THE EFFECT OF PLANT POPULATION AND PLANT ARRANGEMENT OF THE PERFORMANCE OF MAIZE (*Zea mays* L.) AND SORGHUM (*Sorghum bicolor* L. Moench) IN MIXED CROPS

By

GARBA ALIYU LERE

A Thesis submitted to the Postgraduate School, Ahmadu Bello University, Zaria, in partial fulfilment of the requirements for the Degree of Master of Science in Agronomy.

DEPARTMENT OF AGRONOMY

FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY, ZARIA,

NIGERIA

MARCH, 1985

D E C L A R A T I O N

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



GARBA ALIYU LERE

Date: 3-5-85

The declaration is confirmed

(Sgd)

DR. N. M. FISHER
(Major Supervisor)

Date: .....

C E R T I F I C A T I O N

This thesis entitled 'THE EFFECT OF PLANT POPULATION AND PLANT ARRANGEMENT ON THE PERFORMANCE OF MAIZE AND SORGHUM IN MIXED CROPS' BY G. A. IERE meets the regulation governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to Scientific knowledge and literary presentation.

Dr. O. O. Ologunde
Member, Supervisory Committee

(Sgd)
Dr. N. M. Fisher
Chairman, Supervisory Committee

Dr. V. B. Ogunlela
Member, Supervisory Committee

Prof. J. Y. Yayock
Head, Department of Agronomy

Dean, Postgraduate School

Date: 25/VI/85

AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA.

D E D I C A T I O N

To

The Compassionate
The Merciful
The Sustainer of the universe
"When he decrees for a thing,
he says to it BE and IT IS"

ACKNOWLEDGEMENT

I wish to expeess my deep and sincere appreciation to my major supervisor Dr. N.M. Fisher, not only for his guidance and parental advice he had consistently offered me during the course of this study, but also for his moral and financial support. I am really grateful and hope that God will reward him for all that he had done.

I am also indebted to other members of my supervisory committee, namely Dr. O. O. Ologunde and Dr. V. B. Ogunlela for their constructive criticisms and suggestions during the preparation of this thesis. My gratitude is also extended to Dr. K. A. Elemo, for his valuable contribution to the improvement of this write-up.

Sincere appreciation is also extended to the Head of Agronomy Department, Prof. J. Y. Yayock; and other members of staff of the Department for their assistance, encouragement and constructive criticisms, which had a benefitial influence on this work.

I extend gratitude to my parents and relatives, especially Alhaji Aliyu Abdullahi, Alhaji Dabo Mohammad and Isa Aliyu, for their moral and financial support without which this work would not have been possible. In this respect, the Kaduna State Government deserves a special mention for its financial support..

I am also indebted to Mr. Anthony D. Dauda for typing this thesis and to my friends and all other colleagues for their assistance in various ways.

ABSTRACT

A field experiment was conducted at Saminaka and Samaru in 1983 with the aim of determining the effects of plant population and cropping pattern on the yield and yield components of maize and sorghum in mixture. An attempt was aisn made to determine the optimum plant population and cropping pattern for the mixture.

A factorial experiment was laid out in a randomized complete block design with four replications. Combination of two plant populations (44,444 and 66,666 plants ha^{-1}) and six cropping patterns (2:1 and 1:2 of maize: sorghum mixture at alternate row and within row arrangement together with sole maize ana sorghum) made up the treatments.

Increasing plant population of maize in the mixture from 44,444 to 66,666 plants ha^{-1}) increased the grain yield at Samaru but not at Samina.ka. The 2:1 proportion of maize:sorghum at alternate and mixed within row gave better grain yield of maize than the 1:2 proportion, but inferior to the sole maize at both locations. These observations were supported by data on light interception. At both. Samaru and Saminaka, plant population levels and cropping pattern failed to affect the grain yield of sorghum.

There was an average mixing advantage of 20% for the 2:1 and 1:2 proportions at Samaru while at Samin[a]ka, the mixing advantage were *25%* and *30%* for the alternate and mixed row respectively. The land equivalent ratio (LER) gave a similar results with an average of 1.37 and 1.07 for the 2:1 and 1:2

proportions at both sites. At Samaru, all cropping patterns gave higher grain yield at higher plant populations except for a small decline in the 112 mixed row while at Saminaka, three of the mixed crops responded positively to plant populations whereas "both sole crops responded negatively. The alternate row had higher LER at Samaru while the mixed row arrangement had higher LER at Saminaka. It is therefore obvious from this work that the optimum arrangement for sorghum:maize mixture is conclusive. The 2:1 proportions (maize:sorghum) performed better than the 1:2 proportions at both locations.

TABLE OF CONTENTS

CHAPTER		PAGE
	Dedication: : : :	i
	Acknowledgement : : :	ii
	Abstract : : : :	iii
	List of tables : : :	ix
	List of Figures : : :	xiv
	List of Appendices : : :	xv
1.	INTRODUCTION : : : :	1
2.	LITERATURE REVIEW : : :	3
	2.1. Crop Mixture defined : :	3
	2.2. General aspects of plant population and arrangement : : :	3
	2.3. Population effect on grain yield	4
	2.3.1. Sole Maize : :	4
	2.3.2. Shoot characteristics : :	6
	2.3.3. Whole crop yield for animal feed :	7
	2.3.4. Partitioning of assimilate :	9
	2.3.5. Population effect on grain yield of sole sorghum : : :	10
	2.3.6. Shoot characteristics : :	12
	2.3.7. Partitioning of assimilate: :	13
	2.3.8. Population and arrangement in mixed crops : : : :	14
	2.4. Plant population and leaf cover :	15
	2.4.1. Leaf cover and light interception :	15
	2.4.2. Maize leaf cover : :	16
	2.4.3. Sorghum leaf cover : :	17
3.	MATERIALS AND METHODS : : :	18
	3.1. Experimental location : :	18

CHAPTER

		PAGE
3.2.	Crop Varieties : :	18
3.3.	Experimental Design : :	18
3.4.	Experimental Treatment : :	19
3.5.	Iand preparation and crop husbandry: :	19
3.6.	Measurement and observations :	19
3.6.1.	Meteorological data : :	19
3.6.2.	Establishment count : :	21
3.6.3.	Ieaf cover of maize and sorghum :	21
3.6.4.	Plant dry weight : :	21
3.6.5.	Tiller number/net plot : :	22
3.6.6.	Date of heading in sorghum and tasselling in maize : :	22
3.6.7.	Stand count at harvest : :	22
3.6.8.	Lodging count of sorghum and maize :	22
3.6.9.	Plant height : : :	22
3.6.10.	Number of ears and heads per net plots	22
3.6.11.	Grain yield : : :	23
3.6.12.	1000-grain weight : :	23
3.6.13.	Dry weight at harvest : :	23
3.6.14.	Statistical analysis : :	23
3.6.15.	Analysis for total grain yield :	23
4.	RESULTS : : : : :	25
4.1.	Ieaf cover of maize and sorghum at Samaru ; : :	25
4.1.1.	Maize leaf cover: : :	25
4.1.2.	Sorghum leaf cover : :	27
4.1.3.	Total leaf cover of maize and sorghum in mixed crops : : :	32
4.2.	Dry weight of maize and sorghum at Samaru. : : :	35

CHAPTER			PAGE
	4.2.1.	Maize shoot dry weight : : :	35
	4.2.2.	Sorghum shoot dry weight : : :	37
	4.3.	Yield and yield attributes of maize and sorghum in mixed crops :	39
	4.3.1.	Yield attributes of maize at Samaru:	39
	4.3.2.	Yield attributes of sorghum at Samaru	44
	4.4.	Total yield of grain and dry matter in maize and sorghum mixed crops :	50
	4.4.1	Total grain yield : :	50
	4.4.2	Total dry matter : :	52
	4.4.3.	IER for grain yield at Samaru :	52
	4.5.	Yield and yield attributes of maize and sorghum in mixed crop at Saminaka	54
	4.5.1.	Yield attributes of maize :	54
	4.5.2.	Yield attributes of sorghum :	57
	4.6.	Total yield of grain and dry matter in maize and sorghum in mixed crops at Saminaka. : : :	62
	4.6.1.	Total grain yield : :	62
	4.6.2.	Total dry matter : :	62
	4.6.3.	IER for grain yield at Saminaka :	64
5.	DISCUSSION : : : :		66
	5.1.	Differences in grain yield between sole crop maize and sorghum :	66
	5.2.	Advantage of mixing : :	66
	5.3.	- . :	74
	5.4.	:	75
	5.5.	Optimum proportions for maize and sorghum mixed crops at Samaru and Saminaka.	76

CHAPTER		PAGE
6.	SUMMARY AND CONCLUSION : : :	78
7.	REFERNECES : : : :	80
8.	APPENDICES : : : :	86
	SHORT BIOGRAPHY : : :	98

LIST OF TABLES

		Page
1.	Physical and chemical analysis of soil sample taken at 0-15cm depth with an augar from experimental location after harrowing at Samaru and Saminaka, 1985: : :	20
2.	The effect of cropping pattern and plant population on the leaf cover (%) of maize at 6 w.a.s., Samaru 1983 : : :	26
3.	The effect of cropping pattern and plant population on the leaf cover (%) of maize at 8 w.a.s. at Samaru, 1983 : : :	26
4.	The effect of cropping pattern and plant population on the leaf cover (%) of maize at 11 w.a.s. Samaru, 1983 : : :	27
5.	The effect of cropping pattern and plant population on the leaf cover (%) of maize at 15 w.a.s. Samaru 1983 : : :	28
6.	The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 6 w.a.s. Samaru 1983 : : :	28
7.	The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 8 w.a.s. Samaru, 1983.: : :	29
8.	The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 11 w.a.s. Samaru 1983 : : :	31
9.	The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 15 w.a.s. Samaru, 1983: : :	31
10.	The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 18 w.a.s. Samaru, 1983: : :	32
11.	The effect of cropping pattern and plant population on the total leaf cover (%) of maize and sorghum in mixed culture at 6 w.a.s. Samaru, 1983 : : : :	33
12.	The effect of cropping pattern and plant population on the total leaf cover (%) of maize and sorghum in mixed culture at 8 w.a.s. Samaru, 1983. : : : :	33
13.	The effect of cropping pattern and plant population on the total leaf cover (%) of maize and sorghum in mixed crops at 11 w.a.s. Samaru, 1983 : : : :	34

Table		Page
14.	The effect of cropping pattern and plant population on the total leaf cover (%) of maize and sorghum in mixed culture at 15 w.a.s. Samaru, 1983	35
15.	The effect of cropping pattern and plant population on the dry weight of maize shoot at 6 w.a.s. Samaru, 1983	36
16.	The effect of dropping pattern and plant population on the dry weight (g/plant) of maize shoot at 11 w.a.s. Samaru, 1983	36
17.	The effect of cropping pattern and plant population on the dry weight (g/plant) of sorghum shoot at 6 w.a.s. Samaru, 1983.	38
18.	The effect of cropping pattern and plant population on the dry weight (g/plant) of sorghum shoot at 11 w.a.s. Samaru, 1983	38
19.	The effect of cropping pattern and plant population on the dry weight (g/plant) of sorghum shoot at 15 w.a.s. Samaru, 1983	39
20.	The effect of cropping pattern and plant population on the plant count (plants ha^{-1}) of maize, Samaru, 1983	40
21.	The effect of cropping pattern and plant population on the cob number of (cobs ha^{-1}) of maize, Samaru, 1983	40
22.	The effect of cropping pattern and plant population on the cob weight (kg ha^{-1}) of maize at Samaru, 1983	42
23.	The effect of cropping pattern and plant population on the grain yield (kg ha^{-1}) of maize at Samaru, 1983	42
24.	The effect of cropping pattern and plant population on the straw dry weight (kg ha^{-1}) of maize, Samaru, 1983	43
25.	The effect of cropping pattern and plant population on the 1,000-grain weight (g) of maize Samaru, 1983	43
26.	The effect of cropping pattern and plant population on the plant height (m) of maize at harvest, Samaru 1983	45
27.	The effect of cropping pattern and plant population on the harvest index of maize Samaru, 1983	45

Table		Page
28.	The effect of cropping pattern and plant population on the plant count (plants ha^{-1}) of sorghum, Samaru, 1983	46
29.	The effect of cropping pattern and plant population on the number of heads (heads ha^{-1}) of sorghum, Samaru, 1983	46
30.	The effect of cropping pattern and plant population on the dry weight (kg ha^{-1}) of sorghum heads Samaru, 1983	48
31.	The effect of cropping pattern and plant population on the grain yield (kg ha^{-1}) of sorghum Samaru, 1983	48
32.	The effect of cropping pattern and plant population on the straw dry weight (kg ha^{-1}) of sorghum Samaru, 1983	49
33.	The effect of cropping pattern and plant population on the 1000-grain weight (g) of sorghum, Samaru, 1983	49
34.	The effect of cropping pattern and plant population on the plant height (m) of sorghum at harvest at Samaru, 1983	51
35.	The effect of cropping pattern and plant population on the harvest index of sorghum at Samaru, 1983	51
36.	The effect of cropping pattern and plant population on the total grain yield (kg ha^{-1}) of maize and sorghum in mixed culture at Samaru 1983	52
37.	The effect of cropping pattern and plant population on the total dry matter yield (kg ha^{-1}) of maize and sorghum in mixed culture Samaru, 1983	53
38.	The effect of cropping pattern and plant population on the land equivalent ratio (LER) of maize and sorghum in mixed culture at Samaru, 1983	53
39.	The effect of cropping pattern and plant population on the plant count (plants ha^{-1}) of maize at Samaru, 1983	54
40.	The effect of cropping pattern and plant population on the cob number (cobs ha^{-1}) of maize at Saminaka 1983	55

Table		Page
41.	The effect of cropping pattern and plant population on the grain yield (kg ha^{-1}) of maize at Saminaka, 1983. : : :	56
42.	The effect of cropping pattern and plant population on the straw dry weight of (kg ha^{-1}) of maize at Saminaka, 1983 : :	56
43.	The effect of cropping pattern and plant population on the plant height (m) of maize at harvest in meters, at Saminaka, 1983 :	58
44.	The effect of cropping pattern and plant population on the harvest index of maize, at Saminaka, 1983 : : : :	58
45.	The effect of cropping pattern and plant population on the plant count (plant ha^{-1}) of sorghum, at Saminaka, 1983 : :	59
46.	The effect of cropping pattern and plant population on the number of sorghum head, (heads ha^{-1}) at Saminaka, 1983 : :	59
47.	The effect of cropping pattern and plant population on the grain yield (kg ha^{-1}) of sorghum at Saminaka, 1983 : :	60
48.	The effect of cropping pattern and plant population on the straw dry weight (kg ha^{-1}) of sorghum at Saminaka, 1983 : :	61
49.	The effect of cropping pattern and plant population on the plant height (m) of sorghum at harvest in at Saminaka, 1983 : :	61
50.	The effect of cropping pattern and plant population on the harvest index of sorghum at Saminaka, 1983 : : : :	63
51.	The effect of cropping pattern and plant population on the total grain yield (kg ha^{-1}) of maize and sorghum in mixed at Saminaka, 1983	63
52.	The effect of cropping pattern and plant population on the total dry matter (kg ha^{-1}) of maize and sorghum in mixed culture at Saminaka, 1983 : : : :	64
53.	The effect of cropping pattern and plant population on the land equivalent ratio (LER) of maize and sorghum in mixed culture at Saminaka, 1983. : : :	65
54.	Expected yields of grain and dry matter (kg ha^{-1}) for maize and sorghum at two sites :	71

Table		Page
55.	Percent gain in grain yield due to mixing at Samaru and Saminaka : : :	72
56.	Percent gain in dry matter due to mixing at Samaru and Saminaka : : :	74

Figure

		Page
1.	Yield as influenced by replacement proportion (alternate) of maize and sorghum at Samaru, 1983 : : : :	67
2.	Yield as influenced by replacement proportion (mixed row) of maize and sorghum at Samaru 1983 : : :	68
3.	Yield as influenced by replacement proportion (alternate) of maize and sorghum at Saminaka, 1983.	69
4.	Yield as influenced by replacement proportion (mixed row) of maize and sorghum at Saminaka, 1983.	70

Appendix

		Page
A.1.	Daily rainfall (mm) during the cropping season at Samaru, 1983 : : :	86
A.2.	Daily rainfall (mm) during the cropping season at Saminaka, 1983 : : :	87
B.	Temperature, solar radiation and sunshine hours during the cropping season at Samaru, 1983 : : : :	88
C.1.	Analysis of variance for maize leaf cover (%) at 6, 8, 11 and 15 weeks after sowing Samaru, 1983 : : : :	89
C.2.	Analysis of variance for sorghum leaf cover (%) at 6, 8, 11, 15 and 18 weeks after sowing at Samaru, 1983. : : :	90
C.3.	Analysis of variance for total leaf cover (%) of maize and sorghum in mixed culture at 6, 8, 11 and 15 weeks after sowing Samaru, 1983	91
C.4.	Analysis of variance for maize and sorghum leaves, stem and sheath at 6, and 11 weeks after sowing at Samaru, 1983 : :	92
C.5.	Analysis of variance for plant count, cob number, cob weight, grain yield, straw dry weight, 1000-grain weight and plant height of maize at Samaru, 1983 : :	93
C.6.	Analysis of variance for plant count, Head number, Head weight, grain yield, straw dry weight, 1000-grain weight, and plant height of sorghum at Samaru, 1983 : :	94
C.7.	Analysis of variance for plant count, cob number, grain yield, straw dry weigt, and plant height of maize at Saminaka 1983 :	95
C.8.	Analysis of variance for plant count, heads number, grain yield, straw dry weight, and plant height of sorghum at Saminaka, 1983:	96
C.9.	Analysis of variance for total grain yield, total dry matter yield and land equivalent ratio (LER) for Samaru and Saminaka, 1983:	97

CHAPTER 1

INTRODUCTION

Mixed cropping is a common practice among tropical small scale farmers. There is abundant literature on yield advantages of crop mixtures over the sole crops. Recently, there has been a resurgences of interest in research studies on intercropping in the tropics (Okigbo, 1979). Although research and extension workers had hitherto attemrted to convince small-scale farmers in the northern states of Nigeria to shift to sole cropping, such a shift never became a reality (Abalu, 1977). Norman (1976 in his studies of three villages around Zaria showed that 83% of the cultivated area was devoted to mixed cropping with two component crop in mixtures being the most common. The potential role of improved mixed cropping in increasing world food supply has been recognized by many researchers.

Sorghum is the most important cereal crop in Nigeria. It occupies about 45% of the total land devoted to cereal production in the country and account for 44% of the total cereal production It is estimated that about 3.7 million tons of grain are produced annually (Egharevba, 1979). According to Andrews (1972), sorghum constitutes the staple food for the bulk of the population in both Sudan and Guinea savanna ecological zones of Nigeria.

Maize is also a traditional staple food crop but grown mostly in the southern parts of the country, with the area devoted to its production in the northern states fast becoming significant. The fresh grains are eaten roasted or boiled on the cob while the mature dried grains are either cooked with

pulses or processed into porridge. It is also one of the major ingredience used in the poultry industry.

Maize and sorghum mixture is gaining in importance in the southern and northern Guinea savanna zones of the country. In the traditional cropping systems of these zones, maize seems to be replacing millet. In fact, maize-sorghum mixture could be seen as a fairly recent alternative to the traditional millet-sorghum mixture in the northern Guinea savanna.

Some of the most critical problems confronting workers in crop mixtures is the proportion of the component crop and the plant arrangement to adopt in the mixture (Baker, 1979). This study was undertaken with the following objectives.

(i) To study the effect of plant population and cropping pattern on the yield and yield component of maize-sorghum crop mixture.

(ii) To determine the optimum population and cropping pattern for optimum grain yield of maize and sorghum in mixed crops.

CHAPTER 2

LITERATURE REVIEW

2.1 Mixed Cropping Defined

Ruthenberg (1971) defined mixed cropping as the growing of or more crops simultaneously without any row arrangement, while he referred to intercropping as the growing of two or more crops simultaneously in alternate rows. Other authors (Andrews and Kassam, 1976; Willey, 1979) have defined intercropping in same way as mixed cropping as the growing of two or more crops simultaneously on the same piece of land in a year irrespective of the spatial arrangement. The component crops need not necessarily be sown at exactly the same time and their harvest time may be quite different but they are at least grown together for significant part of their life cycle.

2.2 General Aspect of Plant Population and Arrangement

Plant population is defined as the number of plants per unit area of land. Spatial arrangement, on the other hand defines the distribution pattern of the plants over a given land area. The main problem in designing a suitable population for a given crop mixture is that a single plant of one component crop could not always be equated directly to a single plant of another. Replacement mixtures are often used to maintain the population pressure to enable comparison with another factor (Willey and Osiru, 1972). Among farmers with sorghum-based cropping system of the northern Guinea savanna, intercropping must give a full yield of the main crop and some

yield of the intercrop (Baker, 1978).

Hume et al. (1956) suggested that optimum plant population will vary with location and soil fertility. On a very fertile soil, Kohnke and Miles (1951) found that the best yield was obtained by planting at the rate of 37,000 - 49,930 plants ha^{-1} and that drilled maize produced more than either hilling or uniform spaced sowing.

2.3 Population effect on grain yield

2.3.1 Sole Maize

It is important that optimum plant population for maize should be established if maximum grain yield is desired. The optimum plant population for maximum grain yield of maize has been well investigated (Darrold et al 1963). A number of studies have shown the need for a relatively high plant population in order to maximise yield. In the dry western region of the United States corn belt, Hume et al., (1956) studying the effect of stand density on grain yield and kernel moisture in maize at two locations in South Dakota over a period of 10 years found that the highest average yield in the eastern part was obtained with 3.5 plants/hill while in the drier central part of the state 3.3 plants/hill produced the best result. These levels represented about 28,899 and 21,983 plants/ha^{-1} respectively. These results suggested that the optimum plant population for grain yield varied with locations and soil fertility.

In Missouri, Zuber and Grogen (1956) using 12 hybrids at three levels of plant density found that 29,640 plants^{-1} was most suitable. In North Dakota, however, Carlson et al., (1959) showed that on dryland, maximum yield level can be obtained with 27,700 plants ha^{-1} and that irrigation and nitrogen fertilizer had to be applied before a major yield response of both grain and forage could obtained from stands of 49,400 plants ha^{-1}. Muleba (1980) reported on an experiment with three maize varieties at three densities and three levels of fertilizer that all cultivars responded similarly to plant density. Ramirez and Bejerano (1983) reported that the seed yield increased with plant spacing along the row and was generally highest at 0.8m apart with 60,000 plants ha^{-1}. In assessing plant population and grain yield in maize, Bunting and Willey, (1959) reported that 73,000 plants ha^{-1} was optimal for the flint types and early hybrid varieties and that individually spaced plants performed better than those on the hill which was a common practice in the United States, thus facilitating cultivation in two directions at right angles.

Nigeria, however, optimum plant population for most maize varieties appears to be 53,000 plants ha^{-1} and any population beyond 75,000 plants ha^{-1} is likely to be detrimental to grain yield (Anon., 1983). Maximum grain yield production under a

given set of environmental conditions may involve a specific plant population depending on a particular hybrid (Darrold et al., 1963). They reported that total forage production remained at maximum even when plant population was increased further beyond optimum but production of marketable grain may be severely reduced by adopting excessive plant population levels.

2.3.2. Shoot characteristics

Plant characteristics may be affected by population densities. Zuber and Grogen (1956) reported that stalk lodging was more than doubled for each increase of 9,880 plants ha^{-1} starting from 19,760 plants ha^{-1}. Similar reports were given by Shubeck and Cardwell (1955); and Kohnke, and Miles, (1951). Silking date for maize in Indiana was delayed by two days for each increment of 7,400 to 9,880 plants ha^{-1}. These data are similar to the Minnesota result of Shubeck and Cardwell (1955), showing a five-day delay in silking associated with increase in plant population from 8,767 - 43,917 plants ha^{-1}. Contrary to this however, Zuber and Grogen (1956) could not associate any variation in silking date or maturity with an increase in plant population.

Under plant populations denser than optimum, size of maize plants becomes more variable and uniformity of both plants and their inflorescence is reduced (Darrold et al., 1963).

High plant population in maize caused an increase in the incidence of stalk lodging because of a steady decrease in stalk diameter with increase in plant population. Increase in

planting rates also resulted in a decrease in ear size and uniformity. At extremely high rates however, especially when accompanied by drought, the differences in ear size among individual hybrids were completely obliterated whereas under favourable conditions, the decrease was proportional to the plant population for each type (Darrold et al., 1963), Haggar and Couper (1972) reported that a high plant population resulted in shorter and thinner stems while nitrogen fertilizer generally resulted in increased plant height and stem thickness. Eddowes (1969c) reported that competition among plants led to a reduced ear weight per plant which was either due to increasing plant population or by partial defoliation or both.

2.3.3. Whole crop yield for animal feed

The rate of dry matter production and distribution between plant parts is affected by plant population. According to Lucas (1981), dry matter production per unit area increased as plant population increased. He observed that there was no significant difference between plant density treatment until 75 days after sowing when high plant densities of 4.4 and 6.6 plants/m^2 gave significantly higher dry matter yield per unit area than the two lowest densities of 2.6 and 3.3 plants/m^2. This difference was maintained until harvest, a stage at which this was no longer significant. He reported that the highest population reached the peak dry weight by 81 days after sowing while the lowest population attained this at 117 days. He showed that dry matter yield per unit area was higher in the derived savanna than in the forest zone. He therefore, concluded that within

the range of density treatments used, yield-plant density relationship was asymptotic, which corroborates the findings of other workers like Adelana and Milbourn (1972) and Allison and Watson, (1966).

The difference in dry matter production between treatments diminished as the season progressed (Adelana and Milbourn 1972). In their experiment on the effect of maize density on yield of digestible dry matter and grain using three maize hybrids (K75A, A210 and K33), they found that after 23 weeks, not much differences was found between the three most dense populations treatments. According to Adelana and Milbourn (1972b), stem dry weight rose to a peak at 26 weeks after sowing and then declined thereafter (by 48, 38 and 35% for K75A, A210 and K33, respectively), by the time of final harvest at 28 weeks. Haggar and Couper (1972) in their experiment on the effect of plant population on yield of maize grown for silage in Nigeria, found that within most treatments, dry matter yield of leaves reached its peak at approximately 60 days after sowing, while that of stem continued to increase until at least 70 days after sowing. They found that the stem component constituted two thirds of the total dry matter yield while the mean yield of cobs was small and represented approximately 8% of the total yield of dry matter even as late as 80 days after sowing.

Increasing plant population increased the total dry matter significantly with the close spacing (15 x 15cm) outyielding the control (90cm x 10cm) by an average of 16% (Haggar and Couper, 1972). According to these workers increasing

plant population tended to shorten the period taken to reach peak of dry matter yield while proportion in the leaf tended to increase and that in the cob decreased. Planting on the square resulted in an average increase of 20% in dry matter of corn relative to the control spacing. Eddowes (1969a) reported no significant difference in total dry matter yield within a plant population range of 37 - 93 thousand plants ha^{-1}, but that a lower plant population had lower total dry matter yield. He found that a plant population of 37,400 plants ha^{-1} outyielded both lower and higher population in terms of number of ears per unit area.

2.3.4. Partitioning of assimilate

Different maize cultivars have different abilities to translocate assimilates to their respective parts. Adelana and Milbourn (1972) found that among the three cultivars, K33, K75A and A210, used in their experiment K75A had 63% of its total shoot dry matter contained in the ear at final harvest while A210 had only 52% in the ear. They reported that the reproductive to vegetative ratio was higher in K75A than in other cultivars which suggested that it partitioned a higher proportion of total dry matter into ear. This ratio was however, low in the late hybrid K33 which was due to exphasis on higher partitioning of dry matter into reproductive tissue gave higher grain yield Adelana and Milbourn (1972).

Lucas (1981), using two maize varieties FARZ 23 and FARZ 27 found that the FARZ 27 had 64% of the total dry matter as leaves at 30 days after sowing while FARZ 23 had 61%. At peak

of dry matter production, FARZ 23 and FARZ 27 had 38 and 39% of total dry weight in stems and thereafter stem lost dry weight till harvest by 62 and 65% respectively. This indicates a possible remobilization of stem assimilate to the grain. A similar observation was also made by Adelana and Milbourn (1972) who attributed the loss of stem dry weight at harvest partly to respiratory losses but mainly to considerable remobilization of photosynthate from stem to grain. Increase in grain weight was substantial as the stem was loosing weight rapidly enough to assume assimilate remobilization from stem to grain. Van Eijnatten (1963) however, found no eivdnece of assimilate remobilization. This contradictory observation was however, attributed to the fact that the experiment was terminated too early for such evidence to be apparent. On the other hand, it could be possible that the maize variety he used was at that point that it was still receiving adequate current photosynthate.

2.3.5. Population effect on grain yield of sole sorghum

Cropping pattern and population has been found to effect not only grain yield but also other factors like soil temperature and control erosion. Woldenhaus and Lipscomb (1957) reported that narrow-row planting of sorghum was attracting an increasing interest among farmers of the soutern high plains of Kansas. Working on the sandy soils of southern Great Plains, they found that narrow-row sorghum helped to control wind erosion, conserve moisture and reduce surface crusting. In Texas Quinby et al., (1958) found that a stand thicker than 66,000 plants ha^{-1} in normal 90 - 108cm rows may reduced grain yield of sorghum in a

dry year. Brown and Shareder (1959) at Hays, Kansas found that the optimum plant population for a good yield of dryland sorghum was at a row spacing of 25-50cm under the moderate drought of 1955.

Karper (1929) studying grain sorghum and its relationship to rainfall and optimum plant population, emphasized the difference in rainfall and density relationship between genotypes. He found that the optimum population for Kafir for example was 10 times greater in a wet season compared to a dry season. Havelka (1965) found that narrow rows of sorghum did not significantly increase grain yield. However, he found a yield increase of 450-785 kg grain ha^{-1} by seeding in paired rows 30cm apart compared to a single uniform row spacing.

Increasing plant population from 30,000 to 75,000 plants ha^{-1} in 1975 increase grain yield from 4.6 - 6.0 t ha^{-1}. In 1976, however, raising plant population from 150,000 to 450,000 plants ha^{-1} increased grain yield only from 3.2 - 3.7 t ha^{-1} (Hume, and Kobede 1981). This showed that the optimum plant population varied with the year. Thomas and French (1980) reported that grain yield of sorghum ranged from 1541 to 3068 kg ha^{-1} in central Queensland, Australia and that the results did not show a predictable effect of row spacing or plant population densities on grain yield. They however, reported that densities of 80,000 to 136,000 plants ha^{-1} were equally optimum over a range of yield levels and row spacing. According to Anon (1980), increasing plant population density of sorghum from 33,300 to 50,000 plants ha^{-1} at Samaru increased grain yield by 19% but

yield decline slightly when plant density was increased to 66,600 plants ha^{-1}. Andrews (1976) reported that the best grain yield was achieved by the improved short statured sorghum from plant population which were approximately twice those required by a local variety. Similar yields were however, obtained over a wide range of plant population from about 50,000 to 95,000 plants ha^{-1}.

Wahua and Miller (1978), who intercropped sorghum with soybean, found that the grain yield of sorghum increased linearly with increase in plant population in the mixture. Sorghum tillering ability and population density were found to be the major determinants of grain yield in the mixture.

2.3.6. Shoot characteristics

The plant characteristics has been found to be affected by various factors including plant population and method of planting. Brown and Shareder (1959) reported that sorghum plant height is more affected by row width than by plant population Spreading of the plant resulted in more tillering and thus maximum leaf cover. Thomas and French (1980) found that flowering was more uniform and of shorter duration in wide rows. A marked decline in head size (weight/head) was reported when plant population was increased beyond optimum (Anon. 1980) while Anon. (1982) reported that the number of head/m^2 increased markedly with increase in plant densities but head weight significantly declined as plant population increased beyond 50,000 plants ha^{-1}.

2.3.7. Partitioning of assimilates

The final grain yield of sorghum is dependent on the effeciency by which assimilates are accumulated in the head. The dry matter in sorghum grain is derived mostly from assimilate produced after head emergence (Sticler and Pauli, 1961). Also growth before heading affects grain yield only indirectly by determining the size of the inflorencence and of the assimilating system which persists after head emergence. Nosberger and Thorne (1965) reported that preventing assimilation in the head by shading increased the movement of carbohydrates from stem to the grain.

Bebawi (1981) found that allocation of resources within the plant parts varied between cultivars. He found that although Safro was not the most responsive cultivar to nitrogen fertilizer yet it was the most efficient in nitrogen utilization. This efficiency, according to him, was due to its ability to allocate more assimilates for grain than for straw production, which is a desirable character under low input agricultural system.

Goldsworthy (1970) working on a number of sorghum varieties reported that the dry weight of NK300 was much smaller than those of the other varieties, mainly because NK300 is an early maturity variety and is thus planted late in the season. He found that the dry weight of stalk and shoot of Farafara were 3 to 4 times that of NK300. This great difference, he attributed to the much larger weight of stem of 'Farafara'. Heads represented less than 20% of the total dry weight in Farafara and about 50% in NK300. He concluded that the grain

yield of Farafara was limited by the distribution of assimilate within the plant rather than by the total supply of the assimilate. The ratio of respiratory tissue to assimilatory tissue is larger in varieties of cereals with large stem than those small stems, which he thought may explain why the grain yield from all long season varieties was frequently smaller.

2.3.8. Population and Arrangement in Mixed Crops

Mixed cropping has been identified to perform better in terms of total grain yield than the sole crops. According to Andrews (1972) mixed cropping with sorghum gave much greater yields than a single crop of either sorghum or millet. Kassam and Stockinger (1973) working on the millet-sorghum mixed crops reported that mixed cropping is particularly beneficial when it involves two component crops which are of different growth cycle because this allows the greatest scope for making better use of all the available resources. Gain in mixtures has been found to be associated with better light utilization because of the different canopy structure (Anon., 1981). Short Kaura sorghum showed an increase in rate of total dry matter production per unit area after the earlier crop was removed. This suggested that gain in mixtures is possible when one of the crops is harvested 34 days or more earlier or 42 days or more later than the associated crop. It was earlier recommended that cereals of more than six weeks difference in maturity be sown in mixtures (Anon. 1976). Andrews (1974) reported that when a tall and a short variety of sorghum were compared both as sole as mixtures with millet, the short variety was found to be superior both as mixture and as sole crop.

Owonubi (1980) reported that a tall sorghum variety produced the same total dry matter per plant either as mixture or alternate rows, with millet. He also found that the dwarf sorghum variety yielded more grain in mixtures with millet than in pure or alternate stands. This indicated that mixing enhanced grain yield in dwarf sorghum. Mixing significantly increased the yield per row of both millet and sorghum. The response of sorghum to population increase was similar to the response of the sole crop. Maize however, respond differently in mixtures as compared to sole.

Baker (1979) working on cereal mixtures attributed the grain in mixtures to the efficient canopy structure provided by mixing a fast-growing early maturity cereal, with a slow-growing late maturing one. He further suggested using a denser population of either or both components. A series of experiment at the IAR has demonstrated that maize can be grown with millet and sorghum successfully without loss in total grain yield.

2.4. Plant Population and Leaf Cover

2.4.1. Leaf cover and light interception.

Only a part of the solar radiation is intercepted by the leaf surface. The total amount intercepted depends on the total amount of leaf cover, which is a function of the plant population. A fraction of the incoming solar radiation escapes interception by the crop unless there is an optimum leaf cover (Egharevba, 1978). The density of the foliage canopy receiving the light is the most important aspect relating to productivity

and solar radiation (Ghareyba, 1978). Trenbath (1979) summarised results of several experiments and concluded that photosynthetic light use effeciency of the canopy is the product of two components: the proportion of incident light that is intercepted and the effeciency of the canopy itself. Similar results were reported by Natarajan and Willey (1980). Trenbath went on to suggest that mixed cropping should consist of an upper canopy of small inclined leaves with maximum rate of photosynthesis and a lower canopy of a more horizontal leaves arranged possibly in mosaic with low maximum rate of leaf photosynthesis.

2.4.2. Maize leaf cover

Higher leaf cover is more easily achieved and high plant population. Lucas (1981), experimenting with two maize varieties reported that the highest leaf cover for both varieties at the two locations was reached between 61 and 75 days after sowing. He found that the highest leaf cover was at the highest density but this then declined more rapidly than the lower density. Haggar and Couper (1972) reported that increase in plant population significantly increased the leaf cover and thus resulted in better light interception in maize. They found that nitrogen level significantly increased the leaf cover and that at all plant densities, leaf area index (LAI) rose to a peak value and then declined. They observed that increasing plant density reduced the time taken to reach maximum leaf cover.

2.4.3. Sorghum leaf cover

The higher the amount of leaf cover, the more the light intercepted and the greater the grain yield. Sorghum is a cereal crop with a height of about 50-300cm with upright or drooping leaves. According to Kowal (1972), the most important character for predicting grain yield in sorghum is an adequate leaf area to intercept the solar radiation for photosynthesis. Goldsworthy (1970) while working on 2 varieties of sorghum found that plant height, density of foliage and small leaf angle of leaves in relation to incident rediation increased grain yield. He further observed that the life span of leaves is shorter where they are densely shaded.

CHAITER 3

MATERIALS AND METHODS

3.1 Experimental Location

Two trials were conducted during the 1983 cropping season. One trial was located on the IAR farm at Samaru (11° 10'N, 07° 38'E) and the other at Saminaka farm centre (10° 27'N, 08° 41'E). Both locations are in the northern Guinea savanna ecological zones of Nigeria.

3.2 Crop Varieties

The sorghum variety used was short kaura (SK 5912). This is a short statured variety (2-2.2m tall) with yellow grain and has a growing period of 180-190 days. The maize variety grown was TZB (FAZ-34). This is a white seeded variety of 1.8-2m tall and a growing period of about 120 days.

3.3 Experimental Design

A factorial experiment was laid out in a randomized complete block design (RCB) with four replications. The gross plot consisted of nine ridges 0.75m apart, 6m long with an area of 40.5m^2. The net plot at Saminaka had 6 ridges 0.75m apart 6m long with an area of 27m^2 while at Samaru 3 ridges by 0.75m by 6m long was the net plot with an area of 13.5m^2 and the other three ridges reserved for sampling (ridges 3, 4 and 8), while ridges 1, 2 and 9 were left as guard rows at both locations.

3.4 Experimental Treatments

The treatments were made of two factors (peant populations and cropping pattern). Plant populations of 44,444 and 66,666 plants ha^{-1} were used in the trial, while the six cropping patterns were 2:1 and 1:2 proportions of maize:sorghum mixture both in alternate row and within row arrangements together with sole crops maize and sorghum.

At Samaru, the field was previously planted to maize-cowpea during the preceding year while that at Samindka was under sorghum.

The land was disck ploughed and harrowed and a composite soil sample taken from 0-15cm depth on each site and separately analysed for physical and chemical properties (Table 1). Single superphosphate fertilizer was later broadcast at the rate of 40kg P_2O_5 before ridging. Ridging was done at a row distance of 0.75m at both sites with each plot consisting of nine ridges.

Seeds were treated with Aldrex T at the rate of 15g dressing chemical 3 kg^{-1} and later planted with three maize seeds and five to ten sorghum seeds $hole^{-1}$ at a spacing of 30cm and 20cm which when thinned gave plant population of 44,444 and 66,666 plants ha^{-1} respectively. There was a mild attack of stemborer on sorghum and this was controlled by spraying with Carbaryl (Vetox 85 WP) at the rate of 4 kg a.i. 500^{-1} litres of water.

3.6 Measurement and Observations

3.6.1. Meteorological data

These include rainfall and sunshine hours (Appendix tables A1, A2 and B).

Table 1: The physical and chemical properties of the soil of the experimental sites at Samaru and Saminaka in 1983.

Soil characteristics	Samaru	Saminaka
Particle size		
Percentage clay	18.00	10.0
Percentage silt	39.0	34.0
Percentage sand	43.0	56.0
pH values		
in water (H_2O)	5.70	6.20
in 0.01m $CaCl_2$	5.10	6.70
Organic carbon content (%)	0.50	0.50
Available P concentration (ppm)	21.70	13.3
Cation Exchange Capacity	4.2	5.2
Exchangeable bases meq/100 g soil		
Ca	1.85	2.55
Mg	0.502	0.855
K	0.133	0.50
Na	0.348	0.152

3.6.2. Establishment count

The establishment count was conducted four weeks after sowing for both crops at both locations.

3.6.3. Leaf cover for maize and sorghum

Leaf cover was determined at 6, 8, 11 and 15 weeks after sowing (w.a.s.) for sorghum and maize with an additional one at 18 weeks for sorghum using an optical point quadrantas described by Baeumer and de-Wit (1968). The instrument was constructed locally. For observations, a step ladder was used from above the crop canopy.

The leaf cover, was estimated by recording the relative frequency of the leaves of the various species and the bare ground that was seen from a constant angle of 45°. For each plot, the sample consisted of two arcs cutting across the direction of the rows centred on the observer stationed at each end of the row in turn. The estimate was expressed as percentage leaf cover of each component species.

3.6.4. Plant dry weight

Three plants were sampled from ridges three, four and eight in each plot for both maize and sorghum at six, eight and eleven weeks after sowing. These samples were oven dried at a constant temperature of 60°C and the weight recorded.

3.6.5. Tiller number per net plot

The number of tiller per net plot was recorded 6 weeks after sowing.

3.6.6. Date of heading in sorghum and tasselling in maize

The dates of both heading in sorghum and tasselling in maize were recorded.

3.6.7. Stand count at harvest

The total number of plants/net plot at harvest was counted just prior to the harvest of each crop.

3.6.8. Lodging count of sorghum and maize

The number of lodged plants in both maize and sorghum were recorded at harvest.

3.6.9. Plant height

The plant height at harvest was measured for each crop at both locations. A sample of ten randomly selected plants were taken and their height to the tip of the tassel (maize) and panicle (sorghum) were measured. An average plant height for each plot was later calculated.

3.6.10. Number of ears and heads/net plot

The number of maize cobs/net plot and sorghum heads at harvest were counted.

3.6.11. Grain yield

The grain obtained after threshing of both maize and sorghum was further air-dried before weighing.

3.6.12. 1000-grain weight

The weight of 1000-grains of both maize and sorghum were recorded only at Samaru. (The grain yield was bulked at Saminaka after weighing) but prior to counting and weighing of 1000-grains.

3.6.13. Dry weight at harvest

After sun-drying on the field for one week, the maize and sorghum stover were weighed and recorded. Both maize and sorghum stover were weighed and recorded. Both maize cobs and sorghum heads were allowed to dry for three weeks after harvest before they were later weighed and threshed.

3.6.14. Statistical analysis

Data collected were subjected to statistical analysis as described for the randomized complete block design with factorial arrangement with two factors by Cochran and Cox (1967), using the F test for significance.

3.6.15. Analysis of total grain yield

Total grain yield has been used to evaluate mixtures as an alternative to gross return in monetary terms.

Land Equivalent Ratio (LER)

The land equivalent ratio was estimated as ratio of the land required by the sole crop to produce the same yield of the mixed crop. The formula used was as follows:

$$LER = \frac{Y1}{S1} + \frac{Y2}{S2}$$ where

Y1 = yield of maize in mixture

S1 = yield of maize in sole crop

Y2 = yield of sorghum in mixture

S2 = yield of sorghum in sole crops

CHAPTER 4

RESULTS

4.1. Leaf Cover of Maize and Sorghum at Samaru

4.1.1. Maize leaf cover

At 6 weeks after sowing (w.a.s.)

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased leaf cover but not significantly (Table 2). The sole crop however had significantly more maize leaf cover than the mixtures while the 2:1 proportions tended to have a higher leaf cover than the 1:2 proportions though the differences was not significantly. The mixed rows had more leaf cover than the alternate rows in all the proportions.

At 8 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not significantly affect leaf cover of maize (Table 3). The sole crop had significantly more leaf cover than the mixtures while the 2:1 proportions had significantly more leaf cover than the 1:2 proportions. The mixed rows had more leaf cover than the alternate rows although this was not statistically significant.

At 11 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased leaf cover (Table 4). The sole crop had significantly higher leaf cover than the mixtures, especially the alternate rows. The mixed rows had higher leaf

Table 2. The effect of cropping pattern and plant population on the leaf cover (%) of maize at 6 w.a.s. Samaru 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	53.5	30.3	30.8	32.8	32.3	35.9
66,666	58.0	35.5	33.5	38.9	32.9	39.8
Mean	55.6	32.9	32.2	35.8	32.6	

	SE	LSD (0.05)
Population	±1.44	NS
Cropping pattern	±2.28	6.61
Interaction	±3.23	NS

w.a.s. = weeks after sowing

Table 3. The effect of cropping pattern and plant population on the leaf cover (%) of maize at 8 w.a.s. at Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	63.0	47.5	29.5	49.0	31.5	44.1
66,666	70.8	51.3	24.8	58.0	48.0	50.6
Mean	66.8	49.4	27.1	53.5	39.8	

	SE	LSD (0.05
Population	±2.77	NS
Cropping pattern	±4.38	12.7
Interaction	±6.19	NS

Table 4. The effect of cropping pattern and plant population on the leaf cover (%) of maize at 11 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	78.8	58.0	40.8	65.5	48.0	58.2
66,666	84.5	60.2	33.5	62.3	80.8	64.3
Mean	81.6	59.1	37.2	63.9	64.4	

	SE	LSD (0.05)
Population	±2.05	6.1
Cropping pattern	±3.24	9.4
Interaction	±4.58	13.3

leaf cover than the alternate rows and this was significant in 1:2 proportions.

At 15 weeks after sowing:

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased leaf cover (Table 5). The sole crop had higher leaf cover than the mixtures while the 2:1 proportions had more leaf cover than the 1:2 proportions.

4.1.2. Sorghum leaf cover

At 6 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not significantly affect leaf cover (Table 6). The sole crop had significantly higher sorghum leaf cover than the mixtures.

Table 5. The effect of cropping pattern and plant population on the leaf cover (%) of maize at 15 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	75.3	50.8	38.8	47.9	30.2	48.6
66,666	86.5	63.0	32.8	60.8	50.8	58.8
Mean	80.9	56.9	35.8	54.3	40.5	

	SE	LSD (0.05)
Population	±1.95	5.7
Cropping pattern	±3.08	9.0
Interaction	±4.36	NS

Table 6. The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 6 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
P_1	49.1	20.1	22.8	19.0	21.5	26.5
P_2	58.3	21.4	23.0	20.0	22.0	28.9
Mean	53.7	20.8	22.9	19.5	21.8	

	SE	LSD (0.05)
Population	±1.36	NS
Cropping pattern	±2.15	6.2
Interaction	±3.04	8.8

The 1:2 proportions had higher leaf cover than the 2:1 proportions while the alternate rows had higher leaf cover than the mixed rows. The interaction between cropping pattern and population was statistically significant with increasing plant population bringing about increased leaf cover in all the five cropping patterns.

At 8 weeks after sowing

At the higher plant population of 66,666 plants ha^{-1}, the leaf cover was not significantly higher than that at the low plant population of 44,444 plants ha^{-1} (Table 7). The sole crop had significantly higher leaf cover than the mixtures while the 1:2 proportions had significantly more leaf cover than the 2:1 proportion.

Table 7. The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 8 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	62.0	21.8	39.5	20.8	39.3	36.7
66,666	66.0	30.3	45.5	23.8	26.5	38.4
Mean	64.0	26.0	42.5	22.3	32.4	

	SE	LSD (0.05)
Population	±2.64	NS
Cropping pattern	±4.17	12.1
Interaction	±5.90	NS

At 11 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not significantly effect leaf cover (Table 8). The sole crop had significantly higher leaf cover than the mixtures while the alternate arrangements had higher leaf cover than the mixed rows. The 1:2 proportions had significantly more leaf cover than the 2:1 proportions. The interaction between cropping pattern and population was statistically significant with the higher population increasing leaf cover in all cropping patterns except 1:2 mixed rows where it was significantly reduced.

At 15 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} reduced sorghum leaf cover but not significantly (Table 9). The sole crop had significantly higher leaf cover than the mixtures with the 1:2 proportions having more leaf cover than the 2:1 proportions.

At 18 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased leaf cover but not significantly (Table 10). There was a general decline in the leaf cover at 18 weeks compared with 8, 11 and 15 weeks but the sole crop still had significantly more sorghum leaf cover than the mixtures while the 1:2 proportions had more leaf cover than the 2:1 proportions.

Table 8. The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 11 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	80.8	25.5	43.6	18.3	35.5	40.7
66,666	82.3	33.1	53.5	22.5	10.8	40.4
Mean	81.5	29.3	48.6	20.3	23.1	

	SE	LSD (0.05)
Population	±2.02	NS
Cropping pattern	±3.19	9.3
Interaction	±4.52	13.3

Table 9. The effect of cropping pattern and plant population on the leaf cover (%) of sorghum at 15 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	87.4	34.5	49.0	35.5	48.5	50.9
66,666	87.3	24.0	56.5	31.0	31.8	46.1
Mean	87.4	29.3	52.8	33.3	40.0	

	SE	LSD (0.05)
Population	±2.62	NS
Cropping pattern	±4.14	12.0
Interaction	±5.85	NS

Table 10. The effect of cropping pattern and Plant Population on the leaf cover (%) of sorghum at 18 w.e.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	49.0	28.8	25.8	24.4	35.3	32.6
66,666	49.9	29.8	39.3	28.5	32.8	36.0
Mean	49.4	29.3	32.5	26.4	34.0	

	SE	LSD (0.05)
Population	±2.80	NS
Cropping pattern	±4.42	12.8
Interaction	±6.25	NS

4.1.3. Total leaf cover of maize and sorghum in mixed crops

At 6 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased total leaf cover but not significantly (Table 11). The sole maize had higher leaf cover than the sole sorghum and the mixtures except the 1:2 alternate row though the difference was not significant. The alternate arrangements had more leaf cover than the mixed rows though the difference was not significant.

At 8 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased leaf cover of maize and sorghum mixed crops at 8 weeks (Table 12). The sole crops had lower leaf cover than the mixtures while the 2:1 proportions had higher leaf cover than the

Table 11. The effect of cropping pattern and Plant Population on the total leaf cover (%) of maize and sorghum in mixed crops at 6 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	53.5	49.1	50.4	53.6	51.8	53.8	52.0
66,666	58.0	58.3	56.9	56.5	58.9	54.9	57.3
Mean	55.7	53.8	53.7	55.1	53.4	54.4	

		SE	LSD (0.05
Population		±2.19	NS
Cropping pattern	+	±3.78	NS
Interaction		±5.36	NS

Table 12. The effect of cropping pattern and Plant Population on the total leaf cover (%) of maize and sorghum in mixed crops at 8 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	63.0	62.0	69.3	69.0	69.8	70.8	67.3
66,666	70.8	66.0	81.5	70.4	81.8	74.5	74.2
Mean	66.9	64.0	75.4	69.7	75.8	72.2	

	SE	ISD (0.05)
Population	±1.71	5.0
Cropping pattern	±2.97	NS
Interaction	±4.20	NS

1:2 proportions though the differences was not significant.

At 11 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased leaf cover (Table 13). The sole crops had lower leaf cover than the mixtures while the alternate arrangements had more leaf cover than the mixed rows though these differences were statistically significant.

Table 13. The effect of cropping pattern and Plant Population on the total leaf cover (%) of maize and sorghum in mixed crops at 11 w.a.s., Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	78.8	80.8	83.5	84.4	83.5	83.5	82.4
66,666	84.5	82.3	93.3	87.0	84.6	91.5	87.2
Mean	81.6	81.5	88.4	85.7	84.0	87.5	

	SE	LSD (0.05)
Population	±1.92	5.6
Cropping pattern	±3.33	NS
Interaction	±4.71	NS

At 15 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased leaf cover (Table 14). The sole maize had lower leaf cover than others except the 1:2 mixed rows. The 2:1

mixed rows had the highest leaf cover among the mixtures and the sole crops while the 1:2 mixed rows had the lowest leaf cover.

Table 14. The effect of cropping pattern and Plant Population on the total leaf cover of maize and sorghum in mixed crops at 15 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed r w	1:2 Mixed r w	Mean
P_1	75.3	87.4	85.3	87.8	83.4	78.5	83.0
P_2	86.5	87.3	87.1	89.5	91.9	82.5	87.4
Mean	80.9	87.4	86.2	88.7	87.7	80.5	

	SE	LSD (0.05)
Population	$\pm^1.54$	4.5
Cropping pattern	$\pm$2.66	NS
Interaction	$\pm$3.76	NS

4.2. Dry Weights of Maize and Sorghum at Samaru

4.2.1. Maize shoot dry weight

At 8 weeks after sowing

Neither the increase in plant population nor the cropping pattern had any significant influence on the dry weight/plant of maize at Samaru (Table 15). The dry weight of the sole crop was however higher than that of the mixtures.

At 11 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} reduced dry weight/plant of maize but not significantly (Table 16).

Table 15. The effect of cropping pattern and Plant Population on the dry weight of maize leaves, stem and sheath at 6 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
P_1	66.4	55.2	57.1	63.9	54.1	59.3
P_2	59.5	56.3	52.2	50.8	55.6	54.9
Mean	62.9	55.8	54.6	57.4	54.9	

	SE	LSD
Population	±4.10	NS
Cropping pattern	±6.50	NS
Interaction	±9.20	NS

Table 16. The effect of cropping pattern and Plant Population on the dry weight (g/plant) of maize leaves, stem and sheath at 11 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
P_1	95.9	102.1	103.8	90.8	95.8	97.7
P_2	94.2	89.5	91.6	99.1	98.7	94.6
Mean	95.0	95.8	97.7	95.0	97.3	

	SE	LSD (0.05)
Population	±9.50	NS
Cropping pattern	±15.00	NS
Interaction	21.30	NS

4.2.2. Sorghum shoot dry weight

4.2.2. Sorghum shoot dry weight

At 6 weeks after sowing

Neither increase in plant population nor the cropping pattern had any significant influence on the dry weight/plant of sorghum at Samaru (Table 17). The dry weight of the sole crop was lower than that of the mixtures with alternate rows having higher dry weight than the mixed rows.

At 11 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly decreased dry weight/plant of sorghum at 11 w.a.s. (Table 18). The sole crop had produced more dry weight than all the mixtures especially the 1:2 mixed rows which had the smallest dry weight produced. The 2:1 proportions had produced a higher dry weight/plant than the 1:2 proportions.

At 15 weeks after sowing

Increasing plant population from 44,444 to 66,666 plants ha^{-1} reduced dry weight/plant but not significantly (Table 19). The sole crop and the 2:1 alternate row had the highest dry weights/plant followed by the 1:2 mixed row, while the 1:2 alternate row had a smaller dry weight than all others:

Tabee 17. The effect of cropring pattern and Plant Population on the dry weight (g/plant) of sorghum shoot at 6 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	17.7	25.9	30.6	23.0	24.0	24.2
66,666	23.9	26.9	21.6	19.4	27.2	23.8
Mean	20.8	26.3	26.1	21.2	25.6	

	SE	LSD (0.05)
Population	±2.20	NS
Cropping pattern	±3.50	NS
Interaction	±5.00	NS

Table 18. The effect of cropping pattern and Plant Population on the dry weight (g/plant) of sorghum shoot at 11 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	131.4	133.5	125.0	145.2	129.6	136.2
66,666	131.2	131.5	117.5	109.0	95.2	116.8
Mean	131.3	132.5	121.2	129.1	112.4	

	SE	ISD (0.05)
Population	±5.60	16.5
Cropping pattern	±8.90	NS
Interaction	±12.60	NS

Table 19. The effect of cropping pattern and Plant Population on the dry weight (g/plant) of sorghum shoot at 15 w.a.s. Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	285.0	290.3	215.0	264.1	279.0	266.7
66,666	238.0	231.6	222.3	197.0	224.8	222.9
Mean	261.5	261.0	218.6	231.0	251.9	

	SE	LSD (0.05)
Population	±16.50	NS
Cropping pattern	±26.00	NS
Interaction	±36.80	NS

4.3. Yield and Yield Attributes of Maize and Sorghum

4.3.1. Yield and yield attributes of maize at Samaru

Plant Count

The plant count figures were lower than the target plant population for all treatments (Table 20).

Number of Cobs

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased cob number in maize (Table 21). In both proportions, the mixed rows had more cobs than the alternate rows but this was not statistically significant. The sole crop had

significantly more cobs than all the mixtures while the 2:1 proportions had more cobs than the 1:2 proportions.

Table 20. The effect of cropping pattern and Plant Population on the plant count (plant ha^{-1}) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	42,593	27,222	12,222	27,037	14,444	24,705
66,666	61,276	41,481	21.111	44,259	20,741	37,778
Mean	51,945	34,352	16,667	35,648	17,593	

	SE	ISD (0.05)
Population	±538	1561
Cropping pattern	±850	2465
Interaction	±1202	3487

Table 21. The effect of cropping pattern and Plant Population on the cob number (cobs ha^{-1}) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	42,966	33,521	15,357	37,357	19,631	29,703
66,666	55,190	45,744	20,742	46,485	20,372	37,707
Mean	49,078	39,633	18,050	41,763	20,002	

	SE	ISD (0.05)
Population	±1357	3826
Cropping pattern	±2144	6219
Interaction	±3033	NS

Cob yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased cob weight but not significantly (Table 22). The sole crop had significantly higher cob weight than the 1:2 proportions but the 2:1 mixed rows had a cob weight even higher than the sole crop.

Grain Yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased grain yield significantly by 20% (Table 23). The sole maize yield was significantly higher than in the mixtures. Within the mixtures, the 2:1 proportions gave significantly higher grain yield than the 1:2 proportions which gave no significantly higher grain yield than the mixed rows.

Straw Dry Weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased straw dry weight of maize at Samaru by 22% (Table 24). The sole crop had higher straw weight than all the mixtures especially the 1:2 proportions which where significantly lower than the sole crop and the 2:1 proportions. The mixed rows in both proportions gave higher straw dry weight but not significantly higher than the alternate rows.

1,000-grain Wegith

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly decreased the 1,000-grain weight (Table 25). There was no significant effect of cropping pattern on the 1,000-grain weight.

Table 22. The effect of cropping pattern and Plant Population on the cob yield (kg ha^{-1}) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	5402	5167	2741	6223	3815	4670
66,666	6793	5797	3019	6704	3111	5086
Mean	6098	5482	2880	6464	3463	

	SE	LSD (0.05)
Population	±263	NS
Cropping Pattern	±416	1207
Interaction	±589	NS

Table 23. The effect of cropping pattern and Plant Population on the grain yield (kg ha^{-1}) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	3926	2500	1426	2630	1537	2404
66,666	4223	3408	2093	3074	1667	2895
Mean	4074	2955	1759	2853	1602	

	SE	LSD (0.05)
Population	±133	386
Cropping pattern	±210	609
Interaction	±296	NS

Table 24. The effect of cropping pattern and Plant Population on the straw dry weight (kg ha^{-1}) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	4408	3760	1759	500	2000	3286
66,666	4908	4926	2797	4579	2778	3998
Mean	4658	4343	2278	4539	2389	

	SE	LSD (0.05)
Population	±222	644
Cropping pattern	±351	1019
Interaction	±496	NS

Table 25. The effect of cropping pattern and Plant Population on the 1,000-grain weight (g) of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	224	216	229	248	229	230
66,666	218	210	214	231	214	217
Mean	221	214	222	240	222	

	SE	LSD (0.05)
Population	±3.36	9.88
Cropping pattern	±5.31	NS
Interaction	±7.51	NS

Plant Height at Harvest

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased plant height of maize though not significantly (Table 26). The sole crop plants were taller than those of the mixtures. There was no significant difference among the mixtures. The higher population increased plant height in sole crop and 1:2 mixture but not in the 2:1 mixtures, this interaction being statistically significant.

Harvest index:

Increasing plant population resulted in an increase in the harvest index except in the sole crop where increase in plant population reduced the harvest index (Table 27). Generally the sole crop had higher harvest index than all the mixtures, while the alternate rows had higher harvest index than the mixed rows.

4.3.2. Yield attribute of sorghum at Samaru

Plant count

The plant counts were lower than the target population for all treatments (Table 28).

Number of heads

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased the number of sorghum heads at Samaru by 10% which was not statistically significant (Table 29). The sole crop had significantly more heads than all the mixtures except the 1:2 mixed rows and the 2:1 proportions though the differences were not statistically significant.

Table 26. The effect of cropping pattern and Plant Population on the plant height (m) of maize at harvest in metres, Samaru, 1983.

Population Plants ha	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	2.46	2.34	2.23	2.50	1.90	2.29
66,666	2.89	2.31	2.46	2.29	2.29	2.45
Mean	2.67	2.32	2.	2.40	2.10	

	SE	LSD (0.05)
Population	±0.05	NS
Cropping pattern	±0.08	NS
Interaction	±0.11	0.3

Table 27. The effect of cropping pattern and Plant Population on the harvest index of maize, Samaru, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	0.415	0.280	0.317	0.245	0.264	0.304
66,666	0.365	0.318	0.360	0.273	0.283	0.320
Mean	0.390	0.299	0.338	0.256	0.274	

Table 28. The effect of cropping pattern and Poant Population on the plant count (plants ha^{-1}) of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	44,259	12,778	28,148	12,963	27,037	25,037
66,666	55,000	20,926	36,482	18,333	38,148	33,778
Mean	49,630	16,852	32,316	15,648	32,593	

	SE	LSD (0.05)
Population	±273	7,923
Cropping pattern	±432	12,525
Interaction	±610	NS

Table 29. The effect of cropping pattern and Plant Population on the number of heads (heads ha^{-1}) of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1 1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	30,002	12,960	20,742	12,223	21,483	19,483
66,666	36,670	12,779	22,409	12,779	22,594	21,446
Mean	33,336	12,871	21,576	12,501	22,039	

	SE	LSD (0.05)
Population	±2,548	NS
Cropping pattern	±4,028	11689
Interaction	±5,695	NS

Head weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased head weight of sorghum but not significantly (Table 30). The sole sorghum had significantly heavier heads than all the mixtures except the 1:2 alternate row. The alternate rows had heavier heads than the mixed rows while the 1:2 alternate row had heavier heads than all the three mixtures especially the 2:1 mixed rows.

Grain yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased grain yield but not significant (Table 31). There were no significant differences among cropping patterns but the sole crop yielded more than all the mixtrues while the 2:1 alternate row outyielded all the other mixtures especially the 2:1 mixed rows.

Straw dry weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased straw dry weight but not significantly (Table 32). The sole crop gave significantly higher straw weight than all the mixtures while the 1:2 proportions gave significantly higher straw dry weight than the 2:1 proportions especially the 2:1 mixed rows.

1,000-grain weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased 1,000-grain weight though not significantly (Table 33). Differences between the cropping patterns were also

Table 30. The effect of cropping pattern and Plant Population on the dry weight (kg ha^{-1}) of sorghum heads, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alernate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	2204	685	1889	945	1074	1359
66,666	2371	1446	1296	815	963	1378
Mean	2288	1066	1593	880	1019	

	SE	ISD (0.05)
Population	±186	NS
Cropping pattern	±293	850
Interaction	±414	NS

Table 31. The effect of cropping pattern and Plant Population on the grain yield (kg ha^{-1}) of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	806	585	535	661	706	659
66,666	1006	763	584	402	561	663
Mean	906	674	559	537	634	

	SE	LSD (0.05)
Population	± 92	NS
Cropping pattern	±144	NS
Interaction	±204	NS

Table 32. The effect of cropping pattern and Plant Population on the straw dry weight (kg ha^{-1}) of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	8167	2648	5371	2689	5037	4823
66,666	9705	3871	5112	2408	5056	5230
Mean	8936	3260	5241	2648	5046	

	SE	LSD
Population	±444	NS
Cropping pattern	±704	2040
Interaction	±993	NS

Table 33. The effect of cropping pattern and Plant Population on the 1,000-grain weight (g) of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	28.4	31.2	29.9	37.5	29.3	31.3
66,666	30.4	31.2	26.2	31.1	30.8	30.0
Mean	29.2	31.2	28.1	34.3	30.1	

	SE	LSD (0.05)
Population	±1.96	NS
Cropping pattern	±3.09	NS
Interaction	±4.38	NS

not statistically significant though the sole crop had a lower 1000-grain weight than most of the mixtures.

Plant height

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased plant height but not significantly (Table 34). The sole crop was taller than all the mixtures, while the 1:2 proportion had taller plants than the 2:1 proportions.

Harvest index

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased harvest index of sorghum (Table 35). The sole sorghum had a lower harvest index than all the mixtures while the 2:1 proportions had the highest harvest index, especially the 2:1 alternate row.

4.4. Total Yield of Grain and Dry Matter in Maize Maize and Sorghum Mixed Crops at Samaru

4.4.1. Total grain yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased the total grain yield of maize and sorghum significantly (Table 36). The 2:1 proportions gave significantly higher total grain yield than the 1:2 proportions while the alternate rows yielded more grains than the mixed rows in corresponding proportions.

The sole crop maize gave more grain than the grain of maize and sorghum in mixtures combined while the sole sorghum gave less grain than the combined total grain of the mixtures.

Table 34. The effect of cropping pattern and Plant Population on the plant height (m) of sorghum at harvest in meters at Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	2.36	2.25	2.29	2.41	2.31	2.32
66,666	2.35	2.17	2.35	2.11	2.32	2.26
Mean	2.35	2.21	2.32	2.26	2.31	

	SE	LSD (0.05)
Population	±0.046	NS
Cropping pattern	±0.073	NS
Interaction	±0.102	NS

Table 35. The effect of cropping pattern and Plant Population on the harvest index of sorghum, Samaru, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	0.078	0.176	0.074	0.172	0.116	0.123
66,666	0.083	0.144	0.091	0.125	0.094	0.107
Mean	0.081	0.160	0.082	0.149	0.105	

Table 36. The effect of cropping pattern and Plant Population on the total grain yield (kg ha^{-1}) of maize and sorghum in mixed crops at Samaru, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixex row	1:2 Mixed row	Mean
44,444	3085	1961	3291	2243	2645
66,666	4171	2677	3476	2228	3138
Mean	3628	2312	3384	2 36	

	SE	LSD (0.05)
Population	±34.50	390.5
Cropping pattern	±190.00	552.0
Interaction	±269.11	NS

4.4.2. Total dry matter

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increase total dry matter of maize and sorghum in mixed crops at Samaru but not significantly (Table 37). The 2:1 proportions but the 2:1 mixed had the highest total dry weight though all the differences were not statistically significant.

4.4.3. IER for grain yield at Samaru

Increase in plant population from 44,444 to 66,666 plants ha^{-1} increased the land equivalent ratio (LER) for grain yield at Samaru though not significantly (Table 38). The 2:1 proportions had higher LER than the 1:2 proportions. The alternate rows had higher LER than the mixed rows in the 2:1 proportions while the mixed rows had higher LER in the 1:2 proportions in the alternate rows (Based on the mean of the sole crop yield).

Table 37. The effect of cropping pattern and Plant Population on the total dry matter yield (kg ha^{-1}) of maize sorghum in mixed crops at Samaru, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	12,247	11,743	15,152	11,914	12,765
66,666	16,021	12,210	15,707	11,896	13,959
Mean	14,134	11,979	15,430	11,905	

	SE	ISD (0.05)
Population	±622.70	NS
Cropping pattern	±889.69	NS
Interaction	±1245.48	NS

Table 38. The effect of cropping pattern and Plant Population on the land equivalent ratio (LER) for grain yield of maize and sorghum in mixed crops at Samaru, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	1.04	0.94	1.37	1.16	1.13
66,666	1.68	1.12	1.21	1.04	1.28
Mean	1.36	1.06	1.29	1.10	

	SE	ISD (0.05)
Population	±0.08	NS
Cropping pattern	±0.12	NS
Interaction	±0.16	NS

4.5. Yield and Yield Attribute of Maize and Sorghum in Mixed Crops at Saminaka

4.5.1. Yield and yield attributes of maize

Plant count

The plant count was found to be affected by both population and cropping pattern as per treatment (Table 39).

Cob number

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased cob number in maize (Table 40). The sole crop had significantly more cobs than the 1:2 proportions, while differences between the sole and the 2:1 proportions was not statistically significant.

Table 39. The effect of cropping pattern and Plant Population on the plant count (plants ha^{-1}) of maize, Saminaka, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	45,964	28,231	13,888	28.780	12,426	25,838
66,666	60,664	39,286	22,201	38,921	18,364	35,887
Mean	53,264	33,759	18,045	33,851	15,395	

	SE	LSD (0.05
Population	±872	2,530
Cropping pattern	±138	3,999
Interaction	±194	NS

Table 40. The effect of cropping pattern and Plant Population on the cob number (cobs ha^{-1}) of maize Saminaka 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	34,439	27,313	13,521	26,953	1,918	20,829
66,666	43,945	33,804	14,709	38,921	22,201	30,716
Mean	39,192	30,559	14,115	32,937	12,059	

	SE	ISD (0.05)
Population	±230	6,674
Cropping pattern	±364	10,555
Interaction	±514	NS

Grain yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not affect the grain yield of maize significantly at Saminaka (Table 41). The sole crop yielded significantly more than the 1:2 proportions, but not significantly more than the 2:1 proportions.

Straw dry weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} significantly increased straw dry weight. The sole crop produced significantly more straw than did all the mixtures. The 2:1 proportions gave significantly higher straw weight than the 1:2 proportions (Table 42). The mixed rows gave higher straw weight than the alternate rows, though this difference was not statistically significant.

Plant height

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased plant height at Samaneka but not significantly (Table 43). The 2:1 proportions had generally taller plants than all other including the sole crop but the differences were not statistically significant.

Harvest index

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased harvest index of maize (Table 44). The sole crop had the highest harvest index while 2:1 proportions had higher harvest index than the 1:2 proportions.

4.5.2. Yield attribute of sorghum

Plant count

The plant count were lower than the target population for all treatments (Table 45).

Head number

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased sorghum head number significantly at Samaneka (Table 46). The sole crop produced significantly more heads than did any of the mixtures while the 1:2 proportions had significantly more heads than the 2:1 proportions.

Grain yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased sorghum grain yield at Samaneka though not significantly (Table 47). The sole crop gave higher grain yield than all the mixtures but there was no significant effect of cropping pattern.

Table 43. The effect of cropping pattern and Plant Population on the plant height (m) of maize at harvest in meters, Samaneka, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	1.79	1.84	1.58	1.74	1.72	1.73
66,666	1.61	1.75	1.61	1.73	1.64	1.66
Mean	1.70	1.80	1.60	1.74	1.67	

	SE	lsd (0.05)
Population	±0.04	NS
Cropping pattern	±0.06	NS
Interaction	±0.08	NS

Table 44. The effect of cropping pattern and Plant pPopulation on the harvest index of maize, Samaneka, 1983.

Population Plants ha^{-1}	Sole Maize	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	0.412	0.384	0.337	0.374	0.321	0.366
66,666	0.352	0.364	0.295	0.345	0.316	0.335
Mean	0.382	0.374	0.316	0.359	0.318	

Table 45. The effect of cropping pattern and Plant Population on the plant count (plants ha^{-1}) of sorghum, Saminaka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	40,748	13,156	24,759	11,968	22,201	22,568
66,666	50,798	17,724	27,044	17,450	38,555	30,314
Mean	45,773	15,440	25,902	14,709	30,378	

	SE	LSD (0.05)
Population	±1,257	2,647
Cropping pattern	±1,988	5,769
Interaction	±2,810	NS

Table 46. The effect of cropping pattern and Plant Population on the sorghum head number (heads ha^{-1}), Saminaka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	32,468	12,118	22,478	13,505	19,425	19,999
66,666	44,215	19,745	21,275	15,740	13,173	26,389
Mean	38,3428	15,931	21,877	14,523	25,299	

	SE	LSD (0.05)
Population	±1148.25	3333.7
Cropping pattern	±1812.62	5260.2
Interaction	±2563.44	7439.1

Table 47. The effect of cropping pattern and Plant Population on the grain yield (kg ha^{-1}) of sorghum, Samaka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	1553	823	1165	868	1046	1091
66,666	1188	1142	800	686	1096	982
Mean	1370	983	982	776	1071	

	SE	LSD (0.05)
Population	±124	NS
Cropping pattern	±196	NS
Interaction	±278	NS

Straw dry weight

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not significantly affect straw dry weight of sorghum at Samaka (Table 48). The sole crop gave significantly more straw than all the mixtures while the 1:2 proportions gave more straw than the 2:1 proportions but significantly more only in the mixed rows.

Plant height

Increasing plant population from 44,444 to 66,666 plants ha^{-1} did not affect plant height of sorghum significantly at Samaka (Table 49). The mixed rows and the sole crop tended to have taller plants than in alternate rows but the differences were not statistically significant.

Table 48. The effect of cropping pattern and Plant Population on the straw dry weight (kg ha^{-1}) of sorghum. Seminoka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	6395	2124	4065	2193	4020	3759
66,666	7172	2924	3289	2056	4933	4075
Mean	6784	2524	3677	2125	4477	

	SE	LSD (0.05)
Population	±282	NS
Cropping pattern	±445	1164
Interaction	±630	NS

Table 49. The effect of cropping pattern and Plant Population on the plant height (m) of sorghum at harvest (m), Seminoka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	1.80	1.48	1.53	1.80	1.64	1.65
66,666	1.67	1.53	1.80	1.72	1.86	1.72
Mean	1.74	1.51	1.67	1.76	1.75	

	SE	LSD (0.05)
Population	±0.05	NS
Cropping pattern	±0.08	NS
Interaction	±0.11	NS

Harvest index

Increasing plant population from 44,444 to 66,666 plants ha^{-1} decreased harvest index (Table 50). The sole crop had the lowest harvest index while the 2:1 proportion had the highest index. The alternate arrangements had generally higher harvest index than the mixed rows.

4.6. 4.6. Total Yield of Grain and Dry Matter in Maize and Sorghum in Mixed Crops at Saminka

4.6.1. Total grain yield

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased the total grain yield of maize and sorghum mixed crops but not significantly (Table 51). The 2:1 proportions produced more total grain yield than did the 1:2 proportions though the differences between them was not statistically significant.

The alternate arrangement had more grain yield than the sole maize while the sole sorghum has lower grain yield than all the mixtures especially the 1:2 proportions.

4.6.2. Total dry matter

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased total dry weight of maize and sorghum mixed crops at Saminaka but not significantly (Table 52). At Saminaka, the mixed rows had more total dry weight than the alternate rows in corresponding proportions.

Table 50. The effect of cropping pattern and Plant Population on the harvest index of sorghum, Saminaka, 1983.

Population Plants ha^{-1}	Sole Sorghum	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	0.178	0.245	0.200	0.248	0.187	0.212
66,666	0.133	0.246	0.178	0.222	0.167	0.189
Mean	0.155	0.246	0.189	0.235	0.177	

Table 51. The effect of cropping pattern and Plant Population on the total grain yield (kg ha^{-1}) of maize and sorghum in mixed crops at Saminaka, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	2399	1850	2809	1869	2232
66,666	3152	1623	2971	2078	2456
Mean	2776	1737	2890	1974	

	SE	ISD (0.05)
Population	±198.47	NS
Cropping pattern	±280.68	NS
Interaction	±396.94	NS

Table 52. The effect of cropping pattern and Plant Population on the total dry matter (kg ha^{-1}) of maize and sorghum in mixed crops, Saminaka, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	7,553	7,945	8,801	8,251	8,137
66,666	10,244	7,367	9,830	9,818	9,315
Mean	8,899	7,656	9,316	9,035	

	SE	LSD (0.05)
Population	±433.11	NS
Cropping pattern	±612.52	NS
Interaction	±866.23	NS

4.6.3. LER for grain yield at Saminaka

Increasing plant population from 44,444 to 66,666 plants ha^{-1} increased the land equivalent ratio for grain yield at Saminaka though not significantly (Table 53). The 2:1 proportions, as was the case at Samaru had higher LER than the 1:2 proportions. The mixed rows arrangement had higher LER than the alternate rows arrangements in the some proportion. The interaction between cropping pattern and population was statistically significant with increase in population increasing the LER for the 2:1 alternate row and 1:2 mixed row it decreased in the 1:2 alternate rows and 2:1 mixed rows.

Table 53. The effect of cropping pattern and Plant Population on the land equivalent ratio (LER) for grain yield of maize and sorghum in mixed crops, Saminaka, 1983.

Population Plants ha^{-1}	2:1 Alternate	1:2 Alternate	2:1 Mixed row	1:2 Mixed row	Mean
44,444	0.95	1.10	1.37	1.07	1.12
66,666	1.59	0.89	1.36	1.17	1.25
Mean	1.27	1.00	1.37	1.12	

	SE	LSD (0.05)
Population	±0.07	NS
Cropping pattern	±0.10	NS
Interaction	±0.14	NS

An attempt will be made to give possible explanations to the results presented and answer the following questions:

1. Was mixing of maize and sorghum of any adcantage?
2. Which population was better, low or high?
3. Was alternate row arrangements better than mixing plants in the same row?
4. Which proportion was best for maize and sorghum mixed crops?

Differences in grain yield between sole crop maize and Sorghum

The sole maize yield at Samaru was four times higher than the yield of sorghum while at Saminaka, the maize yield was approximately twice the yield of the sole sorghum. The exceptionally poor performance of sorghum relative to maize was an unusual seasonal effect due to the early cessation of rains, especially at Samaru. In multilocational trials between 1979 and 1981, Fisher (1984) obtained mean sole crop yields of 2182 and 1536 kg ha^{-1} for maize and sorghum respectively.

Advantage of Mixing

The sole crop maize was clearly the highest yielding cropping pattern at both sites in 1983, but since this was not predictable before planting time, the best basis of comparing the mixed crops is probably the expected yields at the 2:1 and 1:2 proportions used in the mixed crops treatments.* The replacement diagrams (Figures 1, 2, 3, and 4) infact use this same principles in graphic form.

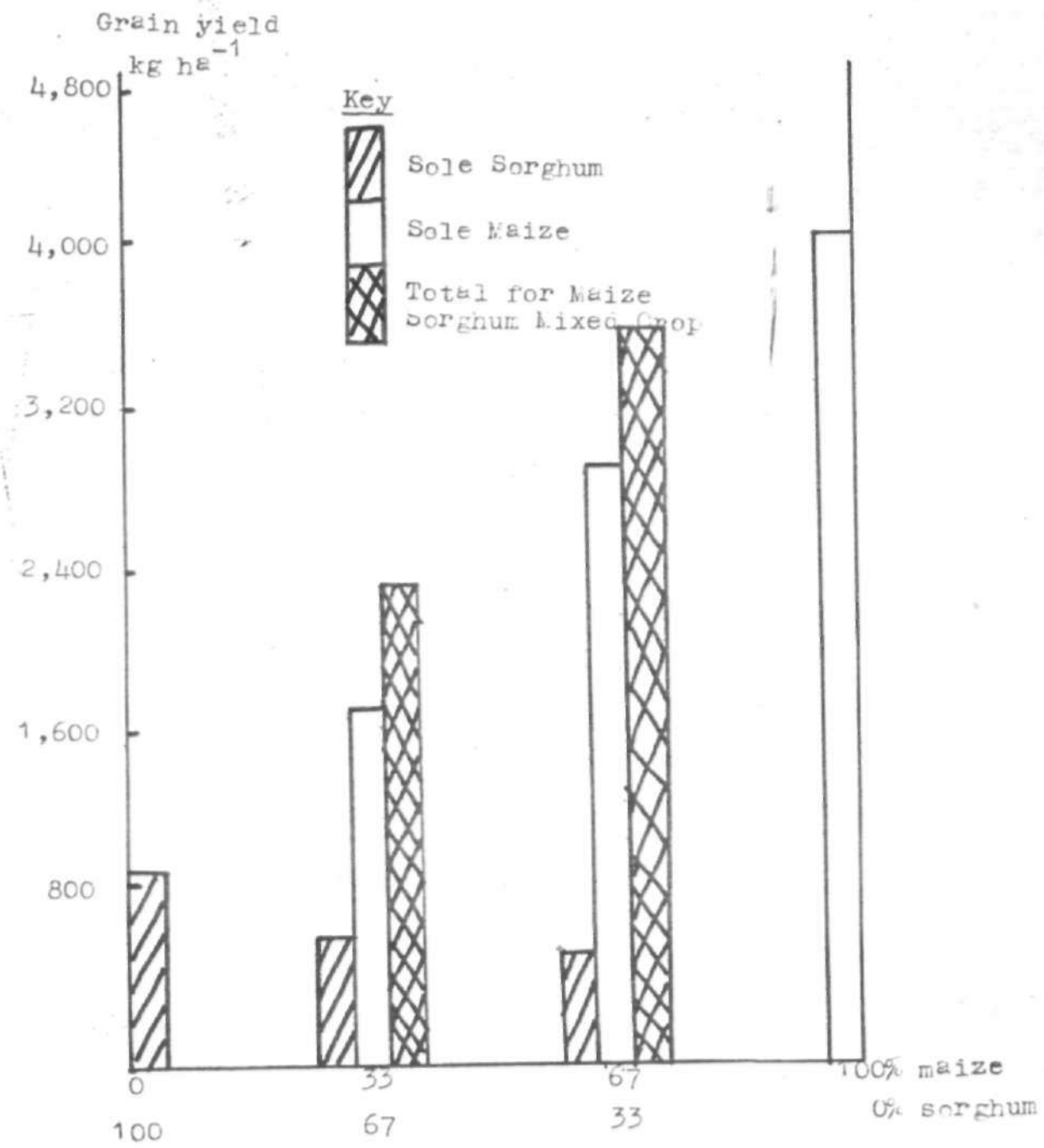


Fig. 1. Yield as influenced by replacement proportion of maize and sorghum at Samaru, 1963.

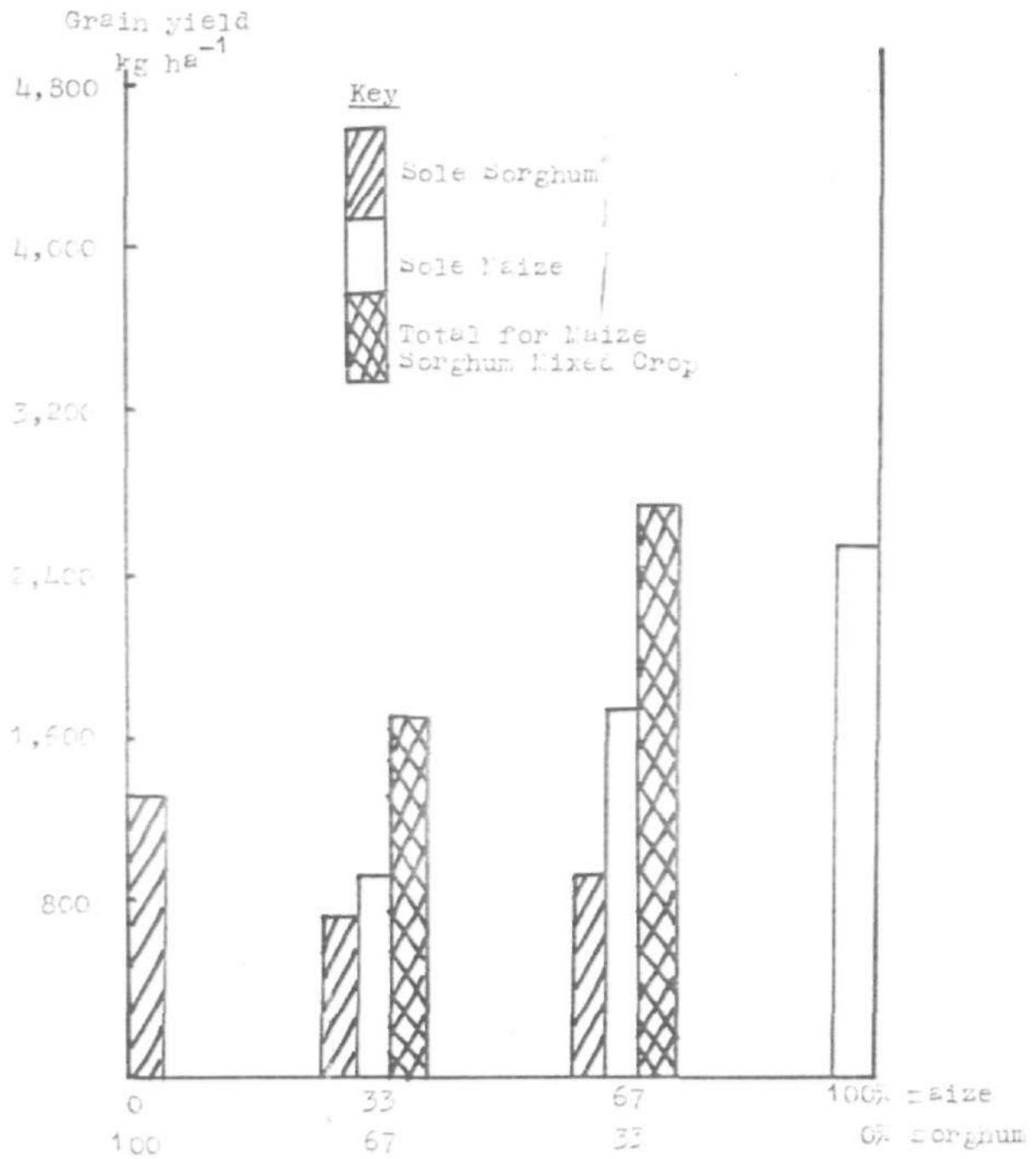


Fig. 2. Yield as influenced by replacement proportions of maize and sorghum at Samaru 1967.

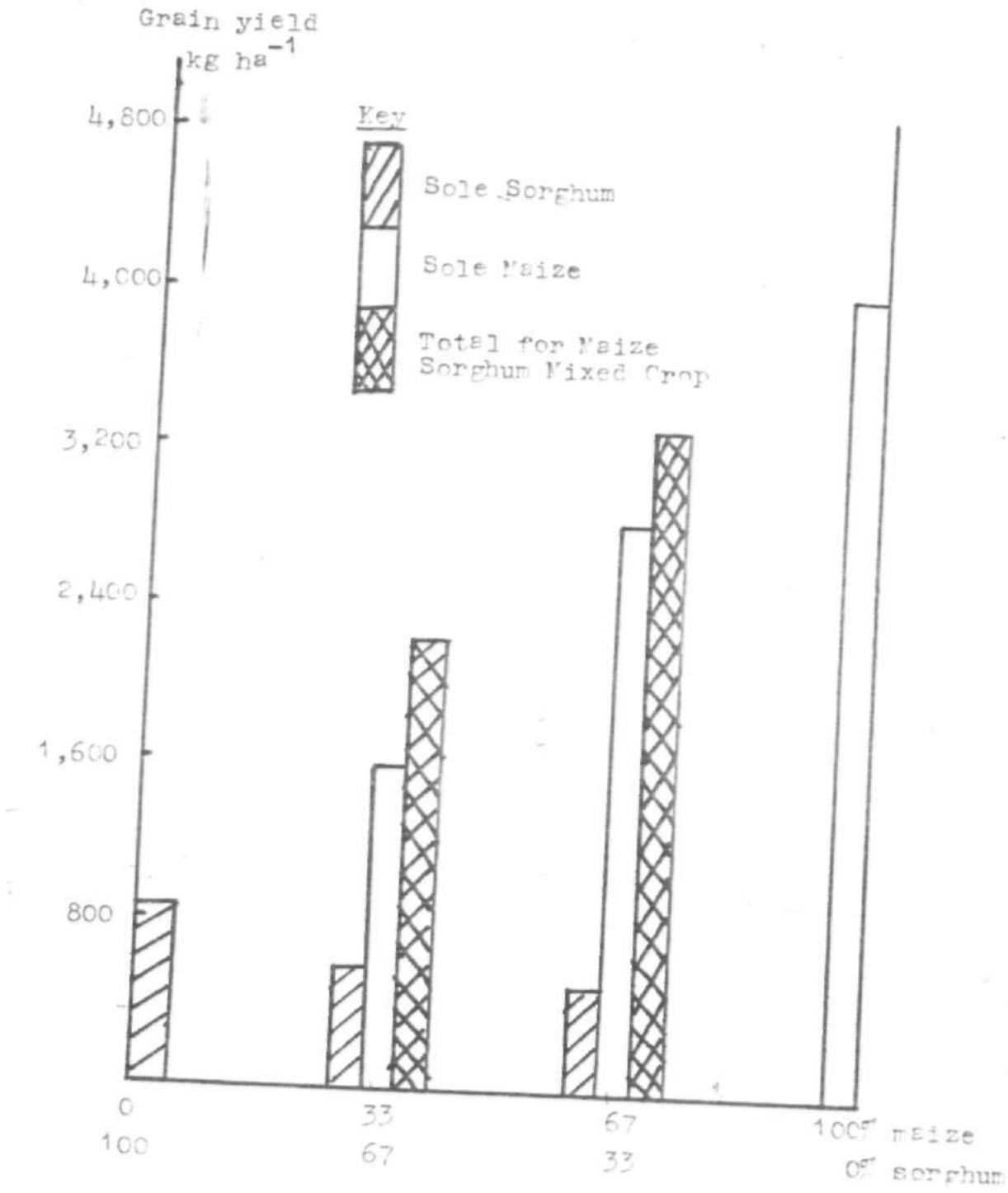


Fig. 3. Yield as influenced by replacement proportions of maize and sorghum at Samaru, 1987.

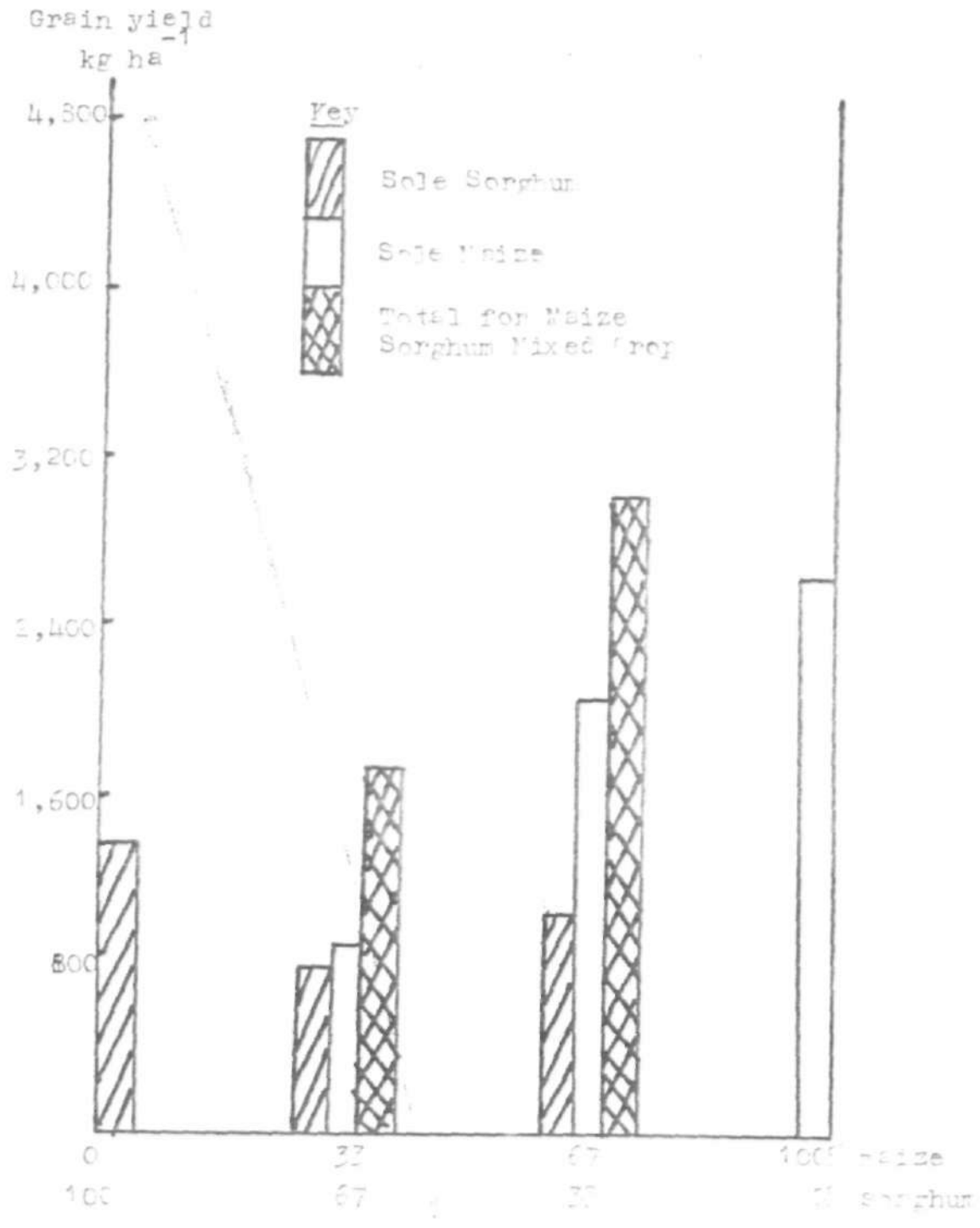


Fig. 4. Yield as influenced by replacement proportions of maize and sorghum at Samaru, 1983.

The expected yields for 2:1 and 1:2 proportions (Maize and sorghum) are shown in table 54. When this is compared with the actual grain yield of the mixed crops (Table 54), yield advantages of 20% and 12% were observed for the 2:1 alternate and mixed row respectively. The Percent gain in grain yield due to mixing at Saminaka were 25% and 30% for the 2:1 alternate and mixed row respectively while for the 1:2 proportion, it was -3% and 10% for the alternate and mixed row respectively.

Table 54. Expected yield of grain and dry matter for maize and sorghum at two sites. kg ha^{-1}

	2:1 Proportions		1:2 Proportion	
	Grain yield	Dry matter produced	Grain yield	Dry matter produced
Samaru	3018	10902	1962	11048
Saminaka	2223	7913	1996	8376

The land equivalent ratio (LER) also gave similar results with the 2:1 proportions at both sites having a higher mixing advantage with an LER averaging 1.32 as against the 1.07 for the 1:2 proportions. At Samaru, the alternate rows had a higher LER than the mixed rows, while at Saminaka, the alternate arrangements performed poorly as compared with the mixed arrangements. Thus the LER and the comparison on the basis of expected grain yield indicate consistently that 2:1 mixture was better than 1:2 at both sites and that alternate rows

arrangement was better at Samaru while mixed rows were best at Saminaka. The difference in the LER were not however statistically significant (Table 38 and 58). The expected

Table 55. Percent change in grain yield due to mixing at Samaru and Saminaka.

	Alternate row		Mixed row	
	2:1	1:2	2:1	1:2
Samaru	20	18	12	9
Saminaka	25	-3	30	10

yields of dry matter for the 2:1 and 1:2 proportion were 10902 and 11048 kg ha^{-1} respectively at Samaru and 7913 and 8376 kg ha^{-1} for the 2:1 and 1:2 proportions respectively, (Table 54). The greater total dry weight produced by the sole sorghum and the 1:2 proportion (sorghum dorminant) can be attributed to the long growing period of the sorghum (180 days) resulting in more total light intercepted and thus more dry matter produced than the sole maize and 2:1 proportion (Maize dominant) which had a shorter life span (120 days). This difference in growing period contributing to more light interception can be seen in leaf cover at 18 weeks when the maize was already harvested but sorghum was still intercepting 49% of the light (Table 10). Similar results were reported by Goldsworthy (1969) whose long season Farafara sorghum variety had 3-4 times more dry matter than the short season NK 300. Stockinger (1973) and Anon (1981) had similar results.

The percent gain in dry matter due to mixing of maize and sorghum at Samaru were 22% and 29% in the 2:1 alternate and mixed row respectively and 9% and 8% for the 1:2 alternate and mixed row respectively. At Saminaka the observations are not consistent with the Samaru result because the gains at Saminaka were 11% and 15% for the 2:1 alternate and mixed rows respectively and -3% and 12% for the 1:2 alternate and mixed row respectively. Thus, mixing advantage at Samaru was most dependent on proportions with the 2:1 proportion having higher mixing advantage. At Saminaka, irrespective of the proportions, the mixed row arrangements had much ihigher mixing advantage than the alternate arrangements. This contrary observation at Saminkaka could probably be attributed to the fairly adequate rainfall there which enhanced dry matter production of the mixed rows where inter-specific competition starts earlier while at Samaru the limited water available due to drought place the mixed row treatment at a disadvantage because its earlier inter-specific competition coupled with water shortage.

The harvest index of sorghum was found consistently higher in mixtures (Table 35 and 50). While that of maize was observed to be reduced by mixing (Table 29 and 44). This further explain the sorghum gain due to mixing. Similar observations was made by Fisher (personal communication) between 1979 to 1981 that there was no difference in maize harvest index but a consistent and significant increase in the harvest index of sorghum due to mixing with maize.

Plant population

The response of grain yield due to change in plant population at both sites is summarised below (Table 56). At Samaru, all the cropping patterns gave higher grain yield at higher plant population ecept for a very small reduction in the 1:2 mixed rows.

Table 56. Change in total grain yield due to increase in plant populations for different cropping patterns at Samaru and Saminaka.

	Sole Maize	Sole Sorghum	Alternate row 2:1	Alternate row 1:2	Mixed row 2:1	Mixed row 1:2
Samaru	297	200	1086	716	185	-15
Saminaka	-593	-365	-753	-227	162	208

The response in the alternate row mixtures was larger than in the sole crops. The result is important in that is occured in a year when sorghum yield was badly affected by drought especially at Samaru. At Saminaka, three of the mixed crops responded positively to the increase in plant population whereas both sole crops responded negatively especially the maize sole crop (Table 56). Although the variation was large and none of the responses were significantly different from zero, the Saminaka results do suggest that a higher plant population would be appropriate for mixed crops than for sole crops.

This agrees with Anon. (1976) who suggested that maize population in the row should be 1.24 times that of the sole crop.

In these experiments, the higher target population of 66,666 plants ha^{-1} which actually had an average of 55,412 plants ha^{-1} in the mixed crops at Samaru and 58,313 plants ha^{-1} at Saminaka was better than the lower populations. Maize-sorghum populations of 60,000 plants ha^{-1} (total) can therefore, be safely recommended though further research will be needed to define the optimum plant population more exactly.

Row arrangement

In all corresponding proportions at Samaru, the alternate arrangements had higher yield than the mixed row arrangements (Tables 23 & 31). At Saminaka, it was the mixed row arrangements that did better than the alternate rows especially for the 1:2 proportions both in grain and dry matter (Table 41 and 47). The mixed rows had generally higher total leaf cover than the sole crops at Samaru.

This indicates better foliage canopy which according to Egharevba (1978) was the most important factor for predicting yield productivity. The better performance was even more pronounced in the dry matter production than in the grain yield.

The contrary observations at Saminaka where the mixed rows had better yield in all proportions and the 2:1 mixed row at Samaru can be explained probably on the basis of rainfall. At Saminaka the rainfall was better than at Samaru in 1983

(Appendix table A_1 and A_2). Inter-specific competition for water probably was more severe in the mixed row at Samaru than at Saminaka putting it at a disaddvantage over the alternate row where inter-specific competition started much later.

Optimum proportions for maize and sorghum mixed crops at Samaru and Saminaka

The 2:1 proportions was clearly much better than the 1:2 proportions in terms of grain yields with an LER averaging 1.08 for the 1:2 proportions at Samaru (Table 38). The 2:1 alternate arrangements and higher mixing advantage (LER 1.36) than the mixed rows (LER 1.29). In the 1:2 proportions, the mixed rows had however, a higher mixing advantage than the alternate row though the differences were not large (Table 38). Similarly at Saminaka the 2:1 proportion had higher mixing advantage with an average IER of 1.32 while the 1:2 proportion had only 1.06. Contrary to what was observed at Samaru however, it was the mixed row here that had higher and better mixing advantage with an IER of 1.37 as against an IER of 1.27 for the alternate row in the 2:1 proportions while the 1:2 mixed rows had an IER of 1.12 as against the IER of 1.00 for the alternate row arrangement (Table 53).

The general and better performance at both sites for the 2:1 proportion can be attributed to the dominance of maize in the mixture. Being fast growing, as earlier noted, it had not only earlier leaf growth but also higher leaf cover than

the 1:2 proportions to intercept solar radiation and convert it into dry matter resulting in higher yield of that proportion. The poorer, lower and later leaf cover of the 1:2 proportions can be seen in the total leaf cover at 6 and 8 weeks resulting in a lower light interception and thus yield (Table 11 and 12).

SUMMARY AND CONCLUSIONS

The year of these experiments, 1983, was an usually dry one with rainfall at Samaru only 610mm compared with a long term average of 1107 mm. At Saminaka, the rainfall was 953mm, compared with an average of 1306mm. The long season (180 days) sorghum variety used in the experiment was much more seriously affected than the short season (110 days) maize variety and thus sole maize outyielded the sole sorghum, especially at Samaru. A yield advantage from 7% to 30% relative to sole crops at the same planting proportion was achieved by growing maize and sorghum in mixtures. The existance of a yield advantage in this very dry year suggests that the mixed cropping system with maize and sorghum gives farmers some insurance against drought.

It was not possible to get the high target plant population of 66,666 plants ha^{-1} at harvest, on the average, there were 55,412 and 58,313 plants ha^{-1} at Samaru and Saminaka respectively. The better performance in crop mixtures at these high population suggests that a total plant population of maize and sorghum can safely be at least 60,600 plants ha^{-1}. Further research is needed to determine the optimum plant population more precisely.

While the alternate row arrangement was better at Samaru, the mixed row arrangement was better at Saminaka. The year being a dry one especially at Samaru, one cannot rule out the

possibility of the mixed row doing equally well at Samaru as was the case at Saminaka if the rainfall had been better in total and in its distribution. Thus further research will be needed in order to give an authoritative recommendation on arrangements. The 2:1 (Maize:Sorghum) proportion was the highest yielding proportion at both sites irrespective of the spatial arrangement. It had a mixing advantage of upto 30% as against the highest mixing advantage of 12% for the 1:2 proportions. Thus for maximum mixing advantage, the 2:1 proportion can be recommended at both locations.

REFERENCES

Adelana, B.O. and Milbourn, G.M. (1972). The growth of maize II: Dry matter partitioning in three maize hybrids. Journal of Agricultural Science (Cambridge), 78, 73-78.

Allison, J.C.S. and C Watson; D.J. (1966). The production and distribution of dry matter in maize after flowering. Annals of Botany N.S. 365-363.

Andrews, D.J. (1974). Response of sorghum varieties to intercropping. Experimental Agriculture, 10, 57-63

Andrews, D.J. (1976). Plant density and grain yield of Nigerian Sorghum. Savanna, 2, 55-60.

Anonymous (1972). Farming Systems and Intercropping Programme. (Cropping Scheme Meeting) IAR, ABU, Zaria.

Anonymous (1974). Farming Systems and Intercropping Programme. (Cropping Scheme Meeting), IAR, ABU, Zaria.

Anonymous, (1976). Farming Systems and Intercropping Programme. Cropping Scheme Meeting (1976) IAR, ABU, Zaria.

Anonymous (1980). Cereal Research Programme. Cropping Scheme Meeting, IAR, ABU, Zaria.

Anonymous (1981). Farming Systems and Intercropping Programme. Cropping Scheme Meeting, IAR, ABU, Zaria.

Anonymous, (1982). Notes on cereal improvement programme. Cropping Scheme Meeting (1982) IAR, ABU, Zaria.

Anonymous, (1982). Notes on Farming Systems Research Programme. Cropping Scheme Meeting, (1982) IAR, ABU, Zaria.

Anonymous, (1983). Notes on the Farming System Research Programme. Cropping Scheme Meeting (1983) IAR, ABU, Zaria.

Baker, E.F.I. (1978). Mixed cropping in northern Nigeria Nigeria I. Cereals and groundnut. Experimental Agriculture, 14, 253-298.

Baker, E.F.I., and Yusuf, Y. (1976). Research with mixed crops at IAR, ABU, Samaru Nigeria. In Symposium on intercropping in semi-arid areas. Morogoro, Tanzania, May, 1976. Samaru Conference paper No. 10.

Baker, E.F.I., (1979b). Population, time and crop mixtures. In proceeding, International Workshop on Intercropping ICRISAT Hyderabad India. 10-13 January, 1979 pp. 52-60.

Baeumer, K. and de-Wit, C.T. (1968). Competitive interference of plant species in monoculture and mixed stands. Netherland Journal of Agricultural Sciences, 16, 103-122.

Bebawi, F.F. and Farah, A.T. (1981). Effect of patterns and methods of sowing on sorghum/striga relations. Experimental Agriculture, 17, 337-341.

Bunting, E.S. and Willey, I.A. (1959). The ultivation of maize for fodder and ensilage. II. The effect of changes in plant density. Journal of Agricultural Sciences (Cambridge), 52, 313-319.

Bond, J.J., Army, J.J. and Lehman, O.R. (1963). Row spacing, plant population and moisture supply as factors in dry land grain sorghum production. Agronomy Journal, 56, 3-6.

Brain, F.B. (1971). Crop production: Cereals and Legumes Academic press. London and New York 446 pp.

Brown, P.I. and Shareder, I.N.D. (1959). Grain yield, evapotranspiration and water use efficiency of grain sorghum under different practices. Agronomy Journal, 51, 339-343.

Carlson, C.W., Alesai, J. and Nickelson, R.U. (1959). Evapotranspiration and yield of corn as influenced by mixtures level nitrogen fertilizer and plant density. Soil Science Society of America Proceedings, 23 242-245.

Cochran, W.G. and Cox, G.M. (1967). Exrerimental Design (2nd edition). Wiley Press, New York and Chichester, 610 pp.

Darrold, E. Termude, Shenk, D.B. and Dirks, V.A. (1963). Effect of population levels on yield and maturity of maize hybrids grown on the Northern Grait Plains. Agronomy Journal, 54, 240-248.

Eddowes, M. (1969). Physiological studies of competition development in Zea mays L. Vegetative growth and ear development in maize. Journal of Agricutural Science (Cambridge), 72, 185-193.

Eddowes, M. (1969b). Physiological studies of competition in Zea mays L. II. Effect of competition among maize plants. Journal of Agricultural Science (Cambridge), 72, 195-202.

Egharevba, P.N. (1978). 'Padiation, plant architecture and crop production'. Samaru Conference paper No. 22, IAR/ABU, Zaria 16 pp.

Egharevba, P.N. (1979). Agronomic practices for improved sorghum and millet production - two papers. Samaru Miscellanous papers No. 90. IAR/ABU, Zaria, 24 pp.

Fisher, N.M. (1979). Polyculture cropping systems of Africa and their implications for appropriate tillage technology. In Proceeding of the Appropriate Tillage Workshop. Zaria, London, Commonwealth Secretariat pp. 65-72.

Goldsworthy, P.R. (1969). The growth and yield of tall and short sorghum in Nigeria. Journal of Apricultural Science, (Cambridge) 74, 109-122.

Goldsworthy, P.R. (1970). The canopy structure of tall and short sorghum. Journal of Agricultural Sciences (Cambridge), 75, 123-131.

Goldsworthy, P.R. and Taylor, R.S. (1970). The effect of plant spacing on grain yield of tall and short sorghum in Nigeria. Journal of Agricultural Science (Cambridge), 75, 1-10.

Haggar, R.J. and Couper, A.C. (1972). Effect of plant populations and fertilizer nitrogen on growth and components of yield of maize grown for tillage in Nigeria. Exrerimental Agriculture, 8, 251-263.

Havelka, Y.D. (1965). Comparison of single row and double row method of planting grain sorghum in Central Texas. Texas Agricultural Exrerimental Station Progress Report, 2349.

Halliday, R. (1960a). Plant population and crop yield Part I. Field Crop Abstracts. 13, 159-167.

Hume, A.N. Dirks, V.A. and Shank, D.B. (1956). Date of and rate of corn planting. South Dakota Agricultural Station Bulletin, 455.

Hume, D.J. and Kobede, Y. (1981). Response to planting date and population densities by early-maturing sorghum Hybrids in Ontario, Canada. Canadian Journal of Plant Science, 61, 265-273.

Kassam, A.H. (1973). In search for greater yields with mixed cropping in Northern Nigeria - a report on Agronomic work. Report IAR/ABU, Zaria, Nigeria.

Kassam, A.H. and Stockinger, K.R. (1973). Growth and Nitrogen uptake of sorghum and Millet in mixed cropping. Samaru Agricultural News Bulletin, 15, 20-32.

Keper, R.E. (1929). Grain sorghum date of planting, spacing expreriment. Texas Agricultural Experimental Bulletin, 424.

Kohnke, H. and Miles, S.R. (1951). Rates and pattern of seeding corn on high fertile land. Agronomy Journal. 43, 488-493.

Kowal, J.M. (1972). Radiation and Potential crop production at Samaru, Nigeria. Savanna, I, 88-101.

Kowal, J. and Andrews, D.J. (1973). Pattern of water availabilit and water use for grain sorghum production at Samaru Nigeria. Tropical Agriculture, 50, 89-100.

Kowal, J.M. and Knabe, D.T. (1972). An agroclimatological Atlas of the Northern State of Nigeria. ABU, Press, Samaru, Zaria, Nigeria.

Lucas, E.O. (1981). The growth of two maize varieties in farmers plots, located at two contiguous ecological zones in Nigeria. Journal of Agricultural Science (Cambridge) 97, 125-134.

Michael, R.I. (1970). Crop Growth and Culture. Iowa State University Press, 349 pp.

Moldenhaus, W.C. and Lipscomb, W. (1957). Narrow row sorghum for soil, water conservation. South Eastern Crops Stalk 11-12.

Muleba, K. (1980). Physiological determinants of grain yield in maize (Zea mays I.) Varieties in different environments. Dissertation Abstract International Bulletin. 4, 1601.

Myers, R.J. and Foale, M.A. (1981). Row spacing and population density on grain sorghum: Simple analysis. Field Crop Research, 4, 147-154.

Natarajan, M. and Wiley, R.W. (1980). Sorghum pigeon pea Intercropping and the effect of plant population density II: Resource use: Journal of Agricultural Science (Cambridge), 55, 59-65.

Norman, D.W. Buntjer, B.J. and Goddard, A.D. (1970). Intercropping observation plots at farmers level. Samaru Agricultural News letter, 12, 97-101.

Norman, D.W. (1972). An economic analysis of three villages in Zaria province II. Input & output study. Vol. I Samaru Miscellaneous paper, No. 37.

Norman, D.W. (1974). Rationalising mixed cropping under indigenous conditions. The example of Northern Nigeria. Samaru Research Bulletin No. 230.

Nosberger, J. and Thorne, G.N. (1965). The effect of removing florets or shading the ear of barley on production, distribution of dry matter Annal of Botany N.S. 47, 635-645.

Okigbo, B.N. (1979). Evaluation of plant interelations and productivity in complex mixtures as a basis for improved cropping systems design. In Proceedings of the International Workshop on Intercropping. ICRISAT, Hyderabad, India. 10-15, January, 1979, pp. 155-179.

Osiru, D.S. and Willey R.W. (1972). Studies on mixtures of dwarf sorghum and beans (Phaseolus vulgaris) with particular reference to plant population Journal of Agricultural Science (Cambriage), 79, 513-540.

Owonubi, J.J. (1980). Effect of plant height on light Interception, water use and yield of sorghum in pure and mixed canopies. Dissertation Abstract International Bulletin, 41 (5), 1601-1602

Quinby, J.R., Kramer, N.W., Stephens, J.C. Iahr, K.A. and Karper, R.E. (1958). Grain sorghum production in Texas. Texas Agricultural Station Bulletin, 912.

Ramirez, R. and Bejerano, A. (1983). Maize (Zea mays L.) yields as a function of population and spacing in Aragua State. Field Crop Abstract, 36: 4029.

Robins, J.S. and Domingo, C.E. (1953). Some effect of severe soil moisture deficit at specific growth stages in corn. Agronomy Journal, 45, 618-621.

Ross, W.M. and Eastin, J.D. (1972). Grain sorghum in the United States. Field Crop Abstract, 25, 169-174.

Ruthenberg, H. (1971). Farming Systems in the Tropics. Oxford University Press, London.

Shubeck, F.E. and Caldwell, A.C. (1955). Effect of fertilizers and straw on corn and of stand soil moisture. Minnesotas Agricultural Experimental Station Technical Bulletin, 213.

Taylor, B.R. (1977). Factors in package of practices for production of maize in Northern Nigeria. Experimental Agriculture, 13, 209-215.

Termude, D.E. Shank, D.B. and Dirks, V.A. (1963). Effect of p population level on yield and maturity of maize hybrids grown on the Northern great plains. Agronomy Journa, 55, 551-555.

Trenbath, B.P. (1976). Plant interaction in mixed crops communities. In Papendiek, P.I., P.A. Sanchez, Multiple cropping. American Society of Agronomy Special Publication No. 27, Wisconsin, USA. pp 76-102.

Trenbath, B.P. (1979). Leaf canopies and utilization of light, light use efficiency of crops and the potential for improvement through intercropping. Proceeding International Workshop on Intercropping. ICRISAT, 1979, 170-188.

Thomas, G.V., French, A.V. (1980). Row spacing and population effect on yield of grain sorghum in Central Queensland. Queensland Journal of Agriculture and Animal Science, 37, 7-77.

Van Eijnatten, C.J.M. (1963). A study of the development of two varieties of maize at Ibadan, Nigerian Journal of Agricultural Science, 61, 65-72.

Wahua, T.A.T. and Miller, D.A. (1978). Relative yield components of intercropped sorghum and soybeans. Agronomy Journal, 70, 287-291.

Willey, R.W. and Osiru, D.S.O. (1972). Studies on mixtures of maize and bean (Phaseolus vulgaris) with particular reference to plant population: Journal of Agricultural (Cambridge), 79, 513-529.

Willey, R.W. (1979). Intercropping - Its importance and research needs parts 1 and 2. Field Crop Abstracts, 32, 1-10 and 73-85.

Williams, W.A., Loomis, R.S. and Lepley, C.R. (1965). Vegetative growth of corn as affected by population density. Crop Science 5, 211-215.

Yayock, J.Y. (1973). The effect of competition within and between cowpea and millet in sole and intercropping systems. Preliminary proposal of Dissertation for Ph.D. Degree ABU, Zaria.

Zuber, M.S. and Grogan, C.O. (1956). Rates of planting studies with Maize. Missouri Agricultural Station Research Bulletin. No. 470

Appendix A 1. Daily rainfall (mm) at Samaru in 1983.

D Date	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
1								2.1	2.0			
2						9.8	11.0	35.0				
3						4.0	Tr	14.5				
4							9.7	1.1	1.1			
5							6.6	0.8	21.0			
6									11.3			
7							0. 9	27.0				
8						0.2	0.3	0.5	16.3			
9					Rr							
10							18.2	17.8				
11					3.5	7.4	0.8		2.6			
12					16.4							
13							0.3		7.4			
14					16.9							
15						6.6			12.0			
16							6.0		10.0			
17					0.1							
18						Tr		48.4	4.6			
19								21.0	1.6			
20					17.2		1.2	14.6				
21						Tr						
22							18.4	0.5				
23					2.0			6.2	Tr			
24					3.0	24.5						
25						1.0	0.5	26.3	3.5			
26					1.3			24.7				
27							0.3					
28					8.9	17.1						
29						3.7						
30												
31					4.0							
					73.3	74.3	107.5	259.7	95.2			

Appendix A 2. Daily rainfall (mm) at Saminaka in 1983

Date	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	De
1				2.5					6.1	6.1		
2					2.5	3.6	18.4	9.5	5.9			
3										10.5		
4								12.4	19.1			
5							19.5	0.7				
6								29.7				
7									4.1	20.3		
88					0.07	52.5			2.1			
9					1.0			11.0	4.3	20.6		
10				7.3	35.7	10.7	10.50	23.0	3.0			
11					12.9				5.0	20.0		
12					12.9	9.70						
13					0.07							
14										4.3		
15					38.3	22.0				9.3		
16						6.50	35.2			15.3		
17												
18						27.80			4.3	43.1		
					19.05	17.90			7.5			
20										2.2		
21									6.2			
22												
23						1.3			11.7			
24					8.0	18.8				2.3		
25						0.5			18.7			
26							16.0	55.8				
27						15.0	3.1					
28						8.0	9.0	41.9	15.2	28.3		
29								48.6				
30							3.0					
31			Tr					1.9				
				9.8	153.49	183.6	218.6	180.2	196.8	10.5		

Appendix B. Temperature, solar radiation and sunshine hours during the cropping season at Samaru in 1983.

Month	Temperature °C Maximum	Minimum	Solar Radiation (langley/Day)	Sunshined Hours/Day
January	29	18	15.0	3.5
February	37	24	20.7	7.1
March	38	29	21.6	7.7
April	41	33	22.5	7.7
May	39	29	21.0	8.6
June	35	28	16.9	6.9
July	33	24	14.8	6.7
August	33	25	12.6	6.7
September	32	25	15.9	7.4
October	33	31	18.9	7.5
November	34	28	19.3	9.3
December	34	25	17.5	8.6

Appendix C 1. Analysis of variance for leaf cover in maize at 6, 8, 11 and 15 w.a.s. at Samaru 1983.

Source	DF	6 w.a.s. MS	8 w.a.s. MS	11 w.a.s. MS	15 w.a.s. MS
Block	3	155.04^{NS}	169.16^{NS}	30.14^{NS}	187.71^{NS}
Population	1	27.22^{NS}	416.02^{NS}	366.02*	1045.5**
Cropping pattern	4	891.51*	1779.11**	2036.11**	2491.72*
Interaction	4	76.84^{NS}	120.96^{NS}	495.40**	191.10^{NS}
Error	27	41.66	153.25	84.01	76.00

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 2. Analysis of variance for the leaf cover of **sorghum** 6, 8, 11, 15 and 18 w.a.s. Samaru, 1983.

Source	DF	6 w.a.s. MS	8 w.a.s. MS	11 w.a.s. MS	15 w.a.s. MS	18 w.a.s. MS
Blocks	3	37.45^{NS}	22.76^{NS}	66.71^{NS}	161.24^{NS}	169.78^{NS}
Population	1	48.40^{NS}	30.63^{NS}	0.90^{NS}	170.41^{NS}	112.22^{NS}
Cropping pattern	4	1676.90**	2226.90**	5156.09**	4349.90**	638.24*
Interaction	4	124.02*	140.24^{NS}	393.79**	172.90^{NS}	63.35^{NS}
Error	27	37.11	139.35	81.55	132.86	156.26

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 3. Analysis of variance for total leaf cover of maize and sorghum in mixed crops at 6, 8, 11 and 15 w.a.s. at Samaru, 1983.

Source	DF	6 w.a.s. MS	8 w.a.s. MS	11 w.a.s. MS	15 w.a.s. MS
Blocks	3	233.28^{NS}	78.69^{NS}	17.94^{NS}	33.70^{NS}
Population	1	106.80^{NS}	627.85*	268.38*	266.02*
Cropping pattern	5	81.93^{NS}	156.39^{NS}	68.75^{NS}	89.78^{NS}
Interaction	5	81.71^{NS}	58.93^{NS}	21.03^{NS}	38.43 ^{NS}
Error	33	114.75	70.44	88.78	56.53

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 4. Analysis for maize and sorghum leaves, stem and sheath at 6 and 11 w.a.s. at Samaru, 1983.

Source	DF	Maize shoot		Sorghum shoot		
		6 w.a.s.	11 w.a.s.	6 w.a.s.	11 w.a.s.	15 w.a.s.
Blocks	3	697^{NS}	753^{NS}	500^{NS}	961^{NS}	26244^{NS}
Population	1	1775^{NS}	837^{NS}	13^{NS}	41485^{NS}	172338^{NS}
Cropping pattern	4	850^{NS}	113^{NS}	541^{NS}	7846^{NS}	26382^{NS}
Interaction	4	650^{NS}	1528^{NS}	645^{NS}	7418^{NS}	15602^{NS}
Error	27	3031	16306	897	5735	48630

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 5. Analysis of variance for plant count, cob number cob wieght grain yield strew dry weight, 1,000-grain weight and plant height of maize at Samaru, 1983.

Source	DF	Plant count plot^{-1} MS	Cob number plot^{-1} MS	Cob weight kg plot^{-1} MS	Grain yield, kg plot^{-1} MS	Straw dry weight, kg plot^{-1} MS	g/1000 grains MS	Plant height (m) MS
Blocks	3	3.63^{NS}	86.00^{NS}	2.22^{NS}	0.48^{NS}	0.58^{NS}	59.17*	0.49^{NS}
Population	1	3697**	1155.63**	3.14^{NS}	4.36*	8.90*	1296.20*	0.04^{NS}
Cropping pattern	4	3118.8*	2792.15**	37.80*	14.77**	20.80*	407.97^{NS}	0.09^{NS}
Interaction	4	102.14*	89.63^{NS}	2.07^{NS}	0.34^{NS}	0.75^{NS}	351.30^{NS}	0.11**
Error	27	10.54	67.08	2.53	0.64	1.80	225.77	0.05

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 6. Analysis of variance for plant count, Head number, Head weight grain yield, straw dry weight, 1000-grain weight and plant height of sorghum at Samaru, 1983.

Source	DF	Plant count plot^{-1} MS	Head number plot^{-1} MS	Head weight, kg plot^{-1} MS	Grain yield, kg plot^{-1} MS	Straw dry weight, kg plot^{-1} MS	g/1000 grains MS	Plant height (m) MS
Blocks	3	1.00^{NS}	147.09^{NS}	2.22^{NS}	0.179^{NS}	0.436^{NS}	13.680^{NS}	0.074^{NS}
Population	1	1392.40**	70.73^{NS}	0.006^{NS}	0.373^{NS}	3.025^{NS}	7.225^{NS}	0.046^{NS}
Cropping pattern	4	2823.04*	1058.56*	4.91*	0.396^{NS}	87.860**	52.514^{NS}	0.027^{NS}
Interaction	4	19.59^{NS}	26.91^{NS}	0.89^{NS}	0.092^{NS}	3.031^{NS}	32.300^{NS}	0.044^{NS}
Error	27	271.43	236.52	1.257	0.305	76.594	7.20	0.042

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 7. Analysis of variance for plant count, cob number, grain yield, straw dry weight and plant height of maize at Saminaka, 1983.

Source	DF	Plant count plot^{-1} MS	Cob number plot^{-1} MS	Grain yield, kg plot^{-1} MS	Straw dry weight, kg plot^{-1} MS	Plant height (m) MS
Blocks	3	282.67^{NS}	456^{NS}	5.30^{NS}	5.306	0.113*
Population	1	9055.42*	3133^{NS}	0.83^{NS}	11.557*	0.011^{NS}
Cropping pattern	4	16545.60*	5767*	46.54**	39.90**	0.032^{NS}
Interaction	4	195.03^{NS}	344^{NS}	2.96^{NS}	2.059^{NS}	0.0068^{NS}
Error	27	111.00	773	9.928	2.496	0.026

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 8. Analysis of variance for plant count, sorghum heads number, grain yield, straw dry weight and plant height of sorghum at Saminaka, 1983.

Source	DF	Plant Count pl t^{-1} MS	Sorghum head number ha^{-1} MS	Grain yield, Grain yield, kg pl t^{-1} MS	Straw dry weight kg pl t^{-1} MS	Plant height (m) MS
Blocks	3	574	479.5^{NS}	3.496^{NS}	16.12^{NS}	0.014^{NS}
Population	1	26881**	2449.5*	1.061^{NS}	2.92^{NS}	0.041^{NS}
Cropping pattern	4	6773**	5656.1**	3.341^{NS}	246.44**	0.088^{NS}
Interaction	4	591.87^{NS}	494.3*	1.56^{NS}	9.87^{NS}	0.056^{NS}
Error	27	230.85	192.79	2.25	11.58	0.046

* Significant at 5% level

** Significant at 1% level

NS Not significant

Appendix C 9. Analysis of variance for total grain yield and total dry matter yield of maize and sorghum in mixed crops, Samaru and Saminaka, 1983.

kg plot^{-1}

Source	DF	Total grain yield at Samaru MS	Total dry matter yield at Samaru MS	IER for grain yield MS	Total grain yield at Saminaka MS	Total dry matter at Saminaka MS	IER for grain yield MS
Blocks	3	1.07^{NS}	3.00^{NS}	0.1956^{NS}	22.56^{NS}	185.43^{NS}	0.829^{NS}
Population	1	4.78	20.80^{NS}	0.165^{NS}	0.118^{NS}	80.99^{NS}	0.1391^{NS}
Cropping pattern	3	6.35*	43.37*	0.174^{NS}	5.85^{NS}	31.52^{NS}	0.2100^{NS}
Interaction	3	1.22^{NS}	11.04^{NS}	.2783^{NS}	10.45^{NS}	27.02^{NS}	0.2686^{NS}
Error	21	0.53	11.33	0.1074	4.60	21.92	0.0777

* Significant at 5% level

** Significant at 1% level

NS Not significant.

APPENDIX D

BIOGRAPHY: Garba Aliyu LERE

Name	:	Garba A. Lere
Date of Birth	:	8th August, 1953
Business Address	:	Agronomy Department, Institute for Agricultural Research, ABU, Zaria
Home Address	:	c/o Alhaji Aliyu Abdullahi, Kofarfada Lere.

Previous Qualifications

Institution attended	From	To	Cert. Diploma/Degree
L.E.A. Primary Schl. Lere	1963	1969	Primary Leaving Certificate
Government College Kaduna	1970	1974	West African School Certificate
College of Arts, Science and Technology Zaria	1974	1976	IJMB Statement of Results
A.B.U. Zaria	1976	1979	B.Sc. Agric. 2:2

Post(s) Held since the Award of First Degree

Organization	From	To	Position
Gusau Agric. Dev. Project	1980	1981	Evaluation Officer II
Sokoto Agric. Dev. Project	1981	1982	Evaluation officer I

Year of Admission for Postgraduate Studies: 1983/84

Admission Number: M.Sc./Agric./4585/82-83