PERFORMANCE OF COWPEA (*Vigna unguiculata* L. Walp) VARIETIES INTERCROPPED INTO MAIZE (*Zea mays* L.) UNDER DIFFERENT PLANTING PATTERNS

BY

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DECLARATION

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

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CERTIFICATION

This Thesis entitled "Performance of cowpea (*Vigna unguiculata*_L. Walp) varieties intercropped into maize (*Zea mays* L.) under different planting patterns" by Ibrahim, Amadu Hadejia meets the regulations governing the award of degree of Master of Science (Agronomy) of Ahmadu Bello University, Zaria and is approved for its contribution to Scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my late father, Alhaji Ibrahim Katala and late Emir of Hadejia, Alhaji Abubakar Maje Haruna.

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ABSTRACT

Field trials were conducted at the Institute of Agricultural Research (IAR) farm, Samaru, Nigeria during 2005 and 2006 cropping seasons to study the performance of cowpea (*Vigna unguiculata* L. Walp) varieties intercropped into maize (*Zea mays* L) under different planting patterns. The treatments tested consisted of factorial combinations of six improved cowpea varieties, namely, SAMPEA-2, SAMPEA-4, SAMPEA-5, IAR-1035, IAR-1074, and IT90K-277-2 which were intercropped with maize variety, TZPBSR in three different planting patterns, namely, 1row maize: 1row cowpea in mixed-rows, 1row maize: 1row cowpea alternate rows and 1row maize: 4 rows cowpea: 1 row maize in alternate rows. The treatments were laid out in a randomized complete block design in a split plot arrangement with three replications. The planting pattern was assigned to the main plot while the variety was assigned to the sub-plot. The result indicated that most of the growth and yield parameters of maize were not significantly ($P > 0.05$) affected by cowpea varieties. There were higher grain and pod yields from variety SAMPEA-2 while variety IAR-1035 produced the lowest pod yield. Planting pattern affected both growth and yield components of cowpea significantly ($P > 0.05$) in both years, with the 1M: 4C: 1M alternate planting pattern having higher values compared with either 1M: 1C alternate or 1M: 1C mixed-row planting pattern. In maize, the 1M: 1C mixed-row planting pattern produced significantly ($P > 0.05$) higher maize grain yield than the 1M: 4C:1M alternate and 1M: 1C alternate planting patterns by averages of 139.8 and 21.9% respectively. Varieties x planting pattern interactions were generally not significant ($P > 0.05$) for all the parameters. The productivity of maize intercropped with cowpea will be enhanced by adopting the IM: IC alternate or 1M: 1C mixed-row planting pattern, if maize is the main crop. However, if ones primary interest is in cowpea grain yield one can recommend that cowpea variety SAMPEA-2 or IAR-1074 under the 1M: 4C:1M alternate planting pattern be adopted since these two varieties performed well in intercropping with maize. The study showed considerable variations among cowpea varieties in their performance in the maize intercrop.

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CHAPTER ONE

1.0 INTRODUCTION

Intercropping is the growing of two or more crops together on the same piece of land at the same time in a systematic manner such that the growth of some or all the component plant types overlap in space and time (Elemo *et al*., 1990). The crops in the intercrop are not necessarily sown at exactly the same time and their harvest time may be quite different, but they are usually "simultaneous" for a significant part of their growing period.

According to a survey conducted in the former Zaria province of Nigeria more than three decades ago, it was found that about 82% of the land cultivated was under intercropping system (Norman, 1974). Similarly, Elemo *et al*. (1990) observed intercropping as a common practice among traditional farmers of the Nigerian savanna. They indicated that no less than 60-70% of the cropped land is devoted to the growing of crops in mixture as opposed to sole cropping. Some of the advantages derived from intercropping by peasant farmers include higher total yield than sole crops, even if yields of component crops are reduced (Elemo *et al.*, 1990). In spite of the predominance of intercropping among farmers in the Nigerian savannah, there was more emphasis on developing sole crop technologies because experimentation with mixtures is tedious to execute and evaluate as a result of the complexity of interaction of the component intercrops. It has also been argued that the greatest difficulty in intercropping is the application of modern inputs like machinery, fertilizer and chemical protectants. However, Fisher (1979) contended that intercropping will continue as an important production system in the tropics for sometime to come because the tropical environment (characterised by erratic rainfall, costly inputs, etc) tends to make the system most attractive.

Cowpea (*Vigna unguiculata* L. Walp) is a major component of traditional cropping systems in Africa, Asia, Central and South America, where it is widely grown in mixtures with other crops in various combinations. The productivity of cowpea in these mixtures is low, mainly due to low plant population, competition under intercropping and lack of crop protection measures. Studies have shown that the productivity of cowpea in these systems could be enhanced through the use of improved varieties, appropriate date of planting with respect to the cereal, higher plant population, improved soil fertility, and suitable spatial arrangements.

Cowpea is mainly grown in mixtures with other crops by smallholder- farmers and a great diversity of crop mixtures have been reported (Mortimore *et al*., 1997). In a survey, Henriet *et al*. (1997) reported the existence of up to forty-three (43) crop mixtures in the Sudan savanna of Nigeria, with a millet-cowpea mixture being predominant. Cowpea is an important as a food crop throughout West Africa more especially in the Sudan savanna, being second to groundnut as a cultivated legume (Purseglove, 1974).

Recently, the International Institute of Tropical Agriculture (IITA) Ibadan, developed some improved cultivars/varieties of cowpea for the savanna ecological zones. These cultivars are said to be superior to the local cultivars in many respects (high yielding, resistant to major pests and diseases, earlier maturity, etc). However, particular attention is now being given to developing cultivars that can fit well into intercropping systems. Along this line, Singh *et al*. (1995) reported that some of the improved cowpea cultivars developed by IITA hold promise for the intercropping systems. Singh and Emechebe (1998) noted good performance of a number of improved varieties, particularly IT90K-277-2, under both sole cropping and intercropping. Thus, there is a good potential for

increasing intercropped cowpea grain and fodder yields through the introduction of suitable improved varieties.

Justification and Objectives

The aim of every maize/legume intercrop farmer in Africa is to increase yield using the limited available labour and capital. More attention is therefore given by this resource-limited farmer to yield and income stability at the expense of sole crop yield. The practice over the years has helped to reduce variability in total biomass, seed production and income due to complementary effects among associated crops (Kumar *et al.*, 1987). For these reasons, intercropping systems are very attractive, not only to small farmers, but also to managers of rural development projects in sub-Saharan Africa. Since studies have shown that subsistence farmers in African countries, such as Nigeria, will continue to adhere to the practice of intercropping and despite this adherence to intercropping systems, most of them do not have the knowledge of the best planting pattern and crop plant proportion to adopt. It is important therefore to accord them the opportunity of being presented with various options that are available in terms of crop combination, spatial arrangement and plant proportion. Since most of the cowpea varieties grown in the Nigerian savannas were selected in sole cropping systems, there is need to evaluate their performance in an intercropping system that is predominant in the area.

The present study was therefore designed to achieve the following objectives:-

1. To determine the best planting pattern and row arrangement for the maize/cowpea intercropping system
2. To assess the performance of different cowpea varieties under intercropping system and thus identify that which is most suited to intercropping with maize.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General

Intercropping, though widely practised, particularly in tropical regions, is often being considered as a "primitive" form of farming that would in time be replaced by sole cropping. However, in spite of the emphasis of research and development on the intensification of monocrop systems, the practice of intercropping remains widespread and evidence is accumulating to indicate that in many situations it may in fact represent a more efficient use of natural resources. Under intercropping, the crops in the mixtures may not be sown at exactly the same time and their harvest time may be quite different, but they are "simultaneous" for a significant part of their growing period (Andrews and Kassam, 1976; Willey, 1979).

Crop production in West and Central Africa is still based on traditional intercropping systems, which may be quite diverse and complex (Norman, 1974; Mortimore *et al*., 1997). In the Sudan savanna and the Sahelian zones, these systems involve intercropping of sorghum (*Sorghum bicolor* L.), millet (*Pennisetum glaucum* L) cowpea and groundnut (*Arachis hypogaea*) in various spatial and temporal arrangements and have evolved over centuries of experience to ensure maximum use of rainfall and available resources for sustainable production of food and fodder.

The cropping systems depend on a number of factors, including local traditions, level of technology, resource availability, and the physical environment. The general objective of farmers is a sustained production (Baker and Norman, 1975) at reasonable levels, at minimal risks, to satisfy subsistence and commercial needs (Beets, 1990). These

needs have increased due to increase in population and consequent reduction in arable land on a per capita basis. Therefore, an important approach to increased agricultural production would be through improving the yield of individual crops per unit area. Farmers with few resources at their disposal have a limited capacity to tolerate production failure. They attach a risk factor to their assessment of agricultural innovations, preferring incremental changes to radical departures from existing practices (Edwards, 1993). Therefore, research must build on these farming practices and aim at risk-free increases in productivity, even if these have to be gradual.

Intercropping is a common practice among traditional farmers of the Nigerian savanna. On the average, not less than 60-70% of the cropped land is devoted to growing crops in mixtures (Elemo *et al*; 1990). Numerous advantages have been ascribed to the continuous practice of intercropping, which include profit maximization (Abalu, 1976), more efficient resource utilization, yield stability and risk minimization (Okigbo and Greenland, 1976; Wien and Smithson, 1979). Crop mixtures which include creeping or spreading broad-leaf crop species also suppress weeds, thus reducing cost of weed control and improvement in the quality of the products (Okigbo and Greenland, 1976).

Willey (1979) observed that apart from these advantages being substantial, they may also be especially important because they are achieved not by means of costly inputs but by the simple expediency of growing crops together. An important advantage is, however, greater stability of yield over different seasons. This is thought to be of particular importance to subsistence farmers.

Intercropping is characteristic of the small-scale farming system in the tropics, and is regarded by many researchers as a "primitive" system, which would eventually be replaced by sole cropping in the course of agricultural development (Willey, 1979).

However, according to Norman (1974) the system is likely to remain a widespread practice up to the future because substantial evidence has been provided to suggest that yield advantages can be achieved by intercropping thus explaining its continued popular adoption in tropical Africa.

2.2 Productivity of Cereal-Legume Mixtures

There is potential to integrate more legumes in the existing cropping systems as intercrops, because growing sole legume crops in fallows has been rejected by smallholder farmers due to labour and land constraints (Kumwenda *et al*., 1996). If legumes are intercropped in a timely manner, competition with the maize crop for light, water and nutrients can be minimized while legume herbage N can be accumulated and maize production increased (Jeranyama *et al*. 1998).

Studies reported by Giller *et al*. (1998), showed that both cowpea and sunnhemp (*Crotalaria juncea*) sown 28 days after maize can produce large amounts of biomass without reducing the yield of the companion maize crop. Baker, (1974) observed that a common feature of many intercropping systems is the mixing of cereals with legumes. This assertion was supported by Willey (1979) who reported that when component crops in a mixture are of different types, greater resource utilization is achieved and competition for resources is minimal.

Willey and Osiru (1972) reported that yields of mixtures were up to 50% higher than what could be achieved by growing the crops separately. It was concluded that the observed yield increase must have been due to a greater utilization of environmental resources. They further suggested that the maize factors which make this possible were probably the different rooting depths of the two crops and their different growth cycles.

Fisher (1979) in his review of intercropping with legumes, stated that even at high levels of yields achieved by using improved varieties and liberal fertilizers, intercropping often had yield advantages of at least 25% over sole crops. In contrast, however, in the northern Guinea savanna ecological zone of Nigeria, using sorghum/soybean mixtures, intercropping reduced sorghum and soybean grain yield by 23% and 39% respectively. The poor performance of soybean in the mixtures was due to shading by sorghum plants while the reduction in sorghum yield was associated with slow growth rate at initial stage, which gave the fast growing soybean a competition advantage (Enyi, 1973; Adetiloye, 1980).

2.3 Performance of Cowpea Varieties in Crop Mixtures

In West Africa, cereals such as pearl millet and sorghum are traditionally intercropped with cowpea (Subbarao *et al*; 1999). Sole cowpea is seldom planted, and cereal/legume rotations are rare. Cowpea is an important crop because of its role in human and animal nutrition. It alleviates food shortage by making more efficient use of water and nutrients, and improving nutrition by providing a source of protein and nutrients not provided by cereals. As a protein source, cowpea is less expensive than meat. Although cropping systems differ from region to region, generally both cereal and cowpeas are sown at very low densities with no fertilizer or other chemical inputs. The productivity of this traditional system is generally low.

Increased cowpea production from intensified cropping systems can play a key role in income generation in West Africa because of the multiple uses of cowpea grain and fodder in human and animal diets (Rachie, 1985). Other benefits of increased cowpea production include improved nutrition for human and animals, improved soil properties to facilitate sustainability, more efficient water use, improved nutrition for children and

substantial opportunities for greater income for women, for instance through marketing of raw or processed cowpea foods, or small-scale livestock raising.

Cowpea (*Vigna unguiculata* (L.) Walp) is a major component of the traditional cropping system in Africa, Asia and Central and South America where it is widely grown in mixture with other crops in various combinations. The productivity of cowpea in these mixtures is low, mainly due to low plant population competition under intercropping and lack of crop protection measures. Studies have shown that the productivity of cowpea in these systems could be enhanced through the use of improved varieties, appropriate date of planting with respect to the cereal, higher plant populations, improved soil fertility, and suitable spatial arrangements.

West and Central Africa account for over 64% of the estimated 12.5 million hectares cultivated to cowpea worldwide (Singh *et al*., 1997). This is followed by Central and South America (19%), Asia (10%), and East and Southern Africa (6%), Cowpea is mainly gown in mixture with other crops and a great diversity of crop mixture has been reported (Mortimore *et al*., 1997).

The performance of component crops in intercropping is determined by competitive ability for the use of limiting environmental resources (Ofori and Stern, 1986; Rees, 1986; Harris *et al*. 1987; Morris and Garrity, 1993; Baldy and Stigter, 1997).

Elemo (1989) reported that not all cultivars that perform well in sole cropping may be suitable in intercropping. The shading effect from the associated crop, like maize, may affect cowpea performance in mixture. Anon (1978) also reported that shading of cowpea resulted in the reduction of number of nodes per stem and the sites for peduncle and pod formation. A similar observation was made by Singh *et al*. (1995) who recorded fewer branches in late-planted cowpea than those planted simultaneously with millet. It has been

noted that in the sahel, millet yield is reduced if millet and cowpea are planted simultaneously (Ntare, 1990; Ntare and Williams, 1992). However, Reddy and Visser (1997) concluded that intercropped cowpea should be sown simultaneously or soon after millet for maximum yield of cowpea. Blade *et al*. (1997) found that delaying cowpea planting by two or three weeks resulted in a cowpea grain yield reduction of over 50% in comparison to simultaneous millet and cowpea planting. Most of the reported work on maize-cowpea mixtures indicated reductions in cowpea yields while maize yields were unaffected (Heizel, 1974; Isenmilla *et al*. 1981; Olufajo, 1988; Cardoso *et al*., 1993).

2.4 Effect of Planting System and Crop Proportion on the Productivity of Crops in a Mixture.

Myaka (1995) showed that in a maize-cowpea intercropping, cowpea yields were 57% higher in the 2:2 (maize: cowpea rows) proportion compared with the 1:1 (maize: cowpea rows) proportion Asafu-Agyei *et al* (1997) found that the 2:2 (maize: cowpea rows) gave higher yields of maize and cowpea, land equivalent ratio (LER) and net benefit than the 1:1 (maize: cowpea rows). Bezerra- Neto and Robichaux (1996) studied the effect of spatial arrangement and density on cotton-cowpea-maize intercrop and reported that the land equivalent ratio for yield was higher in the spatial arrangement involving single rows of cowpea and maize between single rows of cotton. Land equivalent ratios for total biomass and grain yields were not affected as cotton density increased from 25,000 to 75,000 plants ha^{-1}.

However, Bezerra-Neto and Robichaux (1997) noted that component yields and biomass production could be significantly affected by alteration of spatial arrangement and density. They therefore concluded that the most appropriate sowing arrangement in cotton-

cowpea-maize intercropping should be determined by individual requirements of component crops for the development of total biomass and grain yields.

Being strongly competitive, cowpea reduces cotton yields when grown as an intercrop and the extent of yield reduction depends on the cowpea sowing date. However, year-to-year differences in the response of cotton-cowpea intercrop have been reported (Natarajau and Naik, 1992). In wetter years, Myaka and Kabissa (1996) found that cowpea yield was reduced when cowpea sowing was delayed from two to four weeks after cotton, whereas in drier years, cowpea yield was not affected by sowing date. An important consideration with respect to cotton-cowpea intercropping is the time of insecticide application to the cotton component. Since farmers routinely apply insecticide to cotton while cowpea rarely receives insecticidal protection, the main advantage of this mixture is the "incidental" benefit derived by the cowpea crop from the insecticide applied directly to cotton. It is noteworthy that the increase in cowpea grain yield as a result of the insecticide applied to cotton could be as high as 40%. Further improvement in cowpea grain yield in this mixture could probably be achieved using early maturing cowpea varieties whose reproductive phase would coincide with the period of insecticide application to cotton.

The traditional production system involves varied arrangements of the component crops in time and space with implications for crop and livestock productivity, and sustainability (Shetty *et al*., 1995). Spatial arrangements and densities of the component crops have been manipulated in order to enhance complementarity and to reduce competition between the component crops so that the physiological advantage from combining crop components is maximized (Willey and Osiru, 1972; Willey, 1979; Ofori and Stern, 1987). Obuo *et al* (1998) investigated the effect of intra-row spacing on cowpea-sorghum intercrop and found that yields of both component crops were highest at

60 x 20cm inter and intra row spacing respectively. There is evidence that strip cropping with two rows cereal, four rows cowpea offers an opportunity for selective input application and better economic advantage than the traditional one row cereal: one row cowpea spatial arrangement (Singh and Emechebe, 1998; Singh and Ajeigbe, 2002). Mensah (1997) noted that alternating three rows of cowpea with two or three rows of sorghum and one to two insecticide applications gave a yield advantage of 58 to 69% and proposed this as the most productive method to be adopted by subsistence farmers.

Traditional intercropping involved planting cowpea with millet and/or sorghum in a one row cereal: one cowpea row arrangement. Also, the cereals are planted at the onset of rains and cowpea is planted three to four weeks later between cereal rows when the rains have stabilized. Thus, cowpea is shaded by the cereals throughout the growing period. This causes severe reduction of shoot growth as well as root growth of cowpea resulting in very low grain and fodder yields. Recent studies have shown that even though cowpea occupies 50% of land area under intercropping, its grain and fodder yields are between 10 to 20% of those of sole crop cowpea (Singh *et al*; 1997, Terao *et al*; 1997). Even though sole crop cowpea is most profitable, most subsistence farmers plant cowpea as an intercrop with millet or sorghum. This is primarily because the land area available to them is limited and they want to produce a sufficient quantity of cereals for home consumption, and partly because sole crop cowpea requires at least one or two sprays of insecticide to control recalcitrant insect pests such as Maruca and pod bugs. Furthermore, chemicals are often not available even if farmers have financial resources at their disposal. Efforts are therefore being made to develop shade-tolerant cowpea varieties that have resistance to diseases, insect pests, and parasitic weeds, and capable of giving good grain and fodder yields under intercropping with millet or sorghum.

2.5 Varietal Response of Cowpea Grown as a Component in a Mixture.

The local cowpea varieties are highly adapted to intercropping but they have a low harvest index. Terao *et al* (1997) concluded that the type of cowpea adapted to intercropping is the spreading type of cowpea, improved to retain a substantial root system and high translocation efficiency. Singh *et al* (1995) evaluated over 100 local varieties of cowpea in pure stands and intercropping along with improved lines and varieties of cowpea in pure stands and intercropping along with improved lines and reported that only few local lines had desirable growth characteristics under intercropping. They further reported that several improved cowpea varieties were found promising in intercropping with millet.

2.6 Effect of Crop Geometry on Crop Performance

In the savanna ecological zone of Nigeria, farmers adopt different planting arrangements in cereal/legume mixtures. The dominant ones include 1:1, 1:2, 2:4, 2:2, 2:1 and alternate plants within- row. However, Martin and Snaydon (1982) indicated that between- rows intercropping was superior to within-row intercropping probably due to excessive shading in the latter. In support of this argument Monta and De (1980) showed that higher yields of cereal (maize or sorghum) and soyabean were obtained with alternate double row arrangement.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

Two trials were conducted during 2005 and 2006 rainy seasons at the Institute for Agricultural Research (IAR) farm, Samaru (lat 11^0 11'N, long $07^0$38E, 686m above sea level) Nigeria. Samaru is located in the northern Guinea savanna zone of Nigeria. Samaru has a long-term average of 1100mm annual rain fall concentrated in the months of may to September and evapotranspiration usually exceeds precipitation during October – may (Kowal and Knabe, 1972).

3.2 Treatments and Experimental Design

In each trial, the treatments consisted of factorial combinations of six improved cowpea varieties, namely, SAMPEA-2, (IAR353), SAMPEA-4 (IAR 176), SAMPEA -5 (IAR 355), IAR 1035, IAR 1074 and IT90k – 277-2 which were intercropped with maize in three crop arrangements, namely, IM: IC mixed rows, IM: IC alternate rows and IM: 4C: IM alternate rows (M = maize, C = cowpea). The treatments were laid out in a randomized complete block design in a split-plot arrangement with three replications. The row arrangement and variety was assigned to the main and Sub-plot respectively.

Maize variety TZPBSR was used for the trials. The characteristics of the cowpea varieties used are as follows:- SAMPEA-2 (IAR, 353), medium sized and brown seeded, medium maturity (75-90 days), moderately resistant to insect pests and diseases, photo-insensitive with 1.0 –1.5 t ha^{-1} yield potential. SAMPEA- 4 (IAR 176), with a white coat, black eye and large seeds; medium maturity (75-100 days), moderately tolerant to insect pests and diseases, photo- insensitive with 1.2 -2.4 t ha^{-1} yield potential. SAMPEA-5 (IAR

355), medium- sized with dark- brown seed; early maturity (65-75 days), moderately tolerant to insect pests and diseases, photo- insensitive with 1.2 and 2.4 t ha^{-1} yield potential. IAR -1035, light- brown seed; with a rough testa medium maturity (75-80 days), yield potential between 2.0 and 2.5 t ha^{-1} and photo- insensitive. IAR- 1074, brown medium size seed, which is characterised by rough testa, medium maturity (75-80 days), photo-insensitive. The yield potential is between 2.0 and 2.5 t ha^{-1}. IT90k -277-2, a white seed coat with a brown hilum, photo- insensitive, medium maturity (75-80 days), yield potential between 2.0 and 2.5 t ha^{-1}. All cowpea varieties are adapted to the northern Guinea savanna ecological zone.

Maize, variety TZPBSR used is a tall and late- maturing variety. Number of days to mid-silk is about 59- 62 and a yield potential of up to 6.9 tha^{-1}. It is resistant to ear rot and has a good husk cover, large ears, resistant to *Puccinia polysora* and *Bipalaris maydis* (lowland rust and blight), resistant to maize streak virus.It has a height of about 2.3m or more (Menkir *et al*., 2001). It is a characterised shading cereal crop.

3.3 Soil Sampling

Soil samples were collected from three different points at the experimental site prior to the application of fertilizer each season. The samples were randomly collected from the site at 0-30 cm depths using a soil auger after ploughing and harrowing but before ridging. The soil samples were made into a composite sample which was bulked, air-dried and ground, pass through a 2 mm sieve before subjecting it to physico- chemical analysis according to standard procedures described by Black (1965). Results of the physical and chemical analyses are presented in Table 1.

Table 1: Physico-chemical properties of the soil taken from 0-30cm depth of the experimental sites during the 2005 and 2006 cropping seasons at Samaru, Nigeria.

Property	**2005**	**2006**
Chemical property		
pH in H_20 (1:1)	5.50	5.43
Organic carbon (g kg^{-1})	0.42	3.30
Total nitrogen (g kg^{-1})	0.95	1.00
Available P (mg kg^{-1})	23.03	4.46
Exchangeable cation (Cmol kg^{-1})		
Ca	2.37	5.92
Mg	0.08	2.17
K	0.46	0.36
Na	2.87	5.65
C.E.C	4.60	10.00
Particle size distribution(g. Kg $^{-1}$)		
Sand	260.0	200.0
Silt	440.0	580.0
Clay	300.0	220.0
Textual class	Clay loam	Silt loam

3.4 Meteorological Data

Records of temperatures (maximum and minimum), rainfall and relative humidity at Samaru for the 2005 and 2006 cropping seasons were collected from the Meteorological Unit of the Institute for Agricultural Research (IAR). The meteorological data are presented in Appendices I and II.

3.5 Land Preparation

The land was ploughed, harrowed and made into ridges that were 0.75m apart. Weeds on the site were sprayed with glyphosate at a rate of 3.5kg a.i ha^{-1} two weeks prior to land preparation each season. This helped to provide a reasonably weed-free environment at planting time. The gross plot consisted of 8 ridges each 6m long ($36m^2$) while the net plot was made up of 4 inner ridges each 6m long. ($18m^2$).In the case of the 1M: 4C:1M plots, the net plot was made up of 6 inner ridges each 4m long ($18m^2$)

3.6 Cultural Practices

3.6.1 Planting and planting date

In 2005, maize was planted on 5 July, after dressing with Apron-plus (metalaxyl, carboxin,furathiocarb) at the rate of 10g per 3kg seed to protect seed against soil-borne pathogens, while cowpea, which was also treated, was planted on 22 August, at an intra-row spacing of 25cm along the ridges and intra-row spacing of 25cm along the ridges for maize both in 2005 and 2006.

In 2006, maize was planted on 23 June, after seed dressing while cowpea was planted on 18 August, using the same spacing arrangements (25cm intra-row) as that of 2005 described above.

Maize and cowpea seeds were planted by hand at two and three seeds per hole respectively. These were later thinned to one plant per hill in case of maize three weeks after planting.

3.6.2 Weed control

Weeds were controlled manually using a hand-hoe during the 2005 and 2006 cropping seasons. Hoe weeding was carried out in all plots at 4 and 7 weeks after sowing (WAS) for both cowpea and maize. In the 2006 cropping season, hoe weeding was carried out for maize and cowpea in all plots at 3, 6 and 9 WAS.

3.6.3 Fertilizer application

Fertilizer at the rate of 120 kg N ha^{-1} was applied to maize in two split doses, at 4 and 8 weeks after planting using urea (46%) as its source while all the plots received a fertilizer dressing of 22 kg P and 33 kg K per ha^{-1} as single super phosphate and muriate of potash respectively.

3.6.4 Insect control

In both cropping seasons, Sherpa plus (a.i cypermethrin and dimethoate) was applied three times at weekly intervals at the rate of 1.5 litres ha^{-1} using a knapsack sprayer. This was done commencing from flower initiation in cowpea.

3.6.5 Harvesting

Crops harvest(s) from the net plots were used for grain yield determination.

Maize was harvested when the cobs were dry. Further sun-drying of the maize cobs was done before shelling. Cowpea was harvested later, when the leaves had turned yellow and pods sufficiently dry.

3.7 Observations and Data Collection on Cowpea

Observations during the crop growth phase. Collection of periodic data was at 6, 8 and10 WAS.

3.7.1 Plant establishment count.

The plant stands were counted three weeks after sowing and after thinning to give the total number of plants per gross plot. Final stand counts were done on the net plots at harvest time each season.

3.7.2 Number of branches per plant

Five tagged plants were used to estimate the number of branches per plant and average value taken.

3.7.3 Plant height

This was measured from the ground level to the plant apex. Measurements were taken at maturity stage prior to harvest.

3.7.4 Number of days to 50% flowering

The number of days from planting to when about half of the plants in each plot had attained 50% flowering was recorded.

3.7.5 Dry matter accumulation

The plant biomass was determined at 10 WAS. The four cowpea plant samples were cut along at soil surface level from outer ridges of each gross plot and partitioned into leaves, stems, and pods. Each component was put in labelled envelopes and dried in a GallenKamp oven at 70^{o}C to constant weight and its dry weight determined using a top-loading Mettler balance (Model P.120) recorded.

3.7.6 Plant canopy spread

The widths of the canopies of five tagged plants per plot were measured at the flowering stage using a meter rule to determine the extent of plant canopy spread. Mean values were calculated and recorded.

3.7.7 Number of pods per plant

Total number of pods on each of the five tagged plants was counted, and average value recorded.

3.7.8 Number of grains per pod

Twenty dry pods were sampled randomly from each net plot. They were split open and the number of grains in each pod counted. Average values were recorded.

3.7.9 Weight of pods per plant

Pods were harvested from ten sampled plants per plot and weighed on a sensitive Mettler top-loading electronic balance (Model P. 1200) the mean weights were then recorded.

3.7.10 Pod yield per plot

All the dry pods harvested from each net plot were weighed to determine the pod yield per plot using an electronic top- loading Mettler balance (Model P.1200).

3.7.11 grain yield per plot

The dry pods harvested per net plot were threshed and the weight of grains per plot was determined using a salter scale.

3.7.12 Pod yield per hectare

From the pod yield per plot, pod yield per hectare for each plot was determined by converting the yield per plot into kilogram per hectare by extrapolation.

3.7.13 Grain yield per hectare

From the seed yield per plot, seed yield per hectare for each plot was computed by converting it into kilogram per hectare by extrapolation.

3.7.14 Threshing percentage

The threshing percentage of cowpea was calculated from the quotient of seed yield and pod yield expressed as a percentage.

$$\text{Threshing percentage} = \frac{\text{Weight of seeds}}{\text{Weight of pods}} \times 100$$

3.7.15 Crop growth rate (CGR)

The crop growth rate, which is the net gain in dry weight per unit land area per unit time, was calculated using the formula given by Watson (1952). This was determined at 2-week intervals, namely, 4-6, 6-8, and 8-10 WAS.

$$CGR = \frac{W_2 - W_1}{T_2 - T_I} \cdot \frac{1}{LA} (g.\ m^{-2}.wk^{-1})$$

Where, W_1 is plant dry weight at time T_1, W_2 is plant dry weight at time T_2, and LA is the land area covered by the sampled plants.

3.8 Observation and Data Collection on Maize

3.8.1 Number of leaves per plant

The number of leaves per plant of five sampled plants was determined on the basis of the five tagged plants in each plot and average value recorded.

3.8.2 Plant height

This was measured at harvesting (termination of growth) from the ground level to the plant apex using a meter rule.This was done at harvest stage.

3.8.3 Number of days to 50% tasselling

The number of days from sowing to when about 50% of the plants in the net plot had tasselled was recorded.

3.8.4 Dry matter accumulation

At 12weeks after sowing three plants per plot from the discard area were harvested at the soil surface level and cut into pieces before drying in a drying oven at 70ºC to constant weight. The weight of each dried sample was determined using a top-loading Mettler balance (Model P.120).

3.8.5 Plant stand at harvest

The plant stands that survived up to time of harvesting were counted on each Plot and the number recorded.

3.8.6 Number of ears per plot

Five plants were sampled per plot, and the number of ears was counted and the average value recorded.

3.8.7 Grain yield per plot

All the cobs from each net plot were shelled and the grain weighed to give the grain yield per plot using a sensitive Mettler top-loading electronic balance (Model P.1200.

. 3.8.8 Weight of ear per plant.

The ears from ten sampled plants were harvested and weighed using a salter scale and weight recorded. The average weight per plant was determined and then recorded.

3.8.9 Weight of cobs per plant

Cobs from ten sampled plants within the net plot were weighted using a salter scale and the average value was determined and recorded.

3.8.10 100-grain weight.

A total of 100 seeds from each plot were counted and weighed on an electronic top-loading Mettler balance to obtain the weight of 100 seeds.

3.8.11 Cob length.

The lengths of ten cobs from each net plot were measured from bottom of the maize cob to the cob apex using a meter rule and the average value recorded.

3.8.12 Kernel rows per cob

This was derived by counting of all the kernel rows on the maize cob from the ten sampled plants, from each plot and average value determined.

3.8.13 Number of cobs per plant

Five plants in the net plot were sampled, the number of cobs on each plant counted and average value determined and recorded.

3.8.14 Weight of cobs per plot

All the cobs from each net plot were harvested and weighed to determine the cob yield per plot using a salter scale.

3.8.15 Cob yield per hectare

From the cob yield per net plot, cob yield per hectare was determined by converting to kilogramme per hectare by extrapolation.

3.8.16 Grain yield per hectare

From the grain yield per net plot, grain yield per hectare was determined by converting to kilogramme per hectare by extrapolation.

3.8.17 Shelling percentage

This was expressed as percentage of weight of kernels per weight of maize cobs as per the formula shown under.

$$\text{Shelling percentage} = \frac{\text{Weight of kernels}}{\text{Weight of cobs}} \times 100$$

3.8.18 Crop growth rate (CGR)

The crop growth rate, which is the net gain in dry weight per unit land area per unit time, was calculated using the formula given by Watson (1952). This was determined at 2-week intervals, namely, 4-6, 6-8, 8-10 and 10-12 WAS.

$$CGR = \frac{W_2 - W_1}{T_2 - T_I} \cdot \frac{1}{LA} \; (g.\, m^{-2}.wk^{-1})$$

Where, W_1 is plant dry weight at time T_1, W_2 is plant dry weight at time T_2, and LA is the land area covered by the sampled plants.

3.9 Statistical Analysis

The data collected were subjected to analysis of variance using the 'F" test described by Snedecor and Cochran (1967). The various treatment means were then separated using the Duncan's Multiple Range Test (Duncan, 1955.)

CHAPTER FOUR

4.0 RESULTS

4.1 Cowpea Crop Parameters

4.1.1 Shoot height

Maize intercrops had significant ($P > 0.05$) effect on the cowpea shoot height in the 2005 cropping season only. Variety SAMPEA-5 shoot was significantly taller than the other varieties, all of which were statistically at par (Table 2). Shoot height of the cowpea plant was significantly ($P > 0.05$) affected by planting pattern in 2005 cropping season as well. Cowpea under the 1M: 4C:1M alternate planting pattern produced significantly taller shoots than the other two planting patterns, both of which were statistically at par. The cowpea variety x planting pattern interaction for shoot height was not statistically significant ($P > 0.05$).

4.1.2 Number of branches per plant

At 10WAS, number of branches per cowpea was significantly ($P > 0.05$) different in 2005 only (Table 2). SAMPEA-2 had significantly more branches than SAMPEA-4 but was not different from the other varieties which were similar. In 2006 and averaged over both years, the various cowpea varieties did not differ with respect to number of branches.

The effect of planting pattern on number of branches in cowpea was statistically significant ($P > 0.05$) in both years. At 10 WAS, cowpea plants grown under 1M: 4C:1M alternate planting pattern produced significantly ($P > 0.05$) more branches than under the two other patterns in both years. Cowpea variety and planting pattern interaction was not statistically significant ($P > 0.05$).

Table 2: Shoot height (cm) and number of branches of cowpea plant in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern at 10 WAS in 2005 and 2006 cropping seasons at Samaru, Nigeria

Treatment	Shoot height			Number of branches		
	2005	2006	Combined	2005	2006	Combined
Cowpea variety (V)						
SAMPEA 2 (IAR-353)	62.6ab	52.1	57.4	8.9a	6.0	7.5
SAMPEA 4 (IAR-176B)	60.8ab	53.4	57.1	7.3b	7.0	7.2
SAMPEA 5 (IAR-355)	68.3a	53.7	61.0	8.3ab	6.6	7.5
IAR-1035	63.3ab	51.8	57.6	8.3ab	6.6	7.5
IAR-1074	57.9b	54.2	60.2	7.4b	6.1	6.8
IT90K-277-2	66.1ab	51.2	58.7	7.8ab	5.7	6.8
S.E. ±	3.08	1.54	2.31	0.37	0.50	0.44
Planting pattern (P)						
1M: 1C alternate	57.1b	50.9	54.0	7.3b	6.2b	6.8b
1M: 1C mixed-row	61.1b	54.2	57.7	7.9b	5.6b	6.8b
1M: 4C:1M alternate	71.3a	53.2	62.3	8.6a	7.2a	7.9a
SE ±	2.18	1.09	1.64	0.27	0.35	0.31
Interaction						
V X P	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test. C = cowpea, M= maize; WAS = weeks after sowing.

4.1.3 Dry matter accumulation in leaves and stem

Leaf dry matter accumulation at 10WAS was not significantly ($P > 0.05$) different among the six cowpea varieties in both years and in combined (Table 3). However, planting pattern had significant ($P > 0.05$) influence on leaf dry matter in 2005. Leaf dry matter accumulation was highest in the 1M: 4C:1M alternate planting pattern in 2005 only. There was no significant ($P > 0.05$) cowpea variety x planting pattern interaction for leaf dry matter accumulation at 10WAS. Data on stem dry matter accumulation at 10WAS are presented in Table 3. There were no significant ($P > 0.05$) differences among the varieties in stem dry matter. However, stem dry matter was significantly ($P > 0.05$) influenced by planting pattern. Stem dry matter was highest under the 1M: 4C:1M alternate planting pattern compared with the other two planting patterns, which were similar. Cowpea variety x planting pattern interaction for stem dry matter accumulation was not statistically significant ($P > 0.05$).

4.1.4 Crop growth rate

Crop growth rate (CGR) was not significantly ($P > 0.05$) different among the cowpea varieties in all the two years and the combined analysis (Tables 4, 5, and 6). However, planting pattern significantly influenced CGR. The cowpea varieties by planting pattern interactions for CGR were not statistically significant ($P > 0.05$).

Table 3: Dry matter accumulation (g plant^{-1}) in leaves and stem of cowpea plant in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern at 10 WAS in 2005 and 2006 at Samaru, Nigeria

	Leaves			Stem		
Treatment	2005	2006	Combined	2005	2006	Combined
Cowpea variety (V)						
SAMPEA 2 (IAR-353)	18.4	5.7	12.1	16.7	10.8	13.8
SAMPEA 4 (IAR-176B)	17.5	6.1	11.8	15.9	11.6	13.8
SAMPEA 5 (IAR-355)	14.2	6.7	10.5	16.0	11.9	14.0
IAR-1035	16.9	7.5	12.2	15.2	11.0	13.1
IAR-1074	16.9	7.1	12.0	15.9	11.4	13.7
IT90K-277-2	12.0	6.0	9.0	12.5	9.9	11.2
S.E. ±	2.09	0.78	1.44	2.26	1.24	1.75
Planting pattern (P)						
1M: 1C alternate	15.3b	5.7	10.5	15.1b	8.3b	11.7
1M:1C mixed- row	11.5b	6.1	8.8	10.6b	10.4b	10.5
1M: 4C:1M alternate	21.1a	7.8	14.5	20.7a	14.6a	17.7
SE ±	1.48	0.56	1.02	1.60	0.88	1.24
Interaction						
V X P	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test. C = cowpea, M= maize.

Table 4: Crop growth rate (g. m^{-2} . wk^{-1}) of cowpea in maize/cowpea intercropping during the 2005 cropping season at Samaru, Nigeria.

	Crop growth periods (WAS)		
Treatment	**4-6**	**6-8**	**8-10**
Variety (V)			
SAMPEA 2 (IAR-353)	1.8	6.4	5.9
SAMPEA 4 (IAR-176B)	1.7	4.8	5.8
SAMPEA 5 (IAR-355)	1.5	3.7	5.9
IAR-1035	1.2	4.3	6.6
IAR-1074	1.1	3.3	7.0
IT90K-2772	1.3	3.4	3.4
S.E. ±	0.35	1.00	1.37
Planting pattern (P)			
1M:1C alternate	1.7	4.6a	4.4b
1M:1C mixed-row	1.1	2.4b	4.3b
1M:4C:1M alternate	1.4	6.0a	8.6a
SE ±	0.25	0.71	0.97
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to Duncan's multiple range tests.
C=cowpea M= maize WAS =Weeks after sowing

Table 5. Crop growth rate (g. m^{-2} .wk^{-1}) of cowpea in maize/cowpea intercropping during 2006 cropping season at Samaru, Nigeria

	Crop growth periods (WAS)		
Treatment	**4-6**	**6-8**	**8-10**
Variety (V)			
SAMPEA 2 (IAR-353)	1.3	3.8	1.7
SAMPEA 4 (IAR-176B)	1.3	4.6	1.5
SAMPEA 5 (IAR-355)	1.6	4.0	1.8
IAR-1035	1.9	4.1	1.8
IAR-1074	1.7	4.6	1.5
IT90K-2772	1.8	3.8	1.2
S.E. ±	0.31	0.83	0.20
Planting pattern (P)			
1M:1C alternate	1.5	2.8b	1.2b
1M:1C mixed-row	1.3	4.1ab	1.4b
1M:4C:1M alternate	1.9	5.5a	2.1a
SE ±	0.22	0.59	0.14
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to Duncan's multiple range tests.
C=cowpea M = maize WAS = Weeks after sowing

Table 6: Crop growth rate (g. m^{-2}. wk^{-1}) of cowpea in maize/cowpea intercropping combined for the 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Crop growth periods (WAS)		
Treatment	**4-6**	**6-8**	**8-10**
Variety (V)			
SAMPEA 2 (IAR-353)	1.6	5.1	3.8
SAMPEA 4 (IAR-176B)	1.5	4.7	3.6
SAMPEA 5 (IAR-355)	1.6	3.9	3.9
IAR-1035	1.5	4.2	4.2
IAR-1074	1.4	4.0	4.2
IT90K-2772	1.5	3.5	2.3
S.E. $\pm$	0.24	0.65	0.70
Planting pattern (P)			
1M:1C alternate	1.6	4.7b	2.8b
1M:1C mixed-row	1.2	3.2b	2.8b
1M:4C:1M alternate	1.7	5.7a	5.4a
SE $\pm$	0.17	0.4b	0.49
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to Duncan's multiple range tests.
C= cowpea M= maize WAS =Weeks after sowing

4.1.5 Days to 50% flowering

Days to 50% flowering in cowpea was significantly ($P > 0.05$) affected by maize crop in 2005, 2006 and the combined analysis (Table 7). In both years and the combined data, cowpea varieties SAMPEA-5 and IAR -1074 took a longer days to attain 50% flowering compared with variety IAR -1035 while the remaining two varieties were at par in terms of the number of days that took them to attain 50% flowering relative to the other varieties. In the combined analysis, SAMPEA-5, IAR-1074 and SAMPEA-2 plants took longer days to reach 50% flowering compared with IAR- 1035, which require fewer numbers of days to reach 50% flowering. Planting pattern had no significant ($P > 0.05$) effect to 50% flowering in both years and the combined data. Interaction between cowpea varieties and planting pattern on days to50% flowering was not significant ($P > 0.05$).

4.1.6 Canopy spread

There were no significant ($P > 0.05$) effects of the maize intercrop on the canopy spread of cowpea at 8 WAS within the maize/cowpea intercrops in 2005 and 2006 (Table 8). In 2005, planting pattern had no significant ($P > 0.05$) effect on the canopy spread of cowpea but in 2006, cowpea grown under the 1M:4C:1M alternate planting pattern produced plants which had a significantly($P > 0.05$) wider canopy spread than the other two planting patterns, both of which were statistically at par. The differences in the values showed that 1M: 4C: 1M alternate planting pattern produced 32.6 and 55.4% wider canopy spread than the 1M: 1C alternate and 1M:1C mixed-row planting patterns respectively. In the combined analysis, the 1M:4C:1M alternate planting pattern produced cowpea plant with a canopy spread that was 17.2 and 27.0% higher than those of mixed-row and 1M:1C alternate planting patterns, respectively. The interaction between cowpea varieties and planting pattern for cowpea canopy spread was not significant ($P > 0.05$).

Table 7: Days to 50% flowering of cowpea in maize/cowpea intercropping during 2005,2006 cropping seasons and combined at Samaru, Nigeria

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	47.0ab	47.0ab	47.0a
SAMPEA 4 (IAR-176B)	46.0ab	47.0ab	46.3ab
SAMPEA 5 (IAR-355)	48.2a	47.4a	48.0a
IAR-1035	44.3b	44.0b	44.0b
IAR-1074	48.2a	47.4a	48.0a
IT90K-2772	45.1ab	46.0ab	46.0ab
S.E. $\pm$	1.1	1.2	0.8
Planting pattern (P)			
1M:1C alternate	47.4	47.0	47.3
1M:1C mixed-row	46.3	46.0	46.1
1M:4C:1M alternate	46.0	46.0	46.0
SE $\pm$ (S)	0.8	0.8	0.6
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests. C=cowpea, M=maize

Table 8: Canopy spread (cm) at 8WAS of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	35.6	46.3	41.0
SAMPEA 4 (IAR-176B)	36.8	40.4	39.0
SAMPEA 5 (IAR-355)	38.4	49.1	44.0
IAR-1035	38.8	46.1	42.4
IAR-1074	36.1	43.4	40.0
IT90K-2772	39.3	43.6	41.4
S.E. $\pm$	1.81	4.30	2.33
Planting pattern (P)			
1M:1C alternate	38.0	42.3b	40.1b
1M:1C mixed-row	37.1	36.1b	37.0b
1M:4C:1M alternate	37.4	56.1a	47.0a
SE $\pm$ (S)	1.28	3.03	1.64
Interaction	.	.	
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.
C = cowpea, M= maize

4.1.7 Pod yield

Pod yield of cowpea varieties was significantly (P > 0.05) affected by maize intercrop in 2005and 2006 seasons and the two seasons combined data (Table 9). In the 2005 cropping season, variety SAMPEA-4 produced a significantly (P > 0.05) higher pod yield than variety SAMPEA-5 which was statistically at par with the other varieties. In other words, variety SAMPEA-5 produced the lowest pod yield in that year. The pod yield advantage of variety SAMPEA-4 over variety SAMPEA-5 was 59.8%. In the 2006 cropping season, however, varieties SAMPEA-2 and IAR 1074 produced significantly (P > 0.05) higher pod yields than variety IAR-1035 while they were statistically at par with the other cowpea varieties. Cowpea IAR -1035 gave the lowest pod yield among the various varieties and was out yield by variety SAMPEA-2 by as much as 95.0%. In the combined analysis, four of the varieties had significantly (P > 0.05) higher pod yields than two other varieties. Varieties SAMPEA-2, SAMPEA-4, IAR-1074 and IT90K-277-2 had pod yields that were significantly (P > 0.05) higher than that of variety SAMPEA-5. Variety SAMPEA-2 out-yielded variety SAMPEA-5, the lowest pod yielder by 44.5%. Pod yield was also affected by planting pattern in 2005, 2006 and the combined data. Throughout the period of experimentation, the 1M: 4C :1M alternate planting pattern produced significantly(P > 0.05) higher pod yields by 48.6, 38.9 and 46.4% than the other two planting patterns in 2005, 2006 and the combined data respectively. As a result, cowpea grown under the 1M: 4C: 1M alternate planting pattern, out- yielded cowpea under the other two planting patterns which were statistically at par. There were no significant (P > 0.05) interactions between cowpea varieties and planting pattern for cowpea pod yield in both years.

Table 9: Pod yield (kg ha^{-1}) of cowpea in maize/cowpea intercropping during 2005and 2006 cropping seasons at Samaru, Nigeria

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	584ab	234a	409a
SAMPEA 4 (IAR-176B)	633a	180ab	407a
SAMPEA 5 (IAR-355)	396b	167ab	283b
IAR-1035	512ab	120b	316ab
IAR-1074	589ab	203a	396a
IT90K-2772	598ab	182ab	390a
S.E. $\pm$	67.0	24.6	35.7
Planting pattern (P)			
1M:1C alternate	424b	184ab	304b
1M:1C mixed-row	526b	137b	331b
1M:4C:1M alternate	706a	223a	465a
SE $\pm$ (S)	47.4	17.4	25.2
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.
C = cowpea, M = maize

4.1.8 Grain yield

Grain yields of the various cowpea varieties were not significantly ($P > 0.05$) affected by maize intercrop (Table 10)except in 2006, when SAMPEA-2 and IAR-1074 produced significantly ($P > 0.05$) higher grain yields compared with the other cowpea varieties, which were at par. Variety IAR-1035 produced the lowest grain yield in intercropping. Varieties SAMPEA-4, SAMPEA-5, and IT90K-277-2 were all statistically at par. Grain yield of cowpea was significantly ($P > 0.05$) affected by planting pattern in 2005 and the combined. In other words, there was no significant ($P > 0.05$) effect of planting pattern on cowpea grain yield in 2006. In 2005, 1M: 4C: 1M alternate and 1M:1C mixed-row planting patterns produced significantly ($P > 0.05$) higher cowpea grain yields than 1M: 1C alternate planting pattern by 86.9 and 23.2% respectively. In the combined analysis, 1M: 4C: 1M alternate pattern produced significantly ($P > 0.05$) higher cowpea grain yield than the other two planting patterns with a yield advantage of 61.9% over 1M: 1C alternate and 24.8% higher than the 1M:1C mixed-row planting patterns. There were no significant ($P > 0.05$) interaction between cowpea varieties and planting pattern for cowpea grain yield in both years and even the combined data.

Table 10: Grain yield (kg ha^{-1}) of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru ,Nigeria

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	378	126a	252
SAMPEA 4 (IAR-176B)	394	92ab	243
SAMPEA 5 (IAR-355)	278	86ab	182
IAR-1035	344	56b	200
IAR-1074	283	109a	196
IT90K-2772	392	92ab	242
S.E. $\pm$	48.9	14.4	25.5
Planting pattern (P)			
1M:1C alternate	236b	99	168b
1M:1C mixed-row	358a	78	218b
1M:4C:1M alternate	441a	104	272a
SE $\pm$ (S)	34.6	10.2	18.0
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.
C = cowpea, M= maize,

4.1.9 100-grain weight

100-grain weight of cowpea varieties differed significantly ($P > 0.05$) in both 2005 and 2006 cropping seasons and the two seasons combined (Table 11). In the 2005 cropping season, variety SAMPEA-5 produced significantly ($P > 0.05$) heavier grains than varieties SAMPEA-2, IAR-1074 and IT90K-277-2 but was at par with variety IAR-1035. The lightest grains were produced by varieties SAMPEA-2, IAR-1074 and IT90K-277-2, which produced grains which were about 15.8% lighter in weight than grains of variety SAMPEA-5. In the 2006 cropping season, variety IAR-1074 produced heavier grains than varieties SAMPEA-2, SAMPEA-5 and IAR-1035 but was at par with varieties SAMPEA-4 and IT90K-277-2. In the combined analysis, all the other cowpea varieties had significantly ($P > 0.05$) heavier grains than variety SAMPEA-2. All the varieties were statistically at par with the exception of SAMPEA-2, which produced the lightest grains as was the case in 2006.Grains of variety SAMPEA-2 were about 9.8% lighter than grains of the other cowpea varieties. Planting pattern had no significant ($P > 0.05$) effect on 100-grain weight of cowpea in both the 2005 and 2006 cropping seasons. However, in the combined analysis, the mixed-row planting pattern produced significantly ($P > 0.05$) heavier grains than the 1M: 1C alternate pattern, both of which were at par with the 1M: 4 C: 1 M alternate planting pattern. There was no significant ($P > 0.05$) interaction between cowpea varieties and planting pattern on 100-grain weight.

Table 11: 100-grain weight (g) of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	16.0c	13.3d	14.7b
SAMPEA 4 (IAR-176B)	17.4bc	15.8ab	16.6a
SAMPEA 5 (IAR-355)	19.0a	13.7cd	16.3a
IAR-1035	17.7ab	14.9bc	16.3a
IAR-1074	16.2c	16.6a	16.3a
IT90K-2772	16.2c	16.3ab	16.3a
S.E. ±	0.46	0.51	0.49
Planting pattern (P)			
1M:1C alternate	16.6	14.9	15.8b
1M:1C mixed-row	17.4	15.6	16.5a
1M:4C:1M alternate	17.1	14.7	15.9ab
SE ±	0.33	0.36	0.34
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.
C = cowpea, M= maize.

4.1.10 Average pod weight

The average pod weight of cowpea was not significantly ($P > 0.05$) affected by maize cowpea inter crop in both 2005, 2006 cropping season and the two seasons combined (Table 12). However, planting pattern had significant ($P > 0.05$) effect on average pod weight of cowpea in 2006 and in the two seasons combined data. There was no significant ($P > 0.05$) effect in the 2005 cropping season. In both 2006 and combined, mixed- row pattern produced an average pod weight that was higher than the 1M: 1C alternate pattern even though both were at par with 1M: 4C:1M alternate pattern. Interactions between cowpea varieties and planting pattern had no significant effect on average pod weight.

4.1.11 Average pod length

There were no significant ($P > 0.05$) differences on the average pod length of the various cowpea varieties in maize/cowpea intercropping in either of the two years or the combined data (Table13). Planting pattern on the other hand had significant ($P > 0.05$) effect in the 2005 cropping season when the 1M: 4C: 1M alternate planting pattern produces significantly ($P > 0.05$) longer cowpea pods than the other two planting patterns, both of which were statistically at par. There was no significant ($P > 0.05$) interaction between cowpea varieties and planting pattern for average pod length

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Table 12: Pod weight (g) of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	3.6	3.5	3.5
SAMPEA 4 (IAR-176B)	3.3	3.1	3.2
SAMPEA 5 (IAR-355)	3.8	3.9	3.9
IAR-1035	3.2	3.6	3.4
IAR-1074	3.1	3.3	3.2
IT90K-2772	3.4	3.5	3.4
S.E. ±	0.44	0.48	0.33
Planting pattern (P)			
1M:1C alternate	3.0	2.9b	3.0b
1M:1C mixed-row	3.7	4.0a	4.0a
1M:4C:1M alternate	3.5	3.4ab	3.5ab
SE ±	0.31	0.34	0.23
(S)			
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.
C = cowpea, M= maize.

Table 13: Average pod length (cm) of cowpea in maize/cowpea intercropping during . 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	15.0	14.4	14.6
SAMPEA 4 (IAR-176B)	15.2	15.3	15.3
SAMPEA 5 (IAR-355)	15.0	14.9	15.0
IAR-1035	14.6	14.7	14.6
IAR-1074	14.5	15.1	14.8
IT90K-2772	14.7	14.6	14.7
S.E. $\pm$	0.55	0.51	0.37
Planting pattern (P)			
1M:1C alternate	14.5b	15.0	14.7
1M:1C mixed-row	14.0b	15.0	14.5
1M:4C:1M alternate	16.0a	14.5	15.2
SE $\pm$	0.39	0.36	0.26
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.
C = cowpea, M= maize;

4.1.12 Number of grains per pod

Number of grains per pod of cowpea in the various varieties was not significantly ($P > 0.05$) affected by maize intercrop in 2006 and combined except in 2005 there was significant effect (Table 14). Pods of varieties SAMPEA-4, IAR-1074 and IT90K-277-2 contained more grains than those of varieties SAMPEA-5, IAR-1035 and SAMPEA-2.The pods of the former three cowpea varieties contained 27.7% more grains than pods of variety SAMPEA-5. Planting pattern also, did not significantly ($P > 0.05$) affect the number of grains per pod of cowpea. The cowpea varieties and planting pattern interaction for number of grains per pod was not significant ($P > 0.05$).

4.1.13 Pod weight per plant

In both 2005 and 2006, there were no significant ($P > 0.05$) differences in the pod weight of cowpea (Table 15). However, in the combined analysis, cowpea variety SAMPEA-5 had significantly ($P > 0.05$) higher pod yield per plant than IAR-1074.while varieties SAMPEA -2, SAMPEA-4, IAR 1035, and IT90K-277-2 had similar pods weight per plant. Varieties SAMPEA-2, SAMPEA-4, IAR 1035 and IT90k-277-2 were statistically at par. The difference between the variety with highest pod yield per plant and the one with the lowest was 17.1%. Planting pattern had significant ($P > 0.05$) effect on pod weight per plant in both years and the combined analysis. For each of the two years and the combined analysis, cowpea plants grown under the IM:4C:1M alternate planting pattern produced significantly ($P > 0.05$) higher pod weight per plant than the other two planting patterns both of which were statistically at par. The pod weight per

Table 14: Number of grains per pod of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	11.0ab	22.0	16.2
SAMPEA 4 (IAR-176B)	12.0a	13.0	12.3
SAMPEA 5 (IAR-355)	9.4b	11.2	10.3
IAR-1035	11.0ab	11.0	11.0
IAR-1074	12.0a	11.4	12.0
IT90K-2772	12.0a	11.3	12.0
S.E. $\pm$	0.50	4.00	2.03
Planting pattern (P)			
1M:1C alternate	11.0	12.0	11.3
1M:1C mixed-row	11.2	16.4	14.0
1M:4C:1M alternate	11.4	11.1	11.3
SE $\pm$	0.40	2.80	1.43
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.
C = cowpea M= maize

Table 15: Pod weight (g) per plant of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	46.0	46.4	46.2ab
SAMPEA 4 (IAR-176B)	51.1	49.2	50.2ab
SAMPEA 5 (IAR-355)	52.3	53.0	52.7a
IAR-1035	50.0	49.6	49.8ab
IAR-1074	44.6	45.4	45.0b
IT90K-2772	49.2	47.4	48.3ab
S.E. $\pm$	3.15	3.03	2.19
Planting pattern (P)			
1M:1C alternate	37.2b	37.2b	37.3b
1M:1C mixed-row	38.2b	39.8b	39.0b
1M:4C:1M alternate	71.2a	68.4a	69.8a
SE $\pm$	2.23	2.15	1.55
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.
C = cowpea M= maize

Plant under the 1M: 4C: 1M alternate planting pattern was higher than that under 1M: 1C alternate planting pattern by 91.4, 83.9, and 87.1% in 2005, 2006, and the combined data respectively. There were no significant ($P > 0.05$) interactions between cowpea varieties and planting pattern for pod yield per plant.

4.1.14 Number of pods per plant

In the two years, 2005 and 2006 and the combined analysis there was no significant ($P > 0.05$) effect of maize intercrop on the number of pods per plant in the various cowpea varieties (Table 16). Planting pattern, however, significantly ($P > 0.05$) influenced the number of pods per plant of cowpea in each of the two years and the two years combined data. In each of the two cropping seasons and the combined data, cowpea grown under the 1M: 4C: 1M alternate planting pattern produced significantly ($P > 0.05$) higher number of pods per plant than those grown under the other two planting patterns. Mixed-row planting pattern produced the least number of pods per plant in 2006 and the combined, when it produced 43.3 and 42.9% fewer pods per plant respectively. In 2005, 1M: 1C alternate and 1M: 1C mixed-row planting patterns were at par with respect to their effects on number of pods per plant in cowpea. There were no significant ($P > 0.05$) interactions between cowpea varieties and planting pattern for number of pods per plant in both years.

4.1.15 Threshing percentage

The threshing percentage for cowpea varieties did not differ significantly ($P > 0.05$) in maize/cowpea intercropping in 2005, 2006 and the combined (Table 17). Planting pattern also had no significant ($P > 0.05$) effect on the threshing percentage of cowpea, just as there were also no significant ($P > 0.05$) interactions between cowpea varieties and planting pattern for threshing percentage in both years.

Table 16: Number of pods per plant of cowpea in maize/cowpea intercropping during 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	14.2	15.0	14.0
SAMPEA 4 (IAR-176B)	16.0	17.0	16.0
SAMPEA 5 (IAR-355)	15.0	15.0	15.0
IAR-1035	16.0	16.0	16.0
IAR-1074	16.0	15.0	15.0
IT90K-2772	15.0	15.0	15.0
S.E. ±	1.3	1.3	0.93
Planting pattern (P)			
1M:1C alternate	14.0b	14.2b	13.9b
1M:1C mixed-row	12.0b	11.4c	11.6c
1M:4C:1M alternate	21.0a	20.1a	20.3a
SE ±	0.9	1.0	1.0
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests.

C = cowpea, M= maize;

Table 17: Threshing percentage (%) of cowpea in maize/cowpea intercropping during 2005, 2006 cropping seasons at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Variety (V)			
SAMPEA 2 (IAR-353)	65.7	52.7	59.3
SAMPEA 4 (IAR-176B)	64.8	49.4	57.1
SAMPEA 5 (IAR-355)	69.1	48.7	58.9
IAR-1035	66.4	47.0	57.0
IAR-1074	49.7	51.0	50.3
IT90K-2772	68.8	50.5	59.6
S.E. $\pm$	6.07	3.24	3.44
Planting pattern (P)			
1M:1C alternate	62.7	53.0	57.7
1M:1C mixed-row	66.3	51.0	58.7
1M:4C:1M alternate	63.0	46.0	54.6
SE $\pm$	4.30	2.29	2.43
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to Duncan's multiple range test.
C =cowpea M= maize

4.2 Maize Crop Parameters

4.2.1 Plant height

Plant height of maize was generally not affected by cowpea varieties 12 WAS in both years and the two years combined (Table 18). However planting pattern had significant ($P > 0.05$) effect on the plant height of maize in 2006, maize plants grown under mixed-row planting pattern produced significantly ($P > 0.05$) taller plants while the other planting patterns were statistically at par.

4.2.2 Dry matter accumulation

Both cowpea variety and planting pattern had no significant ($P > 0.05$) effect on dry matter accumulation of maize plant at 12WAS in both years (Table 18). Cowpea variety x planting pattern interaction for dry matter accumulation of maize was not statistically significant ($P > 0.05$).

4.2.3 Number of leaves per plant

Number of leaves per plant in maize was not affected by cowpea variety at 10WAS in both years and the combined analysis (Table 19). However planting patterns had significant ($P > 0.05$) effect on the number of leaves of maize in the 2005 cropping season only. Maize plants under the 1M: 1C alternate planting pattern had a higher number of leaves than the two planting patterns both of which were statistically at par. Cowpea variety and planting pattern interaction for the number of leaves of maize was not statistically significant ($P > 0.05$).

Table 18 : Plant height (cm) and dry matter accumulation (g plant^{-1}) of maize plant in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern at 12 WAS in 2005 and 2006 at Samaru, Nigeria

Treatment	Plant height			Dry matter accumulation.		
	2005	2006	Combined	2005	2006	Combined
Cowpea variety (V)						
SAMPEA 2 (IAR-353)	237.0	207.6	222.2	145.8	141.1	143.5
SAMPEA 4 (IAR-176B)	221.1	208.2	215.2	192.2	134.5	163.4
SAMPEA 5 (IAR-355)	235.8	203.2	219.5	189.1	150.8	170.0
IAR-1035	225.4	205.4	215.4	185.8	158.2	172.0
IAR-1074	231.0	211.2	221.1	184.0	140.9	162.5
IT90K-277-2	225.6	208.0	216.8	160.4	141.0	150.7
S.E. ±	5.58	5.60	5.59	17.91	11.88	14.90
Planting pattern (P)						
1M: 1C alternate	224.2	203.7b	213.9	170.5	154.9	162.7
1M: 1C mixed-row	229.7	215.4a	222.6	193.0	135.9	164.5
1M: 4C:1M alternate	334.5	202.7b	268.6	165.2	142.4	153.8
SE ±	3.95	3.96	3.96	12.68	8.40	10.54
Interaction						
V X P	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test. C = cowpea, M= maize.

Table 19: Number of leaves of maize plant in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern at 10 WAS in 2005 and 2006 at Samaru, Nigeria

Treatment	Years		Combined
	2005	2006	
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	13.0	13.0	13.0
SAMPEA 4 (IAR-176B)	13.6	14.0	13.8
SAMPEA 5 (IAR-355)	13.4	13.6	13.5
IAR-1035	13.2	13.2	13.2
IAR-1074	13.3	13.2	13.3
IT90K-277-2	13.3	13.4	13. 4
S.E. ±	0.24	0.40	0.32
Planting pattern (P)			
1M: 1C alternate	13.8a	13.6	13.7
1M: 1C mixed-row	13.4ab	13.5	13.5
1M: 4C:1M alternate	13.2ab	13.2	13.2
SE ±	0.17	0.28	0.23
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test. C = cowpea, M= maize.

4.2.4 Crop growth rate (CGR)

Crop growth rate (CGR) of maize was not significantly ($P > 0.05$) affected by cowpea variety at each of the different growth stages in the 2005 cropping season (Table 20). However during 4-6, 6-8 and 10- 12 WAS in the same year, planting pattern influenced maize CGR significantly. During 4-6 WAS, the mixed-row and 1M: 4C:1M alternate planting patterns, both of which were statistically at par, had higher maize CGR values than the 1M: 1C alternate planting pattern (Table 20). During 6-8 and10-12 WAS, however, the mixed-row pattern produced significantly ($P > 0.05$) higher CGR values than either 1M: 1C alternate or 1M: 4C:1M alternate patterns, both of which were at par. The CGR value under the mixed-row pattern during 6-8 WAS, was 64% higher than the value for the 1M: 4C:1M alternate pattern. Crop growth rate of maize was not significantly ($P > 0.05$) affected by cowpea variety and planting pattern at various growth stages in 2006 (Table 21) except that during 8- 10 WAS planting pattern influenced CGR significantly ($P > 0.05$). Both 1M: 1C alternate and 1M: 4C:1M alternate patterns produced significantly ($P > 0.05$) higher CGR values than mixed-row pattern, even though all three were statistically at par. The CGR value for the 1M: 1C alternate planting pattern was 79.7% higher than the CGR value for the 1M:1C mixed-row pattern. The CGR data combined for both 2005 and 2006 cropping seasons are shown in Table 22. Although cowpea variety had no significant ($P > 0.05$) influence on maize CGR at all the growth stages, during 10- 12 WAS planting pattern influenced CGR significantly ($P > 0.05$). The mixed-row pattern produced maize plants which had a CGR value that was significantly ($P > 0.05$) higher than that for 1M: 1C alternate pattern. The varieties x planting pattern interactions for CGR were not statistically significant ($P > 0.05$).

Table 20: Crop growth rate (g. m^{-2}.wk^{-1}) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the 2005 cropping season at Samaru, Nigeria.

	Crop growth periods (WAS)			
Treatment	**4-6**	**6-8**	**8-10**	**10-12**
Cowpea variety (V)				
SAMPEA 2 (IAR-353)	14.6	15.5	21.2	3.4
SAMPEA 4 (IAR-176B)	17.4	18.6	32.8	5.1
SAMPEA 5 (IAR-355)	15.1	22.5	31.2	4.1
IAR-1035	15.4	21.6	29.7	5.3
IAR-1074	15.7	22.9	28.8	4.4
IT90K-2772	16.5	10.0	19.7	4.9
S.E. $\pm$	2.06	4.47	6.56	0.83
Planting pattern (P)				
1M:1C alternate	13.2b	20.4ab	28.9	3.7b
1M:1C mixed-row	15.7ab	24.6a	28.6	6.0a
1M:4C:1M alternate	18.4a	15.0b	24.3	3.8b
SE $\pm$	1.46	3.16	4.64	0.58
Interaction				
V X P	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = Cowpea, M= Maize; WAS = Weeks after sowing.

Table 21: Crop growth rate (g.m.$^{-2}$wk^{-1}) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the 2006 cropping season at Samaru, Nigeria.

	Crop growth periods (WAS)			
Treatment	**4-6**	**6-8**	**8-10**	**10-12**
Cowpea variety (V)				
SAMPEA 2 (IAR-353)	15.8	19.8	12.9	4.9
SAMPEA 4 (IAR-176B)	18.4	22.2	7.0	4.3
SAMPEA 5 (IAR-355)	19.6	22.6	10.8	4.0
IAR-1035	21.8	22.3	13.0	4.7
IAR-1074	18.1	22.3	9.3	3.7
IT90K-2772	17.2	20.9	12.6	3.2
S.E. ±	4.08	6.24	2.60	0.83
Planting pattern (P)				
1M:1C alternate	18.5	23.9	13.3a	3.8
1M:1C mixed-row	16.4	21.9	7.4b	4.2
1M:4C:1M alternate	20.5	19.2	12.1ab	4.3
SE ±	2.89	4.41	1.84	0.60
Interaction				
V X P	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = Cowpea, M= Maize; WAS = Weeks after sowing.

Table 22: Crop growth rate (g. m^{-2} .wk^{-1}) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern when data were combined for the 2005 and 2006 cropping seasons at Samaru, Nigeria.

	Crop growth periods (WAS)			
Treatment	**4-6**	**6-8**	**8-10**	**10-12**
Cowpea variety (V)				
SAMPEA 2 (IAR-353)	15.2	17.7	17.1	4.1
SAMPEA 4 (IAR-176B)	17.9	20.4	19.9	4.7
SAMPEA 5 (IAR-355)	17.3	22.6	21.0	4.0
IAR-1035	18.6	21.9	21.3	5.0
IAR-1074	16.9	22.6	19.1	4.0
IT90K-2772	16.8	20.0	16.2	4.0
S.E. ±	2.29	3.84	3.53	0.59
Planting pattern (P)				
1M:1C alternate	15.9	22.1	21.1	3.8b
1M:1C mixed-row	16.0	23.2	18.0	5.1a
1M:4C:1M alternate	19.5	17.1	18.2	4.1ab
SE ±	1.62	2.71	2.50	0.42
Interaction				
V X P	NS	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test
C = Cowpea, M= Maize; WAS = Weeks after sowing.

4.2.5 Days to 50% tasselling

Number of days to 50% tasselling in maize was not affected by cowpea varieties in both years and the combined (Table 23). However, while this parameter was affected by planting pattern in 2005 and the combined, there was no significant ($P > 0.05$) effect of planting pattern in the 2006 cropping season.

In the 2005 cropping season, maize plants under the mixed-row and 1M: 4C:1M alternate planting patterns tasseled slightly later than those under 1M: 1C alternate planting pattern. When the data for the two seasons were combined, it was observed that maize plants under the mixed-row pattern tasseled later than those under the 1M: 1C alternate planting pattern even though it was at par with that of the 1M: 4C:1M alternate planting pattern. The interactions between cowpea variety and planting pattern for days to 50% tasselling in maize were not statistically significant ($P > 0.05$).

4.2.6 Number of ears per plant

Number of ears per plant in maize was not influenced by cowpea variety nor planting pattern in both years and the combined for the two years (Table 24). The interactions, between cowpea variety and planting pattern for this same parameter were also not statistically significant ($P > 0.05$).

Table 23: Days to 50% tasselling in maize in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern during the 2005 and 2006 copping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	57.3	57.3	57.3
SAMPEA 4 (IAR-176B)	57.6	57.4	57.5
SAMPEA 5 (IAR-355)	56.9	57.3	57.1
IAR-1035	57.2	57.6	57.4
IAR-1074	57.0	57.1	57.1
IT90K-2772	57.3	57.8	57.6
S.E. $\pm$	0.26	0.26	0.18
Planting pattern (P)			
1M:1C alternate	56.7b	57.5	57.1b
1M:1C mixed-row	57.6a	57.4	57.5a
1M:4C:1M alternate	57.4a	57.3	57.4ab
SE $\pm$	0.18	0.18	0.13
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

Table 24: Number of ears per plant in maize in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the 2005 and 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	1.4	1.4	1.4
SAMPEA 4 (IAR-176B)	1.7	1.6	1.6
SAMPEA 5 (IAR-355)	1.3	1.1	1.2
IAR-1035	1.6	1.13	2.4
IAR-1074	1.7	1.3	1.5
IT90K-2772	1.2	1.2	1.2
S.E. $\pm$	0.90	0.15	0.46
Planting pattern (P)			
1M:1C alternate	1.5	1.3	1.4
1M:1C mixed-row	2.4	1.2	1.8
1M:4C:1M alternate	1.6	1.4	1.5
SE $\pm$	0.64	0.10	0.32
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

4.2.7 Average cob length

Average cob length in maize was not affected by cowpea variety and planting pattern in the 2005 cropping season and when averaged over both years. However, in the 2006 cropping season, longer maize cobs were obtained where maize was in mixture with cowpea variety SAMPEA-4 than with the other varieties, all of which were statistically at par (Table 25). The interactions between cowpea variety and planting pattern for maize cob length were also not statistically significant ($P > 0.05$).

4.2.8 Cob diameter

Cob diameter in maize was not influenced by cowpea variety and planting pattern in both years and the combined. Similarly, the interactions between cowpea variety and planting pattern for maize cob diameter were not statistically significant ($P > 0.05$) (Table 26).

4.2.9 Average cob weight

Average cob weight in maize was not significantly ($P > 0.05$) influenced by cowpea variety in both years and the combined. However, planting pattern had significant ($P > 0.05$) effect in the 2005 cropping season and the combined as maize plants under 1M: 4C:1M alternate planting pattern produced heavier cobs than those in the other two planting patterns (Table 27).

In the combined analysis, plots under 1M: 4C:1M alternate pattern produced maize plants with heavier cobs than the other two planting patterns, both of which were statistically similar. The interactions between cowpea variety and planting pattern for average maize cob weight were not significant ($P > 0.05$) as in Table 27.

Table 25: Average cob length (cm) in maize in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the during 2005 and 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	16.4	14.4ab	15.4
SAMPEA 4 (IAR-176B)	16,2	16.0a	16.1
SAMPEA 5 (IAR-355)	16.1	15.2ab	15.6
IAR-1035	16.0	14.1b	15.1
IAR-1074	15.7	15.3ab	15,5
IT90K-2772	15.5	15.0ab	15.3
S.E. $\pm$	0.40	0.47	0.31
Planting pattern (P)			
1M:1C alternate	15.9	14.5	15.3
1M:1C mixed-row	16.3	15.5	15.9
1M:4C:1M alternate	15.8	14.7	15.2
SE $\pm$	0.29	0.33	0.23
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

Table 26: Cob diameter (cm) in maize in a maize/cowpea intercropping as influenced by Cowpea variety and planting pattern in the 2005 and 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	4.5	4.6	4.6
SAMPEA 4 (IAR-176B)	9.3	4.7	7.0
SAMPEA 5 (IAR-355)	4.5	4.6	4.5
IAR-1035	4.4	4.5	4.4
IAR-1074	4.4	4.5	4.5
IT90K-2772	4.4	4.5	4.5
S.E. $\pm$	1.95	0.06	1.00
Planting system (P)			
1M:1C alternate	4.4	4.5	4.5
1M:1C mixed-row	4.5	4.6	4.6
1M:4C:1M alternate	6.8	4.5	5.7
SE $\pm$	1.38	0.05	0.69
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

Table 27: Average cob weight (g) in maize in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the 2005 and 2006 cropping seasons and combined at Samaru,Nigeria

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	19.2	10.3	14.7
SAMPEA 4 (IAR-176B)	17.2	10.6	13.9
SAMPEA 5 (IAR-355)	20.5	9.9	15.2
IAR-1035	17.8	9.0	13.4
IAR-1074	19.1	9.5	14.3
IT90K-2772	19.6	9.7	14.7
S.E. ±	1.90	0.66	1.00
Planting pattern (P)			
1M:1C alternate	16.8b	9.6	13.2b
1M:1C mixed-row	18.5ab	9.4	14.0ab
1M:4C:1M alternate	21.4a	10.5	16.0a
SE ±	1.34	0.47	0.71
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

4.2.10 Number of cobs per plot

Means for number of cobs of maize per plot were not affected by cowpea varieties in both years, and the combined data (Table 28). However, planting pattern had significant ($P > 0.05$) effect on the number of cobs per plot of maize in both years and the combined for the years. In the 2005, 2006 and mean across the years, maize plants under 1M: 1C alternate and the mixed- row planting patterns produced maize plants with higher number of cobs per plot than plants under the 1M: 4C:1M alternate planting pattern. Both the 1M: 1C alternate and mixed-row planting patterns resulted in values for number of cobs per plot which were statistically at par. The mixed-row planting pattern produced 31.4, 82.3, and 58.7% more maize cobs than the 1M: 4C:1M alternate planting pattern in 2005, 2006 and the combined data. Corresponding superiority of 1M: 1C alternate pattern over the 1M: 4C:1M alternate pattern was 22.4, 69.1and 47.6% respectively. The interactions between cowpea variety and planting pattern for this parameter were not statistically significant ($P > 0.05$).

4.2.11 Mean cob weight per plot

Cob weight per plot of maize was generally not significantly ($P > 0.05$) affected by cowpea varieties in both cropping seasons of (2005, 2006) and the combined for both years (Table 29).However, planting pattern had significant ($P > 0.05$) effect on the cob weight of maize in 2005 and 2006 and in the combined for both years. Cob weight per plot was significantly ($P > 0.05$) higher in the 1M: 1C alternate and mixed-row than 1M: 4C:1M alternate plots. The interactions between cowpea variety and planting pattern for cob weight per plot were not significant ($P > 0.05$) in any of the two years and even in the combined data for both years.

Table 28: Number of cobs per plot for maize in a maize/cowpea intercropping as influenced by cowpea variety and planting pattern in the 2005 and 2006 cropping seasons and combined at Samaru,Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	37.4	55.2	46.3
SAMPEA 4 (IAR-176B)	40.4	52.7	46.6
SAMPEA 5 (IAR-355)	35.8	51.4	43.6
IAR-1035	39.2	52.4	45.8
IAR-1074	34.7	55.2	44.9
IT90K-2772	33.6	34.6	44.1
S.E. ±	3.32	4.30	2.72
Planting system (P)			
1M:1C alternate	38.2a	60.2a	49.3a
1M:1C mixed-row	41.0a	64.9a	53.0a
1M:4C:1M alternate	31.2b	35.6b	33.4b
SE ±	2.35	3.04	1.92
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.
C = cowpea, M= maize.

Table 29: Mean cob weight per plot of maize (g) in maize/cowpea intercropping as ssinfluenced by cowpea variety and planting pattern during 2005, 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	138.3	107.6	123.0
SAMPEA 4 (IAR-176B)	138.3	107.0	122.6
SAMPEA 5 (IAR-355)	139.2	100.3	120.0
IAR-1035	125.4	91.2	108.3
IAR-1074	128.5	102.7	115.6
IT90K-2772	127.0	101.8	114.4
S.E. $\pm$	7.71	5.11	4.63
Planting system (P)			
1M:1C alternate	128.0b	112.1a	120.0b
1M:1C mixed-row	145.3a	118.2a	131.8a
1M:4C:1M alternate	125.0b	75.0b	100.0c
SE $\pm$	5.46	3.62	3.27
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

4.2.12 Number of kernel rows per cob

Means for number of kernel rows per cob were not significantly ($P > 0.05$) affected by cowpea variety and planting pattern in both years and the combined for both years. Similarly, the interaction between cowpea variety and planting pattern for this parameter were not statistically significant ($P > 0.05$) (Table 30).

4.2.13 Grain size (100-grain weight)

The values for 100-grain weight of maize were significantly ($P > 0.05$) affected by cowpea variety only in the 2005 season. In the 2006 season and the combined for both years, however, 100-grain weight of maize was not significantly ($P > 0.05$) affected by cowpea variety as presented in Table 31. In the 2005 season, maize in grown mixture with cowpea variety SAMPEA-5 produced heavier grains of maize than the other cowpea varieties, all of which were statistically at par. Planting pattern had no significant ($P > 0.05$) effect on the value for 100-grain weight of maize in both years and the combined data. The interactions between cowpea variety and planting pattern for grain size were also not statistically significant ($P > 0.05$).

Table 30: Means of number of kernel rows per cob of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern in 2005, 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	13.9	13.4	13.7
SAMPEA 4 (IAR-176B)	14.0	13.8	13.9
SAMPEA 5 (IAR-355)	13.3	13.6	13.4
IAR-1035	14.0	13.6	13.4
IAR-1074	13.9	13.8	13.8
IT90K-2772	14.3	13.6	13.9
S.E. $\pm$	0.30	0.28	0.21
Planting pattern (P)			
1M:1C alternate	14.0	13.8	13.9
1M:1C mixed-row	13.9	13.6	13.7
1M:4C:1M alternate	13.8	13.4	13.6
SE $\pm$	0.21	0.20	0.15
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

Table 31: 100-grain weight (g) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting patterns in 2005, 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	25.0ab	32.8	28.9
SAMPEA 4 (IAR-176B)	25.9ab	32.0	29.0
SAMPEA 5 (IAR-355)	26.7a	26.6	26.7
IAR-1035	23.1b	28.8	26.0
IAR-1074	23.9ab	27.9	25.9
IT90K-2772	23.5b	26.7	25.1
S.E. ±	0.99	2.02	1.12
Planting system (P)			
1M:1C alternate	24.1	28.5	26.3
1M:1C mixed-row	25.7	30.6	28.1
1M:4C:1M alternate	24.5	28.3	26.4
SE ±	0.70	1.43	0.79
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.

C = cowpea, M= maize.

4.2.14 Shelling percentage

The shelling percentage of maize was not significantly ($P > 0.05$) affected by cowpea variety in both years and combined data (Table 32). However, planting pattern significantly ($P > 0.05$) influenced the shelling percentage of maize in both years and the combined for both years. In both cases, maize under the 1M: 4C:1M alternate planting pattern gave a significantly ($P > 0.05$) higher shelling percentage than the other planting patterns, both of which were statistically at par. In 2005, 2006 and the combination for both years, the 1M: 4C:1M alternate planting pattern had a shelling percentage that was 72.1, 41.8 and 61.5 % higher than that for the 1M:1C mixed-row pattern respectively. The interactions between cowpea variety and planting pattern for shelling percentage were not statistically significant ($P > 0.05$).

4.2.15 Grain yield

Cowpea variety had no significant ($P > 0.05$) effect on the grain yield of maize in both years and the combined data (Table 33). However, there was increase in grain yield in 2006 over that of the 2005 cropping season. Planting pattern significantly ($P > 0.05$) influenced grain yield of maize in both years and the combined data. In each of the two years, maize under the 1M: 1C alternate and 1M:1C mixed-row planting patterns produced significantly ($P > 0.05$) higher grain yields than maize under the 1M: 4C:1M alternate planting pattern. However, in the combined analysis, maize under 1M:1C mixed-row pattern gave a significantly ($P > 0.05$) higher grain yield than either of the two planting patterns. The 1M: 4C:1M alternate planting pattern gave the lowest maize grain yield. The 1M:1C mixed-row pattern produced significantly ($P > 0.05$) higher maize grain yield than the 1M: 4C: 1M alternate planting pattern in 2005 and 2006, having out yielded the latter by 139.8 and 225.3% respectively. However, with respect to the combined data for both

years, the 1M:1C mixed-row pattern out-yielded the 1M: 1C alternate and 1M: 4C:1M alternate planting patterns by 22.8 and 185.6% respectively. The interactions between cowpea variety and planting pattern for maize grain yield were not statistically significant ($P > 0.05$).

Table 32: Shelling percentage (%) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern during 2005, 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	24.0	12.0	18.3
SAMPEA 4 (IAR-176B)	23.8	13.0	18.4
SAMPEA 5 (IAR-355)	26.0	13.8	19.9
IAR-1035	26.9	13.4	20.1
IAR-1074	24.9	13.4	19.2
IT90K-2772	25.1	12.8	19.0
S.E. ±	2.91	1.25	1.58
Planting system (P)			
1M:1C alternate	20.6b	12.7b	16.6b
1M:1C mixed-row	20.1b	11.0b	15.6b
1M:4C:1M alternate	34.6a	15.6a	25.2a
SE ±	2.06	0.89	1.12
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range tests. C = cowpea M = maize.

Table 33: Grain yield (kg ha^{-1}) of maize in maize/cowpea intercropping as influenced by cowpea variety and planting pattern during 2005, 2006 cropping seasons and combined at Samaru, Nigeria.

	Years		
Treatment	**2005**	**2006**	**Combined**
Cowpea variety (V)			
SAMPEA 2 (IAR-353)	1647	2627	2137
SAMPEA 4 (IAR-176B)	1718	2419	2068
SAMPEA 5 (IAR-355)	1576	2221	1899
IAR-1035	1708	2290	1999
IAR-1074	1483	2349	1916
IT90K-2772	1631	2532	2081
S.E. ±	206.5	362.2	208.6
Planting system (P)			
1M:1C alternate	1789a	2763a	2276b
1M:1C mixed-row	2182a	3409a	2796a
1M:4C:1M alternate	910b	1048b	979c
SE ±	146.1	256.3	147.4
Interaction			
V X P	NS	NS	NS

Means followed by the same letter(s) within the same column do not differ significantly at 5% level of probability according to the Duncan's multiple range test.
C = cowpea, M= maize.

5.0 DISCUSSION

5.1 Maize Crop

5.1.1 Effects of cowpea varieties

Most of the maize growth and yield parameters were not significantly ($P > 0.05$) affected by cowpea varieties when grown in intercropping with cowpea. Among the growth parameters dry matter accumulation and days to 50% tasselling were not significantly ($P > 0.05$) affected by cowpea varieties while plant height and number of leaves per plant were only significantly ($P > 0.05$) affected at various growth stages in the 2006 cropping season.

Among the yield-related parameters, cob diameter, cob weight, number of cobs per plot, cob weight per plot, number of kernel rows, shelling percentage and grain yield were not significantly ($P > 0.05$) affected by cowpea varieties in the two years of study.

There is abundant evidence in support of the fact that when cereals and legumes are grown together the cereal is usually less affected by the association (Isenmilla *et al.*, 1981; Rao and Wiley, 1983). The observed non-significant effect of cowpea genotype on grain yield of maize in the two trials and the combined analysis corroborates the findings for maize/beans and millet/cowpea intercropping systems which had earlier been reported by Reddy *et al*. (1992) and Odion *et al.* (2000). This pattern of responses suggests low competitive ability of cowpea with the cereals in Singh, 1999.

In a maize-based intercropping study involving cowpea and other crop species, it was reported by Giller *et al.* (1998) that both cowpea and sun hemp sown 28 days after maize can produce large amounts of biomass without reducing the yield of the companion maize crop. Most of the reported work on maize/cowpea mixture indicated a reduction in

cowpea yield while maize yields were generally unaffected by the companion cowpea crop (Heizel, 1974; Isenmilla *et al.* 1981; Olufajo, 1988; Cardoso *et al.*, 1993).

5.1.2 Planting patterns

Averaged over two seasons, plant height and number of leaves of maize per plant were only significantly ($P > 0.05$) affected by planting pattern at a later stage of their growth in the 2005 cropping season, while they were not significantly ($P > 0.05$) affected in the 2006 cropping season. In the 2005 cropping season, the 1M: 1C mixed-row planting pattern produced taller maize plants at 12 WAS. This suggests that the cereal crop was not adversely affected by the below-ground competition with cowpea. It also appears to suggest that cereal crops may have benefited from low inter-specific competition for growth factors in the intercrops (Trenbath, 1974; 1976; Willey, 1979). Planting pattern had significant ($P > 0.05$) effect on maize crop dry matter accumulation in the present study. The greatest dry matter accumulation in maize occurred where the 1M: 4C:1M alternate planting pattern is adopted. This could have been because this planting pattern provided more space in between two contiguous maize plants than did the other two patterns. This therefore, prevented overcrowding and mutual shading among the maize plants, thus providing a better light distribution within the maize canopy. The competition for other growth resources among the maize plants, especially soil moisture and mineral nutrients, was also likely to be at a minimal level. Maize has been described as a high nitrogen-consuming crop and therefore does well where this important nutrient resource is available in abundance, with less competition for it (Balasubramanian *et al.*, 1978; Ologunde and Ogunlela, 1984). It is probable that the N-fertilizer applied to intercropped legume could end up being utilized by the companion cereal crop as a result of the nutrients mobility and the extensive adventitious shallow rooting system of the cereal. This seems likely since

nitrogen has been known to increase both the number of tillers and total dry matter production of millet (Labe, 2000).

Average cob weight for IM: 4C: IM alternate pattern was significantly ($P > 0.05$) higher than that for the IM: IC alternate and 1M:1C mixed-row planting patterns. This observation could be attributed to reduction in inter-specific competition for nitrogen and water on one hand and reduction in nutrient stress among maize plants when arranged alternately (between the rows) as earlier observed by Dalal (1997). This type of plant arrangement benefits both the cereal crop and the companion legume crop because the effect of shading by the cereal crop is reduced while the adverse effects of stress that may occur as a result of competition for nutrients is averted when the 1M:1C inter-row planting pattern is adopted. In addition to these, the relative ease this crop management is likely to provide with respect to fertilizer and insecticide application, weeding and other field operations could have been responsible for the higher cob weight obtained for the IM:4C:IM alternate planting pattern. This is in agreement with the position of Singh and Ajeigbe (2002) who stated that inter-row cropping of two rows of cereal to four rows cowpea gave better input application (fertilizer use, insecticide application, weeding and other field operations) and than the traditional system. The shelling percentage for maize under IM: 4C: IM alternate planting pattern was significantly ($P > 0.05$) higher than that for the IM: IC alternate and 1M:1C mixed-row planting patterns. This could be attributed to the greater ability of maize crop plants to utilize the available growth resources coupled with less inter-plant competition resulting in better assimilate production and its subsequent storage in the available sinks. This result is supported by the findings of Rao and Mathuwa (2000) who alluded to the fact that higher cob and grain yields of 24% over other arrangements were obtained.

The grain yields of maize were significantly (P > 0.05) higher for alternate IM: IC and mixed-row planting patterns than for the IM: 4C: IM alternate planting pattern.Among the reasons that could be advanced for this result was an enhancement of physiological functions that was advantageous and the reduced interplant competition among maize plants. The population of maize in 1M: 1C alternate and 1M:1C mixed-row pattern is higher than 1M: 4C:1M alternate arrangement. The higher population could account for the yield due to more energy interception. It is known that different crop species grown together may sometimes complement each other, more especially when they differ in their use of growth resources such as light, moisture and soil nutrients. Maize and cowpea in the present study were well adapted to each particular light niche (maize is tall while cowpea is short). Thus, a 1M:1C inter-row planting pattern that provided better individual crop orientation with respect to leaf inclination, leaf angle, genotypic heights and canopy architecture made better crop growth and development possible. Similar results have been reported by Elemo *et al* (1990) where a higher population of maize to cowpea produced higher grain yield of both crops. This represents a form of synergy between the cereal and legume crops when both crops are grown in an intercropping system.

Planting pattern influenced maize CGR significantly (P > 0.05). In the 2005 cropping season, the IM: 4C:IM alternate and 1M:1C mixed-row planting patterns produced higher maize CGR values than the other planting pattern, while in the following cropping season, at 10WAS, the alternate IM:IC and IM:4C:IM alternate planting patterns produced significantly (P > 0.05) higher CGR values than the 1M:1C mixed-row planting pattern. Any crop arrangement that allows less interplant competition for growth resources will make a maize crop to grow well and produce higher dry matter as was observed with respect to the IM: 4C: IM alternate planting pattern in terms of its crop growth rate (CGR).

In addition to this, the ability of the maize crop, which is a C_4 species, to quickly respond to available resources, most especially when there is less competition, made the CGR values to be higher in the case of the IM:4C:IM alternate and IM:IC alternate planting patterns. Similar findings that were reported by Tsubo *et al.* (2004) are corroborated by the present result. They stated that crop growth rate is generally higher in C_4 plant species, than in C_3 species; the former grows faster than the beans, a C_3 species, and is therefore more competitive than the beans. The cereal component, maize, in this experiment, usually is taller, has a faster growing or more extensive root system, particularly a larger mass of fine roots and is competitive for soil nitrogen (Carr *et al.*, 1998; Carruthers *et al.*, 2000). This forces the legume component, cowpea in this experiment, to rely on biologically fixed nitrogen from the atmosphere (Jensen, 1996; Huggard – Nielson 2001). This is expressed as a facilitative effect of intercrop component, meaning that maize and cowpea have complementary effects in consumption of nitrogen.

5.2 Cowpea

5.2.1 Effects on cowpea

The significant ($P > 0.05$) differences among the inter-cropped cowpea cultivars with respect to number of days to 50% flowering, number of branches, pod yield and 100–grain weight in maize-cowpea intercrops were observed. This is not unexpected in the view of the fact these characters are under strong genetic control even though they are also influenced to some extent by certain environmental factors (Anonymous, 1985). Abubakar (1992) using soybean as a test crop in his investigation opined that variations in growth characters due to genotype could be associated with the differences in the genetic makeup of the genotype, which ultimately determined their growth habits. In both years, varieties IAR-1074 and IT90K-277-2 had fewer branches and matured later compared with other

cowpea varieties. Higher grain and pod yields were produced by varieties SAMPEA-2 and IAR – 1074 while variety IAR-1035 had the lowest grain yield. This strongly suggests that varieties SAMPEA-2 and IAR-1074 are suitable for use in intercropping with maize, and therefore more adapted for use in intercropping with maize than the other four cowpea varieties. Variety SAMPEA-5 was the variety that produced lowest grain yield hence the least adapted for use in intercropping with maize. On the other hand, varieties SAMPEA-5 and IAR-1035 should not be considered for use in a cowpea/maize intercropping system. One is inclined to believe that variety IAR-1035 is sensitive to the shading effect from the maize intercrop, which is the more aggressive species in the mixture. The differences in the ability of the different cowpea cultivars to exploit environmental resources of light, nutrients and space could also have accounted for the variations observed among these characters (Willey and Osiru, 1972). The significantly ($P > 0.05$) higher grain yield of SAMPEA-2 relative to the yield of the other cowpea varieties could be associated with its higher number of branches, which would mean a higher number of pods per plant. In the two cropping seasons, IAR-1074 and SAMPEA-5 had significantly ($P > 0.05$) higher 100-grain weight, which would partly account for the higher grain yield of the former variety. The significant ($P > 0.05$) differences in mean 100-grain weight among the different cowpea cultivars in the two cropping seasons, could be associated with differences in their ability to exploit growth factors for assimilate production and subsequent mobilization of such assimilate to the

reproductive sinks for grain production.

5.2.2. Planting pattern

The IM: 4C: IM alternate planting pattern produced taller cowpea plants with more branches and wider canopy spread than the other planting patterns, although in the 2006

cropping season, 1M: 1C mixed-row pattern produced taller cowpea plants than IM: IC alternate planting pattern. This could be attributed to the relatively reduced or lack of competition for space and absence of shading effect on the companion cowpea crop from component maize crop. Such a plant arrangement must have provided adequate space for the cowpea plants to grow and express their full growth potential in terms of more branches, more leaves and associated growth characters in the presence of necessary mineral nutrients and other important growth factors. All these might have made the cowpea plant grow taller and the canopy spread further, thus resulting in a better canopy architecture. Elemo *et al.,* (1990), Tsubo and Walker (2002) and Ajeigbe *et al.* (2006) reported similar results in which Elemo *et al.*(1990) reported that better yield advantage in crop mixtures is associated with better utilization of light because of different canopy structures of the intercrops making up the crop mixture. Tsubo and Walker (2002), on the other hand, used radiation transmission model in alternate intercrop canopy study to arrive at such a result, while Ajeigbe *et al.* (2006) working in the Sudan agro- ecological zone of Nigeria obtained higher fodder yields from alternate arrangement of maize and cowpea crops with the cowpea companion crop having more plant rows than maize in the mixture.

Crop growth rate (CGR) for cowpea under the IM:4C:IM alternate and IM:IC alternate planting patterns were higher than the 1M:1C mixed-row planting pattern because these former plant arrangements provided better light (solar radiation) distribution, made nutrients more available per plant and less competitive. These are circumstances that are normally associated with inter-cropping systems under better crop management. Henrik and Peter (1997) adduced similar reasons for such performances in their earlier studies. The 1M: 1C mixed-row planting pattern could not give higher CGR values probably due to the fact that there was aboveground interplant competition since plants in the crop mixtures

were in close proximity. Ajeigbe *et al*. (2006) from their recent intercropping studies in northern Nigeria found that cereal crops imposed stiff competition on companion cowpea crop, especially in a 1M: 1C mixed-row plant arrangement.

Cowpea pod yields from the IM: 4C: IM alternate planting pattern was higher than the other patterns in the present study, and consequently gave higher pod yield per hectare. This eventually resulted in higher cowpea grain yields per hectare under this particular planting pattern. The positive results obtained from this pattern could be associated with differences in relative proportions of the two crop species and proximity of the dominant component crop (maize) in the mixture. While the interplant competition may occur in the 1M:1C mixed-row pattern when the crop proportion or plant population is high, the close proximity of component crops, more especially a dominant crop, such as maize, may adversely affect the dominated crop (cowpea) where there is stiff competition for growth factors. Therefore, the IM: 4C: IM alternate planting pattern in the present study provided a situation where both crop species (cowpea and maize) were separated by ratio 1:4:1 row, thus making plant competition for growth resources reasonably low. This was in contrast to shading effect and stiff competition that were associated with the 1M:1C mixed-row planting pattern. Spatial arrangement of component crops is thus one of the most important agronomic factors that can determine whether or not an intercropping system will be beneficial with regard to yield increase as posited by Olufajo (1995) and Singh and Ajeigbe (2002). Cowpea plants produced more pods per plant under the IM: 4C: IM alternate planting pattern than under the other two planting patterns. This is because under this pattern, the cowpea crop was able to intercept adequate light and had less competition for other growth factors. When there is a conducive environment for the crop to develop and grow properly, the production of dry matter is likely to translate into better assimilate

translocation from the source to the sink. Under the IM:4C:IM alternate planting pattern, cowpea plants could have enjoyed adequate resource supply, with limited competition for growth resources, which later resulted in greater production of assimilate, which was later translocated to the reproductive sinks. Total dry matter accumulation was significantly ($P > 0.05$) higher under the IM: 4C: IM alternate and IM: IC alternate planting arrangements. It seems likely that the inner rows of cowpea under these patterns experienced little or no competition from the tall canopy of the cereal crop, especially for light. Competition for light among component crops has been identified as a major reason for low dry matter production of cowpea in mixtures (Reddy *et al.*, 1990). Therefore, the reduced shading under the two planting patterns, coupled with the minimal competition for growth factors, could have accounted for the high total dry matter accumulation compared with the other two planting patterns, where competition for growth factors was expected to be high due to the relatively close proximity of the component crops. Furthermore, the higher mean cowpea grain yield under IM: 4C: IM alternate planting pattern in the 2005 cropping season and combined could be associated with the high dry matter recorded, and efficient use of other resources. In the present study, average pod length and pod weight per plant were significantly ($P > 0.05$) affected by planting pattern, with the IM: 4C: IM alternate planting pattern being superior to the others. The significant ($P > 0.05$) differences in these cowpea characters among the different planting patterns could be associated with differences in the relative proportions and proximity of the component crops in mixtures. There is evidence that strip cropping with two rows of cereals, four rows of cowpea offers an opportunity for selective input application than the traditional one row of cereal: one row of cowpea spatial arrangement (Singh and Emechebe, 1998; Singh and Ajeigbe 2002). Mensah (1997) noted that alternating three rows of cowpea with two or three rows of

sorghum and one to two insecticide applications gave a yield advantage of 58 to 69% and proposed this as the most productive method to be adopted by subsistence farmers, who generally adopt intercropping rather than sole cropping.

6.0 SUMMARY AND CONCLUSION

6.1 SUMMARY

Field trials were conducted during 2005 and 2006 cropping seasons at the Institute for Agricultural Research (IAR) farm, Samaru (lat 11^{o} 11'N, Long 07^{o} 38'E, 686m above sea level) Nigeria. Samaru is located in the northern Guinea savanna zone of Nigeria. In each trial, the treatments consisted of factorial combinations of six improved cowpea varieties namely, SAMPEA-2 (IAR 353), SAMPEA-4 (IAR-176B), SAMPEA -5 (IAR 355), IAR-1035, IAR -1074 and IT90K-277-2 which were intercropped with maize in three different row arrangements, namely, IM:IC mixed-rows, IM:IC alternate rows and IM:4C:IM alternate rows (M=maize, C=cowpea).The experiment was set up using a randomized complete block design with treatments in a split-plot arrangement using three replications. The planting pattern was assigned to the main plot while the variety was assigned to the sub-plot. Maize variety TZPBSR was used in the trials.

The objectives of the investigation were to determine the best planting pattern and row arrangement for maize-cowpea intercropping and also identify cowpea varieties that are best suited to use in intercropping with maize.

The results indicated that most of the growth and yield parameters of maize were not significantly ($P > 0.05$) affected by cowpea varieties. It was also revealed that, genotype had significant ($P > 0.05$) effect on the growth characters of cowpea in maize-cowpea intercropping. The results also indicated that varieties IAR-1074 and IT90K-277-2

had fewer branches and matured later compared with the other varieties. Higher cowpea grain and pod yields were obtained from variety SAMPEA–2 while variety IAR-1035 had the lowest grain yield.

Planting pattern had significant ($P > 0.05$) effect on most of the growth characters of cowpea studied. Most of the growth characters studied in both trials were of significantly ($P > 0.05$) higher values under IM: 4C: IM alternate planting pattern compared with either IM: IC alternate or 1M:1C mixed-row planting patterns. Yield and yield components of cowpea in both trials were significantly ($P > 0.05$) affected by planting pattern with the highest values recorded under IM: 4C: IM alternate planting pattern. It shows that the intercropping yield advantages were significantly ($P > 0.05$) higher under the IM: 4C: IM alternate planting pattern. The grain yields of maize were significantly ($P > 0.05$) higher for IM: IC alternate and 1M:1C mixed-row planting patterns than the IM: 4C: IM alternate system. Growing of variety SAMPEA-2 or IAR-1074 using 1M: 4C:1M alternate planting pattern is suitable for use in intercropping with maize.

6.2 CONCLUSION

In the context of this study, it can be concluded that, planting 2 maize rows: 4 cowpea rows in combination was appropriate for higher productivity of maize-cowpea intercrops. Thus planting variety SAMPEA-2 under the IM: 4C :IM alternate cereal/cowpea intercropping system can be recommended for higher productivity of both intercrops. There were considerable differences between the cowpea varieties in their performance in the maize intercrop. Result points to the fact that careful selection of cowpea cultivars is required for use in intercropping with maize to optimize the yield of cowpea in the intercrop.

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Appendix I: Meteorological data showing mean rainfall, temperature and relative humidity at Samaru during 2005 rainy season

Month	Rainfall (mm)	Temp (^{o}C) Min.	Max.	Rel. Hum (%)
June	160.2	21.0	31.6	78.4
July	152.6	20.9	30.2	83.0
Aug	235.5	20.1	29.2	87.7
Sept.	222.4	20.3	31.7	74.9
Oct.	26.8	18.5	33.2	57.1
Nov.	-	14.1	34.4	24.0
Dec.	-	13.6	33.2	16.8

Appendix II Meteorological data showing mean rainfall, temperature and relative humidity at Samaru during 2006, rainy season.

Month	Rainfall (mm)	Temperature (^{o}C) Min.	Max.	Relative Humidity (%) (%)
June	126.5	21.1	32.2	72.3
July	232.2	20.8	30.8	78.8
Aug	215.5	20.4	29.9	81.5
Sept.	281.5	20.2	30.9	80.1
Oct.	28.5	20.7	32.3	68.0
Nov.	-	13.6	31.1	22.2
Dec	-	12.5	30.6	18.2

Source: Meteorological unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria

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