Biomass yield, chemical composition and *in vitro* digestibility of maize leaves defoliated at different times

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Abstract

This experiment was conducted to determine the effect of defoliation time on the productivity of maize, forage quality and *in vitro* digestibility of maize leaves (ML). The response of grain yield, plant height, days to 50% silking, ear height and leaf yield as well as the chemical composition of ML variety "Obasuper 2" to defoliation time were evaluated in a randomized complete block design with four defoliation treatments of 3, 6, 9 weeks after planting (WAP) and undefoliated treatment replicated four times. Results showed that defoliating maize at 9 WAP and beyond did not have any significant ($P > 0.05$) effect on the grain and leaf yield as well as the other yield components of maize. Grain and leaf yield at 9 WAP averaged 2778.35 and 975.74 DM kg/ha, respectively. The DM, crude protein (CP) and fibre fractions contents of ML varied significantly ($P < 0.05$) among the defoliation treatments with maize defoliated at 9WAP having a CP content of 12.6%. Ether extract and ash contents were not affected ($P > 0.05$) by defoliation time. The *in vitro* digestibility of ML decreased significantly ($P < 0.05$) with increase in the time of defoliation ranging from 59.2 and 66.4%. It was concluded that maize variety "Obasuper 2" can produce forage of high quality and quantity when defoliated from 9 weeks after planting without any adverse effect on the grain yield of maize.

Keywords: Maize, defoliation, forage, *in vitro* digestibility.

Introduction

Maize is of great economic significance worldwide as human food, animal feed and source for a large number of industrial products.

The diversity of environments under which maize is grown is unmatched by any other crop. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel and cob, which can all

be used to produce a large variety of food and non food products. In the industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products, while in low income countries it is mainly used for human consumption (FAO, 2000).

Maize can be used as a dual purpose crop, serving as a source of grain for humans and forage for livestock through systematic defoliation during the growing season (Abate *et al.*, 1984). Earlier reports showed that defoliated maize leaves of different varieties can be a source of quality feed for ruminants especially among smallholder crop-livestock farmers who produce the majority of maize consumed by man and livestock in most tropical countries (Luer *et al.*, 2004; Vasae *et al.*, 2009). Maize leaves have been found to possess nutritional characteristics that can support the growth of ruminants. Abate and Abate (1954) showed that maize leaves as fodder proved to be more acceptable and of higher nutritional value than napier grass.

The effect of defoliation on grain yield is however important as maize forms the staple diet of most farmers. Defoliation should however be done in such a way that leaves which do not contribute much in grain forming process are removed when their feeding quality is still high (Mutetikka and Kyarissma, 1997). This study aims at determining the productivity of early maturing maize variety "Obasuper 2" widely cultivated by farmers in some parts of south western Nigeria as affected by different stages of defoliation. The chemical composition and *in vitro* DM digestibility of defoliated maize leaves was also assessed.

Materials and Methods

Experimental Site

The experiment was conducted in the Teaching and Research Farm, University of Agriculture, Abeokota, Nigeria. The location is 76 meters above sea level and falls within latitude 7°15'N and longitude 3°25'E, and situated in the derived savannah vegetation zone of south western Nigeria. It experiences approximately eight months of rainfall that is bimodal in pattern. It receives a mean annual precipitation of 1,937mm, with a mean annual temperature of 34.7°C and mean relative humidity of 82%. The field work was conducted on a well drained, deep, friable soil and the experiment commenced during in the early cropping season in the month of March, 2008. Characteristics of the soil of the experimental field is sandy loam and has 1.64% organic carbon, 0.17% total nitrogen, 7.1mg kg⁻¹ available phosphorus, with 4.68, 0.86 and 0.42 meq 100g⁻¹ Ca, Mg and K, respectively, and a pH of 5.5 at 0.14m depth.

Land Preparation and Field Management

For the establishment of the crop farms, a plot of maize in sole cropping was adopted in a randomized complete block design with four defoliation treatments replicated three times. Prior to land clearing, samples of core surface soil were taken, bulked and composite prior to analysis. The land was then ploughed twice at a week interval and harrowed.

Maize seeds "obasuper 2" was planted at a spacing of 90 x 40cm with two seeds per stand. Chemical weed control was carried out using promexin which was applied pre-emergence one day after sowing through a 1SCP knapsack

sprayer, and was supplemented with hoe weeding at 4 weeks after planting. Fertilizer was applied at 10 days after planting at the rate of 100:50:50 NPK per ha. Defoliation was done at 3, 6, 9 weeks after planting (WAP) and undefoliated treatment, served as the control.

Data collection

Data was collected for leaf yield at various intervals of defoliation by harvesting half of the leaves from the soil level with exception of the flag leaf. Plant height was determined by randomly selecting ten (10) plants at maturity per plot from the middle inner rows and their height in centimeters measured using a meter rule from the soil level, while days to 50% silking was counted as the number of days after planting when 50% of the total plants per subplot silk. For the determination of the grain yield, dried maize cobs were harvested from the four middle rows; harvested cobs were shelled, winnowed and weighed as described by Fasao and Elemo (2009).

Chemical and Data analysis

The proximate composition of the defoliated leaves of maize were determined by the method of AOAC (1995), while the *in vitro* DM digestibility was determined as described by Tilley and Terry (1963). Data collected were subjected to analysis of variance using the statistical package (SAS, 1999). Significant means were separated using Duncan Multiple Range Test (Duncan, 1955).

Results and Discussion

The effect of defoliation time on leaf yield, plant height, ear height, days to 50% silking and grain yield of maize are shown in Table 1. Leaf yield increased ($P<0.05$) with increase in the interval of defoliation. Maize defoliated at 3 weeks after planting (WAP) had significantly ($P<0.05$) lower yield of leaves compared to the other treatments. This could be attributed to the defoliation of maize done at the early vegetative stage of the plant which produced few leaves. However, maize defoliated at 9 WAP produced more ($P<0.05$) leaves and compared with the undefoliated treatment, suggesting the availability of these leaves as forage for livestock. Earlier reports by Kirino *et al.* (2001) showed that defoliation offsets the loss of a valuable feed resource which would otherwise be lost since most of the leaves senesce and drops off to be later composted in the soil. The range of 975.7 to 984.7 kg/ha observed for leaf yield of maize defoliated after 9 WAP were lower compared to earlier reports by Fasao *et al.* (2009) for leaf yield of late maturing maize variety (DMR-SR-1-Y). This could be attributed to the variety used as well as the period of defoliation. Moreover, defoliation time had no significant ($P>0.05$) effect on the plant height and ear height of maize defoliated after 3 WAP. The days to 50% silking however decreased significantly ($P<0.05$) with the time of defoliation.

The grain yield of maize increased significantly ($P<0.05$) with an increase in defoliation time. Maize defoliated on or before 6 WAP had significantly ($P<0.05$) lower grain yield compared to those defoliated at 9 WAP and

Table 1: Effect of defoliation time on leaf yield, plant height, ear height, Days to 50% silking and grain yield of maize cultivar (Olasuper-2)

Parameters	Defoliation time (Weeks after planting)				SEM
	3	5	9	UND	
Leaf yield (kg/ha)	185.8 ^a	337.8 ^a	975.7 ^a	984.7 ^a	15.35
Plant height (cm)	187.4 ^a	156.7 ^a	199.5 ^a	201.5 ^a	1.79
Ear height (cm)	72.1 ^b	79.9 ^a	79.6 ^a	81.8 ^a	1.01
Days to 50% silking (days)	49.0 ^a	49.2 ^a	47.5 ^b	47.0 ^b	0.51
Grain yield (Kg/ha)	1971.2 ^c	2392.3 ^a	2778.3 ^a	2915.3 ^a	51.21

a, b, c = means with the same superscripts in a row are not significantly different ($P > 0.05$).

UND = Undeleted

beyond. This could be as a result of the removal of leaves at the early vegetative stage of the plant which corroborated the reports of Weiss and Piper (1992) and Fasae *et al.*, (2009) that grain yield of CERES maize and late maturing maize variety DMR-SR-L-Y respectively were affected by early defoliation. Thornisen and Nafziger (2003) also reported a reduction in grain yield of maize defoliated at different frequency. Maize defoliated at 9 WAP however produced approximately 2778.35kg/ha of maize grain which were significantly ($P < 0.05$) the same with that of the undeleted treatment and falls within the range of 2544 to 3050kg/ha reported by Olaniran *et al.*, (1997) and Kombiok and Elemo (2004) for maize grain yield in Nigeria. This implies that maize defoliated at 9 WAP and beyond can be used as forage for ruminants without any significant effect on the grain yield which is the primary crop.

The reduction in grain yield by about 4.67% in this study for plants defoliated at 9WAP and beyond was lower than 8% reduction reported

by Abare (1994) suggesting that the reduction in grain yield may be considered small. Maize leaves could make significant contribution to the feed of ruminants when properly defoliated, producing quality feed, thereby safe guarding the farmers from feed shortages especially during the dry season.

The effect of defoliation time on the chemical composition of maize leaves is shown in Table 2. The DM of maize leaves defoliated on or before 3 WAP was significantly lower ($P < 0.05$) compared to maize defoliated at later weeks which could be as a result of the stage of maturity. The CP content of ML decreased significantly ($P < 0.05$) with defoliation time suggesting that CP concentration declined with maturity age. This agrees with the report of Fasae and Elemo (2009) for maize variety DMR-SR-L-Y. The range for CP content of ML observed in this study for plants defoliated after 6WAP is however higher to those observed by Kinto *et al.*, (2001) and Fasae and Elemo (2009) which could be due to the early maturing variety of

Figure 1: In vitro dry matter digestibility (%) of maize leaves defoliated at different stages

maize used, nitrogen content in the soil, time of defoliation and cultural practices. The CP content of ML defoliated at 9 WAP and beyond is within the range of 11 to 12% required for sheep production (Galenby, 2002) suggesting that ML possess nutritional characteristics that can support the growth of ruminants.

Moreover, defoliation time had no effect ($P>0.05$) on the ash and ether extract contents of ML. The fibre fractions NDF, ADF and ADL contents of ML differed significantly ($P<0.05$) across the defoliation intervals. The NDF and ADF contents followed the same trend with no significant ($P>0.05$) differences observed in ML defoliated after 3 WAP, while the ADL contents increased ($P<0.05$) with the age of the plant. The

Table 2: Effect of defoliation time on the chemical composition (%) of maize leaves cultivar (Obasaper-2)

Parameters	Defoliation time (Weeks after planting)				SEM
	3	6	9	UND	
Dry matter	87.26 ^a	88.93 ^a	89.99 ^a	91.50 ^a	5.85
Crude protein	15.49 ^c	14.08 ^b	12.62 ^b	10.92 ^b	0.69
Ash	13.46	14.03	11.65	11.55	0.91
Ether extract	6.98	7.29	8.03	7.75	0.26
Neutral detergent fibre	56.40 ^b	65.90 ^a	68.90 ^a	69.36 ^a	2.04
Acid detergent fibre	36.99 ^b	40.35 ^a	40.90 ^a	42.65 ^a	1.64
Acid detergent lignin	7.00 ^c	7.50 ^c	8.75 ^{ab}	9.45 ^a	0.32

a, b, c means with the same super scripts in a row are not significantly different ($P>0.05$)

UND: Undeafoliated

NDP and ADF contents of ML in this study were slightly higher than those reported by Kato *et al.* (2006). The ADL content is however slightly lower to 7.4% reported by Abate and Abate (1994) and fell within the range reported by Pasae *et al.* (2009). The variation in the fibre contents could be as a result of varietal difference, season of planting and management practices employed.

The *in vitro* DM digestibility (IVDMD) of ML were significantly ($P < 0.05$) affected by defoliation time. IVDMD decreased significantly ($P < 0.05$) with the time of defoliation. However, the observed range obtained for IVDMD of ML defoliated at different weeks in this study is similar to those reported for other fodders like *Pennisetum purpureum*, *Marramia aegyptia*, *Tridax procumbens*, *Alchornea cordifolia* and *Aspilia africana* recommended for ruminants (Benavides, 1999; Yusuf, 2009).

Leaves from maize plant defoliated at 3WAP have significantly ($P < 0.05$) higher values for IVDMD compared to the other treatments suggesting that IVDMD of ML decreased with decreases in the protein content of the leaves. However, significant differences ($P > 0.05$) were not observed in ML of plants defoliated from 9 WAP. Also, IVDMD of ML across the treatments reduced with increase in the fibre fractions of the leaves. These differences could be due to the proportion and nature of their fibre as observed by Ruhanya *et al.* (2004) that variation as a result of texture of leaf exists in the fibre content of some browse foliages native to semi arid area in Western Tanzania.

Conclusion

Based on the results of the study, it was concluded that high quality digestible forage can be produced from maize cultivar "Obasuper 2" defoliated at 9 week after planting without any adverse effect on the grain yield of maize. Maize leaves can therefore make significant contribution to the feed of ruminants when properly defoliated, thereby safe guarding the farmers from feed shortages.

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