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Yield and quality of fodder maize intercropped with lablab and cowpea for ruminant feeding in the humid zone of Nigeria

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ABSTRACT: Inadequate feed resources, resulting from pressure on natural grazing systems due to land shortages and insecurity, have threatened food security in Sub-Saharan Africa. To ameliorate this challenge, the study was undertaken to determine the effect of manure on yield and quality of fodder maize intercropped with lablab and cowpea. Land was divided into 40 sub plots in a 5 by 2 factorial arrangement with 4 replicates. Seeds of fodder maize, cowpea and lablab sown either sole maize, lablab, cowpea with no manure (NOMA) or with manure (MANU) and maize intercropped with cowpea (MC) or lablab (ML) with NOMA or with MANU. Results showed that maize and lablab intercrops had significantly ($p<0.05$) higher dry matter yield (DMY) (16.80 tha^{-1}) than maize-cowpea intercrops (13.23 tha^{-1}) ($p<0.05$). The highest ($p<0.05$) value of 1.67 in land equivalent ratio (LER) was recorded for MLMANU ($P<0.05$). Cowpea with manure had the highest ($p<0.05$) CP of 20.20 g 100 g^{-1} ($p<0.05$). Crude fibre (CF) was increased ($p<0.05$) in MNOMA ($p<0.05$). Minerals were increased ($p<0.05$) in the legumes and intercrops ($P<0.05$). There was an increase in DMY in plots with MANU compared to NOMA. Maize-lablab outperformed maize-cowpea in quantity and intercropping maize with lablab and cowpea improved fodder quality and quantity.

Keywords: Fodder, intercrop, legumes, maize.

INTRODUCTION

Farming systems in most developing countries is under serious threat due to increasing population growth, urbanization, climate change and environmental degradation. In Africa, almost all ruminant animals' feed supply is expected from natural rangeland. Due to paucity of land, arable farming is expanding at the expense of traditional grazing land and this is putting pressure on grazing resources resulting in inadequate feed resource for livestock both in terms of quality and quantity (Denekew and Asefa, 2012). Achieving and maintaining satisfactory animal performance throughout the year has been a major challenge to ruminant productivity. This has been the main reason for the migration of the nomadic Fulani herdsmen in Nigeria to move their cattle from one region to another in search of feed for their animals (Ofuoku and Isife, 2010). The problem of land insecurity for adequate feed supply has also discouraged potential ruminant farmers from venturing into the cattle business (Phillip *et al*., 2009).

The traditional feeding system for ruminants is now based on dried pasture and crop residues, which are poor-quality roughages, characterized by high fibre, low nitrogen contents, and slow fermentation rates (Yayneshet, 2010). Feeding poor dietary combination leads to decreased intake, weight loss, increased susceptibility to diseases, low reproduction and invariably reduced overall productivity of ruminant animals. It is against this backcloth that there is increasing interest by animal nutritionists and other researchers to search for means of improving the feed resource base of ruminants for improved productivity to meet the protein needs of the teeming population in Nigeria and other developing countries (Lamidi and Ologbose, 2014).

Maize straw is used as an animal fodder since the ancient times and is considered as an alternative forage source for ruminants' feeding when other forage sources are limited (Shi *et al*., 2021). But **i**nformation about the management of maize as a cereal green forage is emerging in the developing world because the fodder quality of green maize is far excellent, producing better nutritional quality along with a good quantity of biomass than other non-legume cultivated fodder (Chaudhary *et al*., 2012). Maize has the potential to supply large amounts of energy-rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic acid. Thus, forage maize has become a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improves forage intake, increases animal performance and reduces production costs (Iqbal *et al*., 2006). Maize fodder can be utilized as hay, silage, or green chop for ruminants. It has a high content of digestible starch, water-soluble carbohydrates (WSC) and fibre, creating a high-energy feed suitable for ruminants when harvested at the recommended maturity stage but with a relatively low crude protein content which would require some degree of protein supplementation for the animals (Masoero *et al*., 2006; Nadeau *et al*., 2010).

Boosting the energy and protein needs of ruminants could be achieved through cultivating a mixture of growing crops in mixtures. Crop mixtures, generally referred to as intercropping, is a husbandry system in which two or more types of crops are cultivated on the same area of land in the same season, having the potential to boost the forage protein content of diets (Guleria and Kumar, 2016). It has several agronomic benefits such as improvement in soil fertility, efficient use of resources, reduction in damage caused by pest and diseases, and improvement in forage quality through complementary effects of the intercropped forages (Sileshi *et al*., 2011). Intercropping systems in ruminant production are of important benefit such as better productivity and profitability to livestock production through the provision of balanced feed supply to the animals.

Forage legumes provide enough protein, ranging from 12% to as high as 25% depending on species; cultivar, harvest date and local conditions (McDonald *et al*., 2011). However, the use of legumes as a sole feed has also been limited by the availability of fermentable fibre which is available in forage cereals (Mupangwa, 2000). Mixing legumes and grasses serves as the forage supplementary alternative since pure grasses or cereals alone provide poor-quality fodder due to their inherent lower crude protein content. Forage from intercropped legumes with cereals improves the intake of dietary nitrogen, digestibility of poor-quality feed, animal performance and efficiency of roughage feed utilization by ruminants. The improvement in digestibility alone leads to a 15–30% reduction in methane emission per unit of animal product (Njarui and Wandera, 2004).

Lablab (*Lablab purpureus*) is a fast-growing legume that can provide fodder in less than three 3 months after sowing (ILRI, 2013). It is suitable in intercropping systems where it can be cultivated with grasses (Cook *et al.*, 2005). Being palatable to livestock, it is an adequate source of much-needed protein and can be utilized in several different ways. It can be grazed in a pasture setting or as a companion crop to maize, cut as hay, or mixed with corn silage. In several experiments, it has been observed to increase livestock weight and milk production. It was observed that lablab increased the yield of intercropped maize even when the upper part of the lablab plant was cut for livestock feeding (Nyambati *et al*., 2009).

Cowpea (*Vigna unguiculata)* is another precious tropical and subtropical legume especially cultivated grown in the semi-arid regions of the tropics for forage, green pods and grains (Adeyanju *et al.*, 2007). Cowpea green fodder and hay is a nutritious feed material for animals and can also be intercropped with fodder cereal crops for a higher yield and quality compared to sole cropping (Dahmardeh *et al.*, 2009). These researchers found out that intercropping of maize and cowpea resulted in more digestible dry matter and increased crude protein content than maize sole cropping. In maize-cowpea intercropping, cowpea prepares maize with more nitrogen, leading to more N uptake, and therefore, more crude protein of maize in intercropping compared with its sole crop.

The productivity of the intercrops could be influenced by spatial arrangement and the soil fertility status. Therefore, crops grown in mixtures may compete spatially and temporally among species for available resources yielding different outputs. In the cereal-legume intercropping system, the choice of crop species is one of the key considerations in determining the yield and quality of the product (Maitra *et al*., 2020). Most yield intercropping researches have focused on two crop intercropping systems and arable/grain crops. One option to improve the quality and quantity of fodder is the implementation of intercropping practices. To the best of our knowledge, literature on intercropping for fodder production for ruminant feeding in Southwestern Nigeria is quite scanty. Therefore, this study was undertaken to assess the yield and quality of fodder maize intercropped with lablab and cowpea with or without organic manure as combination crops for ruminant feeding.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Ekiti

State, Nigeria. Ado-Ekiti is in the Humid Zone of West Africa (HZWA), which has a tropical climate with bimodal rainfall distribution between April and October with a peak between June and September. Between November and March is the dry season. The location is between latitudes 07°371'N and 05°491'E, with temperatures between 23 and 32°C, a bimodal rainfall range of 1250 to 1460 mm, a mean annual rainfall of 1367 mm, with an average number of wet days of roughly 112 per year.

Land preparation and experimental design

The land was properly ploughed and harrowed with the debris worked into the soil. Upon preparation, the plot was divided into 40 sub-plots measuring 4.5 m by 4.5 m and 1 m walkway in 10 rows and 4 columns using Randomized Complete Block Design (RBCD) in a 5 by 2 factorial arrangement with 4 replicates. The two factors are the type of crop and manure application. The layout is as follows:

1. Maize (Manure, No manure)
2. Lablab (Manure, No manure)
3. Cowpea (Manure, No manure)
4. Maize and Lablab (Manure, No manure)
5. Maize and Cowpea (Manure, No manure)

Seeds of fodder maize (SAMMAZ-54), Cowpea (SAMPEA 14) and Lablab (WHITE RONGAI) were obtained from the National Nigerian Animal Production Research Institute (NAPRI) Shika-Zaria, Kaduna, Nigeria. The experiment lasted for 3 months, between 1st May and 2nd August 2021

Sowing and management practices

A total of 0.5 ha of land was used in the intercrops. Seeds were sown using single-row spacing. Seeds were sown at the rate of 2-3 seeds per hole with a spacing of 30 cm by 30 cm for maize, 50 cm by 20 cm for Lablab, and 30 cm by 20 cm for cowpea. Cured poultry manure was broadcast two weeks before planting into the manure treatment plot at the rate of 1 ton/ha. Upon germination, thinning or supplying was done as the case may be. The plot was secured and fenced using a 16 mm iron rod 5ft tall and barbed wire. All agronomic practices were maintained.

Soil sampling and laboratory analysis

The land was ploughed and harrowed, and surface soil samples (0-15cm) were randomly collected from the experimental plots using soil auger and bulked for a composite sample. The soil was air dried and analysed for physical and chemical properties using the method described in IITA (1979). Some physical and chemical characteristics of the soil in the experimental site such as soil pH, organic matter content, total nitrogen, available phosphorus and other minerals were evaluated while the soil textural class of the soil was determined.

Yield Assessment

Green fodder was harvested at the 2 m x 2 m quadrant in each of the plots at the late milk stage of maize growth. Yield indices that were obtained include green forage yield, land equivalent ratio, and dry matter yield. Green fodder in each of the replicates were harvested and was weighed to obtain the fresh green fodder yield. The fresh weighed fodder was dried under shade for 3 days after which was re-weighed to obtain the dry fodder yield. The Land Equivalent Ratio was calculated as the sum of the fractions of the intercropped yield divided by the sole crop yield.

Chemical analysis

The leaf meals from each replicate were analysed for crude protein, ash, dry matter, crude fibre, neutral detergent fibre (NDF), nitrogen free extract (NFE) and ether extract (EE). The mineral constituents that were analysed include Na (Sodium), P (Phosphorus), K (Potassium), Ca (Calcium) and Mg (Magnesium) using the Atomic Absorption Spectrophotometer according to AOAC (2005) procedure.

Statistical analysis

The data obtained were analysed using a two-way analysis of variance (ANOVA), followed by Duncan’s multiple range comparison at a 5% level of significance ($p<0.05$) with the SAS (2005) Statistical Package.

RESULTS

Some physical and chemical characterizations of the soil and poultry manure in the experimental site are shown in Table 1. The pH of the soil was 6.84, and the textural class revealed the proportion of sand, silt and clay as 58.33 gkg^{-1}, 27.47 gkg^{-1} and 14.20 gkg^{-1}, respectively. The available organic matter was 1.88 gkg^{-1} and phosphorus was 4.63 $mgkg^{-1}$. The soil contained 0.25, 0.26, 1.33, 0.68 and 0.10 $cmolkg^{-1}$ potassium, sodium, calcium, magnesium and total nitrogen, respectively, while the C-N ratio was 6.2:1. The pH of the poultry manure used as an organic fertilizer in the manure treated plot was 5.97. Available P was 7.60 gkg^{-1}. The organic matter and total nitrogen were 18.70

Table 1. Physico-chemical properties of soil and manure.

Characteristics	Soil	Poultry manure
pH	6.84	5.97
Sand (gkg^{-1})	58.33	-
Silt (gkg^{-1})	27.47	-
Clay (gkg^{-1})	14.20	-
Organic carbon (gkg^{-1})	1.88	18.70
Phosphorus ($mgkg^{-1}$)	4.63	7.60
Potassium ($cmolkg^{-1}$)	0.25	3.07
Sodium ($cmolkg^{-1}$)	0.26	0.16
Calcium (gkg^{-1})	1.33	1.29
Magnesium (mgg^{-1})	0.68	0.76
Total Nitrogen ($mgkg^{-1}$)	0.30	3.89
C/N ratio	6.2-1	6.5-1
Textural class	Sandy loam	-

Table 2. Fresh biomass yield, dry matter yield (tha^{-1}) and land equivalent ratio of sole and intercrops of maize, lablab and cowpea.

Treatments	DMY	FBY	LER
MNOMA	10.30^{e}	29.17^{d}	---
MMANU	8.63^{f}	30.03^{d}	---
LNOMA	6.31^{g}	19.57^{e}	---
LMANU	6.33^{g}	21.71^{e}	---
CNOMA	2.17^{h}	7.97^{f}	---
CMANU	2.60^{h}	8.27^{f}	---
MLNOMA	14.90^{b}	47.77^{b}	1.34^{b}
MLMANU	16.80^{a}	53.57^{a}	1.67^{a}
MCNOMA	11.70^{d}	35.47^{c}	1.06^{c}
MCMANU	13.23^{c}	38.32^{c}	1.24^{b}
SEM	0.38	1.38	---

a, b, c, d, e, f, g Means in the same column with same superscript are not significantly different ($p>0.05$). Note: MNOMA (Maize no manure), MMANU (Maize manure), LNOMA (Lablab no manure), LMANU (Lablab manure), CNOMA (Cowpea no manure), CMANU (Cowpea manure), MLNOMA (Maize, lablab no manure) , MLMANU (Maize, lablab manure), MCNOMA (Maize, cowpea no manure), MCMANU (Maize, cowpea manure), MCLNOMA (Maize, cowpea, lablab no manure) MCLMANU (Maize, cowpea, lablab manure).

and 6.89gkg^{-1}, while the values for K, Ca, Na and Mg were 3.07, 1.29, 0.16 and 0.76 $cmolkg^{-1}$, respectively.

Table 2 shows the fresh biomass yield, dry matter yield and land equivalent ratio of fodder maize intercropped with cowpea and lablab, with or without manure. There were significant differences ($p<0.05$) in fresh biomass yield in all the treatments. In the sole cropping categories denoted by maize with or without manure (MMANU, MNOMA), lablab with or without manure (LMANU, LNOMA), and cowpea with or without manure (CMANU, CNOMA), the least fresh biomass yield (FBY) of 7.97 tha^{-1} was recorded for CNOMA. Lablab with manure (LMANU) yielded an appreciable fresh biomass yield of 21.71 tha^{-1} while the highest yield of 30.03 tha^{-1} was obtained from MMANU. For the intercrops denoted by maize-lablab with or without manure (MLMANU, MLNOMA), maize-cowpea with or without manure (MCMANU, MCNOMA), the highest FBY (53.57 tha^{-1}) was obtained when maize was intercropped with lablab with incorporation of manure (MLMANU). There was a significant difference ($p<0.05$) in the yield of MLMANU and MLNOMA (53.57 and 47.7 tha^{-1}) respectively while the other FBYs both in intercrop and sole cropping did not show any significant differences ($p>0.05$) with or without manure.

Results of the dry matter yield (DMY) of maize intercropped with cowpea or lablab with or without manure

Table 3. Proximate characteristics (g kg^{-1}) of leaf meal obtained from maize intercropped with lablab and cowpea, with or without manure.

Forage	DM	CP	CF	ASH	EE	NDF	ADF	NFE
MNOMA	90.10	8.43^{f}	24.57^{a}	6.10^{d}	1.87^{d}	51.50^{a}	35.83^{a}	49.10^{a}
MMANU	90.90	9.20^{f}	23.63^{a}	7.00^{d}	2.17^{d}	51.83^{a}	34.80^{a}	49.03^{a}
LNOMA	89.67	17.10^{b}	17.57^{c}	13.23^{a}	3.80^{b}	39.63^{cd}	29.50^{bc}	38.27^{cd}
LMANU	88.83	18.03^{b}	16.87^{c}	13.63^{a}	4.23^{a}	35.43^{e}	25.47^{f}	37.23^{cd}
CNOMA	90.27	18.33^{b}	13.50^{d}	14.10^{a}	4.07^{a}	40.03^{bc}	27.70^{de}	40.27^{bc}
CMANU	90.23	20.20^{a}	14.13^{d}	14.60^{a}	4.40^{a}	37.63^{de}	26.53^{ef}	35.13^{d}
MLNOMA	89.40	12.40^{e}	20.93^{b}	10.47^{bc}	3.20^{c}	44.17^{b}	31.30^{b}	42.40^{b}
MLMANU	89.70	13.93^{cd}	20.27^{b}	11.60^{b}	4.03^{a}	40.53^{bc}	28.80^{cd}	39.90^{bcd}
MCNOMA	90.03	13.07^{de}	20.33^{b}	9.60^{c}	4.03^{a}	43.13^{b}	31.07^{b}	42.83^{b}
MCMANU	90.43	14.97^{c}	20.87^{b}	10.20^{bc}	4.70^{a}	38.83^{cde}	28.03^{cd}	38.90^{bcd}
SEM	1.25	0.42	0.65	0.49	0.19	1.44	0.88	1.68

a, b, c, d, e, f, Means in the same column with same superscripts are not significantly different (p>0.05). Note: CP (crude protein), DM (dry Matter, CF (crude Fibre), EE (Ether extract), NDF (Neutral detergent fibre), ADF (acid detergent fibre), NFE (nitrogen free extract), SEM (standard error of mean).

showed a similar pattern as obtained in the fresh biomass yield. Sole cowpea with or without manure recorded the least DMY of 2.60 and 2.17 tha^{-1}, respectively, without any significant differences (p>0.05). Compared with CMANU and CNOMA, a significantly higher (p<0.05) yield was obtained in the DMY of LMANU and LNOMA (6.33 tha^{-1} and 6.31 tha^{-1}, respectively). Maize and lablab intercrops with or without manure (MLMANU and MLNOMA) had significantly higher (p<0.05) DMY (16.80 and 14.90 tha^{-1}, respectively) than maize-cowpea intercrops (13.23 and 11.70 tha^{-1}, respectively). However, the DMY of MNOMA (10.30 tha^{-1}) outperformed that of MMANU (8.63 tha^{-1}).

In terms of land equivalent ratio (LER), a significantly highest (p<0.05) value of 1.67 was obtained from MLMANU. There were no significant differences (p>0.05) in the LER of MLNOMA and MCMANU (1.34 and 1.24, respectively). The least value of 1.06 was obtained for MCNOMA.

Table 3 shows the chemical composition of leaf meal of fodder maize intercropped with cowpea, lablab with or without manure. Dry matter showed no significant difference (p>0.05) in all the leaf meals. In the sole cropping categories, the least DM of 88.83 g $100g^{-1}$ was recorded in LMANU. Maize with manure (MMANU) had the highest DM of 90.90 g $100g^{-1}$. There were significant differences (p<0.05) in crude protein (CP) in all the treatments. In the sole cropping categories, the least CP of 8.43 g $100g^{-1}$ was recorded for MNOMA. Cowpea with manure (CMANU) had the highest CP of 20.20 g 100 g^{-1}. For the intercrops, the least CP of 13.07 g $100g^{-1}$ was obtained in MCNOMA.

Crude fibre fiber (CF) contents of the leaf meals ranged from 13.50 g $100g^{-1}$ in CNOMA to 24.57 g $100g^{-1}$ in MNOMA. The CF of the sole cropping legumes were lowest and similar with no significant differences (p>0.05) in LNOMA, LMANU, CNOMA, CMANU (17.57, 16.87, 13.50 g $100g^{-1}$, respectively). Significantly highest (p<0.05) values were obtained in MNOMA and MMANU with 24.57 and 23.63 g $100g^{-1}$, respectively. The CF of the intercrops were significantly higher (p<0.05) than those of sole legumes but they showed no significant differences (p>0.05) among the means (20.93, and 20.27, 20.33, 20.87 g $100g^{-1}$) for MLNOMA, MLMANU, MCNOMA, and MCMANU respectively.

There were significant differences (p<0.05) in the values of ash in all the treatments. In sole cropping categories, the least value of 6.10 g $100g^{-1}$ was obtained in MNOMA. Lablab and cowpea with or without manure had significantly higher (p<0.05) but similar values in all the treatments, which ranged from 13.23 g $100g^{-1}$ in LNOMA to 14.60 g $100g^{-1}$ in CMANU. In the intercrops, the least values (p<0.05) of ash were obtained from MCNOMA at 9.60 g $100g^{-1}$ while those with manure had significantly better (p<0.05) ash values of 11.60 g $100g^{-1}$ for MLMANU.

In the values of ether extract (EE), significant differences (p<0.05) were obtained in all the treatments. In the sole cropping categories, EE had the least value of 1.87 g $100g^{-1}$ in MNOMA and the highest (4.40 g $100g^{-1}$) in CMANU. For the intercrops, MCMANU had the highest value of 4.70 g $100g^{-1}$ while MLNOMA recorded the least value of 3.20 g $100g^{-1}$.

Neutral Detergent Fiber (NDF) in the leaf meals of the treatments also showed significant differences (p<0.05) in the mean values. While there were no significant differences (p>0.05) in the NDF values of MNOMA and MMANU (51.50 g $100g^{-1}$ and 51.83 g $100g^{-1}$, respectively), these values were however higher than those of other treatments. There were considerable variations in the NDF values in sole and intercropped treatments but LMANU showed the least value of 35.43 g $100g^{-1}$ in all the

Table 4. Mineral constituents (g kg^{-1}) of leaf meal obtained from fodder maize intercropped with cowpea and lablab.

Treatments	Na	K	P	Ca	Mg
MNOMA	0.70^{bc}	0.88^{d}	0.25^{f}	0.74^{c}	0.28^{bcd}
MMANU	0.90^{a}	1.03^{cd}	0.33^{cf}	0.79^{c}	0.39^{ab}
LNOMA	0.40^{ef}	1.67^{ab}	0.34^{cf}	1.59^{b}	0.10^{e}
LMANU	0.57^{cde}	1.77^{a}	0.80^{a}	1.91^{a}	0.24^{cde}
CNOMA	0.33^{f}	1.81^{a}	0.48^{de}	1.75^{ab}	0.13^{e}
CMANU	0.47^{def}	1.91^{a}	0.73^{bc}	1.80^{ab}	0.20^{de}
MLNOMA	0.65^{bcd}	1.31^{bc}	0.49^{de}	1.57^{b}	0.40^{ab}
MLMANU	0.75^{abc}	1.32^{bc}	0.72^{bc}	1.73^{ab}	0.43^{a}
MCNOMA	0.61^{cd}	1.05^{cd}	0.57^{c}	1.77^{ab}	0.31^{bc}
MCMANU	0.83^{ab}	1.14^{cd}	0.76^{b}	1.92^{a}	0.42^{a}
SEM	0.06	0.11	0.05	0.11	0.05

a, b, c, d, e, f, means in the same column with same superscript are not significantly different (p>0.05). Note: Na = Sodium, K = Potassium, P = Phosphorus, Ca = Calcium, Mg = Magnesium, and SEM = Standard Error of Mean.

treatments.

The acid detergent fibre (ADF) in all the treatments showed some significant differences ($p<0.05$). In sole cropping, MNOMA and MMANU had significantly higher but statistically similar ($p>0.05$) ADF of 35.83 g100g^{-1} and 34.80 g100g^{-1} respectively among all the treatments. The lowest values were obtained in the sole legume treatments of LMANU, CNOMA and CMANU at 25.47, 27.70 and 26.53 g100g^{-1} respectively.

Table 4 depicts the mineral constituents of the leaf meals from fodder maize intercropped with cowpea and lablab. There were variations in the mineral contents of the leaf meals with or without manure. Sodium (Na) values showed significant differences ($p<0.05$) in all the treatments. It ranged from 0.33 g 100g^{-1} in CNOMA to 0.90 g 100g^{-1} in MMANU. The values of potassium (K) were significantly increased ($p<0.05$) in LNOMA, LMANU, CNOMA and CMANU (1.67, 1.77, 1.81, and 1.91 g 100g^{-1}, respectively) while the least value was obtained in MNOMA at 0.88 g 100g^{-1}. There were significant differences ($p<0.05$) in the values of phosphorus (P) in all the treatments. Fodder maize without manure (MNOMA) had the least value of 0.25 g 100g^{-1} while the highest value was obtained from LMANU at 0.80 g 100g^{-1}.

Calcium (Ca) showed significant differences ($p<0.05$) in all the treatments. The highest value was obtained in LMANU (1.91 g 100g^{-1}) while MNOMA and MMANU had the least values of 0.74 and 0.79 g 100g^{-1}, respectively. There were no significant differences ($p>0.05$) in the Ca content of the leaf meals of the legumes and their intercrops. These values ranged from 1.59 g 100g^{-1} in LNOMA to 1.92 g 100g^{-1} in MCMANU.

Magnesium (Mg) was decreased significantly ($p<0.05$) in the legumes leaf meals. It ranged from 0.10 g 100g^{-1} in LNOMA to 0.24 g 100g^{-1} in LMANU. It was higher in the fodder maize sole crop (0.28 and 0.39 g 100g^{-1} in MNOMA and MMANU, respectively) while the intercrops recorded significantly highest ($p<0.05$) values of Mg which ranged from 0.31 to 0.43 g 100g^{-1} in MCNOMA to MLMANU.

DISCUSSION

Fodder maize intercropped with lablab or cowpea with or without manure as sources of feeding for the ruminants was evaluated for yield and quality. Results revealed that the soil on which the fodder maize, intercropped with cowpea and lablab was cultivated was slightly acidic and sandy loam with moderate organic matter contents, moderate total nitrogen N and low available phosphorus based on soil test criteria established for soil in Nigeria (FDLAR, 2004). This is an indication that the soil in the study area could support moderate growth of crops.

The poultry manure used in this study was moderately acidic with high organic matter. This finding is in agreement with the report of Asiriuwa *et al*. (2013) that soil with high organic matter is rich in nutrients due to improved soil characteristics by lowering penetration resistance and increasing porosity of nutrient intake by plant roots. In addition, the level of organic matter recorded in this study is similar to the values of high organic matter obtained from poultry wastes as reported by some authors (Ayoola and Makinde (2007).

Moreover, the higher forage yield recorded in this study from intercrops compared with the sole cropping is in line with the report of Zhang *et al*. (2015) who reported higher forage yield in cereal legumes intercrops than sole cropping. It is also in consonant with the report of Ijoyah (2012) whose result indicated the superiority of inter-cropping maize fodder and lablab over sole cropping of maize. Mucheru *et al.* (2009) also stated that the main benefit of intercropping is the higher production compared to each crop in the mixture and the more effective use of all resources.

Additionally, sole cropping will always lead to lower biomass yield as seen in the cowpea sown alone which resulted in the least biomass production compared to other planting ratios with maize intercrop. This finding agrees with the works of Eskandari (2012), and Ali and Mohammad (2012) who reported that intercropping maize and legumes together produced more dry matter (DM) than sole cropping either species separately. The increment in DM seen in this study could be due to additive intercropping employed and not a replacement or alternate row intercropping. Besides, the yield increase that was noticed in a maize/soybean strip intercropping arrangement was primarily due to the upsurge in the border rows of maize together with soybeans (Li *et al*., 1999).

In this study, higher land use efficiency was observed in lablab intercropping than cowpea intercropping. This is similar to the result reported when a higher harvest index was recorded in lablab than cowpea intercropped with early maturing maize (Ewansiha *et al*., 2012). Although, in the study by Song *et al*. (2023) maize and cowpea appeared to be the best intercropping combination considering forage productivity and feed value in paddy fields than lablab.

However, some authors reported that there was difference in LER for lablab/cowpea and maize/cowpea (Lemlem, 2013). The reason for these differences might not be unconnected with the variety of seeds sown in different environments but lablab is known for its vigorous vegetative growth and spread.

More importantly, the yield of forage is a very important measure of feed resources as this defines the volume of DM obtainable to livestock (Shi *et al*., 2013). From the above findings, higher LER in intercropping is a pointer to the fact that more land would be required in the practice of sole cropping to obtain the same yield of fodder compared to intercropping. This is a demonstration of the superiority of intercrops over pure stand in terms of the use of environmental resources for plant growth. On the other hand, the use of manure resulted in higher fodder yield than without manure, as the sole legumes and the intercrops performed better in fodder yield than those without manure. Ndengue*t al*. (2022) has earlier reported that using manure in small holder farm management yielded better results in maize/bush bean intercrop. This may be due to improved soil characteristics by lowering penetration resistance and increasing porosity of nutrient intake by plant roots (Asiriuwa *et al*., 2013). In terms of quality, the crude protein (CP) in the leaf meal of MNOMA 8.43 g100g^{-1} was the least of all the treatments which is lower than the 10% recommended for ruminants (Onwuka, 2005). This finding is in consonant with the report of Cusicanqui and Lauer (1999) which stated that corn forage has low protein compared to legume.

Furthermore, the CP of the legumes in this study ranges between 17.10 – 20.20 g100g^{-1}. This is contrary to the CP range of 10.1–17.2 g100g^{-1} reported for some tropical legumes by other researchers (Mupangwa, 2000). However, Gwanzura *et al.* (2012) obtained higher CP value in sole cowpea compared with sole lablab as obtained in this study. The high CP contents in the intercrops which are higher than for the sole maize are indication that leguminous plants such as lablab and cowpea have high potentials to meet the dietary protein requirement of ruminant animals. The higher CP in the intercrops is also in agreement with other studies where legumes also increased CP concentration when in a mixture with maize (Dahmardeh *et al*., 2009).

The crude fibre values obtained in the leaf meals of 13.50 g100g^{-1} in CNOMA to 24.57 g100g^{-1} in MNOMA in this work align with the nutritional requirements for optimum production of ruminants (NRC, 2007). Higher NDF and ADF values recorded for sole maize plantings compared with the intercrops also agreed with the results of other authors (Ayssiwede *et al.,* 2010; Eskandari 2012). The NDF and ADF contents of forage are reflections of the amount of forage that can be utilized used up by animals (Lithourgidis *et al*., 2006). The reduction in the protein content of the intercrops compared with the sole legumes is as a result of the fibre increase attributable to the dilution effect of the maize fodder. However, the yield advantage coupled with a significant reduction in NDF and ADF content can provide feed bulk, and meet the nutrient requirements of livestock with a resultant increase in feed digestibility (Eskandari, 2012).

Although cereals are extensively used in livestock nutrition, for their high dry material production and low price, they have low sustenance value due to their low forage worth because high forage harvest means more crude fibre but fewer ether extract and crude proteins (Eskandari, 2012; Ghanbari-Bonjar, 2000). Whereas, the fodder quality of legumes is high but may have low dry matter content (Ross *et al*., 2005). However, combination of the two as done in this study has the tendency to meet the nutrient requirements needed for ruminant productivity.

Additionally, the constituents of Na, K, P, Ca, and Mg obtained from the leaf meals in this study can be compared with those reported in other studies and are enough to supply the requirements of goats, sheep and cattle (Bannink *et al*., 2010; Adegun 2014).

Conclusions and Recommendation

The results of this study showed that intercropping fodder maize and legume (Lablab and cowpea) resulted in a better fresh biomass yield and productivity due to improved soil fertility by nitrogen fixation into the soil than sole cropping of fodder maize only. Manure application enhanced yield of both sole and intercrops. However, lablab intercrop with maize seems better than cowpea intercrop due to better LER. Maize, cowpea and lablab intercrops contain sufficient amount of minerals, DM, CP, CF, EE and NFE needed by ruminants. Intercropping maize with lablab and cowpea improved fodder quality and quantity. It is therefore recommended that fodder maize should be intercropped with lablab in an intensive feed garden for enhanced ruminant productivity.

CONFLICT OF INTEREST

The authors declare that they have no conflict interest.

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