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Full Length Research Paper

Effect of different crop residue management techniques on selected soil properties and grain production of maize

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Residue addition into the soil environment and the changes associated with their additions are important in planning cultural operations and developing appropriate soil management systems. The objective of this study was to evaluate the effects of different residue management techniques (surface mulch, burning and incorporation, slash and incorporation as well as control) on soil properties and grain yield of maize. In all treatments soil, pH, organic matter (OM) (g/kg), CEC (cmolkg-$^{1)}$, available Phosphorus (mgkg-$^{1)}$ and exchangeable bases (cmolkg-^{1}) improved significantly ($p < 0.05$) relative to the control. Maize grain yield was higher in residue treated plots relative to the control in both cropping seasons irrespective of the treatment. The correlation co-efficient between yield and soil properties showed high values indicating that observed improvements in soil properties in amended plots contributed to higher maize grain yield.

Key words: Residue management, soil environment, soil organic matter, crop production, grain yield.

INTRODUCTION

Soils of Southeast Nigeria are acidic, sandy and physically fragile and are deficient in organic matter, nitrogen and basic cations (Ohiri and Ano, 1989). Because of high cost of chemical fertilizers it becomes necessary to intensify studies into locally available and acceptable soil management strategies to stabilize and improve condition of the soil, their fertility and productivity.

In this part of Nigeria huge amount of crop residues are generated through manual preparation of land for crop production. The residues traditionally viewed as nuisance are associated with mechanical planting difficulties, decreased efficacy of herbicides, release of growth inhibitory allelopathic compounds and ultimately decreased yield (Sandford, 1982). There is need to avoid these problems through proper management of the residues. Ojeniyi and Ighomrore (2004) as well as Owolabi et al. (2003) observed that some of the residue management techniques had varied effects on soil organic matter (SOM) contents. Similarly, Adetunji (1997) as well as Kuku and Omoeti (2003) observed that the management of residues after land clearing influences the fate of soil organic matter (SOM). However, soil fertility can be maintained through maintenance of appropriate levels of SOM (Opara-Nadi et al., 2003; Onofiok, 1993).

The addition of residues into the soil environment and the study of the changes associated with their addition according to Azzez et al. (2007) are important in planning cultural operations and developing appropriate soil management systems. This study aimed at evaluating the effects of different crop residue management techniques, such as surface mulch(SM), slash and incorporation (SAI), burning and incorporation (BAI) and control on the properties and grain yield of maize in a Typic Haplustult in Enugu Southeast Nigeria.

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Abbreviation: CEC, Cation exchange capacity; **SM,** surface mulch; **BAI,** burnt and incorporation; **SAI,** slash and incorporation; **OM** organic matter.

Table 1. Effect of residue management techniques on soil exchangeable bases and CEC.

Treatment	Year 1					Year 2				
	Ca	Mg	K	Na	CEC	Ca	Mg	K	Na	CEC
SM	0.63	1.02	0.08	0.08	18.2	0.80	1.60	0.08	0.10	20.8
BAI	0.80	1.02	0.10	0.07	17.6	0.90	1.80	0.12	0.10	22.8
SAI	0.52	0.91	0.08	0.07	16.7	0.60	1.20	0.10	0.12	20.0
C	0.33	0.69	0.06	0.03	9.81	0.32	0.62	0.05	0.06	10.3
$LSD_{0.05}$	0.015	0.021	0.013	0.013	0.212	0.021	0.024	0.017	0.123	0.158

SM = Surface mulch, BAI = burnt and incorporation, SAI = slash and incorporation, C = control.

MATERIALS AND METHODS

Study site

The experiment which lasted for 2 cropping seasons was conducted in a Typic Haplustult at the permanent site of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology (ESUT) Teaching and Research Farm Agbani, Enugu. The area is located on latitude 06°25^{1}N and longitude 07°15^{1}E at an altitude of 450 m above sea level. Annual rainfall range is between 1700 to 1800 m with bimodal pattern. The soil is an ultisol and also classified as Typic Haplustult (FDALR, 1985).

Land preparation and treatment application

A total land area of 256.5 m^2 was cleared and used for the experiment in the 2007 and 2008 cropping seasons. The experiment was laid out as a complete randomized block design (RCBD) with 4 treatments replicated 5 times. The land after clearing was left untilled while residue generated was allowed to dry for 2 weeks. 20 kg of dry weight of residues was spread evenly on plots measuring 3 × 3 m. The treatments which consisted of 3 residue management techniques (surface mulching (SM), burning and incorporation (BAI), slash and incorporation (SAI)) and control were randomly assigned to the plots. Maize variety oba super II was planted 2 seeds per hole and at a spacing of 0.75 m × 0.25 m. The maize plant was thinned down to one plant/hill 2 weeks after germination to give a total plant population of 53,000 plants/ha. The area was kept relatively weed free through out the experiment which lasted for 2 cropping seasons.

Soil sampling and data collection

Four auger samples for determination of soil chemical properties were randomly collected from 0 to 20 cm depth in each plot. The samples were mixed and composite sub-samples were used for analysis. The composite samples collected before and after the study were analysed for N, OM, P, K, Na, Mg, Ca, pH and CEC. Total Nitrogen percent was determined by macro-kjekdahl method (Bremner and Mulvaney, 1982), available Phosphorus ($mgkg^{-1}$) was determined by Bray II method as outlined by Olsen (1982), organic carbon (%) was analysed by Walkley and Black procedure (Nelson and Somners, 1982). Soil pH in water was determined by the glass electrode pH meter (Maclean, 1982). The exchangeable cations and CEC were determined by the method described by Thomas (1982). Particle size distribution was determined by the hydrometer method. Crop performance data collected at harvest included height and grain yield.

Data analysis

Data collected from the study were analysed using analysis of variance (ANOVA) test based on randomized complete block design according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

The soil in the study area was sandy clay loam in texture with a pH value of 4.7. The soil OM of 11.1 gkg^{-1}, total N of 0.56 gkg^{-1}, and available P of 3.73 mgkg-1 were low. Similarly, the exchangeable cations values of 0.04 (K), 0.4 (Ca), 0.6 (Mg), 0.3 (Na) and CEC value of 12.6 ($cmolkg^{-1}$) were low. The soil represents a typical tropical soil which has been continuously and intensively cultivated without addition of any nutrient. It was, therefore, low in nutrients including N, P and K. Residue management techniques significantly ($p < 0.05$) improved soil exchangeable bases and CEC relative to the control (Table 1). Soil Ca content in the residue management amended plots ranged between 0.52 to 0.80 $mgkg^{-1}$ and 0.60 to 0.90 $cmolkg^{-1}$ in the first and second cropping seasons, respectively. The observed Ca content in the control in the first season was 56, 91, and 142% lower than those in SM, SAI and BAI, respectively. The highest Mg contents of 1.02 and 1.80 $cmolkg^{-1}$ in the first and second cropping seasons were observed in SM and BAI amended plots, respectively. The control had 60, 100 and 140% lower values of K relative to SM, SAI and BAI treatments in the second season. In both seasons, the residue management techniques had significantly higher CEC and non-significant values of total N compared to the control. Surface mulch (SM), BAI and SAI gave relatively higher OM, available P and total N values relative to the control (Table 2). The mean pH, OM, available P and total N values in residue treated plots ranged from 4.6 to 5.1, 0.98 to 1.25%, 2.8 to 3.8 $mgkg^{-1}$ and 0.41 to 0.071%, respectively, in the first cropping season. Slash and incorporation (SAI) of residue gave the highest OM content (1.35%) in the first cropping season while BAI gave the highest total N (0.070%) value in the second cropping season. Observed values of available P in SM in the second season showed 25, 66

Table 2. Effect of residue management techniques on soil pH, OM, total N and available P.

Treatment	Year 1				Year 2			
	pH	OM	TN	Available P	pH	OM	TN	Available P
SM	5.1	1.23	0.071	3.80	5.5	1.39	0.070	4.66
BAI	5.4	1.19	0.062	3.73	5.9	1.26	0.028	2.80
SAI	5.0	1.25	0.065	3.72	5.0	1.32	0.058	3.73
C	4.6	0.98	0.041	2.8	4.5	0.96	0.018	2.53
$LSD_{0.05}$	0.20	0.04	NS	0.01	0.19	0.02	NS	0.02

SM = Surface mulch, BAI = burnt and incorporation, SAI = slash and incorporation, C = Control, TN = total nitrogen.

Table 3. Effect of residue management techniques on plant height (cm) and grain yield ($mgha^{-1}$).

Parameter	Year 1		Year 2	
	Height (cm)	Yield ($mgha^{-1}$)	Height	Yield ($mgha^{-1}$)
SM	182.9	3.0	183.7	3.3
SAI	174.9	2.1	170.0	2.4
BAI	184.2	2.5	131.8	1.2
C	160.6	1.3	131.8	1.2
$LSD_{0.05}$	0.55	0.235	0.24	0.185

SM = Surface mulch, BAI = burnt and incorporation, SAI = slash and incorporation, C = control.

and 84% increase compared to SAI, BAI and control. Similarly, pH was 11, 13 and 7% lower in control plots relative to SM, BAI and SAI plots, respectively in the second cropping season. The observed improvement in soil properties in residue management treated plots could be attributed to the effects of these treatments on soil conditions. Ojeniyi and Falade (1997) reported improved soil condition on crop residue incorporated soil while Maskena et al. (1993) observed that soil incorporation of residues improves soil water relation for plant and microbial activity, thus enhancing nutrient cycling. Power et al. (1998) showed that covering the soil surface with layers of residue increased infiltration and prevented formation of compaction caused by raindrop impact on bare soils. Mbah (2009) observed that, there was improved soil condition and temperature in mulched plots relative to non mulched plots. Ash incorporation into the soil reduces acidity and increase availability of K, Ca and Mg (Araki, 1993; Mbah and Nkpaji, 2009).

Table 3 shows significantly higher plant height and grain yield in residue management treated plots relative to the control in both cropping seasons. Plant height in residue management treated plots ranged between 170.9 to 184.2 cm and 170 to 183.7 cm in the first and second cropping seasons, respectively. The observed plant height values in the residue management treated plots in the first cropping season were 142, 10 and 13% for SM, BAI and SAI higher than the control respectively. Maize grain yield was significantly higher in residue management amended plots than in the control by 6 to 131% and 100 to 167% in the first and second cropping seasons, respectively. The improved soil conditions due to crop residue addition resulted in higher plant heights and grain yield relative to the control in both cropping seasons. The residues improved the soil water relations thus enhancing nutrient cycling and release to the plants. Application of the residues improved soil pH for maize growth and yield since maize does not do well under strongly acidic soil of pH < 5.0. Lawson and Lal (1977) reported that surface applied mulch created favourable soil moisture and temperature range, resulting in higher yield. Similarly, Lal (1973) showed that the adverse effect of temperature on maize and soybeans can be ameliorated by surface mulch application. Using plastic film as surface mulch, Mbah (2009) reported increased maize yield relative to the control. Similarly, Iremirem (1989) reported higher maize yield in residue incorporated plots compared to control while Mbah and Nkpaji (2009) showed that ash incorporation into the soil resulted to higher maize yield relative to the control.

The relationship between selected soil properties and maize grain yield is shown in Table 4. The table shows high correlation co-efficient values between yield and selected soil properties. The high correlation co-efficient indicated that the improvements observed in soil properties as a result of the application of residues contributed to the higher grain yield obtained in the residue amended plots relative to the control.

Table 4. Relationship between selected soil properties and maize yield.

Parameter	Regression model	R^2
Yield Vs CEC (Yr 1)	Y = 0.396 + 0.099 X	0.589
Yield Vs OM (Yr 1)	Y = 1.602 + 0.054 X	0.816
Yield Vs pH (Yr 2)	Y = 0.065 + 0.700 X	0.988
Yield Vs Available P (Yr 2)	Y = -1.311 +0.715 X	0.658

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