
250	NIL	28.3	30.7
SED (±)	1.4	1.4	0.8
LSD (p=0.05)	N.S.	N.S.	N.S.

4.4 Quality

4.4.1 Ginning percentage

Ginning percentage was not significantly affected by cultivar at the two locations over the three-year period (Table 4.49).

Nitrogen application had no significant effect on the ginning percentage of cotton at Samaru (Table 4.49). However, the application of 40 kg N ha^{-1} and above significantly decreased the ginning percentage of cotton at Mokwa during the 1979 and 1980 seasons (Table 4.49).

Plant populations in the range of 50,000 to 250,000 plants ha^{-1} had no significant effect on the ginning percentage of cotton at Samaru. In contrast, increased plant population upto 150,000 plants ha^{-1} significantly decreased the ginning percentage of cotton during the 1980 season at Mokwa (Table 4.49).

The interaction between cultivar and nitrogen level was significant at Samaru during the 1980 season. The difference between the ginning percentage for both cultivars was significant at no nitrogen and 80 kg N ha^{-1} treatments (Table 4.50).

4.4.2 Lint index

The lint index was not significantly effected by

Table 4.49. Main effects of cultivar, nitrogen and plant population on ginning percentage of cotton at Samaru and Nokwa.

Treatment	Samaru		Nokwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	39.4	41.1	34.2	32.7	35.3
Super okra	39.9	40.2	35.5	34.5	34.4
SED (±)	0.60	0.60	0.07	1.14	1.29
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})					
0	39.7	41.1	37.1	37.5	34.5
40	39.0	39.2	25.0	34.3	35.6
80	30.6	41.1	34.1	35.1	36.1
120	40.5	41.2	33.1	30.3	33.2
SED (±)	0.97	0.85	1.24	1.83	1.04
LSD ($\bar{p}$=0.05)	N.S.	N.S.	2.5	3.3	N.S.
Plant population (000 ha^{-1})					
50	40.2	39.0	34.0	40.6	34.5
100	39.5	41.3	34.2	36.7	33.6
150	30.0	39.3	35.7	34.5	34.0
200	40.2	41.2	NIL	31.7	30.5
250	39.6	41.7	NIL	25.5	33.7
SED (±)	1.36	1.22	1.74	2.20	2.50
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	5.3	N.S.

Table 4.50. Interaction between cultivar and nitrogen on ginning percentage of cotton at Samaru in 1900.

Nitrogen level ($kg\ ha^{-1}$)	Cultivar	
	'Samaru 71'	'Super okra'
0	30.2	41.3
40	40.2	39.5
80	40.1	37.0
120	39.1	42.0
SED (±)	1.4	
LSD (p=0.05)	2.9	

cultivar at Samaru (Table 4.51) although the lint index of 'Super okra' was higher than that of S-71 in 1900 and 1901. However, at Makwa, lint index of 'Super okra' was significantly higher than that of 'Samaru 71' during 1979 and 1900 seasons (Table 4.51).

The application of nitrogen had no significant effect on lint index at Samaru but it significantly increased lint index during the 1900 season at Makwa (Table 4.51).

Increased plant population above 50,000 plants ha^{-1} had no significant effect on lint index at Samaru but it significantly decreased lint index in 1900 season at Makwa (Table 4.51).

4.4.3 Seed index

The seed index of 'Super okra' was significantly

Table 4.51. Main effect of cultivar, nitrogen and plant population on lint index at Samaru and Mokwa.

Treatment	Samaru		Mokwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	6.1	6.0	4.5	3.5	5.1
Super okra	6.5	6.6	5.1	5.7	4.9
SED (±)	2.56	2.70	0.25	0.50	0.47
LSD ($\bar{p}$=0.05)	N.S.	N.S.	0.5	1.0	N.S.
Nitrogen level (kg ha^{-1})					
0	6.2	6.2	5.2	5.3	4.0
40	6.1	6.0	4.9	4.2	5.1
80	6.5	6.5	4.6	5.6	5.6
120	6.4	6.4	4.5	3.4	4.6
SED (±)	3.66	3.06	0.35	0.70	0.67
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	1.4	N.S.
Plant population (000 ha^{-1})					
50	6.1	6.2	5.0	0.2	5.2
100	6.3	6.2	4.0	3.3	4.6
150	6.3	6.5	4.6	4.9	4.0
200	6.4	6.6	NIL	4.6	4.1
250	6.4	5.0	NIL	2.0	4.4
SED (±)	5.12	5.40	0.49	0.90	0.94
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	2.26	N.S.

higher than that of 'Samaru 71' except in 1981 season at Mokwa (Table 4.52).

Seed index was not significantly affected by nitrogen fertilization at Samaru and Mokwa (Table 4.52).

Plant population in the range of 50,000 and 250,000 plants ha^{-1} had no significant effect on the seed index of cotton at Samaru while plant population greater than 50,000 plants ha^{-1} significantly decreased the seed index of cotton at Mokwa (Table 4.52).

4.4.4 Micronaire value

There was no significant difference between the two cotton cultivars in terms of the micronaire value of the lint (Table 4.53).

The application of nitrogen progressively and significantly decreased the micronaire value of cotton lint at Mokwa (Table 4.53).

Plant population in the range of 50,000 and to 150,000 plants ha^{-1} had no significant effect on micronaire value of the cotton lint at Mokwa (Table 4.53), although increased plant population upto 150,000 plants ha^{-1} gave lower values.

4.4.5 Bundle strength

Cultivar and nitrogen application had no significant effect on bundle strength (Table 4.53).

Table 4.52. Main effects of cultivar, nitrogen and plant population on seed index of cotton at Samaru and Mokwa.

Treatment	Samaru		Mokwa		
	1900	1901	1979	1900	1901
Cultivar					
Samaru 71	94.4	85.7	84.0	105.2	89.2
Super okra	90.4	97.3	92.6	117.0	88.5
SED (±)	1.93	2.10	0.74	0.72	1.22
LSD ($\bar{p}$=0.05)	3.9	4.4	1.50	1.46	N.S.
Nitrogen level (kg ha^{-1})					
0	94.5	89.0	88.2	110.5	86.7
40	97.9	95.0	87.4	110.0	86.0
80	99.3	92.0	88.2	111.2	92.3
120	90.0	90.0	89.3	112.5	90.3
SED (±)	2.7	3.05	1.06	1.03	1.74
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})					
50	97.6	92.5	92.1	119.4	92.9
100	97.3	92.5	89.7	107.5	92.5
150	96.4	95.4	83.0	109.4	89.2
200	95.0	92.9	NIL	111.9	87.6
250	94.9	84.2	NIL	107.3	82.05
SED (±)	3.70	4.27	1.51	1.47	2.40
LSD ($\bar{p}$=0.05)	N.S.	N.S.	4.2	3.4	5.7

Table 4.53. Main effect of cultivar, nitrogen and plant population on micronaire value and bundle strength at Mokwa in 1979.

Treatment	Micronaire value	Bundle Strength (g tex at 1/8")
Cultivar		
Samaru 71	3.7	22.2
Super okra	3.6	22.2
SED (±)	0.07	0.04
LSD (p=0.05)	N.S.	N.S.
Nitrogen level(kg ha^{-1})		
0	3.8	22.1
40	3.7	22.1
80	3.6	22.4
120	3.4	22.2
SED (±)	0.10	0.06
LSD (p=0.05)	0.2	N.S.
Plant population (000 ha^{-1})		
50	3.7	21.5
100	3.6	22.2
150	3.5	23.0
200	NIL	NIL
250	NIL	NIL
SED (±)	0.14	0.00
LSD (p=0.05)	N.S.	0.22

Plant population in the range of 50,000 to 150,000 plants significantly increased the bundle strength of cotton lint (Table 4.53).

4.5 Chemical Analysis

4.5.1 Nitrogen content of leaves

'Super okra' had a higher percentage of nitrogen in the leaves than 'Samaru 71' (Tables 4.54 and 4.55). At Samaru, the difference in leaf nitrogen content was significant only at seven weeks after sowing in 1979, whereas at Mokwa, the difference was significant in all the three years.

Applied nitrogen significantly increased the percentage nitrogen content of leaves at the seven and 15 weeks after sowing at both locations over the three-year period (Tables 4.54 and 4.55). The nitrogen content of leaves increased up-to 80 and 120 kg ha^{-1} at Samaru and Mokwa (Tables 4.54 and 4.55).

Nitrogen content tended to decrease progressively with increased plant population beyond 50,000 plants ha^{-1} both at Samaru and Mokwa (Tables 4.54 and 4.55). The differences were significant at Samaru at the 15 weeks after sowing in 1980 and at Mokwa at the seven weeks after sowing in 1980 and 1981.

The interaction between cultivar and nitrogen significantly

Table 4.54. Main effects of cultivar, nitrogen and plant population on per cent N in the cotton leaves at Samaru.

Treatment	1979		1980		1981	
	7	15	7	15	7	15 (WAS)
Cultivar						
Samaru 71	2.0	4.3	3.6	4.4	2.0	4.1
Super okra	3.1	4.2	3.6	4.4	2.7	4.24.2
SED (±)	0.07	0.11	0.02	0.07	0.06	0.07
LSD ($\bar{p}$=0.05)	0.14	N.S.	N.S.	N.S.	N.S.	N.S.
Nitrogen level (kg ha^{-1})						
0	2.0	3.6	3.5	4.0	2.0	3.3
40	2.8	4.4	3.7	4.4	2.8	4.1
80	3.0	4.5	3.6	4.5	2.0	4.5
120	3.2	4.5	3.7	4.6	2.6	4.7
SED (±)	0.10	0.15	0.03	0.10	0.09	0.10
LSD ($\bar{p}$=0.05)	0.2	0.3	0.05	0.2	N.S.	0.2
Plant population (000 ha^{-1})						
50	3.0	4.4	3.0	4.4	2.9	4.3
100	3.0	4.3	3.7	4.4	2.8	4.1
150	2.9	4.1	3.6	4.5	2.7	4.1
200	NIL	NIL	3.6	4.4	2.8	4.0
250	NIL	NIL	3.4	4.3	2.7	4.1
SED (±)	0.14	0.21	0.04	0.14	0.13	0.14
LSD ($\bar{p}$=0.05)	N.S.	N.S.	0.09	N.S.	N.S.	N.S.

Table 4.55. Main effects of cultivar, nitrogen level and plant population on the per cent nitrogen in the cotton leaves at Nakwa.

Treatment	1979		1980		1981	
	7	15	7	15	7	15 (WAS)
Cultivar						
Samaru 71	2.4	3.0	2.7	3.0	2.9	4.1
Super okra	2.9	4.2	3.2	4.0	3.1	4.3
SED (±)	0.07	0.07	0.05	0.05	0.07	0.10
LSD ($\bar{p}$=0.05)	0.14	0.14	0.1	0.14	0.14	0.2
Nitrogen level (kg ha^{-1})						
0	2.4	3.2	2.4	3.1	2.0	3.6
40	2.4	3.9	2.8	4.2	3.1	4.6
80	2.8	4.4	2.9	4.2	3.1	4.6
120	3.0	4.6	3.1	4.5	3.3	4.6
SED (±)	0.10	0.10	0.07	0.10	0.10	0.14
LSD ($\bar{p}$=0.05)	0.2	0.2	0.14	0.2	0.2	0.20
Plant population (000 ha^{-1})						
50	2.7	4.1	2.9	4.0	3.1	4.7
100	2.7	4.0	2.6	3.9	2.9	4.3
150	2.6	4.0	2.7	3.9	2.9	4.2
200	NIL	NIL	2.0	3.0	2.9	4.0
250	NIL	NIL	2.0	3.7	3.0	4.0
SED (±)	0.14	0.14	0.10	0.07	0.14	0.10
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	0.2	N.S.	0.23

affected the per cent nitrogen in the leaves at 15 weeks after sowing at Mokwa in 1979. Cultivar Super okra had a higher per cent nitrogen than 'Samaru 71' at all the N levels tested. The per cent nitrogen increased with increase in nitrogen level (Table 4.56).

The interaction between cultivar and plant population was significant on the per cent nitrogen content in the cotton leaves at Samaru at 15 weeks after sowing in 1980 and at Mokwa at seven and 15 weeks after sowing in 1979, and 15 weeks after sowing in 1980. In 1979 at Mokwa 'Super okra' recorded higher percentage nitrogen in the leaves than 'Samaru 71' at all the population levels tested. In 1980, at 15 weeks after sowing there was no significant difference between the two cultivars except at 100,000 plants ha^{-1} where the per cent nitrogen of 'Super okra' was significantly higher than that of 'Samaru 71'. Similarly at Samaru, at 15 weeks after sowing in 1980, there was also no significant difference between the two cultivars except at 250,000 plants ha^{-1} where 'Super okra' recorded a higher per cent nitrogen in the leaves than 'Samaru 71' (Table 4.57).

4.6 Correlation and Regression

4.6.1 Correlation of growth parameters on seed cotton yield

Correlations between growth parameters and seed cotton yield were calculated for 'Samaru 71' and 'Super okra'.

Table 4.56. Interaction between cultivar and nitrogen on per cent nitrogen in cotton leaves at Mokwa in 1979.

Nitrogen level (kg ha^{-1})	Cultivar	
	'Samaru 71'	'Super okra'
0	2.8	3.7
40	3.7	4.0
80	4.2	4.5
120	4.6	4.9
SED (±)	0.10	
LSD (p=0.05)	0.2	

There was low but positive correlation between seed cotton yield and LAI (at 15 weeks after sowing) for 'Samaru 71' and 'Super okra' at Mokwa in 1979 (Table 4.58 and 4.59). Similarly a non-significant correlation was observed between seed cotton yield and LAI (at 15 weeks after sowing) for 'Samaru 71' and 'Super okra' at Samaru in 1980 (Tables 4.60 and 4.61).

In 1980, the correlation between seed cotton yield and LAI (at 15 weeks after sowing), seed cotton yield and plant height (at harvest), seed cotton yield and total dry matter yield (at 15 weeks after sowing) were not significant at Mokwa (Tables 4.62 and 4.63).

Correlation between seed cotton yield and LAI (at 15

Table 4.57. Interaction between cultivar and plant population on per cent nitrogen in the leaves of cotton at Samaru and Mokwa.

Plant population ($000\ ha^{-1}$)	7 WAS, Mokwa, 1979		15 WAS, Mokwa, 1979		7 WAS, Samaru, 1979		15 WAS, Samaru, 1900	
	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'	'Samaru 71'	'Super okra'
50	2.5	2.9	3.0	4.5	4.1	4.0	3.0	3.0
100	2.3	3.0	3.9	4.2	3.2	4.1	3.6	3.7
150	2.5	2.7	3.0	4.1	3.0	4.0	3.7	3.6
200	NIL	NIL	NIL	NIL	3.0	3.0	3.6	3.6
250	NIL	NIL	NIL	NIL	3.5	3.9	3.3	3.6
SED (±)	0.10		0.10		0.15		0.10	
LSD (p=0.05)	0.20		0.20		0.30		0.20	

Table 4.50. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1979.

	Seed cotton yield	Ginning %	Seed index	Lint index	Av. no. of seeds per boll	Av.boll weight	Av.no of mature bolls per plant	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.46*	1.00							
Seed index	0.02	0.20	1.00						
Lint index	0.20	0.47*	0.69	1.00					
Av. number of seeds per boll	0.32	0.32	0.11	-0.19	1.00				
Av. boll wt.	0.30	0.10	0.30	0.10	0.10	1.00			
Av. number of mature bolls per plant	0.79*	0.46*	0.12	0.13	0.26	0.13	1.00		
LAI (at 15 WAS)	0.29	0.12	-0.12	-0.12	0.53*	0.11	0.00	1.00	
Total dry matter (at 15 WAS)	0.04	0.03	-0.17	-0.07	0.49*	0.10	-0.7	0.50*	1.00

* Significant at 0.05 probability level.

Table 4.59. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1979.

	Seed cotton yield	Ginning %	Seed index	Lint index	Av.no.of seeds/ boll	Av.boll wt.	Av.no.of mature bolls/ plant	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.07	1.00							
Seed index	0.06	-0.03	1.00						
Lint index	0.002	0.05*	0.41	1.00					
Av. number of seeds/boll	0.42	-0.19	-0.19	-0.20	1.00				
Av. boll wt.	0.27	0.09	0.41*	0.21	0.004	1.00			
Av. number of mature bolls per plant	0.55*	-0.06	0.31	0.00	0.20	0.00	1.00		
LAI (at 15 WAS)	0.20	0.39	-0.19	-0.30	0.24	-0.01	-0.10	1.00	
Total dry matter yield (at 15 WAS)	0.07	-0.14	-0.15	-0.20	0.24	0.20	-0.23	0.62*	1.00

* Significant at 0.05 probability level.

Table 4.60. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Samaru in 1900.

Seed cotton yield	1.00						
Ginning %	0.21	1.00					
Lint index	0.05	0.50*	1.00				
Seed index	0.19	0.12	0.62*	1.00			
Av. number of seeds/boll	0.10	-0.10	-0.05	-0.14	1.00		
LAI (at 15 WAS)	0.16	0.10	0.04	0.12	-0.14	1.00	
Total dry matter yield (at 15 WAS)	0.12	0.23	0.06	-0.07	0.01	0.61*	1.00
	Seed cotton yield	Ginning %	Lint index	Seed index	Av. no. of seeds/ bolls	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)

* Significant at 0.05 probability level.

Table 4.61. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Samaru in 1990.

	Seed cotton yield	Ginning %	Lint index	Seed index	Av. no. of seeds/ boll	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00						
Ginning %	0.10	1.00					
Lint index	0.24	0.41*	1.00				
Seed index	0.07	-0.16	0.50*	1.00			
Av. no. of drrfd/boll	0.09	-0.01	-0.02	-0.06	1.00		
LAI (at 15 WAS)	0.15	-0.07	0.10	0.10	-0.02	1.00	
Total dry matter yield (at 15 WAS)	0.20	-0.10	-0.01	0.04	0.09	0.07*	1.00

* Significant at 0.05 probability level.

Table 4.62. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1900.

	Seed cotton yield	Ginning %	Lint index	Seed index	Av. boll wt.	Av. no. of seed/boll	Av. no. of mature bolls/plant	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)	Av. plant height at harvest
Seed cotton yield	1.00									
Ginning %	0.07	1.00								
Lint index	0.13	0.30	1.00							
Seed index	0.02	0.00	0.04	1.00						
Av. boll wt.	0.03	0.05	-0.19	0.02	1.00					
Av. no. of seed/boll	0.15	-0.09	0.06	0.02	0.22	1.00				
Av. no. of mature bolls/plant	0.13	0.6	0.10	0.10	0.09	0.00	1.00			
LAI (at 15 WAS)	0.10	-0.23	-0.10	-0.15	-0.02	0.11	-0.37	1.00		
Total dry matter yield (at 15 WAS)	0.03	-0.31	-0.10	-0.12	0.06	0.23	-0.27	0.92*	1.00	
Av. plant height at harvest	0.10	-0.03	-0.15	0.05	0.31	0.52	0.14	0.51*	0.54*	1.00

* Significant at 0.05 probability level.

Table 4.63. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1900.

	Seed cotton yield	Ginning %	Lint index	Seed index	Av. boll wt.	Av. no. of seeds/ boll	Av. no. of mature bolls/ plant	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)	Av. plant height at harvest
Seed cotton yield	1.00									
Ginning %	0.14	1.00								
Lint index	0.002	-0.06	1.00							
Seed index	0.00	0.14	0.20	1.0						
Av. boll wt.	0.07	-0.11	0.32	0.03	1.00					
Av. no. of seed/boll	0.19	0.09	-0.11	0.19	0.02	1.00				
Av. no. of mature bolls/ plant	0.00	-0.15	0.34	-0.04	0.34	0.03	1.00			
LAI(at 15 WAS)	0.06	-0.16	-0.23	-0.10	-0.15	0.32	-0.33	1.00		
Total dry matter yield (at 15 WAS)	0.004	-0.19	0.24	-0.14	-0.10	0.33	-0.20	0.90*	1.00	
Av. plant height at harvest	0.03	-0.07	0.10	-0.02	0.06	0.46*	0.23	0.52*	0.61*	1.00

* Significant at 0.05 probability level.

weeks after sowing) was significant for 'Super okra' in 1981 (r = 0.60). Similarly, significant correlations were observed between seed cotton yield and plant height (at harvest) (r = 0.59) and seed cotton yield and total dry matter yield (at 15 weeks after sowing) (r = 0.59) for 'Super okra' at Samaru in 1981 season (Table 4.65).

4.6.2 Correlation between yield components and seed cotton yield

Ginning percentage and average number of mature bolls per plant were significantly correlated with seed cotton yield for 'Samaru 71' at Mokwa in 1979 (r = 0.46, r = 0.79), respectively (Table 4.58).

There was significant correlation between seed cotton yield and average number of seeds per boll (r = 0.42) (Table 4.59). Similarly, seed cotton yield was significantly correlated with average number of mature bolls per plant for 'Super okra' at Mokwa in 1979 (r = 0.55) (Table 4.59).

At Samaru in 1981, seed cotton yield of 'Samaru 71' was significantly correlated with seed index (r = 0.45) (Table 4.64). However, the average boll weight of 'Super okra' was significantly correlated with seed cotton yield in the same year and location (r = 0.39), (Table 4.65).

At Mokwa in 1981, seed cotton yield of 'Samaru 71' was significantly correlated with average number of mature bolls

Table 4.64. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Samaru in 1901.

	Seed cotton yield	Ginning %	Av. boll wt.	Seed index	Lint index	LAI (at 15 WAS)	Av. no. of seeds/ boll	Total dry matter yield (at 15 WAS)	Plant height at harvest	Av. no. of mature bolls/ plant
Seed cotton yield	1.00									
Ginning %	0.37	1.00								
Av. boll wt.	0.23	0.37	1.00							
Seed index	0.45*	0.52*	0.49*	1.00						
Lint index	0.06	0.49*	0.07	0.45*	1.00					
LAI (at 15 WAS)	0.19	-0.07	0.21	0.09	-0.03	1.00				
Av. no. of seeds/boll	0.07	-0.07	-0.11	0.11	0.01	0.02	1.00			
Total dry matter yield (at 15 WAS)	0.37	-0.09	0.32	0.04	-0.11	0.43*	0.03	1.00		
Plant height at harvest	0.27	-0.17	0.24	0.27	0.03	0.21	0.13	0.52*	1.00	
Av. no. of mature bolls/plant	0.30	0.40*	0.14	0.35	0.00	0.03	0.10	0.12	0.43*	1.00

* Significant at 0.05 probability level.

Table 4.65. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Samaru in 1901.

	Seed cotton yield	Ginning %	Av. boll wt.	Seed index	Lint index	LAI (at 15 WAS)	Av. no. of seeds/ boll	Total dry matter yield (at 15 WAS)	Plant height at harvest	Av. no. of mature bolls/ plant
Seed cotton yield	1.00									
Ginning %	0.35	1.00								
Av. boll wt.	0.39*	0.20	1.00							
Seed index	0.26	0.41*	0.32	1.00						
Lint index	0.22	0.07*	-0.15	0.02	1.00					
LAI (at 15 WAS)	0.60*	-0.15	0.42*	0.13	-0.06	1.00				
Av. no. of seeds/boll	0.17	-0.26	0.23	0.09	-0.23	0.19	1.00			
Total dry matter yield (at 15 WAS)	0.59*	-0.21	0.47*	0.16	-0.12	0.09*	0.25	1.00		
Plant height at harvest	0.59*	0.29	0.55*	0.26	-0.13	0.63*	0.35	0.63*	1.00	
Av. no. of mature bolls/ plant	0.37	0.33	-0.02	0.22	0.23	0.00	0.32	0.00	0.40*	1.00

* Significant at 0.05 probability level.

Table 4.66. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1981.

	Seed cotton yield	Ginning %	Av. no. of mature bolls/ plant	Av. boll wt.	Av. no. of seeds/ boll	Lint index	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)	Av. plant height at harvest	Seed index
Seed cotton yield	1.00									
Ginning %	0.002	1.00								
Av. no. of mature bolls per plant	0.75*	-0.11	1.00							
Av. boll wt.	0.02	-0.19	-0.04	1.00						
Av. no. of seeds/boll	0.02	-0.10	0.21	0.20	1.00					
Lint index	0.00	0.04*	0.004	-0.13	-0.07	1.00				
LAI (at 15 WAS)	0.11	-0.09	-0.11	-0.11	0.24	-0.003	1.00			
Total dry matter yield (at 15 WAS)	0.07	-0.07	-0.12	-0.09	0.35	0.05	0.91	1.00		
Av.plant height at harvest	0.04	-0.04	0.07	0.06	0.31	0.00	0.52*	0.63*	1.00	
Seed index	0.10	0.14	0.20	0.03	0.03	0.64*	0.00	0.16	0.10	1.00

* Significant at 0.05 probability level.

Table 4.67. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1901.

	Seed cotton yield	Ginning %	Av. no. of mature bolls per plant	Av. boll wt.	Av. no. of seeds/boll	Lint index	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)	Av. plant height at harvest	Seed index
Seed cotton yield	1.00									
Ginning %	0.12	1.00								
Av. no. of mature bolls per plant	0.05	0.06	1.00							
Av. boll wt.	0.002	0.06	0.02	1.00						
Av. no. of seeds/boll	0.20	-0.04	-0.01	-0.05	1.00					
Lint index	0.14	0.96*	-0.06	-0.02	-0.02	1.00				
LAI (at 15 WAS)	0.14	0.16	-0.07	-0.15	0.15	0.14	1.00			
Total dry matter yield (at 15 WAS)	0.24	0.15	-0.07	-0.10	-0.19	0.13	0.92*	1.00		
Av. plant height at harvest	0.22	-0.05	0.16	0.10	-0.23	0.01	0.34	0.45*	1.00	
Seed index	0.26	0.35	-0.04	0.03	0.11	0.39	0.07	0.14	0.13	1.00

* Significant at 0.05 probability level.

per plant (r = 0.75 Table 4.66)

4.6.3 Regression of seed cotton yield on nitrogen

The regression of seed cotton yield on nitrogen level for 'Samaru 71' was calculated for the three seasons (1979, 1980 and 1981). The regression equations were worked out as follows for Mokwa:

1979, $Y = 714.6 + 9.36\ x - 0.05\ x^2$ ($r^2 = 0.99$)...(1)

1980, $Y = 599.2 + 6.62\ x - 0.02\ x^2$ ($r^2 = 0.03$)...(2)

1981, $Y = 1012.3 + 7.43\ x - 0.07\ x^2$ ($r^2 = 0.96$)...(3)

where Y = Seed cotton yield kg ha^{-1}

x = Nitrogen level kg ha^{-1}

b =)
c =) Regression constants

Averaged over three seasons, the regression of seed cotton yield on N level was calculated thus for 'Samaru 71' at Mokwa:

$Y = 775.4 + 7.8\ x - 0.05\ x^2$ ($r^2 = 0.93$).....(4)

The regression of seed cotton yield on the nitrogen level using 'Super okra' was highly significant for the three seasons. The regression equations are given as follows:

1979, $Y = 652.0 + 14.43\ x - 0.09\ x^2$ ($r^2 = 0.99$)...(5)

1980, $Y = 665.0 + 14.59\ x - 0.09\ x^2$ ($r^2 = 0.97$)...(6)

1981, $Y = 1339.8 + 11.19\ x - 0.06\ x^2$ ($r^2 = 0.99$)...(7)

Average over three seasons, the regression equation for 'Super okra' was:

$$Y = 805.9 + 13.4 x - 0.09 x^2 \quad (r^2 = 0.90) \ldots\ldots\ldots (8)$$

The regression of seed cotton yield on nitrogen levels using 'Samaru 71' was highly significant for the two seasons at Samaru. The regression equations are given as follows:

$$1980, \quad Y = 1051.4 + 14.76 x - 0.08 x^2 \quad (r^2 = 0.90 \ldots (9)$$

$$1981, \quad Y = 1110.0 + 9.21 x - 0.09 x^2 \quad (r^2 = 0.60) \ldots (10)$$

The mean regression equation for 'Samaru 71' at Samaru was:

$$Y = 1004.7 + 12.0 x - 0.09 x^2 \quad (r^2 = 0.79) \ldots (11)$$

The regression of seed cotton yield on nitrogen levels for 'Super okra' was highly significant for the two years under test. The regression equations for Samaru using 'Super okra' were as follows:

$$1980, \quad Y = 1023.4 + 17.76 x - 0.12 x^2 \quad (r^2 = 0.93) \ldots (12)$$

$$1981, \quad Y = 1103.2 + 16.29 x - 0.10 x^2 \quad (r^2 = 0.92) \ldots (13)$$

The mean regression equation for the two growing seasons at Samaru for 'Super okra' was:

$$Y = 1103 + 17.2 x - 0.11 x^2 \quad (r^2 = 0.93) \ldots\ldots (14)$$

The economic optimum level of nitrogen was calculated for the two cultivars and locations. The optimum nitrogen level at Samaru for 'Samaru 71' and 'Super okra' were 50 and

and 70 kg N ha^{-1}, respectively. The optimum N level at Mokwa for cultivars Samaru 71 and Super okra were 62 and 66 kg N ha^{-1}.

4.6.4 Regression of seed cotton yield on plant population

Using 'Samaru 71' at Mokwa during the 1979, 1980 and 1981 seasons, the regression of seed cotton yield on plant population was studied.

$$1979,\ Y = 55.15\ x - 0.72\ x^2 + 0.003\ x^3 \quad \ldots\ldots\ldots(i)$$

$$1980,\ Y = 21.43\ x - 0.16\ x^2 + 0.0003\ x^3 \quad \ldots\ldots(ii)$$

$$1981,\ Y = 29.77\ x - 0.23\ x^2 + 0.0005\ x^3 \quad \ldots\ldots(iii)$$

The mean regression equation for the three growing season for 'Samaru 71' was:

$$Y = 37.71\ x - 0.33\ x^2 + 0.000\ x^3 \quad \ldots\ldots(iv)$$

The regression of seed cotton yield on plant population for cultivar Samaru 71 was also studied at Samaru during the 1980 and 1981 seasons.

$$1980,\ Y = 33.96\ x - 0.23\ x^2 + 0.0005\ x^3 \quad \ldots\ldots\ldots(v)$$

$$1981,\ Y = 34.56\ x - 0.25\ x^2 + 0.0005\ x^3 \quad \ldots\ldots\ldots(vi)$$

The means regression equation for the two years for cultivar Samaru 71 was:

$$Y = 34.23\ x - 0.24\ x^2 + 0.0005\ x^3 \quad \ldots\ldots\ldots(vii)$$

similar calculations were done for 'Super okra' at the same location.

1980, $Y = 30.24 x - 0.19 x^2 + 0.0004 x^3$.....(viii)

1981, $Y = 29.93 x - 0.17 x^2 + 0.0003 x^3$.....(ix)

The mean regression equation for the two years for 'Super okra' was:

$$Y = 30.09 x - 0.18 x^2 \; 0.0004 x^3 \text{ .....(x)}$$

The optimum plant population was determined using the formula in section 3.6.

Optimum plant populations of 107,500 and 149,500 plants ha^{-1} were obtained for 'Samaru 71' and Super okra', respectively at Samaru.

Since there was a negative response to increased plant population in respect of seed cotton yield at Makwa, it may be assumed that the optimum plant population for both cultivars lie below the range of plant populations tested.

The best model that fitted the yield - population relationship at Samaru was:

$Y = b_1 x - b_2 x^2 + b_3 x^3$ (Willey and Heath, 1969)

where Y = yield of seed cotton kg ha^{-1}

x = plant population in thousand ha^{-1}

b_1 b_2 and b_3 regression coefficients.

4.6.5 Regression of seed cotton yield on yield components

By means of regression analysis, it was possible to

calculate the contribution of single yield component on yield potential of cotton (Figs. 12 and 13).

Increased LAI by one (within a LAI range of 0.5 - 3.5) resulted in 25.3 and 30.2 kg ha^{-1} of seed cotton for 'Samaru 71' and 'Super okra', respectively (Fig.13). Similarly by increasing average number of bolls per plant by one, seed cotton yield was increased by 43.5 and 53.4 kg ha^{-1} for 'Samaru 71' and 'Super okra', respectively.

4.6.6 Multiple regression

Step-wise multiple regression of seed cotton yield on growth and yield components of cotton was calculated (Table 4.6B).

The following regression equations were computed to quantify the relative contribution of yield components x_1 - LAI at 15 weeks after sowing; x_2 - average number of mature bolls per plant; x_3 - average number of fruiting branches per plant; and x_4 - average boll weight to seed cotton yield:

At Samaru using 'Samaru 71':

$$Y = 885.6\ x_1 - 432.3 \quad \text{.....(i)}$$

$$Y = 590.6\ x_1 + 95.6\ x_2 - 310.6 \quad \text{.....(ii)}$$

$$Y = 241.1\ x_1 + 86.0\ x_2 + 165.6\ x_3 - 442.3 \quad \text{...(iii)}$$

$$Y = 255.1\ x_1 + 90.0\ x_2 + 20.0\ x_3 + 86.3\ x_4 - 505.0 \quad \text{.....(iv)}$$

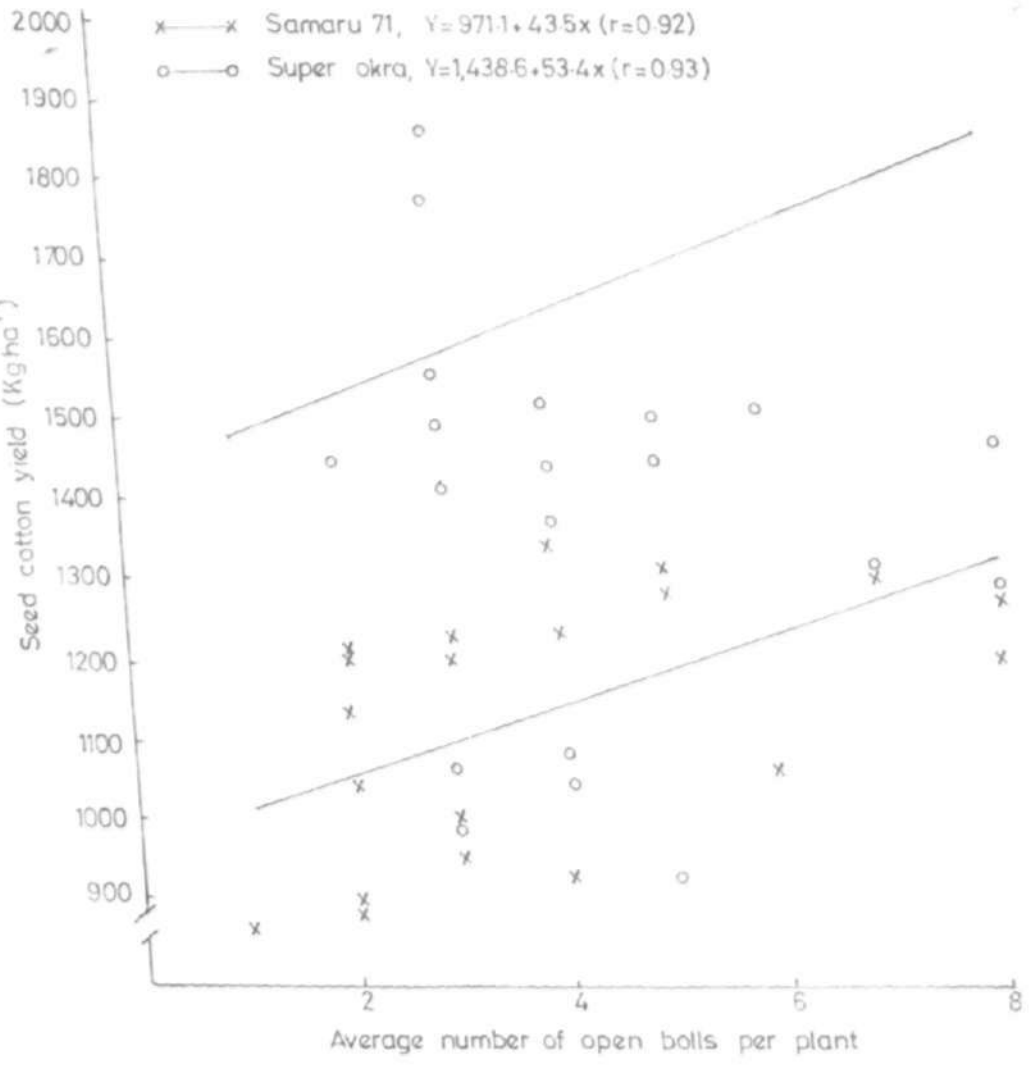


Fig.12 : Regression of seed cotton yield on average number of open bolls per plant • Each point (x,o) represents the mean of six values

Table 4.60. Multiple regression coefficients of seed cotton yield on growth and yield components of cotton indicating their relative contributions at Samaru and Mokwa.

Variables	Multiple regression coefficients (R^2)	Relative contributions %	Multiple regression coefficients (R^2)	Relative contributions %
		Cultivar Samaru 71		
	Samaru		Mokwa	
Av. no. of mature bolls/plant	0.97	52.1	0.90	50.0
LAI at 15 WAS	0.93	42.4	0.05	46.5
Av. no. of fruiting branches/plant	0.97	3.0	0.90	1.0
Av. boll weight	0.97	1.7	0.90	0.9
		Cultivar Super okra		
Av. no. of mature bolls/plant	0.90	52.6	0.90	55.3
LAI at 15 WAS	0.96	33.9	0.91	42.0
Av. No. of fruiting branches/plant	0.99	12.5	0.99	1.2
Av. boll weight	0.99	1.0	0.99	0.7

with the objective of determining the effects of row spacings and plant populations on the three cultivars of cotton under late-sown condition.

4.7.1 Plant height

Cultivar had significant effect on plant height in 1979 and 1980. 'Bar 14/25' produced significantly taller plants than 'Samaru 71' and 'Super okra' which did not differ between themselves for plant height (Table 4.69, Plates II a and b).

Row spacings of 60, 75 and 90 cm had no significant effect on plant height of cotton at Makwa (Table 4.69, Plates II a and b).

Cotton plants at populations of 100,000 and 150,000 plants ha^{-1} were significantly shorter than those of 50,000 plants ha^{-1} in 1979 and 1980 (Table 4.69, Plates II a and b).

4.7.2 Leaf area index

Cultivar differences in respect of LAI were significant at Makwa at 11 weeks after sowing in 1979, 11 and 15 weeks after sowing in 1980 and 15 weeks after sowing in 1981. In all these stages except in 1979, both 'Bar 14/25' and 'Samaru 71' had higher LAI than 'Super okra'. In 1979, only 'Samaru 71' had higher LAI at 11 weeks after sowing than the other two cultivars (Table 4.70).

Row spacing had significant effect on LAI at all stages

Table 4.69. Main effects of cultivar, row spacing and plant population on plant height (cm) of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	130.1	120.1	144.0
Nar 14/25	135.4	147.9	144.5
Super okra	123.5	126.5	137.2
SED (±)	3.63	3.63	4.12
LSD (p=0.05)	7.3	7.3	N.S.
Row spacing (cm)			
60	130.2	134.1	139.1
75	129.5	136.1	143.7
90	127.3	132.3	143.7
SED (±)	5.00	5.00	5.77
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	136.9	140.3	145.4
100	126.3	132.9	143.3
150	123.7	129.4	137.0
SED (±)	3.63	3.63	4.12
LSD (p=0.05)	7.3	7.3	N.S.



Plate II a. The effect of row spacing and plant population on the growth of cotton varieties Samaru 71 and Super okra at 9 WAS at Mokwa at 60 cm row.





Plate II b. The effect of row spacing and plant population on the growth of cotton varieties Samaru 71 and Super okra at 9 WAS at Mokwa at 90 cm row.

Table 4.70. Main effects of cultivar, row spacing and plant population on LAI of cotton at Mokwa.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	0.73	2.06	2.33	2.22	2.93	2.04	1.01	2.31	1.91
Bar 14/25	0.72	2.12	2.03	2.13	3.05	2.14	1.11	2.52	2.04
Super okra	0.72	2.12	2.34	1.90	2.33	1.62	1.02	2.03	1.65
SED (+)	0.04	0.21	0.20	0.10	0.30	0.21	0.15	0.22	0.17
LSD ($\bar{p}$=0.05)	N.S.	0.42	N.S.	N.S.	0.61	0.42	N.S.	N.S.	0.34
Row spacing (cm)									
60	0.03	1.02	2.17	1.03	2.31	1.43	1.02	2.02	1.72
75	0.61	1.03	2.16	1.03	1.41	2.07	1.01	2.13	1.63
90	0.81	3.44	2.41	2.54	3.47	2.34	1.23	2.74	2.15
SED (+)	0.05	0.30	0.20	0.25	0.42	0.29	0.21	0.31	0.24
LSD ($\bar{p}$=0.05)	0.14	0.83	N.S.	0.69	1.17	0.82	N.S.	0.86	N.S.
Plant population (000 ha^{-1})									
50	0.31	1.41	1.53	1.22	2.03	1.23	0.03	1.51	1.51
100	0.72	2.43	2.35	2.34	2.94	2.05	1.25	2.02	2.04
150	1.03	3.24	2.86	2.67	3.35	2.56	1.14	2.53	1.95
SED (+)	0.04	0.21	0.20	0.10	0.30	0.21	0.15	0.22	0.17
LSD ($\bar{p}$=0.05)	0.08	0.42	0.40	0.36	0.61	0.42	0.30	0.44	0.34

of sampling except at 15 weeks after sowing in 1979 and seven and 15 weeks after sowing in 1981. At seven weeks after sowing in 1980 and 11 weeks after sowing in 1980, 90cm spacing resulted in higher LAI than 60 and 75 cm spacings, while at 15 weeks after sowing in 1980 and 11 weeks after sowing in 1981, 90 cm only had significantly higher LAI than 60 cm spacing (Table 4.70).

Plant population significantly affected the LAI of cotton at Mokwa. In the 1979 and 1980 seasons, LAI significantly increased with increased plant population, while in 1981, both 100,000 and 150,000 plants ha^{-1} had similar LAI which were significantly higher than those of 50,000 plants ha^{-1} at the three stages of sampling (Table 4.70).

The interaction between cultivar and row spacing was significant on LAI at 15 weeks after sowing at Mokwa in 1980. With 'Samaru 71', 75 and 90 cm row spacings resulted in higher LAI than 60 cm while in 'Super okra' only 90 cm increased LAI. No difference in LAI was observed between the rows with 'Oar 14/25' (Table 4.71).

4.7.3 Dry matter production

There was no significant difference between the three cultivars in terms of dry matter production except at 15 weeks after sowing in 1979 and 11 weeks after sowing in 1980. In the former, 'Samaru 71' and 'Super okra' produced higher dry

Table 4.71. Interaction between cultivar and row spacing on LAI of cotton at 15 WAS at Mokwa in 1980.

Row Spacing (cm)	Cultivar		
	Samaru 71	Oar 14/25	Super okra
60	1.41	1.62	1.12
75	2.12	1.01	1.93
90	2.41	1.92	1.04
SED (±)		0.30	
LSD (p=0.05)		0.60	

matter than 'Oar 14/25' and in the latter, 'Samaru 71' and 'Oar 14/25' produced more dry matter than 'Super okar' (Table 4.72).

Row spacing had significant effect on dry matter production except at 11 and 15 weeks after sowing in 1979 and seven and 15 weeks after sowing in 1981. In all the cases 90 cm row produced significantly higher dry matter than 60 and 75 cm rows. There was no significant difference between 60 and 75 cm rows (Table 4.72 and Fig. 14).

Plant population had significant effect on dry matter production. During the 1979 and 1980 season the dry matter production increased with increase in plant production. However, during the 1981 season the highest

Table 4.72. Main effects of cultivar, row spacing and plant population on total dry matter production m^{-2} of cotton at Mokwa.

	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WAS)
Cultivar									
Samaru 71	244.50	840.75	1257.25	445.00	951.75	961.75	130.25	562.72	913.00
Dar 14/25	226.25	671.50	900.25	410.00	945.25	933.00	157.75	610.00	951.25
Super okra	249.25	700.75	1261.00	374.50	830.00	802.50	145.50	547.50	826.75
SED (+)	11.70	60.53	104.07	40.53	60.45	84.23	10.00	46.09	83.03
LSD ($\bar{p}$=0.05)	N.S.	N.S.	210.00	N.S.	121.50	N.S.	N.S.	N.S.	N.S.
Row Spacing (cm)									
60	211.50	615.75	1065.25	356.50	709.25	743.50	132.75	510.25	810.25
75	172.00	506.50	1012.50	360.75	793.50	930.50	137.25	529.00	825.25
90	336.50	1010.75	1429.00	504.00	1144.00	1015.50	171.25	600.50	1047.25
SED (+)	16.49	95.95	149.00	53.06	84.63	134.03	14.11	63.84	117.36
LSD ($\bar{p}$=0.05)	45.00	N.S.	N.S.	147.50	235.27	271.00	N.S.	175.25	N.S.
Plant population (000 ha^{-1})									
50	90.00	427.75	700.00	251.50	663.75	610.50	107.25	379.00	700.25
100	275.75	767.75	1274.75	455.00	944.00	940.00	174.50	713.75	1001.25
150	346.25	1025.50	1451.25	522.75	1119.25	1147.25	159.75	636.75	909.25
SED (+)	11.70	60.53	104.07	40.53	60.45	84.23	10.00	46.09	83.03
LSD ($\bar{p}$=0.05)	23.70	137.75	210.00	81.47	121.50	169.30	20.26	94.25	160.50

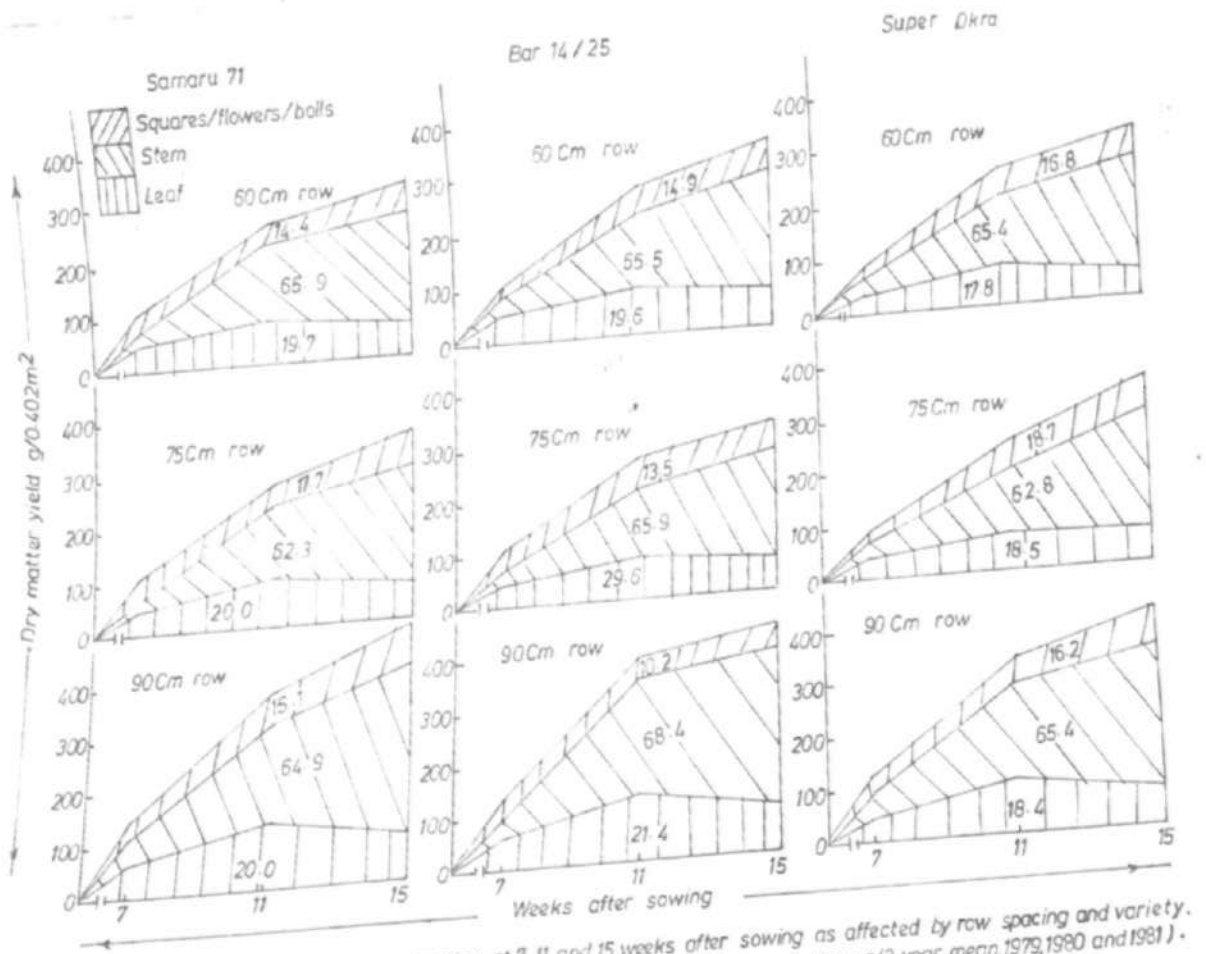


Fig. 14: Cummutative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by row spacing and variety. Figures indicate (%) contribution of each plant part at the [illegible] at Makwa (3-year mean, 1979, 1980 and 1981).

dry matter was produced at 100,000 plants ha^{-1} (Table 4.72 and Fig. 15).

There was a significant interaction between plant population and row spacing on dry matter at 11 weeks after sowing at 150,000 plants ha^{-1}, 90 cm row resulted in higher dry matter production than 60 cm. In all row spacings both 100,000 and 150,000 plants ha^{-1} had higher dry matter than 50,000 plants ha^{-1} (Table 4.73).

Table 4.73. Interaction between plant population and row spacing on total dry matter production m^{-2} of cotton at Mokwa in 1901.

Plant population ('000 ha^{-1})	Row Spacing (cm)		
	60	75	90
50	369.0	391.0	376.7
100	602.2	504.5	951.0
150	561.0	611.0	737.7
SED (±)		70.1	
LSD (p=0.05)		155.4	

4.7.4 Relative growth rate

Cultivar had no significant effect on relative growth rate (RGR) of cotton except during the 1979 season. In 1979, there was no significant difference between

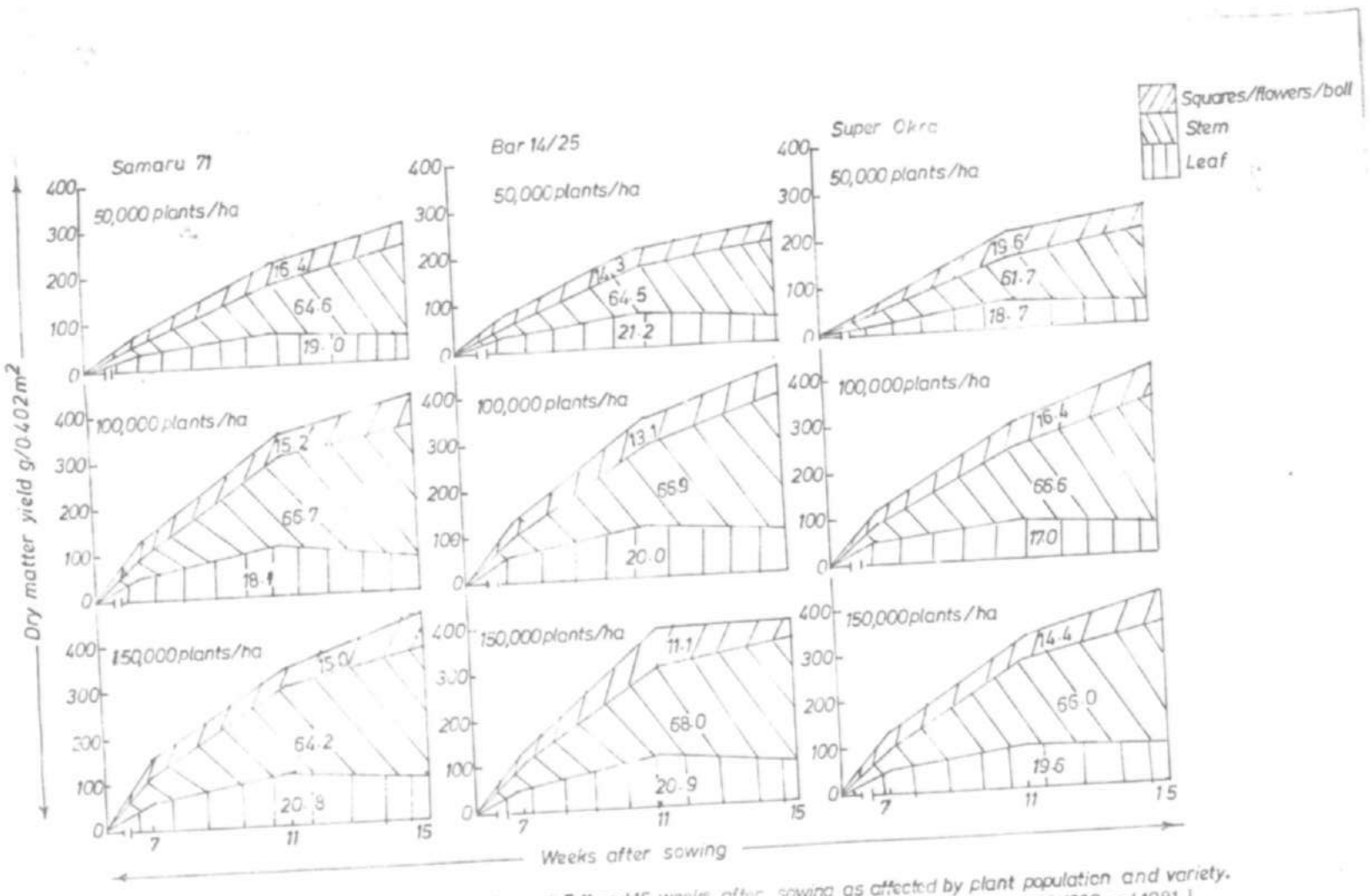


Fig.15: Cummutative dry matter production of cotton at 7, 11 and 15 weeks after sowing as affected by plant population and variety. Figures indicate (%) contribution of each plant part at the 15 WAS at Mokwa (3-year mean, 1979, 1980 and 1981).

the relative growth rate (RGR) of 'Samaru 71' and 'Super okra' but both cultivars had significantly higher relative growth rate than 'Gar 14/25' (Table 4.74).

Row spacing had significant effect on the relative growth rate of cotton except during the 1979 season. In 1980, 90 cm row recorded significantly higher relative growth rate than 60 and 75 cm. There was, however, no significant difference between 60 and 75 cm rows. In 1981, 90 cm row had a significantly higher relative growth rate than 60 cm row. There were no significant differences between 60 and 75 cm and between 75 and 90 cm rows (Table 4.74).

Plant population had significant effect on cotton relative growth rate during the three growing seasons. In 1979, 50,000 plants ha^{-1} had a significantly higher relative growth rate than 100,000 and 150,000 plants ha^{-1}. There was no significant difference between 100,000 and 150,000 plants ha^{-1}. In 1980, 150,000 plants ha^{-1} had a significantly higher relative growth rate than 50,000 plants ha^{-1}. There was no significant difference between 100,000 and 150,000 plants ha^{-1}. Similarly, there was no significant difference between 50,000 and 100,000 plants ha^{-1}. In 1981, 50,000 plants ha^{-1} recorded a significantly higher relative growth rate than 100,000 and 150,000 plants ha^{-1}. The difference between 100,000 and 150,000 plants ha^{-1} was

Table 4.74. Main effects of cultivar, row spacing and plant population on relative growth rate ($g\ g^{-1}\ week^{-1}$) of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	1.12	2.04	1.33
Ser 14/25	0.82	2.03	1.44
Super okra	0.81	1.72	1.22
SED (±)	0.10	0.17	0.11
LSD (p=0.05)	0.20	N.S.	N.S.
Row spacing (cm)			
60	1.02	1.64	1.11
75	1.01	1.63	1.23
90	1.11	2.42	1.55
SED (±)	0.14	0.24	0.16
LSD (p=0.05)	N.S.	0.67	0.32
Plant population (000 ha^{-1})			
50	1.55	1.54	1.64
100	0.92	1.93	1.31
150	0.73	2.32	1.02
SED (±)	0.10	0.17	0.11
LSD (p=0.05)	0.20	0.34	0.22

not significant (Table 4.74).

The interaction between row spacing and plant population on relative growth rate was significant in 1979 and 1981 at Mokwa. In 1979, at 90 cm spacing, relative growth rate significantly decreased with increase in population, while at 60 and 75 cm spacings, 100,000 and 150,000 plants ha^{-1} resulted in lower relative growth rate than 50,000 plants ha^{-1}, only 150,000 plants ha^{-1} resulted in significantly lower relative growth rate than 50,000 plants ha^{-1}. The 90 cm spacing resulted in higher relative growth rate than 60 cm at 150,000 plants ha^{-1} (Table 4.75).

Table 4.75. Interaction between row spacing and plant population on the relative growth rate ($g\ g^{-1}\ week^{-1}$) of cotton at Mokwa in 1979 and 1981.

Plant population ('000 ha^{-1})	Row spacing (cm)		
	60	75	90
		1979	
50	1.0	2.1	2.6
100	1.2	1.3	1.5
150	0.0	0.9	0.9
SED (±)		0.25	
LSD (p=0.05)		0.50	
		1981	
50	1.0	1.0	1.9
100	1.7	1.6	1.6
150	1.0	1.3	1.5
SED (±)		0.15	
LSD (p=0.05)		0.30	

4.7.5 Net assimilation rate

Cultivar had significant effect on cotton net assimilation rate (NAR) during the three growing seasons. In 1979, 'Samaru 71' recorded a significantly higher net assimilation rate than 'Gar 14/25' and 'Super okra'. There was however no significant difference between 'Gar 14/25' and 'Super okra'. In 1980, 'Gar 14/25' recorded a significantly higher net assimilation rate than 'Super okra'. There were no differences between 'Samaru 71' and 'Gar 14/25' and between 'Samaru 71' and 'Super okra'. In 1981, 'Gar 14/25' recorded a significantly higher net assimilation rate than 'Super okra'. The difference between 'Samaru 71' and 'Super okra' was not significant. Similarly, there was no significant difference between 'Samaru 71' and 'Gar 14/25' (Table 4.76).

Row spacing had significant effect on net assimilation rate during 1979 and 1980 seasons. In 1979, 90 cm spacing recorded a significantly higher net assimilation than 60 cm row. Similarly, 75 cm spacing had a significantly higher net assimilation rate than 60 cm spacing. The difference between 75 cm and 90 cm rows was no significant. In 1980, 90 cm spacing had a significantly higher net assimilation rate than 60 cm spacing. There were however no significant differences between 60 and 75 cm spacing and between 75 and 90 cm spacing (Table 4.76).

Table 4.76. Main effect of cultivar, row spacing and plant population on net assimilation rate (g m^{-2} day^{-1}) of cotton between seven and 11 WAS at Makwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	23.1	13.1	17.0
Dar 14/25	16.0	14.7	19.7
Super okra	16.0	9.6	12.6
SED (±)	1.54	2.19	2.79
LSD (p=0.05)	3.9	4.4	5.6
Row spacing (cm)			
60	13.8	10.2	14.5
75	19.9	11.1	15.0
90	23.0	16.2	20.5
SED (±)	2.34	2.59	3.00
LSD (p=0.05)	4.7	5.2	N.S.
Plant population (000 ha^{-1})			
50	13.5	10.1	10.6
100	21.4	17.3	19.6
150	21.0	10.1	19.8
SED (±)	1.94	2.19	2.79
LSD (p=0.05)	3.9	4.4	5.6

Plant population had a significant effect on cotton net assimilation rate during the three growing seasons. In 1979, 100,000 and 150,000 plants ha^{-1} had a significantly higher net assimilation rate than 50,000 plants ha^{-1}. There was no significant difference between 100,000 and 150,000 plants ha^{-1}. In 1980, 100,000 plants ha^{-1} had a significantly higher net assimilation rate than 50,000 and 150,000 plants ha^{-1}. There was no significant difference between 50,000 and 150,000 plants ha^{-1}. In 1981, 100,000 and 150,000 plants ha^{-1} recorded a significantly higher net assimilation rate than 50,000 plants ha^{-1}. There was no significant difference between 100,000 and 150,000 plants ha^{-1} for net assimilation rate (Table 4.76).

4.8 Cultivar, Row Spacing and Plant Population

4.8.1 Number of fruiting branches

Cultivar had no significant effect on the number of fruiting branches except at 11 and 15 weeks after sowing in 1980 and seven weeks after sowing in 1981 seasons. At 11 weeks after sowing in 1980 'Oar 14/25' had a significantly higher number of fruiting branches than 'Samaru 71' and 'Super okra'. There was no significant difference between 'Samaru 71' and 'Super okra'. At 15 weeks after sowing in 1980, 'Oar 14/25' also recorded a significantly higher number of fruiting branches than 'Samaru 71' and 'Super okra'. There was no significant difference between 'Samaru 71' and 'Super okra'.

At seven weeks after sowing in 1901, 'Dar 14/25' and 'Super okra' and higher number of fruiting branches than 'Samaru 71'. There was no significant difference between 'Dar 14/25' and 'Super okra' (Table 4.77).

Row spacing had significant effect on the number of fruiting branches at all the stages of sampling except at seven and 11 weeks after sowing in 1979. At 15 weeks after sowing in 1979, 90 cm row spacing had a significantly higher number of fruiting branches than 60 and 75 cm spacings. There was no significant difference between 60 and 75 cm spacings. At seven weeks after sowing in 1900, 90 cm spacing recorded a significantly higher number of fruiting branches than 60 and 75 cm spacings. There was no significant difference between 60 and 75 cm spacings. At 11 and 15 weeks after sowing in 1900 and seven, 11 and 15 weeks after sowing in 1901, 90 cm spacings recorded significantly higher number of fruiting branches than 60 and 75 cm spacings. There were no significant differences between 60 and 75 cm spacings for all these stages (Table 4.77).

Plant population significantly affected the number of fruiting branches at the different stages of sampling except at seven weeks after sowing in 1900, 11 and 15 weeks after sowing in 1901. At seven weeks after sowing in 1979, 50,000 and 100,000 plants ha^{-1} had significantly more fruiting branches than 150,000 plants ha^{-1}. At 11 and 15 weeks after sowing in 1979, 150,000 plants ha^{-1} had significantly higher

Table 4.77. Main effect of cultivar, row spacing and plant population on the number of fruiting branches m^{-2} of cotton at Makwa.

Treatment	1979			1980			1981		
	7	11	15	7	11	15	7	11	15 (WNS)
Cultivar									
Samaru 71	24.0	31.3	50.0	27.3	31.3	29.3	53.3	85.0	96.0
Der 14/25	25.5	35.0	61.3	30.0	39.0	39.3	57.0	80.3	89.3
Super akwa	24.5	35.0	61.0	27.5	29.5	29.0	57.5	90.0	86.0
SED (±)	1.0	6.4	5.9	2.3	2.6	2.0	1.7	2.2	5.7
LSD ($\bar{p}$=0.05)	N.S.	N.S.	N.S.	N.S	6.3	4.1	3.4	N.S.	N.S.
Row spacing (cm)									
60	24.5	20.5	55.3	26.0	25.5	27.5	40.0	77.3	80.0
75	25.0	30.3	40.0	24.0	29.0	27.3	49.0	76.0	70.0
90	24.5	43.0	76.0	35.5	36.0	42.0	71.5	109.0	112.0
SED (±)	1.4	5.1	0.5	3.2	3.7	2.9	2.4	3.1	0.1
LSD ($\bar{p}$=0.05)	N.S.	N.S.	23.6	9.0	7.5	0.1	0.7	0.6	16.3
Plant population (000 ha^{-1})									
50	26.0	17.0	25.0	27.1	32.3	29.1	53.0	85.9	97.0
100	25.0	34.0	64.0	30.9	39.0	39.5	57.0	80.0	89.3
150	22.0	50.3	91.0	20.5	27.5	29.0	57.0	90.2	85.0
SED (±)	1.0	6.4	5.9	2.3	2.6	2.0	1.7	2.2	5.7
LSD ($\bar{p}$=0.05)	2.0	12.0	11.0	N.S.	5.2	4.1	3.4	N.S.	N.S.

number of fruiting branches than 50,000 and 100,000 plants ha^{-1}. Similarly 100,000 plants ha^{-1} had significantly higher number of fruiting branches than 50,000 plants ha^{-1} at both stages. At 11 and 15 weeks after sowing in 1900, 100,000 plants ha^{-1} had significantly more number of fruiting branches than 50,000 and 150,000 plants ha^{-1}, there was however, no significant difference between 50,000 and 150,000 plants ha^{-1}. At seven weeks after sowing in 1901, 100,000 and 150,000 plants ha^{-1} had significantly more number of fruiting branches than 50,000 plants ha^{-1}. The difference between 100,000 and 150,000 plants ha^{-1} was not significant (Table 4.77).

The interaction between cultivar and plant population was significant on the number of fruiting branches. With 'Samaru 71' increased plant population had no significant effect on the number of fruiting branches. However, increased plant population had significant effect on the number of fruiting branches of 'Super okra'. With 'Oar 14/25' increased plant population significantly decreased the number of fruiting branches (Table 4.78).

The interaction between row spacing and plant population was significant on number of fruiting branches at seven weeks after sowing in 1900 and at 11 weeks after sowing in 1901. At the seven weeks after sowing in 1900, at 60 and 75 cm increased plant population resulted in significant increase

Table 4.79. Interaction between row spacing and plant population on the number of fruiting branches in 1900 and 1901 at Mokwa.

Plant population (000 ha^{-1})	7 WAS, 1900			11 WAS, 1901		
	60	75	90	60	75	90 cm
50	11.3	12.0	12.5	57.5	62.0	50.0
100	20.5	23.3	46.0	86.0	80.3	152.3
150	30.5	30.3	47.3	110.0	100.0	134.3
SED (±)		3.5			8.2	
LSD (p=0.05)		7.0			16.3	

than 'Oar 14/25'. In 1900, 'Super okra' had a higher number of shed bolls than 'Samaru 71' and 'Oar 14/25'. In 1901, 'Samaru 71' and 'Super okra' had significantly higher number of shed bolls than 'Oar 14/25' (Table 4.00).

Row spacing had no significant effect on the number of shed bolls at 13 weeks after sowing at Mokwa.

Plant population had significant effect on the number of shed bolls at 13 weeks after sowing during the three growing seasons. In 1979, 100,000 and 150,000 plants ha^{-1} had significantly higher number of shed bolls than 50,000 plants ha^{-1}. Similarly, in 1900, 100,000 and 150,000 plants ha^{-1} had higher number of shed bolls at 13 weeks after sowing than 50,000 plants ha^{-1}. In 1901, 50,000 and 150,000 plants ha^{-1}

Table 4.00. Main effect of cultivar, row spacing and plant population on the number of shed bolls m^{-2} of cotton at Mokwa.

Treatment	1979	1900	1901
Cultivar			
Samaru 71	3.07	0.22	3.45
Dar 14/25	1.13	0.27	1.11
Super okra	4.65	0.46	4.71
SED (±)	0.42	0.09	0.70
LSD (p=0.05)	0.05	0.10	1.40
Row spacing (cm)			
60	3.60	0.36	3.63
75	2.95	0.32	2.67
90	3.11	0.27	2.96
SED (±)	0.59	0.13	0.90
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	1.50	0.66	2.56
100	3.67	0.20	1.61
150	4.40	0.51	5.10
SED (±)	0.42	0.09	0.70
LSD (p=0.05)	0.05	0.10	1.40

had significantly higher number of shed bolls than at 100,000 plants ha^{-1}. There was, however, higher number of shed bolls at 150,000 plants ha^{-1} as compared with 50,000 plants ha^{-1} (Table 4.00).

The interaction between cultivar and plant population was significant on the number of shed bolls at 13 weeks after sowing at Mokwa in 1979. With 'Samaru 71', there was significant difference in the number of shed bolls at populations of 100,000 and 150,000 plants ha^{-1} as compared with 50,000 plants ha^{-1}. With 'Oer 14/25' the three population levels had no significant effect on the number of shed bolls at 13 weeks after sowing. With 'Super okra' plants at 100,000 and 150,000 plants ha^{-1} had significantly higher number of shed bolls as compared to plants under 50,000 plants ha^{-1}. Similarly, plants under 150,000 plants ha^{-1} shed significantly higher number of bolls than those of 100,000 plants ha^{-1} (Table 4.01).

The interaction between row spacing and plant population was significant on the number of shed bolls at 13 weeks after sowing at Mokwa in 1980. At 60 cm spacing, the number of shed bolls increased significantly with increased plant population. At 75 cm row, there was no significant difference between the three population levels. At 90 cm row, there was significant difference between 100,000 and 150,000 plants ha^{-1} as compared to 50,000 plants ha^{-1} (Table 4.02).

Table 4.01. Interaction between cultivar and plant population on the number of shed bolls m^{-2} of cotton at 13 weeks after sowing at Mokwa in 1979.

Cultivar	Plant population (000 ha^{-1})		
	50	100	150
Samaru 71	1.61	5.05	4.95
Dar 14/25	0.00	1.00	1.45
Super okra	2.27	4.07	6.00
SED (±)		0.73	
LSD (p=0.05)		1.47	

Table 4.02. Interaction between row spacing and plant population on the number of shed bolls m^{-2} of cotton at 13 weeks after sowing at Mokwa in 1980.

Plant population (000 ha^{-1})	Row spacing (cm)		
	60	75	90
50	0.12	0.26	0.00
100	0.15	0.30	0.41
150	0.00	0.30	0.33
SED (±)		0.16	
LSD (p=0.05)		0.32	

4.0.3 Number of mature bolls per plant

Cultivar had significant effect on the number of mature bolls per plant during the 1979 and 1981 seasons. In 1979, 'Super okra' had a significantly higher number of mature bolls per plant than 'Samaru 71' and 'Oar 14/25'. In the same season, 'Samaru 71' recorded a significantly higher number of mature bolls per plant than 'Oar 14/25'. In 1981, 'Oar 14/25' and 'Super okra' had significantly higher number of mature bolls per plant than 'Samaru 71' (Table 4.03). There was no significant difference between 'Oar 14/25' and 'Super okra' (Table 4.03).

Row spacing had no significant effect on the number of mature bolls per plant (Table 4.03).

Plant population had significant effect on the number of mature bolls per plant during the 1979, 1980 and 1981 seasons. During the three seasons the number of mature bolls per plant decreased with increase in plant population. Plant population of 50,000 plants ha^{-1} recorded the highest number of mature bolls per plant, and 150,000 plants ha^{-1} recorded the lowest number of mature bolls per plant (Table 4.03).

The interaction between cultivar and plant population was significant on the number of mature bolls per plant at Mokwa in 1979 only. At 50,000 plants ha^{-1} 'Super okra' had

Table 4.03. Main effect of cultivar, row spacing and plant population on the number of mature bolls per plant at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	6.0	3.0	4.6
Dar 14/25	5.3	3.0	5.7
Super okra	0.4	3.6	5.6
SED (±)	0.6	0.3	0.3
LSD (p=0.05)	1.3	N.S.	0.7
Row spacing (cm)			
60	6.2	3.4	5.6
75	6.6	3.4	5.0
90	7.7	3.7	5.4
SED (±)	0.9	0.5	0.4
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	10.6	5.4	7.0
100	6.1	3.0	4.9
150	3.8	2.0	3.3
SED (±)	0.6	0.3	0.3
LSD (p=0.05)	1.3	0.7	0.7

the highest number of mature bolls per plant. It was closely followed by 'Samaru 71', and 'Dar 14/25' recorded the lowest number of mature bolls per plant. However, at 100,000 and 150,000 plants ha^{-1} there was no significant effect on the number of mature bolls per plant of the three cultivars (Table 4.04).

4.0.4 Average boll weight

Cultivar had significant effect on the average boll weight of cotton during the 1979 and 1980 season. In 1979, 'Super okra' had significantly higher boll weight than 'Samaru 71' and 'Dar 14/25'. 'Samaru 71' had significantly higher boll weight than 'Dar 14/25' (Table 4.05).

Row spacing had no significant effect on the boll weight of cotton except during the 1980 season. Row spacings of 75 and 90 cm had significantly higher boll weight than 60 cm. There was no significant difference between 75 and 90 cm spacings (Table 4.05).

Plant population had significant effect on average boll weight of cotton at Mokwa during the 1979 and 1980 seasons. In 1979, plant population of 150,000 plants ha^{-1} had a significantly lower average boll weight than 50,000 and 100,000 plants ha^{-1}. There was no significant difference between 50,000 and 100,000 plants ha^{-1} in respect of average boll weight. In 1980, 50,000 plants ha^{-1} had

Table 4.04. Interaction between cultivar and plant population on the number of mature bolls of cotton per plant at Mokwa in 1979.

Plant population ($000\ ha^{-1}$)	Cultivar		
	'Samaru 71'	'Dar 14/25'	'Super okra'
50	10.4	7.6	13.0
100	6.0	5.6	6.7
150	3.9	2.9	4.0
SED (±)		1.1	
LSD (p=0.05)		2.2	

significantly higher boll weight than 100,000 and 150,000 plants ha^{-1}. There was no significant difference between 100,000 and 150,000 plants ha^{-1} in respect of average boll weight (Table 4.05).

4.8.5 Harvest ratio

Cultivar significantly effected the harvest ratio of cotton in 1979 and 1981 seasons, although the response was inconsistent. During the 1979 season, 'Super okra' and 'Samaru 71' recorded significantly higher harvest ratio than 'Dar 14/25' while in 1981, both 'Samaru 71' and 'Super okra' had lower harvest ratio than 'Dar 14/25' (Table 4.06).

Table 4.05. Main effect of cultivar, row spacing and plant population on the average bolls weight of (g) of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	3.5	4.8	4.5
Dar 14/25	2.1	4.7	3.7
Super okra	4.4	6.6	5.5
SED (±)	0.25	0.25	1.10
LSD (p=0.05)	0.5	0.5	N.S.
Row spacing (cm)			
60	3.1	4.8	4.4
75	3.5	5.8	4.8
90	3.3	5.4	4.6
SED (±)	0.35	0.35	1.54
LSD (p=0.05)	N.S.	0.97	N.S.
Plant population (000 ha^{-1})			
50	3.5	7.8	4.6
100	3.5	4.3	3.9
150	2.9	4.8	5.3
SED (±)	0.25	0.25	1.10
LSD (p=0.05)	0.5	0.5	N.S.

Table 4.06. Main effects of cultivar, row spacing and plant population on the harvest ratio of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	0.64	0.45	0.25
Gar 14/25	0.40	0.44	0.31
Super okra	0.66	0.53	0.21
SED (±)	0.02	0.04	0.02
LSD (p=0.05)	0.05	N.S.	0.05
Row spacing (cm)			
60	0.59	0.45	0.24
75	0.54	0.39	0.25
90	0.64	0.57	0.20
SED (±)	0.03	0.06	0.03
LSD (p=0.05)	0.0	0.1	N.S.
Plant population (000 ha^{-1})			
50	0.59	0.40	0.26
100	0.61	0.50	0.26
150	0.61	0.44	0.25
SED (±)	0.02	0.04	0.02
LSD (p=0.05)	N.S.	N.S.	N.S.

Row spacing significantly affected the harvest ratio during the 1979 and 1980 seasons. The 90 cm spacing had higher harvest ratio than 75 cm spacing in both years (Table 4.06).

Plant population in the range tested had no significant effect on the harvest ratio of cotton at Mokwa (Table 4.06).

4.0.6 Earliness

The various earliness indices were differentially affected by the factors tested.

Number of days to 50% flowering

Cultivar had significant effect on the number of days to 50% flowering during the three growing seasons. 'Super okra' attained the 50% flowering stage earlier than 'Samaru 71' and 'Dar 14/25' during 1979, 1980 and 1981 seasons. 'Samaru 71' reached the 50% flowering stage earlier than 'Dar 14/25' in 1979 and 1980 seasons (Table 4.07).

Row spacing had no significant effect on the number of days to 50% flowering (Table 4.07).

Plant population had no significant effect on the number of days to 50% flowering (Table 4.07).

Mean maturity date

Cultivar had significant effect on mean maturity date

Table 4.07. Main effect of cultivars, row spacing and plant population on the number of days to 50% flowering of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	61.0	64.6	66.4
Car 14/25	69.1	60.4	66.2
Super okra	60.4	60.4	63.7
SED (±)	0.3	0.4	0.45
LSD (p=0.05)	00.6	0.8	0.9
Row spacing (cm)			
60	63.9	64.2	65.2
75	63.9	64.7	65.3
90	63.5	64.5	65.0
SED (±)	0.42	0.56	0.63
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	63.6	64.3	64.9
100	63.0	64.4	65.5
150	63.9	64.7	65.9
SED (±)	0.3	0.4	0.45
LSD (p=0.05)	N.S.	N.S.	N.S.

(MMD) of cotton at Mokwa. During the 1979, 1900 and 1901 seasons, 'Samaru 71' and 'Super okra' had significantly higher MMD than 'Dar 14/25'. There was no significant difference between 'Super okra' and 'Samaru 71' except in 1901 (Table 4.00).

Row spacing had no significant effect on MMD (Table 4.00).

Plant population had significant effect on MMD. In 1979, plants at 100,000 plants ha^{-1} had significantly lower MMD than plants at 150,000 plants ha^{-1}. There was no significant difference between 50,000 and 100,000 plants ha^{-1}. In 1900, plants at 100,000 and 150,000 plants ha^{-1} matured significantly earlier than those at 50,000 plants ha^{-1}. In 1901, plants at 50,000 ha^{-1} matured significantly earlier than those at 100,000 and 150,000 plants ha^{-1}. Similarly, plants at 150,000 plants ha^{-1} matured significantly earlier than those at 100,000 plants ha^{-1} in 1901 at Mokwa (Table 4.00).

Production rate index

Cultivar had significant effect on production rate index (PRI) of cotton during the 1979, 1900 and 1901 seasons. In 1979, 1900 and 1901 'Samaru 71' and 'Super okra' had significantly higher PRI than 'Dar 14/25'. There was, however, no significant difference between 'Samaru 71' and 'Super okra'

Table 4.00. Main effect of cultivar, row spacing and plant population on the mean maturity date of cotton at Makwe.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	136.9	131.9	150.7
Oar 14/25	144.3	137.5	155.0
Super okra	135.5	132.5	151.3
SED (±)	0.0	1.2	1.7
LSD (p=0.05)	1.6	2.4	3.5
Row spacing (cm)			
60	138.0	131.3	155.0
75	138.4	135.7	154.9
90	139.5	134.0	154.4
SED (±)	1.1.	1.7	2.3
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	138.7	137.0	158.0
100	137.9	131.6	159.0
150	140.0	133.2	155.3
SED (±)	0.0	1.2	1.7
LSD (p=0.05)	1.6	2.4	3.5

(Table 4.09).

Row spacing had no significant effect on FRI of cotton at Mokwa throughout the three seasons (Table 4.09).

Plant population in the range tested had no significant effect on FRI of cotton at Mokwa during the 1979, 1900 and 1901 growing seasons (Table 4.09).

Percentage of first picking to total seed cotton yield

Increased plant population from 50,000 plants ha^{-1} to 150,000 plants ha^{-1} and row spacing resulted in decreased seed cotton yield at first picking (Fig. 16 and 17).

4.9 Yield

4.9.1 Seed cotton yield

In 1979 and 1900, 'Samaru 71' and 'Super okra' had significantly higher seed cotton yield than 'Oar 14/25'. There was no significant difference between 'Samaru 71' and 'Super okra' on seed cotton yield. In 1901 season, 'Super okra' significantly outyielded 'Oar 14/25' but there were no Significant differences between 'Samaru 71' and 'Oar 14/25' and between 'Samaru 71' and 'Super okra'. On the basis of pooled mean, 'Samaru 71' and 'Super okra' significantly outyielded 'Oar 14/25' but there was no significant difference between 'Samaru 71' and 'Super okra' on seed cotton

Table 4.09. Main effect of cultivar, row spacing and plant population on production rate index of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	0.1	10.9	0.3
Car 14/25	2.2	7.6	7.7
Super okra	7.0	10.7	9.6
SED (±)	0.35	2.29	0.60
LSD (p=0.05)	0.7	4.6	1.2
Row spacing (cm)			
60	6.2	15.1	9.1
75	6.4	15.0	0.6
90	5.5	15.2	7.9
SED (±)	0.49	3.21	0.04
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	6.1	16.4	0.9
100	6.3	15.3	0.6
150	5.7	12.4	0.1
SED (±)	0.35	2.29	0.60
LSD (p=0.05)	N.S.	N.S.	N.S.

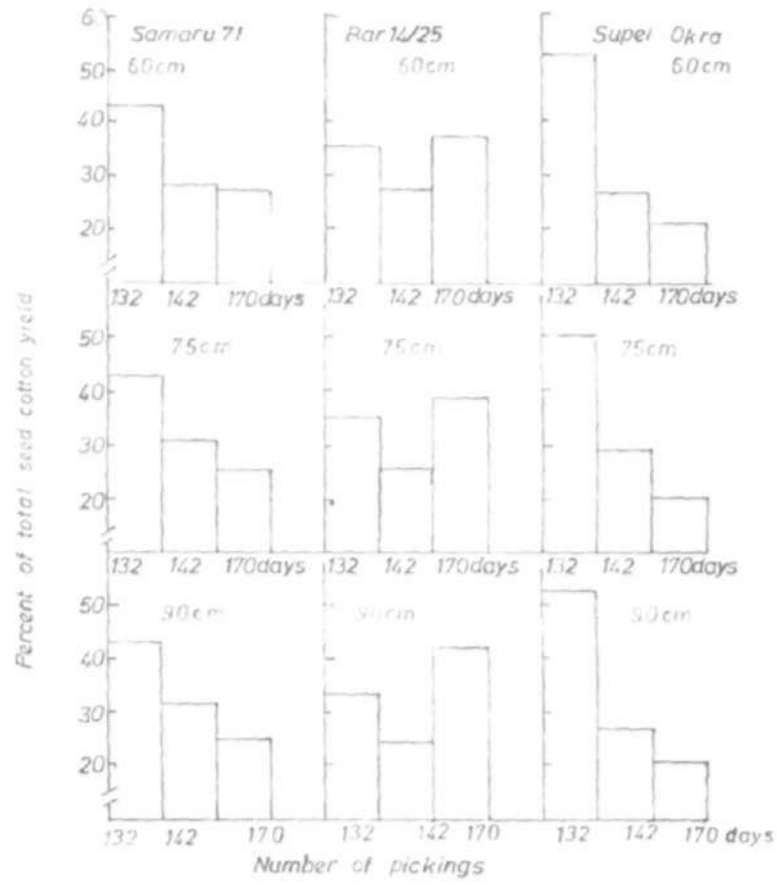


Fig16. First, second and third cotton pickings as percent of total seed cotton yield related to row spacing and variety at Mokwa(3year mean,1979, 1980 and 1981).

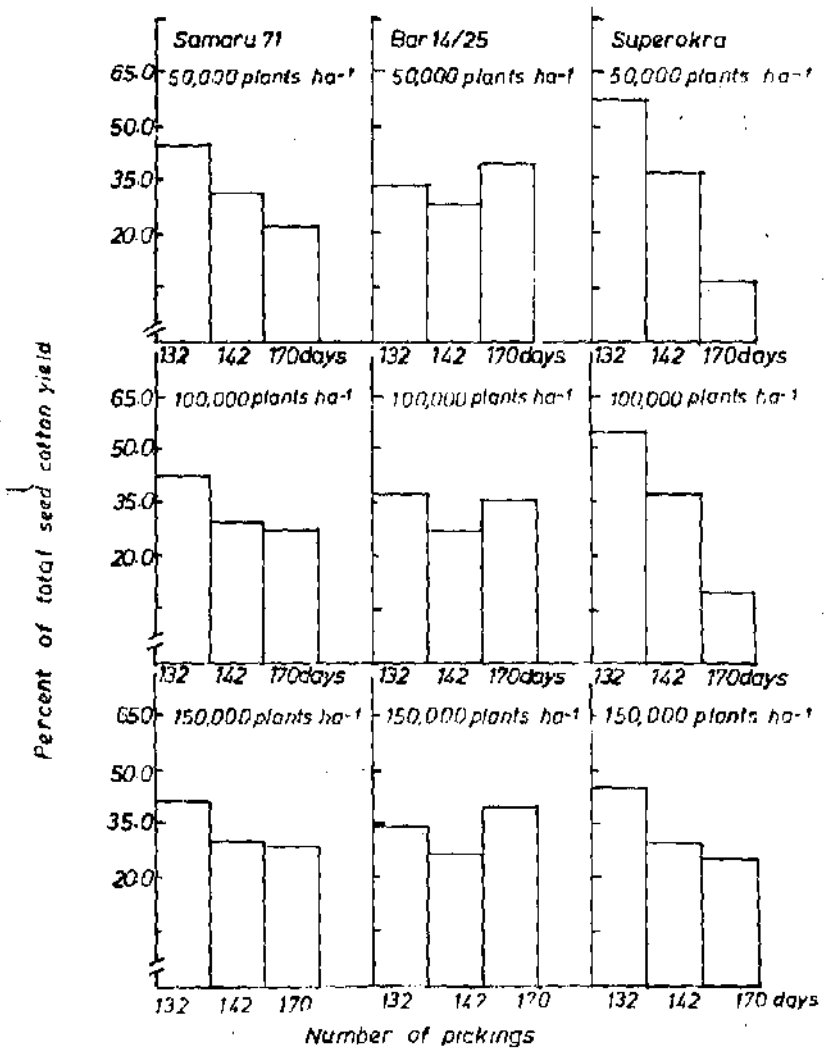


Fig. 19: First, second and third cotton pickings as percentage of total seed cotton yield related to plant population and variety at Makwa (3 year mean, 1979, 1980 and 1981).

yield (Table 4.90).

In 1980, 75 cm spacing significantly outyielded 60 and 90 cm row spacings and 60 cm spacing significantly outyielded 90 cm row spacing. In 1981, both 60 and 75 cm spacing significantly outyielded 90 cm spacing. There was, however, no significant difference between 60 and 75 cm spacing on seed cotton yield. Based on the pooled data, 75 cm spacing significantly outyielded both 60 and 90 cm spacings and there was no significance difference between 60 and 90 row widths (Table 4.90).

In 1981, plants at 50,000 plants ha^{-1} significantly outyielded plants at 100,000 and 150,000 plants ha^{-1} but there was no significant difference in seed cotton yield at 100,000 and 150,000 plants ha^{-1}. Based on pooled analysis, plants at 50,000 plants ha^{-1} outyielded those of 100,000 and 150,000 plants ha^{-1}. There was a gradual decrease in seed cotton yield as the plant population was increased although the difference between 100,000 and 150,000 plants ha^{-1} was not significant (Table 4.90).

The year had significant effect on the seed cotton yield at Mokwa. The seed cotton yield during the 1980 season was significantly higher than those of 1979 and 1981. Similarly the seed cotton yield of 1981 was significantly higher than that of 1979 (Table 4.90).

Table 4.90. Main effect of cultivar, row spacing and plant population on seed cotton yield (kg ha^{-1} at Mokwa.

Treatment	1979	1980	1981	Pooled Mean
Cultivar				
Samaru 71	1006	2153	1203	1507
Dar 14/25	457	1150	1203	939
Super okra	915	2409	1420	1581
SED (±)	07	269.[illegible]	50.[illegible]	05.[illegible]
LSD (p=0.05)	175.[illegible]	541.[illegible]	117.[illegible]	166.[illegible]
Row spacing (cm)				
60	051	1940	1350	1303
75	073	2210	1407	1497
90	733	1569	1141	1140
SED (±)	93.[illegible]	241.[illegible]	52	05.
LSD (p=0.05)	N.S.	271.	145.	166
Plant population (000 ha^{-1})				
50	776	2122	1378	1425
100	059	2012	1315	1395
150	023	1505	1213	1207
SED (±)	07.[illegible]	269.	50.	05.[illegible]
LSD (p=0.05)	N.S.	N.S.	117	166.[illegible]
Year Mean	019	1907	1302	
SED (±)		05.		
LSD (p=0.05)		166		

4.9.2 Lint yield

Cultivar had significant effect on cotton lint yield at Nakwa during the three growing seasons. In 1979, 1980 and 1981 'Super okra' significantly outyielded 'Samaru 71' and 'Car 14/25'. 'Samaru 71' also outyielded 'Car 14/25' (Table 4.91).

In 1979, 75 cm spacing significantly outyielded 60 and 90 cm rows. Similarly, 60 cm spacing significantly outyielded 90 cm spacing. The result was slightly different in the 1980 season where 60 cm spacing significantly outyielded 75 and 90 cm spacings. There was also a significant difference between 75 and 60 cm spacing. In 1981, 75 cm row significantly outyielded 90 cm rows but the difference between 60 and 75 cm rows was not significant (Table 4.91).

Among the three populations tested, 50,000 and 100,000 plants ha^{-1} significantly outyielded 150,000 plants ha^{-1} in 1979. In 1980, there was significant decrease in lint yield with increased plant population. A similar result was observed in 1981 except that the difference between 100,000 and 150,000 plants ha^{-1} was not significant (Table 4.91).

4.9.3 Number of seeds per boll

'Samaru 71' and 'Super okra' had significantly higher number of seeds per boll than cultivar Car 14/25 in the 1979,

Table 4.91. Main effect of cultivar, row spacing and plant population on cotton lint yield (kg ha^{-1}) at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	422	1062	453
Dar 14/25	156	736	390
Super okra	406	1203	555
SED (±)	6.	30.	20.
LSD (p=0.05)	13.	77	57.
Row spacing (cm)			
60	325	1227	643
75	356	1543	505
90	321	696	399
SED (±)	9.	53.	39.
LSD (p=0.05)	26.	149.	110
Plant population (000 ha^{-1})			
50	294	1090	400
100	379	972	471
150	331	745	424
SED (±)	6	30.	20.
LSD (p=0.05)	13	77.	57

1900 and 1901 seasons. There was no significant difference in seed number per boll between 'Samaru 71' and 'Super okra' (Table 4.92).

Row spacing and plant population had no significant effect on the number of seeds per boll during the 1979, 1900 and 1901 seasons at Mokwa (Table 4.92).

The interaction between cultivar and plant population was significant on the number of seeds per boll at Mokwa in 1979. With 'Samaru 71' increased plant population had no significant effect on the number of seeds per boll. Using 'Gar 14/25', there was a significant increase in the number of seeds per boll by increasing the plant population from 50,000 to 100,000 plants ha^{-1}. There was, however, no significant difference between 100,000 and 150,000 plants ha^{-1}. Increased plant population resulted in the decrease of the number of seeds per boll of 'Super okra'. There were significant differences between 50,000 and 150,000 plants ha^{-1} and between 100,000 and 150,000 plants ha^{-1} (Table 4.93.

4.10 Correlation and Regression

4.10.1 Correlation between growth parameters and seed cotton yield

Seed cotton yield of 'Samaru 7' was significantly and possitively correlated with LAI at 11 weeks after sowing

Table 4.92. Main effects of cultivar, row spacing and plant population on the number of seeds per boll of cotton at Mokwa.

Treatment	1979	1980	1981
Cultivar			
Samaru 71	29.4	20.0	32.0
Oar 14/25	18.4	20.6	20.9
Super okre	30.4	20.6	33.3
SED (±)	0.7	0.7	0.7
LSD (p=0.05)	1.4	1.5	1.4
Row spacing (cm)			
60	25.1	25.0	31.7
75	26.3	26.1	30.0
90	26.7	25.3	31.7
SED (±)	0.9	1.0	0.9
LSD (p=0.05)	N.S.	N.S.	N.S.
Plant population (000 ha^{-1})			
50	26.0	25.9	31.9
100	26.6	25.1	31.1
150	25.5	26.2	31.2
SED (±)	0.7	0.7	0.7
LSD (p=0.05)	N.S.	N.S.	N.S.

Table 4.93. Interaction between cultivar and plant population on the number of seeds per boll of cotton at Mokwa in 1979.

Plant population ('000 ha^{-1})	Cultivar 'Samaru 71'	'Oar 14/25'	'Super okra'
50	30.0	16.5	31.5
100	29.7	19.1	31.1
150	20.3	19.7	20.5
SED (±)		1.2	
LSD (p=0.05)		2.4	

(r = 0.71) and total dry matter at 15 weeks after sowing in 1980 (r = 0.01) (Table 4.97). Seed cotton yield of 'Samaru 71' was no significantly correlated with growth parameters in 1979 (Table 4.94).

Similarly in 1980, seed cotton yield of 'Oar 14/25' was significantly and positively correlated with LAI at 11 and 15 weeks after sowing (r = 0.40 and r = 0.61, respectively), and total dry matter yield at 15 weeks after sowing (r = 0.76) (Table 4.96).

Seed cotton yield of 'Super okra' in the same year was significantly and positively correlated with total dry matter

yield at 15 weeks after sowing only (r = 0.89) (Table 4.99).

In 1981, seed cotton yield of only 'Super okra' was significantly and positively correlated with total dry matter yield at 15 weeks after sowing was (r = 0.44) (Table 4.102).

4.10.2 Correlation between yield components and seed cotton yield.

In 1979 at Mokwa, seed cotton yield was significantly and posititively correlated with average boll weight for cultivars Dar 14/25 and Super okra (r = 0.47 and 0.69, respectively) (Tables 4.95 and 4.96).

In 1980, seed cotton yield of 'Samaru 71' was significantly and positively correlated with ginning percentage (r = 0.73), average boll weight (r = 0.86) seed index (r = 0.852), average number of mature bolls per plant (r = 0.80), and average number of seeds per boll (r = 0.86) (Table 4.97).

Seed cotton yield of 'Dar 14/25' in 1980 was significantly and positively correlated with ginning percentage (r = 0.60), average boll weight (r = 0.82), lint index (r = 0.62), seed index (r = 0.80), average number of seeds per boll (r = 0.87), (Table 4.98).

Seed cotton yield of 'Super okra' in the same year was

Table 4.94. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1979.

	Seed cotton yield	Ginning %	Seed index	Lint index	Av. boll wt.	Av. no. of seeds/boll	Av. no. of mature bolls/plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.16	1.00							
Seed index	0.16	0.10	1.00						
Lint index	0.05	0.05	0.09	1.00					
Av. boll wt.	0.11	0.20	0.19	0.19	1.00				
Av. no. of seeds/boll	0.27	-0.31	-0.18	0.07	0.34*	1.00			
Av. no. of mature bolls/plant	0.12	-0.32	-0.10	0.17	-0.09	0.61*	1.00		
LAI (at 11 WAS)	0.06	0.35*	0.13	-0.12	-0.10	0.05	-0.07	1.00	
Total dry matter yield (at 15 WAS)	0.04	-0.12	-0.06	0.03	0.03	0.22	-0.06	0.49*	1.00

* Significant at 0.05 probability level.

Table 4.05. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Sar 14/25' at Mokwa in 1979.

	Seed cotton yield	Ginning %	Seed index	Lint index	Av. boll wt.	Av. no. of seeds/boll	Av. no. of mature bolls/plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.09	1.00							
Seed index	0.26	0.15	1.00						
Lint index	0.04	-0.59*	0.04	1.00					
Av. boll wt.	0.47*	-0.26	0.07	-0.00	1.00				
Av. no. of seeds/boll	0.35	-0.09	0.06	0.15	-0.17	1.00			
Av. no. of mature bolls/plant	0.21	-0.16	-0.09	-0.05	0.01	0.42*	1.00		
LAI (at 11 WAS)	0.12	0.10	-0.04	0.10	0.15	0.40*	0.31	1.00	
Total dry matter yield (at 15 WAS)	0.16	0.07	0.01	0.17	0.16	0.23	0.05	0.66*	1.00

* Significant at 0.05 probability level.

Table 4.96. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1979.

	Seed cotton yield	Ginning %	Seed index	Lint index	Av.boll wt.	Av.no.of seeds/ boll	Av.no.of mature bolls/ plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.05	1.00							
Seed index	0.13	-0.16	1.00						
Lint index	0.03	-0.97*	0.04	1.00					
Av. boll wt.	0.49*	0.01	-0.15	-0.03	1.00				
Av. no. of seeds/boll	0.03	-0.37*	0.37*	0.37*	0.30	1.00			
Av. no. of mature bolls/plant	0.05	-0.16	0.31	-0.14	0.10	0.66*	1.00		
LAI (at 11 WAS)	0.13	0.11	-0.39*	-0.02	-0.25	0.13	-0.06	1.00	
Total dry matter yield (at 15 WAS)	0.14	0.42*	-0.20	0.36*	0.00	0.04	-0.09	0.54*	1.00

* Significant at 0.05 probability level.

Table 4.97. Matrix of coefficients of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1980.

	Seed cotton yield	Ginning %	Av. boll wt.	Lint index	Seed index	Av. no. of seeds/boll	Av. no. of mature bolls/plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.73*	1.00							
Av. boll wt.	0.06*	0.77*	1.00						
Lint index	-0.03	0.13	-0.21	1.00					
Seed index	0.92*	0.83*	0.94*	0.05	1.00				
Av. no. of seeds/boll	0.06*	0.05*	0.92	-0.14	-0.96*	1.00			
Av. no. of mature bolls/plant	0.00*	0.90*	0.09*	0.05	-0.92*	0.93*	1.00		
LAI (at 11 WAS)	0.71*	0.79*	0.74*	0.11	0.02*	0.74*	0.77*	1.00	
Total dry matter yield (at 15 WAS)	0.01*	0.70*	0.91*	0.07	0.95*	0.92*	0.90*	0.72*	1.00

* Significant at 0.05 probability level.

Table 4.90. Matrix of coefficient of correlation (r) between seed cotton yield, growth and yield components of 'Bar 14/25' at Nkwa in 1900.

	Seed cotton yield	Ginning %	Av. boll wt.	Lint index	Seed index	Av. no. of seeds/boll	Av. no. of mature bolls/plant	LAI (at 11 WAS)	LAI (at 15 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00									
Ginning %	0.60*	1.00								
Av. boll wt.	0.02*	0.66*	1.00							
Lint index	0.62*	0.37*	-0.57*	1.00						
Seed index	0.00*	-0.63**	0.93*	0.60*	1.00					
Av. no. of seeds/boll	.07*	0.63*	0.90*	-0.65*	0.95*	1.00				
Av. no. of mature bolls/plant	0.05*	0.74*	0.91*	-0.60*	0.92*	0.93*	1.00			
LAI (at 11 WAS)	0.40*	0.55	0.22	-0.04	0.22	0.20	0.34*	1.00		
LAI (at 15 WAS)	0.01*	-0.20	0.50*	0.39	-0.60*	0.65*	0.60*	0.24	1.00	
Total dry matter yield (at 15 WAS)	0.78*	-0.61*	0.07*	0.75*	0.93*	0.09*	-0.07*	-0.14	0.46*	1.00

* Significant at 0.05 probability level.

Table 4.99. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1980.

	Seed cotton yield	Ginning %	Av. boll wt.	Lint index	Seed index	Av. no. of seeds/boll	Av.no. of mature bolls/plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.76*	1.00							
Av. boll wt.	0.02*	0.76*	1.00						
Lint index	0.50*	0.43*	-0.50*	1.00					
Seed index	0.03*	-0.05*	-0.90*	0.46	1.00				
Av. no. of seeds/boll	0.03*	0.00*	0.92*	-0.40*	0.92*	1.00			
Av.no. of mature bolls/plant	0.03*	0.91*	-0.90*	-0.49*	-0.94*	0.91*	1.00		
LAI (at 11 WAS)	0.11	0.29	0.16	-0.25	-0.12	0.12	0.12	1.00	
Total dry matter yield (at 15 WAS)	0.09*	-0.74*	0.02*	0.47*	0.78*	0.01*	-0.03*	-0.01	1.00

* Significant at 0.05 probability level.

Table 4.100. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Samaru 71' at Mokwa in 1901.

	Seed cotton yield	Ginning %	Lint index	Seed index	Av.boll wt.	Av.no.of seeds/ boll	Av.no.of mature bolls/ plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.35*	1.00							
Lint index	0.25	0.01*	1.00						
Seed index	0.05	-0.04	0.54	1.00					
Av. boll wt.	0.01	-0.07	-0.07	-0.01	1.00				
Av. no. of seeds/boll	0.13	0.09	-0.19	-0.43*	-0.11	1.00			
Av.no.of mature bolls/plant	0.24	-0.37*	-0.30*	-0.12	-0.10	0.00	1.00		
LAI (at 11 WAS)	0.25	0.20	0.35*	0.32*	0.05	-0.09	-0.20	1.00	
Total dry matter yield (at 15 WAS)	0.20	0.22	0.15	0.01	-0.11	0.20	0.32*	0.60*	1.00

* Significant at 0.05 probability level.

Table 4.101. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Dar 14/25' at Mokwa in 1901.

	Seed cotton yield	Ginning %	Lint index	Seed index	Av.boll wt.	Av.no.of seeds/ boll	Av.no.of mature bolls/ plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)
Seed cotton yield	1.00								
Ginning %	0.10	1.00							
Lint index	0.19	0.91*	1.00						
Seed index	0.04	0.23	0.36*	1.00					
Av. boll wt.	0.02	0.14	0.23	0.34*	1.00				
Av. no. of seeds/boll	0.30	0.12	0.14	0.01	-0.05	1.00			
Av.no. of mature bolls/plant	0.46	0.05	0.07	0.19	0.04	0.29	1.00		
LAI (at 11 WAS)	0.22	0.29	0.25	-0.06	-0.10	0.03	0.33*	1.00	
Total dry matter yield (at 15 WAS)	0.10	0.20	0.25	0.14	-0.10	-0.07	-0.20	0.63	1.00

* Significant at 0.05 probability level.

Table 4.102. Matrix of coefficient of correlation (r) between seed cotton yield and growth and yield components of 'Super okra' at Mokwa in 1901.

Seed cotton yield	1.00								
Ginning %	0.33*	1.00							
Lint index	0.31	0.95*	1.00						
Seed index	0.29	-0.24	-0.05	1.00					
Av. boll wt.	0.10	-0.09	-0.00	0.23	1.00				
Av. no. of seeds/boll	0.00	-0.24	-0.19	0.33*	0.16	1.00			
Av.no.of mature bolls/plant	0.15	0.59*	0.50*	0.19	-0.13	-0.06	1.00		
LAI (at 11 WAS)	0.12	-0.24	-0.23	0.00	0.15	-0.29	0.56*	1.00	
Total dry matter yield (at 15 WAS)	0.44*	0.23	0.25	-0.04	-0.05	-0.14	-0.00	0.30	1.00
	Seed cotton yield	Ginning %	Lint index	Seed index	Av.boll wt.	Av.no.of seeds/ boll	Av.no.of mature bolls/ plant	LAI (at 11 WAS)	Total dry matter yield (at 15 WAS)

* Significant at 0.05 probability level.

significantly and positively correlated with ginning percentage (r = 0.76), average boll weight (r = 0.02), lint index (r = 0.50), seed index (r = 0.03), average number of seeds per boll (r = 0.03), and average number of mature bolls per plant (r = 0.03) (Table 4.99).

In 1981, seed cotton yield of 'Samaru 71' was significantly and positively correlated with ginning percentage (r = 0.35) only (Table 4.100). Similarly, seed cotton yield of 'Gar 14/25' and 'Super okra' in the same year were significantly and positively correlated with average number of mature bolls per plant and ginning percentage (r = 0.446; r = 0.33), respectively (Tables 4.101 and 4.102).

4.10.3 Regression of seed cotton yield on plant population

The regression of seed cotton yield on plant population for the three cultivars were calculated. There was a progressive decrease in seed cotton yield with higher plant densities (Fig. 10). The regression equations are given as follows:

'Samaru 71'

$$Y = 2255.00 + 2.7\,x - 0.03\,x^2 \quad (r^2 = 0.71^*)$$

'Gar 14/25'

$$Y = 1477.0 - 4.2\,x + 0.01\,x^2 \quad (r^2 = 0.05^*)$$

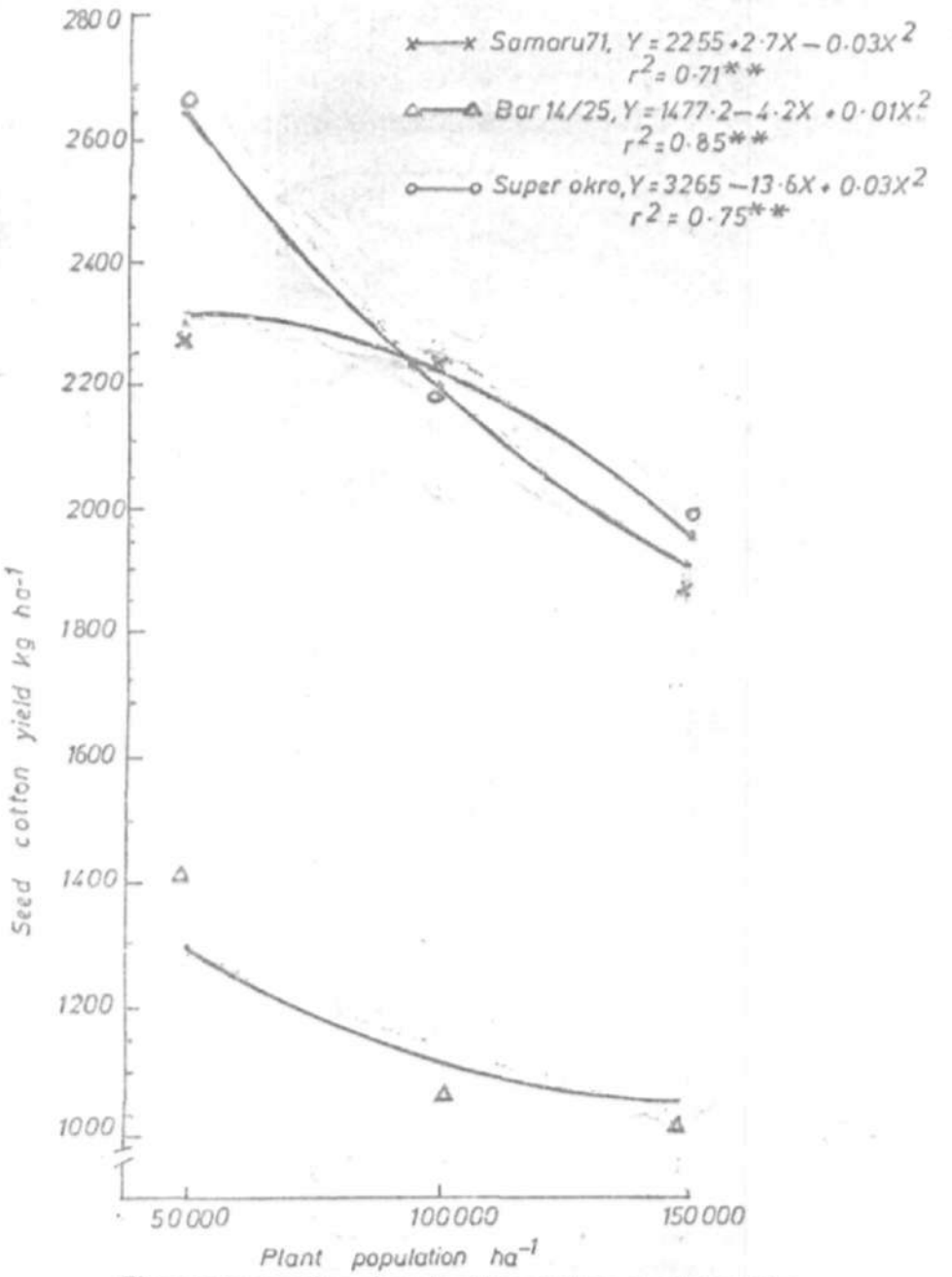


Fig.18 : Regression of seed cotton yield on plant population at Makwa (mean of 1979, 1980 and 1981 seasons

'Super okra'

$$Y = 3265 - 13.6\,x + 0.03\,x^2 = (r^2 = 0.75^*)$$

4.10.4 Regression of yield components on seed cotton yield

Every increase of LAI by one within a range of 0.5 to 3.5 resulted in 17.0 kg ha^{-1} of seed cotton of 'Mar 14/25' (Fig. 13). Similarly, each increse of average boll weight by one gram, within a range of 2.0 to 5.0g, increased seed cotton yield by 207 kg ha^{-1} (Fig. 19).

4.10.5 Multiple regression

Step-wise multiple regression of seed cotton yield on yield components of cotton was studied (Table 4.103 and 104).

The following regression equations were computed to quantify the relative contribution of yield components to seed cotton yield for the three cultivars:

'Samaru 71'

$$Y = 615.0\,X_1 - 331.6 \quad \ldots\ldots\ldots (i)$$

$$Y = 257.3\,X_1 + 255.5\,X_2 - 249.9 \quad \ldots\ldots\ldots (ii)$$

$$Y = 115.2\,X_1 + 142.2\,X_2 + 50.3\,X_3 - 770.4 \quad \ldots\ldots\ldots (iii)$$

$$Y = 10.3.1\,X_1 + 140.9\,X_2 + 663.4\,X_3 + 52.7\,X_4 - 0.60 \quad (iv)$$

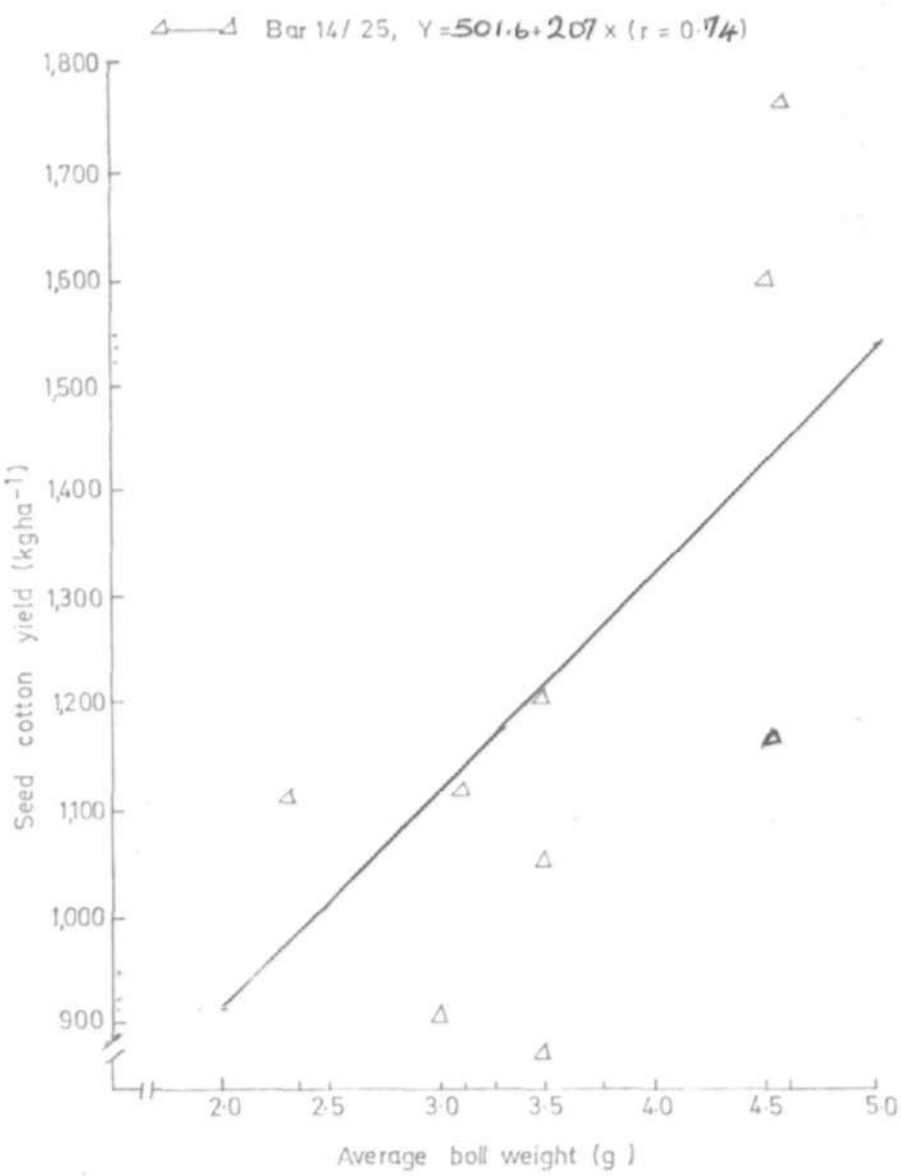


Fig.19 : Regression of seed cotton yield on average boll weight. Each point (Δ) represents the mean of nine values.

Table 4.103. Multiple regression coefficients of seed cotton yield on growth and yield components of cotton indicating their relative contributions at Mokwa.

Variables	Multiple regression coefficients (R^2)	Relative contributions %
	'Samaru 71'	
LAI (at 15 WAS)	0.79	40.4
Av. no. of mature bolls/plant	0.92	39.7
Av. no. of fruiting branches/plant	0.96	11.0
Av. boll weight	0.56	0.1
	'Dar 14/25'	
LAI (at 15 WAS)	0.02	13.5
Av. no. of mature bolls/plant	0.93	4.9
Av. no. of fruiting branches/plant	0.97	0.9
Av. boll weight	0.90	00.7
	'Super okra'	
LAI (at 15 WAS)	0.70	45.0
Av. no. of mature bolls/plant	0.92	36.0
Av. no. of fruiting branches/plant	0.99	10.1
Av. boll weight	0.69	0.1

'Dar 14/25':

$Y = 605.9\ X_1 - 932.6$ ..... (v)

$Y = 416.1\ X_1 + 160.9\ X_2 - 1161.6$ ..... (vi)

$Y = 232.9\ X_1 + 06.0\ X_2 + 105.2\ X_3 - 2606.2$ ..... (vii)

$Y = 102.6\ X_1 + 6\%.4\ X_2 + 103.6\ X_3 + 151.2\ X_4 - 2413.3$ (viii)

'Super okra':

$Y = 753.1\ X_1 - 495.5$ ..... (ix)

$Y = 331.2\ X_1 + 226.5\ X_2 - 330.6$ ..... (x)

$Y = 324.3\ X_1 + 65.6\ X_2 + 77.7\ X_3 - 1460.3$ ..... (xi)

$Y = 322.1\ X_1 + 04.2\ X_2 + 71.3\ X_3 + 30.1\ X_4 - 1467$ (xii)

Where X_1 = LAI at 15 WAS [illegible]

X_2 = Av. no. of mature bolls/plant

X_3 = Av. no. of fruiting branches/plant

X_4 = Av. boll wt. in gram

The actual and expected yields are shown on Table 4.105.

Table 4.104. Pooled multiple regression coefficients of seed cotton yield on growth and yield components of cotton indication their relative contributions (Samaru and Mokwa).

Variables	Multiple regression coefficients (R)	Relative contribution %
	Variety Samaru 71	
Average number of mature bolls plant^{-1}	0.89	47.5
LAI (at 15 WAS)	0.90	45.8
Average number of fruiting branches per plant (at 15 WAS)	0.90	5.8
Average boll weight	0.90	0.9
	Variety Super okra	
Average number of mature bolls per plant^{-1}	0.94	48.0
LAI (at 15 WAS)	0.90	40.8
Average number of fruiting branches per plant (at 15 WAS)	0.99	10.6
Average boll weight	0.99	0.6

Table 4.105. Comparison of computed seed cotton yield with the actual seed cotton yield.

Variables	Cultivars		
	Samaru 71	Super okra	Oer 14/25
Actual seed cotton yield kg ha^{-1}	1,602	1,757	1,345
Computed with equation (i)	1,549 (-0.03)*	1,803 (+0.03)	1,139 (-0.2)
Computed with equation (ii)	1,453 (-0.09)	1,750 (0)	1,259 (-0.06)
Computed with equation (iii)	1,571 (-0.02)	1,854 (+0.06)	1,311 (-0.03)
Computed with equation (iv)	1,621 (+0.01)	1,925 (+0.1)	1,450 (+0.07)

* Parenthesis indicate % deviation of computed values from actual values.

Chapter 5

DISCUSSION

5.1 Seasonal and Site Variations

Soil and climatic variations played strong modifying roles on cotton productivity at Samaru and Mokwa over the three years (1979 to 1981). In general, seed cotton yield grown at 90 cm row, averaged over the three years, was 1,435 and 1,116 kg ha^{-1} at Samaru and Mokwa, respectively. This yield level at Samaru was 22.2% higher than that at Mokwa. The higher yield was manifested in favourable soil, climatic and probably biotic factors at Samaru (northern Guinea savanna) as compared to Mokwa (southern Guinea savanna). The water-holding capacity varied from 31.5 cm m^{-1} soil depth at Samaru (silt loam soil) to 17.4 cm m^{-1} depth (loamy sand soil) at Mokwa (Kowal and Knabe, 1972). The drying cycle of the letter site starts immediately after the rains cease (mid-October). At Samaru, cotton could make the better use of the greater soil water during the reproductive phase. The mean yearly rainfall (1979 to 1981) was also marginally higher at Samaru than at Mokwa, 1,044 mm at Samaru and 1,020 mm at Mokwa (Appendices 1 and 5).

For July-sown cotton, end of August to end of October may be taken as a period of square initiation, flowering and boll development stages. Cotton requires an optimum temperature

range of 22 to 32°C during flowering and boll development states. During this reproductive stage, day time temperature of 26 to 32°C is desirable, but nights should be cool (18 to 20°C) for translocation of photosynthate from the source-leaves to the sink-bolls (Kumar et al., 1982 a). Another factor that favoured higher yields at Samaru was the prevailing temperature during reproductive phase; daytime temperatures of 28.1 to 32.5°C and night temperatures of 17.3 to 19.7°C (Appendix 3). At Mokwa, the daytime temperatures was in the range of 27.3 to 30.9°C (except in 1981 season with 30.8 to 33.3°C). The night temperatures at Mokwa during reproductive phase was also higher than optimum in the range of 20.0 to 22.9°C (Appendix 8), resulting in low seed cotton yield. The optimum temperature at Samaru probably promoted high photosynthetic rates in the daytime and high translocation and low respiratory rates in the nights thus enhancing the productivity. The lower seed cotton yield at Mokwa could have been caused by the low daytime temperatures - reduced photosynthetic rate and high night temperatures that favoured high respiratory rates and low translocation rates (McMichael and Powell, 1971).

Cotton is known to respond favourably to relatively moderate to low humidity and prolonged sunshine hours for better retention of flowers and bolls. It is apperent from Appendices 2 and 6 that relative humidity at Samaru during the reproductive phase was 10 to 40% lower than at Mokwa.

On the other hand, the mean actual sunshine hours at Samaru was in the range of 6.1 to 8.7 hours (mean 7.4 hours) as compared to 4.9 to 7.9 hours (mean 6.4 hours) at Mokwa during the same period (July to October) over the three years. The relatively high humidity, low light intensity, and cloudy weather at Mokwa, probably enhanced vegetative growth (shoot growth) (Grouwer, 1966) and infestation of insect pests complex on the crop as also reported by Pearson and Darling (1950).

In the potential cotton growing areas of northern Nigeria, the favourable growing season is limited by cessation of rainfall in early October. The growing season for late-sown cotton planted in mid-July ranges from 100 to 120 days. The current recommended cultivars of cotton (Samaru 71 and Samaru 77) require a favourable growing season of 150 to 180 days for optimum productivity. It appears that we have been trying to promote long season cultivars under a short growing season. Most of our management recommendation tested under early-sown (June) conditions are not suited for late- (July) and very late-sown (August) conditions. The performance of the variables discussed below have been markedly affected by their adaptability to variation in the environmental conditions as described earlier.

5.2 Cultivar

Averaged over two seasons (1980 and 1981) at Samaru, 'Super okra' outyielded 'Samaru 71' by a margin of 16.0% providing an additional net return of ₦108.12 (Appendix 13 a). Similarly, averaged over three seasons, 'Super okra' outyielded 'Samaru 71' by a margin of 20.7% at Mokwa, giving an additional net return of ₦130.21 (Appendix 13 b). On the basis of pooled data, over seasons and locations, a yield increase of 302 kg ha^{-1} of seed cotton was realised by planting 'Super okra' instead of 'Samaru 71'. A similar higher margin of productivity of 'Super okra' was also exhibited in the second trial at Mokwa. In this case 'Super okra' outyielded 'Samaru 71' by 0.3%. However, both 'Super okra' and 'Samaru 71' outyielded 'Sar 14/25' by margins of 93.3% and 70.3%, respectively.

Lint yield followed a similar trend as that of seed cotton yield at both locations. These findings are confirmed by the work of Karami and Weaver (1962), Jones and Andries et al., (1969), and Thomann (1972) who reported significant increase in seed cotton yield of 'Super okra' leaf type cotton over the normal leaf type cotton. However, Rao and Weaver (1976) reported that 'Super okra' leaf type cotton produced essentially the same amount of seed cotton as the normal leaf type. 'Super okra' thus appears to be more suited to a short growing season. A similar view was shared

by Cook and Doyle (1927).

The very low yields of 'Oar 14/25', a long staple, longer season cultivar at Mokwa was probably caused by the lack of soil moisture for the latter formed bolls to reach maturity. The rains ceased 21 days after the 'Oar 14/25' has attained 50% flowering. At this time about 35% of the fruiting bodies were either at square or flower or young boll stage. The full yield potential of this cultivar could not be exploited because of the short growing period it was exposed to. 'Oar 14/25' is, therefore, not suited to the late planting culture in areas with short rainy season as indicated by Berger (1969). 'Oar 14/25', it seems, is suited only to early planting (May/June).

The superiority of 'Super okra' over 'Samaru 71' and 'Oar 14/25' was manifested in a number of growth and yield contributing characters at both locations, namely : average number of mature bolls per plant, LAI, average number of fruiting branches, and average boll weight. 'Samaru 71' and 'Super okra' seemed to accumulate about the same dry matter yield at seven, 11 and 15 weeks after sowing. However, the partitioning of this dry matter into the component parts revealed varied ratios. While the fruiting bodies constituted about 30% of the total dry matter (between seven and 15 weeks after sowing) at Samaru, this dropped to about four per cent at Mokwa. The fruiting bodies of 'Samaru 71' constituted

17.1% and 3.3% of TDM at Samaru and Mokwa, respectively; while 'Super okra' accumulated 33.2% and 4.1% of its TDM as fruiting bodies at Samaru and Mokwa, respectively. This result is supported by the findings of Karami and Weaver (1962), Rao and Weaver (1976) and Andries et al. (1969) who reported that okra leaf type cottons produced more fruiting bodies than normal leaf type cottons. This also showed higher vegetative top growth at Mokwa of the two cultivars as compared to Samaru location. Under the conditionof high vegetative growth more vegetative than fruiting branches are produced. This was the case for 'Samaru 71' which recorded relatively lower number of fruiting branches as compared to 'Super okra'. It also indicated that 'Super okra' is more determinate in growth than 'Samaru 71'.

Although 'Samaru 71' had a higher LAI than 'Super okra', this was not reflected in seed cotton yield. This seemed to have been caused by the higher photosynthetic efficiency of the lower leaves of 'Super okra'. This view is supported by Pegelow et al. (1977) who reported that the lower leaves of 'Super okra' leaf type cotton were more photosynthetically active than the lower leaves of normal leaf type cotton. Army and Greer (1967) reported that when the LAI of plants with ordinary horizontal leaves (like that of 'Samaru 71') is increased as a result of higher plant density, the lower leaves operate below the compensation point, and may become parasitic. This could have been the case for the high leaf

density of 'Samaru 71'. Horrock et al. (1970) also observed that Super okra leaf type cottons translocated equivalent amounts of ^{14}C- assimilate from each of the source-leaves to the sink-bolls. Although super okra leaf type cotton had only 42% of the leaf area of normal leaf type cotton, they were approximately 2.6 times more efficient than normal leaf cotton in translocating ^{14}C- assimilate from the source-leaves to the sink-bolls.

There was, however, a higher rate of boll abortion in 'Super okra' than in 'Samaru 71' although the harvest ratio of the former was still higher than the latter because of the prolific nature of 'Super okra', Ibrahim (1974) and Kerby and Buxton (1976) associated the high abortion rates of young bolls of 'Super okra' with the reduction in LAI per fruiting position.

'Super okra' appeared to be earlier maturing than 'Samaru 71' as judged by the number of days from planting to 50% flowering (2 days earlier), number of days from planting to first boll opening (3 days earlier), MMD (3 days earlier), PRI (2 kg ha^{-1} day^{-1} more) and the percentage of first cotton picking to the total seed cotton yield. 'Super okra' and 'Samaru 71' produced 80% and 66% of the total seed cotton yield at first picking at Samaru, respectively. At Mokwa, about 45% and 35% of the total seed cotton yield was picked at 19 weeks after sowing from 'Super okra' and 'Samaru 71'

respectively. The earliness character of 'Super okra' was also reported by Cook and Doyle (1927) and Karami and Weaver (1962). The earliness indices demonstrated the suitability of 'Super okra' to a late-sowing culture of Nigerian savanna. This cultivar is high yielding and early maturing and should be used for commercial production.

5.3 Nitrogen

Nitrogen fertilizer showed profound effect on growth, development and yield of cotton at both locations. Application of 40 kg N ha^{-1} to July-sown cotton resulted in 47.5% and 33.1% increase in yield over the control at Samaru and Mokwa, respectively. A further increase to 80 kg N ha^{-1} resulted in diminishing returns. This trend is supported by the findings of Kumar et al. (1982c) who reported that 43kg N ha^{-1} was economic optimum for mid-July sown cotton in the Guinea savanna of Nigeria. This finding contradicts the observation of Hayward (1976) who reported that application of N may decrease seed cotton yield of July-sown cotton in Nigeria. This contradiction was probably due to the prevailing draught in (1971 to 1973) the experimental seasons (Owonubi and Abdulmumin, 1984).

Nitrogen fertilization favourably influenced growth, and yield contributing characters in these studies. It significantly increased initiation, development and maturity of bolls. Nitrogen application also favourably and

significantly increased LAI, plant height, number of fruiting branches, number of mature bolls per plant, boll weight, number of seeds per boll, earliness, percentage nitrogen in the leaves, RGR and NAR. These growth and yield contributing characters favourably increased the seed cotton yield.

Nitrogen application significantly increased the number of mature bolls per plant; the high response at Samaru could be due to the difference in moisture holding capacities of the two soil types as discussed earlier. Application of nitrogen significantly increased LAI of cotton except in 1980 season at Samaru. The poor response of LAI to N in 1980 was probably caused by allocating a plot inadvertently given a basal N application of 30 kg ha^{-1} during seed-bed preparation. The beneficial effect of LAI on seed cotton yield has been explained in part due to higher supply of photosynthate to the developing bolls and the early maturity of bolls (Hamilton et al., 1956; Tucker and Tucker, 1960). Similarly, Verma et al. (1965) also reported that application of N (30 to 100 kg ha^{-1}) increased the number of leaves and number of bolls per plant. Beneficial effect of N on boll number was also observed by Smithson et al. (1976) working at Samaru, Nigeria; N application enabled later formed flowers and bolls to develop to maturity.

Application of nitrogen resulted in increased NAR and

number of fruiting branches. Tucker and Tucker (1968) reported that application of nitrogen increased the meristermatic activities and cell differentiation in cotton plant. During 1980 and 1981 growing seasons, the average boll weight was significantly increased by application of nitrogen upto 80 kg ha^{-1} at Mokwa. The higher increase in seed cotton yield at Samaru with the application of 40 kg N ha^{-1} was an indicator of a higher response to N at this location as compared to Mokwa. This higher response could have been caused by the higher moisture regime in Samaru soil (Kowal and Knabe, 1972). Favourable response of N to July-sown cotton in these field studies was probably as a result of well distributed rainfall (Appendices 1 and 5) during the growth and reproductive phases at Samaru and Mokwa. Beneficial effects of N under favourable moisture supply on seed cotton yield was also reported by Scarsbrook and Pearson (1959). One possible explanation of favourable effect of nitrogen under moderately late-sown (July-sown) cotton could be due to favourable effect of nitrogen on root growth and deeper and more profuse rooting early in the season (Linscott et al., 1962, Viet, 1962 and Gasemark, 1964). These views are supported by Pearson (1963) who stated that N-fertilized cotton is able to withstand drought later on in the dry season as compared to unfertilized crop.

Response of mid-July sown cotton to N application in the savanna is a result of favourable soil moisture in the

root zone. Tucker and Tucker (1968) observed that total N requirement of cotton increases as soil moisture is more favourable. However, as soil moisture decreases especially during the reproductive phase, as observed for late-sown cotton in Nigerian savanna, moisture films become discontinuous and nitrate mobility decreases. The longer this condition persists during the growing season, the less will be the nitrate absorption from the soil. These findings indicate to some extent the reason for poor response of July-sown cotton at Samaru and Mokwa to N levels beyond 40 kg ha^{-1} (Viets, 1962; Radin and Parker, 1979; Kumar et al., 1982c; Kumar, 1983 and Ogunlela et al., 1984).

Application of nitrogen increased the earliness of cotton. The number of days to 50% flowering was hastened by one day, number of days to boll opening was hastened by three days. It also decreased the MMD by three days and increased the PRI by 2 kg ha^{-1} day^{-1} and increased the percentage of seed cotton picked at first picking by about five per cent. Tucker and Tucker (1968) reported increased meristematic activities and cell differentiation with N fertilization. It was probably in this manner that the earliness of the crop was increased. Malik et al. (1977) and Hussein et al. (1979) also reported increased earliness of cotton with nitrogen application. The application of moderate amount of nitrogen enhanced high photosynthetic rate, moisture and nutrient absorption, cell division, cell expansion and

differentiation, high LAI early in the season, and a high rate of protein synthesis. The above processes increased the rate of boll development and maturation. On the other hand, high levels of N may result in excessive vegetative growth at the expense of the reproductive phase, this probably results in delayed flowering and subsequent delay in boll maturity. However, inadequate amounts of N may result in poor growth and delay maturity also (Viets, 1962; Tucker and Tucker, 1960). The above result was also supported by the works of Jackson and Faulkner (1962), and Gopalswamy and Palaniswamy (1974) who reported that moderate levels of nitrogen appeared to increase earliness while higher levels delayed the maturity.

The application of N increased the nitrogen control in cotton leaves at Samaru and Mokwa. Nitrogen content in the different plant parts is related to the amount of nitrogen in the soil that is available to that plant. This varies with the age of the tissue or organ. The per cent N in all tissues (except seed) tend to decrease with maturity. At peak flowering stage more N in the leaves is translocated to the bolls (Tucker and Tucker, 1968).

Application of nitrogen increased bolls shedding at both locations. Applied N (especially the second dose at eight weeks after sowing) aided the reproductive phase giving rise to square initiation, more flowers and bolls. This later formed bolls, because of moisture limitation in relation to

applied nitrogen and low LAI of the mid-July sown cotton were probably starved of photosynthate. This resulted in greater boll abortion and a reduction in the harvest ratio with increased nitrogen application. The limited moisture and photosynthate (from low LAI) could not support many fruiting points, as a result, a greater percentage of fruiting bodies formed were shed and very few developed to maturity.

There is need to apply moderate amounts of nitrogen to mid-July-sown cotton to increase yields. Although 64.0 kg N ha^{-1} was found to be the economic optimum level of nitrogen for late-sown cotton at both sites, the use of 40 kg N ha^{-1} seemed appropriate and practical in view of resource constraints, suboptimal management level of the farmers, and seasonal variations common in the savanna zones.

5.4 Plant Population

The optimum plant population for 'Samaru 71' was 107,500 plants ha^{-1} and 149,500 plants ha^{-1} for 'Super okra'. These crop densities appeared adequate for the mid-July-sown cotton. Using the conventional row spacing of 90 cm, an intra-row spacing of 20 cm keeping two plants per stand gives a plant population of 107,500 plants ha^{-1} for 'Samaru 71'. For a spacing of 75 x 25 cm keeping two plants per stand gives the same plant population.

The optimum plant population of 149,500 plants ha^{-1} can be achieved by these spacings keeping two plants per stand 90 x 15 cm or 75 x 18 cm.

At Mokwa the optimum plant population estimated was outside the range tested. This was also confirmed by the results of the second experiment at Mokwa. There is, therefore, need for a further experimentation using plant population lower than those used in these studies at Mokwa. Meanwhile, the 50,000 plants ha^{-1} could be retained with a spacing of 75 x 54 cm. The optimum plant population for Samaru location was a confirmation of the findings of Lawes (1963) and Brown (1971) who obtained higher yields at plant populations above 50,000 plants ha^{-1} at Samaru, Nigeria. Favourable response to increased plant population by timely sown cotton in terms of seed cotton yield between 79,000 and 155,000 plants ha^{-1} has been reported by Hawkins and Peacock (1970 and 1971), Dridge et al. (1973), and Koli and Morrill (1976).

Plant population upto 100,000 plants ha^{-1} increased the seed cotton yield of mid-July sown cotton at Samaru by a margin of 18.4% over 50,000 plants ha^{-1}. The lack of response in the 1981 season at Samaru seemed to have resulted from the poor rainfall distribution in that year. The rain ceased by the end of September, hence the later formed bolls in the higher plant population plots (because

of excessive competition for moisture and nutrients) probably suffered due to moisture stress and could not reach maturity. The response was, however, different at Mokwa, where increased plant population beyond 50,000 plants ha^{-1} decreased the seed cotton yield by margins of 7.3% and 23.6% (3 year mean) with 100,000 plants ha^{-1} and 150,000 plants ha^{-1}, respectively. The negative response to plant density beyond 50,000 plants ha^{-1} at Mokwa is not consistent with the various yield contributing characters. There was, however, a linear reduction in boll weight only in 1900, and increased shedding of fruiting bodies in 1979 and 1901. This aspect needs further investigation in southern cotton growing zone of Nigeria.

In the second trial at Mokwa, comparing the cultivars, spacing and plant population levels, the results followed a similar pattern with margins of 10.3% and 21.9% decreases in seed cotton yields between 50,000 and 150,000 plants ha^{-1}, respectively. The seed cotton yield from the second trial was much higher than that from the first trial (especially in the 1900 season), probably due to higher soil fertility conditions (Table 4.94, Fig. 23 and Plates 1a and 1b). In this, the rectangularity factor (narrow row) involved in this trial could have accounted for the additional yields. This trial was planted on the flat, the flat bed conserves more moisture and creates favourable soil temperature for

root growth as compared to untied ridges (Arnon, 1972). The narrow row width (of 75 cm) used in this trial significantly increased the seed cotton yield as compared to conventional 90 cm row. The beneficial effects of narrow row cotton are the attainment of the optimum LAI early in the season for the crop development, effective weed control, and reduction in the number of vegetative branches (Oreshears et al., 1960 and Kirk et al., 1969). The overall mean response to the various row spacings were: 9.6% between 60 and 75 cm, in favour of 75 cm row, and 33.6% between 75 and 90 cm rows, in favour of 75 cm row. The 75 cm row space gave the highest seed cotton and lint yields throughout the three growing seasons at Mokwa. To obtain 50,000 plants ha^{-1} using an inter-row of 75 cm, the intra-row spacing has to be 53 cm at two plants per stand. This spacing results in a better rectangularity the 90 x 45 cm spacing currently recommended for cotton production in the Northern States of Nigeria. The increased plant population may restrict root development and depth of penetration, thus reducing the quantity of moisture which can be absorbed from the soil profile (Hearn, 1972). This result showed that with cotton, the optimum plant population is a range of plant densities depending upon the agro-ecological conditions and not a fixed population level (Buxton et al., 1977).

Growth and yield components, namely, TDM, LAI, RGR,

number of fruiting branches, and bundle strength were significantly increased at Samaru and Mokwa with increased plant population. The economic yield was influenced by these parameters to varied degrees. Higher plant population (10 plants m^{-2} or more) significantly increased the LAI at both locations. LAI was positively correlated with seed cotton yield. Although the LAI at the two locations were comparable, this was not reflected in the seed cotton yield at Mokwa, probably due to sub-optimal solar radiation and relatively lower day and higher night temperatures (Appendix 8) which probably favoured low photosynthetic rate and high respiratory losses and inconsequence low translocation rates. The moisture stress at the cessation of rains occasioned by the high population level and soil type might have contributed to the negative response of seed cotton yield to increased plant population. The excessive vegetative growth at Mokwa at the expense of the reproductive growth could have also contributed to the negative response of seed cotton yield to increased plant population. The number of fruiting branches increased with increase in plant population. The favourable response in most cases was observed upto 150,000 plants ha^{-1}. These results are in agreement with the findings of Kerby and Buxton (1976) who also reported increase in the number of fruiting positions at higher plant population (200,000 plants ha^{-1}) than at the lower population (100,000 plants ha^{-1}) in Arizona, U.S.A.

The percentage dry weight accumulation in different plant parts was drastically affected. At Samaru, the percentage dry matter of the fruiting bodies (squares, flowers and bolls) to the cummulative dry matter production ranged from 25.5% to 40.0%, this range was 1.9% to 9.1% at Mokwa between 50,000 and 250,000 plants ha^{-1}. This showed a very low proportion of dry weight translocated for boll formation at Mokwa. The increased RGR in two out of three seasons at Mokwa was not reflected in the seed cotton yield. A similar trend was obtained for NAR. These results confirmed the findings of Watson (1952) who reported that RGR and NAR had demerits as estimators of photosynthesis but placed emphasis on LAI, the former are largely affected by external factors.

Increased plant population increased boll shedding and reduced seed and lint indices. These could have been caused by moisture stress and excessive inter and intra-plant competition for moisture and other nutrients. Poor seed and lint formation gave rise to the low seed and lint indices.

Increased plant population significantly reduced the plant height, seed index and lint index while the number of shed bolls was increased at Mokwa (Plates 1a, b and c). The boll shedding could have been caused by moisture stress, excessive inter-and intra-plant competition. As the plant population increased, the ratio of LAI to the fruiting

positions decreased and thus limited the yield potential of cotton. As discussed earlier the earliness of a crop in a late sown culture is an important production aspect, because of the short growing season. Plant population beyond 50,000 plants ha^{-1} significantly increased the number of days from sowing to first boll opening. The MMD was significantly increased by increased plant population upto 150,000 plants ha^{-1} at both sites in the 1981 season only. This result contradicted the findings of Ray and Richmond (1966), Kirk et al. (1969), and Fowler and Ray (1977) who reported an inverse relationship between PRI and MMD and plant population. However, PRI had an inverse relationship with plant population at both locations. The amount of seed cotton picked at first picking as percentage of total yield can be used as an index of earliness. At Samaru, 69.2% and 76.7% of total seed cotton yield were picked at 50,000 and 150,000 plants ha^{-1} at 140 days after sowing. At Mokwa, 42.7% and 30.9% of the total seed cotton yield were picked at 50,000 and 150,000 plants ha^{-1} at 130 days after sowing (Appendices 10a and 10b). While increased plant population from 50,000 to 150,000 plants ha^{-1} hastened maturity at Samaru, it resulted in a slight delay in maturity at Mokwa.

Increased plant population showed higher leaf nitrogen percentage at the seven weeks after sowing at Samaru in the 1980 season and at the 15 weeks after sowing in the 1980 and

1981 seasons at Mokwa. There was an inverse relationship between the percentage nitrogen and plant population at 15 weeks after sowing at both locations.

Increased plant population increased the competition for nutrients and the total nutrient absorption from the soil. For the late-sown crop, there is need to increase the stand density to make the best use of the environmental factors for increased productivity of cotton.

5.5 Interactions

Interaction between cultivar and plant population was significant on seed cotton yield at Mokwa in 1979, on LAI at Samaru in 1980 and 1981 and at Mokwa in 1979. This interaction was also significant on the number of fruiting branches per plant at both locations in 1979 and 1981. These interactions indicated that 'Super okra' responded to higher level of plant population as compared with 'Samaru 71' (Andries et al., 1979; Thompson, 1972). The canopy structure and high photosynthetic efficiency of the lower leaves of 'Super okra', increase in number of bolls and fruiting branches per plant have been reported by Jackson and Faulkner (1962), Melville and Caldwell (1972), Kerby and Buxton (1976), Buxton et al. (1977) Koli and Morrill (1977) and Koli and Morrill (1977). Interaction between cultivar and plant population was also significant on the number of shed bolls. 'Super okra' is a highly prolific

cultivar in which its total boll load could not be supported by the limited LAI hence not enough assimilates translocated to all the fruiting points. The 'starved' young bolls or squares abort. This view is supported by the findings of Quinn (1974) and Kerby and Buxton (1981) who reported that adjacent fruiting forms competed for available assimilates, and that the potential for developing one boll per sympodial branch was low. The use of cultivars which produce long vegetative branches (like 'Samaru 71') appeared to be inefficient in high population narrow-row culture.

Interaction between nitrogen and plant population was significant on seed cotton yield at Samaru in 1980, average number of mature bolls per plant also at Samaru in 1981 and average number of fruiting branches per plant at Mokwa in 1980 and 1981. These interactions indicated that higher plant density was supported by increased N application, it also revealed that some amount of nitrogen can be compensated by increased plant population. This is supported by the findings of Koli and Morrill (1976).

Interaction between cultivar and nitrogen level was significant on LAI at Samaru and Mokwa in 1979 and also on boll shedding at Mokwa in 1979. 'Super okra' as a result of higher photosynthetic efficiency as discussed earlier, responded more to lower N level (40 kg) than 'Samaru 71'. This view was supported by the findings of Kerby and Buxton (1976).

Interaction between row spacing and plant population was significant on total dry matter yield and number of fruiting branches per metre square. Because of the phylotaxy of cotton a near equidistant arrangement seems more ideal for good crop growth and development. The favourable response of cotton to narrow-row high density culture has also bee reported by Culp et al. (1974), Kerby and Buxton (1976) Payne et al. (1976) and Koli and Morrill (1976).

5.6 Multiple Regression

Stepwise multiple regression of seed cotton yield on growth and yield components was computed. Averaged over two locations, mean number of mature bolls per plant was most closely related to seed cotton yield for 'Samaru 71' and relatively accounted for 47.5% variation in the seed cotton yield. Other yield components influencing the seed cotton yield were in order of their relative importance: LAI (at 15 weeks after sowing), 45.0%; average number of fruiting branches m^{-2} 5.0% and average boll weight 0.9%. Similar contributions by 'Super okra' were in their relative order of importance; average number of mature bolls per plant (40.0%), LAI at 15 weeks after sowing (40.0%), average number of fruiting branches m^{-2} (10.6% and average boll weight (0.6%).

'Dar 14/25' used in the second trial at Mokwa had a completely different relative contribution ratios. The relative contribution of yield components to seed cotton yield

in order of importance was, mean boll weight (00.7%), LAI at 15 weeks after sowing (13.5%), mean number of mature bolls per plant (4.9%) and mean number of fruiting branches m^{-2} (0.9%). Effort should be made to breed high yielding cultivars of cotton by selecting for the above characters.

These results have important practical implication for the practices that improve LAI, average number of mature bolls per plant and number of fruiting branches per unit area. By means of regression analysis, it is possible to determine single or multiple yield components that can be used to predict yield of cotton. For 'Samaru 71' increasing the mean number of mature bolls per plant by one, resulted in 43.5 kg ha^{-1} increase in seed cotton yield. Similar response by 'Super okra' was 53.4 kg ha^{-1} increase in seed cotton. On the other hand by increasing the LAI at 15 weeks after sowing by one, resulted in 25.3, 38.2 and 17.0 kg ha^{-1} of seed cotton for 'Samaru 71', 'Super okra' and 'Dar 14/25', respectively. Average boll weight was the highest contributor to seed cotton yield of 'Dar 14/25', a gram increase in boll weight resulted in 343.7 kg ha^{-1} of seed cotton. Watson (1952) reported that LAI contributed positively to economic yields of field crops. The yield potential of cotton may be improved in the savanna considerably by manipulating the number of mature bolls per plant, LAI at 15 weeks after sowing, average number of fruiting branches m^{-2} and boll weight genetically and agronomically.

Although RGR, NAR and TDM were positively correlated with seed cotton yield, their relative contributions to the economic yield was very low. These parameters are largely influenced by external factors. These findings are supported by the work of Watson (1952) who concluded that RGR, NAR and TDM did not give adequate measure of the economic yield of field crops.

Chapter 6

SUMMARY AND CONCLUSIONS

About 70% of the total cotton production in Nigeria is obtained from the late-sown crop, normally planted in July. This crop is usually not fertilized and at the recommended population of 50,000 plants ha^{-1} does not develop the crop canopy considered optimum and necessary for efficient utilization of solar energy. In consequence the cotton productivity in Nigerian savanna is very poor (190 kg seed cotton ha^{-1}). There is scope to increase cotton production considerably by planting early maturing varieties, judicious fertilization and optimum plant population. Field experiments were, therefore, carried out over a period of three years (1979 to 1981) at Samaru and Mokwa, to study the effect of cultivar, nitrogen fertilization and plant population on growth and yield of late-sown cotton (mid-July).

Between the two locations, seed cotton yield at Samaru was 22.2% higher than that at Mokwa, probably due to favourable soil and climatic conditions. The soil at Samaru had 31% higher water holding capacity in one metre soil depth (active root zone of cotton). The mean seasonal rainfall at Samaru during the growing season was also higher by 16 mm as compared to Mokwa. Minimum and maximum air temperatures and sunshine hours during the flowering and early boll development stages (August to October) were also more favourable at Samaru than

at Mokwa. In view of the above and the relatively less pests infestation, it appears that environmental conditions at Samaru (northern Guinea savanna) were more favourable for cotton production than at Mokwa (southern Guinea savanna).

Between the two cultivars tested, 'Super okra' outyielded 'Samaru 71' by a margin of 16% at Samaru and 20.7% at Mokwa in the first experiment of the latter location. In the second experiment at Mokwa, 'Super okra' also outyielded 'Samaru 71' and 'Dar 14/25' by margins of 0.4% and 93.3%, respectively. The poor performance of the late maturing cultivar, 'Dar 14/25' under these conditions was mainly due to the heavy shedding of flowers and bolls owing to soil moisture stress during the boll development stage. This cultivar is, therefore, not suitable under late planting condition in the Nigerian savanna.

The superiority of 'Super okra' over 'Samaru 71' and 'Dar 14/25' was manifested in a number of growth and yield contributing characters viz., average number of mature bolls plant^{-1}, LAI at 15 weeks after sowing, average number of fruiting branches m^{-2} and average boll weight. 'Super okra' is an early maturing cultivar, which makes it more adaptable to late planting culture. It is also resistant to bacterial blight and its open canopy facilitates an easy and more effective pest control. It is also a more determinate cultivar as compared to 'Samaru 71' and owing to its small stature,

marked by less vegetative but more fruiting branches responded to high population density. It also favourably responded to fertilizer nitrogen especially at moderate level, more than 'Samaru 71'. It is, therefore, advisable to grow 'Super okra' for commercial production in the Nigerian savanna especially under late planting conditions.

The application of nitrogen to late-sown cotton substantially and consistently increased the seed cotton yields at both locations over the three seasons. On the the basis of the pooled data over the seasons and the locations, there were yield increases of 37.3% and 43.6% between 0 and 40 kg N ha^{-1} and between 0 and 80 kg N ha^{-1}, respectively. The mean regression equations of seed cotton yield on nitrogen for both locations were:

Samaru:

$$Y = 1094.0 + 14.5\ x - 0.10\ x^2\ (r^2 = 0.76)$$

Mokwa:

$$Y = 830.7 + 10.6\ x - 0.07\ x^2\ (r^2 = 0.96^{**})$$

The economic optimum levels of nitrogen at Samaru for 'Samaru 71' and 'Super okra' were 50.0 and 70 kg ha^{-1}, respectively, with a mean of 64.0 kg N ha^{-1}. The economic optimum level of nitrogen at Mokwa were 62.0 and 66.0 kg N ha^{-1}. 'Super okra' responded more to N application. Taking into account the hoe farmers' production constraints, 40 kg N ha^{-1} may

be used. In addition to increasing the seed cotton yield, the application of N markedly increased many growth and yield components, among them were: LAI at 15 weeks after sowing, average number of fruiting branches m^{-2}, average boll weight, seed index, total dry matter (TDM) and plant height. Nitrogen fertilization also increased the earliness of the crop. It, however, decreased the harvest ratio and increased boll shedding.

The response of late-sown cotton to plant population varied at the two locations. At Samaru, population densities of 100,000 and 150,000 plants ha^{-1} increased the seed cotton yield by 18.4% and 24.1% over 50,000 plants ha^{-1}, respectively. Several growth and yield components were increased with higher plant population namely: LAI, average number of fruiting branches m^{-2}, TDM, earliness in terms of MMD and number of days from planting to first boll opening. On the other hand, increased plant population resulted in the decrease of plant height, average number of mature bolls per plant, harvest ratio, increased boll abortion, decreased per cent nitrogen in the leaves, delayed maturity in terms of PRI, However, at Mokwa, higher plant population above 50,000 plants ha^{-1} resulted in increased growth and yield components but resulted in yield reductions. By increasing the plant population from 50,000 to 100,000 plants ha^{-1} a yield reduction of 7.2% was incurred. A further increase to 150,000 plants ha^{-1} resulted in 23.6% decrease in the seed cotton yield at Mokwa.

The regression equations of seed cotton yield on plant population were:

Samaru: 'Samaru 71'

$Y = 34.26\ x + 0.24\ x^2 + 0.0005\ x^3$ .....(i)

and that of 'Super okra' was:

$Y = 30.09\ x + 0.18\ x^2 + 0.0004\ x^3$ .....(ii)

At Mokwa, the regression equation was:

$Y = 35.45\ x - 0.37\ x^2 + 0.0013\ x^3$ .....(iii)

and

$Y = 37.71\ x - 0.33\ x^2 + 0.0008\ x^3$ .....(iv)

for 'Samaru 71' and 'Super okra', respectively.

The model that best fitted Samaru data was:

$$Y = b_1x - b_2x^2 + b_3x^3$$

where, Y = yield in kg ha^{-1} of seed cotton

x = plant population in thousands ha^{-1}

b_1, b_2, b_3 = regression constants.

The optimum plant population was calculated using the formula in section 3.6 and equations (i) and (ii) above. The optimum plant population for 'Samaru 71' at Samaru was 107,500 plants ha^{-1} and that of 'Super okra' at the same location was 149,000 plants ha^{-1}. For 'Samaru 71' spacings of 90 x 20 cm or 75 x 25 cm keeping two plants per stand can be used to obtain the optimum plant population. For 'Super okra' spacings of 90 x 15 cm or 75 x 18 cm keeping two plants per stand may be used to obtain the optimum plant population.

There was a negative response to increased plant population at Mokwa for the three cotton cultivars tested. It seemed that the optimum plant population was below the range tested. Lower plant populations than those used in these trials may be tested to determine the optimum plant population of cotton at Mokwa.

Of the three row spacings tested (60, 75 and 90 cm), the conventional row (90 cm) gave the lowest seed cotton yield. The 75 cm row gave 9.6% and 50.7% increases in seed cotton yield over 60 and 90 cm rows, respectively. Much can be gained from the narrow row culture: it improves the rectangularity leading to improved LAI early in the season, and probably more efficient interception of solar energy. Considering the growth pattern of cotton and from the stand point of effective weed control, a near equidistant plant arrangement seems most appropriate.

The interaction between nitrogen and plant population on seed cotton yield at Samaru in 1981 was of practical importance. Cotton responded significantly to 40 kg N ha^{-1} at all the plant population levels tested. While higher population levels did not benefit cotton yield in unfertilized plots.

With the use of stepwise multiple regression, yield

characters viz. LAI at the 15 weeks after sowing, average number of mature bolls per plant, average number of fruiting branches m^{-2}, and average boll weight were identified as the major contributors to seed cotton yield. By means of regression analysis, it is possible to determine single or multiple yield components that can be used to predict yield potential of cotton. These yield components can be used by plant breeders and agronomists to manipulate seed cotton yield genetically and culturally.

Possible Future Investigations

For some time to come, the production of cotton in this country will lie in the hands of the hoe farmers. On hoe farmers' fields, early sowing, use of fertilizers and adequate control of pests are the exceptions rather than the rule. Therefore, with the present standard of management practices and late planting conditions, an early maturing cultivar like 'Super okra' may be more suitable especially when planted on narrow row and high population densities. There is thus need to determine the optimum plant population, including row spacing for the cultivars especially 'Super okra' under late (July) and very late (August) sown conditions, population levels lower than those used in this study should be used in the southern cotton zone especially for 'Samaru 71'. It is necessary to test the rational behind the use of two plants per stand considering the ontogeny of the cotton plant. So far there is no nitrogen fertilizer recommendation for the July sown cotton. It is, therefore, necessary to further investigate and determine the optimum levels of nitrogen, phosphorus and potassium for the late-sown cotton in all the cotton growing zones in Nigeria.

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Appendix I: Mean monthly rainfall (mm) at Samaru

Month	1928-1981	1979	1980	1981
January	0.1	0.0	0.0	0.0
February	1.0	0.0	0.0	0.0
March	6.3	10.4	0.0	0.0
April	37.6	19.0	3.7	100.7
May	122.3	86.3	154.4	90.7
June	160.3	220.2	116.4	159.0
July	222.0	373.8	260.9	254.0
August	277.0	299.8	215.8	260.6
September	218.7	142.8	71.9	133.3
October	35.0	30.0	16.3	0.0
November	1.1	9.8	0.0	0.0
December	0.1	0.0	0.0	0.0
Total	1081.1	1193.7	847.4	1019.1

Appendix 2: Mean monthly relative humidity (%) at Samaru

Month	1920-1981	1979	1980	1981
July	73.0	77.0	75.1	72.9
August	75.7	76.7	82.4	75.7
September	69.4	70.2	69.1	69.4
October	52.0	54.4	55.0	53.9
November	25.2	31.0	23.9	22.7
December	10.8	19.5	19.4	19.0

Appendix 3: Mean monthly maximum and minimum air temperatures (^{o}C) at Samaru.

Month	1938-1981		1979		1980		1981	
	Max	Min	Max	Min	Max	Min	Max	Min
July	28.4	19.5	28.9	19.4	28.7	19.6	28.1	19.5
August	27.7	19.3	28.8	19.7	28.1	19.4	28.4	19.5
Sept	29.4	19.2	29.6	18.9	30.6	19.4	30.1	19.4
October	31.4	17.7	32.1	18.1	32.0	18.8	32.5	17.3
Nov	31.5	15.4	32.3	15.1	31.9	13.9	29.1	14.2
Dec	30.3	13.7	28.3	12.2	28.4	11.7	30.3	12.7

Appendix 4: Mean monthly actual sunshine hours at Samaru.

Month	1954-1981	1979	1980	1981
July	6.1	6.9	6.5	7.7
August	5.3	5.7	6.1	6.5
September	7.0	6.0	7.6	7.7
October	8.0	8.7	8.6	8.7
November	9.4	8.7	8.9	7.1
December	9.4	8.3	7.6	9.3

Appendix 5: Mean monthly rainfall (mm) at Mokwa

Month	1951-1981	1979	1980	1981
January	1.7	0	0	0
February	4.6	0	0	0
March	18.3	6.1	22.1	8.4
April	58.6	102.6	3.8	58.2
May	123.4	65.5	155.2	209.3
June	175.8	216.4	112.0	151.4
July	165.5	133.9	150.1	225.9
August	158.1	200.9	212.3	242.2
September	227.6	221.0	213.6	149.3
October	93.9	20.3	138.4	59.0
November	4.7	4.6	0	0
December	-	0	0	0
Total	1,049.6	971.3	1,007.6	1,103.6

Appendix 6: Mean monthly relative humidity (%) at Mokwa

Month	1964-1981	1979	1980	1981
July	81.4	94.1	81.8	69.0
August	82.1	95.3	79.5	68.7
September	82.9	91.8	87.6	71.0
October	76.8	91.4	87.6	67.4
November	61.0	84.3	76.9	61.5
December	59.4	74.2	63.6	63.7

Appendix 7: Mean monthly actual sunshine hours at Mokwa.

Month	1964-1981	1979	1980	1981
July	5.7	6.5	4.9	5.6
August	4.7	5.3	5.4	5.1
September	5.6	6.0	6.0	5.9
October	7.4	7.4	5.3	7.9
November	8.5	7.7	8.2	7.1
December	8.3	7.9	7.9	7.9

Appendix 8: Mean monthly maximum and minimum for temperatures (^{o}C) at Mokwa.

Month	1964-1981		1979		1880		1981	
	Max	Min	Max	Min	Max	Min	Max	Min
July	29.9	21.8	29.5	22.1	27.3	22.3	31.7	21.9
August	29.4	23.9	28.1	21.1	30.5	21.9	33.3	22.9
September	29.7	21.4	28.7	20.8	29.6	22.4	30.8	21.9
October	31.3	21.1	30.9	21.8	28.0	21.9	32.2	21.7
November	30.9	16.8	29.0	19.4	27.1	19.3	28.5	17.5
December	28.1	14.7	28.5	13.7	26.2	15.4	21.5	13.7

Appendix 9a: First and second seed cotton picking as percentage of the total yield related to nitrogen level at Samaru (2 yr mean).

Cultivar	0		40		80		120	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Samaru 71	64	36	69.9	30.1	65.9	34.1	71.1	28.9
Super okra	74.5	25.5	78.5	21.5	78.9	21.1	77.1	22.9

Appendix 9b: First, second and third seed cotton pickings as percentage of the total yield related to nitrogen level at Mokwa (3 yr mean)

Cultivar	0			40			80			120 kg N ha^{-1}		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Samaru 71	44.2	24.4	31.4	39.5	29.0	31.5	33.3	30.8	35.9	25.2	24.1	50.7
Super okra	51.0	25.4	23.4	48.5	27.5	24.0	43.6	28.2	28.2	41.0	26.9	32.1

Appendix 10a: First and second seed cotton pickings as percentage of the total yield related to plant population at Samaru (2 yr mean and 2 pickings)

Cultivar	50		100		150		200		250(000 ha^{-1})	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Samaru 71	65.8	34.2	74.4	25.6	70	30	66	34	62.5	37.5
Super okra	72.5	27.5	73	27	83.4	16.6	79.8	20.2	84.0	16.0

Appendix 10b: First, second and third seed cotton pickings as percentage of the total yield related to plant population at Mokwa (3 yr mean and 3 pickings).

Cultivar	50			100			150			200			250 (000 ha^{-1})		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Samaru 71	41.1	33.2	25.7	37.2	27.2	35.6	32.2	29.3	38.5	42.9	23.6	33.5	37.6	25.2	37.2
Super okra	44.2	31.1	24.7	48.1	28.4	23.4	45.5	28.8	25.7	52.4	23.5	24.1	52.1	22.3	25.6

Appendix 11: First, second and third seed cotton pickings as percentage of the total yield related to plant population at Mokwa, second project (3 yr mean).

Cultivar	50			100			150 (000 ha^{-1})		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Samaru 71	45.4	31.7	22.9	43.7	29.1	27.2	41.0	30.7	28.3
Bar 14/25	33.4	27.9	38.7	37.3	27.3	35.4	34.0	26.1	39.9
Super okra	56.9	37.7	5.4	54.1	37.3	8.6	45.6	29.3	25.1

Appendix 12: First, second and third seed cotton pickings as percentage of the total yield related to row spacing at Mokwa (3 yr mean).

Cultivar	60			75			90 (cm)		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Samaru 71	43.8	28.5	27.7	43.3	31.0	25.7	43.0	31.5	25.5
Bar 14/25	35.9	27.1	37.0	35.4	25.9	38.7	33.5	24.5	42.0
Super okra	52.5	26.7	20.8	51.4	28.3	20.3	52.6	26.6	20.8

Appendix 13a: Economic returns from the factors based on the mean of seed cotton yield at Samaru.

Treatment	Net Return ₦ ha^{-1}*	Additional Return ₦ ha^{-1}
Cultivar		
Samaru 71	246.54	-
Super okra	334.66	+100.12
Nitrogen level (kg ha^{-1})		
0	165.51	-
40	394.12	+220.61
80	360.59	+195.08
120	282.69	+117.18
Plant population (000 ha^{-1})		
50	196.07	-
100	294.83	98.76
150	323.03	126.96
200	281.87	85.80
250	292.22	96.16

* Computed using unsubsidised prices of fertilizers, seeds, insecticide and extra labour due to increased plant population.

Appendix 13b: Economic returns from the factors based on the mean of seed cotton yield at Mokwa.

Treatment	Net Return ₦ ha^{-1}*	Additional Return ₦ ha^{-1}
Cultivar		
Samaru 71	50.70	-
Super okra	188.91	+138.21
Nitrogen level (kg ha^{-1})		
0	46.17	-
40	155.95	+109.78
80	54.23	+ 9.94
120	76.14	+ 29.97
Plant population (000 ha^{-1})		
50	191.66	-
100	138.26	- 63.40
150	27.23	-174.43
200	91.64	-110.02
250	37.22	-164.44

* Computed using unsubsidised prices of fertilizer, seeds, insecticide and extra labour due to increased plant population.

Appendix 14a: Analysis of variance of seed cotton yield at Samaru in 1980.

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	18733.32	9366.66	0.10	NS
Population (P)	4	1.51" + 006	378109.10	3.06*	SIG
Error (a)	8	703645.04	97955.73		
Subplot					
Nitrogen (N)	3	8.41" + 006	2.8" + 006	51.87**	SIG
Variety (V)	1	3910.21	3910.21	0.07	NS
P X N	12	1.6" + 006	96288.75	1.78	NS
P x V	4	47529.58	11881.90	0.22	NS
N x V	3	169198.42	56399.48	1.04	NS
P x N x V	12	160430.28	13369.19	0.25	NS
Error (b)	70	3.79" + 006	54076.08		
Total	119	1.65" + 007			

Appendix 14b: Analysis of variance of seed cotton yield at Samaru in 1981.

Source of variation	Degree of freedom	Sum of square	Mean	F	Significance
Main plot					
Replication	2	9.65" + 006	4.82" + 006	11.13**	SIG
Population (P)	4	1.69" + 006	422923.03	0.98	NS
Error (a)	8	3.47" + 006	433361.27		
Subplot					
Nitrogen (N)	3	3.47" + 006	1.12" + 006	4.53**	SIG
Variety (V)	1	5.67" + 006	5.67" + 006	22.92**	SIG
P x N	12	6.48" + 006	540105.61	2.10*	SIG
P x V	4	4.20" + 006	1.05" + 006	4.25**	SIG
N x V	3	3.00" + 006	1.00" + 006	4.04*	SIG
P x N x V	12	2.31" + 006	192312.29	0.78	NS
Error (b)	70	1.73" + 007	247393.59		
Total	119	5.72" + 007			

Appendix 15a: Analysis of variance of seed cotton yield at Mokwa in 1979.

Source of variation	Degree of Freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	67318.88	33659.44	1.27	NS
Population (P)	2	499574.54	249787.27	9.40**	SIG
Error (a)	4	106310.42	26577.61		
Subplot					
Nitrogen (N)	3	979145.23	326381.74	16.77**	SIG
Variety (V)	2	4226.89	2113.45	0.22	NS
P x N	6	97535.50	16255.92	0.84	NS
P x V	2	184434.48	92217.24	4.74**	SIG
N x V	3	36006.01	12002.00	0.62	NS
P x N x V	6	45055.77	7509.29	0.39	NS
Error (b)	42	817206.68	19457.30		
Total	71	2.83" + 006			

Appendix 15b: Analysis of variance of seed cotton yield at Mokwa in 1980.

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	2.61" + 006	1.30" + 006	6.34**	SIG
Population (P)	4	1.52" + 006	379288.66	1.64	NS
Error (a)	8	1.65" + 006	205820.67		
Subplot					
Nitrogen (N)	3	2.84" + 006	963434.47	9.64**	SIG
Variety (V)	1	2.09" + 006	2.09" + 006	20.93**	SIG
P x N	12	669345.83	55778.75	0.56	NS
P x V	4	1.21" + 006	301333.41	3.02*	SIG
N x V	3	509748.42	169916.14	1.70	NS
P x N x V	12	2.60" + 006	216818.67	2.17*	SIG
Error (b)	70	6.99" + 006	99923.75		
Total	119	2.27" + 007			

Appendix 15c. Analysis of variance of seed cotton yield at Mokwa in 1981.

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main Plot					
Replication	2	53601.8	26800.9	0.06	NS
Population (P)	4	5.20" + 006	1300527	2.95*	SIG
Error (a)	8	1.76" + 006	220179.3		
Subplot					
Nitrogen (N)	3	1.70" + 006	568169.87	4.5**	SIG
Variety (V)	1	8.23" + 006	8.23" + 006	65.2**	SIG
P x N	12	640682.50	53390.22	0.42	NS
P x V	4	1.30" + 006	325449.8	2.58*	SIG
N x V	3	475049.62	158349.9	1.26	NS
P x N x V	12	1.01" + 006	83986.08	0.07	NS
Error (b)	70	8.83" + 006	126124.7		
Total	119	2.92" + 007			

Appendix 16a: Analysis of variance of seed cotton yield at Nokwa in 1979 (Expt. II)

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	706927.5	353463.8	3.02	NS
Row (R)	2	307162.4	153581.2	1.31	NS
Error (a)	4	468749.2	117187.3		
Subplot					
Population (P)	2	93772.3	46886.2	0.45	NS
Variety (V)	2	5.72" + 006	2.86" + 006	27.71**	SIG
R x P	4	292841.9	73210.5	0.71	NS
R x V	4	31296	7824.2	0.08	NS
P x V	4	744573	186143.3	1.80	NS
R x P x V	8	483259.1	60407.4	0.59	NS
Error (b)	48	4.95" + 006	103196.3		
Total	80	1.38" + 007			

Appendix 16b: Analysis of variance of seed cotton yield at Mokwa in 1980 (Expt. II)

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	646864.5	323432.2	1.6	NS
Row (R)	2	5584164.9	2792082.5	14.1**	SIG
Error (a)	4	794585.8	198646.5		
Subplot					
Population (P)	2	4336995.6	2168497.8	2.4	NS
Variety (V)	2	23598555.3	11799277.6	13.0**	SIG
R x P	4	1090943.8	272736.0	0.3	NS
R x V	4	1987239.0	496809.8	0.5	NS
P x V	4	1615750.3	403947.6	0.4	NS
R x P x V	8	1591475.8	198934.5	0.2	NS
Error (b)	48	43581039.0	907938.3		
Total	80	84827654.1			

Appendix 16c: Analysis of variance of seed cotton yield at Mokwa in 1981 (Expt. II)

Source of variation	Degree of freedom	Sum of square	Mean square	F	Significance
Main plot					
Replication	2	175214.2	87607.1	2.4	NS
Row (R)	2	1.08" + 006	540789.9	14.7**	SIG
Error (a)	4	146920.4	36730.1		
Subplot					
Population (P)	2	373744.3	186872.2	4.1	SIG
Variety (V)	2	650322.0	325161.0	7.1**	SIG
R x P	4	21652.5	5413.1	0.12	NS
R x V	4	138859.3	34714.8	0.76	NS
P x V	4	170272.4	42568.1	0.93	NS
R x P x V	8	399703.9	49963.0	1.1	NS
Error (b)	48	2.20" + 006	45748.1		
Total	80	5.35" + 006			

Appendix 17: Common and chemical names of herbicides and insecticides mentioned in the text.

Common name	Chemical name
Diuron	3- (3, 4 - Dichlorophyenyl) - 1, 1 - dimethylurea.
Fluridone	1 - methyl - 3 - phenyl - 5 - /3 - (trifluoromethyl) phenyl/ - 4 (IH) - pyridinone.
Carbaryl	1-naphthyl methylcarbamate
B.H.C.	Benzene hexachloride
D.D.T.	Dichlorodiphenyltrichloroethane
Cypermethrin	(±) - (cyano-3-phenoxybenzyl (±) cis, trans-3-(2, 2- dichlorovinyl) 2, 2-dimethylcyclopropane carboxylate.

BIOGRAPHY: NDITOI U. A. IDEM

Name: Nditoi U. A. IDEM

Date of Birth: 15th September, 1945

Business Address: Department of Agronomy,
Institute for Agric. Research,
Ahmadu Bello University,
P. M. B. 1044,
Zaria

Home Address: No. 8 Hospital Road,
P. O. Box 54,
Eket, Cross River State

Previous Qualifications: B.Sc. (Agric.), ABU; M.S.(Agronomy), Texas A & M

Institutions Attended:	From	To	Cert./Diploma/Degree
Ikot Eyo Town School, Ikot Eyo, Cross River State	1952	1959	First Sch. Leaving Cert.
Qua Iboe Mission Secondary School, Etinan, Cross River State	1960	1964	West African Sch. Cert.
	1965	1966	Higher School Cert.
Ahmadu Bello University, Zaria	1969	1972	B.Sc. (Agric.)
Texas A & M University, College Station, U.S.A.	1976	1977	M.Sc. (Agronomy)

Posts held since the Award of First Degree:

Organization:	From	To	Position
Institute for Agric. Research, Ahmadu Bello University, Zaria	1972	1976	Asst. Research Fellow
	1976	1979	Research Fellow II
	1979	1981	Research Fellow I
	1981	to date	- Senior Res. Fellow

Year of Admission for Ph.D. Degree: January, 1979

Admission Number: Ph.D./Agric./1536/79-80