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Interaction Effect of Tillage and Poultry Manure on Soil Physical Properties, Nutrient Contents and Yield of Yam on Alfisol in South Western Nigeria

Adeleye, E.O and *Ayeni L.S.

Department of Agricultural Science, Adeyemi College of Education, Ondo, Ondo State, Nigeria

ABSTRACT

Interaction effect of tillage and poultry manure on soil physical properties, nutrient uptake and yam (Dioscorea rotundata) performance was investigated in field experiments involving five (5) soil tillage techniques, namely ploughing (P), ploughing plus harrowing (PH), manual heaping (MH), manual ridging (MR) and zero-tillage (ZT) each combined with poultry manure at the rate of $0tha^{-1}$ and $10tha^{-1}$ in a factorial experiment arranged in split-plot design. Each treatment combination was replicated three (3) times. Data obtained were subjected to analysis of variance using Statistical Analysis System (SAS) Institute Package. Soil moisture, bulk density and total porosity were significantly ($P>0.05$) influenced by soil tillage – poultry manure treatments. Addition of poultry manure to the tillage techniques in the study increased soil total porosity , soil moisture content and reduced soil bulk density and soil temperature. Tillage techniques plots amended with poultry manure enhanced yam leaf nutrient content and tuber yield relative to tillage techniques plots without poultry manure application. It is concluded that the possible deleterious effect of tillage on yam performance can be reduced by combining tillage with poultry manure.
KEY WORDS: Poultry manure, tillage, bulk density, Porosity, tuber yield.

INTRODUCTION

Due to the fragile nature of soils in southwestern Nigeria, appropriate and integrated soil management is necessary for sustaining high soil and crop productivity. Root and tuber crops are sensitive to soil compaction and inadequate aeration and therefore respond well to tillage treatment (1). In the same view Adeleye et al (2) advocated that yam production on alfisols in the Southwestern Nigeria requires tillage and loose soil structure. However, soil tillage induces profound changes in soil fertility status and the changes may be manifested in good or poor performance of crops. Inappropriate tillage practices contribute greatly to the mismanagement of Nigerian soils which often results in excessive soil wash, leaching of nutrients, compaction and destruction of soil structure, loss of soil organic matter (3). Although, forms of soil conserving tillage such as manual clearing and herbicide base zero-tillage were recommended for high rainfall areas of Nigeria for the production of Cereals (4). However, suitability of mechanized tillage, manual tillage and zero tillage when combined with poultry manure has not received research attention on alfisols located in Southwestern Nigeria.

The use of animal manures as soil amendments to sustain adequate crop yields has been found effective for cereals and vegetable crops in Southwestern Nigeria (5,6,7). Adeleye et al (2) reported that the use of poultry manure improved soil physico-chemical properties, nutrient uptake and yield of yam. Application of poultry manure to tillage techniques plots is expected to ameliorate deleterious effects of tillage techniques on soil properties and enhance yield of crops. Increasing yam production in Nigeria on sustained and sustainable basis will be the key for the crop contributing its own share to the solution of the country's food insecurity problem. Therefore, it is important to investigate the combined use of soil tillage techniques and poultry manure, hence, the objective of the study was to determine the interaction effects of soil tillage techniques and poultry manure on soil characteristics and yield of yam.

MATERIALS AND METHODS

Field Experiments and Experimental Design

The study involved five (5) soil tillage techniques, namely ploughing (P), Ploughing plus harrowing (PH), manual ridging (MR), manual heaping (MH) and zero tillage (ZT) each combined with and without

***Corresponding Author:** Ayeni L.S., Department of agricultural science, Adeyemi college of education, Ondo, ondo state, Nigeria. leye_sam@yahoo.com

poultry manure at the rate of 10tha^{-1} in a factorial experiment arranged in split-plot design. The field experimental procedure is as outlined elsewhere by Adeleye et al (2). A total land area of 110mx50m was marked out for the experiment at Gbajia village, Ondo (07^0 05^1N, 04 55^1E) in the rain forest zone of southwestern Nigeria for two farming seasons (2007 and 2008). The land area was divided into three blocks; adjacent blocks were demarcated by 5- metre alley ways. Each block was further divided into five main plots of 15m x15m on the basis of soil tillage techniques which were similarly demarcated by 5-metre alley ways. Each main plot was further divided into two sub plots of 5mx15m on the basis of poultry manure rates which were also demarcated by 5m alley ways. The treatments were assigned to the plots and each replicated three times. The same treated plots were maintained for the two planting seasons. Yam setts having average weight of 300g were planted two weeks after poultry manure had been applied. Other cultural practices were adequately carried out.

Determination of Soil Physical Properties

Soil bulk density, total porosity, temperature and moisture content were determined as described elsewhere by Adeleye et al (2).

Determination of Leaf Nutrient Contents

At five months after planting, mature leaves were collected from 10 tagged yam stands per plot. The leaf samples were oven dried at 65^{o}C for 48 hours and ground for routine chemical analysis. Leaf N was determined using the micro-kjeldahl digestion method. Phosphorus was determined colorimetrically by vanadomolybdate method, K by flame photometer, Ca and Mg were determined by atomic absorption spectrophotometer (8).

Yam Tuber Yield Data

Ten tagged yam stands were selected per replicate (plot) for the measurement of yam tuber yield parameters. Tuber weight was determined using a weighing balance, tuber length and tuber girth with a measuring tape.

DATA ANALYSIS

Data on the soil physical properties, yam tuber yield and leaf nutrients content were subjected to analysis of variance using statistical Analysis System Institute Package (SAS) and the mean values were compared using Duncan's Multiple Range Test at 0.05 level of significance, where F-ratio was significant.

RESULTS

Interaction effect of tillage and manure on soil moisture content was significant (P>0.05) at both cropping seasons (Table 1) Zero-tillage plots amended with poultry manure had the highest mean soil moisture content (100.45 g kg^{-1}) while manually ridged plots without poultry manure had the least mean soil moisture content (58.57 g kg^{-1}) – Poultry manure improved the soil moisture content of plots under the various tillage techniques over the soil moisture content of plots under the corresponding tillage techniques without poultry manure application by 17.4%, 20.7%, 18.1%, 17.2% ad 14.9% for zero-tillage, ploughing, ploughing plus harrowing, manual heaping and manual ridging respectively. Application of poultry manure to the soil tillage techniques lowered the soil temperature relative to tillage techniques plots without poultry manure application. Interaction effect of tillage and poultry manure on soil temperature was significant (P>0.05).

Tillage techniques plots with poultry manure application had lower soil bulk density when compared with the tillage techniques plots without poultry manure application. Reduction in soil bulk density of the various tillage techniques plots with poultry manure was in the range of 5.5%-6.8% over the corresponding tillage techniques plots without poultry manure application. This reduction in soil bulk density of various tillage techniques plots with poultry manure was more in the second cropping season (2008) than the first cropping (2007). Tillage techniques plots amended with poultry manure had relatively higher soil total porosity compared with tillage techniques without poultry manure application. Zero-tillage plots without poultry manure had the least soil total porosity. The highest soil total porosity was obtained in manually ridged plots amended with poultry manure. Interaction effects of tillage and poultry manure on soil bulk density and porosity were significant.

Table 1: Interaction Effect of Tillage and Poultry Manure on Soil Physical Properties

Treatment	Moisture Content g kg^{-1}		Temperature 0^c		Bulk Density g cm^{-3}		Porosity %	
	2007	2008	2007	2008	2007	2008	2007	2008
ZT - M	90.61b	78.49c	30.55c	30.49d	1.50a	1.66a	43.24d	37.07e
ZT + M	106.83a	94.06a	29.60d	30.03d	1.44b	1.60a	44.57c	39.40d
P – M	69.86c	68.06d	31.73b	32.12b	1.42b	1.55b	46.58b	41.44c
P + M	83.86b	80.83b	30.33c	31.53c	1.36c	1.51bc	48.51a	42.86b
PH – M	85.06b	75.85c	31.13b	31.51c	1.48a	1.67a	44.30c	38.11e
PH + M	101.83a	88.18a	30.41c	31.13c	1.43b	1.58b	46.92b	41.28c
MR – M	61.50d	55.88e	32.13a	32.88b	1.39c	1.55b	47.39a	41.66c
MR + M	72.67c	84.54b	31.40b	32.13b	1.36c	1.50c	48.76a	43.32b
MH – M	67.49c	57.81e	32.33a	33.04a	1.41c	1.53c	46.42b	43.17b
MH + M	65.00cd	67.42d	31.53b	30.80cd	1.36c	1.48d	48.68a	44.38a

Means with the same letter in the same column are not significantly different at 5% level using DMRT
NB: ZT-M = zero tillage no manure; ZT + M = zero tillage plus manure; P –M = ploughing no manure; P + M =ploughing + manure; PH-M =ploughing plus harrowing no manure; PH + M= ploughing plus harrowing + manure; MR-M= manual ridging no manure; MR+M = manual ridging + manure; MH-M = manual heaping no manure; MH +M= manual heaping + manure.

Data in table 2 showed significant (P>0.05) interaction effects of tillage and poultry manure on the leaf nutrients concentration at both cropping seasons. Yam grown under different tillage techniques amended with poultry manure contained higher concentration of leaf nutrients than their corresponding tillage techniques without poultry manure application. Yam leaf nutrients concentration under the various tillage techniques amended with poultry manure in the second cropping (2008) were higher than those of the first cropping (2007). However, there was a reduction in the yam leaf nutrient concentration under various tillage techniques plots without poultry manure during the second cropping (2008) when compared with the first cropping (2007). Manually ridged plots amended with poultry manure had the highest leaf nutrients concentration in terms of percent N, P and Mg. Yam grown on ploughed plots amended with poultry manure had the highest leaf K and Ca. Leaf nutrients concentration in yam grown on Zero-tillage plots without poultry manure application had lower leaf nutrients concentration compared to other tillage techniques in the study.

Table 2: Interaction Effect of Tillage and Poultry Manure on Leaf Nutrients Concentration of Yam (*Dioscorea rotundata*)

Treatments	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
ZT – M	3.78d	3.76c	0.23b	0.19c	0.44b	0.31d	0.15b	0.13c	0.16a	0.12c
ZT + M	4.70c	5.50a	0.25b	0.33a	0.57a	0.59b	0.16ab	0.18a	0.17a	0.19ab
P – M	5.03b	3.83c	0.22bc	0.20c	0.44b	0.41c	0.15b	0.13c	0.15b	0.12c
P + M	5.23a	5.57a	0.23b	0.27b	0.55a	0.80a	0.16ab	0.18a	0.17a	0.18b
PH – M	5.10a	4.53b	0.24b	0.20c	0.54a	0.41c	0.18a	0.17b	0.17a	0.14c
PH + M	5.23a	5.40a	0.26ab	0.29b	0.58a	0.60b	0.17a	0.20a	0.17a	0.19ab
MR – M	4..97b	4.73b	0.23b	0.19c	0.39c	0.38c	0.16ab	0.15b	0.15b	0.14c
MR + M	5.03b	5.63a	0.28a	0.33a	0.45b	0.64b	0.16ab	0.17b	0.17a	0.21a
MH – M	4.83c	4.03c	0.20c	0.18c	0.37c	0.37c	0.16ab	0.13c	0.14b	0.13c
MH + M	4.96b	5.10ab	0.28a	0.29b	0.45b	0.57b	0.16ab	0.17b	0.16a	0.20a

Means with the same letter in the same column are not significantly different at 5% level using DMRT

Table 3 shows interaction effect of tillage and poultry manure on yield components of yam. The data indicated significant interaction effect of tillage and poultry manure on yam tuber yield components. Tillage techniques plots amended with poultry manure produced better yam tuber yield parameters than their corresponding tillage techniques plots without poultry manure application. Zero-tillage plots either with or without poultry manure application produced the least yam tuber yield when compared with other tillage-poultry manure combinations in the study. Also, manually heaped plots amended with poultry manure produced the highest tuber yield and this was closely followed by manually ridged plots amended with poultry manure. Decrease in yam tuber-yields from tillage techniques plots amended with poultry manure at second cropping (2008) was with marginal degree when compared with the degree of decrease in yam tuber yield obtained from their corresponding tillage techniques plots without poultry manure.

Table 3: Interaction Effect of Tillage and Poultry Manure on Yield Parameters of Yam (*Dioscorea rotundata*)

Treatments	Tuber Length (cm)		Tuber Girth (cm)		Tuber Yield (tha^{-1})	
	2007	2008	2007	2008	2007	2008
ZT – M	27.10d	21.10d	32.33c	27.27c	20.61d	16.83e
ZT + M	27.67d	22.27d	33.11c	28.47c	21.14d	19.81e
P – M	30.22c	27.73b	34.55c	30.33b	31.21c	27.33c
P + M	32.99b	27.60b	36.00b	31.47b	33.60b	31.04b
PH – M	29.00c	24.50c	33.33c	28.67c	30.41c	24.32d
PH + M	29.66c	26.43c	34.45c	29.17c	32.09c	26.53c
MR – M	30.11c	28.53b	37.78b	31.57b	33.84b	31.51b
MR + M	34.44ab	28.60b	39.89ab	33.90a	37.93a	36.82a
MH – M	35.11a	30.07a	42.55a	35.23a	34.34b	32.41b
MH + M	36.24a	30.67a	46.45a	35.37a	39.91a	37.54a

Means with the same letter in the same column are not significantly different at 5% level using DMRT

DISCUSSION

The high soil moisture content of the zero –tillage plots might partly be due to the increase in soil organic matter of the zero-tillage plots and it could also be attributed to the mulching effect provided by the crop residues left on the soil while the lower soil moisture content of the manually heaped and ridged soils might be attributed to the improved soil total porosity of the tilled soils which might have enhanced vapour movement thereby resulting in moisture evaporation. A decrease in soil moisture content of the tillage techniques plots without poultry manure during the second cropping might partly be due to the structural collapse and soil compaction which might have enhanced drastic reduction in water infiltration rate. Addition of poultry manure improved the soil moisture content in all the tillage techniques, this improvement in soil moisture content might be due to the colloidal and hydrophobic nature of the poultry manure.

The relatively low soil temperature under zero tillage can be attributed to the influence of residues on the soil surface, which might have intercepted the incoming radiation and this reduced soil temperature. Plots amended with poultry manure had lower soil temperature compared with tillage techniques plots without poultry manure. This could be related to the improved soil organic matter content of plots amended with poultry manure which might have enhanced water retention capacity of the soil and consequently reduced soil temperature of the plots. Organic manure is known to improve soil physical properties (9).

The high bulk density of the zero-tillage and mechanically tilled soils has implication for root growth, nutrients uptake and yam tuber induction. High soil density could cause mechanical impedance to root and tuber growth and this would adversely affect nutrient and water uptake. In support of this, Ohiri (10) found that zero-tillage plots in Umudike resulted in low cassava yield owing to high bulk density of 1.6g cm^{-3} ad high mechanical impedance. Addition of poultry manure to the tillage techniques reduced soil bulk density, this reduction in soil bulk density could make appreciable difference in the root growth and proliferation, nutrients uptake and yam performance.

Soil total porosity was relatively higher in tilled plots compared to zero-tillage plots, this is a consequence of soil loosening. Improved soil total porosity of the tilled plots also has implication for root growth, proliferation, water infiltration, aeration and nutrient uptake which could reflect in the performance of crops. This finding is in agreement with the finding of Osunbitan et al (11). Addition of poultry manure to the soil tillage techniques plots improved soil total porosity relative to tillage techniques plots without poultry manure application. Improvement in total porosity might be as a result of the improved soil particle aggregation brought about by the improved soil organic matter content of plots amended with poultry manure.

Higher concentration of nutrients in yam leaf of the tilled plots (MH, MR, P, PH,) might be due to improved macroporosity and aeration due to tillage which might have affected better root growth and uptake of nutrients. Deeper root penetration allowed yam in the tilled plots to tap enough mineral and water while low root density of yam grown in zero-tillage plots might have been responsible for the low nutrients concentration in the yam leaf tissue. In support of this, Ojeniyi et al (12) attributed lower nutrient content and performance of yam on untilled soil to high bulk density which adversely affected tuber growth and nutrient uptake. Addition of poultry manure to the soil tillage techniques plots improved leaf nutrient concentration significantly, cumulative effect of poultry manure application was observed in the leaf nutrient concentration during the second cropping of the plots, this is in agreement with Adenawoola and Adejoro (13) observation that the cumulative agronomic values of some organic manure could be more than five times greater in the post application period than the value realized during the year of application.

The yields obtained from manually tilled plots (MR, MH) were better than those obtained from mechanically tilled plots and zero-tillage plots, this might be due to the lower bulk density and higher total

porosity of the manually tilled plot which might have enhanced root penetration for higher nutrients uptake and tuber induction in the soil. Higher bulk density of the mechanically and zero-tillage plots when compared with that of manually tilled plots might have adversely affected tuber initiation and tuber growth. Better yield obtained with poultry manure under combined use of tillage techniques could be due to the improved soil physical properties which enhanced root growth, nutrient uptake and consequently improved the yam tuber yield. Better yam tuber yield obtained in tillage techniques plots amended with poultry manure when compared with their corresponding tillage techniques plots without poultry manure application might be due to the improved nutrient status although could not be substantiated in this study. In support of this, recent studies had shown that poultry manure increased soil organic matter, nitrogen, pH, phosphorous, (14, 6)

Conclusion

It is concluded that yam production on an alfisol requires tillage and loose soil structure for tuber development. The possible deleterious effect of tillage can be reduced by combining tillage with poultry manure. Addition of poultry manure to the soil tillage techniques in the study improved the soil physical properties; it reduced the soil bulk density and also increases porosity and water holding capacity of the soils.

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