academicJournals

Vol. 10(30), pp. 2866-2874, 23 July, 2015
DOI: 10.5897/AJAR2015.9964
Article Number: 8D9D18754344
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

The effects of tillage methods and intercropping on soil water characteristics, growth and grain yield of maize (*Zea mays* L.) and groundnut (*Arachis hypogaea*, L.) on an alfisol in South West, Nigeria

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Received 2 June, 2015; Accepted 16 July, 2015

A two-year study was conducted on an Alfisol in the humid tropics of southwest Nigeria to investigate the effects of tillage and intercropping on soil water characteristics, performance of maize (*Zea mays* L.) and groundnut (*Arachis hypogea* L.). The experiment was a split-plot design with tillage methods as the main plot and intercropping as the sub-plots in a completely randomized design with four replications. Tillage treatments were conventional tillage (CT) and no-tillage (NT) while the cropping treatments were sole maize, sole groundnut and intercropped maize + groundnut. Gravimetric soil water content (swgc) showed that NT had higher soil water content in all cropping treatments than CT. NT had significantly ($p<0.05$) higher infiltration characteristics than CT in all treatments. Intercropped plot of NT had significantly ($p<0.05$) higher infiltration characteristics compared with intercropped plot of CT. The air-filled porosity in NT intercropping was 29.6% at the 0 to 0.01 m depth, this decreased by 27.3% in CT and for the 0.01-0.02 m depth, it decreased by 7.8%. The yield trend for maize was sole maize NT > NT intercropping > CT intercropping > sole maize CT. For groundnut, the trend was NT sole groundnut > NT intercropped > CT sole groundnut > CT intercropped.

Key words: Tillage, intercropping, soil water retention, infiltration.

INTRODUCTION

In the humid tropics, intercropping is a prominent feature of peasant farming which helps to minimize risks associated with monocultures and assures stable income and nutrition (Okigbo, 1980; Ikeorgu and Odurukwe, 1989; Konian et al., 2013). Maize-groundnut intercropping is often practice under different tillage methods to produce food and obtain cash income from the same piece of land (Ikeorgu and Odurukwe, 1989, Ishaq et al., 2001). Maize (*Zea mays* L.) is the largest cultivated crop in Nigeria in all the ecological zones of the country. Groundnut (*Arachis hypogaea* L), also known as "peanut" or "earthnuts" is referred to a king of "oil seeds" and globally cultivated on an area of 24.62 million hectares of land (FAO, 2013). Yields obtained from the

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two crops when grown as sole crop or when they are intercropped are low due to poor soil fertility and inadequate field management by farmers (Videnovic et al., 2011; Howell, 2011; Patil et al., 2015). The reason for the low yields is because the humid tropics are characterized by highly erosive, erratic and poorly distributed rains (Lal, 1980; Osunbitan et al., 2005; FAO, 2011). The rains generally lead to rapid deterioration of soil properties and declining fertility of these soils (Ishaq et al., 2001, Osunbitan et al., 2005). In the zone, the effects of intercropping and tillage methods on crop performance have often been investigated separately. In intercropping, crops combination such as maize/legume intercrop have been recommended for complementarities in nutrient and water use (Francis, 1986; Patil et al., 2015) and in tillage, no-tillage (NT) with residue mulch have been advocated for the humid tropics (Lal, 1986; Ozipnar and Cay, 2006). This is because NT has been shown to prevent the exposure of the soils to raindrop impact which may lead to soil crusting and compaction (Lal, 1980; Ozpinar and Cay, 2006). In addition the stimulation of biotic activity for nutrient recycling of decomposed residues has been shown to sustain crop yield (Hill, 1990). In this region, there is paucity of information on tillage methods under intercropping. This is due to the complexity of their interaction effects on the crops which tends to discourage researchers and these have led to loss of basic research information on the benefit of intercropping. Therefore, there is a need to carry out research work that focuses on the basic effect of intercropping on soil and water conservation in tillage systems. While many workers have advocated the use of no-tillage for the tropical soil management, the dependent of NT on mulch has made its adoption very slow among farmers. For example, Lal (1976) consistently advocated the use of 4 to 6 Mg ha^{-1} of mulch for a successful NT practice in the zone. Mulching is however time – consuming and requires planting, cutting, transportation and spread of the mulch. Mulch availability is a challenge in the tropics due to rapid decomposition of plant left-over after cropping season due to their inclement climate. To reduce this large dependence on mulch, works in NT methods which earlier emphasized sole cropping should look into intercropping (Ajayi and Babalola, 1991; Patil et al., 2015). Therefore, this paper investigated soil water characteristics as affected by tillage and intercropping as well as the performance of maize intercropped with groundnut under conventional tillage and no-tillage with a view to see if intercropping can help reduce mulch need of no-tillage.

MATERIALS AND METHODS

Description of study site

The study was carried out at the Ekiti State University Teaching and research Farm, Ado Ekiti, located on Latitude 7° 13' 17" N and Longitude 5° 13' 17" E. The area is a tropical climate characterized by distinct dry and wet seasons, the rainfall is seasonal with two peaks in June and October, with mean annual rainfall of about 1367 mm. The mean annual temperature is almost uniform throughout the year with very little deviations from the mean annual temperature of 27°C. The dominant vegetation of the area is forest and the major land use types are arable crop production, cash crop production and other non-agricultural uses. The study area has been cultivated for maize, cassava, cowpea and vegetables and was left fallow for about eight years before the commencement of the study. Some soil physical and chemical of the soil prior to the commencement of the study are presented in Table 1.

Experimental layout and plot size

The experiment was conducted on a 6% slope land. The total land area was 2 ha to allow for tractor turning and pre-field experimental activities. The experiment was a split plot laid out in randomized complete block design with four replications. The tillage treatment formed the main plots while the cropping system formed the sub-plots. The field was ploughed in the East-West direction with sufficient space to allow for tractor turning. East-West CT treatment was followed by East-West strip of land for NT. The CT and NT plot size was 10 m × 36 m. in each strip from this, the cropping plots was 10 m × 10 m and a border row of 2 m each in each plot with a soil and crop sampling areas of 2 m × 2 m in the East-West and North South direction of the tillage treatment. The cropping systems were randomized in the tillage treatments.

Treatment details and design

The size of the selected study site is 2 ha which has been under gliricidia fallow for upwards of ten years. The field was manually cleared and the agronomic practices of tillage and maize – groundnut intercropping were carried out as follow:

Tillage

There were two tillage treatments –

Conventional Tillage (CT): The plots were ploughed once and harrowed twice using the disc plough and harrow respectively.

No-tillage: Parquat (1-1 dimethy 1, 4, 4 bigyridinuim dichloride) was applied at the rate of 3 kg ai to the existing weeds one week before planting. The desiccated weeds served as residue mulch spread on the soil surface.

Crops

The following crops and crop mixture were planted. T_1 = Sole Maize; T_2 = Sole Groundnut and T_3 = Maize + Groundnut.

Planting

***Sole maize*:** Open pollinated yellow maize TZSR – was planted on flat at a spacing of 25 cm × 90 cm with 2 seeds per stand.

Sole Groundnut: Local groundnut seeds variety obtained from Ilorin market were planted at a spacing of 10 × 20 cm with seeds per stand.

Intercropped maize + Groundnut: Maize variety TZSR – Y was planted at 25 x 90 cm with 2 seeds per stand and at 2 weeks after maize planting, the local groundnut seeds variety was planted at a spacing of 10 x 30 cm also at 2 seeds per stand giving a total of 3 rows of groundnut between 2 rows of maize plants.

Fertilization

N and K from calcium ammonium nitrate (CAN) and muriate of potash (MOP), respectively at 200 kg ha^{-1} N and 60 kg ha^{-1} K as muriate of potash 60 kg ha^{-1} while P as single superphosphate were banded to maize plants in sole maize and intercropped plots while they were broadcast in the sole groundnut plots at 2 week after planting. After this application, there was no top dressing.

Weeding and insect control

The CT plots were weeded with a hand hoe twice at 4 and 6 weeks after the planting of the crops. In the NT plots, weeds were hand-pulled from the mulch covered surface of NT plots at 4 and 6 weeks after planting. Insect pest were controlled with KIL SECT 2.5 E.C insecticide containing 25g of Lambela – cyhalothrin per litre at a rate of one litre per hectare mixed in two hundred litres of clean water and applied once at 6 WAP in all the plots.

Sampling area

An area of 2 m × 2 m was demarcated in each plot for the determination of soil water characteristics and crop performance.

Data collection

i. Gravimetric moisture content: Soil moisture content of samples at 0-0.15 m and 0.15-0.30 m depths was obtained using a core sampler at ten different locations within the demarcated area in all plots. The core sampler was 0.082 m in diameter and 0.080 m high and 0.02 m thick. The samples were put in moisture cans and oven-dried at 105°C for 48 h.

ii. Bulk density and saturated hydraulic conductivity: The core samples were used to measure the saturated hydraulic conductivity using the constant-head permeameter method (Klute, 1986) after which the bulk density was determined (Ejieji and Ajayi, 2001).

iii. Soil moisture retention: Soil moisture retention of the 0-0.15 and 0.15-0.30 m depths was determined by the pressure plate extractor (the soil moisture equipment co. California) (Klute, 1986), from the soil moisture retention determination, the following hydrological parameters were calculated.

a. Air-filled pores ($\theta\rho^{F0}$ - $\theta\rho^{F0.1}$),
b. Useful water retaining pores ($\theta\rho^{F0.1}$ - $\theta\rho^{F0.5}$),
c. Transmission pores (pores > 50 mm diameter)

Where: θρ = volume of water and F_0, $F_{0.1}$ and $F_{0.5}$ referred to water content at 0,0.01 and 5 MPa suctions, respectively (Lal and Shukla, 2004).

iv. Infiltration characteristics: These were determined by the double-ring infiltrometer method, in an area, 1 m x 1 m within each plot. The inner ring was 0.3 m in diameter and 0.3 m deep. The outer ring was 0.5 m in diameter and 0.3 m deep. These rings were driven into the soil to a depth of 0.15 m. A constant water level of approximately 0.05m was maintained in the inner ring using the Mariotte bottle technique. The infiltration was analyzed according to Philip's (1957) model in order to compute soil water sorptivity (S) and transmisivity (A) in the following equation:

$$I = At + St^{1/2}$$

$$i = \frac{dI}{dt} = \frac{1}{2}St^{-1/2} + A$$

Where: I = cumulative infiltration, mm; i = instantaneous infiltration rate (volume flux density), mm h-1; A and S = transmisivity and sorptivity, respectively; t = time, min.

The values of A and S were obtained from the graphs plotted from i versus $\frac{1}{\sqrt{t}}$ of the field data. Agronomic data collection: 5 plants were tagged per plot for the determination of growth and yield. The height of each plant was measured using a measuring tape. Measurement was from the ground level to the top of the longest leaf blade or tassel (maize) or the tip of the apical meristem for groundnut.

Yield data: To determine the yield data, groundnut pods and maize cobs from five randomly tagged plants were each put in open bags and air dried thoroughly to a moisture level of 13% before shelling. After shelling, the shelled seeds were weighed and recorded. At ten weeks after planting, five random samples were taken from an area, 1 m x 1 m to determine the stover yield. Samples were oven dried at 65°C until constant weight was attained.

Data analysis

Statistical analysis of data was conducted using the balanced analysis of variance (ANOVA) procedure in MINITAB Statistical software release 15 (MINITAB Inc., 2007). The least significance difference (LSD) test at $P<0.05$ showed significant difference between treatment means.

RESULTS AND DISCUSSION

The area of maximum impact of the tillage implements (0-0.30 m) shows a decrease in sand content with depth (Table 1). The entire profile is moderately gravely with gravel concentration ranging from 10.3% at the 0-0.15 m depth to 17.3% at 0.3-0.6 m depth. Before cultivation, the soil bulk density at the 0-0.30 m depth was low (Table 1). This was probably due to fallow and the protection of the soil surface from rainfall impact (Lal, 1976). The soil has good internal drainage down to 1 m profile depths. This can be inferred from the gradual decrease in the saturated hydraulic conductivity of the soil with depth (Table 1). The soil fertility status was moderate and the soil organic C, total N and available P decreased with depth (Table 1). The exchangeable cations of this soil were of moderate fertility status for soils in the zones (FMANR 1990).

Soil moisture content

The soil moisture content was determined every 2 from 2 weeks after planting (WAP) to 12 WAP. The results showed considerable variation in soil moisture at different depths content among tillage and cropping methods. The

Table 1. Initial soil physical and chemical properties of the study site, Ado Ekiti, Nigeria.

Soil depth (m)	Sand	Silt (%)	Clay	Tex. class	GC	OC (%)	BD (Mg m^{-3})	Ksat (mm h^{-1})	pH_{H2O}	TN (%)	Av. P (ppm)	EX. Cations (cmolc dm^{-3})				
												Ca	Mg	Mn	K	Na
0 to 0.15	77.4	14.3	8.3	LS	10.3	1.72	1.50	32.4	6.9	0.13	33.21	3.41	2.24	4.06	0.26	0.09
0.15 to 0.30	75.9	19.0	5.1	S	12.6	0.80	1.58	26.8	6.4	0.07	26.41	2.12	1.07	6.04	0.16	0.06
0.30 to 0.60	71.7	22.1	6.2	S	17.3	0.65	1.60	21.2	6.1	0.05	20.42	0.68	0.66	5.02	0.09	0.04
0.60 to 1.0	71.6	16.4	12.0	S	14.6	0.40	1.65	18.3	5.9	0.04	18.67	0.52	0.11	1.06	0.05	0.03

GC: Gravel content; Tex: textural; OC: Organic carbon; BD: bulk density, Ksat: saturated hydraulic conductivity; TN: Total nitrogen; Av. P: Available phosphorus; Ex: Exchangeable; LS: loamy sand; S: sandy.

soil moisture content of the three soil layers under tillage and cropping methods are shown in Figures 1, 2 and 3. In the tillage treatments, higher soil water content was observed with no-tillage in all cropping methods than CT. Regardless of tillage and cropping methods, the soil moisture content decrease with depth (Figure 1). In general, intercropped plots in both tillage methods had significantly ($p < 0.05$) higher soil moisture content than the sole crops of maize and groundnut. Visual observation during the experiment indicated that earthworm population was greatly enhanced by maize and groundnut vegetation which protected the bare soil and made soil water content higher in the intercrop. This agrees with the findings of Lal (1990) and Patil et al. (2015) that soil and water conservation are the benefits obtained with the use of residue mulch in no-tillage. The additional surface soil protection in maize-groundnut intercrop enhanced soil and water conservation and with careful selection of intercrops, competition for water under intercropping may be reduced (Patil et al., 2015). Also, the monoculture cultivation of maize and groundnut under no-tillage with residue mulch conserved more water than mono-culture practice in conventional tillage (Figures 1, 2 and 3). The lower soil moisture content in the 20 to 30 cm depth is due to good internal drainage of the site of the experiment at the beginning of the study (Figure 3). The frequent superiority of the soil moisture content at the 0 to 10 cm depth (Figure 1) compared to 20 to 30 cm depth at sampling time is suggested to be due to incomplete gravitational water movement after a rain storm. Temporal changes in soil moisture content is more rapid and variable at the 0 to 10 cm while the changes in soil moisture content at 10 to 20 cm (Figure 2) and 20 to 30 cm depths are similar at both depths. The increased competition for water at lower depths probably led to lower soil moisture content at the 20 to 30 cm depth.

Soil pore characteristics

Temporal changes in soil pore characteristics at 0 to 0.01 and 0.01 to 0.20 m depths are shown in Tables 2 and 3. Pore characteristics at the two depths varied with the pore size distribution which is in turn affected by tillage and cropping methods. Generally, the air-filled pores had higher moisture content than the useful water retaining pores and the transmission pores. Generally, the pattern of soil pore characteristics in all the pores is: intercropped > sole groundnut > sole maize ($p<0.05$). Also, NT plots had higher SMR than CT plots in all cropping methods. The SMR in all the different pore sizes decreased with depth. For example, the air-filled porosity under NT intercropped was 29.6 (% v/v) at the 0-0.01 m depth (Table 2). This decreased to 27.3 (% v/v) in the 0.01 to 0.20 m depth, a decrease of 7.8%. In the CT intercrop, the air-filled porosity was 25.01 (% v/v) at the 0.01-0.20 m depth and 22.4 (% v/v) at the 0.01 to 0.20 m depth, a decrease of 10.4% (Table 3).

Improved soil pore size distribution in the NT and intercropped plots indicates the ability of the soil to improve water supply to the plant. It also signifies improved soil utilization of precipitation leading to reduced run-off and less soil erosion (Lal, 1976).

Infiltration characteristics as affected by tillage and intercropping

The cumulative infiltration data (not graphed) of the soils obtained by summation of the infiltration depths in every 15 min till 180 min for all the treatments was high with high coefficient of variability (Table 4). The highest I was 605 mm for NT and was 59% higher than the lowest which

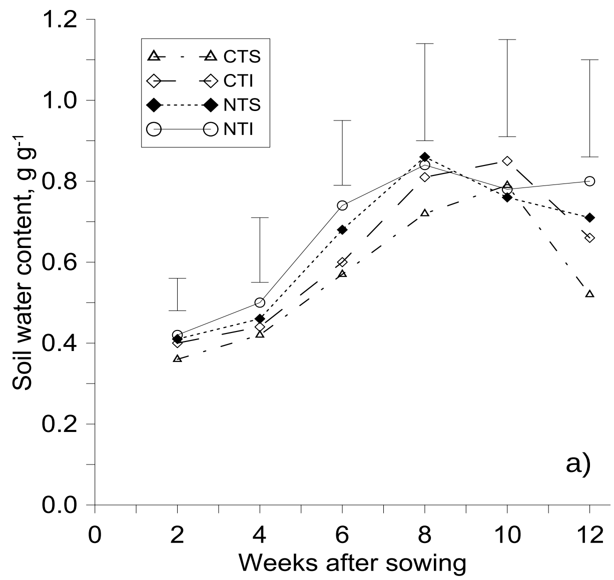

Figure 1. Temporal distribution of soil water content of the 0-0.01 m surface layer of the (a) maize and (b) groundnut field. CTS: Conventional tillage + sole cropping; CTI: Conventional tillage + intercropping; NTS: no-tillage + sole cropping; NTI: no-tillage + intercropping. The vertical bars are the Fisher's LSD values at 5% level of probability.

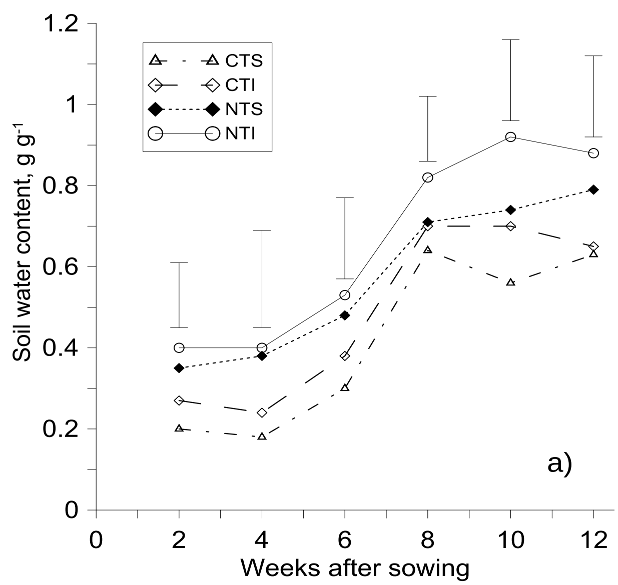

Figure 2. Temporal distribution of soil water content of the 0.01-0.02 m surface layer of the (a) maize and (b) groundnut field. CTS: Conventional tillage + sole cropping; CTI: Conventional tillage + intercropping; NTS: no-tillage + sole cropping; NTI: no-tillage + intercropping. The vertical bars are the Fisher's LSD values at 5% level of probability.

was 248 mm for CT maize. Good ground cover and high biomass production in the sole groundnut plots of CT and NT may be responsible for their high I. Furthermore, the high sand content of these soils (Table 1) may have resulted in a high horizontal components of cumulative infiltration in the soils which led to initial high water entry into the immediate surroundings of the soil (Reynolds et al., 2002). One of the criticisms of the double ring infiltration method is that the shallow double ring infiltrometer technique is usually not very effective in minimizing the horizontal component of water entry into the soil (Reynolds et al., 2002). Both the transmisivity (A) and the sorptivity (S) followed the same pattern as I (accumulative infiltration).

The other was NT intercrop > NT maize > NT groundnut > CT intercrop > CT groundnut >CT maize.

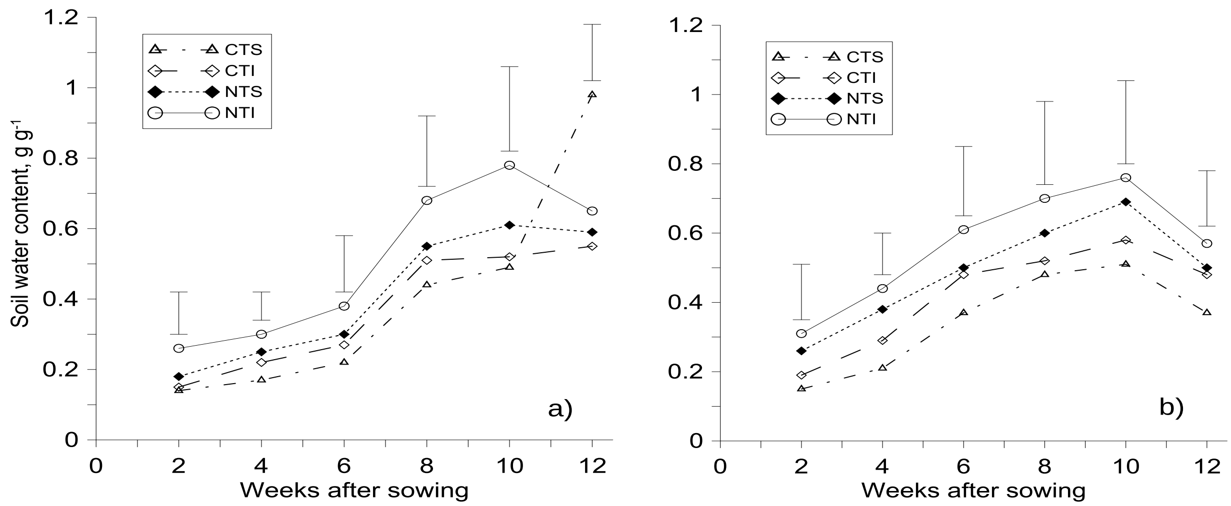

Figure 3. Temporal distribution of soil water content of the 0.02-0.03 m surface layer of the (a) maize and (b) groundnut field. CTS: Conventional tillage + sole cropping; CTI: Conventional tillage + intercropping; NTS: no-tillage + sole cropping; NTI: no-tillage + intercropping. The vertical bars are the Fisher's LSD values at 5% level of probability.

Table 2. Soil pore characteristic (% v/v) of 0-0.01 m soil layer as affected by tillage and intercropping at two years of cropping.

Treatment	Air filled pores	Useful water retention pores	Transmission pores 750 mm
		CT treatment	
Sole maize	14.6^{e}	9.8^{e}	12.34^{e}
Sole groundnut	20.3^{d}	13.1^{d}	14.3^{d}
Maize/groundnut Intercrop	25.0^{b}	15.6^{c}	17.6^{b}
		NT treatment	
Sole maize	22.4^{c}	13.6^{cd}	18.6^{cb}
Sole groundnut	25.3^{b}	21.0^{b}	16.41^{c}
Maize/groundnut Intercrop	29.6^{a}	23.2^{a}	20.56^{a}

CT: conventional tillage; NT: no-tillage. Means followed by the same lowercase letters in each column are not statistically different by Fisher`s LSD test (P≤0.05).

Table 3. Soil pore characteristics of 0.01-0.02 m soil layer as affected by tillage and intercropping.

Treatments	Air filled pores	Useful water retaining pores	Transmission pores
		CT treatment	
Sole maize	15.6^{d}	11.5^{e}	13.5^{d}
Sole groundnut	18.3^{c}	14.2^{d}	16.1^{c}
Maize/groundnut Intercrop	22.4^{b}	18.7^{c}	17.2^{bc}
		NT treatment	
Sole maize	17.8^{c}	14.5^{b}	19.6^{b}
Sole groundnut	23.4^{b}	22.4^{b}	18.2^{b}
Maize/groundnut Intercrop	27.3^{a}	24.9^{a}	21.5^{a}

CT: conventional tillage; NT: no-tillage. Means followed by the same lowercase letters in each column are not statistically different by Fisher`s LSD test (P≤0.05).

The goodness of fit for the infiltration model is high and show good correlation. The high sorptivity and transmissivity of the soils were reflected in the high accumulative infiltration (Table 4).

Table 4. Infiltration characteristics as affected by tillage and intercropping method 2011 and 2012.

Treatment	I	A	S	R^2
		CT treatment		
Sole maize	248	0.55	2.6	0.99
Sole groundnut	371	0.61	3.3	0.99
Maize/groundnut Intercrop	402	1.01	4.5	0.98
		NT treatment		
Sole maize	463	188	4.0	0.99
Sole groundnut	525	1.09	5.1	0.97
Maize/groundnut Intercrop	605	2.11	8.2	0.99
SD	166.2	0.41		
CV, %	48	47		

CT: conventional tillage; NT: no-tillage; SD: standard deviation; CV: coefficient of variation.

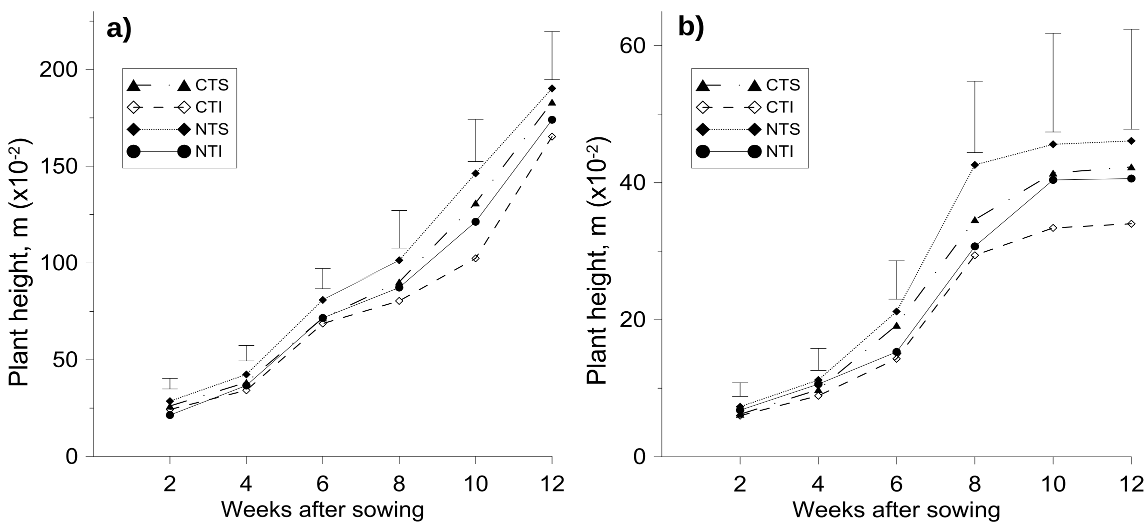

Figure 4. Mean plant height of (a) Maize and (b) Groundnut as affected by tillage methods and intercropping during 2012 growing season. The vertical bars are the Fisher's LSD values at 5% level of probability.

In all, the infiltration characteristics were better in no-tillage than conventional tillage. This is probably due to the presence of mulch. The crop residue mulching absorb kinetic energy of rain drops, thereby reducing surface crusting, water run-off and erosion (Lal, 1980, Videonovic et al., 2011). In addition, the return of crop residue to the soil enhances the soil organic matter content and nutrient cycling (Okigbo, 1980). Soil organic matter encourages good soil structuring which improves soil water properties (Lal, 1976). The increase in biotic activities under NT and intercropping contributed to pedoturbation creating macro pores in a crop and enhance soil aggregation which improved water infiltration. Conversely, CT with the residue buried in the soil exposed the soil surface to the effect of rundrop impact resulting in soil crusting and compaction. This combines with reduced soil macro porosity to limit water infiltration leading to run-off erosion (Lal, 1976; Ajayi and Babalola, 1991).

Crop yield and yield components

Plant height

Plant height is an important yield component, because the more the plant canopy, the more will be the photosynthesis activity which leads to better grain yield (Ikeorgu and Odurukwe, 1989). The average values of the plant height under the two management practices (tillage and cropping system) during the growing period are presented in Figure 4. The trend in plant height is as follows: the NT treatment had significantly ($P<0.05$)

Table 5. Mean maize and groundnut yield and yield components as affected by intercropping and tillage method in 2012.

Treatments	Maize				Groundnut		
Tillage methods	Cropping methods	Stover yield kg(ha)	1000 grain weight (g)	Grain yield (kg/ha)	pods plant^{-1}	seeds pod $^{-1}$	pod yield (kg/ha)
CT	Sole	5.216^{b}	374^{ab}	2.634^{b}	11^{b}	1.7^{a}	1.02^{b}
	Intercropping	3.468^{d}	365^{b}	2.014^{c}	8^{c}	1.7^{a}	0.96^{b}
NT	Sole	6.104^{a}	401^{a}	3.042^{a}	15^{a}	1.8^{a}	1.54^{a}
	Intercropping	4.274^{c}	375^{b}	2.811^{b}	10^{b}	1.7^{a}	1.06^{a}

CT: conventional tillage; NT: no-tillage. Means followed by the same lowercase letters in each column are not statistically different by Fisher`s LSD test ($P \leq 0.05$).

higher plant height compared with CT treatment. Likewise, sole cropping had higher plant height greater than intercropping system. The significantly higher plant height from NT system may be attributed to organic matter which improved soil physical properties under NT system (Lal, 1976), which enabled the maize plant to maximize the use of water and other nutrients. This result contradicts the findings of Rashidi and Keshavarzpour (2007) and Awe and and Abegunrin (2009) who found higher plant height from CT compared with NT system. They concluded that annual disturbance and pulverization caused by tillage practices produce a finer and loose soil structure which in turn enhances seedling emergence, plant population density and crop yield. Similarly, the lower yield from intercropping system may be due to competition for resource use (water, light and nutrients) under intercropping system (Ikeorgu and Odurukwe, 1989). Amanullah et al. (2006) and Awe and Abegunrin (2009) also found that maize performed better in solecropping than intercropping. These authors attributed the better performance in sole cropping to lesser degree of competition for resources except intra–species competition while lower performance in intercropping may be due to both inter-and intra-species competition for nutrients, space and nutrients.

Maize yield

Gran yield of crops is the ultimate objective of all the grain crops. The yield of maize and groundnut in sole crop and mixtures as affected by tillage methods is shown in Table 5. The stover yield was in the order NT maize > CT maize > NT intercrop > CT intercrop. This was also the trend of grain yield in the study (Table 3). Both intercropping and tillage methods did not significantly affect the 1000 grain weight. The highest maize yield was obtained in NT maize (3,042 kgha^{-1}) while the lowest maize yield was obtained in CT intercropping (2,014 kgha^{-1}). The yield of intercropped maize obtained was lower than the sole maize value in all the tillage treatments. The lower maize yield in intercropped plots of both CT and NT has been reported to be due to below and above ground competition between the maize and groundnut. However, the yield of groundnut compensated for the loss of yield in maize under intercropping (Ikeorgu and Odurukwe, 1989; Mehdi, 2013). 1000 grain weight is an important yield - determine factor. It expresses the magnitude of seed development for determining the quality and yield per hectare (Abayomi and Adefila, 2008). The better resource utilization coupled with improved soil and water conservation in intercropping recommended intercropping groundnut with maize in NT practices. Intercropping under NT will be advantageous to grow the crops in season of fluctuating rainfall with drought spell at critical growth stage of the crops (Lal, 1986).

Conclusion

Tillage and intercropping significantly affected water characteristics, growth and yield of maize and groundnut. For all the crop treatments, no-tillage had higher soil water characteristics than conventional tillage. Similarly, despite the likely competition for water in the intercropped plots, soil moisture content and infiltration characteristics were better improved under intercropping than sole cropping. The no-tillage treatment had increased yield as the year of cultivation increased in this study while the conventional tillage had its yield decreased progressively with yearly cultivation. Though in both maize and groundnut crops the grain yield were usually better in intercropping. However, the combined yield of maize and groundnut when intercropped was higher than the sole crops. No tillage and intercropping proved to be a better management option for soil and water conservation in the zone.

Conflict of Interest

The authors have not declared any conflict of interest.

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