Legume Mulch Materials and Poultry Manure Affect Soil Properties, and Growth and Fruit Yield of Tomato

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Summary

Present emphasis on sustainable agriculture requires successful soil resources management geared towards quality soil environment and crop production. Mulching and application of poultry manure (PM) are easy ways to enhance natural soil-nutrient build-up and soil quality protection. Field experiments were carried out to determine effects of mulching and poultry manure on soil properties, growth and yield of tomato (*Solanum lycopersicum* L.). The legume mulch types derived from *Leucaena leucocephala*, *Gliricidia sepium*, and *Acacia auriculiformis*, rates of PM (0 or 10.0 t ha^{-1}) were tested over 2015 and 2016. Legume mulch materials, with or without addition of PM, reduced bulk density and soil temperature and increased porosity, moisture content and soil chemical properties compared with the initial soil status before application of treatments. In both years, with or without addition of PM to mulch, *Acacia* improved soil physical properties and increased soil organic matter (SOM) compared with *Leucaena* and *Gliricidia* mulches that increased N, P, K, Ca and Mg compared with *Acacia* mulch without PM. In 2015, without addition of PM, *Gliricidia* increased tomato growth and yield compared with *Leucaena* and *Acacia*. *Acacia* with addition of PM had the highest value of growth and yield. In 2016, with or without addition of PM, *Acacia* increased growth and yield compared with *Leucaena* and *Gliricidia*. In 2015, addition of PM to *Leucaena*, *Gliricidia* and *Acacia* mulches increased tomato fruit yield by 40.0, 9.2 and 84.9%, respectively. Also in 2016, addition of PM with *Leucaena*, *Gliricidia* and *Acacia* mulches, increased fruit yield of tomato by 43.0, 45.0 and 52.8%, respectively. *Leucaena* and *Gliricidia* mulches enhanced tomato growth and yield through direct nutritional contributions, whereas *Acacia* mulch did so through mulching effects on soil microclimate. *Acacia*+PM produced significantly higher yield, therefore adequate application of PM to mulches should be encouraged, especially where farmers use *Acacia* legume materials as mulch to maximize their contribution to soil and crop productivity.

Key words

Solanum lycopersicum, *Acacia*, *Gliricidia*, *Leucaena*, C:N ratio, lignin

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Introduction

Tomato (*Solanum lycopersicum* L.) is a source of vitamin C (Ilodibia and Chukwuma, 2015). Tomato seed contain 8.5% moisture, 25% crude protein, 20.0% fat, 3.1% ash, 35.1% total dietary fiber, 0.12% Ca, 0.58% P, and, 204 kcal/kg of total metabolizable energy (Persia et al., 2003). The content of the seed is as important as the part of the fruit, because both the seeds and fruits are consumed together. Consumption of tomatoes has been associated with prevention of cardiovascular diseases, cancers and several other diseases mainly due to the antioxidants ascorbic acids, carotenes, lycopene and phenolic compounds (Periago et al., 2009; Weisburger, 1999; Willcox et al., 2003).

Declining tomato yield has been a major concern among farmers in the tropics. In Nigeria, tomato average yield is 10 t ha^{-1} (Dantata et al., 2011), which is lower than the world average of 22 t ha^{-1} (Ojeniyi et al., 2007). Factors contributing to low tomato yield is low soil fertility brought about by continuous cultivation without soil fertility enhancement.

Good soil management is necessary for food production since it affects soil life processes (Obi, 2006). Losing the top soil layer causes loss of soil fertility and hampers production. Alfisol soils of southwest Nigeria have a weak structure, and are highly susceptible to crusting, compaction and accelerated erosion (Lal, 1987). The majority of Alfisols available for crop production in the tropics is weathered and inherently of low organic matter and nutrient status (Nottidge et al., 2005; Opara-Nadi and Lal, 1987). The need for sustainable agriculture requires successful soil resources management geared toward a quality soil environment and good crop production. Mulching and application of poultry manure (PM) are ways to enhance natural soil-nutrient build-up and soil quality protection (Adekiya and Agbede, 2009; Bajorienė et al., 2013). It is recommended that in sustainable farming soil should be covered with composts, chopped straw, and other organic residues to provide crops with nutrients, especially nitrogen (Relf, 2009). Natural organic mulch eventually breaks down and becomes part of the soil and a source of plant nutrients (Bond and Grundy, 2001; Gruber et al., 2008; Sharma et al., 1998).

Legumes are beneficial in programs to maintain soil fertility (Swarup, 1997). They could be either annual or perennial, but due to the seasonal availability of annual legume, perennial legumes are preferred (Akintan et al., 2016). The perennial leguminous plants like *Leucaena leucocephala* (Lam) de Wit, *Gliricidia sepium* (Jacq.) Kunth ex Walp and *Acacia auriculiformis* (A. Cunn. ex Benth.) have been used as mulching material (Palm and Shanchez, 1991).

Poultry manure is used for soil fertility maintenance, growth and yield of tomato (Adekiya and Agbede, 2009; Akanni and Ojeniyi, 2007; Ewulo et al., 2008). The PM contains large amounts of N, P and K and secondary and trace elements, has a low C:N ratio, and serves as a soil amendment by adding organic matter, thereby improving soil structure, porosity (bulk density) and water holding capacity (Adekiya et al., 2016; Dunlop et al., 2015)

Legume residues are generally known to improve crop productivity by enhancing availability of soil N (Azam, 1993). Depending on the nature of the materials, plant materials of low C:N ratio, lignin and polyphenol decompose rapidly and are readily available sources of nutrients for crops. Poor-quality residue (high C:N ratio, lignin and polyphenol) improve crop performance through positive effect on the soil microclimate when applied as mulch (Palm and Sanchez, 1991; Tian et al., 1992; Tian et al., 1993). Decomposing residues of mulch with high C:N ratio, lignin and polyphenol promote N immobilization and make N unavailable in soil to crops. Therefore, adequate N addition to the soil is necessary if farmers must apply this residue with high C:N ratio, lignin and polyphenol as mulch. With application of slow nutrient releasing mulches (high C:N ratio, lignin and polyphenol) addition of poultry manure is required to maximize their contributions to soil and crop production. There is a need to evaluate benefits that result from managing inputs of slow and fast decomposing mulch materials with addition of PM in order to synchronize nutrient release in soil for crop need. The experiment was undertaken to determine combined effects of mulching and PM on soil properties, growth and yield of tomato.

Materials and methods

Field experiments were carried out in the 2015 and 2016 cropping seasons at Owo, Ondo State, Nigeria. Owo is located at 7°12′N and 5°35′E within the forest-savanna transition zone in southwest Nigeria. The soil type at Owo is an Alfisol classified as an Oxic Tropuldalf (USDA, 1999) or Luvisol (FAO, 1998) derived from quartzite, gneiss and schist (Agbede, 2006). The average rainfall varied from 1200-1300 mm in a bimodal pattern with the first rainy season from March to July and a dry spell in August followed by the second rainy season from September to November. The site was mechanically cleared from 2-year-old fallow after cropping maize (*Zea mays* L.). The experiment consisted of a factorial combination of the legume mulch types *Leucaena leucocephala* (Lam.) de Wit, *Gliricidia sepium* (Jacq.) Kunth ex Walp, and *Acacia auriculiformis* (A. Cunn. ex Benth.), the 0.0 and 10.0 t ha^{-1} rates of PM and was repeated in 2015 and 2016. The treatments were arranged in a randomized complete block design with four replications in an area of 307.5 m^2. Each block comprised of six plots, each of which measured 3 × 3 m^2. Blocks were 1 m apart, and plots were 0.5 m apart. The same site was used in the 2 years of the experiment.

The PM used for the experiment was collected from a local poultry farm at Owo. The PM was stacked under shed for one week to allow for mineralization. The soil was prepared by plowing and disking. The PM was weighed at the required rate (0.0 and 10.0 t ha^{-1}) and spread evenly on the appropriate plots using spades and rakes. The PM was allowed to decompose for three weeks prior transplanting of tomato seedlings.

Three-week-old tomato seedlings were transplanted on 15 May 2015 and 17 May 2016. One healthy tomato seedling was transplanted per hole at an inter-row spacing of 50 cm and a 50 cm intra-row spacing providing 36 plants per plot which is equivalent of 40.000 plants·ha^{-1}. One week after transplanting tomato seedlings, fresh green tender stems and leaves of *Leucaena, Gliricidia* and *Acacia* were harvested from nearby hedges. The green mulches were applied directly to the plots at the rate of 5 t·ha^{-1} to cover the soil only where the treatment was 0 t·ha^{-1} PM and cover the spread PM on the soil where the treatment was 10.0 t·ha^{-1} PM. Manual weeding, using hoes, was done three times beginning at two weeks after transplanting and repeated at a three week interval. Tomato plants were individually supported with 1 m stakes at five weeks after transplanting.

Before the start of the experiment, soil physical and chemical properties were determined. Soil samples were collected at intervals using steel coring tubes and were put in an oven set at 100°C for 24 h for determination of bulk density, porosity and gravimetric moisture content. Soil temperature was measured at 15:00 h with a soil thermometer inserted to a 0.10 m depth. The soil samples collected were also bulked, air-dried and sieved using a 2-mm sieve and analysed for particle size, soil organic matter, N, P, K, Ca, Mg and pH. Soil samples were also collected at harvest of tomato from 0–0.15 m depth in 2015 and 2016 on an individual plot basis and similarly analysed for chemical properties. Samples were analysed as described by Carter (1993).

Two weeks after mulch application, soil physical properties (bulk density, total porosity, moisture content and temperature) were determined as described above in all plots and was repeated at 4, 6, 8, 10 and 12 weeks after mulch application.

Just prior to application to plots, samples of the mulch materials and PM were analyzed. Leaf samples were collected randomly from each mulch materials, oven-dried for 24 h at 80°C and ground in a Willey mill. These samples and PM were analyzed for organic C, N, P, K, Ca and Mg as described by Tel and Hagarty (1984). Lignin content of the mulch material and PM was determined from acid-free detergent fiber using the method described by Williams et al. (1986). The total polyphenol in the extract was determined using the Folin Ciocalteu reagent (Makkar and Goodchild, 1996).

Growth and yield data obtained from ten plants per plot that were randomly selected. Plant height, number of leaves, and leaf area were determined at the mid-flowering stage in each year. Fruit yields were evaluated between 72 and 90 days after transplanting. Tomato fruit yield was evaluated based on the cumulative harvests per plot.

Data were subjected to analysis of variance (ANOVA) using the Genstat statistical package (GENSTAT, 2005) to determine effects of treatments on soil physical and chemical properties, growth and yield of tomato. If there was an appropriate significant interaction, it was used to explain results. If interactions were not significant means were separated using Duncan's multiple range test.

Results

The analysis of mulches and PM used indicated that among mulch materials, *Acacia* had significantly the highest C:N ratio, lignin, polyphenol, lignin/N and polyphenol/N values, whereas, *Gliricidia* had the lowest values of these parameters (Table 1). Compared with *Leucaena*, *Gliricidia* and *Acacia,* PM had the lowest values of N, C, C:N ratio, lignin, polyphenol, lignin/N and polyphenol/N, and the highest values of P, K and Mg. *Gliricidia* has the lowest value of polyphenol/N. The soil at the site of the experiment was sandy loam in texture, acidic, high in bulk density and low in organic matter (OM), N, P K Ca and Mg according to the value recommended for crop production (Akinrinde and Obigbesan, 2000) in ecological zones of Nigeria (Tables 2 & 3).

Table 1. Chemical composition of legume mulch materials and poultry manure

	N (%)	C (%)	C/N ratio	Lignin (%)	Polyphenol (%)	Lignin/N Ratio	Polyphenol/N ratio	P (%)	K (%)	Ca (%)	Mg (%)
Leucaena	4.4a[a]	42.3b	10.1c	22.6b	1.9b	5.3b	0.45b	0.21c	1.78c	1.79a	0.38b
Gliricidia	4.4a	48.2a	10.9bc	18.3c	1.5c	4.2c	0.34c	0.24b	2.18b	1.25c	0.39b
Acacia	3.5b	49.1a	14.0a	42.7a	2.7a	12.2a	0.77a	0.18d	1.28d	1.20d	0.34c
PM[b]	2.9c	14.9c	5.1d	6.1d	1.2d	2.1d	0.41b	0.83a	2.43a	1.42b	0.60a

[a] values in columns followed by the same letter are not significantly different, p = 0.05, Duncan's multiple range test; [b] PM = poultry manure.

Table 2. Initial soil physical properties and the interaction effect of year, poultry manure rate and legume mulch materials on soil physical properties

Year	Poultry manure (t ha^{-1})	Mulch material	Bulk density (Mg m^{-3})	Total porosity (%)	Soil temperature (°C)	Moisture content (%)	Initial soil physical property	Value
2015	0.0	*Leucaena*	1.40a[a]	47.2d	32.2a	9.8d	Sand (%)	69.1±5.3
		Gliricidia	1.42a	46.4d	32.8a	9.1d	Silt (%)	15.8±3.1
		Acacia	1.26c	52.5b	29.6c	13.6b	Clay (%)	15.1±3.4
	10.0	*Leucaena*	1.30b	50.9c	30.4b	10.9c	Textural class	Sandy loam
		Gliricidia	1.31b	50.6c	30.6b	10.4c	Bulk density (Mg m^{-3})	1.58±0.05
		Acacia	1.16d	56.2a	26.1d	15.1a	Porosity (%)	40.3±4.1
							Soil temperature (°C)	34.8±4.2
2016	0.0	*Leucaena*	1.39a	47.5c	32.1a	10.9d	Moisture content (%)	8.3±0.2
		Gliricidia	1.40a	47.2c	32.3a	10.2d		
		Acacia	1.20c	54.7b	27.4b	14.9b		
	10.0	*Leucaena*	1.21b	54.7b	26.4c	12.9c		
		Gliricidia	1.24b	53.2b	26.9c	12.6c		
		Acacia	1.06d	60.0a	24.1d	17.1a		
ANOVA response								
Year (Y)			*	*	*	*		
Poultry manure (PM)			*	*	*	*		
Mulch material (M)			*	*	*	*		
Y × PM			*	*	*	*		
Y × M			*	*	*	*		
PM × M			*	*	*	*		
Y × PM × M			*	*	*	*		

* = significant at p = 0.05 probability level. [a] values in columns followed by the same letter are not significantly different, p = 0.05, Duncan's multiple range test.

Table 3. Initial soil chemical properties and the interaction effect of year, poultry manure rate and legume mulch materials on soil chemical properties

Year	Poultry manure (t ha^{-1})	Mulch material	Organic matter (%)	N (%)	P (mg kg^{-1})	K (cmol kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})	Initial soil chemical property	Value
2015	0.0	*Leucaena*	2.61d[a]	0.26c	10.1c	0.23d	2.0c	0.42c	pH (water)	5.9±0.4
		Gliricidia	2.58d	0.28bb	10.9b	0.25c	2.4bb	0.44c	Organic matter (%)	2.41±0.04
		Acacia	3.06b	0.14d	9.4c	0.2e	1.8d	0.31d	Total N (%)	0.18±0.02
	10.0	*Leucaena*	2.72c	0.32a	12.6a	0.28a	2.7a	0.65a	Available P (mg kg^{-1})	9.1±0.3
		Gliricidia	2.75c	0.33a	12.9a	0.29a	2.7a	0.66a	Exchangeable K (cmol kg^{-1})	0.14±0.01
		Acacia	3.56a	0.30a	12.1a	0.27ab	2.6a	0.60b	Exchangeable Ca (cmol kg^{-1})	1.30±0.04
									Exchangeable Mg (cmol kg^{-1}	0.29±0.02
2016	0.0	*Leucaena*	2.84d	0.26d	11.0c	0.24d	2.2d	0.40d		
		Gliricidia	2.79d	0.29c	12.7b	0.27c	2.5c	0.46c		
		Acacia	3.34b	0.21e	10.1d	0.21e	2.0e	0.34e		
	10.0	*Leucaena*	2.91c	0.32ab	13.6a	0.33a	2.7ab	0.56a		
		Gliricidia	2.97c	0.34a	13.9a	0.34a	2.9a	0.56a		
		Acacia	3.79a	0.31ab	13.4a	0.31ab	2.8a	0.53ab		
ANOVA response										
Year (Y)			*	*	*	*	*	*		
Poultry manure (PM)			*	*	*	*	*	*		
Mulch material (M)			*	*	*	*	*	*		
Y × PM			*	*	*	*	*	*		
Y × M			*	*	*	*	*	*		
P M × M			*	*	*	*	*	*		
Y × PM × M			*	*	*	*	*	*		

* = significant at p = 0.05 probability level. [a] values in columns followed by the same letter are not significantly different, p = 0.05, Duncan's multiple range test,

Data on the main effect and possible interactions of legume mulch materials and PM on soil physical properties in 2015 and 2016 are presented in Table 2. In both years, application of legume mulch material and PM improved soil physical properties compared with the initial soil prior to the start of the experiment. In both years without addition of PM, *Acacia* reduced soil bulk density and temperature and increased porosity and moisture content compared with *Leucaena* and *Gliricidia*. Values for *Leucaena* and *Gliricidia* are not different. With addition of PM, *Acacia* improved soil physical properties better with values that are significantly different from those obtained without addition of PM. In all cases, in both years, with or without addition of PM, soil physical property values were similar for *Leucaena* and *Gliricidia*.

Each main effect and the possible interactions affected soil chemical properties. Application of mulch and poultry manure increased soil chemical properties compared with the initial soil prior to the start of the experiment (Table 3). In both years, and with or without addition of PM, *Acacia* increased Soil organic matter (SOM) compared with *Leucaena* and *Gliricidia*. In both years, *Leucaena* and *Gliricidia*, without PM, increased N, P, K, Ca and Mg compared with *Acacia* mulch. With addition of PM, there were no significant differences between *Leucaena*, *Gliricidia* and *Acacia* mulch materials for N, P, K, Ca and Mg.

Each main effect and the possible interactions affected growth and yield of tomato (Figures 1-4). In 2015, without addition of PM, increased tomato growth and yield occurred in the order: *Gliricidia*>*Leucaena*>*Acacia*. With addition of PM, *Acacia* had the highest value for growth and yield of tomato; there were no differences between *Leucaena* and *Gliricidia*. In 2016, without addition of PM, *Acacia* increased growth and yield parameters compared with *Leucaena* and *Gliricidia*, which were similar. With addition of PM in 2016, *Acacia* has the highest values of growth and yield of tomato. In 2015, addition of PM with *Leucaena*, *Gliricidia* and *Acacia* mulches increased fruit yield of tomato by 40.0, 9.2 and 84.9%, respectively. Also in 2016, addition of PM with *Leucaena*, *Gliricidia* and *Acacia* mulches, increased fruit yield of tomato by 43.0, 45.0 and 52.8%, respectively.

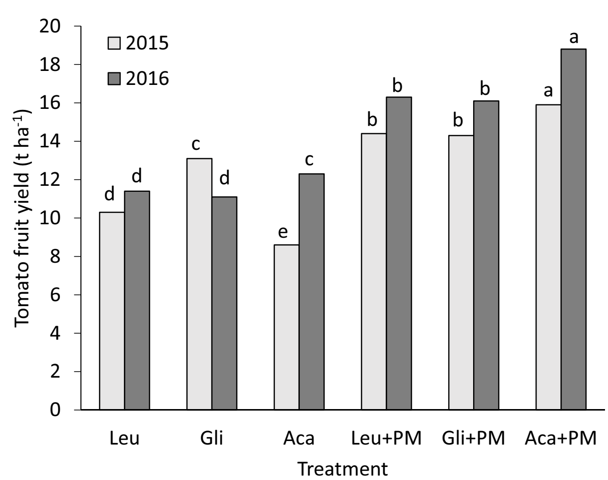

Figure 1. Interaction effect of year, poultry manure rate and legume mulch materials on fruit yield of tomato; Leu = *Leucaena*; Gli = *Gliricidia*; Aca = *Acacia*; PM = poultry manure. For each year, bars carrying different letter are significantly different at 5% level using Duncan's multiple range test

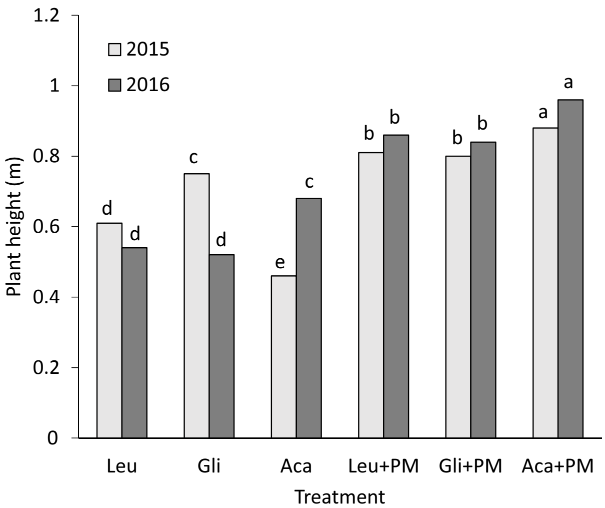

Figure 2. Interaction effect of year, poultry manure rate and legume mulch materials on plant height of tomato; Leu = *Leucaena*; Gli = *Gliricidia*; Aca = *Acacia*; PM = poultry manure. For each year, bars carrying different letter are significantly different at 5% level using Duncan's multiple range test

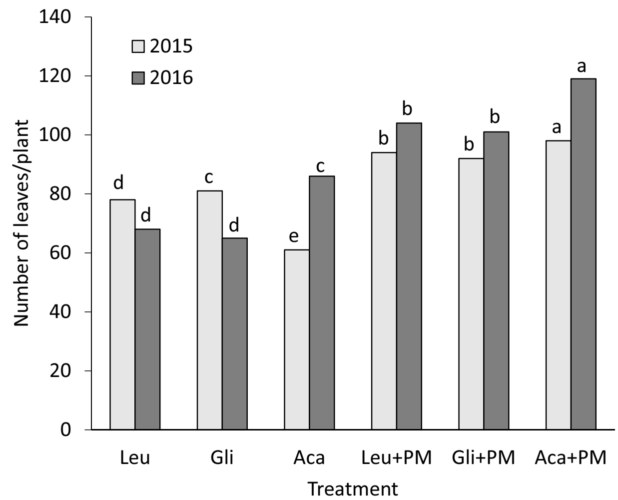

Figure 3. Interaction effect of year, poultry manure rate and legume mulch materials on number of leaves/plant of tomato; Leu = *Leucaena*; Gli = *Gliricidia*; Aca = *Acacia*; PM = poultry manure. For each year, bars carrying different letter are significantly different at 5% level using Duncan's multiple range test

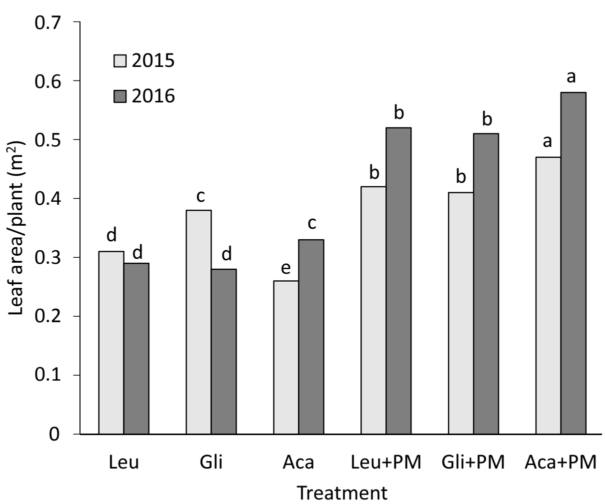

Figure 4. Interaction effect of year, poultry manure rate and legume mulch materials on leaf area/ plant of tomato; Leu = *Leucaena*; Gli = *Gliricidia*; Aca = *Acacia*; PM = poultry manure. For each year, bars carrying different letter are significantly different at 5% level using Duncan's multiple range test

Discussion

Application of legume mulch materials (*Leucaena*, *Gliricidia* and *Acacia*) and PM reduced soil bulk density and temperature, and increased porosity and moisture content compared with the initial soil prior to experimentation. Reduction in soil bulk density could be attributed to increase in SOM, which likely resulted from degraded organic residues by soil microorganisms. Poultry manure can also act as mulch (Akanni and Ojeniyi, 2007).

In both years, without addition of PM, *Acacia* reduced soil bulk density and temperature and increased porosity and moisture content compared with *Leucaena* and *Gliricidia*. The better soil physical properties attributed to *Acacia* could be related to its slower break down providing better soil moisture conservation and reduced soil temperature. *Acacia* mulch provides better insulation and protects soil from direct sunlight and prevents it from crusting by controlling evaporation. *Acacia* mulch is characterized with a high C:N ratio, lignin and polyphenol contents compared with *Leucaena* and *Gliricidia* mulch. These properties made *Acacia* a bit recalcitrant to decomposition and able to effect the soil microclimate compared with other legume mulch materials. Mulch with a high C:N ratio, lignin and polyphenol has positive effects on microclimate (Palm and Sanchez, 1991; Tian et al., 1992, 1993).

With addition of PM, *Acacia* better improved soil physical properties and it is likely due to lower density and temperature and increased porosity and moisture content from the mulch and PM as a result of OM. The interaction effects could be due to residual effects of PM and mulches on soil physical properties as a result of progressive deposition of SOM by the mulches and PM from 2015 to 2016. Tomar et al. (1992) found that mulch material comprised of leaves *Leucaena leucocephala*, *Eucalyptus* hybrid, *Shoeria robusta*, *Broussonatia paprifera* and *Pueraria hirsute* had residual effects on soil physical properties. Better water stable aggregate, porosity, void ratio and air filled porosity due to residual effect of PM had been reported (Isitekhale and Osemwota, 2010) because of the buildup of SOM in the PM.

Increased soil chemical properties, as a result of mulch and PM application, compared with the initial soil before the start of the experiment could be due to the treatments being rich in N, P, K, Ca and Mg and that these nutrients are released into the soil by decomposed mulches and PM. According to Kang et al. (1984) 15 tons of *Leucaena* yielded about, in $kg \cdot ha^{-1}$/year, of 160 N, 15 P, 150 K, 40 Ca and 15 Mg. Adeola and Ogunwale (1992) reported up to 100 kg ha^{-1} of N, 4 kg ha^{-1} of P and 55 kg ha^{-1} of K from a single pruning of *Gliricidia* in Ilesa, southwestern Nigeria. Poultry manure is an effective, natural source of, nutrients (Adekiya et al., 2016; Agbede and Ojeniyi, 2009; Ayeni et al., 2010).

Acacia, in 2015, did not increase soil N compared with initial soil before mulch application. This could be due to immobilization of N as a result of high C:N, lignin and polyphenol contents of the mulch. Polyphenols could bind to organic N (e.g., amino acids and protein) in leaves making the N unavailable, or bind to the soluble forms of organic N released from leaves, forming resistant complexes in soil (Palm and Sanchez, 1991). *Acacia* increased SOM compared with *Leucaena* and *Gliricidia* mulches. The increase in SOM of *Acacia* could be related to its high C:N, lignin, polyphenol contents. Mulches with high C:N, lignin, polyphenol contents generally would favor nutrient immobilization, organic matter accumulation and humus formation. Plant constituents, such as lignin and polyphenol, retard decomposition. In an experiment in southern Nigeria (Juo and Lal, 1977) where management effects of SOM accumulation was compared, a three year fallow with Guinea grass *(Panicum maximum*), which has a high lignin content, maintained a high carbon level compared to that under forest fallow.

In both years, *Leucaena* and *Gliricidia* mulches increased N, P, K, Ca and Mg compared with *Acacia*. *Leucaena* and *Gliricidia* mulches were low in C:N ratio, lignin, polyphenol, lignin/N, polyphenol/N and high in N, P, K, Ca and Mg compared with *Acacia*. Due to high quality of these mulch materials, they decompose quickly and release nutrients to the soil. Giashuddin et al. (1993) reported that N release from *Acacia* leaves reach 40% after 90 days and exceeded 60% after 160 days in the soil, whereas, *Gliricidia* released more than 90% of its leaf N by 90 days. Palm and Sanchez (1990) reported that the decomposition rate and N release patterns of legumes are related to amount of polyphenol compounds in the leaf. Leguminous plants have readily available source of N. This assumption may be incorrect if the plant material has a high polyphenolic content, or a polyphenolic/N ratio higher than 0.5 (Palm and Sanchez, 1991).

In 2015, the increase in the growth and yield of tomato under *Gliricidia* without PM addition could be related to low C:N ratio, lignin, polyphenol, lignin/N, polyphenol/N and relatively high P, K and Mg values. These attributes of *Gliricidia* will lead to fast mineralization and early release of nutrients to a short gestation crop like tomato compared with other mulch materials. The higher yield of tomato under *Gliricidia* mulch is consistent with the soil chemical properties of *Gliricidia* without PM in 2015. The mulch materials improve the microclimatic conditions of the soil for the betterment of crops and degrade and add nutrients to the soil. The mulch effectiveness may not be only in the improvement in physical conditions, but in decomposition and in synchronization of nutrient release with the period of greatest need of the crop.

In 2016, the increase in growth and yield of tomato under *Acacia* mulch compared with *Leucaena* and *Gliricidia*, without addition of PM, could be due to reduced soil bulk density and temperature and increased porosity and moisture content of this treatment. The lower bulk density of *Acacia* enhanced root growth of tomato and nutrient uptake in comparison with tomato mulched with other materials. The improved soil moisture and temperature regimes enhanced root development and nutrient uptake which favoured shoot biomass development in *Acacia* mulched plots. With addition of PM to mulches in both years, *Acacia* had the highest fruit yield of tomato. The superior effect of *Acacia*+PM may be due to better soil physical properties of *Acacia* and optimum availability of nutrients supplied by the PM.

Vegetable crops, such as tomato, are sensitive to increased bulk density which reduces root penetration (Adekiya and Ojeniyi, 2002). Poultry manure is an effective source of nutrients to crops and had balanced nutritional and residual effects on crops and soil. In addition to improving soil physical properties, the humus of slowly decaying leaves like *Acacia* may allow retention of released nutrient from rapidly decomposing PM within the rooting zone fostering greater efficiency of nutrient uptake and increase in yield. Higher N mineralization occurs where both organic amendments were combined, compared to their individual application, indicating a synergistic relationship between the inputs (Palm et al., 2001; Singh et al., 2007).

Conclusion

Legume mulch materials (*Leucaena*, *Gliricidia* and *Acacia*) with or without addition of PM reduced bulk density and soil temperature and increased porosity, moisture content and soil chemical properties compared with the initial soil before application of treatments. In 2015 without addition of PM, *Gliricidia* significantly increased tomato growth and yield parameters compared with *Leucaena* and *Acacia*. With the addition of PM *Acacia* has the highest value. In 2016 with or without addition of PM, *Acacia* significantly increased growth and yield parameters compared with *Leucaena* and *Gliricidia* which are similar statistically.

Leucaena and *Gliricidia* mulches enhance tomato growth and yield through direct nutritional contributions, whereas *Acacia* mulch do so through mulching effects on soil microclimate. The results of this study show that with addition of PM, the different mulching materials increase tomato growth and yield compared with the mulches alone. *Acacia*+PM produced significantly higher yield, therefore adequate application of PM to mulches should be encouraged, especially where farmers use *Acacia* legume materials as mulch to maximize their contribution to soil and crop productivity.

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