Effect of *Terminalia Catappa*Leaf-Mulch andTillage on the yield of Okra (*Abelmoschus esculentus* L.)in Ibadan, Nigeria.

[1]Ogunsesin, A;[2]Onokebhagbe, V.O.* and [1]Ishola, T. M.
[1]Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria.
[2]Soil Science Department, Faculty of Agriculture, Federal University Dutse, Dutse, Nigeria.
*Corresponding author: victor.onokebhagbe@gmail.com. Tel: +2348029880771.

ABSTRACT
Soil management practices such as mulching and tillageare important toolsto improve okra production in agriculture. Theeffects of Terminalia catappa Leaf-mulch (TL) onthe growth and yield of (Long 45-dwarf) okra, under the three commonly practiced tillage systems in Ibadan, was evaluated.Treatments comprised of three levels of Terminalia catappa Leaf-mulch (TL) at0, 5 and 10 t/ha and three tillage methods Flat (F), Manual Heaping (MH) and Manual Ridging (MR).The nine treatment combinations (F0, F/TL5, F/TL10, MH0, MH/TL5, MH/TL10, MR0, MR/TL5 and MR/TL10) were laid out in a randomized complete block design with three replications. Data were collected on Plant Height (PH), Number of Leaves (NL), and Stem Girth (SG); Fresh Leaf weight (FLW) Fresh Stem Weight (FSW) Fresh Root weight (FRW), Number of Pod (NP), Fresh Weight ofPod (FWP) of okra per plant.Data were analyzed using a descriptive Statistics and Anova at 8 0.05.The PH (51.0 and 47.4 cm) NL (7.4 and 7.3) andSG (1.5and 0.9 cm) produced under MR and MH respectively, were all significantly higher than F. ThePH, NL and SG of okra under Terminalia catappa Leaf-mulch (TL) also increased in the following order: TL5>TL10 >TL0 respectively. The FLW (7.0 g/plant), FSW (2.8g/plant), FRW (16.9 g/plant), NP (2.4g/plant) and FPW (32.5 g/plant) under MR were significantly higher than MH and F respectively. The FLW (5.6 g/plant), FSW(1.6g/plant), FRW (10.2g/plant), NP (2.3 g/plant) and FPW (26.7 g/plant) were significantly higher under TL5 than TL0 and TL10 respectively. Relative to F0; MH0, MR0, F/TL5, F/TL10, MH/TL5, MR/TL5, MH/TL10 and MR/TL10 significantly increased FPW by 82.0, 41.0, 10.0, 7.0, 116.0, 213.0, 115.0 and 166.0% respectively. The optimum FPW of okra (42.0 g/plant) produced under MR/TL5was higher than all other treatments combination of manual ridging. Terminalia catappa leaf-mulch applied at 5 t/ha is recommended for okra production in Ibadan.

Keywords:*Terminalia catappa,* Leaf-mulch, Tillage, Yield, Okra.

INTRODUCTION

The production of okra in Nigeria is constrained byunfavourable climatic conditions, low soil fertility, pests and diseases among other factors (Zoellic, 2009; Jegede, 2004).Okra (*Abelmoschus esculentus* L. Moench) is a vegetable of national importance, and this makes it a popularly grown tropical fruit vegetable. It is widely cultivated in the tropics for its green pod yield (Schippers, 2000). The immature fresh pod is cooked as vegetables while the mature dry pod is used as soup thickener (Yandev and Dhanker, 2002). The pods are important sources of vitamins and minerals (Lee *et al*; 1990). Above all, it generates income to the farmers, especially in the dry seasons.

Tillage activities and soil fertility play a significant role in crop production. Favourable crop production requires conducive soil conditions which are brought about by best tillage practices. Tillage involves mechanical working of the surface of the soil to bring about conditions favourable for raising crop plants (Kepner*et al.*, 1982). Tillage activities cut and shatter dense soils to desirable depths. It also improves the capacity of soil to receive rain or irrigation water or to increase percolation of excess water. Tillage helps to incorporate soil organic matter residues, green manure, fertilizers and amendments into the soil. It modifies the thermic capacity of the soil. For instance, activities of microorganism in the soil require adequate amount of moisture and temperature while the availability of soil nutrient for crop physiological developments could be retarded in a fertile soil if there is inadequate supply of moisture and temperature.

The suitability of soil for sustaining plant growth and biological activity is also a function of physical and chemical properties as influenced by the factors in the environment. Many of these factors depend on the quantity and quality of mulch on the soil surface. Mulching involves covering the soil surface with plant materials or crop residues such as straw and stubbles. Mulching is used mostly as a soil conservation process. It improves soil fertility (organic mulch), water percolation and reduces soil temperature variation. Researches are ongoing in the improvement of soil conservative management practices involving the use of Almond (*Terminalia catappa)* leaf- mulch and tillage activities to conserve soil moisture and reduce soil temperature thus enhancing soil properties and pod yield of okra (Agele *et al.,*2000; Awodun, 2007; Ewulo *et al.,*2011). Therefore this study was conducted to evaluate the effects of *Terminalia catappa* leaf-mulch on the growth and yield of okra, under the three commonly practiced tillage systems in Ibadan, Nigeria.

MATERIALS AND METHODS

Description of the study site

The experiment was located at the Teaching and Research Farm along Parry road, University of Ibadan. The university is located at latitude 7°24'N and longitude 3°54'E. Mean annual rainfall is ranges from 1250 to 1500 mm. The area belongs to the Derived Savannah Agro-ecological zone of Nigeria. The soil at the study site was an alfisol, locally classified under Egbeda soil series (Smyth and Montgomery, 1962).The main characteristics of the soil are given in Table 1.

Experimental Materials

Seed of the long 45-Dwarf variety were obtained from the National Institute of Horticultural Research and Training (NIHORT) Ibadan, Oyo state. It is a common early maturity variety

grown in Nigeria. *Terminalia Catappa* leaves used as mulching were collected at various locations in the University of Ibadan Campus.

Soil sampling and analysis

Soil samples were taken at 0-15 cm depth using soil auger in the experimental site. Composite soil samples collected were analysed in the laboratory of the Department of Agronomy, University of Ibadan. The pH of the soil in 1:1 soil water was determined by pH meter. Particle size analysis was done using hydrometer method (Bouyoucos, 1962). Soil organic carbon was determined by Walkey-Black oxidation method (Nelson andSommer1982). Total N, by Macrokjeldahl apparatus (Bremner and Mulvancy, 1982) while available P was determined by Bray P1 method and colour was developed in soil extracts using the ascorbic and acidic blue colour method (Murphy and Riley, 1962). Exchangeable cations were extracted with neutral 1M ammonium acetate solution. Na and K concentrations in the extract were determined by flame photometers, while Ca and Mg were determined using Atomic Absorption Spectrophotometer. The CEC was determined by the summation of exchangeable bases.

Plant analysis

Analysis of raw *Terminalia catappa* leaf wastes was carried out for N, P and K. Nitrogen was determined by Micro Kjeldahl method as described by IITA (1975). The mixture of concentrated nitric, perchloric and sulphuric acid in a ratio of 25: 4: 2 respectively was used to digest 0.5 g of each sample. Phosphorus concentration was determined by vanadomolybdate yellow colorimetric method (Jackson, 1962). Potassium in the digest was measured with flame photometry procedure.

Land preparation and Plot layout

The experimental land size of 20 x 12 m (240 m^2) was cleared manually using machete, while the plot lay out was done using measuring tape, pegs and measuring line. The heap and ridges were manually dug with giant African hoe. Plot size per treatment was 9 x 3 m separated from each other by 1m. Subplots measured 3x2 m.

Experimental Design and Planting

The experiment was 3 x 3 factorial combinations. The 9 treatment combinations were laid out in a Randomised Complete Block Design (RCBD) with 3 replications. The treatments were: Three Methods of Tillage: Flat, Ridge and Heap and Three levels of*Terminalia catappa* mulch: 0, 5 and 10 tha^{-1}.

Okra variety (Long 45-Dwarf) was sown. Two seeds were planted per hole at a spacing of 90 x 30 cm to give plant density of 37,037 plants/ha. Emerged seedlings were later thinned to one. *Terminalia catappa*leaf-mulch was applied to the soil 2 weeks afterplanting (WAP).

Cultural Practices
Crop protection measures were taken against insect pests by spraying with cypermethrin at 10mls per 4.5 litres of water. Weeding was done manually four times before harvesting.

Data Collection
Data was taken from five plants in the middle row. Morphological parameters such as plant height (cm), stem girth (cm), number of leaves of okra per plant were takenat 2 WAP and at 2 weeks intervalthroughout the duration of the research.Number of harvested pods, fresh weight of pods (g) fresh weight of leaves, stem and root (g) were determined using a weighing scale.

Statistical Analysis
Data obtained from the field wassubjected to one-way analysis of variance. Means with significant differences were separated using the Duncan's Multiple Range test at a probability level of 0.05.

RESULTS AND DISCUSSION
The physical and chemical properties of the soil as presented in Table I. The results revealed that the sandy-loam soil had pH of 6.0 which could be described as moderately acidic but within the range of 5.5-6.5 recommended for pepper (Whittaker *et al.*, 1959). However, the soil was not adequate with respect to N (1.2 g/kg), Organic C (1.3 g/kg), Available P (8 mg/kg), K (0.1 cmol/kg) Ca (0.3 cmol/kg) and Mg (0.1 cmol/kg) content of the soil as reported by (Enwenzor *et al*., 1989; Sobulo and Adepetu 1987; Adeoye and Agboola, 1985; Adeoye, 1986; Akinrinde and Obigbesan, 2000) for N (1.5 g/kg), Organic C (8.7 g/kg), Available P (10-16 mg/kg), K (0.2 cmol/kg) and Ca (2 cmol/kg) and Mg (1.5 cmol/kg) respectively. This was probably the reason why there were positive responses of okra to various soil amendments applied.

Table 1: The physico-chemical properties of the soil:

Soil Parameters	Values
pH in H_20 (1:1)	6
Total Nitrogen (g/kg)	1.2
Total Organic carbon (g /kg)	1.3
Available P (mg/kg)	8
Exchangeable bases (cmol/kg)	
Ca	0.3
Mg	0.1
K	0.1
Na	0.1
CEC (cmol/kg)	0.6
Particle size distribution (g/kg)	
Sand	878
Silt	720
Clay	480
Textural class (USDA)	Sandy loam

The raw analysis of the leaves as shown in Table 2, composed of 0.4 % N. 0.04 % P and 2.8 % K and these values were contrast to 2.0 % N, 0.14% P and 1.0 % K recorded for raw almond leaves by David (1996).

Table 2. Showing the raw analysis of *Terminalia catappa* leaves and quantity supplied in kg / ha of the mulch levels.

Plant nutrients	N	P	K
* TCL (%)	0.4	0.04	2.8
Quantity supplied by 5 t /ha (kg / ha)	20	2	140
Quantity supplied by 10 t /ha (kg / ha)	40	4	280

*TCL= *Terminalia catappa* leaves

However, the quantity of the nutrient that 5 and 10 t/ha of the leaves were able to supply was based on their N, P and K compositions as revealed by the analysis in the laboratory. Therefore, on application the 5 t/ha of the almond leaves supplied 20 kg N / ha, 2 kg P/ ha and 140 kg K / ha while the 10 t/ha also supplied 40 kg N / ha, 4 kg P/ ha and 280 kg K / ha respectively.Although the quantity of N and P supplied by 5 and 10 t / ha respectively, were not adequate for vegetable production compared to 50-100 kg N /ha, 20-60 kg P /ha, 20-40 kg K /ha recommended for vegetable production in Nigeria (Ehigiator *et al.,* 2015). The almond leaves were very high in K but extremely low in N and P content as shown in Table 2. Thus, explained the need to compliment with animal manure to boost the N and P. Otherwise more quantity of the leaves may be required to augment for N and P supply in the soil.

Effects of *Terminalia catappa* Leaf-mulch on plant height, number of leaves and stem girth

Tables3, 4 and 5show the effects of *Terminalia catappa* leaf-mulch on morphological traits of okra. Morphological parameters such as plant height, number of leaves and stem girth of okra was higher in the treated plot than untreated plot.

Table 3. Effects of *Terminalia catappa* Leaf-mulch on plant height (cm) of okra

Treatment TL (t/ha)	4WAP	6WAP	8WAP
0	18.6	36.6	40.1 b
5	19.6	39.9	46.7 a
10	19.2	38.7	45.7 a
	NS	NS	

**TL- Terminalia catappa Leaf-mulch*
Means followed by the same letter are not significantly different at P < 0.05.

Table 4. Effects of *Terminalia catappa* Leaf-mulch on number of leaves of okra.

Treatment TL(t/ha)	4 WAP	6WAP	8WAP
0	5.4	6.7a	7.2b
5	5.2	6.7a	8.8a
10	5.0	6.3b	7.9ab
	NS		

**TL- Terminalia catappa Leaf-mulch*
Means followed by the same letter are not significantly different at P < 0.05.

Table 5. Effects of *Terminalia catappa* Leaf-mulch on stem girth (cm) of okra.

Treatment TL (t/ha)	4WAP	6WAP	8WAP
0	0.1	0.7	0.7
5	0.1	0.7	0.9
10	0.1	0.7	0.8
	NS	NS	NS

**TL- Terminalia catappa Leaf-mulch*

NS: Terminalia catappa Leaf-mulch treatments on stem girth not significantly different at P < 0.05.

At 8 WAP, the effectsof the applied*Terminalia catappa* leaf-mulchsignificantly (P< 0.05) increased plant height of okraas shown in table 3 in the following order: TL0 (40.1 cm) > TL10 (45.7 cm) > TL 5 (46.7 cm). Similarly, number of leaves of okra was significantly (P< 0.05) increased in the following order: TL0 (7.2)> TL10 (7.9)> TL 5 (8.8) as presented in Table 4. The general better performance of the mulched plants in terms of height and number of leaves, with

increase in mulch quantity over plants with no mulch could be related to the increase of moisture and nutrient content which tends to stimulate plant growth. This is in accordance with Bhardwaj *et al*., (2011), who reported similar results that mulched plants grow more matured uniformly than unmulched plants.

While stem girth of okra increased in the following order: TL0 (0.7 cm) > TL10 (0.8 cm) > TL 5 (0.9 cm) as shown in table 5. However, there were no significant differences ($P < 0.05$) with respect to stem girth of okra among the levels of *Terminalia catappa* leaf-mulch.

Effects of *Terminalia catappa* Leaf-mulch on yield component of okra

Dry matter yields (leaves, stems and roots), okra pod counts and yields weresignificantly higher in mulch treated plot than the controlas presented in table 6 and 7. Relative to the TL0 (18.5 g/plant); TL10 (26.3 g/plant) and TL5 (26.7 g/plant) significantly enhanced okra fresh pod weight (FPW) by 42.2 and 44.3 % respectively (Table 4 and 7).

Table 6. Effects of *Terminalia catappa* Leaf-mulch on yield (g/plants) components of okra.

*Treatment: TL (t/ha)	Leaf (g/plants)	Stem (g/plants)	Root (g/plants)
0	2.2c	1.1b	4.2c
5	5.6a	1.6a	10.2a
10	5.2b	1.4c	8.2b

**TL- Terminalia catappa Leaf-mulch*
Means followed by the same letter are not significantly different at $P < 0.05$.

Table 7. Effects of *Terminalia catappa* Leaf-mulch on pod yield of okra.

*Treatment: TL (t/ha)	Number of pods	Fresh pod weight (g / plant)	% change weight
0	1.8b	18.5b	0
5	2.3a	26.7a	44.3
10	2.0ab	26.3ab	42.2

L- *Terminalia catappa* Leaf-mulch
Means followed by the same letter are not significantly different at $P < 0.05$.

Positive responses of okra on application of *Terminalia catappa* leaf-mulch could be attributed to its capacity to lower soil temperature, increased soil moisture content and organic matter content of the soil (Lal, 1987; Tian *et al.,* 1992). Hassan *et al*., (1994) reported similar findings that the use of organic mulch gave higher yield of bell pepper than control. Similar findings were

also made by Dixit and Majumdar (1995), who reported an increase inyield of 27.9% and 18.18% starch content of potato with paddy straw mulch over unmulched.

Effects of tillage on morphological traits of okra

Table 8 shows the effect of tillage on morphological traits of okra. Morphological traits such as plant height, number of leaves and stem girth of okra was significantly higher under MR and MH than the Flat tillage.At 8 WAP, MR increased plant height (51.0 cm) of okra over MH (47.4 cm) and F (31.8 cm) by 7.0 and 37.6 % respectively. Similarly, number of leaves (7.4) and stem girt h (1.5 cm) of okra recorded under MR was higher than MH (7.3) and (0.9 cm) and F (6.0) and (0.6 cm) by (1.4 and 18.9 %) and (40 and 60 %) respectively.

Table 8: Effects of tillage on morphological traits of okra

*Tillage system	4 WAP	6 WAP	8 WAP
		Plant height / plant (cm)	
F	13.5b	27.1c	31.8c
MH	22.1a	41.5b	47.4b
MR	23.7a	45.4a	51.0a
		Number of leaves / plant	
F	4.3b	5.9b	6.0b
MH	5.7a	7.1a	7.3a
MR	5.8a	7.3a	7.4a
		Stem girth / plant (cm)	
F	0.1b	0.5b	0.6b
MH	0.2a	0.8a	0.9a
MR	0.2a	0.9a	1.5a

**F= Flat; MH= Manual Heaping; MR= Manual Ridging; TL = Terminalia catappa leaf-mulch*
Means followed by the same letter are not significantly different at P < 0.05.

This result maybe that MR and MH was able to lower soil bulk density over flat tillage and resulted to increase in soil moisture content and nutrient use efficiency of okra plant (Osuji, 1984 and Lal, 1986). The result is also in contrast with results obtained by Ojeniyi and Adekayode (1999), who carried out similar experiment in humid South West of Nigeria to show thatzero tillage produced the best yield of maize and cowpea.

Effects of tillage on fresh component and pod yield of okra

Tables 9, shows the influence of tillage on fresh components of okra. The results revealed that Fresh Leaf Weight (FLW = 7.0 g/plant), Fresh Stem Weight (FSW=2.8 g / plant) and Fresh Root Weight (FRW= 16.9 g / plant) of okra recorded under MR were significantly higher than MH and F respectively.

Table 9. Effects of tillage on fresh component of okra (g / plant) at 12 WAP.

*Tillage system	Fresh Leaf (g/plant)	Fresh Stem (g/plant)	Fresh Root (g/plant)
F	2. 5c	1.0c	5.2c
MH	4.3b	1.7b	12.2b
MR	7.0a	2.8a	16.9a

**F= Flat; MH= Manual Heaping; MR= Manual Ridging; TL = Terminalia catappa leaf-mulch*

Means followed by the same letter are not significantly different by Duncan's Multiple Range Test at P < 0.05.

The results on table 10 shows the effect of tillage on pod counts and yield of okra.The okra pod counts and yield under MR (2.4 and 32.5 g/plant) and MH (2.3 and 26.5 g /plant) respectively, were significantly higher than the pod yield under Flat (F). Jackson *et al.*, (2004) reported similar results with the use of broccoli and lettuce which produced the highest weight under similar tillage and mulching conditions. They also reported that fresh weight of the vegetables cultivated were low with minimum tillage.

Table 10: Effects of tillage on pod yield.

*Tillage system	No of pod/plant	Fresh pod weight (g)/plant	% change in weight
F	1.8b	12.4c	0
MH	2.3a	26.5b	113
MR	2.4a	32.5a	162

**F= Flat; MH= Manual Heaping; MR= Manual Ridging; TL = Terminalia catappa leaf-mulch*

Means followed by the same letter are not significantly different by Duncan's Multiple Range Test at P < 0.05.

Effects of *Terminalia catappa* (TL) leaf-mulch and tillage on yield of okra

Table 11 shows the number and fresh weight of pods under the various combined tillage mulchsystems. The table indicates that mulch (5 and 10 t/ha) and tillage (MH and MR) increased the number and fresh weight of edible pods. This is in agreement with Ewulo *et al*., (2011) who earlier reported similar results that tillage and mulch combinations gave highest values of yield.The number of edible pods ranged from an average of 2.7 under the rates of 5 and 10 (t/ha) of mulch for manual ridging (MR) to 1 at 0(t/ha) mulch under flat tillage system.

Table 11. Effects of combination of *Terminalia catappa*(TL) leaf-mulch and tillage on yield of okra.

*Tillage system	TL level (t / ha)	No of edible pod	Fresh weight of pod (g / plant)	% increased in fresh weight of po
F	0	1	13.4	0
	5	2	14.4	7
	10	1.7	14.8	10
MH	0	2	24.4	82
	5	2.3	28.9	116
	10	2.3	28.8	115
MR	0	2	18.9	41
	5	2.7	42	213
	10	2.7	35.6	166

**F= Flat; MH= Manual Heaping; MR= Manual Ridging;*

NS= Combination of Terminalia catappa leaf-mulch and tillage treatments was not significant at P <0.05.

Fresh weight of pods ranged from 42 g/plant under the mulch rates of 5 t/ha and manual ridging to 13.4 g/plant with 0 mulch rate at flat tillage system. The optimum fresh weight of okra pods (42.0 g/plant) was produced under MR/TL5 compared to other treatments.The lowest number and weight of okra pods were obtained at 0 leaf mulch rate under flat tillage system. Similar results were observed by Albuquerque *et al*., (2001) who arrived at a conclusion that yield was reduced with zero tillage when compared with other tillage systems. Relative to F0; MH0, MR0, F/TL5, F/TL10, MH/TL5, MR/TL5, MH/TL10 and MR/TL10 increased fresh weight of pod by 82.0, 41.0, 10.0, 7.0, 116.0, 213.0, 115.0 and 166.0% respectively.

CONCLUSION

Application of *Terminalia Catappa* leaf- mulch at 5 t / ha produced the best performance compared to other mulch treatments while manual ridging recorded a significant okra green pod yield among the tillage treatments. Better yield results were obtained when tillage was combined with mulch than tillage and mulch alone. For good performance of okra, under a low input system, application of *Terminalia Catappa* leaf- mulch at 5t / ha on okra planted on a manual ridged soil is appropriate for sustainable okra production in Ibadan.

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