EFFECT OF TILLAGE AND POULTRY MANURE RATES ON PHYSIOLOGICAL GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.)

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A field trial was conducted at the Teaching and Research Farm of the University of Ilorin during the 2015 and 2016 cropping seasons to assess the effect of tillage methods and poultry manure application on the growth and yield of sesame. The experiment was laid out as a split plot arrangement, fitted into a randomized complete block replicated thrice. The factors consisted of three tillage methods and four levels of poultry manure application (0, 5, 10, and 15 tha^{-1}). The result revealed that tillage and poultry manure significantly ($P<0.05$) increased the growth and yield of sesame. Increasing the rate of poultry manure resulted in an increase in the net assimilation rate, relative growth rate, and crop growth rate. The yield in 2016 was higher than that of 2015 due to higher rainfall and residual effect of the previous cropping season. Yield per hectare was optimized using conventional tillage method and poultry manure at 15 tha^{-1}. Although the conventional tillage and poultry manure treatments produced the highest yield, the control plot gave the highest cost and returns (return per investment) in the two years of study due to high cost of farm inputs. The result of the study further affirms farmer's reluctance on the use of external inputs for yield enhancement in sesame.

Soil manipulation, organic amendment, performance, sesame

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INTRODUCTION

Sesame (*Sesamum indicum*L.), also known as beniseed in West Africa , belongs to the family Pedaliaceae and it is the third largest export commodity in Nigeria after petroleum and cocoa (*Theobrma cacao* L.)(FAO, 2012;Umar et al., 2014).The potentials of sesame production in Nigeria are high, with an estimated 3.5 million hectare of agricultural land devoted for its cultivation in the Guinea, Sudan, and Sahel savannah zones (Alegbejo et al., 2003; Tunde-Akintunde et al., 2012). The possibility of cultivating under poor soil conditions makes sesame a crop that can be used for mitigating food security in the regions. Nevertheless, the yield of the crop in Nigeria is low, compared to yield elsewhere, e.g. in Venezuela, Saudi Arabia,*Côte d'Ivoire,*and Ethiopia (Abubakar et al., 1998), probably due to poor cultural practices used by local farmers. According to Eifediyi et al. (2015),cultivating the crop early in the season predisposes it to vegetative growth and pest invasion. In addition, traditional sesame growers rarely use fertilizers. Studies have shown that the crop performs well with the application of organic or inorganic fertilizers (Olowe, Busari, 2000; Okpara et al., 2007; Haruna et al., 2011; Haruna, Abimiku, 2012).

In Nigeria, farmers commonly till the soil to improve its physical, chemical, and biological characteristics that alter plant growth and yield (Dinnes et al., 2002; Ozpinar, Cay,2006; Rashidi, Keshavarzpour, 2009; Aikins et al., 2012; Zamir et al., 2013). Crops grown without tillage are stunted and show symptoms of water and nutrient deficiencies because of high surface bulk density, low porosity, retarded infiltration, and low water holding capacity of the soil (Lal, 1979). However, the conventional and traditional tillage methods have negative effects on soil life and increase mineralization of organic matter (Atkinson et al., 2007; Aikins et al., 2012).A zero tillage system, on the other hand, is a conservation method that involves the use of crop residues that aid water infiltration, prevent erosion, and increase organic matter content and agricultural productivity (Opara-Nadi, 1990). Besides, it reduces the cost in machinery investment and the time required for seedbed preparation (Lal, 1984).

The soils of the Guinea savannah zone of Nigeria are characterized by low organic matter content, high temperature, erosion, and low plant nutrient status. These could be improved by the use of organic inputs from the poultry manure that slowly releases nutrients and thus improves soil moisture and nutrient retention (Kroodsma, 1986; Farhad et al., 2009; Suddhiyan et al., 2009;Haruna et al.,2011;Ogbonna, Umar-Shaba, 2012). Previous studies have shown that the use of external inputs in the form of inorganic fertilizer is a *sine qua non* in crop production in the southern Guinea savannah zone of Nigeria and inorganic fertilizer is scarce, expensive, and hazardous to the environment (Adeniyan, Ojeniyi, 2005).However, poultry manure is readily available in the zone, improves the environmental conditions and public health (Ojeniyi, 2000; Maritus, Vleic,2001; Eifediyi et al., 2010).

Till date, the effects of these soil improvement methods on sesame production have not been investigated in the study area. This study, therefore, evaluates the effects of tillage methods, poultry manure on the growth and yield of sesame and their economic implications.

MATERIAL AND METHODS

Site description

The field study was conducted at the Teaching and Research Farm of the University of Ilorin, Ilorin, Nigeria (8°49'N, 4°58'E, and 307m a.s.l.),during the 2015 and 2016 cropping seasons. The site is located in a southern Guinea savannah zone of Nigeria (Fig. 1). The climate of the area is tropical humid with an average rainfall of 1186 mm, mean annual temperature of 29°C, while the average annual relative humidity is about 85%. The soil is well drained and the soil order is Alfisol with a textural class of sandy loam belonging to the Bolorodunro series (Ogunwale et al., 2002). The experimental site was left fallow for two years prior to the establishment of the experiment.

Soil sampling

Top soil (0–30cm) samples were collected in a 4 ×10 m^2 grid, bulked, and a composite sample was collected for physical and chemical analyses. Soil pH was determined (soil: water ratio 1:2.5) using glass electrode (Thomas, 1982). Total N content was determined by micro-Kjeldahl method (Bremner, Mulvaney,1982); available phosphorus was determined following Bray No. 1 method (Kuo, 1996); organic carbon was determined according to Walkley-Black method (Nelson, Sommers, 1982); calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) were extracted with 1N ammonium acetate. Calcium and magnesium in the extract were analysed using an Atomic Absorption Spectrophotometer (AAS) whereas K and Na were determined by flame photometry.

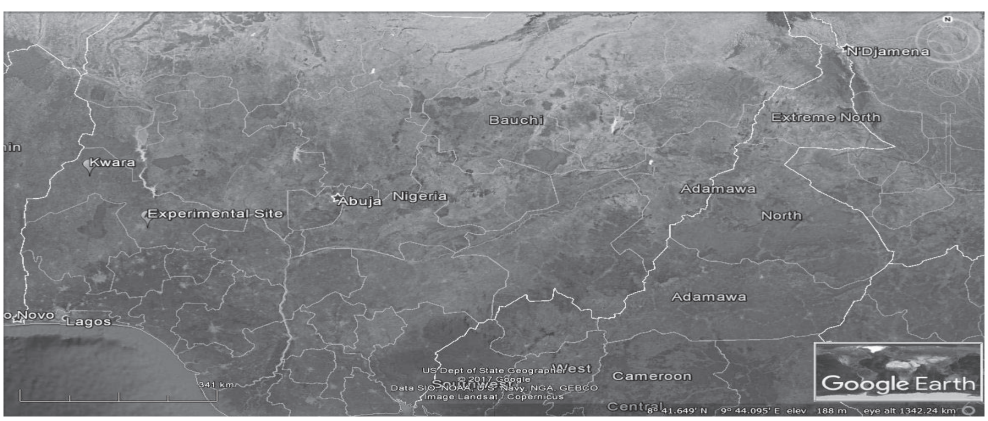

Fig. 1. Map of the experimental site

Table 1. Soil and poultry manure properties of the experimental site before cropping in 2015 and 2016

Properties	Before 2015	Before 2016	Poultry manure 2015	Poultry manure 2016
pH	5.6	6.1	6.5	6.4
Clay (%)	12	12	–	–
Silt (%)	12	12	–	–
Sand (%)	74	74	–	–
Textural class	sandy loam	sandy loam	–	–
Carbon (g kg^{-1})	1.00	1.78	14.35	14.29
Organic matter (g kg^{-1})	1.72	3.07	24.81	24.71
Nitrogen (g kg^{-1})	1.14	1.13	1.9	1.8
Phosphorus (mg kg^{-1})	6.20	7.69	11.28	11.29
Potassium (cmol kg^{-1})	0.14	0.13	0.48	0.47
Calcium ($cmolkg^{-1}$)	1.50	2.30	3.00	3.90
Mg ($cmolkg^{-1}$)	0.26	2.40	2.16	2.17
Na ($cmolkg^{-1}$)	0.14	0.34	0.29	0.30

Experimental design and field layout

The experiment was laid out as a split plot arrangement fitted into a randomized complete block design. The factors consisted of three tillage methods (main plots) namely; minimum tillage (MT) with no tillage but clearing and packing of debris was done by using a cutlass; conventional tillage (CT) done by using a tractor to plough and harrow; and the traditional tillage (TT) carried out by using a west Indian hoe. On the subplots were four levels of organic manure (0, 5, 10, and 15 tha^{-1}) . The treatments were replicated thrice. The size of the main plots was 18 × 24 m with 2 m avenues and sub plots were 3 × 4m with a 1m alleyway. The organic manure was incorporated into the soil two weeks before sowing.

Planting and weed control

Sesame seeds (cultivar Ex-Sudan) were sown by drilling on July 17, 2015 and July 16, 2016 and the seedlings were later thinned to 30 cm within and 30 cm between the rows at three weeks after sowing. Weed control was done by using manual weeding at three and six weeks after sowing.

Growth and yield parameters

Dry matter production and accumulation. Dry matter accumulation was accessed by randomly uprooting two plants from the gross plot, partitioned into leaves, stem and roots at 4, 6, 8, and 10 weeks after sowing (WAS). The plants were then oven-dried at 80°C until a constant weight was attained and weighed by using a sensitive balance. The data were used to estimate net assimilation rate, crop growth rate, and relative growth rate. Net assimilation rate was computed using data from the increase in dry matter production at 4, 6, 8, and 10 WAS.

Crop growth rate (CGR) which is the dry weight increment per unit time was determined from the increase in dry matter production at 4, 6, 8, and 10 WAS. The crop growth rate indices were calculated based on the procedures of Watson (1956):

$CGR=(W_2 - W_1)/p(t_2- t_1)$

where:

W_1,W_2= dry weight of whole plant at time t_1 and t_2, respectively

p = ground area on which W_1 and W_2 are recorded

Net Assimilation Rate (NAR) was computed based on the work of Williams (1946) using the formula

$NAR =((W_2 -W_1)/(t_2 - t_1))\times((\log_e L_2- \log_e L_1)/(L_2 - L_1))$

where:

W_1, W_2= dry weight of whole plant at time t_1 and t_2, respectively

L_1,L_2= leaf weight or leaf area at t_1 and t_2, respectively

$t_2 - t_1$= time interval in days

Relative growth rate (RGR) was computed based on the work of Williams (1946)using the following formula:

$RGR = (\log_e w_2 - \log_e w_1)/(t_2 - t_1)$

where:

W_1,W_2= whole plant dry weight at t_1 and t_2, respectively

$t_2 - t_1$= time interval in days

Yield and yield components. The number of capsules per plant were visually accessed from five tagged

Table 2. Meteorological data of the experimental location in 2015 and 2016

Month	Temperature (°C)				Rainfall (mm)				Relative humidity (%)	
	2015		2016		2015		2016		2015	2016
	max.	min.	max.	min.		rainy day		rainy day		
January	33.9	17.9	36.8	25.8	7.3	1	0	0	91	87.2
February	33.9	22.5	32.2	19.9	4.0	1	24.1	2	91	91.0
March	35.6	20.2	34.8	19.5	25.7	4	23.1	2	92.1	91.0
April	32.1	23.3	32.0	22.5	7.5	2	194.0	6	84.9	91.0
May	35.5	27.7	33.2	22.8	46.7	4	166.0	9	92.1	90.2
June	35.1	20.0	34.6	24.7	48.0	4	232.0	7	92.2	91.0
July	34.5	19.7	38.5	21.5	62.0	3	161.2	9	91.8	91.7
August	34.8	24.5	28.2	21.8	81.2	2	177.9	10	89.1	96.1
September	33.5	21.9	25.7	25.4	198.0	11	332.2	20	85.9	93.8
October	35.1	23.8	31.6	21.7	121.5	6	61.5	9	89.3	93.0
November	35.8	25.5	32.8	22.1	0	0	7.8	1	88.9	90.8
December	36.3	27.0	33.3	19.7	0	0	0	0	85	85.5

source: Lower Niger River Development Authority, Ilorin

plants(the net plot); the seed yield from the net plots was harvested at maturity before the capsules dehisced and were dried.

The yield per ha (kg) was extrapolated from the net plot.

Harvesting. Harvesting was manually done by hand picking the capsules from the net plots, which were put in labelled bags to minimize seed loss due to capsules dehiscence and were later sun-dried.

Data analysis

Data collected were subjected to analysis of variance (ANOVA) using the GenStat software package (Version17) and mean comparison was done using the Duncan Multiple Range Test(DMRT) at 5% level of probability.

Cost and returns analysis

The analysis of cost and returns was used to determine the economic implications of the operations. This was done by estimating the cost, revenue, and gross margin of the production process on per hectare basis. Return on capital invested was also derived from the cost and returns analysis and used as profitability index (Olukosi, Erhabor, 1998; Olukosi et al., 2006; Falola et al., 2013). Revenue was computed as monetary value of the total farm output sold or consumed by the farmer's household plus that given out as gifts or used for other purposes. The variable costs included fees, seeds, labour, herbicides, fertilizers, and pesticides.

Gross margin (GM) is the difference between the gross value of farm output (also known as gross farm income (GFI) and the total variable cost (TVC). It is a useful planning tool in situations where fixed capital is just a negligible portion of the farming enterprises (Olukosi, Erhabor, 1998; Olukosi et al., 2006)

$$GFI = T \times W \quad (1)$$

where:
GFI = gross farm income
T = unit price of output
W = quantity of farm output

$$GM = GFI - TVC \quad (2)$$

where:
GM = gross margin
GFI = gross farm income (gross value of output)
TVC = total variable cost.

Return on capital invested (RI)is defined as gross margin divided by total variable cost

$$RI = GM/TVC \quad (3)$$

RESULTS

Physical andchemical properties of soil and poultry manure

The data on properties of soil and poultry manure presented in Table 1.The soil of the study area is moderately acidic to slightly acidic, sandy loam and low in the plant nutrients evaluated, therefore needs organic amendment. The organic matter content was low to moderately low, the nitrogen content was low to medium, phosphorus low to moderate, potassium low to

Table 3. Effects of tillage and poultry manure on the net assimilation rate (g m^{2}per day) of sesame between 4–6, 6–8, and 8–10 weeks after sowing in 2015 and 2016

Treatments	Year 2015			Year 2016		
	weeks after sowing			weeks after sowing		
	4–6	6–8	8–10	4–6	6–8	8–10
Tillage						
MT	14.95^c	7.11^b	–0.01	5.42^a	3.00^a	2.74^a
CT	20.25^a	9.76^a	–0.05	4.35^b	4.07^a	2.80^a
TT	16.55^b	3.50^c	0.27	2.37^c	2.30^b	2.03^b
Tillage DMRT (0.05)	*	*	ns	*	*	*
PM levels (t ha^{-1})						
0	14.47	11.01	0.05^c	3.45	2.15	0.84^c
5	11.46	4.74	0.13^b	3.04	1.89	1.81^c
10	22.29	4.46	–0.06^d	6.01	2.51	4.14^b
15	20.79	6.96	0.17^a	3.70	3.89	6.69^a
PM DMRT (0.05)	ns	ns	*	ns	ns	*
Interaction DMRT (0.05)	ns	ns	ns	ns	ns	ns

MT = minimum tillage, CT = conventional tillage,TT = traditional tillage, PM = poultry manure,DMRT = Duncan multiple range test, 0.05=significant at 0.05 probability level, ns = not significant at 0.05 probability level; a–d = ranking * = significant

moderate, calcium low to moderate, magnesium moderate to high, sodium low to moderate, while poultry manure was slightly acidic and high in all the nutrient contents evaluated except potassium and sodium.The ratings were based on the work of Lindsay, Norvell (1978) and Esu (1991).

Meteorological data

The data on temperature, rainfall, and relative humidity are presented in Table 2. The data on temperature indicated that during the months of cultivation, the temperatures for 2015 were higher than 2016, while rainfall for the period of 2016 was higher than in 2015 with more rainy-days. Relative humidity for the two seasons was high, but that of 2016 was higher. The meteorological data revealed that the year 2015 experienced lower rainfall, higher temperature, and higher relative humidity than 2016.

The effects of tillage and poultry manure on the net assimilation rate of sesame at 4–6, 6–8, and 8–10 WAS are presented in Table 3. The data showed that tillage methods had a significant (P<0.05) effect on the net assimilation rate at 4–6 and 6–8WAS in 2015 with conventional tillage producing the highest values than the other tillage methods, but it was not significant between 8 and 10 WAS. There was a reduction in the value of net assimilation rates with maturity due to partitioning into flowers and seeds. The application of 15 tha^{-1}of poultry manure produced the highest net assimilation rate but no significant difference was recorded across the sampling periods except between 8 and 10 WAS. There was a decline in the net assimilation rate as the plant matured. In 2016, conventional tillage produced the highest net assimilation rate, which was significant across the three sampling periods than the other tillage methods. A similar trend as in the 2015 cropping season was observed when poultry manure was applied. However, no significant interaction between tillage and poultry manure was observed.

The effect of tillage methods and poultry manure on the relative growth rate of sesame at 4–6, 6–8, and 8–10 WAS in 2015 and 2016 is presented in Table 4. In 2015, between 4 and 6 WAS, the conventional tillage produced the highest value which was not significantly different from the other tillage methods, but between 6 and 8 WAS, produced the highest values which was significantly different(P< 0.05) from the other tillage methods. The application of 15 tha^{-1} of poultry manure produced the highest relative growth rate at 4–6 WAS, but no significant difference was observed, however between 6 and 8 WAS the application of poultry manure at 15 tha^{-1}produced the highest values which differed significantly (P<0.05) from the other rates. During the 2016 cropping season, the conventional tillage produced the highest relative growth rate, which was not different from the other tillage methods. In addition, at 4–6 WAS, the application of poultry manure at 15 tha^{-1}produced the highest relative growth rate, which was not significantly different from the other rates. However at 6–8 and 8–10 WAS the application of poultry manure at 15tha^{-1}produced the highest values, which was significantly different (P<0.05) from the other rates. Nevertheless, no significant tillage and

Table 4. Effects of tillage and poultry manure on the relative growth rate (mg g^{-1}per day) of sesame between 4–6, 6–8, and 8–10 weeks after sowing in 2015 and 2016

Treatments	Year 2015		Year 2016		
	weeks after sowing		weeks after sowing		
	4–6	6–8	4–6	6–8	8–10
Tillage					
MT	0.78	0.10^{a}	0.39^{b}	0.11^{a}	0.05^{a}
CT	0.81	0.07^{b}	0.65^{a}	0.06^{b}	0.03^{b}
TT	0.64	0.03^{b}	0.59^{a}	0.05^{b}	0.02^{b}
Tillage DMRT (0.05)	ns	*	*	*	*
PM levels (t ha^{-1})					
0	0.65	0.07^{b}	0.48	0.07	0.02^{b}
5	0.61	0.08^{a}	0.48	0.08	0.03^{ab}
10	0.81	0.06^{c}	0.60	0.07	0.04^{a}
15	0.90	0.06^{c}	0.60	0.08	0.04^{a}
PM DMRT (0.05)	ns	*	ns	ns	*
Interaction DMRT (0.05)	ns	ns	ns	ns	*

MT = minimum tillage, CT = conventional tillage,TT = traditional tillage, PM = poultry manure, DMRT = Duncan

ultiple range test, 0.05= significant at 0.05 probability level, ns = not significant at 0.05 probability level; ^{c} = ranking, * = significant

Table 5. Effects of tillage and poultry manure on the crop growth rate (g m^{-2}per day) of sesame between 4–6, 6–8, and 8–10 weeks after sowing in 2015 and 2016

Treatments	Year 2015			Year 2016		
	weeks after sowing			weeks after sowing		
	4–6	6–8	8–10	4–6	6–8	8–10
Tillage						
MT	2.87^{c}	2.17^{b}	0.00^{b}	3.10^{b}	2.16^{b}	1.75^{b}
CT	7.17^{a}	4.91^{a}	0.30^{a}	6.28^{a}	5.25^{a}	4.73^{a}
TT	5.05^{b}	3.07^{b}	-0.06^{b}	5.53^{a}	4.73^{a}	4.59^{a}
Tillage DMRT (0.05)	*	*	*	*	*	*
PM levels (t ha^{-1})						
0	3.91^{b}	3.17	0.04	4.03^{c}	3.96^{c}	0.67^{d}
5	3.92^{b}	3.25	0.17	3.77^{c}	3.10^{d}	1.93^{c}
10	5.23^{a}	3.76	–0.06	4.82^{b}	4.55^{b}	5.72^{b}
15	6.12^{a}	4.28	0.16	6.01^{a}	5.26^{a}	8.80^{a}
PM DMRT (0.05)	*	ns	ns	*	*	*
Interaction DMRT (0.05)	ns	ns	ns	ns	ns	ns

MT = minimum tillage, CT = conventional tillage,TT = traditional tillage, PM = poultry manure, DMRT = Duncan multiple range test, 0.05= significant at 0.05 probability level, ns = not significant at 0.05 probability level; $^{a–d}$ = ranking, * = significant

poultry manure interaction was observed except at 8–10 WAP in the 2016 cropping season.

The effect of tillage and poultry manure on the crop growth rate in 2015 and 2016 of sesame at 4–6, 6–8, and 8–10 WAS is presented in Table 5. In 2015, the data showed that the conventional tillage had the highest mean values during the sampling periods which were significantly different ($P<0.05$) from the

Table 6. Effects of tillage and poultry manure on the yield components of sesame in 2015 and 2016

Treatments	Year 2015			Year 2016		
	No of capsules per plant	Yield of net plot (g)	Yield (kg ha^{-1})	No of capsules per plant	Yield of net plot (g)	Yield (kg ha^{-1})
Tillage						
MT	26^{b}	23.61	513.17^{b}	25^{c}	30.59	679.60^{b}
CT	54^{a}	24.75	550.08^{a}	84^{a}	32.42	720.60^{a}
TT	58^{a}	24.98	554.58^{a}	53^{b}	31.82	707.20^{a}
Tillage DMRT (0.05)	*	ns	*	*	ns	*
PM levels (t ha^{-1})						
0	38^{c}	17.49^{c}	388.11^{c}	22^{b}	24.72^{d}	549.40^{d}
5	38^{c}	23.17^{b}	515.11^{b}	30^{b}	29.44^{c}	654.20^{c}
10	47^{b}	25.03^{b}	540.44^{b}	43^{b}	32.62^{b}	725.10^{b}
15	56^{a}	32.11^{a}	713.44^{a}	122^{a}	39.64^{a}	881.0^{a}
PM DMRT (0.05)	*	*	*	*	*	*
Interaction DMRT (0.05)	ns	*	*	ns	*	*

MT = minimum tillage, CT = conventional tillage, TT = traditional tillage, PM = poultry manure, DMRT = Duncan multiple range test,0.05= significance at 0.05 probability level, ns = not significant at 0.05 probability level; $^{a-d}$ = ranking , * = significant at 5%

other tillage methods. Moreover, increasing the rate of poultry manure application between 4 and 6 WAS led to a progressive increase in the crop growth rate, the15 tha^{-1}produced the highest values which was significantly (P<0.05) different from the other levels. However, at 6–8 and 8–10 WAS, no significant difference was observed when poultry manure was applied. In 2016 cropping season, conventional tillage produced the highest mean values which were significantly different (P<0.05) from the other tillage methods. The 15 tha^{-1}of poultry manure produced the highest crop growth rate which was significantly different from the other levels. But no significant interaction between tillage and poultry manure application was observed.

The effect of tillage and poultry manure on yield components of sesame in 2015 and 2016 is presented in Table 6. In 2015, the data revealed that conventional tillage had the highest mean value for the number of capsules which was significantly different (P<0.05) from the other tillage methods. In addition, increasing the poultry manure rates resulted in an increase in the number of capsules per plant, the 15 tha^{-1} treatment produced the highest number of capsules across the tillage methods which was significantly different (P<0.05) from the other rates except at the conventional tillage method where it was at par with 10 tha^{-1}. The control produced the lowest number of capsules. The data on the net yield per plot, indicated that the conventional tillage produced the highest mean value; this was at par with the traditional tillage method which was significantly different (P<0.05) from the minimum tillage. The 15 tha^{-1} rate produced the highest net yield per plot which was not significantly different from the 5, 10 tha^{-1} and the control. Although the conventional tillage produced the highest yield per hectare, it was at par with the traditional tillage method. The 15 tha^{-1} produced the highest yield per hectare which was not significantly different from the yield at 10 tha^{-1}. In 2016, the result for conventional tillage method was significantly different (P<0.05) from the others in respect to its effect on the number of capsules. The application of 15 tha^{-1} of poultry manure was observed to produce the highest number of capsules per net plot and the result was significantly different (P<0.05) from the other levels. Conventional tillage produced the highest net yield per plot and yield per hectare which were significantly different (P<0.05) from the other tillage methods, while the 15 tha^{-1} of poultry manure produced the highest net yield per plot and yield per hectare which were significantly different (P<0.05) from the other rates.

The cost and returns analysis of the influence of tillage and poultry manure on the growth and yield of sesame in 2015 and 2016 is shown in Table 7. The total revenue was made up of income from sales of the output based on the different treatments considered. In 2015, sum of ₦ 100 068.15, 108 143.10, and 107 265.60 (Nigeria's currency naira) were realized from using MT, CT, and TT while total revenue of ₦203 880, 216 180, and 212 160 were realized in 2016. The total revenues which accrued by using poultry manure rates in 2015 were ₦ 75 681.45, 99 946.45, 105 385.80, 139 100.80, and 139 100.80, whereas in 2016 the revenue which accrued to the farmer was ₦164 820,196 260, 217 530, and 264 100. The total variable cost components were used due to the

Table 7.Cost and returns analysis in 2015 and 2016 in Nigeria's currency (naira ₦)

	Year 2015				Year 2016			
	Total revenue (sales) (a)	Total variable cost (b)	Gross margin c = (a–b)	Return per investment d = (c/b)	Total revenue (sales) (a)	Total variable cost (b)	Gross margin c = (a–b)	Return per investment d = (c/b)
Treatment								
MT	100068.15	38 500	61568.15	1.59	203880	38 500	165380	4.30
CT	108143.10	36 500	71643.10	1.96	216180	36 500	179680	4.93
TT	107265.60	40 000	67265.50	1.68	212160	40 000	172160	4.30
PM levels (t ha^{-1})								
0	75681.45	20 000	55681.45	2.78	164820	20000	144820	7.24
5	99946.45	45000	54946.45	1.22	196260	45000	151260	3.36
10	105385.80	70000	35385.80	0.50	217530	70000	147530	2.11
15	139100.80	95000	44100.80	0.46	264300	95000	169300	1.78

1 USdollar = ₦ 320

fact that the fixed components were very negligible. In 2015 and 2016, a total variable cost of ₦38 500, 36 500, and 40 000 were incurred from using MT, CT, and TT, respectively, whereas using different levels (0, 5, 10, and 15 tha^{-1}) of poultry manure in 2015 and 2016, a total variable cost of ₦ 20 000, 45 000, 70 000, and 95 000) were incurred. In 2015, a gross margin of ₦ 61 568.15, 71 643.10, and 67 265.50 was realized from MT, TT, and CT.

Table 7 presents the cost and returns analysis for the different tillage practices and application of poultry manure at different levels. There was a general increase in return on investment from year 2015 to 2016. This increase was due to the increase in total revenue (sales) of the sesame seed produced in the two years. Among the three tillage practices, the highest revenue (₦ 71 673.10 in 2015 and ₦ 179 680 in 2016) and return on investment (₦ 1.96 in 2015 and ₦ 4.93 in 2016) were earned from conventional tillage (CT). Further interpretation of these results means that there was increase in the return on investment using CT from ₦ 1.96 in 2015 to ₦ 4.93 in 2016 as against the other two tillage practices. In the same vein, the lowest production costs (₦ 36 500 each in 2015 and 2016) were incurred using CT than the other tillage practices while the highest costs of production (₦ 40 000 each in 2015 and 2016) were incurred by the use of traditional tillage (TT) than the other two tillage practices. This could be attributed to the high cost of labour in clearing, packing of debris and land preparation.

On the economic implications of using poultry manure at different levels of treatment, the returns per investment in the two years of study were highest in the control treatment. Although this return could be attributed to the lowest cost incurred at the control level, while the revenue derived from the other levels of treatments surpassed that of control.

DISCUSSION

The soil of the experimental site was moderately acidic (2015) to slightly acidic (2016). It was sandy loam in texture, classified as Alfisol with inherent low fertility as reported by Lal (1979). The moderately high carbon content and organic matter in 2016 may be attributed to the previous cropping soil management and the residual effect of the poultry manure that was applied. This is because the quality of organic material which can be introduced into the soil either by natural returns through roots, stubble and root exudates or artificial application in the form of organic manures (Agboola, Omueti, 1982) and organic matter improves soil aeration, reduces nutrient leaching, and increases microbial activity. Akande et al. (2003) also suggested that the application of organic manure could improve crop production when soil nutrients are low. Organic matter, nitrogen, phosphorus, and potassium are the major determinants of soil fertility in most tropical soils because they are required for proper plant growth and development. The lower N content of the soil at the beginning of the 2016 cropping season may be attributed to its high usage compared to P and K in the 2015 cropping season as supported by Shehu et al. (2009) and to the fact that N is the most limiting plant nutrients in Nigeria farmlands as observed by Obisesan (2000). In 2016, there was an improvement in the soil nutrients before organic amendment, except nitrogen and phosphorus that were lower; this may be attributed to the usage and residual effect of the manure applied in the previous year. The analysis of the poultry manure showed it was slightly acidic and indicated that the nutrient contents were high except potassium and sodium; thus the essential nutrients should have been readily available for sesame plant absorption. Amanullah et al. (2010) reported that poultry manure contains a considerable amount of the essential nutrients, organic matter, hence has an impact on soil pH and liming. Chastain et al. (2003) opined that animal manure contains available essential plant nutrients, which could add organic matter to the soil and reduce the soil pH.Grant (1967) in his study on fertilizer application in soil under peasant agriculture emphasized the role of manure in moderating soil temperatures and that its continued use can progressively improve soil cation exchange capacity (K, Ca, and Mg) and buffer soil pH. Ruiz-Porras et al. (2007) observed that organic manure improved soil fertility, soil physical and chemical characteristics. Adeleye et al. (2010) also confirmed that poultry manure application improved soil physical properties, reduced soil bulk density, temperature, and increased total porosity and soil moisture retention capacity.

According to weather data, in the year 2015 higher temperatures and lower rainfall distribution than in 2016 . The results obtained from this study showed that differences in the factors of the environment must have contributed significantly to the expression of the morphological traits and yield components. However, the increase in precipitation in 2016 resulted in a greater number of capsules and yield per net plot, which invariably produced better yield per hectare than in the year 2015. This is in agreement with the findings of Tunde-Akintunde et al.(2012) who stated that though sesame is a drought tolerant plant, it performs better under relatively high temperature and moderate rainfall. This may be responsible for the higher yield of the crop in 2016. In addition, changes in other biotic and edaphic factors of the environment may also be implicated (Ogbonna, Umar-Shaba, 2012). There was a variation in the growth and yield attributes of the crop, yet the same variety and cultural practices were carried out during the period of cultivation. Haruna et al. (2011) suggested that this could be attributed to weather variability. More so, residual effects of 2015 and increased precipitation in 2016 might have played a significant role in the increase of the yields in 2016.

The result of this study revealed that physiological growth indices such as net assimilation rate, relative growth rate, and crop growth rate were significantly increased by poultry manure at early stages of growth but declined significantly, beyond which there was no discernible increase. This is due to the translocation of assimilates to developing sinks (flowers, capsules, and seeds) at this stage. Similar results had earlier been reported by Mondal (2007) in mungbean (*Vigna radiata*). Moreover, these growth indices such as NAR, RGR, and CGR resulted in increased yield experienced in the two years of study. This is in consonance with the findings of Yingzhong, Yishou (2002), Kumar, Vivekanandan (2009), and Sanipan et al. (2010) who reported a relationship between growth characters and yield of sesame. Each increase in the rate of poultry manure consistently increased CGR significantly; also the significant response of NAR and RGR to poultry manure application could be attributed to the fact that it contains essential nutrients needed for plant growth and development (Ogbonna, Umar-Shaba, 2012); they further confirmed that organic manure improves the soil physical properties, thus enhancing crop growth and yield. However, the variation in this growth and yield characters could be attributed to the environmental change in weather condition during the period of study. The effect of conventional tillage on the number of capsules, yield per plant, and yield per ha was significantly higher than the other tillage methods. This is in line with the findings of Uzun et al. (2012) who suggested that conventional tillage methods produced higher yields of sesame than minimum tillage. The seed yield, days to 50% flowering, plant height, number of capsules per plant, and number of seeds per capsule were also positively affected by the conventional tillage method. The traditional and minimum tillage must have experienced increased leaching of nutrients, the loss of soil water through increased evaporation, and the loss of organic matter through increased biological activity and oxidative processes (Agboola et al., 1998). The increase in growth and yield parameters of sesame in conventional tillage can be adduced to nutrients and soil moisture near the root zone of the crop. This was supported by Dinnes et al. (2002) and Shahzad et al.(2014) that conventional tillage practices enhanced sesame production.The application of 15 tha^{-1} of poultry manure produced significantly higher number of capsules, yield per plant, and yield per ha compared with the other levels of applied manure. Increasing the rate of manure from 5 to 10 and 15 tha^{-1} significantly increased these attributes in the two cropping seasons. This is in contrary to Haruna et al. (2011) who suggested that 5 tha^{-1} of poultry manure produced the highest yield of sesame and that increasing the rate reduced the yield because excessive manure and nitrogen application has been reported to reduce the number of capsules per plant and yield per hectare but enhanced plant growth. This contradicts Mondal et al.(1992) who reported that the application of 10 $tha^{-1}$of poultry manure significantly increased the seed yield of sesame compared to other levels of application. Conventional tillage method produced the highest number of capsules, yield per plant, and yield per hectare. This tillage system must have destroyed hardpans or compacted layers that might hamper root development. This also allowed degradation of organic matter through stimulation of microbiological activities which resulted in making available the essential plant nutrients while also improving the soil water holding capacity as supported by Sharma, Behera (2008) and Aikins et al. (2012).

The cost and returns analysis of the use of tillage methods and different levels of poultry manure further affirms the farmers' position of not using any form of fertilizer for sesame cultivation. This is attributable to high cost of land preparation and other inputs. The increase in the revenue in the second season can be adduced to an increase in the price of the commodity. In 2015, the cost of sesame seeds was ₦195 000.00 but increased to ₦300 000.00 per tonne in 2016.The cost of land preparation using manual labour in Nigeria is relatively exorbitant and that explains why the conventional tillage gave the highest return per investment in the two years of the trial. In the same vein, the high cost of production significantly contributed to the final return on investment using different application levels of farmyard manure. However, the control plot gave the highest return per investment. This may be attributed to poor response of sesame to fertilizer and other inputs (Uzun, Cagirgan, 2006).

CONCLUSION

From the result of this study, it is apparent that the growth characters measured were the highest using the conventional tillage method at 15 tha^{-1} of poultry manure. Yield per ha was optimized using the conventional tillage method at 15$tha^{-1}$of poultry manure. Using the conventional tillage method and 15$tha^{-1}$of poultry manure therefore met the nutritional requirements and hence increased the yield of sesame. Although the tillage methods and poultry manure gave the highest yield, the control plot gave higher return per investment due to the high cost of tillage (land preparation) and transportation of poultry manure.

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