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Full Length Research Paper

Tillage and mulch influence on soil physical properties, plant nutrient composition and performance of pepper (capsicum annum L) and sorghum (sorghum bicolor L)

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Field experiments were conducted at Akure in the rainforest zone of Southwest Nigeria to study the effect of tillage and mulching in production of pepper (*Capsicum amnum*) and sorghum (*sorghum bicolor*). The soil physical properties, plant nutrient content, growth and yields of pepper and sorghum were evaluated. Zero tillage (herbicide based), manual clearing (MC), ridge (R) and heap (H) without and with weed residue mulch (M) were studied, Ridge or heap without mulch reduced soil bulk density and temperature compared with MC or MC + M. Tillage (H, R) increased leaf N, P and Ca in pepper, mulch increased leaf N, P, K, Ca and Mg and highest values of P, K, Ca and Mg were recorded for H + M and R+M. Tillage and mulch significantly increased pepper height, number of leaves, branches, fruits and fruit weight hence H+M and R+M had higher values of the parameters. Relative to MC, the H, R, MC+M, H+M and R+M increased fruits weight by 497, 448, 540, 876 and 903% respectively. The values for fruits weight were 457, 432, 500, 896 and 968%. Tillage increased dry matter yield of sorghum significantly, while dry matter yield, plant height, leaf area and grain yield were significantly increased by mulching. Highest grain yields were given by R + M and H+M. Relative MC, the MC+M, R+M and H+M increased grain yield by 23, 51 and 49% respectively. Tillage plus mulching significantly enhanced performance of pepper and sorghum.

Keywords: Pepper, sorghum, soil, ridge, heap, tillage, mulch.

INTRODUCTION

Pepper (*Capsicum annum*) and sorghum (*Sorghum bic*olor *L*) are essential food crops in tropical countries and are grown mainly in Savanna ecologies where rainfall is less compared with humid regions. The pepper is a spice noted to contain more minerals than others; it contains 13% protein and relatively high Fe (Udoh *et al.,* 2005). Sorghum is a staple crop and raw material for industries and its silage is fed to livestock (Udoh et al., 2005), The stem commonly used as food colour additive has both nutritive and antimicrobial property taken as beverages when steeped or boiled in water in many homes in Nigeria (Adetuyi, 2004; Adetuyi, 2007)

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Consumption of pepper accounts for about 20% of the average vegetable consumption per person per day in Nigeria. (Erinle, 1989; Alegbejo, 2002).The yields obtained by local farmer are low (Adigun 2001). Factors attributed to low yield include variety, pests, diseases and soil infertility. In case of sorghum, the grain yield of 500 – 800kg ha^{-1} is also low due to extreme soil physical conditions such as temperature, moisture and air. The two crops therefore require development of soil management package that could conserve soil moisture, increase availability of nutrients, moderate soil temperature, and reduce soil compaction. These attributes are expected to enhance crops productivity. Hence the purpose of this work is to investigate effect of tillage – mulch combinations on the performance of the crops.

Research information is quite scarce on tillage requi-

irement for pepper and sorghum (Agbede and Ojeniyi, 2009a) in the forest savanna zone of Nigeria and the response of the crops to soil management package which combined tillage with mulch. Tillage has been proved to benefit stem and root development (Erdem et al., 2006; Erdem et al., 2007). Agbede and Ojeniyi (2009b) showed that sorghum can be grown successfully with combination of poultry manure and zero tillage on alfisol of the forest-savanna zone of southwest Nigeria. Mechanized tillage was found to aggravate loss of soil organic matter and nutrients hence zero tillage plus manure combination was recommended whereas studies in the drier savanna zones of Africa indicate that tillage is essential for sorghum. (Ojeniyi and Agboola, 1995).

There is need for more research work on the effect of tillage and mulch on pepper nutrient uptake. Soil management practices such as tillage and mulching are useful in improving soil physical, chemical and biological conditions for enhanced crop performance (Christopher *et al.* 2011; Al-Rawahy et al., 2011; Moniruzzaman et al., 2007). The practices could improve availability of nutrients, root growth and availability of soil water and moderate soil temperature (Ojeniyi and Ighomrore, 2004; Awodun et al., 2007) The purpose of this work is to investigate suitability of combinations of mulch with traditional manual tillage methods for production of pepper and sorghum and their effect on soil physical properties and crops performances.

MATERIALS AND METHODS

Experiment with pepper

Experiment was conducted at Federal College of Agriculture Akure (FECA) and Federal University of Technology Akure (FUTA) in the rainfall zone of southwest Nigeria in dry season of 2009 (August to December) and rainy season of 2010 (April to July). Local variety of pepper 'Rodo' (*Capsicum annum*) was raised in the nursery in boxes (100 x 60 x 60cm) filled with mixture of garden soil and poultry manure. Seedlings were transplanted to the field at seven weeks after sowing. Before transplanting, both sites were manually cleared and residues dominated by Siam weed (*Chromolaena odorata*) were packed and preserved as mulch material.

Treatment combinations tried on pepper were (a) Heap (H) (b) Heap plus mulch (HM), (c) Ridge (R), (d) Ridge + Mulch (RM), (e) Manual Clearing (MC) and (f) Manual clearing + Mulch (MCM). Treatments were allocated using randomized complete block design and replicated three times. Each plot was 4 x 4m, ridging and heaping was done to meet spacing specification for pepper in each plot. Transplanting was done in the evening in August 2009 at 50cm within and 100cm between rows to give 32 plants per plot. Mulching was done immediately after transplanting using preserved partially dried weeds collected from each site. Hoe weeding was done at three weeks interval using the weeds removed to augment the mulch at each occasion.

At 7 and 11 weeks after transplanting data on plant height, number of leaves and branches were taken using 8 plants selected per plot, mean values was calculated and means for the two sites calculated. Cumulative number and weight of fruits were recorded

Leaf samples of pepper collected in each plot before flowering were oven-dried at 70^{o}C and milled. Chemical analysis was done as described by AOAC (1990). Nitrogen was determined by Kjeldahl method. Samples ashed at 500^{o}C for 6 hours in furnace were extracted using nitric-perchloric-acid mixture for determination of P by vanadomolybdate colorimetry, K by flame photometer, and Ca and Mg by EDTA titration.

At harvest of pepper, three core samples were collected in each plot and moisture content was determined on dry weight basis. Bulk density was determined by the core method (Grossman and Reinsch, 2002). Soil temperature was determined using soil thermometer inserted to 5cm with three readings per plot at 15.00 hour. Mean values of soil physical properties were calculated to cover both sites of study. Cumulative number and weight of fruits were recorded per plot basis.

Experiment with Sorghum

Two trials to investigate the effect of tillage and mulching on growth and yield of sorghum were conducted in dry season of 2007 (August to December) and rainy season of 2009 (April to July) at the Federal University of Technology, Akure (100^{o}N, 5'E, 10^{o} N, 5'E) in southwest Nigeria. The trial consisted of 4 x 2 factorial combinations of tillage involving manual clearing followed by spraying of paraquat (1-1-dimethyl-4-4-bipyridinium) at 1.6 kg ha^{-1}, zero tillage ZT, manual clearing MC, Ridge R and Heap (H) and surface application of mixed dry grass and rice straw mulch (0, 12t ha^{-1}). Treatments were assigned to plots using randomized complete block design with three replicates. Plots were manually cleared, each plot was 3 x 3m and sorghum seeds were planted at 90cm between rows and 30cm within rows. Mulching was done by surface application immediately after planting. All plots received NPK 15 – 15 -15 fertilizer at 200kg ha^{-1} and were weeded manually at 3 and 7 weeks after planting (WAP).

Data were collected on four plants selected per plot for determination of plant height at 50% anthesis, number of leaves, leaf area (graph method), root and

Table 1. Soil Physical Properties at FECA and FUTA

Treatment	Bulk density g/cm^2		Moisture Content (%)		Temperature ^oC	
	FECA	**FUTA**	**FECA**	**FUTA**	**FECA**	**FUTA**
MC	1.17	1.17	7.1	7.9	35.1	34.1
MC+M	1.13	1.15	11.7	14.1	32.4	31.4
H	1.14	1.14	7.3	10.3	35.1	33.3
H+M	0.98	0.96	11.8	14.3	31.5	30.4
R	1.14	1.13	7.5	10.3	35.1	33.6
R+M	0.97	0.94	11.8	14.1	31.4	30.4
LSD (0.05)	0.07	0.05	3.4	3.2	1.85	1.56

Table 2. Effect of tillage and mulching on nutrient composition of pepper (means for two sites)

Treatment	**N (%)**	**P (%)**	**K (%)**	**Ca (%)**	**Mg (%)**
MC	3.97	0.16	2.37	0.70	0.16
MC+M	5.89	0.19	2.58	0.84	0.52
H	4.98	0.43	2.27	0.84	0.16
H+M	5.78	0.78	2.77	0.98	0.20
R	4.60	0.38	1.90	0.93	0.14
R+M	5.26	0.65	2.46	0.93	0.34
LSD (0.05)	0.76	0.10	0.29	0.08.	0.05

shoot weight at harvest, and seed weight.

Data Analysis

Data were subjected to two-way analysis of variance to determine treatment effects. Treatment means were separated using Fisher's least significance different test

RESULT AND DISCUSSION

Data on soil bulk density, moisture and temperature are shown in Table 1. In the pepper experiment, heap and ridge reduced soil bulk density, this influence of heap and ridge on soil bulk density has been reported by various researchers (Agbede and Ojeniyi, 2003; Ewulo, 2005), there was no significant difference ($p>0.05$) between manual clearing (MC), heap (H) and ridge (R) at FECA and FUTA. MC gave the highest bulk density value at FECA and FUTA while R+M gave the lowest value at the two sites; this is similar to the report of Ewulo (2005). Mulch generally improves soil bulk density especially in combination with tillage, and is consistent with the findings of Nottidge et al. (2005), Ewulo (2005) and Akanbi and Ojeniyi (2007). Ridge with mulch (R+M) most conserved soil bulk density followed by Heap with mulch (H+M) and Manual clearing+Mulch (MC+M) in line with the observation of Ewulo (2005). Tilled soils has high and similar moisture contents compared with MC which might have been due to protective surface dry soil (soil mulch) given by breaking capillarity. Mulch significantly ($p>0.05$) conserve soil moisture when applied in tilled and manually cleared plot (MC), similar observation had been reported (Akanbi and Ojeniyi, 2007; Al-Rawahy et al., 2011, Yang et al., 2007). Mulch in tilled soil (R+M and H+M) had high and similar moisture with MC+M. Increase in soil water between 6 – 7% on fine sandy loam due to mulching has been reported (Edward *et al.,* 2000; Smolikowiski et al., 2001). Tillage did not influence soil temperature significantly but mulch reduced soil temperature significantly (Ewulo, 2005; Akanbi and Ojeniyi 2007; Ojeniyi et al., 2009). Ridge+Mulch (R+M) had the lowest temperature at two sites in Akure, Nigeria (Ewulo, 2005).

Table 2: Shows data on leaf nutrient composition of pepper. Tillage increased leaf N, P and Ca of pepper compared with MC. This is attributable to reduction in soil density and loose soil structure which enhanced root growth and hence nutrient uptake especially in case of P which is not so mobile in soil. Erdem *et al* (2006) and Ogbodo (2011) reported better pepper root growth under tillage methods due to reduction in soil bulk density. Mulch increased leaf N, P, K, Ca (not on ridge soil) and Mg. Some studies earlier found that mulches of chromolaena and gliricidia pruning increased soil and plant nutrients (N, P, K, Ca, Mg) content in cowpea, cassava and maize (Ojeniyi and Ighomorore, 2004; Awodun et al., 2007; Akanbi and Ojeniyi, 2007). On decomposition and mineralisation nutrients were released from mulches (Nottidge et al.,

Table 3. Effect of tillage and mulching on growth parameters of pepper at 7 and 11 weeks after transplanting (WAT)

Treatment	Plant height (cm)		No of leaves		No of branches	
MC	16.1	26.5	42.2	67.2	5.5	14.5
MC+M	22.3	41.6	98.0	211.0	15.5	40.0
H	24.2	37.2	104.3	187.0	15.8	41.7
H+M	25.6	46.8	125.8	274.2	20.2	56.7
R	23.8	40.3	110.8	228.0	15.7	39.8
R+M	24.2	49.7	114.0	298.2	15.0	55.3
LSD (0.05)	4.5	8.6	63.2	62.6	8.5	17.4

Table 4. Yield of pepper as influenced by tillage and mulching (means for two sites)

Treatment	No of fruits Per plant (g)	Weight of fruits Per plants (g)
MC	9.3	23.7
MC+M	59.5	142.3
H	55.5	132.0
H+M	90.8	236.2
R	51.0	125.7
R+M	93.3	253.1
LSD (0.05)	41.1	125.5

Table 5. Effects of tillage and mulching on growth and yield variables in sorghum – 2007

Treatment	Root weight (g)	Shoot weight (g)	Plant height (cm)	Leaf area (m^2)	Seed weight (g)	Grain field t/ha
Zero tillage	49.4	284	558	509.1	40.6	1.51
Zero tillage + Mulch	53.1	321	579	554.2	50.9	1.88
Manual clearing	46.8	272	569	491.3	40.4	1.50
Manual clearing +Mulch	50.9	319	583	531.8	50.0	1.85
Ridge	40.3	328	570	421.3	40.9	1.51
Ridge + Mulch	55.156	354	573	54.6	60.9	2.26
Heap	47.6	323	566	418.4	40.6	1.51
Heap + Mulch	53.5	343	571	544.3	60.4	2.24
LSD (0.05)	36	31.3	17.8	26.3	0.56	0.52

2005a; Nottidge *et al.,* 2008). Because tillage and mulch separately increased nutrients uptake in pepper, the highest nutrients content especially in case of P, K, Ca and Mg were recorded for H + M and R + M.

Table 3 shows data on growth of pepper. Tillage increased plant height, number of leaves and branches. Erdem (2007) had earlier reported increase in leaves fresh weight and leaves number of pepper under four tillage methods. Mulch increased the growth parameters. Hence tillage plus mulch had highest values of growth parameters compared with MC, tillage alone or MC + Mulch.

Table 4, indicates that tillage or mulch increased member and weight of fruits significantly. Hence combination of tillage with mulch gave highest values of yield. Relative to MC, the H, R, MC+M, H+M and R+M increased number of fruits by 497, 448, 540, 876 and 903% respectively. The values for weight of fruits were 457, 432, 500, 896 and 968%. Highest values of yield recorded for tillage plus mulching are consistent with highest values of plant, P, K, Ca and Mg recorded for the treatment. It is therefore suggested that these nutrients are important in pepper nutrition.

Table 5 and 6 show data on growth and yield of sorghum in 2007 and 2008 respectively. Zero tillage can conveniently substitute for heap and ridge with regards to most of the sorghum growth and yield variables considered in 2007 and 2008. Ridge and Mulch gave the highest root, shoot, seed weight and grain yield for the two years and the value similar with that of Heap and Mulch. Earlier study revealed higher grain yield in R + M and H + M and the values for both treatments were similar (Awodun and Ojeniyi, 1998). Zero tillage and mulch gave the highest leaf area, and

Table 6: Effects of tillage and mulching on growth and yield variables in sorghum – 2008

Treatment	Root weight (g)	Shoot weight (g)	Plant height (cm)	Leaf area (m^2)	Seed weight (g)	Grain yield t/ha
Zero tillage	47.6	277	576	611.4	40.2	1.49
Zero tillage + Mulch	52.4	325	604	627.6	50.5	1.87
Manual clearing	45.8	263	549	511.7	40.1	1.48
Manual clearing + Mulch	50.3	325	567	528.3	50.2	1.86
Ridge	49.3	285	584	570.2	41.0	1.52
Ridge + Mulch	52..5	331	574	613.4	60.6	2.25
Heap	48.7	273	4575	614.4	40.8	1.51
Heap + Mulch	51.4	331	591	625.1	60.5	2.24
LSD (0.05)	2.5	13.6	23.7	26.3	0.63	0.53

compares favourably with R+M and H+M with regards to root, shoot, grain weight, plant height and leave area, Manual clearing and mulch also compares favourably with R+M and H+M. Al-rawahi (2011) reported that mulch resulted in higher growth parameter and yield of sorghum. Earlier study revealed manual clearing had the lowest root, shoot, seed, grain weight, plant height and leave area in 2008.

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