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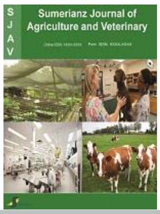

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Soil Properties and Rainfed Maize Yield as Influenced by Tillage Practices Integrated With Soil Conservation Practices in Makurdi, Nigeria

Agber P. I.*
Department of Soil Science, College of Agronomy, University of Agriculture Makurdi, Nigeria

Gani A. T.
Department of Soil Science and Land Resources, Federal University Wukari, Nigeria

Adekeye A. S.
Department of Soil Science, College of Agronomy, University of Agriculture Makurdi, Nigeria

Abstract

This research was conducted at Teaching and Research Farm of the University of Agriculture, Makurdi during 2013 and 2014 cropping seasons to assess the effect of different tillage practices combined with some agronomic soil conservation practices on soil physical properties and maize yield. The experiment consisted of twelve treatments namely: zero tillage + soybean, zero tillage + cowpea, zero tillage + mulch, zero tillage + maize-only, surface-hoeing + soybean, surface-hoeing + cowpea, surface-hoeing +mulch, surface-hoeing + maize-only, manual ridging + soybean, manual ridging + cowpea, manual Ridging + mulch and manual Ridging + maize-only. These treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Data collected were analyzed using ANOVA and the significant means were separated using F-LSD. Tillage and agronomic practices significantly affect soil physical properties and maize seed yield during 2013 and 2014 cropping seasons. Tilled plots lowered surface soil bulk density and increase soil porosity compare to the untilled plots. The magnitude of variations of results obtained however depends on the agronomic practice involved. Tilled plots combined with either soybean or cowpea gave better maize seed yield compare to untilled plots. Soybean or cowpea should therefore be inter-cropped with maize as the combinations will improve soil fertility and increased yield of maize.
Keywords: Maize; Tillage practices; Agronomic practices; Rainfed; Makurdi; Soybean; Cowpea.

1. Introduction

Soil is a key natural resource. Its productivity is the integrated effect of management [1]. The suitability of a soil for sustaining plant growth and biological activity is a function of its physical and chemical properties [2]. Tillage affects both the physical and chemical characteristics of the soil. The choice of appropriate tillage practice has been a problem to the farmers [2].

A major staple crop grown widely in the Sub-Humid Guinea Savanna Zone of Nigeria is maize; its cultivation and utilization have increased due to greater demands for consumption and industrial purposes. Hence, more land is being opened up yearly to sustain increase demands. Continuous cropping by farmers in the study area causes a decline in soil fertility and therefore reduction in the yield of maize crop. Poor choice of implements and soil management practices, inappropriate tillage systems, and seed bed types have been identified as major constraints to maize crop production in the savanna agro-ecological zones of Nigeria [3]. Selection of appropriate management practices such as tillage, fertilization, surface cover, irrigation, as well as modification of the soil surface optimizes maize yield [3]. Conservation agriculture, defined as minimal soil disturbance (no - till) and permanent soil cover (mulch) combined with rotations is found to be a sustainable system for maize production [4]. This work was therefore planned to assess the effects of different tillage practices complimented with selected agronomic soil conservation practices on soil physical and chemical properties and yield of maize.

2. Materials and Methods

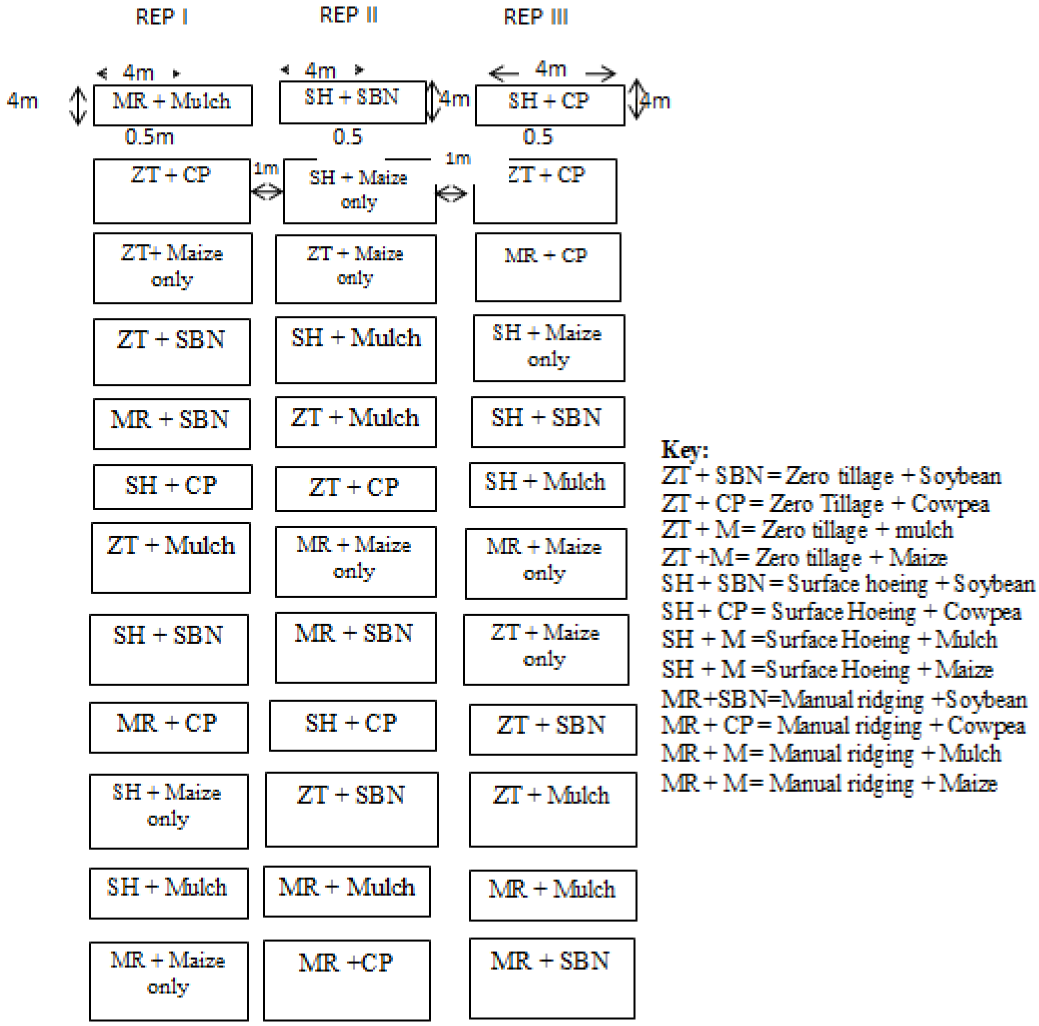
2.1. Field Experiment

Field experiments were carried out at the Teaching and Research Farm of University of Agriculture, Makurdi, Nigeria, during the 2013 and 2014 cropping seasons. The site is located on Latitude 7^0 41^1N and Longitude 8^0 37^1E at an elevation of 97 m above mean sea level on a slope of 4%. The site has a mean annual rainfall of 1,250mm and mean temperature of 28^0C.The dominant vegetation at the site include guinea grass (*Panicum maximum*), gamba grass (*Andropogongayanus*) and elephant grass (*Pennisetumpurperum*). The site used for the experiment was fallowed for about 4 years. The experiment consisted of twelve treatments, namely: Zero tillage + cowpea (ZT + CP), zero tillage + soybean (ZT + SBN), zero tillage + Mulch (ZT + M), Surface – hoeing + Soybean (SH + SBN), surface- hoeing + cowpea (SH+CP), surface - hoeing + mulch (SH + M), manual ridging + Cowpea (MR + CP), manual ridging + soybean (MR + SBN), manual ridging + mulch (MR + M), zero tillage + maize only, surface –

*Corresponding Author

hoeing + maize only, manual ridging + maize only. The treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Individual plots have a dimension of 4m x 4m with an alley of 1m between blocks and 0.5m between plots giving a total land area of 756m^2 as presented in Figure 1.

Figure-1. Field Layout of Experimental Plots



2.2. Land Preparation and Planting

The vegetation of the experimental field was manually cleared. No primary or secondary tillage operation was carried out on the zero tillage plots (ZT). Soil disturbance was limited to the manual clearing and opening of slots for seed placement during planting. Weed control was done by handpicking. The surface hoeing (SH) plots were done manually by turning the top 10cm of the soil with hoe while the manual ridging (MR) plots were ridged manually. Weed control for each of them was done by hoeing.

Maize variety QPM, was planted. The seeds were sown at three (3) seeds per hole at a spacing of 75cm apart and 50cm within rows and later thinned to two (2) plants per stand at two weeks after planting to give a plant density of 53,333 per ha. A week after maize germination, cowpea (UAM 09 – 1046 – 6 – 2 variety) and soybean (TGX – 1448 – 2E variety) were planted in their respective plots. Two (2) seeds of cowpea were planted between two maize stands, while soybean was drilled between two maize stands. Mulching materials were applied 4 t/ha, as recommended by Lal [5] unto the appropriate plots at one week after maize germination.

2.3. Fertilizer Application

Maize received a uniform fertilizer application of 200kg/ha of NPK 15:15:15 in a split application. The first application was done two (2) weeks after planting, while the second application was done at six (6) weeks after planting.

2.4. Soil Sampling and Analysis

Soil samples were collected at 0 – 15cm depth, using soil auger. Composite sample was taken at the beginning of the experiment and after crop harvest, in each of the plots for physical and chemical analysis. The Bouyoucos [6] hydrometer method (1951) was used to determine the particle size distribution of the samples. Soil bulk density was determined using the core method [7]. The Soil pH in water (1:1) was determined using the pH meter. The wet oxidation method of Black [8] was used to determine the organic carbon content of the samples. The organic carbon was determined using dichromate oxidation method and total nitrogen using macro-kjeldahl digestion method [9].

Available P was determined by Bray – 1 extraction [10]. The CEC was determined by neutral, 1N ammonium acetate method. The exchangeable cations were determined by Atomic Absorption Spectrophotometer (A A S). Base Saturation was determined by dividing the sum of exchangeable bases by CEC and multiplying by 100.

2.5. Crop yield

The three inner rows of each plot were harvested for yield determination. The maize cobs of the five tagged plants from each plot were weighed, their length were determined and then threshed. The weight of 200 grains was taken. Data collected were subjected to analysis of variance (ANOVA) and the significant means were separated using F-LSD.

3. Results and Discussion

3.1. Soil Properties at the Start of the Experiment

Table 1 shows the results of the laboratory analysis of soil physical and chemical properties of the study area at the start of the experiment in 2013. The soil is loamy-sand and slightly acidic. It is low in total nitrogen, available phosphorus, soil organic matter and high bulk density. The exchangeable calcium, magnesium and potassium as well as the cation exchange capacity (CEC) were low. The insufficient levels of the major nutrients in the soil showed that it would not be able to meet the notional needs of the maize plants. Application of tillage complimented with soil conservation practices are expected to improve the soil nutrional status and hence reduce its bulk density.

Table-1. Soil physical and chemical status in 2013 before treatment application

Parameters	Value
Sand (%)	77.6
Silt (%)	13.2
Clay (%)	9.2
Bulk density (g/cm^3)	1.46
pH in water	5.93
Porosity (%)	45
Organic carbon (%)	0.92
Organic matter (%)	1.59
Total Nitrogen (%)	0.06
Available Phosphorus (ppm)	2.0
Exchangeable Potassium (Cmol/Kg)	0.28
Exchangeable Calcium (Cmol/Kg)	3.60
Exchangeable Cagnesium (Cmol/Kg)	1.52
Exchangeable Codium (Cmol/Kg)	0.55
Cation Exchange Capacity (Cmol/Kg)	6.80
Base Saturation (%)	87.5

3.2. Effect of Tillage and Soil Conservation practices on Soil Physical Properties

The effect of tillage and conservation practices on soil physical properties is presented in Tables 2 and 3 for 2013 and 2014 cropping seasons respectively. In the 2013 cropping season, the zero tillage plots of soybean, cowpea, mulch and maize only had significantly highest bulk density values of 1.45, 1.44, 1.44 and 1.44 g/cm^3 and lowest porosity values of 45, 46, 46 and 46 % respectively (Table 2).The above results were closely followed by surface hoeing treatment plots complimented with soybean, cowpea, mulch and maize with their respective bulk density values of 1.40, 1.40, 1.41 and 1.42 g/cm^3 and porosity values of 47, 48, 47 and 46 %, respectively. The manual ridging plots of soybean, cowpea, mulch and maize had significantly relatively lower bulk density values of 1.39, 1.38, 1.40 and 1.39 g/cm^3 with their respective porosity values of 47, 48, 47 and 47 % (Table 2). In 2014 cropping season, the soil bulk density as influenced by the tillage and conservation methods followed the same trend like that of 2013 (Table 3)

The volumetric water content was also significantly influenced by tillage and conservation practices. The manual tillage plots of cowpea had significantly higher volumetric water content values both in 2013 and 2014 cropping seasons. (Tables 2 and 3). Results from this study showed higher bulk density values for the zero tillage treatments compared to surface hoeing and manual ridging where lower bulk density values were observed. The reason for this is that the untilled soil was not inverted and therefore, was compacted and hence had higher penetration resistance and bulk density. This phenomenon had been earlier reported by Horn [11], Kay [12]; Ali [13] and Ojeniyi [14] that higher bulk density and greater soil mechanical strength are normally associated with non-tilled soils than with tilled soils. Higher bulk density values observed on the zero tillage treated plots may have been responsible for lower porosity values and hence lower water infiltration, lower water content, poor seedling emergence and root penetration compared with manual ridging and surface hoeing. Agbede and Ojeniyi [15] reported that heaping and ridging raised total porosity and reduced soil bulk density when compared with zero tillage. Relatively, lower bulk densities values were observed on plots treated complimentarily with cowpea than those treated with mulch, soybean and maize. This could be attributed to higher organic matter build up on plots treated with cowpea and subsequent increased porosity values which led to increase water infiltration rate and hence, higher water content.

Table-2. Soil physical properties as affected by tillage and soil conservation practices (2013)

Treatments	**BD (g/cm^3)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Porosity (%)**	**GWC (%)**
Zero tillage + soybean	1.45	83.6	9.2	7.2	45	13.5
Zero tillage + cowpea	1.44	87.6	7.2	5.2	46	18.1
Zero tillage + mulch	1.44	83.6	9.2	7.2	46	14.4
Zero tillage + Maize only	1.44	79.6	11.2	9.2	46	13.3
surface hoeing + soybean	1.40	81.6	11.2	7.2	47	18.3
surface hoeing + cowpea	1.40	85.6	7.2	7.2	48	19.6
surface hoeing + mulch	1.41	83.6	9.2	7.2	47	11.8
surface hoeing + Maize only	1.42	79.6	11.2	9.2	46	10.6
manual ridging + soybean	1.39	83.6	9.2	7.2	47	13.7
manual ridging + cowpea	1.38	79.6	11.2	9.2	48	20.2
manual ridging + mulch	1.40	83.6	9.2	7.2	47	21.4
manual ridging+ Maize only	1.39	83.6	9.2	7.2	47	14.5
LSD (0.05)	0.04	3.76	2.47	1.61	NS	1.65

Table-3. Soil physical properties as affected by tillage and soil conservation practices (2014)

Treatment	**BD (g/cm^3)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Porosity (%)**	**GWC (%)**	**VWC (%)**
Zero tillage + soybean	1.44	81.6	9.2	9.2	46	12.7	18.3
Zero tillage + cowpea	1.43	81.6	9.2	9.2	46	24.5	35.0
Zero tillage + mulch	1.43	79.6	11.2	9.2	46	13.6	19.4
Zero tillage + Maize Only	1.44	85.6	9.2	5.2	46	12.4	17.9
surface hoeing + soybean	1.39	81.6	9.2	9.2	47	17.4	24.2
surface hoeing + cowpea	1.40	83.6	9.2	7.2	47	18.8	26.3
surface hoeing + mulch	1.40	83.6	9.2	7.2	47	17.9	15.3
surface hoeing + Maize Only	1.40	79.6	11.2	9.2	47	9.6	13.4
manual ridging + soybean	1.38	83.6	9.2	7.2	48	12.9	17.8
manual ridging + cowpea	1.37	83.6	9.2	7.2	48	20.1	17.9
manual ridging + mulch	1.39	81.6	9.2	9.2	48	18.7	28.8
manual ridging + Maize only	1.38	75.0	13.2	11.2	48	14.3	26.6
LSD (0.05)	0.03	1.67	1.78	1.63	N.S	1.45	1.48

3.3. Effect of Tillage and Soil Conservation Practices on Maize Yield and Yield Parameters

The results obtained in 2013 and 2014 cropping seasons showed that there were significant effects of the treatments on the maize yield and yield parameters (Table 4). In 2013 cropping season, the longest cob length and cob weight of 18.80 cm and 0.96 kg respectively were produced from manual ridging + soybean. The smallest cob length of 11.20cm and cob weight of 0.43kg were produced from zero tillage + sole maize plot. Similarly, manual ridging + soybean gave the highest grain yield of 2.76 t/ha. The least grain yield value of 1.37 t/ha was obtained from zero tillage + soybean. Similar results were obtained in the year 2014

The lower bulk density and higher porosity values observed in manual ridging and surface hoeing plots of soybean and cowpea might have facilitated good root penetration, water infiltration into the soil which might have resulted to increased nutrient uptake of maize in these plots compared with zero tillage plots where higher bulk density and lower porosity values were observed, The biomass of soybean and cowpea produced during the first cropping season in 2013 might have decomposed and increased the organic matter content of the soil which the crops made use of in 2014. That also might have facilitated high values of maize seed yield and other yield parameters in surface hoeing and manual ridging plots. Findings of this work is therefore consistent with that of Ojeniyi [16] who compared the effects of manual tillage with hoe and no-tillage on nutrient availability and maize yield and found that tillage with hoe increased maize yield significantly.

Table-4. Effect of tillage and conservation practices on the yield and yield parameters of maize (2013 and 2014)

	2013				2014			
Treatment	**Cob Length (cm)**	**Cob weight (kg)**	**200seed weight (g)**	**Grain Yield (t/ha)**	**Cob length(cm)**	**Cob weight (kg)**	**200 seed weight (g)**	**Grain yield (t/ha)**
Zero tillage + Soybean	12.80	0.43	35.67	1.46	14.80	0.53	37.67	1.51
Zero tillage +cowpea	12.00	0.60	40.33	1.60	14.00	0.70	42.33	1.65
Zero tillage + mulch	12.40	0.57	49.67	1.51	14.40	0.67	51.67	1.56
Zero tillage + Maize	11.20	0.50	50.67	1.52	13.20	0.60	52.67	1.57
Surface hoeing + soybean	18.07	0.91	53.33	2.76	20.07	1.08	57.00	2.81
Surface hoeing + cowpea	17.00	0.96	52.00	2.20	19.00	1.06	54.00	2.25
Surface hoeing +mulch	12.87	0.55	49.33	1.37	14.87	0.65	51.33	1.42
Surface hoeing+maize	13.47	0.52	53.00	1.48	15.47	0.62	55.00	1.53
Manualridging + soybean	18.80	0.92	53.00	2.47	20.80	1.02	55.00	2.52
Manual ridging + cowpea	14.87	0.65	45.33	1.70	16.87	0.75	47.33	1.75
Manual ridging + mulch	14.00	0.64	50.60	1.68	16.00	0.74	52.67	1.73
Manual ridging + maize	14.13	0.62	51.00	1.51	16.13	0.72	53.00	1.56
LSD 0.05	0.16	0.18	1.46	0.02	0.168	0.168	0.168	0.17

4. Conclusion

Tillage and agronomic practices significantly affect soil physical properties and maize seed yield during 2013 and 2014 cropping seasons. Tilled plots lowered surface soil bulk density and increase soil porosity compare to the untilled plots. The magnitude of variations of results obtained however depends on the agronomic practice involved. Tilled plots combined with either soybean or cowpea gave better maize seed yield compare to untilled plots. Soybean or cowpea should therefore be inter-cropped with maize as the combinations will improve soil fertility and increased yield of maize

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