CEREAL/LEGUME ROTATION EFFECTS ON SOIL CARBON AND NITROGEN AND GRAIN YIELD OF MAIZE IN THE SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Soil fertility attributes relevant to improved crop yield can be enhanced by crop rotation with natural and herbaceous legume fallows. Trials were established at Minna and Mokwa, both in the southern Guinea savanna agro ecological zone of Nigeria during the 2011 and 2012 cropping seasons, to determine the effect of crop rotation with *Aeschynomene histrix* and natural fallows on soil organic carbon (SOC), soil total nitrogen (STN) and grain yield of succeeding maize. The nitrogen fertilizer replacement value (NFRV) of the *A. histrix* was also estimated at both sites. In 2011, the *A. histrix* and natural fallow fields were established and followed in 2012 by maize with inorganic N fertilizer rates of 0, 60, 90 and 120 kg N ha^{-1} at both locations. The experimental design was a split plot, with the two fallows as the main plots and inorganic N levels as the sub-plots. At both sites, SOC was significantly increased by both fallows. Soil total N was significantly increased by natural fallow at Mokwa and by A. histrix fallow at Minna. Maize grain yield after both fallows were statistically at par after both fallows at the two sites. There was response to inorganic N fertilization by grain yield at both sites. Lowest grain yield was obtained without inorganic N fertilization, which was significantly lower compared to those fertilized, that had comparable grain yields. Inorganic N fertilizer rate of 60 kg ha^{-1} seems to be optimum for profitable grain yield of maize at both locations. The estimated NFRV of *A. histrix* for Minna was relatively low, 4 kg N ha^{-1}, while that of Mokwa was relatively high, 47 kg N ha^{-1} . At Minna, the effects of both fallows on grain yield of maize were due mainly to increased SOC content, but at Mokwa, they were due to increased soil N.

Key words: *Aeschynomene histrix*, Maize, Nitrogen Fertilizer Replacement Value, Soil organic carbon, Savanna.

INTRODUCTION

Maize (*Zea mays* L.) has become one of the most important cereal crops of the world after rice with respect to cultivated area. In Nigeria, about 3.5 million metric tons of maize grain produced in 1999 from 3.2 million hectares was estimated to have increased to 7.0 million metric tons in 2003 from the same hectarage (FOS, 2004). However, in 2007 and 2008, maize production amounted to 67.4 to 75.3 million metric tons (FAO, 2009). Maize production has caught up with, or even surpassed sorghum and millet in much of the savanna areas of West Africa.

This phenomenal increase in maize production in Nigeria over the past few years, was attributed to its use as human food, livestock feed, raw material for the flour milling, brewing, pharmaceutical, and starch-making industries, as well as research activities leading to the development of input and management technology resulting in increased grain yield (Fakorede *et al.*, 2003; FAO, 2009). It is well adapted to the savanna ecology with mono-modal rainfall distribution and 120 to 180 growing period (Carsky and Iwuafor, 1999).

The N requirement of maize is relatively high. It has been reported that the soil must supply 60 kg N ha^{-1} in plant available form for each ton of maize grain produced (Weber *et al.*, 1995). This high requirement of N by maize, coupled with the inherently low N status of the soils of the savanna agro ecological zone of Nigeria, make N to be one of the most important constraints to maize production. Hence, external input of N is inevitable for maize production. But in Nigeria, like other developing countries, due to high cost and infrastructural problems resulting in poor distribution of inorganic N fertilizer, farmers have little or no access to fertilizers. The integration of legumes into the cropping system can therefore, be an option to improve the N nutrition of maize (Carsky *et al.*, 2001).

Herbaceous legumes when rotated with cereals offer potentially high N contribution to the cereals, if seed is not harvested and if biomass is not fed to animals (Carsky and Iwuafor, 1999). Studies have reported positive rotation effects of herbaceous legumes on subsequent cereal yields in the savanna agro ecological zone of Nigeria (Adeboye *et al.*, 2005a; Oikeh *et al.*, 1998; Tarawali, 1991). The yields benefit have been attributed to improved soil fertility, especially increased soil N availability following the legume through biological N fixation (Yusuf *et al.*, 2009a), stimulation of mineralization rates (Peoples and Crasswell, 1992), enhancement of soil microbial activity (Adeboye *et al.*, 2005a), release of N from the breakdown of roots and nodules after harvest (Brophy and Heichel, 1989), higher soil organic carbon (Yusuf *et al.*, 2009b) and other rotation effects (Sanginga *et al.*, 2002).

The N fertilizer replacement value (NFRV) or the N-fertilizer equivalence is one of the most common methods used for estimating the N contribution from legumes in rotation. It is defined as the amount of fertilizer N required by a non-legume in the absence of a legume, to obtain grain yields equivalent to those obtained when the non-legume followed legume in rotation (Hestermann, 1988). The NFRV of herbaceous legumes are usually relatively high when they are grown for more than one year or when their residues are incorporated into the soil. Tarawali (1991), estimated the NFRV of *Stylosanthes hamata* when grown for 2 to 4 years to be approximately 45 kg N ha^{-1} in the Guinea savanna of Nigeria. The NFRV of another herbaceous legume, *Centrosema pascuorum*, with the residues incorporated, was estimated to be 34 kg N ha^{-1} in the northern Guinea savanna of Nigeria (Adeboye, 2008). The higher values obtained when the residues are incorporated, have been suggested by Costa *et al.* (1989), to be probably due to faster release of N from residues incorporated, due to direct contact with the soil enzymes which will facilitate decomposition of the residues.

The herbaceous legume, *Aeschynomene histrix* is a fast growing and decomposing green manure with high potential as a legume fallow in the humid tropics (Muhr *et al.*, 1999). It thrives well in habitat with sandy, clay, acidic, neutral, well drained and low fertility soils and is moderately drought tolerant (Merkel *et al.*, 2000). *Aeschynomene histrix* has a rapid growth and ability to fix large quantities of N, thus enriching the poor tropical savanna soils (Peters and Schultz-Kraft, 2009). It grows wildly and widely in the southern Guinea savanna agro ecology of Nigeria. Despite all these positive attributes of the plant, not many studies have been carried out, to evaluate its effect on soil properties and grain yield when rotated with maize in the southern Guinea savanna. Our objectives therefore, were to determine the rotation effect of the legume on soil organic carbon, soil total nitrogen and maize grain yield and estimate its NFRV when rotated with maize. This study is part of a study that investigated the use of the *A. histrix* for *Striga hermonthica* control in the southern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Experimental sites

The field experiments were conducted in 2011 and 2012 cropping seasons, at the Teaching and Research Farms of Federal University of Technology, Gidan Kwano, Minna (9° 31.860' N; 6° 27.244'E; 254 m) and at Teaching and Research Farms of Niger State College of Agriculture, Mokwa (09° 18' N; 05° 50' E), both in the southern Guinea savanna ecology. Rainfall pattern of both sites is monomodal with the rainy season in Minna starting in April or May and ending in

Table 1: Monthly rainfall of both sites during the period of study

Month	Rainfall (mm)			
	Year			
	2011		2012	
	Sites			
	Minna	Mokwa	Minna	Mokwa
January	0.0	0.0	0.0	0.0
February	1.5	58.0	0.0	0.0
March	0.0	0.0	0.0	20.1
April	258.0	88.0	34.2	43.4
May	140.4	235.4	204.5	165.0
June	67.3	123.0	96.5	174.0
July	194.7	268.2	333.1	346.0
August	160.4	132.0	376.9	423.2
September	301.8	111.4	337.2	487.0
October	100.3	38.0	158.0	76.3
November	0.0	0.0	0.0	12.1
December	0.0	0.0	0.0	0.0
Total Rainfall	1,224.4	1054	1540.4	1747.1

October, while that of Mokwa started in March or April and ended in October or November. Monthly rainfalls during the period of study at both sites are shown in Table 1. The soil of the Minna site was classified as Typic plinthustalf (Lawal *et al.,* 2012), with loamy sand surface soil texture, slightly acidic, low organic carbon, N, and medium phosphorus. Mokwa site also had loamy sand surface soil texture, slightly acidic, low organic carbon and N, but with high phosphorus. Selected soil physical and chemical properties of both sites before land preparation in 2011 are shown in Table 2. The two fields were heavily infested with *Striga hermonthica* which makes them to be sparingly cultivated with maize and sorghum over the years with no fertilizer application.

Treatments and experimental design

The two sites had the same treatments, experimental designs and plot sizes. At the commencement of the experiment in 2011, treatments consisted of two fallows, natural fallow (NF) and *A. histrix* fallow (AF). The field was divided into two blocks and each block divided into three to give three replicates. Each block was separated from one another by a strip of 2 m width and the treatments randomly assigned to each block.

Table 2: Some soil physical and chemical properties of both sites before planting in 2011

Properties	Values	
	Minna	Mokwa
Sand (g kg^{-1})	860	795
Clay (g kg^{-1})	47	89
Silt (g kg^{-1})	93	116
Textural class	Loamy sand	Loamy sand
pH (H_2O)	6.8	6.7
Organic carbon (g kg^{-1})	2.39	3.30
Total N (g kg^{-1})	0.15	1.80
Available P (mg kg^{-1})	12	18
Exchangeable acidity (cmol kg^{-1})	0.04	0.11
Exchangeable Na (cmol kg^{-1})	0.23	0.09
Exchangeable K (cmol kg^{-1})	0.36	0.19
Exchangeable Ca (cmol kg^{-1})	2.77	4.96
Exchangeable Mg (cmol kg^{-1})	1.65	0.98
ECEC (cmol kg^{-1})	5.05	6.32

In the following year, 2012, the treatments were four, inorganic N fertilizer levels of 0, 60, 90 and 120 kg ha^{-1}. The experimental design was a split plot arrangement fitted to a Randomized Complete Block with three replicates. The main plot treatments were the two fallows, NF and AF and the subplots were the four N levels. There were 24 subplots with gross plot dimensions of 3 m by 8 m (24 m^{2}).

Crop establishment and Management

Both sites have the same crop establishment and management. In 2011, the NF and AF fields were established. The entire field was manually cleared and the AF portion ploughed. *Aeschynomene histrix* was manually sown by broadcasting 20 kg of the seed mixed with 50 kg of soil ha^{-1}. The fallow blocks were not weeded, while the *A. histrix* blocks were weeded by hand-pulling when necessary during the season. In the following year, 2012, existing vegetation in all the plots was incorporated by manual ploughing and ridging at 75 cm apart. Maize variety, SUWAN 1 highly susceptible to Striga was manually sown at 3 seeds per hill, spaced 50 cm within rows. The seedlings were thinned to 2 plants per hill at 2 weeks after sowing (WAS), to give a plant population of about 53,333 plants ha^{-1}. Basal application of 30 kg P ha^{-1} as single superphosphate and 30 kg K ha^{-1} as muriate of potash were carried out after thinning. Inorganic N fertilizer as urea was split-applied to plots that were to receive N fertilizer. At 2 WAP, one-third of the N was applied, while the remaining two-third was applied 5 to 6 WAP. Fertilizers were applied by side banding at about 5 cm away from the seedlings and at about 5 cm deep along the ridge. In 2012, all the plots were hoe-weeded at 3 and 6 WAP followed by careful hand-pulling of weeds other than Striga.

Table 3: Effects of fallows on soil organic carbon at both sites

Treatment	Soil Organic Carbon (g kg^{-1})					
	Sites					
	Minna			Mokwa		
	Initial Value in 2011	Value at the beginning of 2012	Percentage Change	Initial Value in 2011	Value at the beginning of 2012	Percentage Change
Fallow	2.30 (0.05)			3.30 (0.05)		
Natural		4.24 (0.35)^{a}	84		5.90 (0.37)^{a}	44
A. histrix		3.93 (0.07)^{a}	71		4.80 (0.54)^{a}	31

Standard error of means in parenthesis

a- By t-test between each treatment and initial value indicates significant difference at $P < 0.05$

Table 4: Effects of fallows on soil nitrogen at both sites

Treatment	Soil total nitrogen ($g\ kg^{-1}$)					
	Sites					
	Minna			Mokwa		
	Initial Value in 2011	Value at the beginning of 2012	Percentage Change	Initial Value in 2011	Value at the beginning of 2012	Percentage Change
Fallow	0.15(0.02)			1.77(0.15)		
Natural		0.19 (0.003)^{NS}	19		2.40 (0.25)^{a}	26
A. histrix		0.21 (0.003)^{a}	40		2.22 (0.13)^{a}	20

Standard error of means in parenthesis
a- By t-test between each treatment and initial value indicates significant difference at $P < 0.05$
NS – Not significantly different from initial value at $P < 0.05$

Sampling and Analysis

For initial characterization of the field, at both sites, surface soil (0 – 15 cm) samples were collected with an auger, along four diagonal transects, from ten points each, thoroughly mixed and bulked to give four composite samples, prior to land preparation. In 2012, surface soil samples were collected from each subplot before planting, at tasselling stage and physiological maturity of the maize. Samples were collected from three points, between two plant stands and furrow, along three diagonal transects, mixed thoroughly and bulked to give one composite sample per plot. All the soil samples were air-dried, crushed gently and passed through a 2 mm sieve for analysis

Particle size distribution was determined by Bouyoucos hydrometer method (Klute, 1986). Soil reaction was determined potentiometrically in 1:2.5 soil to water suspension with the glass electrode pH meter. Organic carbon was determined by the Walkley and Black wet oxidation method (Nelson and Sommers, 1982). Exchangeable bases were determined by extraction with neutral 1 N NH_4OAc. Potassium and sodium in the extract were determined with flame photometer, while calcium and magnesium were determined using atomic absorption spectrophotometer. Exchangeable acidity was determined by titrimetric method using 1 N KCl solution. Effective cation exchange capacity (ECEC) was estimated by summation method of exchangeable acidity and exchangeable bases. Available phosphorous was extracted by the Bray P1 method. The P concentration in the extract was determined colorimetrically using the spectrophotometer. Total N was determined by Kjeldahl digestion method (Bremner and Mulvaney, 1982).

Table 5: Effects of fallowing and inorganic nitrogen fertilization on grain yield of maize at both sites

Treatments	Grain yield (kg ha^{-1}) Sites	
	Minna	Mokwa
Fallow (F)		
Natural	1085^{a}	1595^{b}
A. Histrix	1208^{a}	2193^{a}
SE±	90	288
Significance	NS	*
Nitrogen fertilizer (kg N ha^{-1}) (N)		
0	547^{b}	1253^{b}
60	1290^{a}	2415^{a}
90	1436^{a}	2037^{a}
120	1492^{a}	1871^{ab}
SE±	592	407
Significance Interaction	**	*
F x N	NS	NS

Means in the same treatment column with different letter are significantly different at $P < 0.05$
** Significantly different at $P < 0.01$, * Significantly different at $P < 0.05$
NS Not significant.

Maize grain yield analysis was carried out by harvesting maize ears in the two central rows leaving out the border plants at both ends (net plot of 5.25 m^2). These were shelled, air-dried and weighed. The grain yield was adjusted to 12 % moisture content for each plot. The NFRV of the *A. histrix* was estimated by the method described by Carsky *et al.* (2001). The response of maize to urea N in the natural fallow plot was fitted to a linear model. The intercept is the grain yield after fallow with no N fertilizer and the slope is the response of maize to fertilizer N.

NFRV = Yield after legume with no N fertilizer — Intercept / slope

Statistical analysis

Statistical analysis including analysis of variance (ANOVA) and means separation were significant by Student Neuman Keuls test were computed using the General Linear Model Procedure of SAS verson 9.0 (SAS, 2002). Paired t-tests were also used to compare means of the soil chemical properties.

RESULTS AND DISCUSSION

Soil organic carbon and total nitrogen

There was a significant ($P < 0.05$) effect of fallowing on soil organic carbon (SOC) at both sites (Table 3). The two fallows, natural fallow (NF) and *A. histrix* fallow (AF), significantly increased the SOC, with NF having a higher increase compared to the AF. At both sites, NF produced higher biomass (data not shown) which was incorporated and may be responsible for the higher increase in SOC by NF. Increase in SOC has been reported to be related to the amount of biomass produced by fallows and incorporated by Huang *et al.* (2007). Changes in SOC are dependent on incorporation of crop residue (Al-Kaisi *et al.*, 2005; Karlen *et al.*, 2006). The relatively lower increase by AF may also be partly attributed to higher rate of mineralization of legume residues, due to its low C/N ratio (Swift, 1987) and more contact with soil enzymes, when incorporated. Costa *et al.* (1989) has reported that incorporation of legume residues ensures more contact with soil enzymes, with consequent faster rate of mineralization.

The effects of the two fallows on soil total nitrogen (STN) at both Minna and Mokwa are shown in Table 4. The AF significantly ($P < 0.05$) increased STN at both sites, but was not significantly increased by NF at Minna. The lack of increase in Minna by NF may be ascribed to the relatively low N content of the biomass compared to the biomass of AF. At Minna, the N content of biomass of NF and AF were 0.80 and 1.40 g kg^{-1} respectively. However, there was a higher increase of 40 % by AF at Minna, compared to less than 26 % increase recorded for both fallows at Mokwa. These results might be due partly to higher rainfall in Mokwa (Table 1), which will leach out mineralized N in the form of nitrate from the soil. The relatively high increase of SOC by 71 % by AF at Minna may also be responsible for the higher increase in STN. Soil organic matter is the main source of N in the soil (Brady and Weil, 2001). Using the bulk density of 1.52 kg dm^3 reported for the soils of Minna area (Odofin *et al.*, 2011) and the weight of a hectare furrow slice of 2,280t, at Minna, the additional N in AF plots was 137 kg ha^{-1}, while at Mokwa, it was 144 kg ha^{-1} by NF plots and 103 kg ha^{-1}, by AF plots, when their residues were incorporated. Similar increase in STN with incorporation of residues of natural fallow and herbaceous legumes in the savanna zone has been reported by other workers (Adeboye *et al.*, 2005b; Carsky *et al.*, 1997; Yusuf *et al.*, 2009b). The relatively higher increase by AF compared to NF may be ascribed to mineralization of their residues (Muyinda *et al.*, 1988), enhancement of soil microbial activity and possibly heterotrophic N_2 fixation (Ladha *et al.*, 1989) and release of N from the breakdown of their roots and nodules (Brophy and Heichel, 1989).

Maize grain yield

The effects of fallowing and inorganic N fertilization on maize grain yield at both sites are shown in Table 5. At Minna, maize grain yield was not significantly ($P > 0.05$) affected by fallowing. Natural fallow had yield of 1,085 kg ha^{-1}, which though not significantly different, but was lower than 1,208 kg ha^{-1} recorded for the AF. Although the increase in STN by NF was lower, 19 %, compared to 40 % increase by AF, the comparable grain yield obtained could probably be due to incorporation of all fallow residues resulting in high SOC. Increase in soil organic matter level will result in increase in soil fertility, nutrient supply, porosity, permeability and thus, soil productivity (Gray and Morant, 2003). Results obtained are consistent with that of other workers in the same savanna agro ecological zone of Nigeria (Yusuf *et al.*, 2009b). Contrary to results of Minna site, there was significant effect of fallowing on maize grain yield at Mokwa. The AF recorded significantly higher grain yield, which was 38 % higher than that of NF, in spite of the comparable increase in the soil total N by both fallows. However, there was higher amount of organic carbon in the soil of NF, which might have resulted in immobilization of more N, with consequent lower amount available for immediate uptake by the growing crop. The immobilization of N results from high soil C/N ratio (Palm *et al.*, 2001). Comparably, across the two fallows, grain yield was higher at Mokwa compared to Minna. These results might not be unconnected with the C/N ratio of the soils in both sites. The C/N ratio of the soils under NF and AF were 22 and 19 respectively at Minna, while both fallows had similar ratio of 2 at Mokwa.

There was clear evidence that N nutrition is a major constraint to maize production due to response of grain yield to inorganic N fertilization at both sites. Grain yield without inorganic N fertilization were lowest at both sites, which were significantly lower than that of the other inorganic N levels. Similar response to inorganic N fertilizer has been reported in the same area by Adeboye *et al.* (2009). All the N fertilized maize at both sites had statistically similar grain yield. These results suggest that application of 60 kg N ha^{-1} seems to be optimum for maize in this area. Adeboye *et al.* (2009) have also reported 90 kg N ha^{-1} to be optimum for maize in these areas. In the West African savannas, 60 to 120 kg N ha^{-1} had been recommended by Carsky and Iwuafor (1999). Series of trials conducted in savanna zone, led to a recommendation of 100 to 120 kg N ha^{-1} (Chude *et al.*, 1994). A rate of N which usually gives reasonable return has

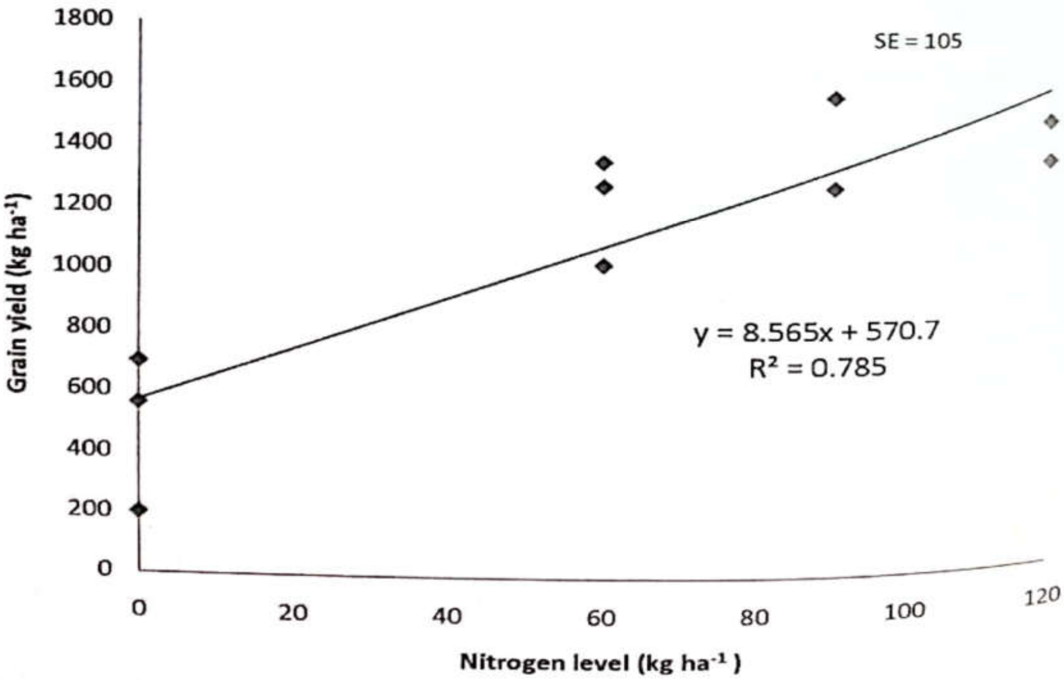

Fig.1 Response of maize grain yield to inorganic nitrogen fertilizer at Minna site

been put at 60 kg N ha^{-1} by Carsky *et al.* (1997). Across the N levels, grain yields were higher at Mokwa compared to Minna. These might be due to relatively higher fertility of the soil of Mokwa, especially in terms of N and P (Table 2).

Generally, maize grain yields recorded for both sites were relatively high, thus confirming the assertion that the most suitable zone for maize are areas characterized by 120 to 180 days of growing period in a monomodal rainfall pattern, which are characteristic of the study sites. Yield potential is high in the zone compared to wetter and drier environments, because of adequate moisture, relatively low disease pressure, high solar radiation, and low night temperature (Carsky and Iwuafor, 1999). Also, grain yields were higher at Mokwa irrespective of the treatments, probably due to reasons advanced earlier. At both sites, the interactive effect of fallowing and N fertilization on grain yield was not significant. This indicates that N effect might not be solely responsible for maize grain yield obtained, but could be as a result of significant reduction in *Striga hermonthica* parasitism by fallowing and inorganic N fertilization recorded at both sites. Striga population was reduced by as much as 92 % by both fallowing and inorganic N fertilization at both sites (data not shown).

Nitrogen fertilizer replacement value

The response of maize succeeding natural fallow to inorganic N fertilization at both sites is shown in Figs. 1 and 2. The estimated N fertilizer replacement value (NFRV) of the *A. histrix* at Minna was relatively low, 4 kg N ha^{-1}. The NFRV obtained appears to be an underestimation of the N contribution of *A. histrix*. This is because, the N content in the soil was increased by as high as 137 kg ha^{-1}. However, most of the N could have been leached beyond the maize roots zone, due to rapid mineralization of the *A. histrix* residue that would have resulted in lack of synchrony between N availability and maize uptake. Other non-nitrogen benefits, especially reduction in *Striga hermonthica* parasitism observed at the site, may have played a role in the grain yield of maize. The low NFRV may be partly attributed to the use of fallow as control. The use of fallow as control is likely to give lower estimate of NFRV compared to continuous cereal monoculture, because of N export by the cereal and because of pests and diseases problem (Carsky *et al.*, 2001). The significant increase in SOC by fallowing, which not only improve the soil nutrient content, but improve soil physical properties, resulting in good growth and yield of maize may also have contributed to the low NFRV.

The NFRV at Mokwa was relatively higher, 47 kg N ha^{-1}, compared to that of Minna site, probably due to high N content in the soil. The high value could also be due to other non-nitrogen benefits observed, especially reduction in *Striga hermonthica* parasitism similar to what was obtained at Minna site and high contents of organic carbon and phosphorus in the soil. The biomass yield of the legume is usually increased with consequent high NFRV when the soil is fertilized with P (Tarawali, 1999; Carsky *et al.*, 2001). The availability of N is usually identified as responsible for the greatest proportion of the beneficial effects of cereal/legume rotation, though other benefits including improvement in the soil microbial biomass can also be important (Adeboye *et al.*, 2006). The value is comparable to 34 kg N ha^{-1} recorded for similar herbaceous legume, *Centrosema pascuorum* in the same savanna agro ecological zone by Adeboye (2008). Tarawali (1991) estimated the NFRV to be approximately 45 kg N ha^{-1} after 2 – to 4 – year fodder banks, composed of *Stylosanthes hamata*

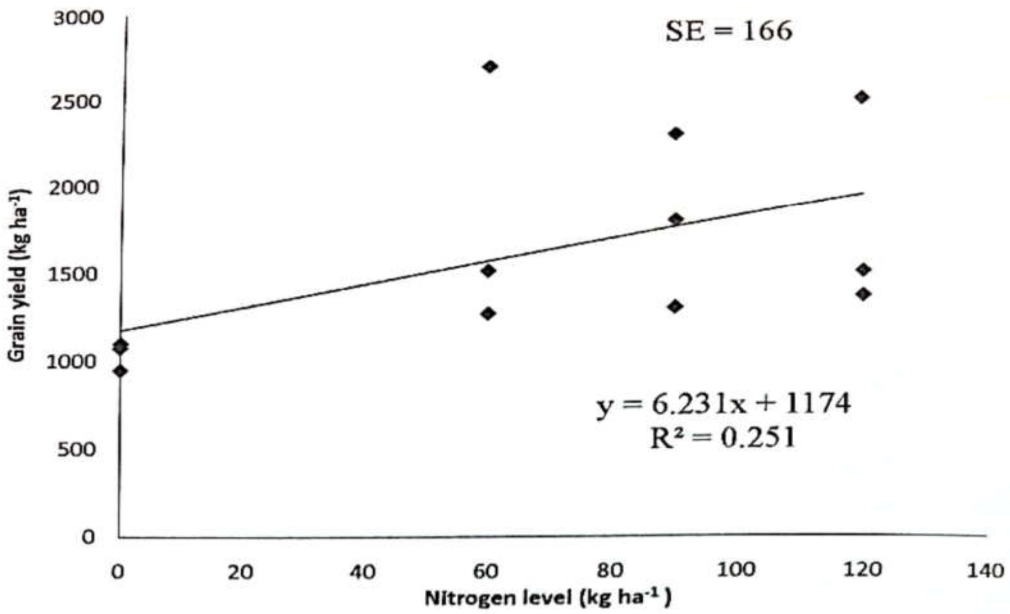

Fig. 2 Response of maize grain yield to inorganic nitrogen fertilizer at Mokwa site.

that had phosphorous application, in four sites in the Guinea savanna of northern Nigeria. The incorporation of the *A. histrix* residues could also have been responsible for the relatively high value obtained. This is because estimation of the NFRV of a legume is usually affected by the management of the legume residues. Higher value is recorded when the residues are incorporated into the soil, than when they are exported from the field. The incorporation of the residues will ensure faster release of N and higher N returned to the soil, due to direct contact with soil enzymes which will facilitate decomposition of the residues (Costa *et al.*, 1989).

CONCLUSION

From the results of this study, at the two sites, both natural and *A. histrix* fallows improved the soil organic matter and hence, the physical, chemical and biological properties of the soil for good crop growth. Incorporation of the *A. histrix* residues substantially increased the soil N content. Maize rotation with natural fallow was as equally good as rotation with *A. histrix*, with respect to maize grain yield at Minna site, but at Mokwa, rotation with *A. histrix* gave a better grain yield. There was response to inorganic N fertilizer application, suggesting the need for N application to maize for optimum grain yield at both sites. Nitrogen rate of 60 kg ha^{-1} was optimum for maize grain yield at both sites. A very low amount of N was contributed to the succeeding maize crop by *A. histrix* at Minna, compared to higher amount at Mokwa site.

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