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Effects of defoliation time of maize on leaf yield, quality and storage of maize leafs as dry season forage for ruminant production

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ABSTRACT

Shortage of feed during a dry season has remained a challenge to improving ruminant production in Nigeria. This study was aimed to develop a dry season feed for ruminants based on the production of hay from maize defoliation. Five maize defoliation treatments of maize at 4, 8, 12 and 16 weeks after planting as well as the undefoliated treatment was used to assess the leaf yield, quality and storage of maize leafs in a randomized complete block design with three replicates. Results showed that maize defoliation on or before 12 weeks after planting (WAP) reduced ($P < 0.05$) leaf and grain yields but produced the highest leaf dry matter (DM) with the highest level of crude protein. However, maize defoliated at 12WAP produced more leaf DM/ha and a crude protein content of about 12% with no reduction ($P > 0.05$) in grain yield. The crude protein content of maize leafs decreases ($P < 0.05$) with delayed defoliation while the fiber contents increased ($P < 0.05$). Storing maize leafs for 4 months did not have any significant effect ($P > 0.05$) on the DM and crude protein content as well as the weight of the leafs. It was therefore, concluded that the production of quality hay from maize leafs for dry season feeding of ruminants could be obtained by defoliating maize from 12 WAP and stored for a period of four months without significantly ($P < 0.05$) affecting the maize grain yield.

Key words: Maize, defoliation, forage, storage

Los efectos del tiempo de defoliación en el rendimiento, calidad y almacenamiento de las hojas de maíz como forraje estacional para la producción de rumiantes

RESUMEN

La escasez de comida durante la temporada estival constituye un desafío para la mejora de la producción de rumiantes en Nigeria. Este estudio focaliza en el desarrollo de alimento para rumiantes en la época estival, basado en la producción de heno a partir de la defoliación de maíz. Cinco tratamientos experimentales: un tratamiento testigo (sin defoliar) y cuatro tratamientos tras 4, 8, 12, y 16 semanas de la plantación, respectivamente, son utilizados para la valoración del rendimiento, calidad y almacenamiento de las hojas de maíz mediante un tratamiento de bloques aleatorios replicado tres veces. Los resultados mostraron como la defoliación del maíz, durante las primeras 12 semanas tras la plantación (WAP), aunque redujo el rendimiento de la hoja y el grano ($P < 0,05$), promovió la mayor cantidad de materia seca en hoja (DM) y el nivel más alto de proteína en el forraje. Por su parte, la defoliación del maíz en 12 WAP produjo una mayor DM/ha y un nivel de proteínas alrededor del 12% sin reducción ($P > 0.05$) en la producción del grano. Mientras el contenido de proteínas en el forraje decreció ($P < 0.05$) con defoliaciones tardías, el contenido de fibra aumentó ($P < 0.05$). El almacenamiento del maíz por cuatro meses no obtuvo ningún efecto significativo ($P > 0.05$) en la producción de DM, en el contenido proteico ni en el peso de las hojas. Por tanto, se puede concluir afirmando que se obtiene un heno de buena calidad como forraje estacional para la producción de rumiantes a las 12 WAP, sin obtener ningún beneficio representativo ($P < 0.05$) en el grano de maíz por su almacenamiento durante un período de cuatro meses.

Palabras clave: Maíz, Defoliación, Forraje, almacenamiento

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INTRODUCTION

The introduction of forages and crop residues into a crop – livestock farming systems in the tropics have been identified as one of the most ecological and economically viable means of recycling nutrient for natural resource management (Reynolds & Jabbar, 1994). Plants and its by products utilized in the feeding of livestock have long been a fundamental link in the food chain, especially in the smallholder traditional system. When these plants are properly produced and preserved, they have been found to be a potential feed resource for ruminants, especially during the dry season when forages are scarce thereby helping to reduce the cost associated with feeding concentrates and supplements (Wanapat et al., 1997; Schroeder, 2004). Therefore, continued research into providing good quality, year round feed for ruminants is very important. In particular, the agronomic characteristics of adapted forage species need to be explored to achieve maximum benefits from them.

Maize forage is nutritious to ruminants and contains an appreciable amount of protein, fat, vitamins and carbohydrates. They have been reported to increase productivity thus increasing the potential contribution of ruminants to man's meat, in a very cost effective manner (Abate & Abate, 1992; Kiruiro et al., 2001; Halima & Chauhan, 2003.). Several experiments have been carried out to evaluate the effect of defoliation on maize productivity (Kayango- Male & Abate, 1982; Fasae, 2008).

The goal of this research is to produce a dry season forage for ruminants by evaluating the effects of defoliation time on leaf yield, chemical composition and storage of maize leafs variety Downy mildew resistance strain (DMR-SR-L-Y) which is a late maturing variety and streak resistance, commonly cultivated in the early season by farmers in South Western Nigeria because of its adaptability to the environment.

MATERIALS AND METHODS

Experimental site

The experiment was conducted on the Teaching and Research Farm of the University of Agriculture, Abeokuta, Nigeria in the 2005 and 2006 cropping seasons. The site is located on latitude $7^{0}15'$N and longitude $3^{0}25'$E and 76 meters above sea level in the forest savannah transition zone of South Western Nigeria. It receives an average annual precipitation of 1,037mm, with a average annual temperature of 34.7 ^{o}C and average relative humidity of 82%. The soil of the experimental field is sandy loam and has 1.48% organic carbon, 0.14% total Nitrogen, 8.0mg kg $^{-1}$available Phosphorus, with 4.99, 0.86 and 0.45 meq 100g $^{-1}$ Ca, Mg and K, respectively, and a pH of 5.9 at 0.15m depth. Maize was planted on 29th April, 2005 and 11th May, 2006 at the same site with the same treatment allocated to each plot.

Maize Cultivation and Management

Five defoliation treatments of 4, 8, 12 and 16 weeks after planting (WAP) with the undefoliated treatment were arranged in a randomized complete block design with three replicates. The maize was sown at two seeds/ hill on 90 centimeters spaced rows and 40 centimeters along rows. Primextra herbicide was applied pre-emergent at planting and supplemented with hoe weeding for 5 weeks. Fertilizer was applied 10 days after planting and the second dose was applied at 4 WAP using a compound NPK (15:15:15) fertilizer at the rate of 100kg ha^{-1}.

At various stages of defoliation, half of the maize leafs from the soil level from each plant was pruned and weighed. The days to 50% silking (DTS) was measured as number of days after planting when 50% of the total plants per subplot silk, while the cob length was obtained from 10 selected cobs harvested for the grain yield. These cobs were picked randomly and arranged along a meter rule on a table, the average value of these cobs was taken as the cob length. The grain yield was obtained by selecting dried maize cobs from the four middle rows in each replicate at 17 weeks after planting. Harvested cobs were shelled, winnowed and weighed.

Storage process

Maize leafs were defoliated at 12WAP from the established plot. They were chopped using hand operated chuff cutter to small pieces and thereafter sun dried for 5 days to a moisture content of about 10%. While drying, the leafs were turned at regular intervals and then put into 20kg bags and stored for six months in a well ventilated room, where chemical changes due to storing were monitored.

Chemical analysis

The proximate composition of the defoliated and stored leafs of maize was determined by the method of AOAC (1995). The DM content was determined by oven drying at 65^{0}C for 24 hours to constant weight; crude protein content was analyzed by Kjeldahl method (%N x 6.25) and fat content by Soxhlet fat extraction method. The concentration of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of the leaf samples were also estimated by the method of Van Soest & Robertson (1985).

Statistical analysis

Data obtained were based on randomized complete block design and subjected to analysis of variance using the statistical package of SAS (1999). Significant means was separated using Duncan Multiple range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The defoliating maize (Table 1) on or before 8 weeks after planting (WAP) produced significant ($P< 0.05$) lower leaf and grain yields in both years, which might be attributed to the removal of the leafs at early vegetative stage. This is in consonance with the findings of Prioul (1983) and Crookstom & Hicks (1988) that early defoliation of maize leads to yield reduction.

Moreover, in this experiment, the defoliation of maize on or before 8WAP was done before the days to 50% silking.

Table 1. Leaf yield, days to 50% silking, cob length and grain yield of maize cultivar DMR-SR-L-Y as affected by defoliation time in two years.

Tabla 1*. Afectación de un tiempo de defoliación máximo de dos años en la productividad de hoja, los días para el 50% de la madurez floral, la longitud de la mazorca y la productividad del grano para la variedad de maíz DMR-SR-L-Y*

Defoliation - time (Weeks after planting)	Leaf yield (Kg ha^{-1}) + 2005 - 2006	Days to 50% silking+2005 - 2006	Cob length (cm) + 2005 - 2006	Grain yield (Kg/ha) + 2005 + 2006
4	727b - 983c	58a - 58a	13.0c - 12.7c	2077b - 2399c
8	995ab - 1139bc	56b - 57ab	13.6bc - 13.8c	2253b - 2651bc
12	1114a - 1317a	54c - 56bc	15.0ab - 14.9ab	2677a - 2963ab
16	1078a - 1296a	54c - 55bc	16.6a - 16.2a	2780a - 3129a
Undefoliated	983ab 1267ab	53c - 55c	16.4a - 16.3a	2834a - 3112a
Mean	979 - 1200	55.2 - 56.4	14.9 - 14.8	2494 - 2851
CV (%)	8.71 - 6.86	1.81 - 2.29	6.07 - 6.40	15.91 - 7.19
SE±	90.01 - 27.45	0.58 - 0.43	0.52 - 0.31	62.69 - 68.33

+Means followed by the same letter in a column are not significantly different (P<0.05)

This could have resulted in the delayed silking of up to 5 days observed in both years, thereby affecting the speed of crop development, either directly or indirectly through an effect on growth which if slowed, may affect cell differentiation at the onset of the next stage of crop development. Also, defoliation of maize before or on 8WAP produced tiny (P< 0.05) cobs suggesting that cob size was affected by early defoliation, which invariably affected the grain yield. However, defoliating maize at 12WAP and beyond in both years did not have any significant effect (P > 0.05) on the leaf and grain yields. This, however, shows that the severity of reduction in maize grain yield resulting from the loss of leafs depended on the position and age of the removed leaf.

The range of 979 to 1200 kg DM/ha obtained for leaf yield of maize plants defoliated in both years across the defoliation treatments were higher than 400kg DM/ha reported by Mutetikka & Kyarisiima (1997) when leafs below the ear were harvested. Higher leaf yield of 1500kg DM/ha was reported by Abate & Abate (1994). The variety used coupled with the season of planting and the time of maize defoliation may be reasons for the variations in comparison to the results obtained in the present study.

Maize grain yields of plants defoliated from 12WAP in the present study compared favorably with the range reported by other authors for most maize varieties in Nigeria. (IART, 1991; Olasantan *et al*., 1997; Ogunbodede *et al.,* 2001). This implies that with the variety under investigation, maize can be used as a dual-purpose crop, serving as a source of forage for livestock, as well as grains for human consumption when defoliated from 12WAP.

The results of this study further revealed that the shorter the period of defoliation, the higher the quality of leafs (Table 2). This shows that, higher quality of leafs could be obtained with plants harvested at a much earlier age, as the age of the harvest influences the nutrient composition of forages (Norton, 1994). Moreover, the low crude protein content of maize leafs, left on the plant undefoliated at harvest could be due to the deterioration in quality pursuant to decline in crude protein and increase in crude fiber fractions of the leafs (Fernandez-Rivera & Klopfenstein, 1989).

The values obtained for crude protein content in this study for undefoliated maize leafs left to dry on plants are higher than 7 to 9% reported by Mutetikka & Kyarisiima (1997) for early maturing maize variety. The variation could be attributable to the location, variety used and the cultural practices employed.

The effects of the length of storage on chemical composition of the stored maize leafs defoliated at 12WAP are shown in Table 3. The DM contents of maize leafs significantly increased (P < 0.05) as the months of storage increases, indicating loss in moisture. Storing maize leafs for a period of 4 months from the onset of storage did not have any significant (P >0.05) effect on the CP content. Also, the fiber fracti-

Table 2. Average dry matter, crude protein and fibre composition (%) of maize leafs at different defoliation time in two years

Tabla 2*. Contenido medio de materia seca, proteína y composición de la fibra (%) para las hojas de maíz en función de un tiempo de defoliación de dos años*

Defoliation time (Weeks after planting)	Dry matter 2005 - 2006	Crude protein 2005 - 2006	Neutral detergent fibre 2005 - 2006	Acid detergent fibre 2005 - 2006	Acid detergent lignin 2005 - 2006
4	89.8b - 88.7c	13.9a - 15.3a	62.3a - 60.4	39.1a - 38.5a	7.8 - 8.1a
8	90.2b - 89.1bc	12.3ab - 14.4ab	63.7ab - 61.0	39.4a - 37.9ab	8.2 - 7.6ab
12	90.9ab - 91.9ab	11.7bc - 12.9bc	65.2ab - 61.3	39.1a - 36.9ab	8.9 - 7.3ab
16	91.7a - 92.4ab	10.9c - 11.6c	65.8b - 62.4	41.3ab - 36.3ab	9.2 - 7.1ab
Undefoliated	92.9a - 93.1a	10.4c - 10.9c	65.9b - 62.5	43.0b - 35.0b	9.4 - 6.7b
Mean	91.1 - 91.1	11.8 - 13.0	64.6 - 61.9	40.4 - 36.9	8.7 - 7.4
CV (%)	1.33 - 1.81	7.60 - 9.17	2.41 - 3.33	3.54 - 4.44	8.21 - 9.99
SE±	0.62 - 0.55	0.44 - 0.39	0.78 - 0.69	0.72 - 0.55	0.26 - 0.20

+Means followed by the same letter in a column are not significantly different (P<0.05)

Table 3. Effect of length of storage on the chemical composition (%) of maize leafs in two years.

Tabla 3*. Efecto de un período de almacenamiento de dos años en la composición química de las hojas de maíz*

Months of storage	Dry matter 2005 - 2006	Crude protein 2005 - 2006	Chemical		Constituents
			Neutral detergent fibre 2005 - 2006	Acid detergent fibre 2005 - 2006	Acid detergent lignin 2005 - 2006
0	90.3b - 91.7c	11.7a - 12.9a	65.2 - 61.3	39.1 - 36.9	8.9 - 7.3
1	90.3b - 91.8c	11.7a - 12.6a	64.4 - 61.2	38.9 - 36.5	8.7 - 7.3
2	90.7b - 92.2c	11.4a - 12.2ab	63.9 - 61.0	38.4 - 36.5	8.5 - 7.0
3	90.9b - 92.4c	10.9ab - 11.9ab	63.9 - 60.7	37.8 - 36.4	8.5 - 6.9
4	91.0b - 92.5bc	10.7ab - 11.7ab	63.4 - 60.0	37.7 - 35.9	8.1 - 6.7
5	93.1a - 92.9b	10.5b - 10.9b	62.8 - 59.3	37.1 - 35.3	7.8 - 6.6
6	93.4a - 94.1a	9.9b - 10.3c	62.2 - 59.1	36.4 - 35.0	7.8 - 6.4
Mean	91.4 - 92.5	10.9 - 11.7	63.7 - 60.4	37.9 - 36.1	8.3 - 7.0
CV (%)	0.92 - 1.50	7.35 - 9.04	1.65 - 3.26	2.38 - 3.31	8.90 - 6.55
SE±	0.24 - 0.28	0.08 - 0.10	0.31 - 0.43	0.20 - 0.18	0.03 - 0.04

*Means followed by the same letter in a column are not significantly different (P<0.05)

ons NDF, ADF and ADL contents were not affected (P > 0.05) with increase in the months of storage in both years. Owing to the very good weather condition at harvesting time, the drying process in this study was very fast. At the time of bagging the hay, the average DM content of 90.9% for maize leafs showed that a total loss in DM content of 9% is rather low, thereby, demonstrating rather satisfactory results. The decline (P < 0.05) in the crude protein content of maize leafs after 4 months of storage during a hay making process could be pursuant to weather conditions and mechanical influences.

However, the crude protein content of maize leafs stored from the onset to 4 months of storage fell within the acceptable range of 11 to 12% crude protein content required for a moderate level of ruminant production (Gatenby, 2002). This suggests that maize leafs could be stored as hay for 4 months without affecting the quality, thereby serving as a source of feed to ruminants in the dry season.

The loss in the weight of maize leafs (Figure 1) after 4 months of storage might be due to the consistency of the structural component of the leafs being lost over time. This agrees with the reports of Evans (2001) who noted that the time required to dry a crop from its initial moisture content down to about 15% moisture content can be influenced by a number of factors such as plant species, texture, density of a crop, soil moisture and the way the crop is handled. This implies that weight loss of forages during hay making could be influenced by the type of forage species, kind of hay making equipments, storage facilities, and weather conditions at harvesting and mechanical manipulation like drying and storing.

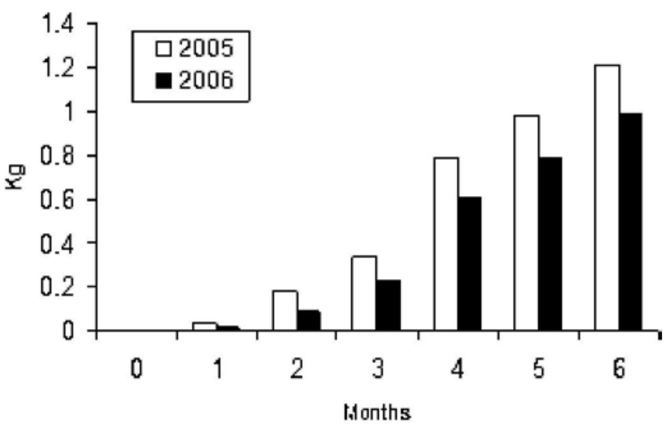

Figure 1. Loss in weight of stored maize leafs defoliated at 12 weeks after planting.

Figura 1. *Pérdida en el peso de las hojas almacenadas de maíz a lo largo de las 12 semanas posteriores a la plantación*

CONCLUSION

The severity of reduction in maize grain yield resulting from the loss of leafs depended on the position and age of the removed leaf.

With the variety used, defoliating maize at 12WAP produced high quality forage with no reduction in grain yield. Also, dried and stored maize leafs for a period of 4 months has high nutritive value, which allows them as food for ruminants in a dry season.

Maize, therefore, has a potential of been used as a dual-purpose crop, serving as a source of forage for livestock, as well as grain for human consumption when defoliated at 12 weeks after planting.

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