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Influence of pre-application handling techniques of *Tithonia diversifolia* Hemsl. A. Gray residues on sesame, in south-western Nigeria.

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1 SUMMARY

The nature of organic plant residues to be applied or the pre-application handling techniques adopted by farmers should be adequately considered since efficient utilization of nutrients in the organic residues by crop-plants is nature-at-application dependent. Comparative greenhouse studies were carried out between July and October, 2006, at the Ladoke Akintola University of Technology, Ogbomoso and the Institute of Agricultural Research and Training (I.A.R. & T), Ibadan, Nigeria, to assess the effects of pre-application handlings of Tithonia on growth and yield components of sesame. The treatments introduced were *Tithonia diversifolia* residues applied (at the recommended N-rate) as green, dried, composted and ash, urea, and the control. The trial was arranged in a completely randomized design, replicated three times. Green Tithonia-residues significantly ($p < 0.05$) improved Sesame growth and yield parameters compared to urea and other organic manures applied. Application of green Tithonia biomass resulted in significantly ($p < 0.05$) higher oil contents and increased number of capsules per plant by 361.1 % and 384.5 % at Ogbomoso and Ibadan respectively. The least oil contents were obtained from Tithonia ash application, which were not significantly different from the control at both locations. Thus, Tithonia biomass is a potential fertilizer material that could be best applied in green form. Moreso, burning of Tithonia plant residues or use of Tithonia ash should be discouraged for effective and efficient utilization of its nutrients.

2 INTRODUCTION

Sesame (*Sesamum indicum*) belongs to the family Pedaliaceae and the genus Sesamum. Sesame is one of the oldest cultivated oil-rich plants in the world (Langham and Wiermeers, 2006). It is a non-leguminous annual flowering green plant cultivated primarily for its small edible seeds rich in oil and protein of about 50 % and 25 % respectively (Weiss, 2000; Langham and Wiermeers, 2006). It is the only cultivated species in the genus Sesamum. The precise natural origin of sesame species is unknown but numerous wild relatives are occurring mostly in Africa. However, the greatest genetic diversity exists in the tropical Africa but was believed to have been introduced to India at a very early date, where a secondary center of diversity is well developed (Alegbejo *et al.,* 2003; Olaoye, 2007). It is an erect and self-pollinating plant usually with pubescent branching stem reaching a height ranging from 0.50 to 2.50 m, depending on varieties and favorability of soil nutrition / environmental conditions (Sharma, 2005; Leye, 2006). Sesame is usually propagated by seeds and matures 70-150 days after sowing (Indu and Savithri, 2003). Flowering starts 38-45 days after sowing and stops at 70-120 days after sowing (Langham and Wiermeers, 2006). It is relatively a drought-tolerant crop but can die in standing water (Weiss, 2000; Anonymous, 2007; Ray *et al.,* 2004). Cultivation of sesame is now widely extended beyond the tropical and subtropical zones to temperate and sub-temperate zones of the world (Ali *et al.,* 2000; Boureima *et al.,* 2007). In Nigeria today, sesame is widely cultivated in the derived, northern and southern guinea, Sudan and Sahel savannas (Alegbejo *et al.,* 2003). It is a versatile arable crop useful for human and livestock consumptions, industrial raw materials, health treatments and beautification (Jefferson, 2003; Sharma, 2005; El-Habbasa *et al.,* 2007).

Tithonia diversifolia commonly referred to as Mexican sunflower, is an aggressive weed shrub commonly grown in many parts of the world. In the South-western Nigeria, the weed had predominantly suppressed many common weeds including *Chomolaena odorata,* , grassy weeds including *Imperata cylindrica* and many crop-plants, in competition (Jama *et al.,* 2000; Nziguheba *et al.,* 2002; Olabode *et al.,* 2007; Chukwuka and Omotayo, 2008). The aggressive nature and high growth rate of Mexican sunflower had been reported to be attributed to its possible allelopathic effects on the neighboring weed seeds and the smothering effects on their seedlings (Baruah *et al.,* 1994; Boureima *et al.,* 2007). Green biomass from Tithonia is rich in nitrogen (N) and phosphorus (P) and the fertilizer values are better than those from Calliandra and other weeds (Mango, 1999; Olabode *et al.,* 2007). Mexican sunflower possesses both fertilizer attributes as well as phytotoxic growth inhibiting qualities (Baruah *et al.,,* 1994; Ayeni *et al.,* 1997). In organic crop production, soils are usually amended by plant and animal residues such as farmyard manure, green manure and compost, for improving crop productivity and soil physico-chemical properties (Cooperband, 2002). Organic manures generally improve soil Cation Exchange Capacity (CEC), ensure a slow release of its nutrients but maintain nutrients availability and soil fertility for a long period of time (Jama *et al.,* 2000; Bahman *et al.,* 2004; Babajide *et al.,* 2008). Compost improves the yield and performance of a crop and it is most appropriate in the maintenance of soil moisture and population of beneficial soil microbes for efficient crop production (Akanbi *et al.,* 2002; Akanbi *et al.,* 2005). Adequate and regular maintenance of soil organic matter is one of the most important conditions to be met, in order to stabilize agricultural systems in the humid and sub-humid tropics. This could be achieved by adopting suitable cultural practices and ensuring 'additional' regular supply of organic materials to the soils (Akanbi *et al.,* 2005; Chukwuka and Omotayo*,* 2009).

Nitrogen contributes up to 50 % of all the nutrients inputs. This makes nitrogen a great determinant of farmers' crop yield (Hansen *et al.,* 2000; Akanbi, 2002). Growth ceases and new cells fail to form, in the absence of nitrogen (Enwezor, *et al.,* 1989; Stout *et al.,* 2000; Tejada *et al.,* 2005). However, nitrogen is one of the most critical elements needed to be carefully managed under modern and sustainable crop production. This is very necessary because of its significant roles in crop production as well as the high level volatilization and leaching losses from farmlands, particularly in the tropics where rainfall is torrential and solar radiation is very high. Nitrogen is the most dynamic nutrient element and becomes the first limiting nutrient as land use intensifies (Tiessen *et al.,* 2003; Akanbi *et al.,* 2005). It is taken up in the highest amount by crops and its role in plants cannot be easily substituted. Its supply in the soil is the most important factor limiting growth and yield (Akanbi, *et al.,* 2002).

3 MATERIALS AND METHODS

3.1 Locations, sites history and land clearing / preparation: Greenhouse experiments were carried out both at Ladoke Akintola University of Technology (LAUTECH), Ogbomoso (latitude

8^0 10' N and longitude 4^0 10' E) which falls under southern guinea savanna vegetation zone of Nigeria and the Institute of Agricultural Research and Training (I.A.R&T), Ibadan (latitude 7^0 30' N and longitude 3^0 45' E) which falls under derived guinea savanna vegetation zone of Nigeria. These two vegetation zones are located in the south-western Nigeria similarly characterized by bimodal rainfall distribution whereby the early rainy season starts in late March and ends in late July/early August, followed by a short dry spell in August and finally the late rainy season from August to November. The annual mean rainfall is between 1150 mm and 1250 mm. The soil samples used at Ibadan and Ogbomoso were Alfisols belonging to Egbeda and Olorunda soil series respectively (Smyth and Montgomery, 1962). The experimental sites had been under cultivation of either arable inter-planted or mixed crops (okra, maize, cassava, pepper, cowpea and yam), before the experiments were set up. Land clearing and preparation were carried out manually, following farmers' conventional practice, using hoe, cutlass, mattock and rakes.

3.2 Preliminary experiments on different pre-application handling techniques of Tithonia biomass: The above-ground biomasses / shoots of Tithonia plant containing only the stems, branches and leaves were obtained from the fallowing experimental plots at the Teaching and Research Farms, LAUTECH, Ogbomoso. The plants were monitored from emergence and were cut at eight weeks after emergence (i.e. before flowering). The methodology of application of the underlisted Tithonia biomasses (green Tithonia, dried Tithonia, Tithonia ash and composted Tithonia), was based on two principles: (i) dry weight basis and (ii) nutrient (N) concentration. Preliminary experiments were carried out to provide clues for applying these different Tithonia biomasses in relation to the four major ways of general handling of plant biomasses on farmers' plots in the tropics: (i) preplanting burying / plough-in of green Tithonia biomass (ii) preplanting burying / plough-in of dried Tithonia biomass (iii) preplanting burning followed by burying of Tithonia ash and (iv) compost making followed by preplanting incorporation of the Tithonia compost made into the soil. Therefore, in the preliminary experiments, 1kg samples from fresh green Tithonia biomass were separately weighed in forty places and air dried for 14 days to obtain the mean dry weight of all the forty samples. Random collection of samples from any twenty out of the forty air dried 1kg samples was carried out. A composite sample was made from these twenty samples for determination of the nutrient concentrations in the laboratory according to IITA, (1982). The remaining twenty air dried 1kg samples were then carefully burnt to determine the mean dry weight.

The nitrogen content obtained was 3.95 % N of the dry weight of the Tithonia biomass. The recommended rate of nitrogen required for optimum performance of Sesame was calculated based on this 3.95% N concentration for the dried Tithonia biomass. The value or quantity obtained was then multiplied by 4 to determine the equivalent nutrient concentration in the green Tithonia (since 0.25kg dried Tithonia = 1kg green Tithonia). The weight value obtained for green Tithonia was then multiplied by 0.08 to determine the equivalent nutrient concentration in the residual Tithonia ash after burning the same amount of Tithonia biomass. After composting, samples were collected from the matured dried compost for determination of its nutrient concentrations (IITA, 1982). The percentage nitrogen concentration in the composted Tithonia was then used directly to determine the amount needed to meet up the recommended nitrogen rate required for Sesame production in the study areas.

3.3 Pre-application handling techniques of Tithonia-biomass

3.3.1 Preparation of dried Tithonia: Fresh Tithonia plants were cut and shredded (into smaller fragments of less than 5 cm in length with stem girths ranging from 2.8 cm to 4.2 cm). These materials were air-dried for 14 days to reduce the moisture content to less than 6%. These dried materials were used as dried Tithonia-biomass incorporated into the soil before sowing. The equivalent N-content of the dried Tithonia biomass (as obtained from the laboratory analysis) was used to determine the amount of Tithonia biomass needed to be applied to meet up the N-requirement of sesame.

3.3.2 Preparation of green Tithonia: Fresh Tithonia plants were cut and shredded (as indicated above). These were applied fresh to the soil and mixed thoroughly as green Tithonia-biomass at two weeks before sowing. Application of green Tithonia-biomass to meet the recommended plant requirement was done based on the equivalent N-content obtained from laboratory analysis of the dried Tithonia biomass.

3.3.3 Preparation of Tithonia-ash: Fresh green Tithonia plants were cut and shredded (as above). These materials were air-dried for 14 days. Burning of the Tithonia biomass was done using galvanized combustion cylinder of 1.5 m height and 100.0 cm circumference. Occasional turnings were done to ensure even burning. These burnt materials were included as a treatment in order to serve as good representative of the likely response expected from Sesame when grown on a seasonally-burnt Tithonia farmland compared to either ploughed-in green Tithonia or ploughed-in dried Tithonia or composted Tithonia biomass. Application of Tithonia-ash to meet the recommended plant requirement was done based on the equivalent N-content obtained from laboratory analysis of the dried Tithonia biomass.

3.3.4 Preparation of Tithonia-compost: The compost used was prepared mainly from Tithonia biomass and cured poultry manure. Fresh Tithonia plants available at the fallowing experimental plot were cut at eight weeks after emergence and shredded (into smaller fragments of less than 5 cm in length with stem girths ranging from 2.8 cm to 4.2 cm). These materials were air-dried for 14 days to reduce the moisture content to about 6%.The poultry manure was obtained from the poultry section of the livestock production unit at the Teaching and Research Farms, LAUTECH, Ogbomoso. Stone, metals and other foreign / non-biodegradable materials were carefully removed from the manure before air drying for ten days. Samples were randomly collected from both the Tithonia plant materials and cured manure for laboratory chemical analyses using standard methods (IITA, 1982). Compost was prepared according to Abad *et al* (1997) and Akanbi (2002).

3.4.1 Soil sampling and analyses: During land preparation at each site, pre-planting collection of soil samples was carried out using soil auger at a depth of 0-15 cm, for laboratory analyses of the soil physical and chemical properties. Samples were bulked into a composite sample. The sample was then air-dried, crushed and sieved through 2mm and 0.5mm meshes for the determination of particle size, pH (H_2O), total nitrogen (N), organic carbon, available phosphorus (P), iron (Fe), copper (Cu), zinc (Zn), the exchangeable cations (Ca, Na, Mg, and K) and exchangeable acidity (Akanbi, 2002).

3.4.2 Collection of soil samples and filling of pots : Soil samples used for the pot experiments were collected from the soil depths of between 0-15 cm at the designated experimental fields located at the Teaching and Research Farms, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso and the Institute of Agricultural Research and Training (I.A.R & T), Ibadan. Each pot was filled with 10 kg soil.

3.5 Experimental design and treatments: The treatments introduced were *Tithonia diversifolia* residues applied at recommended N-rate of 80 kg N ha^{-1} (Babajide *et al.,* 2010), as green, dried, composted and ash, urea, and the control. The trial was arranged in a completely randomized design, replicated three times.

3.6 Sowing, fertilizer application and maintenance of Sesame under green house conditions : Sesame seeds of variety E8 were surface sterilized by using 95% ethanol for 10 seconds and later rinsed six times with sterile water after shaking for three to five minutes in 3% hydrogen peroxide (H_2O_2). Five seeds were sown in each pot. Emerged seedlings were later thinned to one per pot, at one week after sowing (WAS). The sowing dates at Ogbomoso and Ibadan respectively were 6th and 10th March, 2006. All organic and inorganic fertilizers applied were at the recommended rate of 80 Kg N ha^{-1} (Babajide *et al.,* 2010). Urea fertilizer (46% N), was used as the only inorganic nitrogen (N) source (where applicable, two split applications of urea fertilizer were done at four weeks after sowing (4 WAS) and seven weeks after sowing (7 WAS). Application of manure or plant biomass was done by incorporating the materials into the soil two weeks before Sesame seeds sowing. Regular watering was maintained when necessary. Pots were manually weeded by careful hand pulling of all the emerging weed seedlings from the pots on weekly basis.

3.7 Data collection on Sesame: Data were collected on growth and yield parameters. The growth parameters determination commenced at 6 WAS. The growth and yield parameters were measured (Akanbi *et al.,* 2005; Fathy and Mohammed, 2009; Babajide *et al.,* 2010).

3.8 Harvesting, plant sampling and analyses of Sesame: Each of the experiments was terminated at 14 WAS, on October 30th and 31st, 2006 at Ogbomoso and Ibadan respectively. Plants were harvested by cutting the stem at the ground

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level and the roots were carefully uprooted, washed and air-dried. All the shoots and roots were then carefully packed into corresponding envelopes (65 cm by 30 cm) and oven-dried at a temperature of 80^0C to a constant weight for five days. Plant contents of P, K, Ca, Mg, Mn, Na, Zn and Cu were determined (IITA, 1982). From the digest, P concentration was determined by the vanadomolybdate yellow colorimetric method using spectrophotometer (Spectronic 20). The K and Ca were determined by using flame photometer (Cornin Model 400) while Mg, Fe, Zn and Cu were determined with atomic absorption spectrophotometer (AAS) of the Bulk Scientific Model (Akanbi *et al.,* 2005). Random selection of 1000 dried seeds of Sesame per treatment was done for determination of oil content using soxhlet apparatus and n-Hexane (60^0C) as an extraction solvent according to A.O.A.C. (1980).

3.9 Statistical analysis: Data analysis was done through analysis of variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) according to SAS, (2007).

4 RESULTS

4.1 Soil characteristics: The pre-cropping chemical and physical analyses of the soil samples used at the two experimental locations (Ibadan and Ogbomoso) were slightly acidic i. e. with pH 6.20 and 6.00 respectively (Table 1). Ibadan had higher Organic Carbon (4.56g kg^{-1}) than Ogbomoso (4.20 g kg^{-1}). Total N was lower at Ibadan than Ogbomoso but the available P was 28.3 % higher at Ibadan than Ogbomoso. Also, Fe, Cu, Zn, K & Mg concentrations were higher at Ibadan than Ogbomoso. Similar values were recorded for exchangeable Na at both locations while the exchangeable Ca and acidity were higher at Ogbomoso than Ibadan. The soil samples used at both locations were texturally sandy loam (Table 1).

Table 1: Pre-cropping chemical and physical properties of the soil samples used for the experiments at both Ibadan and Ogbomoso in the year 2006

Properties	Ibadan	Ogbomoso
pH (H_2O)	6.20	6.00
Organic Carbon (g kg^{-1})	4.56	4.20
Total N (g kg^{-1})	0.18	0.14
Available P (mg kg^{-1})	5.62	4.03
Fe (mg kg^{-1})	12.10	11.86
Cu (mg kg^{-1})	3.30	2.90
Zn (mg kg^{-1})	3.28	3.10
Exchangeable K (cmol kg^{-1})	0.26	0.22
Exchangeable Na (cmol kg^{-1})	0.24	0.24
Exchangeable Ca (cmol kg^{-1})	20.81	22.06
Exchangeable Mg (cmol kg^{-1})	3.02	2.82
Exchange. acidity (cmol kg^{-1})	0.28	0.34
Sand (%)	78.03	82.80
Silt (%)	10.01	7.00
Clay (%)	11.96	10.20
Textural class	Sandy loam	Sandy loam

4.2 Amounts and distribution of rainfall: The experiment was carried out between July and October, 2006 at Ibadan and Ogbomoso. The mean rainfall on monthly basis throughout the experimental periods ranged from 86.00 mm and 259.00 mm at Ogbomoso and between 100.70 mm and 302.15 mm at Ibadan (Table 2). Rainfall was higher (195.40 mm) at Ogbomoso than Ibadan (100.70 mm) in July but dropped in August to 86.00 mm while it increased to 116.65 at Ibadan. In September, it increased to 259.00 mm and 302.15 mm at Ogbomoso and Ibadan respectively.

Monthly mean rainfall dropped at both sites to 250.70 mm at Ogbomoso and 112.45 mm at Ibadan (Table 2).

Table 2: Amount and distribution of rainfall at the experimental locations in the year 2006.

	Amounts of Rainfall (mm)	
Months	**Ogbomoso**	**Ibadan**
January	0.60	21.05
February	1.00	1.90
March	79.40	45.05
April	97.50	63.05
May	192.40	120.90
June	129.70	134.40
July	195.40*	100.70*
August	86.00*	116.65*
September	259.00*	302.15*
October	250.70*	112.45*
November	0.10	20.65
December	0.00	0.00
Annual Total Rainfall	1291.80	1038.95

* = Months covering the growing periods of Sesame trials at Ogbomoso and Ibadan in 2006.
Sources: Nigerian Meteorological (NIMET) Station, Ilorin and International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

4.3 Chemical properties of the composted materials and matured compost: Lower values of Mg, Fe, Zn and Cu were obtained from the matured compost, compared to any of the materials used for compost making (Table 3). The pH value of the matured compost is higher than any of the Tithonia materials and poultry manure used for composting (Table 3). Also, the values of N (%), P (%), and K (%), Ca (g kg^{-1}) and organic C (g kg^{-1}) improved in the matured composted and were better than any of the materials used for composting. Lower values of Mg, Fe, Zn and Cu were obtained from the matured compost, compared to any of the materials used for compost making (Table 3).

Table 3: Chemical properties of the composted materials and matured compost

Properties	**Tb**	**Pm**	**Mc**
pH (H_20)	5.90	6.00	6.20
N (%)	3.95	3.20	4.00
P (%)	0.46	0.32	0.51
K (%)	2.16	1.10	2.19
Ca (g kg^{-1})	9.10	8.60	9.26
Mg (g kg^{-1})	3.52	4.00	4.60
Fe (mg kg^{-1})	12.20	14.20	12.80
Zn (mg kg^{-1})	138.40	155.00	146.50
Cu (mg kg^{-1})	31.60	30.61	31.00
Organic C (g kg^{-1})	36.50	33.60	38.40

Tb = Tithonia biomass, Pm = poultry manure, Mc = matured compost.

4.4 Growth parameters of Sesame under different handling techniques of Tithonia biomass : The values of plant height obtained from application of green Tithonia were not significantly ($p < 0.05$) different from those obtained from application of composted Tithonia biomass from 6 to 12 weeks after sowing (WAS) at Ogbomoso (Table 4). At Ibadan, plant height values obtained from the composted Tithonia application were not significantly ($p < 0.05$) different from those of the green Tithonia biomass from 6 to 8 WAS only but the values were significantly ($p < 0.05$) lower than those of green Tithonia biomass from 10 to 14 weeks after sowing (Table 4). The values were significantly ($p < 0.05$) higher than other treatments tested. The control and (or) the Tithonia ash produced significantly ($p < 0.05$) lowest values of plant height at the two locations (Table 4). Green Tithonia biomass supplied adequate nutrient for best leaf production of Sesame at different weeks after sowing at the two experimental locations (except for 12 WAS at Ogbomoso), as shown in Table 5. On application of green Tithonia biomass, leaf shedding between 12 and 14 WAS was significantly lower compared to the other treatments at the two locations (Table 5). Composted Tithonia biomass had similar numbers of leaves compared to those obtained from the green Tithonia at Ogbomoso, but the number of leaves produced on application of composted Tithonia biomass was significantly lower at Ibadan from 6 to 14 WAS (Table 5). Application of Tithonia ash had either similar or significantly lower values of number of leaves at different weeks after sowing, compared to the control. At the two experimental locations, application of green Tithonia biomass had significantly ($p < 0.05$) higher stem circumference at different ages, compared to the other forms of Tithonia biomass applied at both experimental locations (Table 6). The values of the stem circumference obtained from those under green Tithonia biomass were not significantly different from those under composted Tithonia biomass at 6, 8 and 12 WAS at Ogbomoso but significantly ($p < 0.05$) lower at Ibadan from 10 to 14 WAS. Application of Tithonia ash had stem circumference which were either not significantly ($p < 0.05$) different from or significantly ($p < 0.05$) lower than the control at the two experimental locations, at different weeks after sowing (Table 6).

Table 4: Plant height (cm) of Sesame as influenced by Tithonia handling techniques at different weeks after sowing (WAS) at Ogbomoso and Ibadan

	Ogbomoso					**Ibadan**				
Treatments	**6**	**8**	**10**	**12**	**14**	**6**	**8**	**10**	**12**	**14**
Control	22.8c	31.4d	36.7d	50.2d	55.7e	21.4c	26.5d	34.2e	47.8e	56.0e
Urea	40.7b	72.8b	93.7b	112.8b	124.5c	41.5b	75.5b	89.1c	110.6c	122.3c
Green	62.6a	86.1a	119.1a	136.4a	155.7a	59.4a	88.9a	120.9a	138.9a	148.1a
Dried	29.6c	53.3c	66.6c	91.2c	101.2d	39.4b	58.4c	70.4d	89.7d	99.7d
Composted	63.5a	81.3ab	108.9a	126.2a	137.8b	60.8a	85.2a	111.4b	128.4b	137.6b
Ash	12.3d	28.1d	31.5d	35.8e	40.7f	13.9c	18.9e	28.8f	35.2f	44.8f

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$, using DMRT.

Table 5: Effect of Tithonia handling techniques on number of leaves of Sesame at different weeks after sowing (WAS) at Ogbomoso and Ibadan

	Ogbomoso					**Ibadan**				
Treatments	**6**	**8**	**10**	**12**	**14**	**6**	**8**	**10**	**12**	**14**
Control	17.2c	22.7c	29.4c	37.0d	24.7d	17.4e	22.1e	29.3e	28.8e	19.7e
Urea	28.7b	36.3b	51.9b	63.7c	40.0c	9.8d	36.1d	44.1d	42.5d	30.6d
Green	38.1a	48.4a	78.1a	89.7b	92.0a	45.5a	51.6a	79.9a	84.1a	82.1a
Dried	29.3b	38.9b	52.6b	66.0c	52.9b	32.5c	39.1c	54.2c	56.8c	52.0c
Composted	41.9a	53.5a	75.0a	96.0a	90.0a	42.1b	48.7b	68.9b	72.8b	73.6b
Ash	16.5c	17.9c	23.5d	29.0e	19.1d	12.7f	18.6f	23.1f	24.0e	14.7e

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$, using DMRT.

4.5 Number of capsules, seed yield and oil content of Sesame under different handling techniques of Tithonia biomass: Significantly ($p < 0.05$) higher number of capsules per plant was produced by application of green Tithonia biomass (Table 7). Application of green Tithonia biomass increased number of capsules per plant by 361.1 % and 384.5 % at Ogbomoso and Ibadan respectively. The values obtained from the composted Tithonia were significantly lower than that of green Tithonia at both locations (Table 7). The control and Tithonia ash had 21.1 and 15.1 and 21.9 and 18.5 number of capsules per plant at Ogbomoso and Ibadan respectively, which were not significantly different. Application of green Tithonia biomass to Sesame resulted in significantly ($p < 0.05$) higher oil contents followed by composted Tithonia biomass at Ogbomoso and Ibadan respectively (Table 7). Tithonia ash application resulted in the least oil contents which were not significantly different from the control at Ogbomoso and Ibadan respectively (Table 7). Sesame under the application of green Tithonia biomass had significantly ($p < 0.05$) higher total seed yield of 2.64 tonsha^{-1} and 2.59 tonsha^{-1} at Ogbomoso and Ibadan respectively which significantly ($p < 0.05$) increased total seed yield by 418.6 % at Ogbomoso and 402.5 % at Ibadan, compared to the control (Fig. 1). Composted Tithonia had significantly ($p < 0.05$) lower (compared to green) total seed yield values of 2.23 kgha^{-1} and 2.20 kgha^{-1} at Ogbomoso and Ibadan respectively (Fig. 1).

Table 6: Effect of Tithonia handling techniques on stem circumference (cm) of Sesame at different WAS at Ogbomoso and Ibadan

	Ogbomoso					Ibadan				
Treatments	**6**	**8**	**10**	**12**	**14**	**6**	**8**	**10**	**12**	**14**
Control	0.2d	0.2d	0.5d	1.0d	2.0d	0.2d	0.2d	0.5e	1.0e	2.0e
Urea	0.5bc	0.7b	3.0b	4.7b	6.0b	0.5bc	0.7b	2.8c	3.8c	5.6c
Green	0.6ab	0.9a	4.1a	6.5a	7.7a	0.7a	1.0a	4.0a	6.3a	7.3a
Dried	0.5c	0.5c	1.6c	2.6c	4.7c	0.4c	0.5c	2.2d	3.2d	4.8d
Composted	0.6a	1.0a	3.1b	6.2a	6.4b	0.6ab	0.9a	3.3b	5.7b	6.6b
Ash	0.1d	0.2d	0.3d	0.4d	0.6e	0.3d	0.2d	0.4e	0.5f	0.8f

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$, using DMRT.

Table 7: Effect of different forms of Tithonia application on number of capsules and oil contents of Sesame at Ogbomoso and Ibadan

	Ogbomoso		Ibadan	
Treatments	**No of Capsules Plant^{-1}**	**Oil content (%)**	**No of Capsules Plant^{-1}**	**Oil content (%)**
Control	21.1e	43.80e	21.9e	43.53e
Urea	72.0c	46.30d	70.5c	46.03d
Green	97.3a	62.57a	106.1a	63.00a
Dried	61.8d	50.13c	62.0d	50.27c
Composted	88.5b	59.77b	87.4b	60.33b
Ash	15.1e	41.87e	18.5e	44.07e

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$, using DMRT.

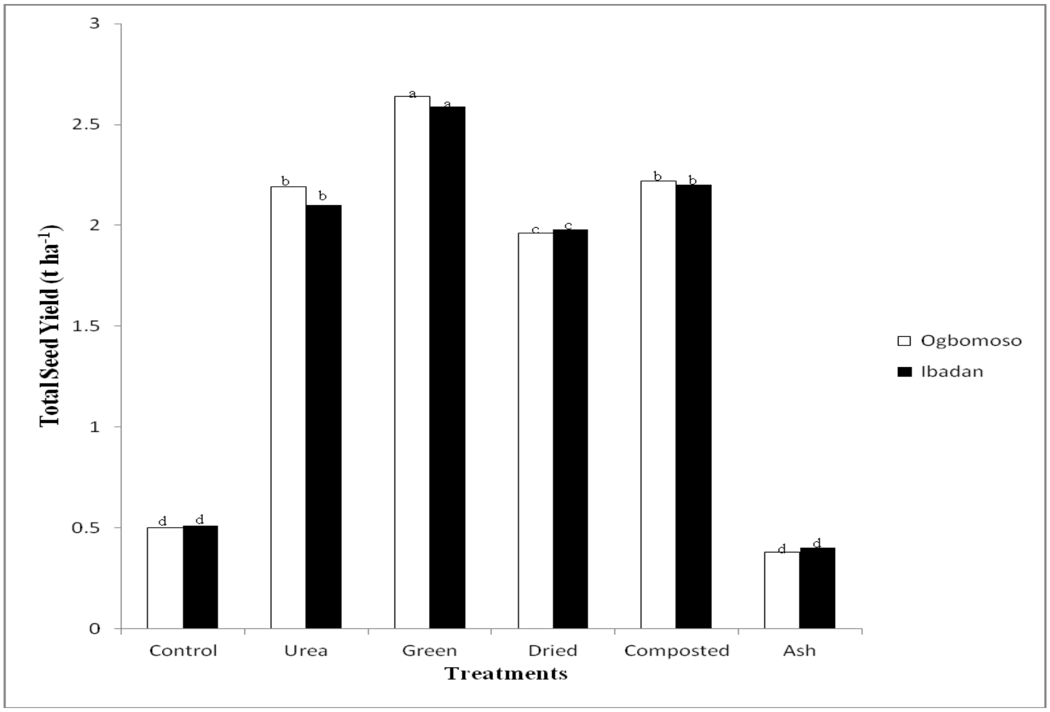

Fig. 1: Effect of different forms of Tithonia application on total seed yield of Sesame at Ogbomoso and Ibadan
Means followed by the same letters are not significantly different at $p \leq 0.05$, using DMRT.

5 DISCUSSION

The values of N (%), P (%), K (%) Ca (g kg^{-1}), Organic C (g kg^{-1}) obtained from the matured Tithonia compost used were higher than those from the materials used for composting. This is a reflection of significance of composting crop residues which creates a better improvement in the nutritional compositions of the compost over the materials used for compost making. These results supported the findings of Ghosh *et al.,* 2004; Chukwuka and Omotayo, (2008); (2009) and Akanbi, (2002) who reported variation in the percentages of nutrient concentrations of organic manure depending on the sources, handling techniques and management strategies. However, the lower values of Mg, Fe, Zn and Cu observed in the matured compost compared to those of the materials used for compost making could be attributed to one or more of the factors that could induce variation in the percentages of nutrient concentrations of organic manure as indicated above. The significant effects of application of different forms of Tithonia biomass at the recommended rate of 80 kg Nha^{-1} on Sesame growth and yield parameters followed this order; green Tithonia > composted Tithonia > dried Tithonia > Tithonia ash and (or) the control. Green Tithonia biomass significantly improved all the growth and yield parameters at the two locations, compared to other forms of Tithonia biomass tested and the control. Application of green Tithonia biomass significantly ($p < 0.05$) reduced leaf shedding in Sesame plants from 12 to 14 WAS compared to other forms of Tithonia biomass counterparts tested and the control. This may be simply attributed to the possibility of abundance of nitrogen available in green manure which flows slowly and continuously over a longer period of time. This continuous flow may therefore benefit improved and prolonged leaf production in Sesame as observed at both experimental locations. These results agreed with the reports from earlier researchers (Chukwuka *et al.*, 2008; Nziguheba *et al.,* 2002; Akanbi, 2002), who reported that organic manures are reservoirs of nutrients which are slowly released into the soil system over a long period of time. Application of other Tithonia biomass tested (except the Tithonia ash) produced significantly higher values of growth and yield parameters compared to the control. This re-emphasizes the importance of organic manure to crop production as earlier reported (Sonke, 1997). The significantly lower values of the growth and yield parameters were not observed only in the control (which received no application of any of the different forms of Tithonia biomass tested) but also to those Sesame plants which received application of Tithonia ash. Although, the nutrient concentrations (particularly N) in the Tithonia ash is believed to be very low as a result of volatilization via burning of the Tithonia biomass, but the reduction of plant growth and yield parameters below the values obtained from that of the control is a major aspect of the concerns observed from these research findings which forms a basis for further scientific studies. However, in relation to the growth and yield parameters obtained, such significantly lower values from Tithonia biomass application, than the control may be due to the fact that, burning of Tithonia biomass induced formation of some chemical compounds which made the biomass to exhibit antagonistic effects over regular flow of available soil nutrients and (or) inhibitory effect over the release of inherent nutrient in the Tithonia ash applied. Moreso, Baruah *et al* (1994) and Adoyo *et al* (1997) had earlier reported pesticidal and allelopathic properties as well as the release of other harmful inhibitory chemicals by *Tithonia diversifolia*. Burning of Tithonia biomass and application of Tithonia ash as a fertilizer material should be totally discouraged, for maximum utilization of its nutrients

6 CONCLUSION

Improved sesame growth and yield parameters observed under different forms of Tithonia application (except for the Tithonia ash) has re-established the fact that Tithonia is a potential fertilizer material and soil amendment, which could be used by farmers for economic management of their crops within the limited land resources. However, it is recommended that the biomass should be applied as green manure, in order to ensure best supply of adequate nutrients required for improved Sesame production. Moreso, amongst other handling techniques, burning of Tithonia biomass or application of Tithonia ash should be totally discouraged, so as to allow efficient utilization of its concentrated nutrients. Finally, further future research studies are required on Sesame in order to explain more clearly the reasons why the values of growth and yield parameters obtained from those plants which received Tithonia ash biomass were significantly lower (even than the control), at the two locations.

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