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Original Research Article

Chemical composition of two maize varieties at different levels of green manure application

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Abstract

This study evaluated the chemical composition of two maize varieties at different levels of green manure application. The bucket experiment was laid in 2 × 3 factorial arrangement comprising two maize varieties (Oba super 2 and Suwan I) and three green manure application levels (0, 6.3 and 12.6 t/ha). The results showed that Oba super 2 had a lower ($p < 0.05$) Crude Protein (CP) (8.91%) content, but had a higher ($p < 0.05$) ether extract (8.83%) and ash (9.83%) contents as compared to Suwan I. Maize fertilised with 6.3 t/ha of green manure had the highest CP (10.13%) and ash (9.96%) contents. Interaction effect of variety and level of green manure application showed that the least CP content (7.61%) was recorded for unfertilised Oba Super 2 maize, whereas the highest CP content (10.21%) was recorded for Suwan I maize fertilised with 12.6 t/ha of green manure. There were no significant ($p > 0.05$) differences in the Neutral Detergent Fibre (NDF), Acid Detergent Lignin (ADL), hemicellulose and cellulose contents of the two maize varieties evaluated. However, the Acid Detergent Fibre (ADF) content was significantly ($p < 0.05$) higher (32.33%) in Oba Super 2 variety. The rising amounts of green manure applied significantly ($p < 0.05$) increased both the NDF and ADF. There was no consistent variation in the NDF content as influenced by interaction of both factors with the highest (60.67%) NDF content recorded for unfertilised Oba Super 2 maize. Calcium, potassium and phosphorus contents declined with the increasing amount of green manure added. Our results show that the green manure application improved the nutritional qualities of the planted maize and should be used in practice.

Keywords: fibre composition; fodder crop; mineral contents; organic fertiliser; proximate composition

INTRODUCTION

In Nigeria, ruminants experience under-feeding particularly during the dry seasons because of shortage or lack of forage and low nutritive quality of available crop residues. The available residues such as maize stover, maize cob, maize husk and cereal straws cannot meet the nutritional requirements of ruminants (Jonathan et al., 2008). Maize cobs are utilised as an animal feed since the time of cereal cultivation as they are unavoidably produced as cereal by-products. Maize grain is used to feed all domesticated animals and the whole maize plant is generally utilised for ruminants mostly as silage (Aquino et al., 1999). The whole maize plant is additionally available in dried and ground forms for ruminant nutrition and could be also useful in rabbit production. Attractive forage qualities include high dry matter yield, high protein content, high energy contents (high digestibility), high intake potential (low fibre content), and optimum dry matter content at harvest for adequate forage fermentation (Carter et al., 1991).

One of the serious issues confronting ruminant production in the tropics is the lack of quality feed for the livestock, and soil fertility issues in most tropical pastures (Aderinola, 2007). The forages are of lower nutritive quality (Akingbade et al., 2004) because native grasses are grown on low fertile soil which is not well appropriate for cropping (Humphreys and Partridge, 1995). The productivity of soils under long-term crop production has been declining for many years and this is also a challenge experienced in most developing countries (Kang et al., 1990). Although high crop yields can be obtained with the utilisation of inorganic fertilisers, different factors such as low income levels of the farmers and the increasing cost of the manures have accounted for the low utilisation of inorganic fertilisers by farmers (Tian et al., 1993; Buckles et al., 1998). Alternative ways to reduce nutrient insufficiency and declining soil efficiency are to explore natural sources of fertilisers such as farmyard manure (Gyamfi et al., 2001), however, applying farmyard manure has a few disadvantages like increased labour and cost to convey the manure from the farmyard to field.

In an agricultural system, where a steady supply of farmyard manure is often difficult, an alternative method of application of organic matters is green manuring and this is an old practice of using crops primarily as a soil amendment and a nutrient source for other crops, which lost importance as the use of mineral fertilizers became widespread. However, it is now expected to regain importance as a result of an increased interest in organic food production (Thorup-Kristensen et al., 2003; Dahlin et al., 2005; Cherr et al., 2006). Significant cost of fertilisers, increasing concern for ecological stability and economical soil efficiency have prompted renewed interest in green manure and organic fertilisers (Fageria, 2007). Research on green manure in West Africa is dated back to 1920's when mucuna was tested as an improved fallow species in South Western Nigeria (Faulkner, 1934) and since then, countless herbaceous legumes have been tested. In many parts of West Africa, green manure has been adopted as a low input technique for addressing the issue of declining soil fertility emerging from populace pressure, intensive cultivation and shortening neglected periods (Manyong et al., 1999).

The flow of nutrients in and out of agricultural systems is generally described by lower storage capacity, less cycling effectiveness, continual shortfall and net expulsion of nutrients, unlike natural system where biomass production is in balance with nutrient reserves (Hendrix et al., 1992). The utilisation of organic fertilisers to replenish depletion in soil fertility and diminish contamination to the climate which oftentimes occurs as a result of persistent utilisation of chemical fertilisers is gaining interest around the world, among the natural sources of manure are farmyard manure, compost and green manures. The more promptly available green manures from leguminous crop therefore constitute a significant potential source of nitrogen (N) and organic manure (Meelu et al., 1994). Evans et al. (1983) demonstrated that the utilisation of green manure by small scale farmers in developing countries would not only increase crop yield by numerous folds, but would likewise improve the physical and chemical properties of the soils with minimum environmental risk.

With increasing challenges in agriculture regarding environmental change, outrageous climate conditions, soil degradation and land contamination by the over-utilised agricultural synthetic substances, growing green manure proves to be a practical method of securing the long-term productivity of farmlands. When soils lose their fertility, ability to cultivate crops and plant to sustain its health is reduced. Green manuring is the act of planting crops that will be turned into the soil with the purpose to increase organic matter and replenish nutrients. Regardless of the enormous beneficial impacts of green manuring, it is not a common practice among peasant farmers, who contribute up to 98% of the food consumed in Nigeria (Ozowa, 1995).

Green manure crop can be a crop, or crop-derived fertilizer, that is incorporated directly in situ or brought from a distance (mobile green manure). It can be grown during parts of the growing season, throughout the whole year or for several years, depending on cropping system and the purpose of the green manure, but the characteristic that all the different forms of green manure have in common is that they are non-commercial crops (Suhr et al., 2005). One of the advantages of organic manure is that they supply more than one of the, many substances required by plants for their growth (Amos et al., 2015). We hypothesised that the application of green manure will increase the nutritional quality of planted maize. Therefore the aim of this study was to determine the chemical composition of maize grown from green manure legumes.

Table 1. Physico-chemical analysis of the soil

	0	6.3	12.6
		t/ha	
pH (%)	6.77	6.56	6.57
Sand (%)	92.27	92.07	91.20
Silt (%)	1.41	2.43	3.47
Clay (%)	6.32	5.5	5.33
Ca (Cmol)	3.63	3.65	3.85
Mg (Cmol)	1.05	1.12	1.18
K (Cmol)	0.12	0.15	0.17
Na (Cmol)	0.33	0.35	0.38
Al+H (Cmol)	0.05	0.06	0.06
ECEC (Cmol)	5.47	5.36	5.45
Base saturation (%)	98.65	97.77	98.51
N (%)	0.05	0.07	0.11
Organic carbon (%)	0.66	0.71	0.97
P (mg/kg)	11.46	12.79	12.97
Mn (mg/kg)	40.36	38.84	45.57
Fe (mg/kg)	2.2	3.52	11.89
Cu (mg/kg)	0.72	1.02	0.94
Zn (mg/kg)	2.87	3.37	2.83

AL+H = Exchangable acidity
ECEC = Effective cation exchange capacity

MATERIALS AND METHODS

Experimental site

The experiment was carried out in buckets which were put in an open area, protected from rodents within the premises of College of Animal Science and Livestock Production, while the laboratory analysis was carried out at the laboratory of Department of Pasture and Range Management, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.

Soil sampling

Buckets were filled with 7 kg (dry weight) top soil and sub-samples were taken from the buckets, sieved with 4 mm sieve to remove coarse materials and analysed for physical and chemical indicators.

Sourcing of planting materials and experimental procedure

The maize varieties (Oba super 2 and Suwan 1) used in this study were sourced from a reputable agro-allied company in Ogun State and the varieties were selected on the basis of high yield, adaptability to the climatic zone and resistance to diseases whereas the browse plant used as green manure (*Leucaena leucocephala*) was harvested from a fully mature tree within the premises of the University. The leaves and twigs of *L. leucocephala* were incorporated at 20 and 40 g (DM) per bucket; equivalent to 6.3 t/ha and 12.6 t/ha, respectively, and allowed to decompose for three weeks. After decomposing, soil samples were taken for routine analysis. Then two maize seeds were sown within a depth of 3–5 cm in each bucket.

Experimental design

The experiment was laid out in 2 × 3 factorial design consisting of two (2) maize varieties (Oba super 2 and Suwan I) and three (3) levels of green manure application (0 g, 20 g which is equivalent to 6.3 t/ha and 40 g which equivalent to 12.6 t/ha) with ten (10) replicates. The maize plants were harvested at 9 weeks after sowing.

Laboratory analysis

Proximate composition: The dry matter, crude protein, ether extract and ash contents of the milled maize varieties were determined according to A.O.A.C. (2000). Non-fibre carbohydrate was calculated as NFC = 100 – (CP + Ash + EE + NDF).

Fibre fraction analysis: Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) contents of the milled maize varieties were determined with the procedure of Van Soest et al. (1991). Cellulose content was taken as the difference between ADF and ADL while the hemicelluloses content was calculated as the difference between NDF and ADF.

Mineral content determination: The milled maize varieties were analysed for macro nutrients (calcium, phosphorus, potassium and magnesium) and micro minerals (copper, iron, zinc and manganese) contents with atomic absorption spectrophotometry (Fritz and Schenk, 1979).

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) and treatment means was separated using Duncan Multiple Range Test (DMRT) using the SAS (1999) package.

RESULTS

There were significant ($p < 0.05$) differences on the crude protein (CP), ether extract (EE) and ash contents of the maize varieties evaluated (Table 2). Oba super 2 significantly ($p < 0.05$) had lower CP content (8.91 %), but had significantly ($p < 0.05$) higher EE (8.83 %) and ash (9.83 %) contents than Suwan I. The green manure application levels significantly ($p < 0.05$) affected the proximate composition parameters in which dry matter (DM) content ranged from 91.75 % recorded for maize fertilised with 6.3 t/ha of green manure, to 93.58 % recorded for maize fertilised with 12.6 t/ha of green manure. Crude protein and ash contents

Table 2. Proximate composition of two maize varieties as affected by levels of green manure application

Factors	Dry matter	Crude protein	Ether extract	Ash	Non-fibre carbohydrate
Maize varieties					
Oba Super 2	92.94	8.91^{b}	8.83^{a}	9.83^{a}	14.71
Suwan I	92.28	10.13^{a}	7.79^{b}	9.11^{b}	14.72
SEM	0.88	0.05	0.67	0.03	1.40
Levels (t/ha)					
0	92.50^{ab}	8.86^{c}	7.75^{b}	8.86^{c}	11.93^{b}
6.3	91.75^{b}	10.13^{a}	8.25^{ab}	9.96^{a}	15.49^{a}
12.6	93.58^{a}	9.59^{b}	9.08^{a}	9.57^{b}	16.71^{a}
SEM	1.15	0.41	0.23	0.08	0.09

^{a,b,c}: means on the same column with different superscript are statistically significant ($p < 0.05$); SEM: Standard error of the mean

Table 3. Interaction effect of varieties and levels of green manure application on proximate composition (%) of maize

Maize varieties	Levels (t/ha)	Dry matter	Crude protein	Ether extract	Ash	Non-fibre carbohydrate
	0	94.50^{a}	7.61^{c}	8.67^{ab}	8.61^{d}	14.44^{bc}
Oba Super 2	6.3	92.00^{ab}	10.16^{a}	8.50^{ab}	9.54^{bc}	16.81^{ab}
	12.6	92.33^{ab}	8.96^{b}	9.33^{a}	9.18^{c}	12.87^{cd}
	0	90.50^{b}	10.07^{a}	6.83^{b}	9.12^{c}	18.98^{a}
Suwan I	6.3	91.50^{b}	10.10^{a}	8.00^{ab}	10.39^{a}	14.18^{bc}
	12.6	94.83^{a}	10.21^{a}	8.83^{ab}	9.96^{ab}	10.99^{d}
SEM		3.42	0.42	1.42	0.45	0.53

^{a,b,c,d}: means on the same column with different superscript are statistically significant ($p < 0.05$); SEM: Standard error of the mean

Table 4. Fibre composition of two maize varieties as affected by levels of green manure application

Factors	NDF	ADF	ADL	Hemicellulose	Cellulose
Maize varieties					
Oba Super 2	58.44	32.33^{a}	7.67	26.11	24.67
Suwan I	57.44	30.78^{b}	7.33	26.67	23.44
SEM	0.67	1.16	1.55	2.40	2.76
Levels (t/ha)					
0	57.83^{b}	30.00^{b}	8.00	27.83	22.00
6.3	56.17^{c}	31.00^{b}	7.17	25.17	23.83
12.6	59.83^{a}	33.57^{a}	7.33	26.17	26.33
SEM	1.33	1.15	0.67	1.76	1.43

^{a,b,c}: means on the same column with different superscript are statistically significant ($p < 0.05$)
NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin

followed the order 6.3 > 12.6 > 0 t/ha. The contents of ether extract increases (7.75 < 8.25 < 9.08 %) as the level of green manure increases (0 < 6.3 < 12.6 t/ha).

The interaction effect of the variety and green manure application levels was significant ($p < 0.05$) on the proximate composition parameters evaluated (Table 3). The DM content ranged from 90.50 % recorded for unfertilised Suwan I maize to 94.83 recorded for Suwan I maize fertilised with 12.6 t/ha of green manure. Suwan 1 with 12 t/ha green manure had the highest (10.21 %) CP content although there was no significant ($p > 0.05$) differences between Oba Super 2 with 6.3 t/ha, Suwan 1 without green manure application and Suwan 1 with 6.3 t/ha green manure the least (7.61 %) CP content was recorded in Oba Super 2 without green manure application. Oba Super 2 with 12.6 t/ha green manure recorded the highest (9.33 %) ether extract content and there were no significant differences between unfertilised Oba Super 2, Oba Super 2 with 6.3 t/ha and Suwan 1 with 6.3 and 12.6 green manure application. Meanwhile, Suwan 1 with 6.3 t/ha green manure had the highest

Table 5. Interaction effect of varieties and levels of green manure application on fibre composition (%) of maize

Maize varieties	Levels (t/ha)	NDF	ADF	ADL	Hemicellulose	Cellulose
Oba Super 2	0	60.67^{a}	31.33^{ab}	8.67	29.33^{a}	22.67^{ab}
	6.3	55.00^{c}	32.00^{ab}	6.67	23.00^{b}	25.33^{ab}
	12.6	59.67^{ab}	33.67^{a}	7.67	26.00^{ab}	26.00^{ab}
Suwan I	0	55.00^{c}	28.67^{b}	7.33	26.33^{ab}	21.33^{b}
	6.3	57.33^{bc}	30.00^{ab}	7.67	27.33^{ab}	22.33^{ab}
	12.6	60.00^{ab}	33.67^{a}	7.00	26.33^{ab}	26.67^{a}
SEM		2.14	1.84	1.34	0.43	0.64

^{a,b,c}: means on the same column with different superscript are statistically significant ($p < 0.05$)
NDF: Neutral detergent fibre; ADF: Acid detergent fibre; ADL: Acid detergent lignin

Table 6. Mineral contents of two maize varieties as affected by levels of green manure application

	Ca	K	P	Fe	Cu	Zn
		g/kg			mg/kg	
Maize varieties						
Oba super 2	4.31^{a}	24.05^{a}	1.88^{b}	390.10^{a}	9.83^{a}	11.74^{a}
Suwan 1	4.38^{a}	27.32^{a}	2.71^{a}	205.78^{b}	4.97^{b}	11.17^{a}
SEM						
Levels (t/ha)						
0	3.91^{c}	21.78^{b}	1.57^{b}	432.37^{a}	8.13^{a}	11.47^{a}
6.3	4.29^{b}	27.60^{a}	2.61^{a}	196.35^{c}	6.74^{a}	11.89^{a}
12.6	4.83^{a}	27.67^{a}	2.72^{a}	265.10^{b}	7.33^{a}	11.01^{a}
SEM						

^{a,b,c}: Means in same column with different superscripts are significantly ($p < 0.05$) different.
SEM = Standard error of the mean

Table 7. Interaction effect of varieties and levels of green manure application on mineral contents

Maize varieties	Levels (t/ha)	Ca	K	P	Fe	Cu	Zn
			g/kg			mg/kg	
Oba super 2	0	3.89^{c}	18.60^{c}	1.31^{c}	705.28^{a}	12.10^{a}	12.43^{ab}
	6.3	4.24^{c}	24.99^{bc}	2.09^{b}	175.80^{d}	8.73^{b}	13.63^{a}
	12.6	4.79^{ab}	28.56^{b}	2.25^{b}	289.23^{b}	8.65^{b}	9.17^{c}
Suwan 1	0	3.93^{c}	18.56^{c}	1.83^{bc}	159.46^{d}	4.17^{c}	10.50^{bc}
	6.3	4.33^{bc}	26.65^{b}	3.12^{a}	216.90^{cd}	4.75^{c}	10.15^{c}
	12.6	4.87^{a}	36.74^{a}	3.20^{a}	240.98^{bc}	6.00^{c}	12.85^{a}
SEM		0.09	1.36	0.14	32.49	0.56	0.39

^{a,b,c}: Means in same column with different superscripts are significantly ($p < 0.05$) different
SEM = Standard error of the mean

(10.39 %) ash content and Suwan 1 without green manure application recorded the highest non-fibre carbohydrate content of 18.98 %

There were no significant ($p > 0.05$) differences in the NDF, ADL, hemicellulose and cellulose contents of the maize varieties evaluated (Table 4). However, the ADF content was significantly ($p < 0.05$) higher in Oba Super 2 (32.33 %), than in the Suwan I (30.78 %) maize variety. The amounts of green manure applied significantly ($p < 0.05$) influenced th NDF but there was no significant difference in varieties without green manure and varieties with 6.3 t/ha as regards to ADF content which was significantly lower than varieties with 12.6 t/ha.

There were significant ($p < 0.05$) differences in the fibre composition of maize due to the interaction effect of the varieties and green manure application levels except the ADL content (Table 5). There was no consistent variation in the NDF content; the highest (60.67 %) NDF content was recorded for the unfertilised Oba super 2 maize. Irrespective of the variety, the ADF and cellulose contents decreased as the green manure application amounts increased. Hemicellulose content ranged from 23.00 % in maize fertilised with 6.3 t/ha of green manure to 29.33% in unfertilised Oba Super 2 maize variety.

Suwan 1 maize variety only had higher (2.71 g/kg) content of phosphorus and Oba super 2 was significantly ($p < 0.05$) higher in iron (390.10 mg/kg) and copper (9.83 mg/kg) contents. There was a decline in calcium, potassium and phosphorus contents as the levels of green manure application increased (0 < 6.3 < 12.6 t/ha). Although, there was statistically difference in potassium and phosphorus contents at 6.3 and 12.6 t/ha level of green manure application and there was no significant ($p > 0.05$) difference in the micro mineral contents except Iron (Table 6). Calcium content increased with the increased green manure application in both maize varieties whereby Suwan 1 had highest (4.87 g/kg) content and there was also an increase in potassium and phosphorus contents as the green manure application increased from 0 to 12.6 t/ha in both maize varieties with Suwan 1 at 12.6 t/ha application level recorded the highest potassium (36.74 g/kg) and phosphorus (3.20 g/kg) contents. Fe and Cu contents was highest (705.28 and 12.10 mg/kg, respectively) in Oba Super 2 without green manure application and there was statistically similarity in Cu content of Suwan 1 at all levels of green manure application. Also, there was statistically similarity in Zn content of Oba Super 2 with 6.3 t/ha green manure and Suwan 1 with 12.6 t/ha green manure application (Table 7).

DISCUSSION

The whole maize plant is a forage with a moderate content of fibres and low content of crude protein (CP) which ranged from 4 to 13% per DM, and acid detergent lignin ranged between 1.0 and 7.4% per DM (Dardenne et al., 1993). The CP content of maize varieties examined suggested that they contain nutritional attributes that can support ruminant production as they were in the range of 8 to 11% recommended for growing ruminants as reported by Gatenby (2002). They are accordingly satisfactory for meeting the protein requirement for growing ruminants, in this manner producing a significant level of ammonia in the rumen to guarantee an effective digestion process (Orskov, 1995). The CP contents of maize varieties examined were above the critical (7%) limit below which intake of forages by ruminants and rumen microbial activity would be antagonistically influenced (Van Soest, 1994) and the CP were higher than the critical value of 7.7% or 77 g/kg recommended for small ruminants (NRC, 1981) yet lower than the minimum protein requirement of 10–12% suggested for dairy feedlot (ARC, 1985). The values fell within the range reported by Peter et al. (2008) for five (5) maize varieties which also surpassed the value of 7.4 and 6.5% reported by Amodu et al. (2014) for two maize varieties harvested at 105 and 119 days after sowing, respectively. The variations in the crude protein content might be due to the varieties of maize used and this is in agreement with the findings of Awun et al. (2001) who reported significant difference in crude protein content in maize varieties.

The increase in crude protein content observed in the present study with green manuring, rather than what was noticed in unfertilised (control) treatments inferred that the application of the green manure might have made more nitrogen accessible to the plants for uptake, than when left unfertilised. The current discernment confirmed the findings of Fabunmi and Balogun (2015) that the timely application of organic fertilisers such as green manure could synchronise nutrient release with plant interest for short cycle crops with high demand such as maize. Nutrients from the green manure crops were progressively released or mineralised when the crop was incorporated into the soil and hence decomposed (COG, 1992). As a consequence, the subsequent uptake of the released nitrogen by the plants, being a basal segment of amino acid might have improved the protein content and increment in crude protein contents with nitrogen application from green manure sources, were in a like manner reported by Ahmad (1999) and Ali (2000). The levels of green manure application did not affect the ether extract contents of the fodder and this varied from the findings of Ayub et al. (2002) who reported a decline in fat contents with nitrogen application for less mature plants. Ash content in a food substance shows inorganic remaining parts after the organic matter has been consumed by extreme heat and gives an estimate of the whole mineral substance of a food. The variations in the ash content of the maize varieties established that differences existed in the chemical composition of the maize varieties assessed. Higher ash content recorded for Oba Super 2 infers that perhaps the varieties had a better mineral uptake potential over Suwan I. In general, the ash content recorded for both maize varieties was higher than the range of total ash content reported by Ullah et al. (2010) for ten maize varieties grown in Pakistan and the values reported by Kumar and Kweera (2014) for five maize varieties.

Neutral detergent fibre (NDF) is a significant factor in ration formulation as it reflects the proportion of forage that can be consumed animals (Bingol et al., 2007). Content of NDF is negatively correlated with intake and digestibility (Oramas and Vivas, 2007). Thus, to obtain forages with high energetic value, it is important to utilise maize hybrids with NDF contents less than 60 %. This study revealed that the varieties of maize were comparable in their NDF and ADL contents; however, the ADF content was higher in Oba Super 2, which implied that in terms of digestibility Suwan I might have better digestibility attributes, since ADF is an extent of digestibility. The results of the present study indicated that increasing NDF content as the level of green manure application increased was in contrary with the report of Hoekstra et al. (2007), that changes in the nutritional composition related with the fertilisation, either by organic or inorganic sources is normally noted by decreasing structural constituents in the plants, and also against the findings of Cox and Cherney (2001), that fibre content declines at higher fertiliser application rate. The clarifications for the differences in the results of the present study, and the previous studies, might not be unconnected to the presence of stem materials which likewise increased with fertilisation. This further shows the significant contribution that the presence of stem material had modified the nutritional quality of the plants. This observation was the same for ADF content which was also higher in plants that received higher green manure levels, instead of the unfertilised, and those fertilised at lower green manure rate. Typically, the implication of increasing structural constituents is that dry matter intake and digestibility might be impaired (Albayrak and Mevlüt, 2011). As indicated by McDonald et al. (1995) and Gillespie (1998), NDF is inversely related to the plants' digestibility, and higher levels infer lower digestibility. However, the levels of NDF and ADF contents recorded in the present study were at levels that can be degraded by animals.

The ADF content in plant is used to estimate energy value of maize because it is constituted from cellulose, lignin and proteins and it is the component that is most related to forage digestibility (Castillo et al., 2009). The ranges of values obtained in this study were similar to the range of 27.3–34.7 % reported by INIFAP (2006) for the ADF content in maize fodder. The increase in ADF and cellulose contents as observed the plant matured might be clarified by the fact that increase in plant maturity prompts the production of more stems growth and invariably increasing their structural constituent. This agrees with the reports of Rao et al. (2007) and Turgut et al. (2008) that a decline in quality related to plant maturity is a consequence of the dilution effect of higher yield in the presence of a consistent measure of accessible minerals in the soil. During the maturing process in plants, photosynthetic products are more rapidly concerted to structural components, hence having the impact of decreasing protein and soluble carbohydrate and increasing the structural cell wall components (Ammar et al., 2004).

The major factors influencing mineral contents of forages are species, variety of plant, soil and environmental factors, stage of maturity and use of manure. Akinsoyinu and Onwuka (1988) reported that the presence of mineral elements in animal feed is significant for the metabolic processes in animals. Higher contents of calcium, phosphorus and potassium were found in Suwan 1, however with a lower content of iron than Oba super 2. The range of values recorded for Ca in this study was above the critical level of 3 g/kg DM recommended for ruminants (McDowell et al., 1993). The phosphorus concentration in this study was also above critical value of 2.5 g/kg DM for ruminants and a mean value of 1.2 g/kg DM as reported by Muhammad et al. (2004), and phosphorus content obtained in this study was in accordance with the requirement for cattle (1.1–4.8 g/kg), pregnant heifers and dairy cows (0.9–2.0 g/kg) (Eastridge, 2006). Hence, the difference in the mineral contents may be due to genetic factors or environmental factors such as irrigation frequency, soil composition and green manure used.

CONCLUSION AND RECOMMENDATION

The green manure application improved the nutritional qualities of the maize and the structural constituents were higher in Oba Super 2 except the crude protein content. There was also an increase in structural constituents and macro mineral contents as green manure application levels increased. Incorporation of green manure is recommended because it increases soil fertility which eventually improves the nutritional qualities of plants.

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CONFLICT OF INTEREST

The author declared no conflicts of interest with respect to research, authorship and publication of this article.

ETHICAL COMPLIANCE

The authors have followed the ethical standards in conducting the research and preparing the manuscript.

REFERENCES

Aderinola O. A. (2007): Herbage production and utilization of *Andropogon tectorum* as influenced by fertilizer application and legume intercrop. Ph.D. Thesis, Department of Animal Production Health, Ladoke Akintola University of Technology, Ogbomoso.

Ahmad B. (1999): Effect of different levels of nitrogen and seedling density on growth, yield and quality of maize fodder. M.Sc. (Hones) Agric. Thesis, Department of Agronomy, University of Agriculture Faisalabad, Pakistan.

Akingbade A. A., Akinlade J. A., Aderinola O. A. (2004): Pasture production and utilization in the derived Savannah of Nigeria. Damanik Publication Mapo Post Office Ibadan, pp. 16–20.

Akinsoyinu A. O., Onwuka C. F. I. (1988): Mineral constituents of some browse plants used in ruminant feeding in southern Nigeria. Nigerian Journal of Animal Production 15: 57–62.

Albayrak S., Mevlüt T. (2011): Changes in the forage yield and quality of legume–grass mixtures throughout a vegetation period. Turkish Journal of Agriculture and Forestry 37: 139–147.

Ali S. (2000): Effect of different levels of nitrogen and seedling rates on growth, yield and quality of Sorghum fodder. M.Sc. (Hones) Agric. Thesis, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Ammar H., López S., González J. S., Ranilla M. J. (2004): Chemical composition and digestibility of some Spanish browse plant species. Journal of Science and Food Agriculture 84: 197–204.

Amodu J. T., Akpensuen T. T., Dung R. J., Tanko A. M., Abubakar J. A., Hassan M. R., Jegede J. O., Sani I. (2014): Evaluation of maize accessions for nutrients composition, forage and silage yields. Journal of Agricultural Science 6: 178–187.

Amos H., Voncir N., Fagam A. S., Garba A. (2015): Effect of cattle manure on the growth and yield performance of maize (Zea mays saccharata) varieties under irrigation. Scholars Journal of Agriculture and Veterinary Sciences 2: 319–323.

AOAC (2000): Official methods of analysis 15th edition. Association of Official Analytical Chemists, Washington, D.C.

Aquino P., Carrión F., Calvo R. (1999): Selected Maite Statistics. In: CIMMYT. World Maize Facts and Trends 1997/98. CIMMYT. Mexico D. F. Becker M., Ladha J. K., Ali M. 1995: Green manure technology: potential, usage, and limitations. A case study for lowland rice. Plant and Soil 174: 181–194.

ARC (Agricultural Research Council) (1985): Nutrient requirements of ruminant livestock. Commonwealth Agricultural Bureaux, Farnham Royal, London, UK.

Awun T. H., Maqsooh M., Usman M., Hussain M. I. (2001): Studies on hybrid and synthetic cultivars of maize for forage yield and quality. Pakistan Journal of Biological Science 1: 232–234.

Ayub M., Nadeem M. A., Tanveer A., Hussain A. (2002): Effect of different levels of nitrogen and harvesting times on the growth, yield and quality of sorghum fodder. Asian Journal of Plant Science 1: 59–61.

Bingol N. T., Karsli M. A., Yilmaz I. H., Bolat D. (2007): The effects of planting time and combination on the nutrient composition and digestible dry matter yield of four mixtures of vetch varieties intercropped with barley. Journal of Veterinary Animal Science 31: 297–302.

Buckles D., Eteka A., Osiname O., Galib M., Galian O. (1998): Cover crops in West Africa: contributing to sustainable agriculture. International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria.

Carter P. R., Coors J. G., Undersander D. J., Albrecht K. A., Shaver R. D. (1991): Corn hybrids for silage: an update. Roth. In: Proceedings of annual corn and Sorghum research conference, 46th Chicago American Seed Trade Association, Washington DC, pp. 141–164.

Castillo J. M., Rojas B. A., Wingching J. R. (2009): Nutritional value of silage made with a mixture of corn in different stages of growth. Agronomia Mesoamericana 12: 59–66.

Cherr C. M., Scholberg J. M. S., McSorley R. (2006). Green Manure Approaches to Crop Production: A Synthesis. Agronomy Journal 98: 302–319.

COG (1992): Canadian organic growers Green manures Field crop handbook: 1.5. info@eap.mcgill.ca.

Cox W. J., Cherney D. J. R. (2001): Row spacing, plant density and nitrogen effects on corn forage. Journal of Agronomy 93: 597–602.

Dardenne P., Andrieu J., Barriere Y., Briston R., Demarquilly C., Femenias N., Lila M., Maupetit P., Riviere F., Ronsin T. (1993): Composition and nutritive value of whole maize plants fed fresh to sheep. II. Prediction of the in vivo organic matter digestibility. Annales de Zootechnie 42: 251–270.

Dahlin S., Kirchmann H., Kätterer T., Gunnarsson S., Bergstrom L. (2005): Possibilities for improving nitrogen use from organic materials in agricultural cropping systems. Ambio 34: 288–295.

Eastridge M. L. (2006): Major advances in applied dairy cattle nutrition. Journal of Dairy Sciences 89: 131–132.

Evans D. O., Yast R. S., Lunden G. W. (1983): A selected and Annotated Bibliography of Tropical Green Manures and Legumes. Research Extension Series, Hawaii Institute of Tropical Agriculture and Human Resources, No. 208, 221 p.

Fabunmi T. O., Balogun R. O. (2015): Response of Maize (*Zea mays* L.) to green manure from varying populations of cowpea in a derived savannah of Nigeria. African Journal of Food and Agriculture 15: 10138–10152.

Fageria N. K. (2007): Green manuring in crop production. Journal of Plant Nutrition 30: 691–719. DOI: 10.1080/01904160701289529

Faulkner O. T. (1934): Some experiments with leguminous crops at Ibadan, southern Nigeria, 1925–1933. Empire Journal of Experimental Agriculture 2: 93–102.

Fritz J. S., Schenk G. H. (1979): Quantitative Analytical Chemistry. 4th Ed., Allyn and Bacon, Inc., Boston, Massachusetts, USA.

Gatenby R. M. (2002): Sheep. The Tropical Agricultural Series. McMillan Publishers, pp. 408–515.

Gillespie J. R. (1998): Animal Science. Delmar Publishers, International Thompson Publishing Company, 1204 p.

Gyamfi E., Loos H., Anthofer J. (2001): Farmers' perceptions of adoption of soil fertility technologies. Paper presented at the International Conference of the Soil Science Society of Ghana (26th February to 2nd March 2001) held at Tamale, Ghana.

Hendrix P. F., Coleman D. C., Crossley D. A. (1992): Using Knowledge of nutrient cycling processes to design sustainable agriculture. Journal of Sustainable Agriculture 2: 63–81.

Hoekstra R. A., Bartels M., Verweij C. J. H., Boomsma D. I. (2007): Heritability of autistic traits in the general population. Archives of Pediatric and Adolescent Medicine 161: 372–377.

Humphreys L. R., Partridge A. (1995): A Guide to better pastures for the tropics Published by NSW Agriculture, 5th edition: Grass for the tropics: Guinea grass (*Panicum maximum*).

Instituto Nacional de Investigaciones Forestales, Agricolasy Pecucarias (INIFAP) (2006): Maize forrajero de alto rendimientoy calidad nutricional Libro Cientifico. No 3 Ed 1st ed, Mexico.

Jonathan S. G., Fasidi I. O., Ajayi A. O., Adegeye O. (2008): Biodegradation of Nigerian wood wastes by *Pleurotus tuber regium* (Fries) Singer. Bioresource Technology 99: 807–811.

Kang B. T., Reynolds L., Atta-Krah A. N. (1990): Alley Farming. Advances in Agronomy 43: 315–359.

Kumar U., Kweera B. (2014): Comparative analysis of nutritional value and aflatoxin level of maize grain from different site of Rajasthan. International Journal of Scientific and Technology Research 2: 333–335.

Manyong V. M., Houndékon V. A., Sanginga P. C., Vissoh P., Honlonkou A. N. (1999): Mucuna fallow diffusion in southern Benin. Impact, International Institute of Tropical Agriculture, Ibadan, Nigeria.

McDonald P., Edwards R. A., Greenhalgh J. F. D., Morgan C. A. (1995): Animal Nutrition, 5th edition. Longman, U.K., 607 p.

McDowell L. R., Conrad J. H., Hembry F. G. (1993): Minerals for Grazing Ruminants in Tropical Regions. University of Florida, Gainesville, USA.

Meelu O. P., Yadoinder S., Bijah S. (1994): Green manuring for soil productivity improvement. World Soil Resources Reports, No. 76, FAO Rome.

Muhammad M. J. (2004): Effect of sowing date and NPK fertilizer on growth and yield of quality protein maize in Northern Guinea Savanna of Nigeria. Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria, pp. 31–37.

NRC (1981): Nutritional Energetics of Domestic Animals and Glossary of Energy Terms. Washington, DC: National Academic Press.

Oramas W. C., Vivas Q. N. J. (2007): Evaluation of two hybrids and one variety of corn (*Zea mays*) in intensive crop and association with pean (*Phaseolus vulgaris*), for silage. Revista de la Facultad de Ciencias Agropecuarias 5: 28–35.

Orskov E. R. (1995): Optimizing rumen environment for cellulose digestion. In: Rumen Ecology Research Planning (Eds R. J. Wallace and A. Lahlou-Kassi). Proceedings of a Workshop held at ILRI, Addis Ababa, Ethiopia, 13–18 March 1995. pp. 177–182.

Ozowa V. N. (1995): Information needs of small scale farmers in Africa: The Nigerian example. Quarterly Bulletin of the International Association of Agriculture information specialist, IAALD/CABI; 40:1.

Peter K., Rayns F., Rosenfeld A. (2008): Green manures: A review conducted by HDRA as part of HDC Project FV 299. An investigation into the adoption of green manures in both organic and conventional rotations to aid nitrogen management and maintain soil structure, 37 p.

Rao S. C., Northup B. K., Philips W. A., Mayeux H. S. (2007): Inter-seeding novel cool-season annual legumes to improve Bermuda grass paddocks. Crop Science 47: 168–173.

Statistical Analysis System Institute Inc. (1999): SAS/ 24. STAT Programme, Carry, NC: SAS Institute Inc.

Suhr K., Thejsen J., Thorup-Kristensen K. (2005). Grøngødning, eftergrøder og daekafgrøder. Holmegaard, J. & Jørgensen, O. T. (eds). Dansk landbrugsrådgivning, Landcentret. Landbruksförlaget. 264 pp. In Danish.

Thorup-Kristensen K., Magid J., Stoumann Jensen L. (2003): Catch crops and green manures as biological tools in nitrogen management in temperate zones. Advances in Agronomy 79: 227–302.

Tian G. G., Kang B. T., Brussard L. (1993): Mulching effect of plant residues with chemically contrasting composition on maize growth and nutrients accumulation. Plant and Soil 153: 179–187.

Turgut L., Yanar M., Tuzemen N., Tan M., Comakli B. (2008): Effect of maturity stage on chemical composition and in situ ruminal degradation kinetics of meadow hay in Awassi sheep. Journal of Animal Veterinary Advances 7: 1061–1065.

Ullah I., Ali M., Farooqi A. (2010): Chemical and nutritional properties of some maize (*Zea mays* L.) varieties grown in NWFP, Pakistan. Pakistan Journal of Nutrition 9: 1113–1117.

Van Soest P. J. (1994): Nutritional Ecology of the Ruminant. 2nd edition, Ithaca, NY, USA: Comstock Publishing Associates/ Comell University Press. 47 p.

Van Soest P. J., Robertson J. B., Lewis B. A. (1991): Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74: 3583–3597.

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