

## The residual effect of *Stylosanthes* fodder banks on maize yield at several locations in Nigeria

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### Abstract

The response of maize to N on natural pasture (fallow), or following *Stylosanthes* pastures (fodder banks) was investigated at 4 locations in central Nigeria. Maize planted in the fodder banks outyielded that on the natural fallow at each level of applied N. Without applied N, the average grain yields were 1.7 t/ha in the fodder bank and 0.8 t/ha in the natural pasture areas. In well managed fodder banks, the maximum yield of maize was obtained at 60 kg/ha N in comparison with the recommended rate of 120 kg/ha N for a natural fallow or continuously cultivated soil.

In the first year of cropping 45 kg/ha N had to be applied to maize grown outside the fodder banks to produce the same grain yield as unfertilized maize following a good *Stylosanthes* pasture. Grain yields of maize were lower in the second year but again, higher yields were obtained from inside than outside the fodder bank areas.

The response of maize inside the *Stylosanthes* pastures was discussed in relation to land history and the way in which the pastures were managed.

### Resumen

*Se investigó la respuesta del maíz al N en pasturas nativas (como cultivo de descanso) o alternado con pasturas de Stylosanthes (como bancos alimenticios) en 4 localidades en la región central de Nigeria. En cada uno de los niveles de N aplicado, el maíz plantado posteriormente a los bancos alimenticios tuvo un mayor rendimiento que el maíz plantado siguiendo un descanso con pasturas nativas. El rendimiento en grano promedio, sin la aplicación de N, fue 1.7 t/ha en los bancos alimenticios y 0.8 t/ha en las áreas de*

*pasturas naturales. En los bancos alimenticios bien manejados el rendimiento máximo del maíz fue obtenido con 60 kg/ha N en comparación con 120 kg/ha N recomendado para los cultivos subsiguientes a descansos naturales o para los suelos cultivados continuamente.*

*En el primer año de cultivo fue necesario aplicar 45 kg/ha N al maíz plantado fuera de los bancos alimenticios para producir el mismo rendimiento en grano que el maíz sin fertilizar plantado después de una buena pastura de Stylosanthes. Los rendimientos en grano del maíz fueron menores en el segundo año pero de nuevo, los rendimientos en las áreas de los bancos alimenticios fueron mayores que afuera de ellas.*

*La respuesta del maíz en las pasturas de Stylosanthes es discutida en relación al historial de la tierra y a la forma en cual las pasturas fueron manejadas.*

### Introduction

Inadequate nutrition in the dry season has been identified as the main constraint to cattle production in the Subhumid Zone of Nigeria (ILCA 1979; Kaufmann 1986). During this season, the crude protein (CP) content of the natural pasture falls below 7%. As a result animals loose body weight, milk production is low, calf mortality is high and conception is low because of nutritional anoestrus (Otchere 1986).

In view of these constraints, ILCA developed a system of fodder banks. These are small areas of forage legumes (usually *Stylosanthes* Spp.) established by pastoralists near their homesteads for dry season supplementation of animals (Mohamed-Saleem and Suleiman 1986). These legumes maintain a crude protein concentration greater than 8% for much of the dry season. Animals with access to fodder banks perform better than those grazing on natural pasture (Bayer 1986; Mani 1986).

Legume pastures lead to the accumulation of soil N (Vallis and Gardener 1984) which can also

be exploited for crop production. The use of this concept to increase the yield of subsequent crops has been extensively documented (Heichel *et al.* 1981; Hoyt and Leitch 1983; Groya and Sheaffer 1985; McCown *et al.* 1988; Nnadi and Haque 1988; Hulugalle 1989). Work in Nigeria (Mohamed-Saleem and Otsyina 1986) has shown that maize grown on land previously under fodder banks gave higher yields than that on natural fallow or continuously cultivated land. The yield of maize was related to the length of time the land had been under *Stylosanthes*. This study used a systematic design in only 2 locations.

The objective of this study was to expand the initial studies of Mohammed Saleem and Otsyina (1986) by investigating the response of maize to N inside and outside fodder bank areas in 4 locations.

## Materials and methods

### Sites and pasture

The trial, which commenced in 1986, was conducted at 4 locations in central Nigeria: Abet, Kaduna State; Ganawuri, Plateau State; Makurdi, Benue State and Kontagora, Niger State. A description of the climate and soils at the 4 locations is given in Table 1.

**Makurdi.** The fodder bank consisting of *S. guianensis* cv. Cook was established in 1983 (Otsyina *et al.* 1987) using seed and fertilizer rates of 10 kg/ha and 12 kg/ha P, respectively. The legume grew vigorously with plant height > 2 m and a yield of 8 t/ha (M.A. Mohammed-Saleem, personal communication). The pasture was top dressed annually with 8 kg/ha P.

**Abet.** The *S. hamata* cv. Verano (10 kg/ha) was established in 1982 with 12 kg/ha P. It was top

dressed annually with 8 kg/ha P. Regeneration and yield of the legume was always high (5.7 t/ha). Early season grazing was used to control grass growth.

**Kontagora.** *S. guianensis* cv. Cook was established in 1982 at a seed rate of 10 kg/ha. There were high yields of legume (6 t/ha) in the first 2 or 3 years but the proportion of the legume in the herbage was lower in subsequent years due to invasion by grasses. Fertilizer was applied in the year of establishment at the rate of 12 kg/ha P and subsequent top dressing applications were 8 kg/ha P.

**Ganawuri.** *S. guianensis* cv. Cook was established in 1984 (seed rate of 10 kg/ha and 12 kg/ha P) and was only 2 years old when the present study commenced. Although the pasture was top dressed with 8 kg/ha P, legume yields were comparatively low (3.7 t/ha) due to it being a degraded soil and subject to overgrazing.

### Experimental procedure

The treatments were:

- A. (i) An area previously under *Stylosanthes*
- (ii) A non-stylo area that had not been cropped (fallow) for at least 4 years
- B. Three N rates: 0, 60 and 120 kg/ha N as urea.

A split plot design was used with N rates as the sub-plots. Treatments were replicated 4 times. Each plot consisted of five 5 m long ridges tilled to a height of 30 cm and spaced at 1 m intervals. Plant spacing was 20 cm within rows, giving a population of 50,000 per ha. Initially, 3 seeds of the maize variety TZSRW, were planted per hole and later thinned to 1 plant per stand. A basal application of 60 kg/ha each of P and K was applied to all plots in the form of single superphosphate and muriate of potash, respectively. The urea was

Table 1. Description of experimental sites

Location	Makurdi	Abet	Kontagora	Ganawuri	
Longitude	7°44'N	9°40'N	10°17'N	9°0'N	
Latitude	8°35'E	8°10'E	6°02'E	8°35'E	
Soil Type	Ferrasol	Lithosol	Red Ferrasol	Lithosol	
Mean annual rainfall (mm)	1986 1987	1096 1187	1270 1440	— —	1112 1500
pH (1:1, soil/water)	5.70	5.30	5.90	5.20	
Organic Matter (%)	0.14	0.36	0.70	1.03	
Total N (%)	0.042	0.086	0.056	0.094	
Available P (ppm)	6.3	1.8	2.8	5.5	
Available K (me/100 g soil)	0.15	0.13	0.27	0.22	

<sup>1</sup> Phosphorus was extracted by the Bray No 1 procedure.

applied (covered within ridges) in 2 equal applications (at planting and 6-8 weeks after sowing). Weeds were controlled by hoeing 5 and 8 weeks after planting. At harvest the cobs from each plot were plucked, dehusked, dried and threshed to determine the grain yield at 14% moisture.

In 1987, the experiment was again cropped with the same variety of maize. Basal P and K were applied as in 1986 but no further N was applied.

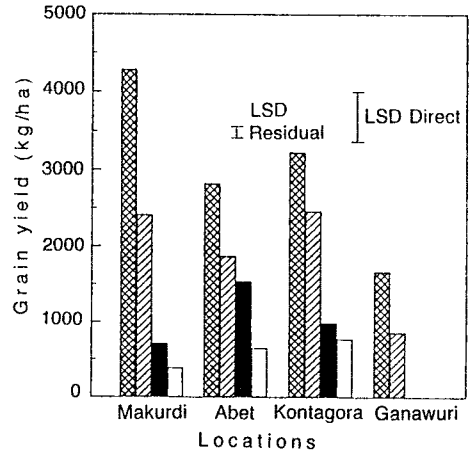
**Soil analysis**

Soil samples were collected at a depth of 15 cm from the fallow areas of the experimental sites in the year in which the respective fodder banks were established. This was done to give an indication of the chemical and physical properties of the soil in each site. All soil analyses were done on air-dry samples. The pH of the soil was determined by using 1:1 soil/water ratio and organic carbon by Walkley-Black method (Allison, 1965). Exchangeable bases were obtained by leaching soils with 1 N NH<sub>4</sub>OAc at pH 7.0. Total N was determined by the micro-Kjeldahl method. Available P was extracted with Bray No. 1 solution and the P in solution determined using the ascorbic acid method (Wantanabe and Olsen 1965).

**Results**

Grain production inside the fodder banks on the first year's crop was higher and in most cases (Makurdi, Abet and Ganawuri) twice that on the natural fallow at all levels of N (Figures 1, 2a, 2b and 2d). There was also a trend in this direction at Kontagora (Figure 2c). Although there was a very strong response to fertilizer N, plots that were not fertilized with N inside the *Stylosanthes* pasture still produced a reasonable crop yield. The averages at the 4 locations were 1.72 t/ha of grain inside and 0.82 t/ha outside the fodder bank (Figure 3). Averaged across all sites approximately 45 kg/ha N had to be applied to maize grown outside the fodder bank to raise its yield to that of maize planted on unfertilized plots inside the stylo pastures (see A-B-C in Figure 3).

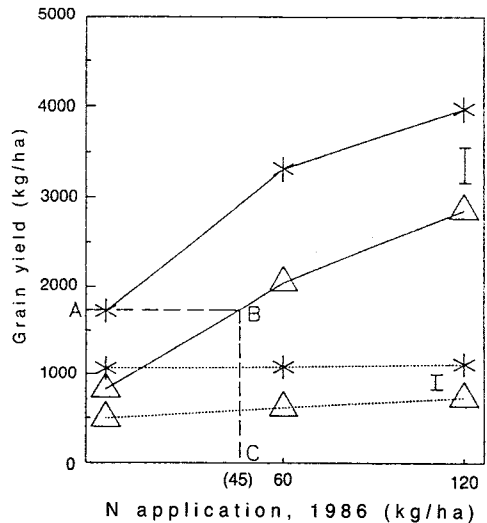
The grain yields from the crops grown on the same plots in the second season (without any further N fertilizer) were substantially lower than in the first year at all 3 sites for which we have



**Figure 1.** Direct and residual effects of N on grain yield of maize inside and outside fodder banks, in 4 locations (averaged over all N levels).

▨ Direct inside, ▧ Direct outside, ■ Residual inside, □ Residual outside.

The bars represent the LSD for P = 0.05.

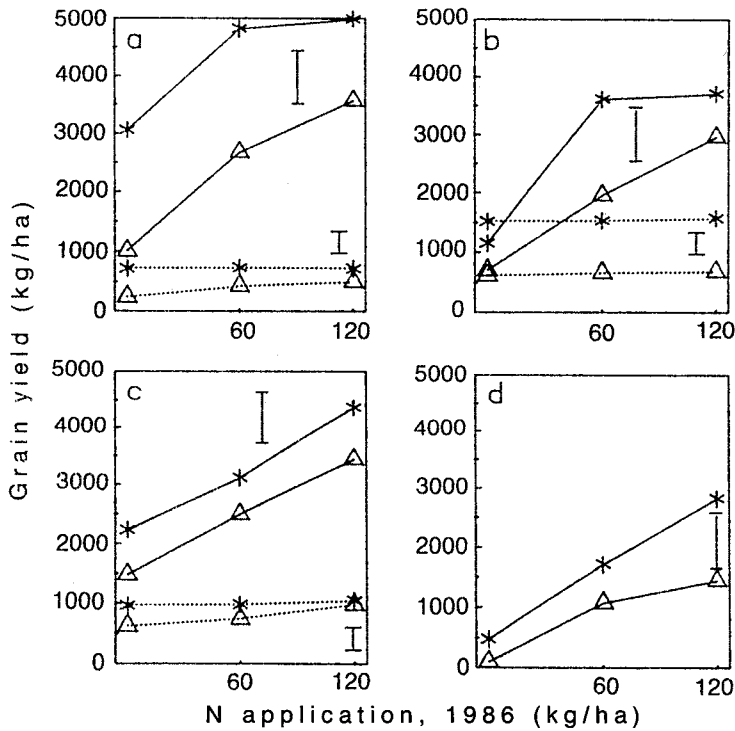


**Figure 3.** Direct and residual effects of N on grain yield of maize inside and outside fodder banks (averaged over all sites).

—\*— Direct inside, —△— Direct outside, -\*- Residual inside, -△- Residual outside.

The bars represent the LSD for P = 0.05.

data (Figures 1, 2a, 2b and 2c). There was a slight response to the previous year's N at 2 of the natural pasture sites (Figures 2a and 2c) but the overall effect (Figure 3) was insignificant. Considered over all 3 locations and all rates of



**Figure 2.** Direct and residual effects of N on grain yield of maize inside and outside fodder banks at 4 locations (a: Makurdi; b: Abet; c: Kontagora; d: Ganawuri). \* Direct inside,  $\triangle$  Direct outside, \* Residual inside,  $\triangle$  Residual outside. The bars represent the LSD for  $P = 0.05$ .

previous year N, the grain yield inside the fodder banks (1.08 t/ha) was significantly greater than the average yield outside the fodder bank (0.61 t/ha).

### Discussion

Maize in plots that had previously been planted with stylo performed better than that sown on land that had been under natural vegetation (Figure 1). This may be attributed to an increase in total soil N fixed by the legume and improved soil physical properties such as bulk density, infiltration rates, and field moisture capacity (Mohamed-Saleem and Otsyina 1986; Mohamed-Saleem *et al.* 1986). However, these authors expressed caution with respect to changes in the physical properties of the soil since they were not monitored before and after the experiment. Thus some of the differences they observed may have been due to inherent variability of the soils. Vallis (1972), Myers (1976), Wetselaar (1967) and

Tarawali *et al.* (1987) have shown significant increases in available soil N and total soil N in soils in which legumes have been grown.

The maize planted outside the fodder banks required 45 kg/ha N to produce the same yield as that of maize on unfertilized plots within the legume pastures. These results suggest that the legume may have contributed the equivalent of 45 kg/ha N. The average grain yield in unfertilized plots inside the fodder banks (1.72 t/ha) was comparable to the average yield (1.80 t/ha) of maize grown by local farmers using the recommended NPK fertilizer rate of 120:60:60 kg/ha in the Savanna zone (Powell 1984).

Responses to N application varied between locations (Figures 1 and 2) probably because of differences in land history and crop and pasture management. Further research would be needed to quantify and categorize the contributions of the various factors. The best maize growth was obtained at Makurdi (Figure 2a) where maize yielded almost 5 t/ha with 60 kg/ha N, with no

further response to the higher application. This was probably because N fixation was enhanced by the vigorous stand of *S. guianensis*.

The fodder bank in Abet was originally owned and managed by a co-operating pastoralist but was later taken over and managed by ILCA. Stylo regeneration and productivity has always been impressive. The pattern of response at Abet (Figure 2b) was similar to that at Makurdi but the yields were about 30% lower.

The fodder bank at Kontagora used to be one of the best *Stylosanthes* pastures but due to poor management, the fodder bank was invaded by nitrophilous grass such as *Pennisetum* (Mohammed-Saleem *et al.* 1986). This may have reduced the nitrogen available to the subsequent crop (Tarawali *et al.* 1987). Maize yield responded linearly to fertilizer levels up to 120 kg/ha N in this fodder bank (Figure 2c) in contrast to the response at Makurdi and Abet.

The maize at the Ganawuri fodder bank had the lowest yield (Figure 2d). This was partly because the *S. guianensis* pasture was cropped after only 2 years and N-accrual by the legume was probably still low. Termites were also a problem in this location causing severe damage to both maize and *Stylosanthes* plants. In the 1987 residual study, termite attack on the crop was so extensive that the experiment in this site had to be abandoned.

In order to maximize benefits to both crops and livestock production, *Stylosanthes* pastures have to be managed just like arable crops (Okaiyeto and Kallah 1987). This requires a good seed-bed preparation, high quality seeds, correct seed rates, adequate fertilizer and early season control of weeds to ensure good stylo establishment. Shrubs should be slashed periodically and pastures must be fenced to prevent inappropriate grazing. Areas infested with termites should be avoided as fodder bank sites.

There was no significant response to residual fertilizer N for maize planted inside or outside the fodder banks (Figure 3). Yields were lower in the second than in the first year though the rainfall level and distribution in both years was similar in all the locations (Table 1). Though overall yields were lower in the second year, the proportional increase in yield due to the previous legume fodder bank over no legume was similar to that in the first year. This suggests that there was still some residual effect of N from the legumes but that it was insufficient for optimum growth of maize. Superior yield of

maize in the fodder bank in the second year could also be due to improvement in soil physical properties. Hulugalle (1989) quoted by Yilala (1989), showed that the higher grain and dry matter yield of maize following forage legume pastures was associated, among other factors, with increased levels of soil organic matter, C:N ratio, higher infiltration rates, greater proportion of macropores and higher subsoil root growth. Adeoye (1987) reported an improvement in soil physical properties in areas that were preceded by *Stylosanthes* pastures. Also the regenerating stylo within the fodder bank may have acted as green manure in the second season when killed during the weeding operations (Chatterjee *et al.* 1979).

Fodder bank management and utilization requires intermittent grazing of the pastures for 2–3 hours a day during 3–4 months of the dry season. The greater dry matter production should support cattle far longer than a fallow and this may lead to a higher return of dung and urine per unit area within the legume pasture than the natural fallow. However, most dung is deposited at night during resting and Powell and Mohammed-Saleem (1987) reported that cattle dung and urine deposited during crop residue grazing made negligible contribution to subsequent soil fertility.

In conclusion, the results of these trials show that crop response attributable to N from fodder banks is related to the performance of the stylo grown previously and this in turn is determined by location, the age of the fodder bank and the way in which the pasture has been managed.

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