EFFECT OF TILLAGE METHOD ON GROWTH, GRAIN YIELD AND NUTRIENT CONTENT OF SORGHUM (*Sorghum bicolor* L.) IN FOREST SAVANNA TRANSITION ZONE OF NIGERIA

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ABSTRACT

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Field experiments were established at Rufus Giwa Polytechnic, Owo (RUGIPO) and Isuada both in Owo area of Southwest Nigeria in late season (commencing) September 2004, early season commencing April 2005 and late season commencing August 2006 to select suitable soil preparation method for sorghum cultivation in the forest-savanna transition zone of Nigeria, five tillage methods were compared to their effect on growth and yield parameters and nutrient content of the crop. Tillage methods were herbicide-based zero tillage (ZT), manual clearing (MC), disc ploughing (PL), ploughed plus harrowing (PLH) and ploughing plus two passes of harrow (PLHH). Compared with zero tillage methods (ZT, MC), mechanized tillage methods caused reduction in plant height, leaf area, stalk girth, dry matter and grain yield. Mechanized methods also gave lower N, P, k, Ca and Mg content of the plant. Growth and yield parameters reduced with increased implement pass; hence, PLHH gave least values of these parameters and nutrient content. Grain yield was reduced by 11 to 25% as a result of mechanized tillage which was not favourable to performance of sorghum.

Keywords: Sorghum, tillage, soil, nutrient, growth, yield

INTRODUCTION

In Africa, Sudan and Nigeria are major cultivators of sorghum. Of the total national hectarage in Nigeria, close to 99% is found in the Savanna zone. However, due to increasing demand for sorghum in food and brewery industries, sorghum cultivation has been extended to the more humid forest-savanna transition zone. In the zone, sorghum stalk is also used as stake material in yam cultivation. Hence, there is need to initiate strokes into crop and soil management requirements for sorghum in the forest savanna transition zone. Tillage is important for enhancing sorghum productivity (Abimiku *et al.*, 2002).

Studies on tillage requirements of sorghum were mainly carried out in arid or semi-arid zones. Except the work of Jasa carried out in USA, studies in Africa and Pakistan (Ayub *et al.*, 2003) found that sorghum required deep tillage (Ayub *et al.*, 2003), ridging (Abimiku *et al*., 2002) and ploghing (Olufayo *et al.*, 1994; Willocks, 1979) for deep root growth and enhanced grain yield. Jones (1987) in Botswana concluded that for sorghum grown in semi-arid or arid zones, prospects of zero or shallow tillage are poor.

The aim of this work was to examine the suitability of zero tillage methods (manual clearing and herbicide-based zero tillage) for sorghum cultivation in the forest-savanna transition zone of Nigeria. There is need to promote zero tillage in the humid zones since the soils (often alfisols) have been found to be highly susceptible to degradation with repetitive mechanized tillage and this led to loss of crop yield (Ojeniyi, 1986, 1988, 1989, 1990, 1993; Ojeniyi and Ogbonaya, 1994; Ojeniyi and Agboola, 1995; Ojeniyi and Adekayode, 1999; Odedina *et al*., 2007; Lal, 1997). Reduced or zero tillage was recommended for maize, cowpea and okra (Ojeniyi and Agboola, 1995). In this work, the effect of two zero tillage methods and three mechanized methods on growth, grain yield and nutrient content of sorghum was studied in the forest-savanna transition (FST) zone of Southwest Nigeria.

MATERIALS AND METHODS

Field Experiment

Field experiments were established at Rufus Giwa Polytechnic, Owo (RUGIPO) and Isuada both in Owo area of Southwest Nigeria in late season (commencing) September 2004, early season commencing April 2005 and late season commencing August 2006. The soil is sandy loam alfisol (Oxic Tropuldalf). There are two rainy seasons, one from March to July and the other from mid-August to November. The rainfall values for 2004, 2005 and 2006 were 1135, 1015 and 1241mm respectively. Owo area is in the rainforest-savanna transition zone.

The trial each year and at each location consisted of five tillage treatments namely: (a) zero tillage-manually clearing with cutlass and residue in surface followed by spraying with Gramoxone (herbicides) at 51t/ha, (b) manual clearing with residue removed, (c) disc ploughing after clearing, (d) disc ploughing + harrowing, and (e) disc ploghing + harrowing twice. The treatments were arranged in a randomized complete block design and replicated three times. Each plot was 12 x 10m. Three sorghum seeds were sown per stand manually at 90 x 30cm. Fully emerged plants

were thinned to one per stand two weeks after sowing to give 37,037 plants per ha. Weeding was done at 3 and 8 weeks after sowing. The same treatment was allotted to each plot for the 3 years of study.

Growth and Yield parameters

Ten plants were randomly selected per plot for data collection. Plant height and leaf area per plant (by graph method) more determined at 120 days after sowing. At 6 months after sowing, selected plants were excavated and root-severed. The number roots were counted and stem girth measured using vernier caliper. Root and fresh matter were oven-dried at 80^0C for 48 hr to determine dry weights. Air-drying of grains was done to 12% moisture content.

Leaf Analysis

In 2006 (third crop), sorghum leaves collected from all plots in each location at 120 days after sowing were analyzed. The samples were oven-dried at 82^0C for 48 hr before grinding. Leaf N was determined using micro-kjeldahl digestion method. Samples were dry ashed at 500^0C for 6 hr in a furnace and extracted using 10% itch for determination of P, k, Ca and Mg. Leaf P was determined using vanadomolybdate colorimetry, k using flame photometer, and Ca and Mg by EDTA titration method (AOAC 1990).

Soil Physical Properties

Composite surface (0-15cm) soil samples were collected over the experimental sites for mechanized analysis using hydrometers method. The bulk density was determined using steel core.

Statistical Analysis

Data collected were subjected to analysis of variance and treatment means were compared using the least significant difference (LSD) at P>0.05.

RESULTS AND DISCUSSION

The sandy-loam soils at the experimental sites had fairly high bulk density (Table 1). ZT and MC respectively gave highest and similar values of growth parameters such as plant height, leaf area and stem girth (Table 2). This indicates that mechanized tillage did not favour sorghum. In fact, the growth parameters decreased with intensity of tillage in 2004 (Table 1), 2005 and 2006 (Table 3). The overall mean values of plant height for ZT, MC, PH, PLH and PL2H were 5.41, 5.41, 5.20, 5.19 and 4.80 respectively. The values for leaf area were 1.22, 1.18, 1.15, 1.11 and 0.92. It was also observed that root dry weight tended to reduce with increasing intensity of tillage (Tables 4, 5 and 6) although tillage did not affect root weight significantly (P>0.05) in 2004 and 2005. This is especially true at Rugipo in 2006.

Therefore, the growth of sorghum was adversely affected by mechanized and repetitive tillage compared with zero tillage as represented by ZT and MC. In fact, the values of plant height, leaf area and stem girth were generally and significantly lower for PL2H compared with other treatments.

Dry matter and grain yield were also reduced by mechanized tillage in 2004 (Table 4), 2005 (Table 5) and 2006 (Table 6). Thus, in line with the observation in growth parameters, the ZT and MC had highest and similar values for dry matter and grain yield. However, zero tillage gave higher values than manual clearing. Mechanized tillage was advantageous in terms of sorghum yield. The overall mean grain yield for ZT, MC, PL, PLH and PL2H were 1.27, 1.24, 1.13, 1.12 and 0.95t/ha respectively. Compared to ZT, PL, PLH and PLHH reduced grain yield by 11, 12 and 25%. Since tillage was not advantageous to sorghum, it implies that the initial soil bulk density values of 1.50g/cm^3 recorded for the sandy loam soil was hot limiting to sorghum in the forest savannah transition zone. Loss in growth and yield of sorghum due to tillage is attributable to reduced nutrient uptake as a result of reduced root and crop growth in tilted soils. Table 7 shows that PL, PLH and PLHH gave smaller leaf N, P, k, Ca and Mg concentration compared to ZT and MC. The effect of tillage on leaf N at Isuada, leaf P at Rugipo and leaf Ca at Rugipo was significant (P>0.05). The ZT consistently had highest leaf nutrient status followed by MC. Although PH, PLH and PLHH had lower and similar leaf N, P, k, Ca and Mg concentrations, PLHH gave least values; ZT also gave least values of root weight in the three means of stirly. Therefore repetitive mechanized tillage which reduced root growth also reduced nutrient uptake, especially N, P and Ca led to reduced growth and grain yield of sorghum. Goldsworthy (1964) and Tabo (1995) had highlighted the importance of availability of N and P in determining sorghum performance.

Table 1. Soil properties at experimental sites

Property	Rugipo	Isuada
Sand %	68	65
Silt %	14	16
Clay %	18	19
Texture	Sandy-loam	Sandy-loam
Bulk density g/cm^3	1.50	1.48

Table 2. Effect of tillage methods on growth of sorghum in 2004

Tillage method	Plant height		Leaf area m^2		Stem girth cm	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	4.74	4.59	1.18	1.12	2.25	2.19
Manual clearing	4.71	4.58	1.15	1.08	2.23	2.16
Ploughing	4.71	4.55	1.13	1.06	2.22	2.16
Ploughing + Harrowing	4.69	4.53	1.12	1.05	2.18	2.14
Ploughing + 2 Harrowings	4.38	4.26	0.88	0.81	1.94	1.92
LSD (0.05)	0.26	0.24	0.04	0.05	0.11	0.15

Table 3. Effect of tillage methods on growth of sorghum in 2005

Tillage method	Plant height m		Leaf area m^2		Stem girth cm	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	5.93	5.89	1.33	1.26	3.55	3.17
Manual clearing	5.92	5.87	1.30	1.21	3.53	3.16
Ploughing	4.93	5.86	1.28	1.18	3.51	3.08
Ploghing + Harrowing	4.92	5.85	1.21	1.12	3.51	3.08
Ploghing + 2 Harrowings	4.33	5.29	1.03	0.98	3.11	2.85
LSD (0.05)	0.25	0.42	0.07	0.06	0.14	0.12

Table 4. Effect of tillage methods on growth of sorghum in 2006

Tillage method	Plant height m		Leaf area m^2		Stem girth cm	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	5.76	5.41	1.25	1.22	2.88	2.48
Manual clearing	5.68	5.41	1.22	1.18	2.86	2.45
Ploughing	5.65	5.20	1.20	1.15	2.84	2.39
Ploughing + Harrowing	5.63	5.19	1.13	1.11	2.83	2.35
Ploughing + 2 Harrowings	5.32	4.80	0.95	0.92	2.54	2.16
LSD (0.05)	0.24	0.22	0.12	0.08	0.06	0.04

Table 5. Effect of tillage methods on root shoot and grain yield of sorghum in 2004

Tillage method	Root dry weight g/plant		Shoot dry weight t/ha		Grain yield t/ha	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	50.4	47.6	20.4	19.5	0.75	0.69
Manual clearing	49.6	47.2	19.5	18.9	0.71	0.66
Ploughing	49.5	47.4	19.5	18.9	0.57	0.53
Ploughing + Harrowing	49.5	47.3	19.4	18.8	0.57	0.52
Ploughing + 2 Harrowings	48.6	45.6	16.9	15.9	0.52	0.49
LSD (0.05)	NS	NS	2.2	2.3	0.13	0.12

Table 6. Effect of tillage methods on root shoot and grain yield or sorghum in 2005

Tillage method	Root dry weight g/plant		Shoot dry weight t/ha		Grain yield t/ha	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	64.3	61.3	27.1	25.9	1.61	1.53
Manual clearing	63.5	60.8	26.1	25.0	1.56	1.51
Ploughing	64.0	59.4	26.0	24.7	1.55	1.48
Ploughing + Harrowing	63.2	60.5	26.0	24.6	1.55	1.46
Ploughing + 2 Harrowings	60.8	58.8	23.5	21.6	1.27	1.19
LSD (0.05)	NS	NS	2.2	2.5	0.23	0.21

Table 7. Effect of tillage methods on root shoot and grain yield of sorghum in 2006

Tillage method	Root dry weight g/plant		Shoot dry weight t/ha		Grain yield t/ha	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	59.9	57.7	26.5	25.4	1.57	1.27
Manual clearing	59.5	56.9	26.2	24.9	1.53	1.45
Ploughing	59.4	56.1	24.1	22.4	1.36	1.28
Ploughing + Harrowing	58.8	56.3	23.6	21.8	1.34	1.27
Ploughing + 2 Harrowings	52.1	51.5	19.9	18.4	1.15	1.09
LSD (0.05)	2.9	2.3	1.95	1.65	0.18	0.16

Table 8. Effect of tillage methods on leaf nutrient composition of sorghum (%) in 2006

Tillage method	N		P		K		Ca		Mg	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
Zero tillage	1.77	1.75	0.52	0.44	1.49	1.21	1.18	1.49	0.36	0.52
Manual clearing	1.72	1.64	0.47	0.39	1.45	1.12	0.74	1.38	0.28	0.35
Ploughing	1.65	1.58	0.42	0.38	1.29	1.01	0.74	1.31	0.26	0.31
Ploughing + Harrowing	1.64	1.59	0.42	0.39	1.32	1.02	0.70	1.33	0.27	0.31
Ploughing + 2 Harrowings	1.58	1.54	0.33	0.37	1.24	0.98	0.69	1.21	0.23	0.28
LSD (0.05)	NS	0.09	0.12	NS	NS	NS	0.24	NS	NS	NS

CONCLUSION

This work concludes that zero tillage was most suitable for sorghum in the forest-savanna transition zone. Mechanized tillage reduced growth and nutrient uptake and yield of sorghum. The advocacy of zero tillage is consistent with the need to reduce soil manipulation and attendant degradation of soil.

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