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Relative-Influence of Different Residue Management System on Nutrient Concentration, Uptake and Yield of Maize in Southwestn Nigeria

O.S. Shittu, A.S. Fasina and O.J. Aruleba
Department of Crop, Soil and Environmental Sciences, University of Ado-Ekiti, Nigeria

Abstract: The relative effect of different residue management (burning in situ, incorporation of burnt residue, incorporation without burning, surface mulching and Burning) on nutrient concentration, uptake and yield of maize was investigated at Ado-Ekiti, Southwest Nigeria. Residue management significantly ($p \leq 0.05$) affected uptake of K, Ca and Mg on plots with burnt-in situ residue. Uptake of N, P, K and Mg was quantitatively higher in surface mulch plots in the second year than other residue management plots. During the second year of planting the surface mulched plots increase grain yield of maize at a positively higher percentage (26.5%) than any other residue management. This shows that residue management using surface mulch was an effective nutrient source for sustaining soil management and improving yield of maize.

Key words: Relative influence, different residue, management system, nutrient cocentration yeild of maize

INTRODUCTION

Crop farmers in tropical countries such as Nigeria are faced with problems of supplying adequate and balanced nutrients for crops because of low soil nutrients and organic matter status of continuously cropped soils and scarcity of high cost of fertilizers. Therefore, farmers who are mainly small holders depend on organic sources of nutrients such as plant residues.

Different residue management is a soil management approach to moderate soil temperature and conserves moisture. However, there is different plant residue management obtainable in different places under different agro-ecological zone. Almy *et al.* (1989) listed the different types of residues management practices by farmers in Southwest province of Cameroon to include clearing from the field, burning, surface and in corporation into mounds and beds. While effect of these residues on soil physical properties has received much research attention, the comparative effect of different residue management on soil chemical properties and crop nutrient status requires more study. Previous studies (Budelman, 1989; Ojeniyi and Adetoro, 1993; Ojeniyi and Falade, 1997; Awodun and Ojeniyi, 1999; Olasantan, 2001) showed that residues of chromolaena odorata and Glirincida Sepium improved soil and plant nutrient status and yield of crops such as yam, okra and tomato. The study investigates the relative influence of different residue management on nutrient concentration and uptake and yield of maize in South West Nigeria.

MATERIALS AND METHODS

Environmental setting: The study was located in Ado-Ekiti, a town on Latitude 7.3^{0}N longitude 5.3^{0}E. The town is the capital of Ekiti State. The soils are formed by the very old rocks of the pre-cambian basement complex. The soil was an alfisol/oxic-Tropudalf-USDA Taxanomy or ferruvic Luvisol-FAO/UNESCO. The soil was well drained with appreciable amounts of quartz, stones, gravel and ironstone concretions down to 50 cm. The region has a tropical humid climate with distinct wet and dry seasons. The wet season is from late March to October with little dry seasons in July and August. The mean annual temp. is 27°C with a maximum range of 9°C while the mean annual rainfall is 13676 mm with double maximum range. The area falls within the high forest zone where the rich tropical forest once thrived. It is however, noted that a lot of human activities have replaced the lowland rainforest with derived Savannah. This has resulted in secondary forests thickets, fallows and herbaceous vegetation.

Agricultural crops are mainly tree crops like oil palm, cocoa, kola and some arable crops like maize, cocoyam, cassava, melon and plantain.

Site description and analysis: The experiments were conducted for two years between 2001 and 2002 at Teaching and Research Farm, University of Ado-Ekiti in South Western Nigeria.

The soil was an alfisol (Oxic-Tropudalf-USDA Soil Taxonomy or Ferruvic Luvisol-FAO/UNESCO). The soil

Corresponding Author: A.S. Fasina, Department of Crop, Soil and Environmental Sciences, University of Ado-Ekiti, Nigeria

was well drained with appreciable amounts of quartz, stones, gravel and ironstone concretions down to 60 cm.

Surface soil samples (0-15cm) were taken from each of the treatment site each year. The soil samples were air-dried crushed and sieved with 2 mm sieve. Routine analysis were done for particle size distribution using hydrometer (Bouyoucos, 1951) method and pH was measured using glass electrode pH meter at 1:1 soil to water ratio. The percentage of organic carbon was determined by the Walkey Black wet oxidation method (Walkey and Black, 1934) while percent total N was determined by macro Kjedal method (Jackson, 1962). The percent organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. Available P was determined by the method of Bray and Kurtz (1945) while exchangeable cations were determined by extracting with neutral normal NH_4OAC as described by Jackson (1958). The K and Na were then measured with the flame photometer while Mg and Ca were determined on the atomic absorption spectrophotometer. The Exchangeable Acidity (EA) was determined by the titration method (Jackson, 1958). The Effective Cation Exchange Capacity (ECEC) was thus calculated as the sum of the exchangeable bases (K+Na+Ca+Mg) and EA expressed as in cent mol kg^{-1} of soil. The percent base saturation was calculated as the sum of the exchangeable base expressed as a percentage of ECEC.

Pre-cropping soil sampling: Prior to the start of each experiment, 25 random surface (0-15 cm) soil sampling were taken by augering from different location on each experimental field.

The experimental size was cleared in early March 2001 and the residue generated were left to dry for about 3 weeks; The previous crops are mainly coca, kola and some arable crops like yam, maize, cassava being grown. The residues generated were imposed in five different ways after the marking out of the plots.

The residue were imposed as follow: Residue baled, residues incorporated without burning, residues incorporated after burning, residues burnt in sit and residues used as mulch.

The experimental zdesign was Randomized Complete Block (RCB) with 3 replicates. Each plot measured 12×5 m and this gave the farm size 0.02 has Sole Maize Variety FARZ (TZB) was planted 2 weeks after the imposition of the treatment at a spacing of 90×40 cm with 4 seeds per stand. They were later thinned to two seeds per stand after one week of emergence. Pre-emergence herbicide gramozone + primextra was sprayed for weed control. Growth parameters as well as yield and yield component were deter mined.

The field was re-prepared for another planting in March and the treatments were re-imposed in situ using the resulting residues. The same maize variety was planted and same cultural practices and data collection were also carried out. The establishment of this experiment commenced with land cleaning in the month of March 2001. Residue generated were predominantly Chromolaena odorata with sparse Talinum triangular, Tridax procumbens and few Cynodon dactylon were left in the field to dry for three weeks. The different plots were marked out and residues on them evenly spread with the removal of cut trees and shrubs.

Plant analysis: Five plants at 4WAP were randomly sampled form each plot and sub-sample for whole plant and ear-leaf were dried at 65°C. Data on cob yield and maize grain yield were also taken. Sub-samples of whole plant and ear-leaf were dried at 65°C and Over-dried sub samples were ground for Nutrient (N, P, K, Ca and Mg) analysis. Total N was analyzed by Micro-Kejldah digestion of 0.5g sample, followed by distillation titration. For the determination of P,K, ca and Mg 2 g samples were wet digested with a mixture of 20 mL con HNO_3, 5 mL conc. H_2504 and 5 mL $HClO_4$. Phosphrous in the digest was measured Colorimetrically by vanadomohybdate yellow method using spectronic 20 at 400NM wavelength; K and Ca by flame photometry and Mg by the atomic absorption spectrophotometer. Nutrient uptake was obtained using the equation

$$Nu = \frac{\text{Nutrient concentration} \times \text{dry matter}}{100}$$

Data analysis: All data collected were subjected to simple statistical analysis and analysis of variance following the procedure of Steel and Torrie.

RESULTS AND DISCUSSION

Soil fertility evaluation: The PH of the soil for both years was slightly acidic (6.50 and 6.63). Total N at the start of the experiment was 0.09% but dropped to 0.07% at the second planting. The initial available P before the first cropping was 6.32 mg kg^{-1} and in the second 6.30 mg kg^{-1} and is generally lower than the critical value of P for Southwestern Nigeria, 12-15mg kg^{-1} (Agboola, 1982). The K content was adequate (0.25) in the first year and 0.30 in the second and falls within the critical level for K for soils in Southwestern Nigeria which is 0.20-0.25 cmol kg^{-1} (Agboola, 1982). The low Effective Cation Exchange Capacity (ECEC) and high are characteristics of highly weathered tropical soils. The soil is sandy with low clay content (Table 1).

Table 1: Physical and chemical properties of soil before the treatment imposition in 2001 and 2002

Soil properties	2001	2002
Physical properties (g %)		
Sand	76	74
Silt	30	28
Clay	15	13
Textural class	Sand loam	Sandy loam
chemical		
PH (H_20)	6.5	6.63
Org C (%)	6.21	6.10
Total N (%)	0.09	0.07
Avail P (mg kg^{-1})	6.32	6.30
Exch. basses (cmo kg^{-1})		
K	0.25	0.30
Ca	0.41	0.44
Mg	0.08	0.08
Na	0.14	0.15
Exch. acidity	0.25	0.28
ECEC	1.00	1.10
Bases saturation %	70.3	71.50

The results of analysis of the soil samples collected before planting in the two cropping years showed that the content of percent organic carbon, exchangeable K and Na are quite high and above the critical level as reported by Adepetu (1986) and Adeoye (1986) except that of Nitrogen which was below the critical level of 0.2% recommended by Adeoye (1986). However, the available P level and exchangeable Ca and Mg content are lower than the critical levels considered optimum by Sobulo and Osiname (1981) and Adeoye and Agboola (1985).

Influence of different residue management system on nutrient concentration and uptake: Table 2 and 3 shows the influence of different residue management systems on Nutrient concentration (6WAP) and uptake by maize for 2001 and 2002, respectively.

Residue management at 6 WAP produced variable effect on uptake and concentration. Nutrient uptake at first year of planting (2001) was significant for K, Ca and Mg (Table 3) while there were no significant difference in nutrient content of maize in both years (2001 and 2002 Table 2). Eneji (1997) and Kutu (2000) obtained similar reports on effects of different clearing methods in nutrient uptake of maize. However, the uptake of K and Mg during the year 2001 was significantly higher in burning in-situ plot than any other plot, while Ca uptake was also significantly higher than any other residue management. Although Ca uptake for burning in-situ was not significantly different from that obtained for surface mulching (Table 3). Uptake of N, P, K and Mg with the exception of Ca was quantitatively higher in surface mulching plots in the 2nd year (2002-Table 3) than other residue management plots.

From the results obtained in the 2nd year of cropping, the uptake of all the nutrients except Ca is below the critical level. This could have been responsible to the lower grain yield obtained in Burning in situ, incorporation of burnt residue and Bailing plots (Table 4). The higher grain yield obtained in incorporation without burning and surface mulching in year 2002 even with slightly lower nutrient uptake might be due to other environmental factors apart from the nutrient status.

Influence of different residue management systems on yield and yield components of maize: The field dried Cob weight and grain yield were significantly ($p \leq 0.05$) affected by the different plant residue management during the 2001 cropping season (Table 4) Grain yield in bailing, incorporation of burnt residue and residue burnt in situ during the 2001 cropping cycle were not different significantly but quantitatively higher in the bailing plot. IRA (1988) working in western highlands of Cameroon also reported that incorporation of plant residue give higher maize grain yields than burning during the first year of cropping cycle.

However, during the second year of cropping there were no significant differences in the field dried cob weight although maize field cob weight was quantitatively higher in the treatment with residue burnt insitu.

During the second year of cropping (2002) maize grain yield under insitu burning, incorporation without burning and surface mulching were not significantly different although the latter gave a higher yield. A similar result was obtained by Nguimbo and Balasubramanian (1992) who reported higher though not significant grain yield when residue was applied at the surface than when incorporated into the soil both in a particular location of similar soil type. However, during the 2nd year (2002) all measured parameters on grain yield dried cob weight during the second year decreased by between 5.2 and 1.6 and 19.6% respectively, with the exception of plant residue with surface mulching and incorporation of residue without burning for field dried cob weight and maize grain yield.

The decreased yield (approximately 22.9%), obtained under plant residue incorporation during 2001 over 2002 cropping cycle was similarly reported by Biederbeck *et al.* (1980). They attributed this to more straw N from the system and a reduction in the soil ability to mineralize N. It may also be due to a higher quantity of plant residue incorporated into the soil during 2001 and 2002 cropping season which might have equally brought about higher straw immobilization and N losses. The use of plant residue as surface Mulch increased field dried cob weight by 25% while plant residue incorporation without burning gave in increase in the field dried cob weight between both years.

Table 2: Nutrient contents of maize plant samples 6wap under different residue management residue

	Nutrient content (g Kg^{-1} dry matter) 2001					2002				
Residue	N	P (mg g^{-1})	K	Ca	Mg g kg^{-1}	N	P (mg g^{-1})	K	Ca	Mg g kg^{-1}
Burning in Situ	1.62	0.56	10.24	12.78	4.12	1.35	0.54	10.13	10.06	5.23
Incorporation of burnt residue	1.66	0.60	6.86	10.25	3.89	0.62	0.50	7.28	10.08	3.24
Incorporation without burning	1.23	0.52	8.34	9.89	4.05	1.46	0.51	8.56	12.78	3.45
Surface mulching	1.23	0.52	8.34	9.89	4.05	1.46	0.51	8.56	12.78	3.45
Burning	0.96	0.64	7.85	11.26	3.16	0.80	0.47	8.74	10.16	3.20
%CV. L.S.D (5%)	38.7	(0.12)	15.2	18.1	8.6	49.5	3.2	23.4	25.3	10.2

Table 3: Nutrient uptake (g kg^{-1}) by maize plant under different residue management

	Nutrient content (g g^{-1}) dy matter) 2001					2002				
Residue management	N	P (mg g^{-1})	K	Ca	Mg	N	P (mg g^{-1})	K	Ca	Mg
Burning-in-Situ	0.93	0.41	4.76	7.28	2.28^{a}	0.46	0.23	3.17	4.11	1.02
Incorporation of burnt residue	0.70	0.21	3.13^{ab}	4.69^{b}	1.17^{b}	0.22	0.20	2.76	4.28	0.73
Residue	0.52	0.21	2.89^{b}	5.89^{ab}	0.84^{b}	0.58	0.25	3.43	5.60	1.56
Surface mulching	0.78	0.27	3.58^{b}	5.42^{b}	1.06	0.82	0.32	3.82	6.85	1.79
Burning	0.48	0.28	2.89^{b}	5.89^{ab}	1.25^{b}	0.25	0.16	2.45	3.83	0.65

Table 4: Percent change in field dried cob weight (T/HA) and maize grain yield (T/HA) after treatment with different residue management

	Field dried cob weight (t ha^{-1})			Maize grain yield (t ha^{-1})		
Treatment	Year 2001	2002	Percent change	Year 2001	2002	Percent change
Burning-in- situ	5.7^{a}	5.4	-5.2	3.2^{ab}	3.1^{a}	-3.1
Incorporation of burnt residue	5.4^{a}	5.2	-16	3.5^{b}	2.7^{ab}	-22.9
	5.2^{a}	5.2	0	2.9^{b}	3.3^{a}	12-1
Surface mulching	3.9^{b}	5.2	25	2.5^{b}	3.4^{a}	26.5
Bailing	61^{a}	4.9	-19.6	3.8^{a}	2.1^{b}	-44.7
(S.E.)	(0.39)			(0.36)		
c.v.%		24.3+			32+	

Note: Negative value indicates percent reduction: L.S.D. at 5%; Figures in parentheses indicate standard error at $p \leq 0.05$, +Indicates coefficient of variability. Means for treatment over the two years having the same superscript letter are not statistically significant

Maize grain yield was increased by 26.50% when plant residue was used as surface mulch. Plant residue incorporation similarly increased maize grain yield by 12.1%, however, plant residue by bailing gave the highest reduction in filed dried cob weight and grain yield by 19.6 and 44.7%, respectively.

CONCLUSION

Plant residue management significantly ($p \leq 0.05$) affect nutrient uptake particularly K, Ca and Mg in the first year with K and Mg uptake significant higher in plots with residues burn't in-situ and surface mulched plots. Ca uptake was also significantly higher in plots with residue burn't in-situ and surface mulched plots.

Both field dried cob weight and grain were significantly ($p \leq 0.05$) affected by the different plant residue managements in both years, with Burning in situ and bailing given the best maize yields from the field.

During the second year of cropping, the surface mulched plots increase maize grain yield at a positively higher percentage than other residue managements.

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