PERFORMANCE OF IMPROVED GROUNDNUT VARIETIES IN MILLET BASED CROPPING SYSTEMS

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DECLARATION

I hereby declare that this work is the product of my own research effort; undertaken under the supervision of Prof. I. B. Mohammed and Prof. S. G. Mohammed has not been presented and will not be presented elsewhere for the award of a degree or certificate. All sources of literature have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work undertaken and the subsequent preparations of this thesis by Aminu Muhammad (SPS/10/MAG/00006) were carried out under our supervision

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DEDICATION

This work is dedicated to my parents Late Alhaji Muhammad S. Umar and Hajiya Aishatu Ahmad who prayed for my success in life.

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ABSTRACT

A field experiment was carried out during 2012 growing season at the Agricultural Research Station Minjibir of Institute for Agricultural Research Samaru and Hadejia Jama'are River Basin Development Authority Project Farm Wudil, all situated within Sudan Savannah Ecological Zone to evaluate the performance of improved groundnut varieties in Millet-based cropping system. Four varieties of groundnut, SAMNUT 21, SAMNUT 22, SAMNUT 23 and a local variety (Kampala) with two millet varieties, SOSAT C-88 and a local variety were used. The treatments consisted of three row arrangements - 1:1, 1:2 and 2:4. The treatments were laid out in factorial combinations laid out in split plot design. To the main plot the row arrangement was allocated while the crop varieties were allocated in the sub-plot. The results showed that row arrangement affected growth and yield characters of groundnut varieties at both locations. Leaf area, plant height, number of leaves and number of branches were increased at both locations. The treatments had significant effect on the yield of groundnut varieties at both locations. All the row arrangements had LER greater than 1 at both locations, which indicated yield advantage when crops are grown in mixtures. The competitive ratios calculated also showed that groundnut was more competitive in association with millet plant. Significant differences were not recorded on kernel yield production among the groundnut genotypes but SAMNUT 23 produced higher kernel yield at both locations than all other groundnut varieties. For the Millet varieties, significant differences were recorded on grain yield production with SOSAT C-88 out yielding the local variety at both locations. In addition to this, row arrangement of 2:4 promoted higher performance. It was also observed that row arrangement of 2:4 favoured higher grain yield for both millet and groundnut kernel yield. From the results of the study therefore, it can be concluded that the 2:4 row arrangement and combination of SOSAT-C 88 with SAMNUT 23 is suggested for both locations and others having similar soil and weather conditions that prevailed during the 2012 rainy season.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Intercropping is a crop management system involving two or more crops grown together for at least a portion of their production cycle and planted sufficiently close to each other so that inter-specific competition occurs (Sulliva, 2003; Dugje, 2004). Depending on the agro-climatic variations, 50-80% of rainfed crops are planted as intercrops in different parts of the developing countries. It is also a common practice in West Africa, where cereal/legume intercropping systems predominate.

Most of intercropping systems consist of at least one high energy food crop, such as maize, sorghum or millet, and one crop that serves as a source of protein, minerals and vitamins, such as cowpea, groundnut and vegetables. Although the yield of the crops in the intercrop may be lower than the yield of their respective sole crops, the combined effect of intercrop generally ensures greater land use efficiency. 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, 1979b). The system becomes more vital in a situation where soils are poor, rainfall is less and unreliable, and inputs are not available (Henriet *et al.,* 1997). However, according to Norman (1974), the system is likely to remain a widespread practice in the future because substantial evidence has been provided to suggest that yield advantages can be achieved by intercropping to explain its continued persistence in tropical Africa.

Groundnut (*Arachis hypogaea* L.) is an annual legume, which is also known as peanut, earthnut, monkeynut and goobers. It is the 13th most important food crop and 4th most important oilseed crop of the world. Groundnut kernels are a nutritional source of vitamin E, niacin, falacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium. Groundnut kernels are consumed directly as raw, roasted or boiled kernels; or oil extracted from the kernel is used as culinary oil. It is also used as animal feed (oil pressings, seeds, green material and straw) and industrial raw material (oil cakes and fertilizer). These multiple uses of groundnut plant makes it an excellent cash crop for domestic markets as well as for foreign trade in several developing and developed countries (Wiess,2000).

Groundnut is one of the most popular and universal crops cultivated in more than 100 countries in six continents. It is grown in 25 million hectares with a total production exceeding 35 million metric tons (FAO, 2006). Groundnut is produced in the northern states of Nigeria especially Kano, Taraba, Plateau, Nassarawa, Niger, Jigawa, Zamfara, Kebbi, Sokoto, Katsina, Kaduna, Adamawa, Yobe, Borno, Bauchi and Gombe (Taru *et al.*, 2008).

In Nigeria, groundnut is one of the most popular commercial crops. It is estimated that over 2 million hectares of land are planted to groundnut in Nigeria. It is grown for its edible nuts, while its husk (shell) is used as fuel, and livestock feed (Taru *et al.*, 2008).

Millet is a warm-weather annual grass or cereal grown for its edible seeds. Millet is useful where a grain crop is needed to capitalise on short growing periods. This role is most important in the dry tropics, where the period with adequate rainfall for crop growth is short, or in the regions of more adequate rainfall, where a short – season grain crop can be grown as a secondary plant, following a main crop on the same land (Ker, 1995). The most important characteristic of millet is its unique ability to tolerate and survive under adverse condition of continuous drought as compared to most other cereals like sorghum and maize (LCRI, 1997). The major millet producing countries are: India (10.3 million MT), Nigeria (5 million MT), Niger (3.9 million MT), Mali (1.8 million MT), Burkina Faso (1.1 million MT), and Chad (0.9 million MT) (FAOSTAT, 2014).

Nkama (1998) outlined the uses and traditional food preparations of millet in Nigeria. The grain serves as food for the majority of people of the dry land of Africa who utilize it in the form of a semi porridge, called 'tuwo', eaten with soup; a refreshing drink, called 'kunu'; a thick porridge consumed when mixed with milk, called 'Fura' and the popular pap or 'Akamu', and many more. Generally, the grain is produced for domestic consumption and has little commercial status. The stems are used for thatching/fencing, as a source of domestic fuel and livestockfeed.

1.2 Statement of the Problem

Nowadays food security is the main challenge of humans. Throughout much of the Sudan and Sahel region of Nigeria, rural livelihood is undermined by poverty, rapid environmental and resource base degradation due to drought, desertification, precipitation, soil degradation and poor agronomic practices. These constraints cause hardship to the people, resulting in serious malnutrition and poor health condition among the vulnerable groups, especially women and children. The rapid increases in human population and exploitative use of the renewable resources have worsened food shortage. Cropping system is one of the important factors that limit groundnut production. The bulk of groundnut production in Nigeria and other developing countries is carried out by small-scale farmers who use traditional combinations often involving 2-6 crops. More so, the crops are not grown on any definite row arrangement, so that some of the farming operations, such as weeding, spraying and harvesting are either made tedious or even impossible. Most of the farmers in the savannah region cultivate local varieties of cowpea, groundnut, soy bean, millet, sorghum and maize in various intercropping systems. The yields obtainable from these mixtures are very low due to both biotic and abiotic stress factors (Mortimore *et al.*, 1997; Singh and Ajeigbe, 2002). There is, therefore, the need to increase the yield per unit area through the improvement in the cropping pattern, and the use of improved varieties of crops that will increase yields.

1.3 Justification of the Study

Groundnut production in Nigeria started around 1912 in response to the high world prices. In the 1950s, Nigeria was among the leading exporters of groundnut to Europe. Nigeria reached a peak production of 1.5 million metric tons in 1973, but fell drastically to as low as half a million metric tons (FAO, 2006). High demand for export, the desire for self sufficiency in food production and to restore Nigeria back to its former position, have neccesitated the need to study and find out ways of improving groundnut production. Practising an intercropping pattern with proper crop arrangement and using appropriate component crop have been found to be among ways of increasing yield and productivity of the component crops. In addition, improved crop varieties have greater potentials over local cultivars in the provision of food security to the ever growing population. This is so because most improved cultivars are high yielding, early maturing, drought resistant, and resistant to most pests and diseases. Intercropping generally provides yield advantage compared with sole cropping (Willey, 1979a). The advantage was as much as 50-80%. It is therefore important to evaluate the performances of some improved groundnut varieties under different cropping systems so as to come up with some suggestion (s) for better and increased millet/groundnut intercrop performance.

1.4 Objectives

Improved seed varieties have greater potentials over local cultivars in the provision of food security to the ever growing population. This is so because most improved cultivars are (relative to local varieties) high yielding, early maturing, drought tolerant, and resistant to most pests and diseases, etc. (Agboola and Eniola, 1990) confirmed this by reporting that the practice of intercropping could be more successful and advantageous when improved varieties of seeds are used. Because of the continuous decline in soil productivity and increase in the human population, the intensification of agricultural systems and adoption of improved practices remain the keys to sustainable food production in the savannah region. With this in view, the objectives of this work were to determine the:

1. The performance and yield potential of improved groundnut varieties in millet intercrops.
2. The effect of planting arrangement and millet varieties on the performance of groundnut varieties in mixture.
3. The effect of planting arrangement and groundnut varieties on the performance of millet varieties in mixture.
4. The competitive ability of groundnut and millet under intercrop.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Intercropping

Intercropping is a common cropping system, especially in developing countries where subsistence agriculture is prevalent. It is seen as a system of improving crop production among poor farmers (Singh, 1981). Crops in intercropping system can be in different combinations, ranging from cereal/cereal, cereal/legume, cereal/tuber crops, cereal/vegetable or even legume/vegetable. There are four distinct types of intercropping subsystems according to Andrews and Kassam (1976). These are as follows:

Strip Intercropping: This is a situation whereby two or more crops are grown simultaneously on different strips but wide enough apart to allow independent cultivation and narrow enough apart for the crops to interact agronomically.

Row Intercropping: A situation whereby two or more crops are planted in alternate rows.

Mixed Cropping: It is a situation whereby two or more crops are grown simultaneously on a row without any distinct row arrangement.

Relay Intercropping: In this case, a second crop is planted after the first crop has reached an advanced stage of growth and development.

The commonest forms of intercropping are mixed and row intercropping (Andrews and Kassam, 1976).

There are several advantages of intercropping, which makes it a major cropping system for food production in many developing countries of the world. These are proper utilization of available environmental resources such as light, moisture, nutrients and space (Blade, 1992). It reduces weed invasion on farmlands, since some of the component crops may be cover crops, which shield the soil surface against the growth of weeds. It reduces damages caused by pests and diseases. It ensures greater stability of crop production by producing some yield, even if some of the component crops fail (Andrews, 1974). Intercropping also controls erosion, reduces leaching of nutrients and helps to maintain soil fertility. It gives higher economic returns when compared to sole cropping and brings about a reduction of risk due to crop failure (Odo and Futuless, 2002). Intercropping also helps to solve the problem of shortage of land that is common in most developing countries (Danlarai, 2005).

The disadvantages of intercropping include competition for moisture and nutrients in the soil, and also for light among component crops (Gomez and Gomez,1983). It is also usually difficult to control weeds, pests and diseases in intercropping, especially when herbicides and other chemicals that would control weeds, pests and diseases on the crop may affect the other crops negatively. Fertilizer application is also more difficult in intercropping than in sole cropping because, the fertilizer requirement of each crop may differ (Okigbo and

Greenland, 1976). Intercropping also creates shading of the shorter crops by the taller ones, thereby reducing light intensity reaching such crops (Danlarai, 2005).

Furthermore, it is very difficult to mechanize for operations such as planting, harvesting and fertilizer application in intercrops than in sole crops (Okigbo and Greenland, 1976). It has also been discovered that, some varieties of crops may be unsuitable as intercrops because they produce toxins that affect other crops directly or indirectly (Trenbath, 1975).

2.2 Spatial Arrangement in Intercropping

Spatial arrangement is the distribution pattern of crop plants on the soil surface, which determines the shape of the area available to individual plants (Willey, 1979). At present, several indices are used in evaluating crop productivity in mixtures. Indices such as Land Equivalent Ratio (LER) and Relative Yield (RY) have been used in several studies (Wahua and Miller, 1978; Crookston and Hill, 1979; Francis and Sterni, 1987) to select efficient mixtures and spatial arrangement in intercropping system.

The planting pattern plays a significant role in intercropping by determining the efficiency of utilizing environmental resources by the associated crops. Anonymous (1992) conducted an investigation on wheat/onion intercrop and reported that grain yield of wheat in sole crop was 222.9 kg/ha, but in mixture yield ranged from 102 to 177 kg/ha. However, when alternate stand and alternate row arrangements were considered separately, alternate stand gave higher grain yield (177kg/ha) compared to alternate row arrangement, which recorded 102kg/ha. This arrangement also gave 80% better cash returns than sole crop. The trial carried out at ICRISAT with three rows of groundnut and one row of sorghum gave yield advantage as high as 38% (Rao and Willey, 1980). Tarhakar and Rao (1979) also reported a yield advantage of 57% for three rows of groundnut and one row of sorghum as against sole cropping.

2.3 Effects of Row Arrangement on Groundnut and Cereals Productivity

The main intercropping systems in Nigeria are cereals/legumes, root and tuber crops/cereals and legumes/ tuber crop. The cropping systems are used to maximize production and diversify crops from parcel of land either in time or space than would be obtained by one crop. However, spatial arrangements of crops is another form of intercropping when two or more crops are grown in separate rows or alternating rows on the same piece of land. In spatial arrangements, the crops involved compete for growth resources such as light, water, carbon dioxide and nutrients. Differences in the canopies of crops appear to provide more efficient light use by spatial arrangements than by sole cropping.

Competition is one of the factors that can have a significant impact on yield of mixtures compared with pure stands (Caballero *et al.*, 1995). Higher yields have been reported when competition between two species of the mixtures have lower competition than within the same species (Vandermer, 1989). Competition can also have a significant impact on the growth rate of the different species used in spatial arrangements.

A number of advantages have been advanced for the use of spatial arrangements in place of sole cropping. According to Steiner (1984), spatial arrangements bridge the gap between planting and new harvest "the hungry season" where early maturity crops are planted at the beginning of the rainy season. According to Andrews and Kassam (1976), intercropping reduces the damage caused by pest and diseases and ensures greater yield stability by producing from the same field even if some of the crop fails.

2.4 Performance of Groundnut in Intercrops

Cereal-legume mixture is the common form of intercropping practiced by most small scale farmers in the tropics and subtropics. In the developing world, groundnuts are commonly grown in intercropping systems, especially by small farmers who use traditional combinations often involving up to 5-6 crops. Detailed statistics of farming practice are difficult to obtain, but it has been estimated that 95% of the groundnuts in Nigeria and 56% in Uganda are grown as mixtures with other crops (Okigbo and Greenland 1976). In the Northern Guinea Savanna Zone of Nigeria, reported that only about 16% of the total area under groundnut was in sole cropping while about 70% was in 2-4 crop mixtures. Yields obtained from the crop are traditionally low due to a combination of factors including unreliable rains, little technology available to small scale farmers, pest and disease occurrences, poor seed technology and agronomic practices, as well as increased cultivation on marginal lands (Konlan *et al.*, 2013). Groundnut production in Nigeria started around 1912 in response to the high world prices. In the fifties and sixties, Nigeria was among the leading exporter of groundnut. Nigeria reached a peak production of 1.5million metric tons in 1973 but later fell drastically due to pests and diseases attack, the coincidence of oil boom in Nigeria about the same time (Ntare, *et al.,* 2005), poor farming techniques and management, inadequate land available for farming and the shifting of government attention from agriculture to oil industry. The dismantling of marketing board including that of groundnut as a result of SAP, caused a lot of farmers who could not cope, to shift from groundnut to other crops (Ilu and Damisa, 2002). Groundnut is grown in 26.4 million hectares across the globe with a total production of 37.1 million metric tons with average production of 1.4 metric t/ha (FAO, 2006). Leading producing states in Nigeria are Kano, Jigawa, Zamfara, Kebbi, Sokoto (Taru *et al.* 2008). The multiple uses of groundnut plant make it excellent as crop and for foreign trade in the world (Ahmad *et al.,* 2007). The main reason for using a multiple cropping system is the fact that it involves integrating crops using space and labor more efficiently (Baldy and stigter, 1997). Cereal and legume intercropping is recognized as a common cropping system throughout tropical developing countries (Ofori and Stern, 1987).

2.5 Performance of Cereals in Intercrops

Intercropping is a popular farming system among small-scale farmers in the tropics (Ruthenerg, 1980; Vandemer, 1992). It is a form of multiple cropping where two or more different crops are grown on the same farm at the same time. There are two types of intercropping: mixed intercropping and strip intercropping. Mixed intercropping is the growing of two or more crops simultaneously with no distinct row arrangement. Strip intercropping is the growing of two or more crops simultaneously in different strips in the alternate arrangement, which are wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically. Intercropping sorghum and groundnut may increase, decrease or not affect yields of sorghum and groundnut depending on the spatial arrangement of the intercrops (Okiror *et al*., 1997). Sorghum is one of the major cereal crops where as groundnut is one of the most important legumes grown in Nigeria savanna. Most of the production of cereals come in mixture of two or more of the cereals and legumes (Odion, *et al.,* 1990; Olufajo, 1990; Olabanji, 1997; Dugje, 2004). Savanna zone is the most ideal of the climatic zones in Nigeria that best supports cereal and legume production (Kowal and Kassam, 1978; Ayoade, 2002). Sudan savanna with mean annual rainfall of 600-900mm and growing seasons of 90-140days (Ker, 1995) has the potential of supporting cereal and legume crops.

2.6 Groundnut Varietal Performance

Development of photoperiod-insensitive groundnut cultivars with improved plant types and a shorter time to maturity have gave researchers the opportunity to improve groundnut performance in cereal intercrops. Andrews (1974), studying the response of sorghum varieties to intercropping, concluded that the practice of intercopping could be made more advantageous by the use of improved crop varieties. Therefore, competitive relations in mixture may be manipulated by choice of variety (Andrews, 1974) and by the time of planting. Tefera and Tana (2002) reported the performance of sorghum and groundnut cultivars that was studied in sale cropping and intercropping systems at Babile in the semiarid area of eastern Ethiopia in 1996, 1997 and 1999. In their findings, late-maturing cultivars of groundnut and sorghum gave higher dry pod yield and grain yield on the average, respectively, when intercropped with early-maturing cultivars of the associated crops. Furthermore, they stated that the significant varieties among groundnut cultivars in yield and yield revealed that sole cropping may not provide the appropriate environment for selecting varieties intended for use in intercropping. The scientists reported that the productivity of intercropping by total land equivalent ratios (LER), was higher than sole cropping, indicating the presences of temporal complementarily in the use of growth resources.

2.7 Groundnut/Millet Intercrop

The groundnut/millet combination is especially important on the lighter soils of the semi-arid tropics, notably in West Africa and India. A series of crop physiological experiments have been carried out to study the growth patterns and the resource use in this combination to determine how yield advantages are achieved. Reddy and Willey (1980a) compared sole crops with a single intercrop treatment of 1 row millet: 3 rows groundnut, Sole millet showed a very rapid rate of growth, achieving 8134 kg/ha of dry matter in 85 days. Sole groundnut growth rate was somewhat slower, and this crop achieved 4938kg/ha of dry matter in 105 days. Dry matter yield of each crop in intercropping is given in comparison with an expected yield; this being the yield that would be achieved if the crop experienced the same degree of competition in intercropping as in sole cropping. Groundnut growth very closely followed the expected dry matter yield of 75% of its sole crop yield, whilst millet produced approximately twice its expected dry matter yield of 25% of its sole crop yield. In effect, this means that groundnut produced about the same yield per plant in intercropping as in sole cropping, while the much more dominant millet approximately doubled its yield per plant in intercropping. The combined dry matter yield in intercropping is given in comparison with the yield expected, if there was no yield advantage (or disadvantage) of intercropping, i.e. the LER = 1 (LER = Land Equivalent Ratio, or the relative land area required as sole crops to produce the yields achieved in intercropping). The reasearch also showed that with time there was an increasing dry matter yield advantage for intercropping; at final harvest the actual LER was 1.29, i.e. an advantage of 29% for intercropping. Grain and pod yields closely followed this pattern and actual LERs were 0.71 for groundnut and 0.55 for millet, giving a total LER of 1.26, or an overall yield advantage of 26% for intercropping.

2.8 Productivity of Cereal-Legume Mixtures

Intercropping generally provides yield advantage compared with sole cropping (Willey, 1979a). The advantage was as much as 50-80% from intercropping of long season crops (Rao and Willey, 1983; Adipala *et al.,* 1997; Spratt and Chowdhury, 1978) and 25-40% for combinations of short and long season crops (Willey and Osiru, 1972; Faris *et al.,* 1983; Wahua and Miller, 1978).

There are abundant reports to the effect that there are significant advantages in the yields of intercrops over their various sole crops (Norman, 1972; Egharevba, 1984; Baker 1978; Andrews, 1972). Higher yield advantages depend on the form and magnitude of the interactions that occur between the crops in those mixtures (Trenbath, 1976). Any intercropping system must maximize complementary effects between the component crops to ensure the fullest and most efficient use of available resources. The advantages of intercropping, in most cases (Willey and Osiru, 1972; Osiru and Willey, 1972; Natarajan and Willey, 1979), have been largely attributed to differences in the time of maturity of the crops, and so to temporal differences in the use of limiting resources, especially light. According to Natarajan and Willey (1980) and Willey (1979a) the advantage of intercropping usually results from the complementary use of growth resources over time and space. The combined intercrop canopy or root systems may make greater and/or more efficient use of light, water and nutrients than the component sole crops. The proximity of crops in intercropping suggests a close intermingling of root systems, which might result in a greater exploitation of available nutrients.

However, Trenbath (1974) and Willey (1979b) reported that efficient use of light by the combined intercrop canopy particularly for the combinations of C_4 (maize) and C_3 (soybean) crops, might be an important factor responsible for higher advantage. Several other investigators also reported substantial advantages from intercropping systems of maize or sorghum with soybean or cowpea (Willey and Osiru, 1972; Odion *et al.,* 1994, 2000). However, no advantage is realized in situations where a vigorous and competitive cereal completely dominates the legume (Ahmed and Rao, 1982).

In a study on management and productivity of major cropping systems in the Sudan savanna of northern Nigeria, van Ek *et al.* (1997) reported that grain and fodder yields of cowpea in cereals ranged from 0-132 and 105-1820 kg/ha, respectively. Cereal yields were high and highly variable. Millet and sorghum grain yields ranged from 131 to 2600 and 0 to 4903 kg/ha, respectively. The major constraints in the productivity of each system appeared to be low fertility, low population, lack of crop protection, shading of cowpea and moisture stress for sorghum and late cowpea. Ahmed and Rao (1982) using maize/soybean intercrop combination indicated that intercropping was more productive than growing the two crops separately, with LER values of 1.42-1.64. In millet/cowpea intercrop studies, Bationo *et al.* (1991) obtained intercrop advantages of 20-70% compared with 28-53% for millet/groundnut systems while Faris *et al.* (1983) reported 32% for maize/cowpea intercrop. Azam-ali *et al.*

(1990) in sorghum/groundnut mixture observed that an increase in the productivity of an intercrop can be ascribed either to a spatial advantage before the removal of the first species or to a temporal advantage between the removal of the first and harvest of the second crops. Odion *et al.* (2000) in northern Nigeria reported LER values ranging from 21-40% for millet/cowpea. The higher LER indicates a higher biological efficiency of the mixtures resulting from a better utilization of environmental factors (Willey, 1979; Reddy and Willey, 1981). However, in Niger, Reddy *et al.* (1992) reported an intercrop advantage of 46% for millet/cowpea mixture.

Ampong – Nyarko *et al.* (1994) studied sorghum/cowpea intercrop and reported that intercropping reduced the numbers of stem borer, *Chilo partellus* in sorghum and thrips *Megalurothrips sjostedti* in cowpea. In the unprotected cowpea, monocrop yield was reduced by 94% while intercrop yield was reduced by 51%. However, Andrews (1972) in Samaru, Nigeria, using sorghum/cowpea mixture observed that the main source of gain in the intercropping system came from planting early maturing and late maturing crops together, since no one crop alone can efficiently utilize the whole wet season.

2.9 Competition and Resource Use in Intercrops

A greater emphasis is being placed on cropping systems research because of the increasing awareness of the important role that resource management can play in improving crop yields. To manipulate an intercrop system for enhanced productivity, we need to understand the main growth-determining factors. Crops growing together compete for light, water and nutrients, and there may also be biochemical interactions.

Multiple or intercropping systems are characterized by within and among species diversity in both time and space dimensions. Temporal diversity is achieved when the demands of the intercrop species on the environment differ over time. The spatial diversity however, occurs when intercrop species meet their environmental resource requirements from different sources (Francis, 1994). According to Andrews (1972) and Osiru and Willey (1972) yield advantages of 50% or more could be obtained if the temporal differences between crops are about 5-6 months. Azam-ali *et al.* (1990) reported that an increase in the productivity of an intercrop can be ascribed either to a spatial advantage before the removal of the first species or to a temporal advantage between the removal of the first and harvest of the second crops.

A possible avenue for further reduction in competition for growth resources is through the use of early/medium maturity varieties of cowpea and manipulation of the arrangement of the component crops (Mohta and De, 1980; Natarajan and Willey, 1985). Andrews (1972) observed that inter-crop competition must be less than intra-crop competition. Competition between component crops is greatly alleviated when their maximum demands on the environment occur at different times (crops with different growth cycles or by stagger planting) and which meet their demands from different sources.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Field experiments were conducted during the 2012 rainy season at the research farm of Institute for Agricultural Research (IAR) located at Wasai village, Minjibir Local Government Area, and Hadejia River Basin Development Authority (HJRBDA) project Located at Wudil local Government, Kano State, Nigeria. The site both falls under the Sudan ecology characterised with mean annual rainfall range of 560-1000mm (Craufurd and Wheeler,1999) minimum mean temperature of 21 ^{o}C and maximum mean temperature of 35 ^{o}C and reddish brown loamy sands with loamy and clayey surface. The area is characterized by tropical wet and dry climate (Olofin, 1987).

3.2 Soil Analysis

Soil samples were collected from the two experimental sites at 0-15 cm and 15-30cm depth, air dried at room temperature ground and sieve before being analysed for physical and chemical properties as described by Black (1965).

3.3 Meteorological Data

Data on the weather conditions at Wasai and Wudil were obtained from IAR meteorological sub-station of Kano, and from KUST Wudil. The meteorological data that were of interest included rainfall, temperature and relative humidity.

3.4 Crop Varieties

The crop varieties used for this experiment were SAMNUT 21, SAMNUT 22, SAMNUT 23 and a local groundnut variety (Maibargo/Kampala). For Millet, SOSAT C-88 and a local variety (Gero) were used. All the groundnut improved varieties were obtained from IAR research station in Kano, while the local varieties were obtained from a local farmer.

3.4.1 SAMNUT 21

This variety was developed jointly by the University of Georgia in the USA and released by the Institute of Agricultural Research (IAR) in Nigeria. It results from a cross between (RMP 12 × ICGS (E) 52). It is a medium-maturing variety with vegetative cycle between 115 and 120 days. It is a Virginia type and is resistant to groundnut rosette disease (GRD) and foliar diseases. It has high oil content estimated at 51%. The potential pod yield is about 2.5 tons and 4 tons of haulm on-station and about 1.5 tons on-farm under the best agronomic practices. It was officially released in 2001 but was introduced in on-farm trials in many northern states since 1996. The adaptation zone is between 700 mm to 1000 mm annual rainfall (Ndjeunga *et al*., 2013).

3.4.2 SAMNUT 22

This variety is also known as M572.80 I under IAR nomenclature.

It was selected in 1980 under irrigation at IAR's Mokwa research station in Central Nigeria. It results from a cross between RMP 91 x (4753.70 x 3520.71). It is a medium maturing variety with a vegetative cycle of between 115 to 120 days. It is of Virginia type, resistant to GRD and tolerant to Cercospora leafspots. It has moderate oil content estimated to be 45%.

The potential on-station pod yield is about 2.5 tons/ha and 1.5 tons on-farm. It was officially released in 2001 but was already introduced in on-farm trials in many northern states since 1996. The adaptation zone is the Sudan and Guinea savannah zones (which have average annual rainfall of 700-1500 mm ((Ndjeunga *et al*., 2013).

3.4.3 SAMNUT 23

This variety is also known as ICGV-IS 96894 under ICRISAT nomenclature. It results from a cross between ICGV-SM 85048 and RG 1. It was developed by ICRISAT in partnership with IAR. It is an early maturing variety with vegetative cycle between 90 and 100 days. It is of Spanish type, resistant to GRD and foliar diseases. It has high oil content estimated to be 53%. The on-station potential pod yield is about 2.0 tons and 4.0 tonnes of haulm. On-farm yield potential is about 1.5 tons. It was officially released in 2001 but was already introduced in on-farm trials in many northern states since 1996. The adaptation zone is between 700-1000 mm annual rainfal (Ndjeunga *et al*., 2013).

3.4.5 SOSAT C-88

High yielding and early maturing with thick stem of about 16 mm panicle width and shape, adapt to Sahel and Sudan where rainfall is in the ranges of 400-800mm. It matures within 85-95 days and yield 2.5-3.5kg/ha. It is drought tolerant (Nkama, 1988).

3.4.6 Local millet variety

It is late maturing and non-photosensitive. Early millet account for about 90% of the total area cropped to millet. The period for crop growth is short. Therefore a period of 3 to 5 months rainfall is required. Yield is less than 1 ton per hectre.

3.5 Treatments and Experimental Design

The treatments consisted of four groundnut varieties [SAMNUT 21, SAMNUT 22, SAMNUT 23 and Kampala (local)] and two millet varieties [SOSAT C-88 and Gero (local)] combined in three row arrangement (1:1 ,1:2, 2:4) and sole crop of the six varieties of the test crop. The thirty treatments were laid out using split plot design in three replications. To the main plots, the row arrangement was allocated, while the crop varieties were allocated to the subplots.

3.5.1 Plot size

The gross plots consisted of 6 ridges 0.75 m apart and 6 m long giving a total area of 27 m^2. An alley of 0.5 m was left between the plots and 1m distance was left between the replications.

3.6 Cultural Practices

3.6.1 Land preparation

The land was cleared, harrowed and ridged using a tractor. Appropriate plots were marked out and pegged. Ridges were made 75 cm apart. plots were then laid out as per ratio of crop arrangement.

3.6.2 Sowing

Seeds of the test crops were sown in their respective treatment plots. Sowing was manually done at inter-row and intra-row spacing of 75 cm×25 cm. For the groundnut, two seeds were sown per hole at the depth of about 2.5 cm two weeks after millet was planted. For the millet, the 75 cm by 25 cm ridge was sown at 3 to 4 seeds/hole (5 kg per hectare). It was thinned to 2 plants per stand at 2 weeks after sowing.

3.6.3. Fertilizer application

For the groundnut, starter dose of of 20 kg N ha^{-1} was applied after emergence. Application of 54 kg P_2O_5 and 20 kg K_2O ha^{-1} was done during land preparation. For the millet, 60 kg of N ha^{-1} was applied 3 week after planting. 30 kg of P_2O_5 and 30 kg K_2O were applied per hectare were applied during land preparation.

3.6.4 Weed control

Weeding of the plots was done manually using hoes. Three hoe weeding were carried out at 3, 6 and 9 WAS.

3.6.5 Harvesting

For the groundnut, harvesting was done after the foliage turned slightly yellow and the pods began to turn brownish with darkened veins by careful examination of the internal surface of the shell. The plants were lifted manually using hoe and were put on the ridges upside down which made them to sun dry quickly.

For the millet harvesting, the stalks from each net plot were cut as close to the ground level as possible and the panicle were severed at the base. The panicles were bagged and sundried for two weeks before threshing. For both crops, manual threshing was done to separate the kernels from the chaff and the seed grain from the panicle.

3.7 Data Collection

In each plot, 5 plants were randomly selected and tagged manually within the sampling rows for data collection. The characters were measured at 4, 6, 8, 10 and 12 weeks after sowing.

3.7.1 Growth characters of Millet

Millet plant height (cm): The heights of the five sampled plants were measured using a meter rule from the ground level to the tip of the panicles before harvest and the means were recorded as plant height in cm.

Millet number of leaves per plant: The number of full expanded green leaves on the randomly selected plants of millet were counted and their means expressed as number of leaves per plant.

Leaf area plant (cm^2): The leaf area per plant of millet was measured by multiplying the length of the leaf with the greatest width of the leaf multiplied by the number of the plant, and the means were recorded and then multiplied by a factor 0.8 to determine the leaf area as described by Sticker *et al*.(1961).

3.7.2 Yield character of Millet

Panicle number: This was obtained by counting the panicles or herad of millet produced in each plot.

Panicle weight (kg/plot): This was determined after harvest by measuring the weights of sun dried panicles of each plot using weighing balance (Acculab EC-211).

Panicle length: Mean lengths of five panicles from each plot were measured using meater rule and there average (in cm) was computed and recorded)

Grain yield (kg/ha): The total grain yield produced by the millet was determined at harvest by shelling the entire panicles harvested from the net plots. The grain yield was determined by weighing the shelled grains with a weighing balance and the value obtained coverted to kilograms per hectare.

3.7.3 Growth Characters of Groundnut

Plant height (cm): The heights of five sampled groundnut plants were measured using a meter rule from the ground level to the tip of the plant and the means were recorded as the plant heights.

Number of leaves: Number of fully expanded green leaves of the randomly selected tagged plants of groundnut were counted and their means expressed as number of leaves per plant.

Leaf area per plant (cm^2): The lengths and maximum widths were measured in cm for each expanding leaflet. Leaf area of the central leaflet of the groundnut trifoliates were estimated from [A×length×width)+(B×length)+(C×width)]. The constants A, B and C were derived using Li Cor model 3000 (Li –Cor, Inc.) leaf area meter.

3.7.4 Yield Characters of Groundnut

Number of branches per plant: Branches from the randomly selected plants of groundnut are counted and later average number of branches per plant determined.

Number of pods per plant: The number of pods for each tagged in each plot was counted and later the average number of pods per plant determined.

Pod weight per plant (g): The pods obtained above were weighed using weighing balance and the average thereafter determined.

Hundred Seed per plant (g): This was determined by counting and weighing 100 pods from each plot.

Kernel yield per hectare: This was determined by harvesting all the pods in the net plot followed by drying, threshing and winnowing to separate the chaff from the kernel. The kernels were then weighed to get the kernel weight for each plot in Kg. This was thereafter extrapolated to get the kernel yield per hectare in tonne.

3.8 Assessment of Mixture Productivity

3.8.1 Land equivalent ratio

Assessment of the productivity of the mixture was determined using the land equivalent ratio (LER) as described by Mead and Willey (1980).

LER = (Mya ÷ Sya) + (Myb ÷ Syb)

Where Mya = Mixture yield of crop A which is millet , Sya = Sole yield of crop A (millet)

Myb = Mixture yield of crop B (Groundnut) , Syb = Sole yield of crop B (Groundnut)

3.8.2 Competitive ratio

It gives the assessment of whether the association of the two component crops advantageous or not. In other words, it gives a clear idea about which crop is more competitive in the association. It is calculated as follows:

For species 'a' $CR_a = \frac{LER_a}{LER_b} \times \frac{Z_{ba}}{Z_{ab}}$

For species 'b' $CR_b = \frac{LER_b}{LER_a} \times \frac{Z_{ab}}{Z_{ba}}$

Where Z_{ab} = Proportion of crop 'a' grown in association with specie 'b', Z_{ba} is equal to proportion of crop 'b' grown in association with specie 'a'. If CR_a is greater than one, crop 'a' is more competitive than crop 'b'. If the it is less than one, crop 'a' is less competitive than crop 'b'. The reverse is true for CR_b. (Willey, 1979).

3.9 Correlation studies

Correlation analysis was carried out to show type and magnitude of associations between kernel yield and growth characters of groundnut at Wudil and Minjibir.

3.10 Data Analysis

Data collected were subjected to analysis of variance (ANOVA), and least significant difference (LSD) was used to differentiate between treatment means as described by Snedecor and Cochran (1976).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Physico-chemical properties of the soil of the experimental sites

The results of the soil analysis at the experimental sites revealed that the soil textural class of both locations was loamy sand. The soil pH at Minjibir was moderately acidic (5.1) while at wudil, it was slightly basic (7.02). At Minjibir and Wudil the soil recorded very low organic carbon 0.36 and 1.55 g/kg , respectively. The total nitrogen content of Wudil and Minjibir soil were 0.31 and 0.181 g/kg respectively, which were low. The available Phosphorus of both Wudil and Minjibir were 7.15 mg/kg and 4.6mg/kg. In both locations, Potassium and Calcium were very low (Table1).

4.1.2 Total monthly rainfall and mean temperature covering the experimental period

Appendix 1 presents the result of rainfall received and temperatures at the experimental sites from May to October 2012. The results indicated that Wudil received a total rainfall of 939.8 mm and the mean minimum and maximum temperatures of 20 and 37.1 ^oC, respectively. The highest rainfall received was recorded in the month of August (384.2mm) while the lowest rainfall was recorded in the month of October (1mm). No rainfall was recorded thereafter. The highest mean temperature was recorded in the month of May 2012. For Minjibir, the trend was the same but there were slight differences in the values. The values for wudil are higher and the length of rainy season was a bit longer.The highest rainfall received was recorded in the month of August (348.1) and by the mionth of october the rainfall ceased.No further rainfall was recorded threafter.

Table 1. Physico-Chemical Properties of the Soil of the Expermental Sites at Wudl and Minjibir in 2012 Rainy Season.

Properties of soil	Wudil	Minjibir
	0 – 30cm	0 – 15cm; 15 – 30cm
pH in water	7.02	5.1 ; 5.0
Total N(g kg^{-1})	0.31	0.23 ; 0.181
Organic carbon (g kg^{-1})	0.36	0.21 ; 1.55
Total p (mg/kg)	7.15	76.7 ; 46.0
Kcmol (+) kg^{-1}	0.6	0.22 ; 0.297
Ca Cmol (+) kg^{-1}	3.0	3.0 ; 17.70
Zn traces		
Pb (mg/kg)	-	0.0/2 ; trace
Sand (%)	81	91.7 ; 89.8
Salt (%)	8	4.0 ; 4.2
Clay (%)	11	4.2 ; 6.0

Textural class	Loamy sand	Sand loam	Sand loam

Source: Kano State Agricultural and Rural Development Authority. Land Management Unit-Technical Services Department

4.1.3 Effect of row arrangement and two millet varieties on leaf area (cm^3) of four groundnut varieties

Table 2 shows that groundnut varieties differed significantly in leaf area at both locations. Greater leaf area production was exhibited by the local groundnut variety (Kampala) at 4WAS at both locations but later at 6, 8 and 10WAS in Wudil SAMNUT 22 produced the highest leaf area. At Minjibir however, at 6 and 8WAS SAMNUT 22 produced the highest leaf area and at 10WAS SAMNUT 23 recorded the highest leaf area production. Likewise groundnut varieties show significant differences due to cropping systems, 1:2 intercropping system resulted in significantly higher leaf area compared to cropping systems of 2:4 and 1:1 in both locations. Groundnut leaf area was not influenced by companion millet genotypes at both locations.

Table 3 shows the result of interaction between Millet and cropping system on groundnut leaf area at 10WAS.The result indicated that there was no difference between 1:1 and 2:4 cropping systems,when SOSAT was involved,but both produced lower leaf areas of groundnut when compared with 1:2 cropping system. On the other hand,the leaf areas recorded by all the cropping systems differed significantly when local variety was sown.

Table 4 indicates interaction between millet and groundnut on groundnut leaf area. The Table reveals varietal differences in leaf area production among the groundnut varieties. SAMNUT 23 produced higher leaf area than all others. The table further reveals that SAMNUT 23 in companion with local millet variety produced groundnut with highest leaf area.

Table 2. Effect of Row Arrangement and Two Millet Varieties on Leaf Area (cm^2) of Four Groundnut Varieties at Minjibir and Wudil in 2012 Rainy Season.

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	445b	557b	649c	853c	397c	710b	888a	623c
SAMNUT 22	458b	657a	778a	927a	503b	797a	886a	706b
SAMNUT 23	457b	523c	724b	872b	406c	573c	674b	862a
KAMPALA	481a	523b	581dd	651	569a	579cc	512	619c
SE±	58	55.3	10.4	57	73	82	10.2	86
Millet varieties (M)								
SOSAT C88	460	530	624	718	460	642	687	605
LOCAL	458	614	742	932	476	687	791	80.0
SE±	44	35	95	35	59	75	51	52
Row Arrangement								
1:1	450b	561b	698a	835b	506a	595c	701b	699b
1:2	450b	634a	716a	919a	392b	739a	939a	785a
2:4	475a	521c	634b	722c	507a	658b	577c	622c
SE±	53	43	11.6	43	73	92	63	64
Interactions								
G×M	**	**	**	**	**	**	**	**
G×A	**	**	**	**	**	**	**	**
M×A	**	**	**	**	**	N.S.	**	**
G×A ×M	**	**	**	**	**	**	**	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 5 shows interaction between groundnut and cropping system on groundnut leaf area. The table reveals that SAMNUT 21 and the local groundnut variety were not affected by the cropping systems, but varietal differences exist among the other groundnut varieties.

Table 6 show that SAMNUT 22 produced significantly higher leaf area than all other varieties. Cropping system of 1:2 produced the highest leaf area. Intercropping groundnut variety with local millet variety produced significantly higher leaf area that all other groundnut varieties. Table 10 The result show that all the three factors affected leaf area production of groundnut varieties, the table indicated that intercropping SAMNUT 22 variety with local Millet variety at croppiong system of 1:2 produced highest leaf area.

Table 7 shows interaction between Millet and Cropping System on groundnut leaf area at 10WAS in Minjibir. The result indicated that there was no difference between cropping system of 1:2 and 2:4 when SOSAT was involved, but both produced higher leaf area of groundnut when compared with cropping system 1:1.On the other hand the leaf area recorded by all the cropping systems differs significantly when local Millet was sown, it was also observed that cropping system of 2:4 did not affect leaf area production of the gropundnut varieties.

Table 8 The result indicated significant difference among the groundnut varieties with SAMNUT 22 producing highest leaf area, the table further reveals that the involvement of both Millet varieties leads to significant difference in leaf area production among the groundnut varieties.Higher leaf area was produced when local Millet variety was involved.

Table 3. Interaction Between Millet and Cropping System on Groundnut Leaf Area at 10WAS in Wudil

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	706.7d	749.2c	700.0d

Local	963.3b	1090.0a	745.0c
S.E ±	6.10		

Table 4. Interaction Between Millet and Groundnut on Groundnut Leaf Area at 10WAS in Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	880.0c	798.9e	615.6g	580.0h
Local	825.6d	1054.4b	1128.9a	722.2f
S.E ±	78.0			

Table 5. Interaction Between Groundnut and Cropping System on Groundnut Leaf Area at 10WAS in Wudil

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	836.7d	803.3e	1053.3b	646.7gh
1:2	858.3d	1226.7a	943.3c	650.0g
2:4	863.3d	750.0f	6200h	656.7g
S.E	95.5			

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 6. Interaction Between Millet, Groundnut and Cropping System on Groundnut Leaf Area at 10WAS in Wudil

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	713.3k	786.7ghi	613.3l	713.3k
	1:2	820.0g	810.0g	753.3ij	513.3m
	2:4	1006.7d	800.0g	450.0m	513.3m

Local	1:1	960.0e	820.0g	1493.3b	580.0l
	1:2	796.7gh	1643.3a	1133.3c	786.7ghi
	2:4	720.0jk	700.0k	760.0hi	800.0g
S.E ±					

Table 7. Interaction Between Millet and Cropping System on Groundnut Leaf Area at 10WAS in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	571.7d	613.3c	630.0c
Local	526.7b	957.5a	615.8c
S.E ±	9.14		

Table 8. Interaction Between Millet and Groundnut on Groundnut Leaf Area at 10 WAS in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	694.4c	551.1e	631.1d	543.3e
Local	552.2e	860.0b	1093.3a	694.4c
S.E ±	11.81			

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 9. Interaction Between Cropping System and Groundnut on Groundnut Leaf Area at 10WAS in Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	678.3d	480.0g	1053.3a	585.0f
1:2	470.0g	1068.3a	966.7b	636.7de
2:4	721.7c	568.3f	566.7f	635.0e
S.E ±	14.46			

Table 10. Interaction Between Millet, Cropping System and Groundnut on Groundnut Leaf Area at 10WAS in Minjibir

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	496.7hi	520.0h	606.7g	663.3fg
	1:2	540.0h	513.3h	873.3d	526.7h
	2:4	1046.7c	620.0g	413.3j	440.0ij
Local	1:1	8.600d	4.400ij	15.000b	5.067h
	1:2	400.0j	1623.3a	1060.0c	746.7e
	2:4	396.7j	516.7h	720.0ef	830.0d
S.E ±	20.45				

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 9 The table reveals that varietal difference exist between the groundnut varieties,the local variety produced the least in terms of leaf area production while SAMNUT 23 produced the highest,the result also reveals that the cropping system significantly affectedthe leaf area production of the groundnut with cropping system of 1:2 influencing highest leaf area production.

4.1.4 Effect of row arrangement and two millet varieties of number of leaves of four groundnut varieties

Table 11 shows that the groundnut varieties differ significantly on leaf number produced in both locations. The local variety (Kampala) produced the highest number of leaves at 4WAS at both locations, but at 6, 8 and 10WAS sampling period SAMNUT 21 superceeded all other groundnut varieties in number of leaves production at both locations. The groundnut number of leaves production was influenced significantly by the row arrangement.Row arrangement of 2:4 at 4WAS produced groundnut variety with the highest number of leaves at both locations. At 6,8 and 10WAS, row arrangement of 1:2 produced the groundnut varieties with the highest number of leaves at Wudil. In Minjibir,however, significant difference was not recorded at 6WAS, row arrangement of 2:4 produced groundnut variety with the highest number of leaves at 10WAS.

Table 12 shows interaction between millet and cropping system on groundnut leaf number, the result indicates significant effect when cropping system was involved. Changing the cropping system led to change in leaf number production. The cropping system of 1:2 produced significantly higher number of leaves than all others. The table also indicated that millet variety affected leaf number production. SOSAT in companion with the groundnut plant produced the highest number of leaves. The same trend was observed at Minjibir (Table 16).

Table 13 indicates interaction between millet and groundnut on groundnut leaf number at 10WAS in Minjibir. The table indicates that both factors influence leaf number production. The local groundnut variety produced significantly higher number of leaves than all others while SOSAT C-88 variety in companion with any of the groundnut variety produced groundnut plants with higher number of leaves. The trend was however different in Wudil as can be seen in Table 17. SAMNUT 21 intercropped with local variety of millet produced higher number of groudnut plant leaves.

Table 14 indicates interaction between cropping system and groundnut on groundnut leaf number production. The table shows that both factors significantly affected leaf number production. Among the groundnut varieties SAMNUT 21 produced significantly higher leaf number than all others, changing the cropping system resulted in increase in leaf number, the cropping system of 1:2 produced significantly higher leaf number. Similar result was obtained in Wudil (Table 18).

Table 15 indicate second order interaction involving all the factors. The table indicate that all the three factors significantly affected groundnut leaf number production, variety wise SAMNUT 21 produced the highest leaf number, cropping system of 1:2 produced significantly higher groundnut plant leaf number. Among the millet varieties SOSAT variety in companion with groundnut produce groundnut with significantly higher number of leaves. The trend was the same in Wudil (Table 19).

Table 16 The result show that the two factors affected leaf number production of the groundnut varieties. Cropping system of 1:2 produced groundnut with highest number of leaves than all others, while SOSAT involvement leads to production of higher leaf number.

Table 11. Effect of Row Arrangement and Two Millet Varieties on Four Groundnut Varieties Leaf Number During 2012 Rainy Season

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								

SAMNUT 21	94.94c	443.9a	512.2a	597.5a	92.61c	432.6a	561.6a	623.3a
SAMNUT 22	90.56d	287.0d	368.4d	408.6d	91.56c	394.2d	409.6d	454.6d
SAMNUT 23	96.94b	315.7c	385.60c	487.2c	101.5b	357.7c	422.1c	523.8c
KAMPALA	108.9a	345.9b	434.90b	504.5b	110.1a	430.4b	511.7b	588.3b
SE±	0.382	1.79	1.743	1.236	0.534	0.584	0.701	0.475
Millet varieties (M)								
SOSAT C88	87.78	368.03	441.31	528.83	88.17	426.03	509.92	589.83
LOCAL	107.9	328.33	401.31	470.17	109.78	359.03	442.72	505.28
SE±	0.672	1.379	1.504	0.845	0.625	0.368	0.666	0.605
Row Arrangement								
1:1	99.5b	319.67b	392.00c	466.71c	99.71b	355.75	440.29c	502.12c
1:2	85.04c	425.00a	481.83a	540.92a	89.33c	427.62	510.96a	565.50b
2:4	108.96a	299.88c	402.08b	490.88b	107.88a	394.21b	477.71b	575.04a
SE±	0.823	1.689	1.842	1.034	0.765	0.451	0.816	0.742
Interactions								
G×M	**	**	**	**	**	**	**	**
G×A	**	**	**	**	**	**	**	**
M×A	**	**	**	**	**	**	**	**
G×A ×M	**	**	**	**	**	**	**	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 12. Interaction Between Millet and Cropping System on Groundnut Leaf Number at 10WAS in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	446.75e	741.50a	581.25b
Local	557.50d	389.50f	568.83c
S.E ±	1.050		

Table 13. Interaction Between Millet and Groundnut on Groundnut Leaf Number at 10WAS in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	643.00b	482.33f	553.33d	680.67a
Local	603.67c	426.89g	494.44e	496.11e
S.E ±	0.840			

Table 14. Interaction Between Cropping System and Groundnut on Groundnut Leaf Number at 10WAS in Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	544.000f	424.83j	557.00e	482.67i
1:2	735.00a	396.17k	520.33g	610.50c
2:4	591.00d	542.83f	494.33h	672.00b
S.E ±	1.029			

Means along the same column and row having different letter are significantly different at p ≤ 0.05 using DMRT.

Table 15. Interaction Between Millet, Cropping System and Groundnut on Groundnut Leaf Number at 10WAS in Minjibir

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	439.00q	417.67s	469.33o	461.00p
	1:2	880.00a	614.33h	752.67c	719.00d
	2:4	610.00i	415.00s	438.00q	862.00b
Local	1:1	649.00f	432.00r	644.67g	504.33n
	1:2	590.00j	178.00u	288.00t	502.00m
	2:4	572.00k	670.67e	550.67l	482.00n
S.E ±	1.455				

Table 16. Interaction Between Millet and Cropping System on Groundnut Number of Leaves at 10WAS in Wudil

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	428.58e	707.75a	450.17d
Local	504.83c	374.08f	531.58b
S.E ±	1.463		

Means along the same column and row having different letter are significantly different at $p \leq 0.05$ using DMRT.

Table 17. Interaction Between Millet and Groundnut on Groundnut Number of Leaves at 10WAS in Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	593.11b	485.89e	517.89c	518.44c
Local	601.89a	331.44g	456.67f	490.67d
S.E ±	1.734			

Table 18. Interaction Between Groundnut and Cropping System on Groundnut Number of Leaves at 10WAS in Wudil

		Groundnut			
	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
	1:1	526.67d	368.50k	494.80f	477.17g
	1:2	680.17a	374.83j	503.67e	605.00b
	2:4	585.67c	482.67g	463.67h	431.50i
S.E ±	2.123				

Means along the same column and row having different letter are significantly different at p ≤ 0.05 using DMRT.

Table 19. Interaction Between Millet, Groundnut and Cropping System on Groundnut Number of Leaves at 10WAS in Wudil

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	402.33n	411.33m	448.33k	452.33k
	1:2	772.00a	618.33d	719.33b	721.33b
Local	1:1	651.00e	325.67p	540.67h	502.00i
	1:2	588.33f	131.33r	288.00q	488.67j
	2:4	566.33g	537.33h	541.33h	481.33j
S.E ±	3.003				

Means along the same column and row having different letter are significantly different at p ≤ 0.05 using DMRT.

4.1.5 Effect of row arrangement and two millet varieties on number of branches of four groundnut varieties

Table 20 shows that number of branches were significantly affected by groundnut varieties and row arrangement. In Minjibir, Local Groundnut variety, Kampala, produced the highest number of branches at 4WAS. However, at 6WAS, 8WAS, and 10WAS SAMNUT 21 produced the highest number of branches. Next to SAMNUT 21 was the local variety (Kampala), SAMNUT 22 and SAMNUT 23 production of branches was statistically not different.

In Wudil, however, significant difference was only observed among the groundnut varieties at 4WAS and 8WAS only with the local variety (Kampala) producing the highest number of branches at 8WAS. SAMNUT 21 produced the highest number of branches.

Row arrangement of 2:4 produced the highest number of branches at 4WAS, while the row arrangement of 1:2 produced groundnut variety with highest number of branches at 6WAS and 8WAS, at the end of the sampling period of 10WAS row arrangement of 1:1

produced the groundnut variety with highest number of branches, this was observed in both locations.

Table 20. Effect of Row Arrangement and Two Millet Varieties on Number of Branches of Four Groundnut Varieties at Minjibir and Wudil in 2012 Rainy Season

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	7.05c	13.11	18.11a	21.5	7.50bc	13.94a	19.94a	23.06a
SAMNUT 22	7.66ab	11.56	13.89b	16.94	6.94c	10.50c	14.00d	17.17c
SAMNUT 23	7.44bc	11.89	14.99b	16.89	7.78b	10.83c	15.11c	17.39c
KAMPALA	8.05a	12.17	13.83b	17.44	8.56a	11.83b	16.05b	19.61b
SE±	1.555	0.437	0.385	0.384	0.205	0.225	0.182	0.303
Millet varieties (M)								
SOSAT C88	7.38	12.22	15.81	19.11	7.72	12.47	17.83	20.69
LOCAL	7.72	12.14	14.56	17.28	7.67	11.08	14.72	17.92
SE±	0.089	0.222	0.236	0.296	0.177	0.198	0.085	0.165
Row Arrangement								
1:1	6.45c	12.17b	16.79a	21.17a	7.17b	11.33b	17.95a	22.79a
1:2	7.12b	13.42a	15.75a	18.50b	7.42b	13.33a	17.62a	20.33b
2:4	9.08a	10.96c	13.00b	14.92c	8.50a	10.67b	13.25b	14.79c
SE±	0.109	0.272	0.288	0.363	0.216	0.242	0.104	0.202
Interactions								
G×M	**	**	**	**	**	**	**	**
G×A	**	N.S.	**	**	**	**	**	**
M×A	**	**	**	**	**	**	**	**
G×A ×M	**	N.S.	**	**	**	**	**	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 21 indicates interaction between millet and cropping system on groundnut plant. It indicates that cropping system of 1:1 produced no significant difference among the gro undnut varieties in companion with any of the two millet varieties. Cropping system of 1:2 produced significantly higher number of branches, millet varieties can also be seen to influence branch number production with the local variety producing the least number of branches, similar result was obtained in Wudil as can be seen in Table 25.

Result of interaction between millet and groundnut on groundnut branch number from Table 22 indicates that among the groundnut varieties SAMNUT 21 and SAMNUT 22 shows no significant difference in terms of number of branch produced when intercropped with either of the 2 companion millet varieties, however when millet plants are kept constant SAMNUT 21 produced significantly higher number of branches, while SAMNUT 23 produced the best. The trend was however different in Wudil. Table 26 shows no significant difference was observed among the branch number produced by groundnut varieties due to influence of SOSAT (millet) variety, except SAMNUT 21 which was significantly different from all other. So also the local variety significantly affected SAMNUT 21 only.

Table 23 indicates the result of interaction between cropping system and groundnut on groundnut branch number. It shows significant difference among the groundnut varieties, SAMNUT 21 produced significantly higher branch number which was statistically different from all others, while cropping system of 1:1 produced statistically higher branch number. Similar trend was observed in Wudil (Table 27).

Table 24 indicates second order interaction involving all the three factors. The table shows that SAMNUT 21 variety produced statistically higher number of branches when intercropped with the local millet variety at cropping system of 1:1. The experiment yielded similar result in Wudil (Table 28).

Table 21. Interaction Between Millet and Cropping System and Groundnut on Groundnut Branch Number at 10WAS in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	22.92a	23.05a	16.08b
Local	22.67a	17.58b	13.50d
S.E ±	0.286		

Table 22. Interaction Between Millet and Groundnut on Groundnut Branch Number 10WAS in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	23.33a	17.67c	20.33b	21.44b
Local	22.78a	16.67c	14.44d	17.78c
S.E ±	0.407			

Means along the same column and row having different letter are significantly different at $p \leq 0.05$ using DMRT.

4.1.6 Effect of row arrangement and two millet varieties on plant height of four groundnut varieties

Table 29 shows significant difference was observed on groundnut varieties plants heights throughout the sampling period; SAMNUT 22 produced the highest plant height throughout the sampling period in Wudil but was statistically similar to the local variety. Next to SAMNUT 22 and the local groundnut variety in height was SAMNUT 23, this was the same in both locations.

The cropping system significantly affected the plant height of the groundnut genotypes. Cropping system of 2:4 produced the tallest groundnut plant height throughout the sampling period in both locations, this was followed by cropping system of 1:2 in Wudil,in Minjibir however, cropping system of 1:1 produced second highest plant heights at 6 and 8WAS and at 10WAS.

Significant interaction between millet by groundnut, millet by cropping system, groundnut by cropping system and millet by groundnut by cropping system was observed on groundnut plant height at 10WAS.

Table 23. Interaction Between Cropping System and Groundnut on Groundnut Branch Number 10WAS in Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	29.17a	19.33d	23.17b	1950d
1:2	23.00b	18.50d	18.83d	21.00c
2:4	17.00e	13.67f	10.17g	18.33de
S.E ±	0.498			

Table 24. Interaction Between Millet, Cropping System and Groundnut on Groundnut Branch Number 10WAS in Minjibir

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	27.33b	18.00h	25.33bc	21.00ef
	1:2	23.33cd	22.33de	24.67c	22.00de
	2:4	19.33fgh	12.67kl	11.00lm	21.33def
Local	1:1	31.00a	20.67ef	21.00ef	18.00gh
	1:2	22.67de	14.67ij	13.00jk	20.00fg
	2:4	14.67ij	14.67ij	9.33m	15.33i
S.E ±	0.704				

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 25. Interaction Between Millet and Cropping System on Groundnut Branch Number at 10 WAS In Wudil

	Cropping System		
Millet	1:1	1:2	2:4

SOSAT	20.17a	20.75a	16.42b
Local	22.17a	16.25b	13.42c
S.E ±	0962		

Table 26. Interaction Between Millet and Groundnut on Groundnut Branch Number at 10WAS in Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	20.56ab	18.00c	78.44c	79.44bc
Local	22.44a	15.89d	15.33d	15.44d
S.E ±	0.555			

Means along the same column and row having different letter(s) are significantly different at $p < 0.05$ using DMRT.

Table 27. Interaction Between Groundnut and Cropping System on Groundnut Branch Number at 10 WAS in Wudil

	Groundnut			
Cropping system	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	27.50a	19.67c	20.33bc	17.17de
1:2	22.00b	16.33ef	16.67ef	19.00cd
2:4	15.00fg	14.83fg	13.67g	16.17ef
S.E ±	0.680			

Table 28. Interaction Between Millet, Groundnut and Cropping System on Groundnut Branch Number at 10 WAS in Wudil

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	23.17bc	18.00f	19.67def	19.33def
	1:2	20.67cde	20.67cde	22.33bc	19.33def
	2:4	17.33fg	15.33gh	13.33hij	19.67def
Local	1:1	31.33a	21.33bcd	21.00b-e	15.00gh
	1:2	23.33b	12.00ig	11.00j	18.67ef
	2:4	12.67hij	14.33hi	14.00hi	12.67hij
S.E ±	0.962				

Means along the same column and row having different letter(s) are significantly different at $p < 0.05$ using DMRT.

Table 29. Effect of Row Arrangement and Two Millet Varieties on Plant Height (cm) on Four Groundnut Varieties at Minjibir and Wudil in 2012 Rainy Season

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	8.16c	15.59c	24.91b	30.78	8.25a	19.32b	27.89bc	33.17b
SAMNUT 22	10.57a	21.17a	26.56a	35.11a	10.92c	23.50a	29.56a	36.83a
SAMNUT 23	9.58b	17.23b	24.22c	30.06b	9.45b	17.50c	26.72c	33.81b
KAMPALA	10.36a	17.22b	26.00a	35.11a	10.62c	15.61d	28.56ab	36.39a
SE	0.235	0.349	0.226	0.38	0.186	0.395	0.479	0.345
Millet varieties (M)								
SOSAT C88	8.86	16.99	24.98	33.28	9.45	20.06	27.36	35.31
LOCAL	10.49	18.62	25.86	32.25	10.17	17.92	29.00	34.69
SE	0.133	0.217	0.395	0.307	0.136	0.215	0.447	0.184
Row Arrangement								
1:1	10.33a	16.94b	24.51b	31.00c	10.60c	18.58b	27.96b	33.67c
1:2	8.63b	16.11b	25.08b	33.08b	8.82a	17.96c	26.50c	34.67b
2:4	10.06a	20.36a	26.67a	34.21a	10.00b	20.42a	30.08a	36.67a
SE	0.163	0.266	0.484	0.376	0.166	0.263	0.547	0.225
Interactions								
G×M	N.S.	**	**	**	N.S.	**	N.S.	**
G×A	**	**	**	**	**	**	**	**
M×A	**	N.S.	N.S.	**	**	**	N.S.	**
G×A ×M	N.S.	**	**	**	**	**	**	**

Means followed by same letter(s) in same column are not significantly different (P<0.05%)
Using least significant difference. N.S. = Not significant

Table 30 indicates interaction between millet and cropping system on groundnut plant height. It shows that cropping system of 2:4 produced significantly higher plant height than all others. Millet variety significantly affected the height of groundnut plant, SOSAT variety in companion with groundnut produced significantly higher plant heights. The result was the same in Wudil (Table 34).

Table 31 shows interaction between millet and groundnut on groundnut plant height. From the table the interaction shows that both factors affected groundnut plant height. Significant difference was observed among the groundnut varieties plant height. SAMNUT 22 produced statistically higher plant height among the groundnut plants while SAMNUT 23 plant height was not affected by the two millet varieties. There was no much difference from results obtained in Wudil. Table 35.

Table 32 indicates interaction between groundnut and cropping system on groundnut plant height in Wudil. Result from the table shows that the two factors both significantly affected plant height,it shows that varying the cropping system affected plant height,among the groundnut varieties SAMNUT 22 produced groundnut plant with highest height at cropping system of 2:4. Table 33 shows interaction involving all the three factors, in Wudil there was no difference between SAMNUT 22 and the local variety in terms of plant height,the two varieties produced the highest plant heights than others while the cropping systems of 2:4 and 1:1 produced groundnut varieties with higher plant heights.The involvement of the two Millet varieties did not produce difference in the plant heights of the groundnut varieties. In Minjibir,however, all the three factors significantly affected the plant heights of groundnut varieties with SAMNUT 22 producing highest plant height at cropping system of 2:4.

Table 30. Interaction Between Millet and Cropping System on Groundnut Plant Height at 10WAS in Wudil

	Cropping System		
Millet	1:1	1:2	2:4

SOSAT	28.50d	34.58b	36.75a
Local	33.50b	31.58c	31.67c
S.E ±	0.531		

Table 31. Interaction Between Millet and Groundnut on Groundnut Plant Height at 10WAS in Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	31.67de	36.44a	30.78ef	34.22bc
Local	29.89ef	33.78cd	29.33f	36.00ab
S.E ±	0.557			

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 32. Interaction Between Groundnut and Cropping System on Groundnut Plant Height at 10WAS in Wudil

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	28.33f	30.33e	31.00e	34.33bc

1:2	30.83e	34.33bc	31.83de	35.33b
2:4	33.17cd	40.67a	27.33f	35.67b
S.E ±	0.682			

Table 33. Interaction Between Millet, Groundnut and Cropping System on Groundnut Plant Height at 10WAS in Wudil

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	24.67k	30.67gh	30.00ghi	28.67hij
	1:2	34.00c-f	36.67c	33.67f	34.00c-f
	2:4	36.33cde	42.00a	28.67hij	40.00a
Local	1:1	32.00fg	30.00ghi	32.00fg	40.00a
	1:2	27.67ij	32.00fg	30.00ghi	36.67bcd
	2:4	30.00ghi	39.33ab	26.00jk	31.33fgh
S.E ±	0.965				

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 34. Interaction Between Millet and Cropping System on Groundnut Plant Height at 10WAS in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	32.50d	35.42b	38.00a
Local	34.53bc	33.92c	35.33b
S.E ±	0.318		

Table 35. Interaction Between Millet and Groundnut on Groundnut Plant Height at 10WAS in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	34.56bc	38.56a	33.22c	34.89b
Local	31.78d	35.11b	34.00bc	37.89a
S.E ±	0.464			

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 36. Interaction Between Millet, Cropping System and Groundnut on Groundnut Plant Height at 10WAS in Minjibir

		Groundnut			
Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	28.00m	35.33efg	34.00f-i	32.67h-k
	1:2	36.00ef	35.00fg	36.00ef	34.67fgh
	2:4	39.67cd	45.33a	29.67lm	37.33e
Local	1:1	31.00kl	32.33ijk	33.33g-k	42.67b
	1:2	32.00ijk	31.67jkl	34.67fgh	37.33de

	2:4	32.33ijk	41.33bc	34.00f - i	33.67g – j
S.E ±	0.804				

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

4.1.7 Effect of row arrangement and two millet varieties on stover yield (kg/ha), pod weight (kg/ha) and 100-seed weight (g)of four groundnut varieties

Varietal differences were observed in Stover production among the groundnut genotypes, local variety produced the highest Stover yield in both locations, this was followed by SAMNUT 23, but was not statistically different from SAMNUT 22, the lowest Stover production was by SAMNUT 21 at Wudil, in Minjibir there was no any statistical difference in Stover production.(Table 37)

Row arrangement affected stover production among the groundnut varieties. In Wudil row arrangement of 2:4 and 1:1 produced the highest Stover yield, in Minjibir no significant differences were recorded among the three row arrangement.

Pod weight: significant differences were not recorded among the groundnut varieties, there was also no significant effect due to millet variety, row arrangement did not affect stover production in both locations throughout the sampling period.

The 100-seed weight/gm: Significant effect was only recorded in Minjibir among the groundnut variety on 100-seed weight production, the highest 100-seed weight was recorded by the local groundnut variety (Kampala) which was followed by SAMNUT 23. The least 100-seed weight production was by SAMNUT 21.

No significant difference was recorded due to association between groundnut genotype and the millet intercrop.

Row arrangement: Significant differences were only recorded at Wudil Row arrangement of 2:4 produced highest 100-seed weight but statistically not different with row arrangement of 1:1, row arrangement of 1:2 produced the least 100-seed weight of groundnut.

Interaction between millet and cropping system on 100-seed weight of groundnut. Table 38 shows that cropping system of 1:2 produced the highest seed weight. Among the two millet varieties, SOSAT C-88 and local millet variety did not affect 100-seed weight production significantly in Wudil. In Minjibir (Table 42), however, the local millet variety significantly affected 100-seed weight production, intercroping of local millet variety with any of the groundnut variety at cropping system of 2:4 produced groundnut plant with significantly higher 100-seed weight.

Interaction between millet and groundnut on 100-seed weight productions. Table 39 shows no any significant difference among the groundnut plant variety when intercropped with the two companion millet varieties. The two millet companion crops did not affect 100-seed weight production.The trend was similar in Minjibir,(Table 43).

Interaction between groundnut and cropping system in Wudil both factors affected 100-seed weight production can be seen from Table 40 the local groundnut veriety produced statistically higher 100-seed weight, cropping system also influenced 100-seed weight production with cropping system of 2:4 and 1:1 producing statistically higher 100-seed weight. In Minjibir (Table 44), however, shows different. SAMNUT 23 produced higher 100-seed weight than all but was statistically same with all the varieties. Cropping system of 1:1 and 2:4 produced statistically same 100-seed weight of groundnut.

Table 37. Effect of Row Arrangement and Two Millet Varieties on Stover Yield (kg/ha), Pod Weight (kg/ha) and 100-Seed Weight of Four Groundnut Varieties at Wudil and Minjibir During 2012 Rainy Season

Treatment	Stover yield (kg/ha)		Pod weight (Kg)		100-seed weight	
Groundnut Variety (G)	Wudil	Minjibir	Wudil	Minjibir	Wudil	Minjibir
SAMNUT 21	2763c	4265b,	1692	1530a	59.7a	43.2c
SAMNUT 22	3402b	4362b	1464	1479a	59.7a	43.8bc
SAMNUT 23	3514b	4421b	1641	1508a	62.1a	46.8b
KAMPALA	4212a	5392a	1496	1433a	55.9a	54.6a
SE	64.9	294.5	115.9	101.3	2.17	1.103
Millet varieties (M)						
SOSAT C88	2876	4145	1600	1494	58.5	53.4
LOCAL	4069	5075	1547	1481	60.2	40.7
SE	31.9	220.2	57.6	55	1.34	0.684
Row Arrangement						
1:1	3738a	4777	1609	1488a	61.8a	47.8
1:2	2938b	4311	1473	1421a	53.5b	46
2:4	3743a	4741	1638	1554a	62.8a	47.4
SE	26.1	269.7	70.6	67.3	1.64	0.839
Interactions						
G×M	**	N.S.	N.S.	N.S.	**	**
G×A	**	N.S.	N.S.	N.S.	N.S.	N.S.
M×A	**	N.S.	N.S.	N.S.	**	**
G×A ×M	**	N.S.	N.S.	N.S.	**	**

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

Table 38. Interaction Between Millet and Cropping System on 100-Seed Weight of Groundnut at Wudil

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	52.04a	52.30a	55.92a
Local	43.63b	39.73bc	38.90c
S.E ±	1.187		

Table 39. Interaction Between Millet and Groundnut on 100-Seed Weight of Groundnut at Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	55.38a	50.08b	55.10a	53.12ab
Local	31.00d	37.52c	38.47c	56.01a
S.E ±	1.515			

Table 40. Interaction Between Groundnut and Cropping System on 100-Seed Weight of Groundnut at Wudil

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	35.15e	49.18b	47.33bc	59.67a
1.2	48.22bc	42.95cd	47.85bc	45.03bi
2.4	46.20bc	39.27de	45.17bc	59.00a

S.E ±	1.855

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 41 and 45 show interactions between millet, groundnut and cropping system on groudnut 100-seed weight production in Wudil and Minjibir respectively. In both locations, all the three factors affected 100-seed weight production. In Wudil. Local groudnut variety intercropped with SOSAT C-88 at cropping system of 1:1 produced higher 100-seed weight of groundnut than all others. In Minjibir, the trend was however different with SAMNUT 21 at 2:4 cropping system intercropped with millet variety producing higher seed weight than all others.

Table 46 shows interaction between millet and cropping system on groundnut stover weight in Wudil,the table reveals that no significant difference occurs between both factors on groundnut stover yield. However, cropping system, of 2:4 produced higher stover weigh whicht was at per with all others.

Table 47 shows interaction between millet and groundnut on groundnut stover weight, significant difference was observed among the groundnut genotypes with SAMNUT 21 producing higher stover yield which was not statistically different from SAMNUT 22 and local groundnut variety local millet variety influenced higher groundnut stover production.

Table 48 indicates interaction between groundnut and cropping system on groundnut stover weight both factor affects stover production among the groundnut variety, varietal differences was observed among the groundnut genotypes with SAMNUT 21 producing higher stover production but statistically indifferent from the rest of the varieties, while cropping system of 2:4 produced significantly higher stover production but was at per with all other.

Table 49 indicates interaction between cropping system, millet and groundnut on groundnut stover weight all the three factors affected stover production. The table shows that the groundnut varieties differ significantly with SAMNUT 23 producing higher stover weight than all other groundnut variety, cropping system of 2:4 produced higher stover yield than all others while the local millet variety with the groundnut plant produced higher stover weight production.

4.1.8 Effect of row arrangement and two millet varieties on four groundnut varieties kernel yield and productivity of mixture of four groundnut varieties.

Groundnut kernel yield: In Wudil SAMNUT 23 produced the highest yield of groundnut kernel but was not statistically different from SAMNUT 21 and SAMNUT 22, Kampala the local variety produced the least kernel yield when compared to all other groundnut varieties.(Table 50)

However, in Minjibir no any statistical difference was recorded among the groundnut varieties, even though highest kernel yield was produced by SAMNUT 23.

Kernel yield production were significantly influenced by the row arrangement with row arrangement of 2:4 and 1:1 producing the groundnut varieties with higher yield than row arrangement of 1:2 for both locations.

The two companion millet crop shows no significant difference on the yield of the groundnut varieties.

Table 41. Interaction Between Cropping System, Millet and Groundnut on 100-Seed Weight of Groundnut at Wudil

Millet		Groundnut			
		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.1	39.30gh	57.27cde	44.37fg	67.23a
	1.2	65.43ab	51.77def	61.00abc	31.00i
	2.4	61.40abc	41.20gh	59.93abc	61.13abc
Local	1.1	31.00i	41.10gh	50.30ef	52.10de
	1.2	31.00i	34.13hi	34.70hi	59.07bcd
	2.4	31.00i	37.33ghi	30.40i	56.87cde
S.E ±		2.624			

Table 42. Interaction Between Millet and Cropping System on Groundnut 100-Seed Weight at Minjibir

Millet	Cropping System		
	1:1	1:2	2:4
SOSAT	58.17bc	63.8b	53.1c
Local	64.9b	43.1d	72.6a
S.E ±	2.32		

Table 43. Interaction Between Millet and Groundnut on Groundnut 100-Seed Weight at Minjibir

Millet	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	50.1c	63.9ab	72.1a	48.0c
Local	69.3a	55.4bc	52.1c	63.9ab
S.E ±	2.98			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 44. Interaction Between Groundnut and Cropping System on 100-Seed Weight of Groundnut at Minjibir

	Groundnut

Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	65.7abc	56.3cd	57.0cd	68.2ab
1.2	54.8d	58.2b-d	58.0b-d	42.8e
2.4	58.7bcd	64.5a-d	71.3a	56.8cd
S.E ±	3.65			

Table 45. Interaction Between Cropping System, Millet and Groundnut on 100-Seed Weight of Groundnut at Minjibir

		Groundnut			
Millet		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.1	62.7d-h	51.3g-k	56.6f-j	64.7c-g
	1.2	60.0d-i	73.7bcd	82.0ab	39.7klm
	2.4	27.7m	66.7c-f	78.3abc	39.7klm
Local	1.1	68.7b-k	61.3d-h	58.0e-i	71.7b-e
	1.2	49.7h-k	42.7jkl	34.0olm	46.0i-l
	2.4	89.7a	62.3d-h	64.3c-g	74.0bcd
S.E ±	5.16				

Table 46. Interaction Between Millet and Cropping System on Groundnut Stover Weight Kg/ha at Wudil

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	4344a-d	4549abc	3541bd
Local	5210ab	4073cd	5941a
S.E ±	381.4		

Table 47. Interaction Between Millet and Groundnut on Groundnut Stover Weight kg/ha at Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	4946abc	3812cd	4380bcd	3442d
Local	5838a	4941abc	4462bcd	5085ab

S.E ±	422.6

Table 48. Interaction Between Groundnut and Cropping System on Groundnut Stover Weight kg/ha At Wudil

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	5368abc	4833a-e	3712e	5196a-d
1.2	5312abc	3858de	4062b-e	4013cde
2.4	54.95a	4394a-e	5488ab	3586e
S.E ±	517.6			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 49. Interaction Between Cropping System, Millet and Groundnut on Groundnut Stover Weight kg/ha at Wudil

		Groundnut			
Millet		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.1	5352a-f	4082c-h	4293c-h	3651c-h
	1.2	5267a-f	4070c-h	5067b-g	3792c-h
	2.4	4218c-h	3284d-h	3779c-h	2884h
Local	1.1	5384a-e	5584abc	3131gh	6742ab
	1.2	5357a-e	3645c-h	3058gh	4233c-h
	2.4	6772ab	5505a-d	7198a	4288c-h
S.E ±	732.0				

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Effect of interaction between millet and cropping system on groundnut yield. Table 51 shows interaction between millet and cropping system on groundnut kernel yield the result indicates no any significant difference were observed among the cropping system, however, cropping system of 2:4 produced higher kernel yield than others, millet variety significantly affected kernel production with local millet in companion with any of the four groundnut variety producing higher kernel yield than intercropping with SOSAT millet variety. The trend was same in Minjibir but with lower kernel yield (Table 55).

Interaction between millet and groundnut on groundnut kernel yield. Table 52 shows that both factors significantly affects kernel yield production with SAMNUT 21 producing higher kernel yield but was statistically similar to local variety, intercropping groundnut with local millet variety produced statistically higher kernel yield. In Minjibir (Table 56), however, the result was similar.

Interaction between groundnut and cropping system on groundnut yield. Table 53 indicates that among the groundnut varieties SAMNUT 21 produced significantly higher kernel yield than all others, but was statistically similar to SAMNUT 22, the table also shows that cropping system 1:1 produced groundnut plant with higher kernel yield than all others. The trend was similar at Minjibir (Table 57).

Table 54 indicates interaction between millet, groundnut and cropping system on groundnut yield production,it shows that SAMNUT 21 produced higher kernel yield than all others but are statistically similar to SAMNUT 22 and the local variety while cropping system of 1:1 produced groundnut with higher kernel yield but was statistically similar to the two other cropping systems, intercropping with local variety produced significantly higher kernel yield than with SOSAT variety. In Minjibir (Table 58), the trend was similar.

Interaction between millet and cropping system on land equivalent ratio of groundnut in Minjibir (Table 59). Significant difference was observed when the local millet was intercropped with the groundnut only, cropping system of 1:1 produced no any significant difference when groundnut was intercropped with the millet variety, however cropping system of 1:1 and 2:4 produced significant difference, when groundnut variety was intercropped with the millet local variety higher land equivalent ratios where obtained.

Table 60 indicates interaction between millet and groundnut on land equivalent ratio (L.E.R.) of groundnut in Minjibir. The result indicated higher land equivalent ratio value when local variety of groundnut was intercropped with the local millet.

Table 61 indicates interaction between groundnut and cropping system on L.E.R. in Minjibir. The result indicated higher L.E.R. when local groundnut varieties at ratios 1:1 and 2:4 where intercropped with any of the groundnut variety.The result further reveals that there was no significant difference among the groundnut variety due to cropping system.Changing the cropping system did not result into any significant change.The highest value of 2.443 was obtained when local groundnut variety was intercropped with Millet variety at 1:1 cropping system,this was followed by intercropping local variety of groundnut with Millet at cropping system of 2:4.All the values were above one.

Table 50. Effect of Row Arrangement and Two Millet Varieties on Kernel Yield (kg/ha) of Four Groundnut Varieties and the Productivuty of Mixture

Treatment	Grain yield (Kg/ha)		Relative yield		Land equivalent ratio		Competitive ratio	
Groundnut Variety (G)	WUDIL	MINJIBIR	WUDIL	MINJIBIR	WUDIL	MINJIBIR	WUDIL	MINJIBIR
SAMNUT 21	897.9a	899.7	0.836b	0.864b	1.749c	1.742c	0.255b	0.328
SAMNUT 22	906.1a	896.6	0.613c	0.616c	1.494d	1.557c	0.256b	0.443
SAMNUT 23	912.2a	919.9a	1.00a	1.034a	1.996b	2.026b	0.215c	0.315
KAMPALA	860.0b	897.7	0.974ab	0.991a	2.229a	2.265a	0.317a	0.283
SE±	9.62	9.97	0.0366	0.0376	0.0551	0.0476		
Millet varieties (M)								
SOSAT C88	853.9	866.7	0.852	0.857	1.792	1.737	0.24	0.318
LOCAL	934.2	931.2	0.861	0.895	1.942	2.058	0.28	0.371
SE±	7.52	6.41	0.026	0.0232	0.031	0.0292		
Row Arrangement								
1:1	932.0a	929.9a	0.913a	0.920b	1.875ab	1.930a	0.347a	0.45

1:2	834.3b	836.4b	0.767b	0.777a	1.768b	1.815b	0.247b	0.32
2:4	915.2a	930.6a	0.889a	0.931b	1.958a	1.947a	0.19c	0.28
SE±	9.21	7.84	0.0318	0.0284	0.0379	0.0357		
Interactions								
G×M	**	**	**	**	**	**		
G×A	**	**	**	N.S.	N.S.	**		
M×A	**	**	N.S.	**	N.S.	N.S.		
G×A ×M	**	**	N.S.	N.S.	**	**		

Means followed by same letter(s) in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 51. Interaction Between Millet and Cropping System on Groundnut Yield kg/ha at Wudil

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	854.2bc	877.8a	829.8c
Local	1009.8a	790.8d	1001.9a
S.E ±	13.02		

Table 52. Interaction Between Millet and Groundnut on Groundnut Yield kg/ha at Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	736.1e	974.0c	1018.0b	687.6f
Local	1059.8a	838.1d	806.4d	1032.4ab
S.E ±	13.98			

Table 53. Interaction Between Groundnut and Cropping System on Groundnut Yield kg/ha at Wudil

Cropping System	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	1110.3a	802.8f	830.2ef	994.7c
1.2	864.7de	864.8de	894.7d	713.2g
2.4	728.8g	1050.5ab	1011.6bc	872.2di
S.E ±	17.12			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 54. Interaction Between Cropping System, Millet and Groundnut on Groundnut Yield kg/ha at Wudil

Millet		Groundnut			
		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
Soset	1.1	941.7gh	722.0j	871.0i	882.0hi
	1.2	863.3i	976.3fg	1030.0ef	641.7k
	2.4	403.3m	1223.7a	1153.0bc	539.0l
Locat	1.1	1259.0a	883.7hi	789.3j	1107.3cd
	1.2	866.0i	753.3j	759.3j	784.7j
	2.4	1054de	877.3hi	870.7i	1205.3ab
S.E ±	34.21				

Table 55. Interaction Between Millet and Cropping System on Groundnut Yield kg/ha at Minjibir

Millet	Cropping System		
	1:1	1:2	2:4
SOSAT	854.9c	888.2b	857.1c
Local	1004.9a	784.7d	1004.1a
S.E ±	7.55		

Table 56. Interaction Between Millet and Groundnut on Groundnut Yield kg/ha at Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	727.2d	980.0b	1045.8a	713.9d
Local	1072.2a	813.2c	794.0c	1045.4a
S.E ±	9.75			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 57. Interaction Between Groundnut and Cropping System on Groundnut Yield kg/ha at Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	1082.5a	810.2g	815.2fg	1011.8c
1.2	866.7de	850.7ef	891.7d	736.7h
2.4	750.0h	1029.0bc	1052.8ab	890.5d
S.E ±	11.95			

Table 58. Interaction Between Cropping System, Millet and Groundnut on Groundnut Yield kg/ha at Minjibir

		Groundnut			
Millet		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.1	916.3de	766.7jk	834.3ghi	902.3ef
	1.2	856.3fgh	962.7d	1077.0c	656.7m
	2.4	409.0o	1210.7ab	1226.0ab	582.7n
Local	1.1	1248.7a	853.7fgh	796.0ij	1121.3c
	1.2	877.0efg	738.7kl	706.0c	816.7hi
	2.4	1091.0c	847.3gh	879.7efg	1198.3b
S.E ±	16.89				

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

4.1.9 Land equivalent ratios (LER)

Table 50 shows the combined land equivalent ratio of groundnut and millet in intercrop at Wudil and Minjibir. All crop proportions resulted to LER of equal to one or more than one. In both location the local variety produced the highest LER followed by SAMNUT 23,the lowest yield advantage was produced by SAMNUT 21 in Wudil.

In both locations (Wudil and Minjibir) intercropping the groundnut varieties with the millet produced no any significant yield advantage,

Row arrangement produces significant yield difference with row arrangement of 1:1 and 2:4 producing highest yield advantage.

Table 59. Interaction Between Millet and Cropping System on Land Equivalent Ratio at Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	1.702b	1.844b	1.830b
Local	2.049a	1.692b	2.086a
S.E ±	0.0536		

Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.687cd	1.454d	2.146b	1.881c

Local	1.812c	1.534d	1.846c	2.577a
S.E ±	0.0743			

Table 60. Interaction Between Millet and Groundnut on Land Equivalent Ratio at Minjibir

Means along the same column and row having different letter are significantly different at P≤0.05 using DMRT.

Table 61. Interaction Between Groundnut and Cropping System on Land Equivalent Ratio at Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	1.645de	1.455e	1.953bc	2.443a
1.2	1.825cd	1.517e	1.932bc	1.798cd
2.4	1.778cd	1.512e	2.102b	2.440a
S.E ±	0.0910			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

4.1.10 Competitive ratio

Table 50 shows competitive ratio of groundnut varieties relative to companion millet variety. The result shows that groundnut is more competitive than millet in the groundnut/millet mixture because all the calculated values are less than 1 which is an indication that groundnut is more competitive than millet in the confirmation.

4.1.11 Effect of row arrangement and four groundnut varieties on leaf area of two millet varieties

Table 62 shows that millet varieties did not differ in leaf area production in both locations. Groundnut varieties affected the leaf area production of millet varieties in Wudil at 4WAS only, but in Minjibir there was significant effect on leaf area production due to groundnut varieties ,at 4WAS millet intercropped with SAMNUT 21 produced millet plants with highest leaf area, while the local variety of groundnut intercropped with Millet produced Millet with the highest leaf area at 6WAS, at 8WAS SAMNUT 22 intercropped with millet varieties produced the highest leaf area, at 10WAS SAMNUT 23 intercropped with millet produced millet plant with highest leaf area.

Row arrangement significantly affected leaf area production, in Wudil at 4WAS only, but at Minjibir highest leaf area production occurs at cropping system of 2:4 throughout the sampling period.

Table 63 shows the result of interaction between millet and groundnut on millet leaf area shows that both factors significantly affected the leaf area production, SAMNUT 22 influenced higher millet leaf area production among the 2 millet varieties. Statistically higher leaf area production was produced by the SOSAT variety.

Table 64 indicates interaction between groundnut and cropping system on millet leaf area production. It shows that SAMNUT 21 in companion with millet plant produced higher leaf area at cropping system of 2:4.

Table 65 shows interaction between, millet, groundnut and cropping system of leaf area production of millet. Table 65 shows that SAMNUT 23 in companion with millet produced significantly higher leaf area of millet plant at cropping system of 2:4, the table also shows that SOSAT millet variety produced higher leaf area than the local variety.

Table 62. Effect of Row Arrangement and Four Groundnut Varieties on Leaf Area of Two Millet Varieties at Wudil and Minjibir in 2012 Rainy Season

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	58.17 a	123.73	202.07	260.28	37.83 a	94.05 b	149.3c	212.83 c
SAMNUT 22	23.11 c	84.46	153.83	266.44	26.92 b	77.70 c	189.00 a	229.56 b
SAMNUT 23	22.48 c	71.07	177.34	228.06	17.72 d	69.78 d	162.61 b	238.22 a
KAMPALA	31.90 b	130.61	186.06	263.78	22.73 c	99.99 a	134.91 d	192.11 d
SE±	1.821	1.832	0.472	751	0.186	0.199	3.38	0.403
Millet varieties (M)								
SOSAT C88	42.83	96.41	175.84	256.78	34.76	82.12	156.51	249.56
LOCAL	25.00	108.52	183.81	252.5	17.83	88.63	161.4	186.81
SE±	1.237	1.137	0.267	0.507	0.124	0.112	2.36	0.315
Row Arrangement								
1:1	25.23 b	91.19	174.22	229.42	16.27 c	74.51 b	154.40 b	196.50 c
1:2	38.58 a	108.82	157.42	243.88	29.26 b	90.74 a	128.91 c	214.17 b
2:4	37.93 a	107.40	207.83	290.62	33.36 a	90.89 a	193.50 a	243.87 a
SE±	1.515	1.393	0.327	0.621	0.152	0.137	2.89	0.386
Interactions								
G×M	**	N.S.	N.S.	N.S.	**	**	**	**
G×A	**	N.S.	N.S.	N.S.	**	**	**	**
M×A	**	N.S.	N.S.	N.S.	**	**	**	**
G×A ×M	**	N.S.	N.S.	N.S.	**	**	**	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 63. Interaction Between Millet and Groundnut on Millet Leaf Area at 10WAS In Minjibir

Millet	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	182.89f	302.22a	228.67b	224.44d
Local	242.78c	156.89h	187.78e	159.78g
S.E ±	0.586			

Table 64. Interaction Between Groundnut and Cropping System on Millet Leaf Area at 10WAS in Minjibir

Cropping system	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	156.67j	266.00c	200.33c	163.00i
1:2	178.00h	209.67f	270.50b	198.50g
2:4	303.83a	213.00e	243.87d	214.83e
SE ±	0.717			

Table 65. Interaction Between Cropping System, Millet and Groundnut on Millet Leaf Area at 10WAS in Minjibir

Millet	Groundnut				
	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	64.67t	357.00c	139.00q	143.67p
	1:2	160.67o	247.00j	361.00b	271.33g
	2:4	323.33d	302.00e	365.67a	258.33i
Local	1:1	248.67j	175.00m	261.67h	182.33l
	1:2	195.33k	171.67n	179.67l	125.67r
	2:4	284.33f	124.00rs	122.00s	171.33n
S.E ±	1.014				

Means along the same column and row having different letter are significantly different at p≤ 0.05 using DMRT.

4.1.12 Effect Of Row Arrangement And Four Groundnut Varieties On Number Of Leaves Of Two Millet Varieties

Table 66 shows that millet varieties did not show any significant difference in number of leaf production in both locations.

When millet plant varieties were intercropped with groundnut varieties in Wudil no any significant difference occur in Minjibir, however, significant difference was observed with SAMNUT 21 and 23 producing highest leaf numbers.

Row arrangement in Wudil did not affect production of leaf number. In Minjibir however row arrangement of 2:4 produced highest number of millet plant leafs at 4WAS, at 6WAS row arrangement of 1:1 produced millet plant with highest number of leafs at 8WAS no significant difference in number of leaves production at 10WAS. Row arrangement of 1:2 produced millet plants with highest number of leaves.

Interaction between millet and cropping system on millet number of leaves. Table 67 shows that both factors significantly affected number of leaves produced, cropping systems 1:2 and 1:1 produced statistically higher but similar number of leaves, for the millet significant varietal difference was exhibited, with the local variety producing higher number of leaves than SOSAT.

Interactions between millet and groundnut on millet number of leaves. Table 68 indicates that intercrop of SAMNUT 21 and SAMNUT 23 produced millet with higher number of leaves with the local variety producing highest number of leaves.

Table 69 indicates interaction between cropping system and groundnut on milliet leaf area. It can be observed from the table that intercropping SAMNUT 21 with either of the millet crops produced higher leaf numbers of millet plants. Cropping system of 1:2 produced significantly higher leaf number than other cropping systems.

Table 70 indicates interactions between cropping system, millet and groundnut on millet number of leaves. All the three factors significantly influenced the production of leaf number, SAMNUT 21 intercropped with either of the millet variety produced millet plant with higher number of leaves, number of leaves produced is however statistically similar to the value obtained when intercropped with SAMNUT 23, cropping system of 1:1 and 1:2 produced significantly higher leaf number than cropping system of 2:4, varietal significant difference was not observed between the two millet variety but the local variety produced higher number of leaves

Table 66. Effect of Row Arrangement and Four Groundnut Varieties on Leaf Number of Two Millet Varieties in Wudil and Minjibir in 2012 Rainy Season

Treatment	Wudil WAS				Minjibir WAS			
	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	4.55	7.5	8.55	9.94	4.77a	7.11b	8.00b	9.38a
SAMNUT 22	4.50	7.16	8.33	9.94	4.33b	6.83c	7.38c	8.66b

SAMNUT 23	4.72	7.50	8.88	10.78	4.50ab	7.83a	8.83a	9.38a
KAMPALA	4.33	7.16	8.00	9.00	4.16b	6.67c	7.33c	8.55b
SE±	0.126	0.157	0.136	0.231	0.139	0.096	0.194	0.122
Millet varieties (M)								
SOSAT C88	4.22	6.52	7.79	9.33	4.5	6.91	7.77	8.8
LOCAL	4.83	8.13	8.91	8.00	4.38	7.3	8	9.19
SE±	0.108	0.110	0.056	0.166	0.077	0.082	0.13	0.095
Row Arrangement								
1:1	4.29	7.41	8.08	9.58	4.25b	7.37a	7.66	8.95b
1:2	4.58	7.16	8.58	9.96	4.45ab	7.12b	8.04	9.29a
2:4	4.70	7.41	8.66	10.21	4.62a	6.83c	7.95	8.75b
SE±	0.132	0.135	0.068	0.203	0.094	0.101	0.159	0.116
Interactions								
G×M	N.S.	**	N.S.	N.S.	N.S.	**	N.S.	N.S.
G×A	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.	**
M×A	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.	**
G×A ×M	**	**	N.S.	N.S.	N.S.	**	**	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 67. Interaction Between Millet and Cropping System on Millet Number of Leaves at 10WAS in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	9.417ab	8.500ce	8.500d
Local	8.500ce	10.083a	9.000bc
S.E ±	0.1646		

Table 68. Interaction Between Millet and Groundnut on Millet Number of Leaves at 10WAS in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	8.778bcd	8.778bcd	9.222abc	8.444d
Local	10.000a	8.556cd	9.556ab	5.667cd
S.E ±	0.1772			

Table 69. Interaction Between Cropping System and Groundnut on Millet Number of Leaves at 10WAS In Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	8.667b-e	8.833bcd	10.167a	8.167e
1:2	10.500a	8.667b-e	8.833bcd	9.167b
2:4	9.000bc	8.500cde	9.167b	8.333de
SE ±	0.217			

Means along the same column and row having different letter (s) are significantly different at p≤ 0.05 using DMRT.

Table 70. Interaction Between Cropping System, Millet and Groundnut on Millet Number of Leaves at 10WAS in Minjibir

Groundnut

Millet	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	8.000hij	10.000cd	12.000a	7.667ij
	1:2	8.667fgh	8.000ghi	6.667k	10.333bc
	2:4	9.667cde	8.000hij	9.000efg	7.333jk
Local	1:1	9.333def	7.667ij	8.333ghi	8.667fgh
	1:2	12.333a	9.000fg	11.000b	8.000hij
	2:4	8.333gh	9.000efg	9.333def	9.323def
S.E ±	0.3069				

Means along the same column and row having different letter (s) are significantly different at $p \leq 0.05$ using DMRT.

4.1.13 Effect of row arrangement and four groundnut varieties on plant height of two millet varieties.

Table 71 shows that significant differences were not observed on millet varieties plant height throughout the sampling period in both locations.

The two millet varieties exhibit significant differences in heights when intercropped with groundnut varieties, at 4WAS millet crops intercropped with SAMNUT 21 variety produced the tallest millet plant, at 6,8 and 10WAS the tallest millet plant was produced with SAMNUT 23. In Minjibir the trend was similar.

Row arrangements influenced of the Millet varieties plant heights, row arrangement of 1:2 produced millet plants with tallest plant height at 4 and 6WAS, at later stage of 8 and 10WAS row arrangements of 2:4 produced millet plant with highest height. In Minjibir however no any significant difference was recorded due to row arrangement.

Table 72 indicates interaction between millet and cropping system on millet plant height. Table 72 shows that cropping system of 2:4 did not affect the local millet variety interms millet plant height. All the three cropping systems did not produced significant difference among the millet plant, however, cropping system of 1:1 produced higher plant heights than the two other cropping systems.

Table 73 indicates interaction between millet and groundnut on millet plant height. Table 73 shows significant difference due to groundnut variety on the millet plant height, SAMNUT 22 produced statistically higher millet height than the remaining groundnut varieties. Cropping system of 1:2 produced significantly higher millet plant height than all other cropping systems. It also shows that SAMNUT 22 was the only groundnut variety affected by the local millet crop.

Table 74 shows interaction between groundnut and cropping system on millet plant height at 10WAS in Minjibir. Both factors affected plant height of millet plant. Millet plant intercropped with SAMNUT 22 produced millet with highest height at cropping system of 1:2.

Table 75 indicates interaction between millet, groundnut and cropping system on plant height. It shows that SAMNUT 22 and SAMNUT 23 in companion with millet significantly produced millet plants with higher plant heights than all other groundnut varieties, higher plants heights was observed among the local variety but not statistically different from SOSAT variety.

Table 71. Effect of Row Arrangement and Four Groundnut Varieties on Plant Height of Two Millet Varieties (cm) in 2012 Rainy Season

	WUDIL (WAS)				MINJIBIR (WAS)			
Treatment	4	6	8	10	4	6	8	10
Groundnut Variety (G)								
SAMNUT 21	13.25a	19.06b	97.89c	127.61b	12.44	18.17	129	126.56
SAMNUT 22	10.94b	20.28a	112.61b	141.11a	11.17	19.44	108	138.39

SAMNUT 23	9.92c	17.83c	123.56a	146.44a	9.97	16.89	118	144.72
KAMPALA	11.71b	16.00d	112.44b	130.06b	10.86	14.33	96	137.11
SE±	0.271	0.354	0.630	1.925	0.232	0.433	25.1	0.386
Millet varieties (M)								
SOSAT C88	12.72	19.81	106.33	128.72	11.66	19.06	87	130.78
LOCAL	10.19	16.78	116.92	143.89	10.56	15.36	138	142.61
SE±	0.202	0.209	0.452	1.475	0.187	0.291	17.6	0.217
Row Arrangement								
1:1	10.53b	16.00c	108.04c	131.12c	10.65	15.33	103	134.71
1:2	12.71a	20.12a	110.54b	135.88b	11.45	19.79	109	136.17
2:4	11.12b	18.75b	116.29a	141.92a	11.23	16.50	125	139.21
SE±	0.248	0.256	0.553	1.807	0.229	0.356	21.6	0.266
Interactions								
G×M	**	**	N.S.	N.S.	**	**	N.S.	**
G×A	N.S.	**	N.S.	N.S.	**	**	N.S.	**
M×A	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	**
G×A ×M	**	**	N.S.	N.S.	**	**	N.S.	**

Means followed by same letter in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 72. Interaction Between Millet and Cropping System on Millet Plant Height at 10WAS in Minjibir

	Cropping system		
Millet	1:1	1:2	2:4
SOSAT	113.92c	130.50b	141.75a
Local	148.33a	141.25a	142.08a
S.E ±	2.555		

Table 73. Interaction Between Millet and Groundnut on Millet Plant Height at 10WAS in Minjibir

Millet	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	108.22d	151.56a	141.78b	113.33d
Local	147.00ab	130.67c	151.11ab	146.78ab
S.E ±	2.782			

Table 74. Interaction Between Groundnut and Cropping System on Millet Plant Height at 10WAS in Minjibir

Cropping System	Groundnut			
	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1:1	115.00f	131.17e	141.33cd	137.00de
1:2	119.83f	171.83a	138.50de	113.33f
2:4	148.00c	120.33f	159.50b	139.83cde
SE ±	3.407			

Means along the same column and row having different letter (s) are significantly different at p≤ 0.05 using DMRT.

Table 75. Interaction Between Millet, Groundnut and Cropping on Plant Height Area at 10WAS in Minjibir

Millet	Groundnut				
	C.S	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1:1	102.67jk	145.67ef	103.33jk	104.00
	1:2	82.00l	170.33abc	147.67ef	122.00hi
	2:4	140.00fg	138.67fg	174.33ab	114.00ijk
Local	1:1	127.33ghi	116.67hij	179.33a	170.00abc
	1:2	157.67cde	173.33ab	128.33gh	104.67jk
	2:4	156.00de	102.00k	144.67ef	165.67bcd
S.E ±	4.818				

Means along the same column and row having different letter (s) are significantly different at p≤ 0.05 using DMRT.

4.1.14 Effect Of Row Arrangement And Four Groundnut Varieties On Number Of Panicles/Ha, Panicle Length And 1000-Grain Weight (G) Of Two Millet Varieties

Table 76 shows that millet varieties differed significantly in terms of panicle number per hectare production, SOSAT C-88 produced lower number of panicles than the local variety in both locations as shown in Table 76.

Row arrangement did not significantly affect the number of panicles produced by the millet varieties for both locations

Groundnut varieties intercropped with millet influence number of panicle produced with SAMNUT 23 intercropped with millet producing the millet with highest number of panicle in both locations

Shorter panicles length was produced by the local variety in both locations. Row arrangement significantly affected length of panicles in Minjibir only with row arrangement of 1:1 producing the longest panicle.

The groundnut varieties did not show any influence in the length of the millet panicle in both locations.

The 1000-grain weight for SOSAT C-88 was higher than that of the local variety in both locations. The row arrangement influenced 1000-grain weight production in Minjibir only with row arrangement of 2:4 and 1:2 producing higher 1000-grain weight than 1:1 row arrangement. 1000-grain weight was not significantly affected.

Groundnut varieties in companion with millet did not significantly affect 1000-grain weight production of millet in both locations.

Table 76. Effect of Row Arrangement and Four Groundnut Varieties on Number of Panicles Per Hectre, Panicle Length and 1000-Grain Weight of Two Millet Varieties in Wudil and Minjibir in 2012 Rainy Season

	1000-Grain Weight (g)		Panicle Length (cm)		Number of Panicles ha^{-1}	
Treatment Groundnut Variety (G)	MINJIBIR	WUDIL	MINJIBIR	WUDIL	MINJIBIR	WUDIL
SAMNUT 21	9.65b	9.74	35.05	36.7	100747ab	70749b
SAMNUT 22	9.94a	9.54	32.5	36.4	96550b	68707b
SAMNUT 23	9.90a	9.5	34.2	35.7	104218a	82575a
KAMPALA	9.80ab	9.5	33.76	35.2	94748b	67611b
SE±	0.1	0.12	0.94	1.3	3386	3964
Millet varieties (M)						
SOSAT C88	10.35a	10.05a	41.66a	44.72a	89092b	65654b
LOCAL	9.28b	9.23b	26.12b	27.98b	109040a	79165a
SE±	0.08	0.09	0.68	0.09	2635	2941
Row Arrangement						
1:1	9.55b	9.6	34.91a	36.95	99780	75620
1:2	10.05a	9.65	32.84b	35.150	98355	69211

2:4	10.02a	9.62	32.89b	35.18	98350	69201
SE±	0.1	0.09	0.68	0.09	2285	3524
Interactions						
G×M	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
G×A	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
M×A	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
G×A ×M	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Means along the same column and row having different letter are significantly different at $p \leq 0.05$ using DMRT.

4.1.15 Millet grain yield

The millet varieties showed significant difference on millet grain yield production with SOSAT C-88 out yielding the local variety at both locations (Table 77).

Millet varieties when intercropped with groundnut varieties shows significant difference in both location. The highest yield grain of millet was observed when millet was intercropped with local millet variety.

Row arrangement inMinjibir, shows no any significant difference in grain yield production, while at Wudil, highest grain yield was recorded with groundnut and millet intercropped at 2:4 row arrangements.

Table 78 indicates interaction between millet and cropping system on millet yield in Minjibir. Table 78 indicates that row arrangement significantly affect millet yield production, row arrangement of 1:2 and 2:4 produced significantly higher millet grain yield than cropping system of 1:1, however higher millet grain was produced by SOSAT variety which was statistically higher than the local variety. The trend was however different in Wudil (Table 83) Higher yield value was obtained, with SOSAT variety at cropping system of 2:4.

Interaction between millet and groundnut on millet yield in Minjibir. Table 79 shows that both factors significantly affected the grain yield of millet, intercropping either of the millet plant with the local groundnut variety produced higher millet grain yield, varietal difference was observed between the two millet varieties on millet yield production with the local millet variety producing higher grain yield but statistically similar to SOSAT variety. The trend was different in Wudil as can be seen in Table 83. The local groundnut variety produced significantly higher grain yield when intercropped with local millet.

Table 80 Interaction between groundnut and cropping system on millet yield in Wudil. It shows significant difference on millet yield due to influence of groundnut variety. Local variety intercropped with either of the millet produced higher millet grain yield. The trend was the same in Wudil as can be seen in Table 84.

Table 81 Interaction between groundnut, cropping system and millet on millet grain yield. The Table shows that all the three factors affected millet grain yield. SOSAT C-88 produced statistically higher grain yield than the local variety. Cropping system of 1:1 produced higher grain yield than all other cropping systems. The table also indicated that intercropping Millet with local groundnut variety produced millet plant with higher grain yield.

4.1.16 Land equivalent ratio

Table 77 indicates the values of land equivalent ratios of groundnut and millet in intercrops at Minjibir and Wudil, all crop proportions resulted to LER of equal to 1 or more than 1. Local variety gave the highest yield advantage of 90% which was higher REthan that of the SOSAT C-88 variety which gave 80%, in Wudil local variety gave 100% yield advantage which was also higher than the LER of SOSAT variety of 70 %.

In both locations intercropping millet with local groundnut variety resulted in higher LER value.Row arrangement of 2:4 gave the highest LER when groudnut varieties were intercropped with Millet

Table 77. Effect of Row Arrangement and Four Groundnut Varieties on Grain Yield on Two Millet Varieties in Wudil and Minjibir in 2012 Raing Season

	Grain Yield (kg ha^{-1})		Relative Yield		Land Equivalent Ratio	
Treatment	MINJIBIR	WUDIL	MINJIBIR	WUDIL	MINJIBIR	WUDIL
Groundnut Variety (G)						
SAMNUT 21	755.2c	733.3c	0.889	0.903	1.749	1.742
SAMNUT 22	735.0c	734.3c	0.991	0.944	1.494	1.557

SAMNUT 23	821.6b	786.8b	0.921	0.944	1.996	2.026
KAMPALA	961.9a	953.0a	1.251	1.284	2.229	2.265
SE±	13.4	13.33	0.0259	0.0261	0.0551	0.0476
Millet varieties (M)						
SOSAT C88	925.2	886.6	0.903	0.885	1.792	1.737
LOCAL	711.4	717.1	1.123	1.178	1.942	2.058
SE±	9.16	8.37	0.0354	0.0237	0.0310	0.0292
Row Arrangement						
1:1	796.9	776.1b	0.998	1.011	1.875	1.930
1:2	821.4	796.9ab	1.009	1.030	1.768	1.815
2:4	836.5	832.5a	1.031	1.052	1.958	1.947
SE±	11.22	10.25	0.0433	0.029	0.0379	0.0357
Interactions						
G×M	**	**	**	**	N.S.	N.S.
G×A	**	**	**	N.S.	N.S.	N.S.
M×A	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
G×A ×M	**	**	**	**	N.S.	N.S.

Means followed by same letter(s) in same column are not significantly different (P<0.05%) using least significant difference. N.S. = Not significant

Table 78. Interaction Between Millet and Cropping System on Millet Yield kg/ha in Minjibir

	Cropping System		
Millet	1:1	1:2	2:4
SOSAT	847.6b	940.5a	987.4a
Local	746.2c	702.3cd	685.6d
S.E ±	15.87		

Table 79. Interaction Between Millet and Groundnut on Millet Yield kg/ha in Minjibir

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL

SOSAT	955.1ab	807.2c	974.2ab	934.1b
Local	525.2e	662.8a	667.8d	989.8a
S.E ±	18.80			

Table 80. Interaction Between Groundnut and Cropping System on Millet Yield kg/ha in Minjibir

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	596.7e	721.8cd	819.8b	1049.3a
1.2	853.8b	787.3bc	846.8b	797.7b
2.4	815.0b	695.8d	796.3b	1038.8a
S.E ±	23.03			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 81. Interaction Between Cropping System, Millet and Groundnut on Millet Yield kg/ha in Minjibir

		Groundnut			
Millet		SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	1.1	710.0hi	717.3hi	785.7gh	1177.3a
	1.2	1158.3ab	974.0de	1079.7bc	550.0kl
	2.4	1087.0abc	730.3hi	1057.7bc	1075.0cd
Locat	1.1	483.3l	726.3hi	854.0fg	921.3ef
	1.2	549.3kl	600.7jk	614.0jk	1045.3cd
	2.4	543.0kl	661.3ij	535.3kl	1002.7cde
S.E ±		32.57			

Table 82. Interaction Between Millet and Cropping System on Millet Yield kg/ha at Wudil

	Cropping System

Millet	1:1	1:2	2:4
SOSAT	800.8c	882.2b	976.9a
Local	751.5d	711.6de	688.2e
S.E ±	14.50		

Table 83. Interaction Between Millet and Groundnut on Millet Yield kg/ha at Wudil

	Groundnut			
Millet	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
SOSAT	936.2b	806.3c	918.6b	885.3b
Local	530.3e	662.2d	655.1d	1020.7a
S.E ±	18.35			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT.

Table 84. Interaction Between Groundnut and Cropping System on Millet Yield kg/ha at Wudil

	Groundnut			
Cropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	LOCAL
1.1	581.3f	749.0de	760.0cde	1014.2a
1.2	815.3bc	748.5de	795.8bcd	827.8b
1.3	803.2bcd	705.3e	804.7bcd	1017.0a
S.E ±	31.78			

Means along the same column and row having different letter (s) are significantly different at P≤0.05 using DMRT..

4.1.17 Correlation studies

The results of correlation analysis to show type and magnitude of associations between kernel yield and growth characters of groundnut at Minjibir and Wudil were presented at Table 85 and 86 respectively. The significant correlation between some growth and yield parameters as indicated in the result could be attributed to positive direct and indirect effects of those components on the performance and productivity of the groundnut. In Minjibir, it was observed that significant positive correlations were obtained between leaf area, number of leaves and number of branches. At Wudil the kernel yield was positively correlated between leaf area and number of branches.

Table 85. Simple Correction Matrix Between Kernel Yield and Growth Characters of Groundnut at Minjibir in 2012 Rainy Season

	1	2	3	4	5	6	7
1	1						
2	0.54	1					

3	0.36**	0.26*	1				
4	0.07	0.04	0.10*	1			
5	0.30*	-0.10*	-0.26*	-0.30*	1		
6	0.13*	-0.05	-0.06	-0.18	-0.06	1	
7	0.04	0.14*	-0.01	0.19	-0.2	-0.26*	1

Table 86. Simple Correction Matrix Between Kernel Yield and Growth Characters of Groundnut at Wudil in 2012 Rainy Season

	1	2	3	4	5	6	7
1	1						
2	0.26*	1					
3	0.65	0.21	1				
4	0.21	0.23*	0.14*	1			
5	0.25 *	-0.16	0.07	-0.28	1		
6	0.09*	0.01	0.18	0.14*	-0.08*	1	
7	0.08*	0.09*	0.43*	0.04	-0.05	-0.07	1

1. Grain yield, 2. Leaf area 3. Number of leaves 4. Plant height 5. Number of branches 6. 100 kernel weight 7. Stover weight
** =significant at 1%, * significant at 5%

4.2 DISCUSSION

4.2.1 Performance of groundnut

Differences were exhibited among the groundnut genotypes evaluated in respect to their performance with respect to plant growth and yield. This differences were exhibited among groundnut planted in same location and at different locations, parameters evaluated included leaf area, number of branches produced, leaf number, plant height 100-seed weight, kernel yield production, land equivalent ratio and yield per hectare.

In terms of growth parameters among the groundnut genotype, SAMNUT 21 produced the highest number of branches in both locations among the groundnut varieties, again SAMNUT 21 performed better in terms of leaf number production among the groundnut genotypes in both locations. However, comparing the leaf area production among the genotypes SAMNUT 22 produced the highest leaf area in Wudil while SAMNUT 23 performed better in terms of leaf area production for Minjibir significant differences was also exhibited among the groundnut genotypes in terms of plant height, SAMNUT 22 in this case performed better.

Significant differences was also produced among the genotype in terms of the yield attributes evaluated, SAMNUT 21 in both locations produced the highest Stover yield, other attributes like , pod weight and 100-seed weight kernel yield per hectare also shows some differences.

These differences both for growth and development exhibited by the genotype were attributed to their differences in their genetic make-up as was established by Castiglioni *et al.* (2008). Patel (2005) also reported that potential differences exist in growth and development among groundnut varieties.

Another difference observed was differences in leaves and performance when the values are compared location where this could be attributed to the difference in the activities of the genotype in terms of their responses to soil and water there efficiency as reported by (Dotray *et al.* 2001) in addition to this Cooper (2008) found out that some of the difference found among groundnut genotype in terms of growth and development is not only controlled by genetic make-up but combination of both genetic and environmental factin during development (micro-climatic factors) this is in aggrement with some differences in terms of performance observed among some of the attributes evaluated when compared location wise.

4.2.2 Effect of row arrangement on growth and development of the groundnut genotype

Row arrangements significantly affected most of the yield and growth parameters evaluated, these parameters include branch number, kernel yield, plant height branch number, kernel yield, Stover weight production and L.E.R. This is mainly due to the principle of competition, finding by Muhammad *et al*., (2000) on millet – cowpea intercropping confirms that where millet density is high or component crops proximity was close, competition tends to the intense. Gautam *et al*., 1985 also reported the same another research who is in conformity with the above finding is Ajeigbe (2006) who reported that under wider arrangement the groundnut is less stressed hence they are able to make better use of solar radiation for pod production the least value recorded for leaf number production, leaf area and plant height in row arrangement of 1:1 could reactive be attributed to this i.e due to the proximity between the crops shielding could have resulted between the crops ie (etiolation) the taller ones on the shorter ones as reported by (eghaverba 1979).

4.2.3 The L.E.R.

Values of all the treatment were above one which is an indication of better land the efficiency compared to their sole crops, L.E.R value, above one implies complementarities in resources utilisation by component crops (Muoneka *et al*., 2007) other researcher (Adeleye, 1999; Agbaje *et al*., 2002) had also confirmed higher land productivity intercrops than other systems of production most L.E.R of Minjibir were greater than those of Wudil which was attributed to micro-climatic differences.

4.2.4 Performance of millet

Millet plant affected the performance of the groundnut genotype, however the effect are mainly due to principles of competition, local millet affected the performance of the groundnut genotypes most this is due to the local millet having higher number of leaf area, leaf number and plant height would definitely require more resources, consequently higher competition will be faced by groundnut intercropped with the local and then had to lower available soil moisture that promotes seed germination (ICRISAT, 1994). The taller local millet will also cause more serious shading to the under-growing groundnut which will consequently affect the performance of the groundnut. In addition to this many studies on intercropping concluded that cereal (C_4) plants have depressive effect on legumes (C_3 plants) and cereal crops with C_4 photosynthesis pathway such as millet have been known to be dominant when ntercropped with c_3 crops like groundnut. (Muoreke *et al*., 2007)

4.2.5 Millet intercrop

The two millet varieties had significant differences on attributes evaluated like, plant height, leaf area, leaf number grain yield 1000 seedweight, panicle length, panicle weight and L.E.R.

The differences among the millet varieties with respect to height are controlled by genetic make-up of the crop as established by Castighoni *et al*. (2008) differences in plants heights is attributed to genetic background of a genotype. Other finding were of the view that height is not controlled singly by genetic background, but combination of both genetic and enviromental factors during development, this is what was also recorded by Cooper (2001). This statement is supported by this result generally the two millet varieties differed in heights with the local being taller to the SOSAT C-88 in both locations in comparing them, genetically local millet is taller, but comparing the height, location wise, the result shows that both millets had taller plants in Wudil than in Minjibir this is better explained by the influence of micro-climate. This is probably the same for other growth attribute like, leaf area and leaf number evaluated

Row arrangement and groundnut genotype did not significantly affect number of panicle, length and weight of the of the panicle in both locations.

Significant higher 1000 gram weight were produced by SOSAT-C88 in both locations Table 76 although no effect was observed to have influenced millet grain yield by any of the groundnut genotypes in both locations. Thus the groundnut did not exert a significant effect on the 1000-grain weight. In studies by Muhammad *et. al.* (2008) on significant/cowpea intercropping concluded that higher 1000 seed weight of sorghum could be attributed to moderate competition from the companion crops. Similar studies indicated that grain attribute are very little affected because of taller canopy structure which enables them to capture sufficient sunlight (Ntare *et al.*, 1989; Reddy *et al.*, 1992). The advantage in 1000 gram weight sassat C-88 could most probably be due to varietal potentiality.

Land equivalent ration values of the treatments were above one L.E.R in Wudil were greater than those in Minjibir. L.E.R was higher in local millet base intercrop in Wudil, the local millet superseded the SOSAT which gives the local millet an advantage to contribute more to the system Muoreke *et al.* (2007), concluded that cereal crop being a C_4 plants have dominant contribution in intercropping and this in most cases determine the L.E.R.

Row arrangement had no signioficant effect on LER on both locations. L.E.R was also not significant among the groundnut genotypes in both locations.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Field experiment was carried out during 2012 growing season at the research farms of Agricultural Research Station Minjibir, institute of agricultural Research Samaru and Hadejia Jama'are River Basin Development Authority Project, Wudil all situated within Sudan Savannah Ecological zone to study the performance of improved groundnut varieties in millet based cropping system.

Three improved groundnut varieties SAMNUT 21, SAMNUT 22, SAMNUT 23 and a local variety (Kampala) with two millet varieties SOSAT-C-88 and a local variety were used for the study. They were mixed in three different row arrangements (1:1, 1:2, 2:4 and sole for the purpose of calculating L.E.R). The treatment factors were combined and laid on a split plot design

Kernel yield per hectare

The result of the study revealed that among the improved groundnut varieties there was no significant difference in their kernel yield production in both locations however, there were different trends on their yield production were recorded in both locations by SAMNUT 23, kernel yield was significantly higher in row arrangement of 2:4. Among the groundnut genotype Stover yield was greater by SAMNUT 21 at row arrangement of 2:4 intercrop conbination involving local millet on both locations resulted in superior LER than with SOSAT C-88. There was considerally higher L.E.R when millet was intercropped with at 2:4 row arrangement for both locations.

MILLET

Findings from the study revealed that SOSAT C-88 grain yield per hectare was significantly higher than that of the local variety, SOSAT C-88 also produced significantly higher panicle length.

5.2 Conclusion

From the result of the study it could be concluded that all the three factors (millet varieties, row arrangement and groundnut genotype) have significant effect in influencing the productivity of intercrops. In addition, no L.E.R less than one (1) was obtained from any of the combinations. This is an indication that intercrops have yield advantage when they are compared to sole cropping.

5.3 Recommendation

From the results of this study, it could be suggested that SAMNUT 23 intercropped with SOSAT C-88 planted at row arrangement of 2:4 in both locations is recommended for higher grain yield in both locations.

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APPENDIX I

Appendix I. Monthly Rainfall, Mean, Minimum and Maximum Temperature at the Experimental Sites in 2012 Rainy Season

Month	Rainfall (mm)		Temperature (oC)			
	Minjibir	Wudil	Minjibir		Wudil	
			Min.	Max.	Min.	Max.
May	18.1	21.1	21	43	19	42
June	201.8	229.3	20	37	21	36
July	198.2	231	20	34	20	36
August	348.1	384.2	20	34	21	34
September	68.1	73.2	21	36	20	36
October	0	1	19	38	19	36
Total	834.3	939.8				

Source: ABU, Agricultural Research Station (IAR), Kano, Department of Meteorological Sevices and Geography Department, Kano University of Science and Technology, Wudil.