DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. M. Baba and has not been presented anywhere for the award of a Degree or Certificate. All sources have been duly acknowledged.

IBRAHIM ABDULLAHI GUMEL

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CERTIFICATION

This is to certify that the research work for this thesis and the subsequent write-up (Ibrahim Abdullahi Gumel SPS/12/MAS/00012) were carried out under my supervision.

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Supervisor

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APPROVAL PAGE

This thesis has been examined and approved for the award of Master of Science in Animal Science of Bayero University Kano, Nigeria.

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DEDICATION

This research work is dedicated to my son and two daughters: Abdullahi Ibrahim ,Bilkisu Ibrahim and Rabiatu Ibrahim.

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ABSTRACT

Two studies were conducted to evaluate the compatibility of *Sorghum almum* grass in mixture with 3 legume forages (*Lablab purpureus*, (lablab) *Stylosanthes hamata* (verano) and *Macroptilium bracteatum* (burgundy bean)) in terms of the nature of competition, dry matter yield and morphological characteristics as well as chemical composition of mixtures. The first experiment was conducted in Bayero University Kano. The experimental design was randomized complete block design consisting of 15 treatments replicated in four blocks, distances between blocks and plots were 1m and 0.5m, respectively. The treatments were *Sorghum almum* legumes mixtures in the ratio of 0:4, 1:3, 2:2, 3:1, and 4:0. Seeds of grass and legumes were sown in 1x1m^2 plots on 5th August, 2014.The result of the study revealed that total dry matter yield was significantly ($P<0.05$) higher in 2:2 grass-lablab mixtures (2675kg/ ha) among mixtures, while lablab had the highest ($P<0.05$) total dry matter yield (3513kg/ ha) among legumes in mixtures. Total relative yield values were higher at 2:2 grass-legumes mixture compared to 1:3 and 3:1 mixtures. It was concluded that there was no advantage in intercropping between *Sorghum almum* and the duo of *Lablab purpureus* and *Stylosanthes hamata* based on relative yield values of less than 1 although *Sorghum almum*-lablab 2:2 had the highest dry matter yield among mixtures. Competition indices parameters such as relative yield, relative crowding coefficient favored 2:2 sowing ratio. Experiment 2 evaluated the dry matter and chemical composition of mixture of *Sorghum almum* and legumes (*Lablab purpureus*, *Stylosanthes hamata* and *Macroptilium bracteatum*) at 2:2 sowing ratio. The treatments consisted of three grass-legumes mixtures (*Sorghum almum-Lablab*, *Sorghum almum-Stylosanthes* and *Sorghum almum-burgundy*) repeated 4 times in a completely randomized design. The result of the study indicated that *Sorghum almum*-lablab mixture had numerically higher dry matter yield compared to other mixtures. Chemical composition parameters such as CP, EE, Ash, Calcium and Magnesium were observed to be higher in *Sorghum almum*-lablab mixture while, values for ADF and NDF were the least. Other quality parameters such as (Dry Matter Digestibility, Dry Matter Intake and Relative Feed Value) were similarly higher in *Sorghum almum*-lablab mixture. Based on the dry matter yield values and nutritive value Sorghum almum-lablab mixture 2:2 ratio was recommended.

COMPATIBILITY OF COLUMBUS GRASS (*Sorghum almum*) WITH THREE FORAGE LEGUME SPECIES

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B. AGRICULTURE

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO, IN PATIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ANIMAL SCIENCE

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Livestock production all over the world is based on Pasture (Lascano, 2001). In Nigeria like in most tropical countries, livestock production is constrained by availability and quality of Pasture during a particular period of the year (dry season) especially in the Northern part of the country. Report carried out by the Food and Agricultural Organization, (FAO) has shown that only 23% of the world's total area or 3.4 billion hectares is permanent grassland and the tropics account for 1.3 billion hectares as either wild or cultivated fodder plants (FAO, 1993). One of the ways to reduce the effect of seasonal variation in quantity and quality of pastures is by intercropping legumes into cereal crops. A combination of a legume with a grass is the most common type of intercropping. Many of successful crops grown by intercropping worldwide consist of cereal/legume mixtures (Francis, 1989). During the dry season the protein content of the predominantly grass pasture could be lower than 7% required for efficient rumen function. Since adequate nutrition is essential for high rates of gain *i.e.* ample milk production, efficient reproduction and adequate profits, it is therefore, necessary to provide livestock with protein supplements when forage quality is low.

Forage quality and seasonal distribution of bio-mass of grass-legume pastures have proved superior to sole establishment of grasses or legumes grown alone (Minson, 1990). In addition, grass-legume mixtures have higher advantages over pure stands by reducing the incidence of bloat from pure legumes pasture, reduction in occurrence of diseases and insect pests as well as level of soil erosion (Mannteje 1984; Lulseged 1985; Minson, 1990).Increasing the quality of forage available is one of the best methods of improving overall feeding efficiency. Intercropping of grass forages with legume is capable of increasing the protein content of the overall ration. Legumes are good sources of protein and can be used to compensate for grass protein shortage (Gebrehiwots *et al.*, 1996). Thus, growing of grass/legume mixtures can boost the forage protein content of diets. Intercropping, which is defined as the growing of two or more crop species simultaneously in the same field during a growing season (Ofori and Stern, 1987), is important for the development of sustainable food production systems, particularly in cropping systems with limited external inputs (Adesogan *et al*., 2002). This may be due to some of the potential benefits for intercropping systems such as high productivity and profitability (Yildirim and Guvence, 2005), improvement of soil fertility through the addition of nitrogen by fixation and excretion from the component legume (Hauggaard Nielsen *et al*., 2001), Intercropping has been shown to produce higher and more stable yields in a wide range of crop combinations. Muhammad *et al.,* (2009) reported total dry matter yield of (12.50). DMt ha^{-1} was obtained with treatment that had of 50% *Sorghum almum* plus 50% *Centrocema pascourum*.

However, the benefits of intercropping of grasses and legumes may be rendered unattainable as a result of superior competitive ability of the grass over legume leading to reduction in the content of the legumes. Hence, the need to grass and legumes species for compatibility before establishment. The survival of legumes in grass/legume mixtures has always been faced with problems in the tropical regions. It is therefore, thought that the growth habit of legumes may influence its survival in the mixtures. Furthermore, the chemical composition of pastures, determines their quality in term of intake and digestibility, the percentage of CP in the diet of an animal, determines intake similarly, for NDF, while ADF determines digestibility. The experiment aims at evaluating the compatibility of (*Stylosanthes hamata erect* growth habit), (*Lablab purpureus*, *Macroptlium bracteatum* Climbing/Trailing growth habit) with *Sorghum almum* grass.(Columbus grass).

1.2 PROBLEM STATEMENT

The resultant decline in quantity and quality of feeds during dry season constitute serious setback to animal production in the drier part of the tropic in terms of reduction in feed intake, growth rate, productive, and reproductive abilities. In order to mitigate this problem, the development of grass legumes mixtures is advocated. In the light of the foregoing it follows that in a soil which is deficient in N_2 the grass crop will absorb most of the mineral N_2. This will compel the legume to fix more N_2 than when grown as a monoculture provided other factors, such as light and water, are not limiting. While intercropping usually includes a legume which fixes nitrogen, applied nitrogen may still confer some benefits to the system, because the grass component depends heavily on nitrogen for maximum yield (Ofori and Stern, 1986). Technologies aimed at increasing productivity of crops and livestock, while enhancing wellbeing of farmers and minimizing resource degradation must be developed (Mapiye *et al*., 2007). Apart from the direct contribution to livestock production through the provision of protein, legumes can improve the productivity of cereal crops by increasing the amount of nitrogen available for uptake (Giller 2001). Legumes offer a possible lower-cost alternative to nitrogen fertilizers and purchased protein supplements for improving smallholder dairy production (Mapiye *et al*., 2006). Successful utilization of grass-legumes in intercropping systems depends on the selection of locally adapted (climate and edaphic) species with good associative ability (Mapiye *et al*., 2007).

1.3 JUSTIFICATION

It is generally understood that the combination of a grass and legumes is most common among farmers in the semi-arid tropics and would benefit them in resource limiting condition, compared with corresponding sole crops. Yield advantages have been recorded in many grass-legume intercropping systems, including soybean-sorghum (Ghosh *et al*., 2009) maize-cowpea (Eskandari and Ghanbari, 2009), wheat-fababean (Ghanbari Bonjar, 2000). The reason of yield advantage of intercropping are mainly environmental resources such as water, light and nutrients can be utilized more efficiently in intercropping than in the respective sole cropping systems (Liu *et al*., 2006). The underlying principle of better environmental resource use in intercropping is that if crops differ in the way they utilize resources when grown together, they can complement each other and utilize resources better than when they grown separately (Willey, 1996). Inspite of the aforementioned attributes of grass-legume mixtures, the development of successful grass-legume mixture is still problematic in the tropics. The continual search for compatible grass-legumes mixtures therefore becomes imperative.

1.4 OBJECTIVES OF THE STUDY

The main objective of the study was to find out mixtures of grass and legumes that are compatible and at the same time produced better yield among grass/legume mixtures,

While other objectives include

I. To determine the nature of competition between *Sorghum almum* and three other forage legumes (*Stylosanthes hamata*, *Lablab purpureus, Macroptilium bracteatum*) in terms of relative yield, aggressivity index and relative crowding coefficient.

II. To determine dry matter yield and morphological characteristics of grass/legumes mixtures and monoculture cropping.

III. To determine the chemical composition of grass/legumes mixtures and other nutritive value indices such as Dry matter digestibility, Dry matter intake and Relative feed value.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 EFFECT OF GRASS-LEGUME MIXTURES ON THE PERFORMANCE OF ANIMALS

Several experiments have shown that pure legume silages and legume dominated silages can increase milk production compared to that obtained from pure stands grass silages (Castle *et al*., 1983; Dewhurst *et al*., 2003a). Higher content of White clover (Trifolium repens) in the pasture swards led to increase in daily milk yield of cows from 1–3 kg in several short-term experiments when the same dry matter herbage allowance was offered to dairy cows grazing pure Perennial ryegrass and mixed pastures (Phillips and James, 1998; Ribei, milk yield increased with increasing white clover content in the diet and reached a maximum when the proportion of white clover averaged 50–60%.The positive effect of Red clover ro-Filho *et al*., 2003). In a study carried out by (Harris *et al.,* 1998). With housed dairy cows (Trifolium pratense) relative to grass has been explained by higher voluntary intake at similar digestibility. Higher voluntary intake is ascribed to higher concentration of cell contents in red clover than in grasses resulting in faster rates of particle breakdown in the rumen and more rapid clearance of particles from the rumen (Frame *et al.*, 1998). Red clover silage has often proved to be superior to lucerne (*Medicago sativa*) silage in relation to milk yield relative to feed intake (Broderick *et al*., 2001; Dewhurst *et al*., 2003b; Hoffman et al., 1997), and lamb grazing red clover had higher live weight gain than those grazing lucerne (Fraser *et al*., 2004). Broerick *et al.* (2001).

Red clover containing diets have increased ruminal non-ammonia N_2 flow in terms of increased flows of microbial and dietary N_2 entering the small intestine when compared with grass silage (Dewhurst *et al*., 2003a; Vanhatalo *et al*., 2006) and with lucerne.

Consequently, higher apparent N_2 conversion from feed N_2 to product N_2 is often observed on red clover than on grasses or lucerne (Broderick *et al*., 2001; Vanhatalo *et al*., 2006). However, due to high N_2 content improved N_2 efficiency relative to grasses or other legumes are not consistent (Bertilsson and Murphy, 2003; Van Dorland *et al*., 2006).

The lower intake of grass silage is the most remarkable features when comparisons are made across silage types. Legumes silage generally leads to higher intake than grass silages of comparable digestibility. Huhtanen *et al*.(2007) reported a curvilinear trend with increasing intakes as legume silage replaced grass silage up to 0.80 inclusions. The same situation was reported by Cheng *et al,* (2011) who Compared grass silage with mixtures of legume and cereal silage-despite lower digestibility the latter lead to higher intakes .this effect is not confined to legume silage total intakes and short-term of total mixed rations based on maize silage were higher than those based on grass silage, (Abrahamse *et al.,* 2008)

2.2 NITROGEN FIXATION IN LEGUMES AND BENEFITS

Nitrogen (N) occurs in the atmosphere as $N_{2,}$ a form that is not useable by vascular plants. N_2 must first be fixed, or reduced, to ammonia (NH_4^+) by prokaryotic organism such as eubacteria and *Cyanobacteria*. Thus, an important feature of the *Cyanobacteria* and *Cyanolichens* in soil crust is their ability to fix atmospheric nitrogen as this fixation is an aerobic process, which *Cynobacterial* place in *hetrocysts*, which are specialized thick walled cells with enhanced respiration that lack oxygen-producing photosystem (pearl 1990). Heterocystic genera commonly occurring in soil crust include: *Anabaena, calothrix cylindrospermum Dicothrix, Hapalosiphon, Nodularia ,Noatoc,plectonoma, Shizothrix,* and *scytonema* (Harper and Marble, 1988).With a few exceptions, the formation and development of nitrogen-fixing root nodules is the result of a symbiotic relationship between leguminous plants and soil bacteria collectively called rhizobia, but including more specifically the genera *Azorhizobium, Allorhizobium, Bradyrhizobium, Mesorhizobium, Rhizobium* and *Sinorhizobium*. Exceptions to the rhizobia–legume symbiosis include the actinomycete Frankia species, which are well-known partners in the formation of symbiotic nitrogen-fixing nodules on non-legumes such as Casuariana and Alnus species (Soltis *et al*. 1995; Vessey *et al. 2*005),The importance of nodulation and nitrogen fixation to agriculture, natural ecosystems and the global nitrogen cycle are indisputable (Graham and Vance 2003). Legumes are cultivated on 12–15% of available arable land and constitute more than 25% of the world's primary crop production. They provide roughly 200 million tons of nitrogen per year.

Yields are generally higher ingrass/legumes mixtures because of more efficient light utilization and transfer of symbiotically fixed nitrogen to grasses (Ledgard, 1991).Baba *et al*., (2013). In grasslands, symbiotically fixed N_2 by legumes can range from 100 to 380 kg of N_2 ha^{-1} year^{-1}; also exceptionally large amounts of over 500 kg of N ha $^{-1}$ year $^{-1}$ have also been reported (Boller and Nosberger, 1987; Ledgard and Steele, 1992; Zanetti *et al.,* 1997; Carlsson and Huss-Danell, 2003). In addition, in mixed grass-legume systems, between 10 and 75 kg of N_2 ha ˉ1 year ˉ1 are transferred from legumes to grass; the amount depends on the donor and the receiver plant species (Pirhofer-Walzl *et al*., 2012).with the amount of symbiotically fixed N_2 being tightly coupled to the gap between N_2 demand and N_2 availability from mineral N_2 sources, at different scales from plant physiology to the whole ecosystem (Soussana and Hartwig, 1996; Hartwig, 1998; Soussana and Tallec, 2010).Biological nitrogen fixation by grain legume crops has received a lot of attention (Eaglesham *et al*., 1981; Giller *et al.*, 1991; Izaurralde *et al*., 1992; Giller and Cadisch, 1995; Peoples *et al*., 2002) because it is a significant N_2 source in agricultural ecosystems (Heichel, 1987; Dakora and Keya, 1997). However, studies on N_2 fixation in complex cereal-legume mixtures are few (Stern, 1993; Peoples *et al*., 2002). Intercropping usually includes a legume which fixes N_2 that benefits the system, and a cereal component that depends heavily on nitrogen for maximum yield (Ofori and Stern, 1986; Cochran and Schlentner, 1995). Controlled studies have shown a significant direct transfer of fixed-N_2 to the associated non-legume species (Eaglesham *et al*., 1981; Giller *et al.,* 1991; Frey and Schüepp, 1993; Stern, 1993; Elgersma *et al.*, 2000; Hogh-Jensen and Schjoerring, 2000; Chu *et al.*, 2004). There is evidence that the mineralization of decomposing legume roots in the soil can increase N_2 availability to the associated crop (Dubach and Russelle, 1994; Schroth *et al*., 1995; Evans *et al*., 2001). In mixed cultures, where row arrangements and the distance of the legume from the cereal are far, nitrogen transfer could decrease. Research has shown that competition between cereals and legumes for nitrogen may in turn stimulate N_2 fixation activity in the legumes (Fujita *et al*., 1990; Hardar-son and Atkins, 2003). The cereal component effectively drains the soil of N_2, forcing the legume to fix more N_2. Therefore it is important to manipulate and establish how the management practice in legume-cereal mixtures may influence N_2 fixation and nutrition in the traditional African cropping systems Cape Town South Africa. (Ndakidemi, 2006).

In forage crop production systems, grass-legume mixtures are preferred due to their several advantages over monoculture. They have ability to fix atmospheric free nitrogen into the soil by symbiotically living with bacteria of *Rhizobium* species and sustenance of soil fertility (Albayrak *et al.* 2004). Annual legumes are low-yielding, particularly in areas with low rainfall and hinder harvest because it normally lays on the soil surface (Lithourgidis *et al*. 2006). On the other hand, small grain cereals provide high dry matter yields but they produce forage with low protein. Legumes are rich in terms of protein concentration, whereas cereals have higher carbohydrate contents, and cereals benefit from the nitrogen fixed by legumes when they are grown together. Several researches reported that annual legume-cereal mixtures resulted in high yields and high nutritional quality as compared with cereals alone (Karadağ and Büyükburç, 2003; Agegnehu *et al.* 2006; Yolcu *et al*. 2009; Balabanlı *et al*. 2010). Benefits of mixture include greater uptake of water and nutrient, enhanced weed suppression, and increased soil conservation in the legume mixtures with cereals, it is essential to be known the rates of the legume and cereal species on high forage yield and quality. (Vasilakoglou *et al*. 2005).

2.3 NUTRITIVE VALUE OF GRASS/LEGUMES MIXTURES

Animal performance mainly depends on the quality of forage available to livestock (Lazzarini *et al.*, 2009; Woolley *et al*., 2009). Forage quality is defined as the capacity of forage to provide the required nutrients to livestock (Adesogan *et al.*, 2006; Muir *et al.*, 2007; Newman *et al*., 2006). Determining the nutritional value of forages is important in livestock nutrition, because effective livestock production is related to the amount of nutrients in the forage (Schut et al., 2010). Total digestible nutrient (TDN), crude protein (CP) and metabolism energy (ME) are often used as indicators of forage quality (Pinkerton, 2005; White and Wight, 1984). France (2000) noted that the nutritional value of forage depends on the amount of proteins and digestible carbohydrates. In addition, ash, lignin, cellulose, crude fiber, phosphorus carotene and some other plant chemical compounds are also measured as indicators of forage quality. El-Waziry (2007) and Rhodes and Sharrow (1990). Plant morphology for both cereals and legumes has three main plant parts, leaf, stem and grain. As a structural component of the plant, stems typically contain more fiber for supports. Leaves, on the other hand, provide a means for capture and utilization of energy from sunlight and trend to be lower in fiber content than stems (Wilman and Rezvani-Moghadam, 1998). Thus, stems usually are lower in digestibility than leaves, and stem digestibility declines more rapidly with increased plant maturity than that of leaves (Gebrehiwot *et al*., 1996). Differences between leaf and stem digestibility are normally greater in forage legumes than cereals (Buxton, 1996). Given the large difference between the digestible fiber content of stems and leaves, the proportion of leaf to stem in given forage plant relates directly to its forage quality (Ghanbari-Bonjar, 2000). Also, the grain mainly comprises digestible components such as starch and protein. Consequently, grain to Stover ratio is considered as an indicator for variety selection when high quality forage is required (Coors *et al*., 1997).

2.4 DIGESTIBILITY OF GRASS/LEGUMES MIXTURES

Most available ruminant feeds during dry season have been described as fibrous, resulting in low digestibility and poor livestock production (Richard *et al*., 1994). Protein supplementation of grass diets with forage legumes is essential to achieve high productivity in the animals. Forage legumes are known to have an important role in the nutrition of ruminants in terms of providing energy, protein, minerals element for chewing and ruminant (Ahmad *et al*., 2000; Ranibar, 2007). This protein supplementation affects voluntary feed intake and digestibility positively. The use of forage legumes such as lablab as feed supplements has been shown to enhance intake of poor quality forages, improve growth rates and increase production efficiency in ruminants (Orden *et al*., 2000). Feed intake increases as digestibility of energy increases and as crude protein content of the feed increases.

2.5 LEGUMES

2.5.1 *Lablab purpureus* (l.)

The common names of Lablab purpureus: Hyacinth bean, field bean, pig-ears, rongai dolichos, lab-lab bean, poor man's bean, Tonga bean (English); Hausa name: Wake Dan Inusa.

2.5.2 Origin and Distribution

The wild forms of lablab are believed to have originated in India (Deka and Sarkar, 1990) and were introduced in to Africa from Southeast Asia during the eight century (Kay 1979). *Lablab purpureus* is native to Africa: Angola, Botswana, Cameroon, Chad, Cote D'Ivoire, Ethiopia, Gabon, Ghana, Kenya, Malawi, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa (Cape Province, Natal, Orange free state, Transvaal), Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe. Western India Ocean: Madagascar. It's now widely cultivated pan-tropically Skerman, Camron and Riveros, (1991).

2.5.3 Soil Requirements

The crop grows on wide range of soils from deep sands to heavy clays, provided the drainage is good and from pH 4.5 – 7.5 (Kay 1979). Low salinity tolerance with symptoms of chlorotic leaves; have been found to reduce growth of the plant. Lablab does not always nodulate well with native strains of rhizobia but some virgin soils in the sub-tropical part of Australia which appears to have suitable native rhizobia populations, which have resulted in good growth without inoculation of seed. The seed should be inoculated with a cowpea-type, Brady rhizobium strain as it does not easily nodulate with native rhizobia (FAO, 2012). Natural pastures must be cultivated for successful establishment (FAO, 2012).

2.5.5 Moisture Requirement

The crop adapts to annul rainfall regimes of 650-3,000 mm. Cook et al. (2005) Drought tolerant when establish, and it grow where rainfall is less than 500 mm, Lablab purpureus loses leaves during prolonged dry season (harmattern).Capable of extracting soil water from at least 6 m depth, even in heavy-textured soils. (Cook et al., 2005). Lablab grows at altitudes from sea level to elevations of up to 2,000 m as l in tropical environments (Anthony, 2006). The crop will only tolerate short periods of flooding but intolerant to poor drainage. (Anthony, 2006).

2.5.6 Temperature

Grows best at average daily temperatures of 18-30^{o}C and is tolerant of high temperature. Lablab was able to grow at low temperature of about 3^{o}C for short a period. Frost susceptible, but tolerates very light frosts. More tolerant of cold than either *Mucuna pruriens or cowpea (Vigna unguiculata)*.Will grows at altitudes from sea level to elevations of up to 2,000 m in tropical environments (Cook et al., 2005). Lablab is a legume that thrives well in the dry season between November and February in the northern Nigeria. It is drought resistant and is usually sown after the normal cropping season, thereby acting as a buffer crop for ruminant feed during the dry season (Adu et al., 1992).

2.5.7 Fertilizer Application

It is common to grow lablab without fertilizer applications, sowing in sandy soils often required applications of phosphorus and Sulphur and benefit from application of lime in very acid soils. Lablab is an N-fixing legume that can be incorporated into cereal cropping systems. It can effectively prevent soil fertility decline by N fixation (20 to 140 kg residual N/ha into the soil) and break weed and diseases cycles. Fixed N is then available for the next crop in the rotation (Mullen, 1999). The lablab canopy prevents soil dehydration from sun and wind while the lower leaves are shed and provide mulch to the soil (Mullen, 1999).

2.5.8 Nutritive Value of Lablab

Lablab forage has an average crude protein content of about 18%, which varies from 13 to 24% depending on local conditions and stage of harvest (Muduru et al., 2008; Linga et al., 2003). Fresh forage and hay can have a similar nutritive value,(Linga et al., 2003). a situation which favours harvesting at the optimum stage with appropriate methods of conservation and storage. The green forage remaining after seed harvest can be sun-dried but its protein content is lower (13-14% DM) (Iyeghe- Erakpotobor et al., 2007).

2.6 *MACROPTILIUM BRACTEATUM*

2.6.1Distribution

Native to *South America*: Argentine (Salta, Jujuy, Formosa), Bolivia (Santa Cruz), Brazil (Bahia, Minas Gerais, Sao Paulo), Paraguay, Peru (La Libertad), Venezuela (Anzoategui). (Anonymous, 2005).

2.6.2 Morphological Description

Macroptilium bracteatum exhibit Erect and trailing growth, Leaves trifoliolate with stipules about 5 mm long, and pedicel ±4 cm long; leaflets 3.4-6 cm long and 3-3.8 cm wide, Peduncle glabrous, 10 -15 cm long, and with a whorl of bracts close to the base; flowers in the upper third of the receme, purple – red I colour with small bracts at the base of each flower; calyx pubescent with 5 teeth. Fruit linear, 4- 9 cm long with 9-17 seeds. Seed almost cylindrical, 2.5-4 mm long and 3 – 4 mm in diameter; brown black or tan in colour, almost always mottled;17,000 seeds/kg. (Anonymous, 2005).

2.6.3 Soil Requirement

Mostly collected from light to medium textured soils, but adopts well to heavy clays. The pH of this soil has most often been near neutral to alkaline, it has also been collected on soil of pH 4.5. The key characteristic required for M. bracteatum is a slightly acid to alkaline soil reaction. (Anonymous, 2005).

Despite the range of light textured soil at the point of collection, M. bracteatum was selected for use on heavy textured soils which are invariably Alkaline at and near the surface. Seed production is conducted in Queensland on moderately acid, duplex soils of granitic origin. (Anonymous, 2005).

2.6.4 Moisture Requirement

Macroptilium bracteatum suited in area with annual rainfall from 400-1,600 mm but it being used in subtropical environments with summer-dominant rainfall between 600 and 1,000 mm. very drought tolerant and has persisted for at least 3 year on shallow clay soils extreme mid-season droughts. (Anonymous, 2005).

2.6.5 Temperature

Macroptilium bracteatum has mostly been collected between about 10 and 27^{o}S, and up to 12^{o}N. It occurs at average annual temperature 17.5^{o}C to lower altitude areas with average annual temperature of 25^{o}C it germinate and commence growth at lower temperatures than many other tropical and subtropical legumes. If moisture is available, it germinates and commences regrowth some weeks earlier than *Clitoria ternatea* in spring in the subtropics. In the higher altitude substropics where early spring rains can often occur, this is one of its most valuable characteristic. In addition to its capacity to grow in cooler temperatures, M. bracteatum has been successfully in pasture area that typically have high summer temperature (>35^{o}C). (Anonymous, 2005).

2.6.6 Fertilizer Application

Applications of 10-20 kg/ha P at sowing improve performance on old cropping soils. Molybdenum and sulphur may also be necessary in some situation. (Anonymous, 2005).

2.6.7 Nutritive Value

While there is little information on nutritive value available, animal growth rates suggest burgundy bean produce high quality feed. Burgundy bean has been reported to have had a leaf analysis of 3.2%N, 0.23% P and ADF OF 29.3%, which was lower than that of Butterfly pea but greater than for Seca stylo *(Stylosanthes scabra)*. Nutritive values of burgundy bean stems at the same time were 2.0%N, 0.22% P and ADF of 37.3% which was similar to those of butterfly pea (*C. ternatea)*. In another measurement of forage quality, burgundy bean produced 19.8% protein, less than the levels for lucerne *(M.sativa),* 22% and butterfly pea 24.5%. (Anonymous, 2005).

2.7 ***STYLOSANTHES HAMATA (l.)***

Common names Caribbean Stylo (English); pencil flower, mother segal (West Indies); tebeneque (Venezuela); cheesytoes (USA); Verano (Spanish); thua-hamata (Thailand); lucy Julia (Cayman) Islands). (Cook *et al* 2005).

2.7.1 Morphological Description

(*Stylosanthes hamata* (L.)Taub.) is a semi-erect, annual or short-lived perennial tropical legume, up to 75 cm high. Its stems are slender, multi-branched, non-determinate and pubescent on one side but without bristles, unlike the Townsville stylo, *Stylosanthes humilis*, which has many bristles. The leaves are trifoliate with shiny, lanceolate leaflets, 19-37 mm long and 3-6 mm broad. The inflorescence is a compact oblong spike bearing 8 to 14 small, yellow, hairy and papillonaceous flowers. The single-seeded pods are erect and segmented. The upper segment is glabrous and hooked, 6-7 mm long including the length of the hook (Cameroon, 2010; Cook *et al* 2005). The seeds are kidney-shaped, dark brown, mottled and 2-2.5 mm long. There is a wide range of Caribbean stylo genotypes, differing in their ploidy. Diploid types are adapted to a wider range of latitudes, altitudes and rainfall ranges than tetraploid types (FAO, 2012; Cameroon, 2010; Edye *et al* 1992). In Australia, two tetraploid cultivars (*Verano* in 1973 and *Amiga* in 1988) have been released as pasture legumes. Amiga produces more perennial plants and more seeds than Verano, in drier and cooler environments (Cameroon,2010; Edye 1997) . Diploids are generally not sown for pastures (Edye *et al*., 1992).

2.7.2 History and Distribution

Sylosanthes hamata originated from the Caribbean Islands, Southern Florida, Central America and South America, where it is mainly found in Colombia, Venezuela and Brazil (Edye *et al* 1992).It is now also found in India, West Africa and Northern Australia. There are only minimal morphological differences between tetraploid and diploid genotypes but their growing preferences are different. Tetraploid types are found in a narrow range of latitudes (9°N to 11.5°N) and generally below an altitude of 500 m. They are best adapted to drier areas with pronounced dry season (Cook *et al* 2005).

2.7.3 Soil Requirement

Stylosanthes hamata were of two types, diploids and tetraploids. The diploids are not well adapted to acid soil conditions, originating from predominantly alkaline soils, from coarse coral beach sands to relatively heavy clays, where pH is not less than 6.2. the tetraploids from Venezuela that provide the common cultivars, grow on acid to alkaline soils (pH 5.4-8.0, usually acid to slightly acid) of various textures, but not the heavy clays. (Cook *et al* 2005). They are tolerant of low P, but may respond to applied S. they extend the range originally set by S. humilis, which was largely restricted to infertile, acid, sandy surface soils, on to alkaline soils. While there are no general comments on salinity tolerance, it appears 'Verano is more tolerant of moderate salinity levels than S. humilis Tetrapoids from Florida are very different to those from Venezuela. (Cameroon, 2010; Edye). *Stylosanthes hamata* is resistant to anthracnose, unlike some other *Stylosanthes* species (Coulibaly *et al*., 1996).

2.7.4 Moisture Requirement

Annual rainfall in the regions where diploid are found ranges from 1,000-2,000 mm in Florida, from 980-1,500 mm in the Caribbean and from 350-1,000 mm in northern South America. The tetraploids mainly occur in low to very low rainfall areas with a pronounced dry season. (Cook *et al* 2005). However, the cultivars, both of which originate from an area of ca. 500 mm annual rainfall, are successfully planted in situations receiving 500-2,000 mm with 700-900 considered ideal. (Cameroon, 2012) *Stylosanthes hamata* behaves as an annual. Some forms have quite good flood tolerance. (Cameroon, 2012).

2.7.5 Fertilizer Application

Stylosanthes hamata can extract phosphors from soil low in available soil P. Respond strongly to applied P. Application of 10-20 kg/ha P at planting at every 2 or 3 8 ppm (mg/kg) improves both plant and animal performance. Molybdenum and sulphur may also be necessary in some situations.

2.7.6 Nutritive Value

Stylosanthes hamata contains about 16% DM as protein (10-24% DM) and is, therefore, less rich in protein than other tropical legumes such as *Leucaena* or *Gliricidia*. Lower protein content has been observed in West Africa, 6-10% DM in sub-humid Nigeria, or 11% DM in the Sudano-Sahelian region (Coulibaly *et al*., 1996).Fibre content is variable and rather high, with an average of 33% DM as crude fibre (24-49% DM). Lignin content also tends to be high. Nutrient composition is likely to vary with the stage of maturity and the leaf to stem ratio. For instance, Caribbean stylo hay harvested at 90 days after sowing had a higher protein and nutrient digestibility in goats than hay harvested at 150 days (Singh *et al.,*2001).

2.8 *SORGHUM ALMUM*

Common names Almum grass, almum sorghum, columbus grass, sorgho Argentine, columbusgras, sorgo negro, pasto colon, five-year Sorghum.Columbus grass is a natural hybrid between *Sorghum halepense* (L.) (Johnson grass) and *Sorghum bicolor* (L.) Moench (grain sorghum) (USDA, 2010; Hacker, 1992).

2.8.1 Morphological Description

Columbus grass (*Sorghum almum* Parodi) is a robust, short-lived perennial. It has numerous tillers and thick short rhizomes. Culms are thick and solid and can reach up to 4.5 m. The leaves are 2.5-4.0 cm wide and waxy. The inflorescence is a large pyramidal panicle with secondary and tertiary branches, generally drooping as seed ripens (Cook et al., 2005). Columbus grass is one of the most valuable summer forage and fodder crops in semi-arid and sub-humid areas (FAO, 2010).

2.8.2 Origin and Distribution

Columbus grass is thought to have originated in Argentina. It is now found Worldwide within 25°N and 30°S and from sea level to 700 m altitude. (Feedipedi, 2016). Occurrence of Sorghum almum has also been reported in Alabama, Illinois, Louisiana, Mississippi, Oregon, Texas, and Wisconsin (USDA-NRCS 2012).

2.8.3 Soil and Water Requirement

Optimal growth conditions are annual rainfall ranging from 460 to 760 mm, average day-temperatures between 15°C and 22°C, on fertile, well-drained loamy soils or heavy clays, with soil pH ranging from 5 to 8.5 (FAO, 2010; Cook et al., 2005). Columbus grass may withstand drought periods but has no tolerance of water logging or flooding (FAO, 2010; Cook et al., 2005). Its growth is impaired below 15°C but it can survive mild frosts if the stand is well established (Cook et al., 2005). Columbus grass is also one of the most salt-tolerant grasses with *Chloris gayana, Panicum coloratum, Pennisetum clandestinum* and *Digitaria eriantha*. (FAO, 2010).

2.8.4 Fertilizer Application

Columbus grass responds well to N, P and K fertilization and generally yields 4-12 t DM/ha, sometimes up to 20t DM/ha(Cook et al., 2005). Seeds yield and 0.3-1.6 t /ha (Cook et al., 2005). It requires a high level of nutrition for yields to be maintained, and does well as a pioneer species sown in the ashes of burnt brigalow (Acacia harpophylla) in Queensland where there is a high initial nitrogen status after years of growth of this leguminous tree. The application of fertilizer improved the in vitro gas production, suggesting enhanced fermentation (Lanyasunya et al., 2007b).

2.8.5 Nutritive Value

The nutritive value of Columbus grass greatly depends on the age of regrowth and it provides good feed only on soils which are at least moderately fertile (Hacker, 1992; Cook et al., 1995).). Columbus grass (Sorghum almum) is widely recognized and valued for its high yield of palatable herbage suitable for intensive animal production (Muhammad et al. 1994). Sorghum almum is a short-lived perennial forage grass which is easily established from seed with rapid growth and fodder yield accumulation within the year of establishment (Muhammad, 1993). The yield of the grass at 7 weeks after planting was reported by to be 8.7 tonnes fresh or 1.3 tonne DM/ha (Kallah *et al.*1999). Between 6 and 14 weeks, crude protein decreased from 15.6 to 5.2, NDF increased from 52 to 69%. Dry matter and nitrogen degradability decreased from 41 to 32 % and 48 to 33 % respectively (Lanyasunya et al., 2007a). The application of fertilizer improved the in vitro gas production, suggesting enhanced fermentation (Lanyasunya et al., 2007b).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENT I

3.2 STUDY AREA

The study was conducted at University Teaching and Research Farm, Bayero University, Kano. Kano lies between latitude 9° 30’ and 12° 30’ N, longitude 9° 30’ and 8° 42’ E in the Sudan savannah ecological zone of Nigeria. The annual temperature and relative humidity ranges between 38°C to 43°C and 40 to 51.3%, respectively (Olofin, 2007). Mean annual rainfall ranges between 500 mm to 1000 mm (KNARDA, 2001). The soil of the area is sandy loam with the following proportions of N, P and K 0.1%, 0.00099%, and 0.0269%, respectively.

3.3 SOIL SAMPLE AND ANALYSIS

Prior to planting, composite soil sample were collected at 12 points within the experimental field of 18m x15m, at 0-15cm depth using a soil auger. Sub-samples of the soil were oven-dried and passed through 2 mm sieve for analysis to determine the particle size using Bouyoucos Shydrometer as described by Gee and Bauder,(1986). The N was determined by regular micro-kjeldhal Method described by Bremner (1982), Potassium (K) was determined using Flame Photometer described by Gul and Mahpara (2009) and Phosphorus (P) was determined using Atomic Absorption Spectrometer determine by Procedures described by AOAC (1999).

3.4 SEEDS TREATMENT

Two legume seeds were treated with hot water at 80°C for 3 minutes to break seed dormancy; (Macroptilium bracteatum, *Stylosanthes hamata*) the Seed were dressed with pesticide (Apron Maxx RTA) to protect them from pests and soil borne diseases.

3.5 LAND PREPARATION AND SOWING OPERATION

Land preparation was carried out with aid of disc ploughs and harrows to break the soil in to clods and pulverize the soil respectively. Experimental layout consisted of 4 blocks with each block containing 15 treatments. Distances between block and plot were 1m and 0.5m, respectively. Seeds of grass and legume were sown in holes dug at the 4 corners of $1x1m^2$ plot about 0.25 m away from the margin. Both monocultures and mixtures were sown in the ratio of 0:4, 1:3, 2:2, 3:1 and 4:0 grass, grass-legume mixtures, and legumes respectively in line with Dewitt's 1960 replacement principle. Seedlings of both grass and legumes were thinned to 3 stands per sowing hole at 2-3 weeks post sowing.

3.6 EXPERIMENTAL TREATMENTS AND DESIGN: were as follows

(A) Treatment with *Lablab* legumes

(1) *Sorghum almum: Lablab purpureus (0:4).*

(2) *Sorghum almum: Lablab purpureus (1:3).*

(3) *Sorghum almum: Lablab purpureus (2:2).*

(4) *Sorghum almum: Lablab purpureus (3:1).*

(5) *Sorghum almum: Lablab purpureus (4:0)*

.

Treatment with *Macroptilium* legumes

(6) *Sorghum almum: Macroptilium bracteatum (0:4)*

(7) *Sorghum almum: Macroptilium bracteatum (1:3)*

(8) *Sorghum almum: Macroptilium bracteatum (2:2)*

(9) *Sorghum almum: Macroptilium bracteatum (3:1)*

(10) *Sorghum almum: Macroptilium bracteatum (4:0)*

Treatment with *Stylosanthes* legumes

(11) *Sorghum almum + Stylosanthes hamata (0:4)*

(12) *Sorghum almum + Stylosanthes hamata (1:3)*

(13) *Sorghum almum + Stylosanthes hamata (2:2)*

(14) *Sorghum almum + Stylosanthes hamata (3:1)*

(15) *Sorghum almum + Stylosanthes hamata (4:0)*

The treatments were laid out in randomized complete block design (RCBD) replicated in four blocks.

3.7 FERTILIZER APPLICATION EXPERIMENT 1

Plots containing grass-legume mixtures received basal dose of 50kg P and K, fertilizer while the control with sole grass received 50kg /ha of NPK, respectively. The sources of fertilizer were N (Urea), P (SSP) Single Super Phosphate and K from Muriate of Potash (MOP).

3.8 PARAMETERS MEASURED AT HARVEST

3.9.1 Dry Matter Yield

Dry matter yield was determined by harvesting the plant materials at appropriate height of about 5cm above the ground level. Materials were separated into the component species fresh weights were taken and recorded the materials were oven dried at 65°C for 72 hours to determine the yield on dry matter basis.

Dry matter yield formula

$$\%DM = 100 - [(\text{original weight} - \text{dry weight}) \div \text{original weight}] \times 100$$

3.9.2 Leaf to Stem Ratio, Leaf Area and Number of Tillers

Leaf/stem ratio was determined by separating the plants in each plot in to leaf and stems both fresh and dry weights were taken, Leaf area was measured using leaf area meter model YMJ-A Portable at harvest and The number of tillers/per plant of grass was counted on plot by plot basis.

3.9 STATISTICAL ANALYSIS

The data generated were subjected to Analysis of Variance (ANOVA) using the (SAS 1992) version 9.2. Differences among means were separated using L.S.D.

3.10 COMPETITION INDICES MEASURED

3.10.1 Relative Yield (RY)

Relative yield this shows the degree to which different species in a mixture share common resources.

The relative yield of the components in mixtures was calculated using the equations of De Wit (1960):

Relative yield of grass

RYG = DMYGL/DMYGG (1)

Relative yield of legumes

RYL = DMYLG/DMYLL (2)

Total relative yield

TRY = (1) + (2)

Where:

DMYGG is the dry matter yield of grass ‘G’ monoculture.

DMYLL is the dry matter yield of legume ‘L’ monoculture.

DMYGL is the dry matter yield of grass component ‘G’ grown in mixture with legume ‘L

DMYLG is the dry matter yield of any legume component ‘L’ grown in mixture with grass ‘G. (De Wit 1960).

3.10.2 Relative Crowding Coefficient (RCC)

The relative crowding coefficient refers to the relative competitive ability of one species over the other (De Wit 1960).

RCC

For 50:50 ratio

Relative crowding coefficient grass component = dry matter yield of grass component divided by dry matter yield grass monoculture minus dry matter yield grass component.

DMYGL)

Relative Crowding Coefficient of Legumes Component = dry matter yield legumes component divided by dry matter yield of legumes monoculture minus dry matter yield legumes component.

For mixtures different from 50:50

Relative crowding coefficient grass component = dry matter yield of grass component times sown proportion of legume in mixture divided by dry matter yield grass monoculture minus dry matter yield of grass component times sown proportion of grass in mixture.

DMYGL)ZGL

Relative crowding coefficient legume component = dry matter yield of legume component times sown proportion of grass in mixture divided by dry matter yield legume monoculture minus dry matter yield of legume component times sown proportion of legume in mixture.

DMYLG)ZLG (Ghosh,2004).

3.10.3 <u>Aggressivity Index</u>

This shows the aggressor and aggresee in a relationship between two species (McGilchrist 1965 , McGilchrist and Trenbath 1971):

For 50:50

Aggressivity Index of grass component= dry matter yield of grass component divided by dry matter yield legume monoculture minus dry matter yield legume component divided by dry matter yield legume monoculture.

(DMYLG/DMYLL)

Aggressivity Index of legume component= dry matter yield of legume component divided by dry matter yield grass monoculture minus dry matter yield grass component divided by dry matter yield grass monoculture.

(DMYGL/DMYGG)

For mixtures different from 50:50,

Aggressivity Index of grass component= dry matter yield of grass component divided by dry matter yield of grass monoculture times sown proportion of grass in mixture minus dry matter yield of legume component divided dry matter yield of legume monoculture times sown proportion of legume in mixture.

ZLG)

Aggressivity Index of legume component= dry matter yield of legume component divided by dry matter yield of legume monoculture times sown proportion of legume in mixture minus dry matter yield of grass component divided by dry matter yield of grass monoculture times sown proportion of grass in mixture.

ZGL)

Z = sown proportion in the ratio.

3.11 EXPERIMENT II

Experiment two was conducted based on the result of experiment 1.The sowing ratio that produced the highest dry matter yield and showed favorable competition indices was used to establish mixtures of *Sorghum almum* and three legumes, (*Stylosanthes hamata*, *Lablab purpureus, Macroptilium bracteatum*).

3.12 EXPERIMENTAL LOCATION

The Experiment was conducted at the Screen House of Agronomy Department of the Faculty of Agriculture, Bayero University, Kano. The soil of the area is sandy loam soil with the following proportions of N, P and K (0.09%, 0.00089%, and 0.0273%) respectively).

3.13 TREATMENT COMBINATION EXPERIMENT

Sorghum almum + Lablab purpureus (2:2)

Sorghum almum + Macroptilium bracteatum (2:2)

Sorghum almum + Stylosanthes hamata (2:2)

3.14 TREATMENT AND EXPERIMENTAL DESIGN EXPERIMENT 1

The treatments were three grass-legumes mixtures (*Sorghum almum + Lablab, Sorghum almum +Stylosanthes hamata* and *Sorghum almum+ Macroptilium bracteatum*) repeated 4 times in a Completely randomized design.

3.15 SEED TREATMENT AND PLANTING OPERATION

Legume seeds (*Macroptilium bracteatum* and *Stylosanthes hamata* were treated using hot water at 80^{o}C for 3 minute to break seed dormancy while *Lablab purpureus* was not treated. A soil mixture comprising sand/loamy soil was prepared at the ratio of 1:3, respectively. 50kg of the mixture was put in (12) plastic containers, with the dimensions of 62cm (width), 31cm (base width) and 28cm (depth). Water was sprinkled onto the soil mixture contained in the plastic containers, seeds of grass-legume mixtures were sown on 22nd April, 2015, at the rate of 10 seeds per sowing hole dug into the soil, the seed were then lightly covered. Inter and intra row distance between plants was 25cm.

3.16 FERTILIZER APPLICATION

All forage mixtures of experiment two received P and K fertilizer at the rate of 50kg /ha each plot.

3.17 Harvesting of Experiment II

Harvesting was done on 8th July 2015, at 12 week post sowing which coincided with 50% flowering of burgundy bean, and *Sorghum almum* at soft dough stage the following parameters were measured as in experiment 1.

Dry Matter Yield

Leaf Area

Leaf /Stem Ratio

Tiller Number

After harvest and determination of dry matter, (as in experiment 1) the dried materials were ground using hammer mill to pass through 2mm sieve. The ground materials were used for chemical analysis.

3.18 CHEMICAL COMPOSITION OF MIXTURES

Chemical Composition of mixtures was determined by grinding samples to pass through 2 mm sieve the material was stored in an air tight plastic container. Samples were used for determination of Crude Protein (CP), ash, ether extract (EE), according to procedures described by (AOAC 1999). Fibre fractions, (acid detergent fibre ADF and neutral detergent fibre NDF) were determined according to the procedures described by Van Soest., *et al.*(1991). Mineral Composition of mixtures Phosphorus (P) and calcium (Ca) were determined by Atomic Absorption Spectrometer procedures described by AOAC (1999). Potassium (K) was determined using flame photometer described by Gul and Mahpara, (2009). Other nutritive value indices such dry matter intake (DMI) and Dry matter digestibility were calculated. Relative feed values (RFV) were calculated according to the following equations adapted by Horrocks and Vallentine (1999):

DMI = 120 / %NDF dry matter basis,

DDM = 88.9 – (0.779 × %ADF, dry matter basis),

RFV = %DDM × %DMI × 0.775.

3.19 STATISTICAL ANALYSIS

The data generated were subjected to analysis of variance (ANOVA) using the (SAS 1992) version 9.2. Differences among means were separated using least significant different (L.S.D).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS EXPERIMENT I

4.1.1 Dry Matters Yield of Forages in the Mixture

The dry matter yields of grass legume and total are shown in Table 1. Dry matter yield values of grass in 2:2 grass-legume mixtures were highly significantly greater ($P<0.05$) than those of other mixtures (1:3 and 3:1), among the grass in mixture with legumes, the grass in grass Stylo mixture 2:2 tended to record higher dry matter yield (872kg/ha) followed by the grass in grass –burgundy mixture (811kg/ha) with the least recorded by grass in grass-lablab mixture (744kg/ha). In the case of legumes in mixture lablab in grass-lablab mixture (3:1) (2179kg/ha), lablab in grass-lablab mixture 2:2 (1931kg/ha) and burgundy in grass-burgundy mixture 2:2 (1705kg/ha) recorded highly significantly greater yield ($P<0.05$) than the rest of the treatments except for lablab in grass-lablab mixture 1:3 (1256kg/ha) found to be at par with burgundy in grass-burgundy mixture (2:2).

4.1.2 Total Dry Matter Yield

Grass monoculture recorded highly significantly greater yields ($P<0.05$) than monocultures of legumes and mixture except in the case of monoculture of lablab observed to be statistically at par with its corresponding grass monoculture, among the mixture 2:2 grass-legume mixtures seemed to record higher total dry matter yields compared to other mixtures (1:3and 3:1) irrespective of the species involved in the mixtures. Total dry matter yield was highest in *Sorghum almum*-burgundy (4:0) (4264kg/ha). In the case of legume monocultures lablab recorded the highest yield (3513kg/ha) followed by Stylo (1235kg/ha) with burgundy the least. Total dry matter yield was highest in 2:2 grass-lablab mixture (2675kg/ha) among mixture.

Table 1: Dry Matter Yield of Grass, Legumes and Mixtures

TREATMENT	DMYG (kg/ha)	DMYL (kg/ha)	TDMY (kg/ha)
SVL (0:4)	-	-	3513^{b}
SVL (1:3)	597^{b}	1256^{bc}	1854^{b}
SVL (2:2)	744^{a}	1931^{a}	2675^{c}
SVL (3:1)	245^{c}	2179^{a}	2424^{c}
SVL (4:0)	-	-	3862^{ab}
SVB (0:4)	-	-	558.3^{h}
SVB (1:3)	618^{b}	287.3^{d}	915^{fgh}
SVB (2:2)	811^{a}	1705^{ab}	2516^{c}
SVB (3:1)	293^{c}	387^{d}	680^{gh}
SVB (4:0)	-	-	4264^{a}
SVS (0:4)	-	-	1235^{efg}
SVS (1:3)	595^{b}	800^{cd}	1395^{def}
SVS (2:2)	872^{a}	701^{cd}	1573^{de}
SVS (3:1)	290^{c}	895^{cd}	1185^{efg}
SVS (4:0)	-	-	4218^{a}
P value	<.0001	<.0001	<.0001

Means with different superscripts within the same column are significantly different ($P<0.05$).DMYG =dry matter yield grass, DMYL=dry matter yield legume, TDMY=total dry matter yield, 4.1.3 Relative Yield

The relative yield legumes appeared to be higher than those of the grass (Table 2.), among the grass and legumes relative yield was higher at 2:2 grass legumes mixtures compared to 1:3 and 3:1 except in 1:3 grass-Stylo mixture. All mixtures had relative yield total of less than 1 except *Sorghum almum* burgundy 2:2 (3.31).

Table 2: Relative Yield of Grass, Legumes and Mixtures

TREATMENTS	RYG	RYL	TRY
SV L (1:3)	0.097^{bc}	0.356^{b}	0.453^{b}
SV L (2:2)	0.195^{a}	0.542^{b}	0.737^{b}
SV L (3:1)	0.064^{c}	0.382^{b}	0.446^{b}
SV B (1:3)	0.11^{b}	0.552^{b}	0.662^{b}
SV B (2:2)	0.189^{a}	3.119^{a}	3.309^{a}
SV B (3:1)	0.069^{c}	0.314^{b}	0.383^{b}
SVS (1:3)	0.114^{b}	0.665^{b}	0.778^{b}
SVS (2:2)	0.207^{a}	0.578^{b}	0.785^{b}
SVS (3:1)	0.069^{c}	0.299^{b}	0.368^{b}
P value	<.0001	<.0001	<.0001

Means with superscript within the same column are significantly different (P<0.05), RYG = relative yield grass, RYL = relative yield legume, TRY= Total Relative Yield.

4.1.4 Relative Crowding Coefficient (K)

Relative crowding coefficient in legumes seemed to be higher compared to grass except in *Sorghum almum*-Lablab (2:2) and *Sorghum almum*-burgundy (2:2) (Table 3.). The higher K value recorded signifies higher competitive ability of the legumes compared to the grass. All 1:3 grass legumes and 3:1 legumes mixture had significantly higher K value than (2:2) grass -legumes combination similarly for grasses. The species appeared to the equally matched at 2:2 ratio combinations given the seemingly lower K values.

Table 3: Relative Crowding Coefficient of Grass and Legumes

TREATMENT	RCCG	RCCL
SVL (1:3)	0.32[a]	2.81[a]
SVL (2:2)	-744[b]	-1930[d]
SVL (3:1)	0.21[a]	1.86[a]
SVB (1:3)	0.37a	6.12a
SVB (2:2)	-811[bc]	-1702[c]
SVB (3:1)	0.22[a]	1.43[a]
SVS (1:3)	0.39[a]	10.45[a]
SVS (2:2)	-871[c]	-701[c]
SVS (3:1)	0.22[a]	1.31[a]
P value	<.0001	<.0001

Means with different superscripts within the same column are significantly different (P<0.05). RCCG = relative crowding coefficient grass, RCCL = relative crowding coefficient legume.

4.1.5 Aggressivity Index

The aggressivity index of grass in all mixture irrespective of sowing proportion showed negative sign while those of legumes were positive (Table 4). This is indicative of the fact that the legumes were more aggressive than the grass.

Table 4: Aggressivity Index of Grass and Legumes

TREATMENTS	AIG	AIL
SVL (1:3)	-0.971^{d}	0.971^{cd}
SVL (2:2)	-0.355^{c}	0.355^{d}
SVL (3:1)	-0.190^{bc}	0.190^{de}
SVB (1:3)	-2.039^{a}	0.039^{f}
SVB (2:2)	-2.926^{e}	2.926^{a}
SVB (3:1)	-0.108^{b}	0.108^{e}
SVS (1:3)	-1.881^{de}	1.881^{b}
SVS (2:2)	-0.731^{c}	0.731^{d}
SVS (3:1)	-0.667^{d}	0.667^{cd}
P value	<.0001	<.0001

Means with different superscript within the same column are significantly different (P<0.05). AIG = aggressivity index grass, AIL = aggresivity index legumes

Morphological characteristics of grass and legumes are shown in Tables 5

4.1.6 Leaf Area.

The leaf area of grass in the mixture was highly significantly greater (P<0.05) In *Sorghum almum*-Stylo (1:3 and 2:2) compared to other mixtures in the case of legumes, *Sorghum almum* Stylo (2:2 and 3:1), and *Sorghum almum*-lablab (1:3 and 3:1) had highly superior (P<0.05).Leaf area than other mixtures.

4.1.7 Tillers Number

The number of tillers produce by grass in mixtures was not significantly different ($P<0.05$) except in the case of grass in *Sorghum almum* /lablab (2:2) that produced highly significantly ($P<0.05$) number of tillers than grass in *Sorghum almum*- Stylo mixtures (3:1).

4.1.8 Leaf to Stem Ration

Leaf to stem in grass was highly significantly greater ($P<0.05$) in *Sorghum almum*-lablab (2:2) compared to other mixtures. In the case of legumes the leaf to stem ratio in *Sorghum almum*-lablab (1:3) was highly significantly higher ($P<0.05$) than those of *Sorghum almum*-burgundy (1:3) and *Sorghum almum*-Stylo (1:3).

Table 5: Morphological Characteristics of Grass and Legumes

TREATMENTS	LAG	LAL	TILLER(s)	L/SG	L/SL
SVL (1:3)	112.3^{b}	130^{a}	23.8^{ab}	0.864^{b}	0.949^{a}
SVL (2:2)	87.4^{c}	94.4^{b}	27.3^{a}	2.24^{a}	0.793^{ab}
SVL (3:1)	99.4^{bc}	119^{a}	25.3^{ab}	1.411^{b}	0.825^{ab}
SVB (1:3)	76.1^{c}	28.7^{c}	25^{ab}	0.683^{b}	0.622^{b}
SVB (2:2	77^{c}	24.9^{c}	25.5^{ab}	0.660^{b}	0.798^{ab}
SVB (3:1)	31.7^{d}	24.8^{c}	23.3^{ab}	0.654	0.804^{ab}
SVS (1:3)	137^{a}	21.8^{c}	25^{ab}	0.860^{b}	0.724^{b}
SVS (2:2)	144^{a}	143^{a}	23^{ab}	1.036^{b}	0.746^{ab}
SVS (3:1)	87.3^{c}	141^{a}	19^{b}	0.81^{b}	0.828^{ab}
P value	<0.001	<.0001	0.052	0.002	0.045

Means with different superscripts within the same column are significantly different ($P<0.05$). LAG = Leaf area grass, LAL = leaf area legume, L/SG = Leaf to stem ratio grass, L/SL = Leaf to stem ration legume.

4.2 DISCUSSION

EXPERIMENT I

4.2.1 Dry Matter Yield

Dry matter yield is a measured of pasture productivity. The higher dry matter yield recorded by grass monocultures compared to monoculture of legumes and mixture (Table 1) may probably be due rapid rate of growth in grasses and their fibrous root system which enabled them to extract nutrient and water from the ground. Baba *et al.,* (2011) reported higher dry matter yield in grass compared to monocultures of legumes and mixture. Similarly, caballero *et al.,* (1995) reported lower yield of mixtures than monocultures which they attributed to competition between the intercropped species. The greater dry matter yield recorded by 2:2 grass-legume mixture may be explained in the context that the dry matter yield of the grass component seemed to be favored more at this ratio, perhaps due to more nitrogen made available to the grass via nitrogen fixation.

4.2.2 Relative Yield

The higher relative yield of legumes compared to grass in mixture (Table 2) lent credence to the higher dry matter yields recorded by legume in mixture (Table 1) this indicates that the relative yield is a function of dry matter yield of the component species in mixture. The relative yield of less than 1 in mixtures with the exception of guinea-burgundy mixtures (2:2) meant that there was no advantage in intercropping. Ansen *et al.,* (2004) reported no yield advantage in pea cereal forage mixture compared to cereal forage sole crop.

4.2.3 Relative Crowding Coefficient (K) and Aggressivity Index

The higher relative crowding coefficient of legumes compared to grass (Table 3) in almost all mixtures is indicative of higher competitive ability of legume compared to grass in mixture. Tessema and Baars (2006) reported higher mean relative crowding coefficient values of panicum and chloris in mixture with medicago and desmodium and attributed it to higher dry matter produced by panicum and chloris thus more competitive. The positive aggressivity index recorded by legumes compared to grass (negative) in this study is indicative of higher competitive ability of the legumes compared with the grass. Tessema and Baars (2006) showed that positive aggressivity index recorded by panicum and chloris in mixtures was indicative of superior competitive ability of the grasses compared to the legumes.

4.2.4 Tiller Number And Leaf to Stem Ratio

The higher tiller number and leaf to stem ration in sorghum-lablab 2:2 compared to other mixture must have contributed to the highest dry matter yield recorded by sorghum-lablab (2:2). Greater number of tiller connotes greater yield, while higher amount of leaves meant higher photosynthetic capacity.

4.3 RESULTS

EXPERIMENT II

4.3.1 Forage Dry Matter Yield

The dry matter yields of grass-legumes and total are shown in Table 6. The dry matter yield of grass was not significantly different among the mixtures, however, numerically, dry matter yield of grass in the grass lablab mixture tended to be higher (7377kg/ha) compared to the grass in *Sorghum almum*-burgundy and *Sorghum almum*-stylo. In the case of legumes, lablab had the highest dry matter yield (429 kg/ha) followed by Stylo (351 kg/ha) and burgundy (88 kg/ha). For mixtures, *Sorghum almum*-lablab produced higher yield (7806 kg/ha) compared to *Sorghum almum*-burgundy (7300 kg/ha) and *Sorghum almum*-stylo (5002 kg/ha). The dry matter yield in *Sorghum almum*-burgundy appeared to be higher than that of *Sorghum almum*-stylo. Percentage grass and legume were numerically higher in *Sorghum almum*-burgundy and *Sorghum almum*-Stylo respectively.

Table 6: Dry Matter Yield of Grass, Legume and Mixtures (kg/ha)

TREATMENT	DMYG	% grass	DMYL	% legumes	TDMY
SVL (2:2)	7377	94.5	429	5.4	7806
SVB (2:2)	7212	99	88	1	7300
SVS (2:2)	4651	93	351	7	5002
P value	0.296		0.666		0.278

Means with same letters within same column are not statistically different. ($P<0.05$). DMYG= dry matter yield grass, DMYL=Dry matter yield Legumes, TDMY= Total dry matter yield.

Morphological characteristics of mixtures are shown in Table 7.

4.3.2 Leaf Area

Leaf area grass was not significantly different among mixtures, however, numerically, leaf area of grass in grass-lablab tended to be higher (46.4) compared to *Sorghum almum*-burgundy (31.5) and *Sorghum almum*-stylo (28.9). In the case of legumes, significant differences were observed. Lablab produced superior ($P<0.05$) leaf area (25.03) than burgundy (2.95). No significant difference was observed between Stylo (10.58) and burgundy (2.95).

4.3.3 Number of Tillers

The number of tillers produced by grass was not significantly different among mixtures, however grass in grass lablab tended to produce highest tiller (18.25) compared to grass in *Sorghum almum*-Stylo (14.25) and *Sorghum almum* burgundy (13.25).

4.3.4 Leaf to Stem Ratio

Significant differences were found among mixtures in respect of leave to stem ratio recorded by grass. The grass in *Sorghum almum*-stylo had significantly higher ($P<0.05$) leaf to stem ratio than grass in *Sorghum almum*-burgundy. Leaf to stem ratio of legumes in mixtures were not significantly different.

Table 7: Morphological Characteristics of Mixtures

TREATMENT	LAG	LAL	TILLER (cm)	L/SG	L/SL
T1 SVL	46.4	25.03^{a}	18.25	0.623^{ab}	1.713
T2 SVB	31.5	2.95^{b}	13.25	0.553^{b}	1.530
T3 SVS	28.9	10.58^{ab}	14.25	0.755^{a}	1.885
P value	0.425	0.056	0.201	0.046	0.383

Means with same letters within same column are not statistically different.LAG=Leaf area grass, LAL=Leaf area legumes, PHG= Plant height grass, PHL=Plant height legumes, L/SG=Leaf to stem ratio grass, L/SL=Leaf to stem ratio legumes.

4.3.5 Chemical Analysis.

Chemical analysis of mixtures were shown in table 8

Percentage ash was greater ($P<0.05$) in *Sorghum almum*-lablab than *Sorghum almum* Stylo, no significant difference was found between *Sorghum almum*-burgundy and *Sorghum almum*-lablab ditto for *Sorghum almum* burgundy and *Sorghum almum* Stylo. Other proximate component of mixtures such as CP and EE were not significantly different among mixtures, however, in absolute terms CP and ether extract tended to be higher in *Sorghum almum*-lablab mixture compared to *Sorghum almum* Stylo and *Sorghum almum* burgundy. Fibre fractions (NDF and ADF) were also not significantly different, however, both tended to be lower in *Sorghum almum* lablab compared to *Sorghum almum* Stylo and *Sorghum almum* burgundy. In the case of mineral composition of mixtures, no significant difference were found among mixtures, however, Ca and mg had numerically higher values in *Sorghum almum*-lablab compared to *Sorghum almum*-burgundy and Stylo.

Table 8: Proximate Composition, Fibre Fractions in and Mineral Composition of Mixtures

TREATMENT	ASH	CP	EE (%)	ADF	NDF	Ca	Mg (g/kg)	P
SVL (2:2)	6.57[a]	19.9	1.33	32	44	3.42	1.63	11.4
SVB (2:2)	5.23[ab]	19.1	1.17	35.9	50.8	2.69	1.59	14.8
SVS (2:2)	4.57[b]	17.9	1.67	39.4	51	2.71	1.39	14.6
P value	0.046	0.563	0.274	0.264	0.456	0.250	0.783	0.409

Means with different superscripts within the same column are significantly different

4.3.6 Digestible Dry Matter, Dry Matter Intake and Relative Feed Value.

The digestible dry matter, dry matter intake and relative feed value are shown in Table 9. There were no significant different significant differences among mixtures in terms of Dmd, Dmi and Rfv, however, the trios were observed to be higher in numerical values in *Sorghum almum*-lablab mixture compared to *Sorghum almum*-burgundy and *Sorghum almum*-Stylo mixtures

Table 9: Nutritive Value of Mixtures

TREATMENT	DMD	DMI	RFV
T1 SVL	63.9	2.83	138.9
T2 SVB	60.9	2.37	112.2
T3 SVS	58.2	2.37	106.8
P value	0.263	0.350	0.130

Means with different superscripts within same column are significantly different DMD=Dry matter digestibility (%), DMI= Dry matter intake (%) of body weight, RFV=Relative feed value.

4.4 DISCUSSION EXPERIMENT II

4.4.1 Dry Matter Yield and Morphological Characteristics of Forage Mixtures

Dry matter production is a function of the nature of competition among various species in a mixture. Although no significant differences were observed, the seemingly higher dry matter recorded in *Sorghum almum*-lablab mixture may indicate better compatibility in this mixture compared to other mixtures, this is buttressed by the fact that the yields of both grass and legumes were higher in this mixture than other mixtures. Seresinhe *et al* (1994) reported that inclusion of legumes in pasture mixture stimulated the growth and increased nitrogen uptake of grass. Nyfeler *et al* (2009) reported similarly The higher dry matter yield recorded by lablab among legumes in mixture with *Sorghum almum* may have enriched the soil better through the activities of nitrogen fixing bacteria leading to somewhat higher productivity of both the grass and legume in *Sorghum almum*-lablab mixture compared to other mixtures .This is further supported by the fact that both grass and legume in *Sorghum almum*-lablab mixture had higher leaf area suggestive of a higher capacity to capture solar radiation for photosynthesis. Amanullah *et al*. (2013) in an experiment to determine growth dynamics in Oats (Avena sativa L) at different nitrogen and phosphorus application indicated positive relation between leaf area and photosynthesis.

The higher number of tiller in (absolute terms) recorded by the grass in *Sorghum almum* -lablab mixture agrees with the report of Brown and Ashley (1974) who observed that increased nitrogen availability increased tillering.

4.4.2 <u>Chemical Composition of Forage Mixtures</u>

Proximate component, such as Crude protein and ether extract were observed to be higher in *Sorghum almum*-lablab mixture, the higher Cp content in this mixture may be attributed to higher proportion of lablab in terms of dry matter yield compared to other legumes (Stylo and burgundy). In the case of ether extract ,the higher value observed in *Sorghum almum*-lablab mixture may probably be due to the fact that lablab had started seeding prior to harvest hence oil from the seeds could have increased the ether extract content of the mixture. The lower values NDF and ADF recorded by *Sorghum almum*-lablab mixture compared to other mixtures confers some nutritional benefit to the mixture as it is indicative of a feed with higher digestibility.

Mineral content of mixtures (Ca and mg) were higher in *Sorghum almum*-lablab mixture compared to other mixtures, this again could be due to the higher proportion of lablab in the mixture compared to other legumes. Miles and Manson (2000) reported higher mineral content in forage legumes than grasses. The mineral content of the current study, meet the requirement for beef cattle nutrition as reported by NRC (2000).

Other nutritive value indices such as DMD, DMI and RFV were higher in *Sorghum almum*-lablab mixture compared to other mixtures this is suggestive of higher quality pasture made possible by the higher dry matter yield of the lablab in mixtures. This is consistent with the result of Ezenwa and Aken'Ova (1998) who observed that legumes do contribute significantly to the nutritive value of grass species in legumes grass mixture Lithourgidis *et al., (*2006) reported that the RFV index can be used to predict the intake and energy value of the forages. The RFV of current study ranged from138.9 to 106.8. Albayrak (2012) gave the categorization of RFV in forages as follows 151 (Prime), 150-125 (Premium), 124-103 (Good), 102-87 (Fair), 86-75 (Poor), Less than 75 (Rejected).

In the light of the above, the quality of the mixtures produced ranged from good to premium there by corroborating the earlier statement.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Two studies were conducted to evaluate compatibility of *Sorghum almum* grass in mixture with 3 legume forages (*Lablab purpureus*, *Stylosanthes hamata* verano and *Macroptilium bracteatum* burgundy bean) in terms of the nature of competition, dry matter yield and morphological characteristics as well as chemical composition of mixtures. The experiment was conducted in the field of the Faculty of Agriculture Bayero University, Kano.

The experimental design was randomized complete block design consisting of 15 treatments replicated in four blocks distances between blocks and plots were 1m and 0.5m respectively. The treatments were *Sorghum almum* legumes mixtures in the ratio of 0:4, 1:3, 2:2, 3:1, and 4:0.Seeds of grass and legumes were sown in 1x1m^2 plots on 5th August, 2014 in accordance with De Wit (1960) replacement principles.

The result of the study indicated that grass monoculture recorded significantly higher total dry matter yield ($P<0.05$) than monoculture of legumes and mixtures except in the case of monoculture of lablab observed to be statistically at par with its corresponding grass monoculture. Total dry matter yield was highest in 2:2 grass lablab mixtures (2675kg /ha) among mixtures, while lablab had the highest total dry matter yield (3513kg /ha) among legume mixtures. Total relative yield values were higher at 2:2 grass-legumes mixture compared to 1:3 and 3:1mixtures.

It was concluded that there was no advantage in intercropping between *Sorghum almum* and the duo of *Lablab purpureus* and *Stylosanthes hamata* based on relative yield values of less than 1 although *Sorghum almum*-lablab 2:2 had the highest dry matter yield among mixtures. Competition indices parameters such as relative yield, relative crowding coefficient favored 2:2 sowing ratio.

Experiment 2 evaluated the dry matter and chemical composition of mixture of *Sorghum almum* and legumes (*Lablab purpureus*, *Stylosanthes hamata* and *Macroptilium bracteatum*) at 2:2 sowing ratio. Experiment was conducted at screen house of the Agronomy Department of the Faculty of Agriculture Bayero University Kano.

The treatments consisted of three grass legumes (*Lablab purpureus*, *Stylosanthes hamata* and *Macroptilium bracteatum*) repeated 4 times in a completely randomized design, the seeds were sown in 12 plastics containers on 22^{nd} April, 2015 containing 50kg soil mixture 3:1 loam/sand respectively.

The result of the study indicated that most of the parameters measured were not significantly different however, in absolute value dry matter yield value of grass (7377 kg/ha) and legume (429 kg/ha) were higher in *Sorghum almum*-lablab mixtures compared to other mixtures. Similarly for total dry matter yield of mixtures (7806 kg/ha) morphological characteristics such as leaf area grass, leaf area legumes as well as tiller were observed to be greater in *Sorghum almum*-lablab in numerical values compared to other mixtures.

Chemical composition parameters such as Cp, Ee, Ash and % Calcium and magnesium were observed to be higher in *Sorghum almum*-lablab mixture while, the values for ADF and NDF were the least. Other quality parameters (dry matter digestibility, dry matter intake and relative feed value) were similarly higher in *Sorghum almum*-lablab mixture based on the dry matter yield values and nutritive value Sorghum almum-lablab mixture 2:2 ratio was recommended.

5.2 CONCLUSION

The first experiment indicated no yield advantage in the mixture of *Sorghum almum*-lablab and *Sorghum almum-Stylosanthes hamata.* (Relative yield values less than 1) although *Sorghum almum*-lablab 2:2 recorded higher dry matter yield compared to other mixtures. The result of the second experiment also showed no significant differences among most of the parameters measured. However, in absolute value *Sorghum almum*-lablab tended to have higher dry matter yield compared to other mixtures. There by confirming the result of the first experiment in terms of dry matter yield.

Nutritive value parameters also seem to favors *Sorghum almum*-lablab .in conclusion therefore *Sorghum almum*-lablab 2:2 is recommended for establishment if the goal of the farmer is to achieve higher dry matter yield and nutritive value. The only snag is the fact that none of the mixtures had 30% proportion of legume in mixture as advocated by most researchers in grass-legumes mixtures.

5.3 RECOMMENDATION

- If the goal of the farmer is to achieve higher dry matter yield and nutritive value, *Sorghum almum*-lablab 2:2 mixture was recommended.

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