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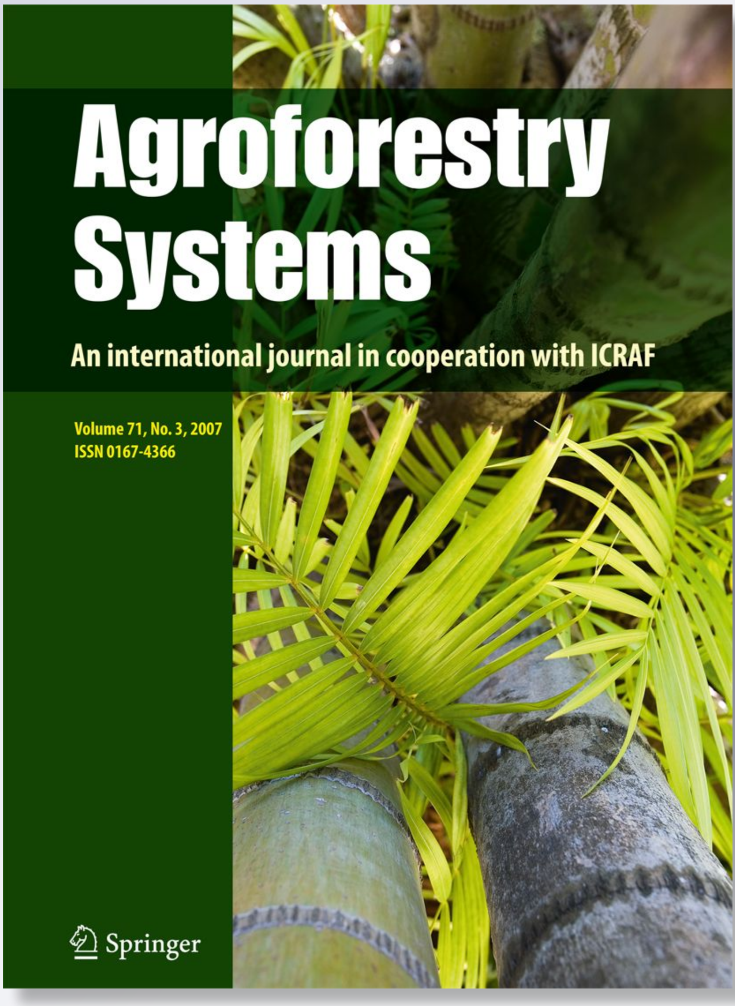

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Growth, yield and vitamin C content of radish (*Raphanus sativus* L.) as affected by green biomass of *Parkia biglobosa* and *Tithonia diversifolia*

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Abstract The study was conducted to determine the effect of green biomass of *Parkia biglobosa* and *Tithonia diversifolia* on growth, yield and vitamin C content of radish (*Raphnus sativus* L.). The potential of *T. diversifolia* as green manure has been discovered by a number of researchers while there is paucity of information and research work on the potentials of *P. biglobosa* in supplying crop nutrients despite the numerous nutrient compositions contained in the leaves. Both *P. biglobosa* and *T. diversifolia* are capable of providing adequate biomass for crop growth and sustainability. The contribution of 10 tonnes ha^{-1} tithonia to the growth and yield of radish was comparable to that of NPK while the potentials of parkia at all rates was not fully expressed in the growth and yield due to its slow mineralisation. Combination of varying levels of *P. biglobosa* and *T. diversifolia* also contributed to the growth and yield of radish though the effects were not significant. It can therefore be concluded that the use of *T. diversifolia* at 10 tonnes ha^{-1} as organic manure is sufficient for the cultivation of radish as it performed similar to application of 200 kg ha^{-1} NPK fertilizer and based on the fact that it is readily available and eco-friendly compared to NPK that is costly and may have adverse effect on the environment.

Keywords Green biomass · Parkia · Radish · Tithonia · Vitamin C and yield

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Introduction

Radish (*Raphanus sativus* L.), is an annual crop in the mustard family (Brassicaceae), grown for its large succulent taproot. Radish originated in Europe and Asia. Today, radishes are favorite crop for home gardeners because they are easy and quick to grow.

Crop production depends greatly on soil fertility and the continuous decline in soil fertility is a major constraint to agriculture (Mucheru-Muna et al. 2007). This decline in soil fertility is the result of natural and managerial activities such as leaching, erosion and crop harvest, continuous cultivation and overgrazing (Macharia et al. 2011) and this decline of soil nutrients will continue unless there are means of replenishing the lost nutrients (Mucheru-Muna et al. 2007).

Means of nutrient renewal may be through organic and/or inorganic fertilizer. Inorganic means of nutrient renewal use chemical fertilizer to improve soil fertility and crop yield but the use is limited by environmental pollution and cost (Joëlle et al. 2010) which make them unavailable to farmers (Mafongoya et al. 1997). Organic means of replenishing the soil include the use of green biomass, plant residues and plant litters, animal wastes and so on, which decompose and nitrify the soil. Plants through its litter fall or the direct incorporation of its leaves and residues into the soil has helped to improve the soil nutrient level through decomposition (Mafongoya et al. 1997), as well as ameliorating soil physical properties to sustain crop production (Egbe et al. 2012). Application of organic materials as soil amendments is an important management strategy that can improve and uplift soil-quality characteristics and alter the nutrient cycling through mineralization or immobilization turnover of added materials (Abbasi et al. 2015). The use of leguminous green manure in cropping fields is economically feasible due to their high nitrogen-fixing potentials (Rinaudo et al. 1983) and these plants are considered to be high quality resource for microorganisms and as a result they decompose and release nitrogen quickly (Palm and Sanchez 1990).

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).

In Nigeria and many other African countries, rural farmers adopted the use of different types of organic materials to improve the soil fertility contrary to the use of inorganic fertilizer that is scarce, costly and may have adverse effect on the environment. Notable amongst the materials used as green biomass for nutrient renewal, increased soil fertility and improve soil physical and chemical properties includes—*Chromolaena odorata*, *Acacia spp*, *Mucuna procumbens*, *Parkia biglobosa, Tithonia diversifolia, Prosopis africana, Vitellaria paradoxi, Leucaena leucocephala, Gliricidia sepium* e.t.c.

Parkia biglobosa (Jack.) R.Br.Ex. G. Don. have been known to be a native of Africa and it's an important multipurpose tree of West African Savannah land and one of the most common species of the parkland agro-forestry system (Sacande and Clethero 2007). *P. biglobosa* popularly known as the African locust bean tree belongs to the Fabaceae family (Alabi et al. 2005). It is a perennial deciduous tree occurring in a belt between 5° N and 15° N (Don 2007), 7–20 m tall, and in some cases it can reach up to 30 m (Sabiiti and Cobbina 1992). In recent years, more attention have been given to economically important species of tree plants especially *P. biglobosa* due to an increasing recognition of its contribution to fulfil basic needs of people, household economics, food security and conservation of natural resources (Joshi and Joshi 2009). Little work has been done by researchers on the potential of *P. biglobosa* as a green manure. However *P. biglobosa* is a perennial tree legume which is capable of contributing to recycling soil nutrient (Alabi et al. 2005).

Tithonia diversifolia (Hemsl.) A. Gray is a species of flowering plant in the Asteraceae family that is commonly referred to as Mexican sunflower, tree marigold, Japanese sunflower or Nitobe chrysanthemum. It is native to eastern Mexico and Central America but has a nearly pan tropical distribution as an introduced species (USDA 2011). It has shown great potential in raising the soil fertility in soils depleted in nutrients (Achieng et al. 2007). Originating in Mexico; research has shown its potential in benefiting poor African farmers (Jama et al. 2000). This plant is a weed that grows quickly and has become an option as an affordable alternative to expensive synthetic fertilizers and has shown to increase plant yields and the soil nutrients of nitrogen (N), phosphorus (P), and potassium (K) (Jama et al. 2000). It 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*. The aggressive nature and high growth rate of Mexican sunflower had been reported to be attributed to its possible allelopathic effects on the neighbouring weed seeds and the smothering effects on their seedlings (Boureima et al. 2008).

The potential of *T. diversifolia* as green manure has been discovered by a number of researchers. Partey (2010) found *T. diversifolia* to be an important source of organic fertilizer in improving crop yield. It is a high quality organic source of nutrient release and supplying capacity (Olabode et al. 2007).

Both *P. biglobosa* and *T. diversifolia* are fast growing leguminous tree and weed respectively capable of providing adequate biomass for crop growth and sustainability. This is important from the point of view of sustainable development concept in the tropics where most of the soils are fragile and nutritionally poor.

Despite the numerous nutrient composition contained in the leaves of *P. biglobosa* and because they are readily available and possibly save farmers cost of production, there is paucity of information and research work on its potentials in supplying crop nutrients, hence, the study was conducted to determine its potential when applied as sole and in combination with leaves of *T. diversifolia* which has already been identified and widely used as source of organic fertilizer in improving crop growth and yield using radish as the test crop based on its health benefit.

Materials and methods

The experiment was carried out during 2015 and 2016 cropping seasons at Landmark University Teaching and Research farm, Omu-aran, (7°45′N and 9°30′N and longitudes 2°30′E and 6°25′E) Nigeria, with annual rainfall of about 1300 mm. Pre-cropping soil samples were collected from each plot during the cropping seasons and bulk to determine the physico-chemical properties of the soil.

The land was ploughed once and harrowed twice to give a well pulverized soil after which beds of 2 m × 2 m size were made to represent a plot. The gross plot size and net plot size were 1536 and 112 m^2 respectively. Fresh leaves of *P. biglobosa* were collected from a tree of about 5 years old that was pruned in a plantation and shredded from the twigs while leaves of *T. diversifolia* were collected from 2 months old plants. The leaves were cut into pieces for easier decomposition using a sharp knife before incorporation into the soil.

The following treatment combinations were incorporated fresh into the soil as green biomass to a depth of about 5 cm based on the layout and were left for two weeks to decompose before seed sowing—10 tonnes ha^{-1} Parkia (T1), 10 tonnes ha^{-1} Tithonia (T2), 7.5 tonnes ha^{-1} Parkia + 2.5 tonnes ha^{-1} Tithonia (T3), 5.0 tonnes ha^{-1} Parkia + 5.0 tonnes ha^{-1} Tithonia (T4), 2.5 tonnes ha^{-1} Parkia + 7.5 tonnes ha^{-1} Tithonia (T5), 200 kg ha^{-1} NPK fertilizer (T6) and Control (T7). Treatments were arranged in a Randomized Complete Block Design (RCBD) replicated four times.

Seventy two 'French breakfast' variety of radish seeds were sown at a depth of 5 cm on a prepared 2 m × 2 m bed at two seeds per hole with 30 cm × 30 cm inter and intra-row spacing. Plants were thinned to one plant per stand one week after sowing leaving a total number of 36 plants per bed. Inorganic fertilizer (NPK 20:10:10) was manually applied to the assigned plots at the rate of 200 kg ha^{-1} two weeks after sowing by side placement 5-8 cm away from the base of the plant.

Radishes reached maturity four to 6 weeks after sowing. At 6 weeks after sowing (WAS), the crop was manually harvested using hand to uproot the radish root with its leaves still on. Thirty six plants with varying number of leaves, root weight, root length and root diameter were harvested per bed.

The following parameters were taken during the experiment, plant height, number of leaves, biomass yield, root weight, leaf weight, root length and root diameter. Data collected were subjected to Statistical Analysis of Variance (ANOVA) using S.A.S (2000). The significant treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

Laboratory analysis of *P. biglobosa* and *T. diversifolia* leaves and Vitamin C content of radish leaves and roots

Leaf samples of *P. biglobosa* and *T. diversifolia* were collected and oven-dried for 24 h at 80 °C and grinded in a Willey mill. These samples were analysed for leaf N, P, K, Ca and Mg as described by Tel and Hagarty (1984). Leaf N was determined by the micro-Kjeldahl digestion method. Ground samples were digested with nitric-perchloric-sulphuric acid mixture for the determination of P, K, Ca and Mg. Phosphorus was determined colorimetrically using the vanadomolybdate method, K was determined using a flame photometer and Ca and Mg were determined by the EDTA titration method (AOAC 2000). The percentage of organic carbon in the sample was determined by the Walkley and Black procedure using the dichromate wet oxidation method (Nelson and Sommers Nelson and Sommers 1996). Sample pH was determined by using a soil–water medium at a ratio of 1:2 using Jenway digital electronic pH meter model 3520 (Ibitoye 2006). Vitamin C content of radish leaves and roots were determined by using the indophenol dye method (Singh et al. 2007).

Results

The pre-planting soil analysis is as shown in Table 1. The result of the soil analysis for the period of 2 years revealed that both the soil physical and chemical properties share similar characteristics. The pH of the soils were strongly acidic, the nitrogen, available phosphorus and the exchangeable K were low while the exchangeable Na, Ca, and Mg were all suitable. The organic carbon (OC) and organic matter (OM) were also low.

Table 2 shows the laboratory analysis of the chemical composition of *P. biglobosa* and *T. diversifolia* leaves which indicated that *P. biglobosa* leaves had higher P, Mg, OC and C:N values compared to *T. diversifolia* leaves which had higher Ca and moisture content (MC) than *P. biglobosa* leaves. The values of pH, N, K and Mg were not significantly different.

Table 1 Soil physical and chemical properties of the soil before experiment prior sowing (0–15 cm)

Soil property	2015	2016
Sand %	76.12	76.00
Silt %	12.00	13.00
Clay %	11.88	11.00
Textural class	Sandy loam	Sandy loam
pH (water)	5.25	5.36
Total N (%)	0.14	0.16
Organic C (%)	1.30	1.32
Organic matter (%)	2.24	2.27
Exchangeable K (cmol kg^{-1})	0.19	0.13
Exchangeable Na (cmol kg^{-1})	0.50	0.66
Exchangeable Ca (cmol kg^{-1})	2.70	3.17
Exchangeable Mg (cmol kg^{-1})	0.92	0.55
Available P (mg kg^{-1})	8.5	9.6

Effect of *P. biglobosa* and *T. diversifolia* green biomass on plant height and number of leaves of radish

Table 3 shows that, application of levels of both *P. biglobosa* and *T. diversifolia* in 2015 and 2016 had significant effect on plant height and number of leaves when compared to the untreated control (T_7).

Application of 10 tonnes ha^{-1} T (T_2) increased plant height and number of leaves in both years. There was no significant difference in these parameters when other treatment combinations (T_3, T_4 and T_5) and NPK (T_6) were applied on number of leaves and when 2.5 P + 7.5 T (T_5) and NPK (T_6) were applied on plant height in both years.

Effect of *P. biglobosa* and *T. diversifolia* green biomass on biomass yield, root weight and leaf weight of radish

Application of NPK fertilizer recorded heavier biomass yield, root and leaf weight in 2015 and 2016 which was similar to the effect of application of 10 tonnes ha^{-1} T (T_2) on all the parameters measured in 2016 and when 2.5 tonnes ha^{-1} P + 7.5 ha^{-1} T (T_5) was applied on leaf weight in both years. Application of other treatments resulted in varying degrees of increase in biomass yield, root and leaf weight which were not statistically similar with each other. The control (T_7) gave significantly lower values for all the parameters in both years (Table 4).

Effect of *P. biglobosa* and *T. diversifolia* green biomass on root length and root diameter of radish

The yield parameters are shown in Figs. 1 and 2. Relative to the control (T_7) which gave least values for root length and diameter, other treatments resulted in varying levels of increase in the parameters. In both years, values obtained from the application of NPK fertilizer (T_6) significantly increased root length and diameter which was closely followed by the values obtained from the application of 10 tonnes ha^{-1} T (T_2).

Table 2 Nutrient composition of fresh *Parkia biglobosa* and *Tithonia diversifolia* leaves

	pH	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Organic C (%)	C:N	Moisture content (%)
P. biglobosa	6.01a	4.10a	0.94a	3.10a	3.90a	3.80b	34.0a	8.3a	19.50b
T. diversifolia	5.90a	3.95a	0.53b	3.16a	3.52a	5.41a	30.5b	7.7b	28.30a

Means in a column under any given treatment followed by the same letter do not differ significantly at 0.05 level of probability using the Duncan's Multiple Range Test (DMRT)

Table 3 Effect of *Parkia biglobosa* and *Tithonia diversifolia* green biomass on plant height and number of leaves of radish (*Raphanus sativus* L.) in 2015 and 2016

Treatment (t ha^{-1})	Plant height (cm) at 4 WAS		Number of leaves at 4 WAS	
	2015	2016	2015	2016
10 P (T_1)	16.17c	17.20b	7.60b	7.70b
10T (T_2)	20.33a	20.95a	8.77a	9.20a
7.5 P + 2.5 T (T_3)	17.20b	17.90b	8.00a	8.60a
5.0 P + 5.0 T (T_4)	17.90b	18.85ab	8.00a	8.85a
2.5 P + 7.5 T (T_5)	19.50a	20.52a	8.5a	9.21a
NPK (T_6)	19.33a	19.37a	8.5a	8.74a
Control (T_7)	10.43d	11.97c	6.60c	6.66c

Means in a column under any given treatment followed by the same letter do not differ significantly at 0.05 level of probability using the Duncan's Multiple Range Test (DMRT)

P Parkia, *T* Tithonia, *t ha^{-1}* tonnes per hectare, *WAS* weeks after sowing

Table 4 Effect of *Parkia biglobosa* and *Tithonia diversifolia* green biomass on biomass yield, root and leaf weight of radish (*Raphanus sativus* L.) in 2015 and 2016

Treatment (t ha^{-1})	Biomass yield (kg ha^{-1})		Root weight (kg ha^{-1})		Leaf weight (kg ha^{-1})	
	2015	2016	2015	2016	2015	2016
10 P (T_1)	46.59f	47.32d	32.09e	32.33d	14.42c	14.99c
10T (T_2)	78.14b	84.95a	55.87b	60.55a	22.30a	24.46a
7.5 P + 2.5 T (T_3)	49.69e	60.11c	33.98cd	40.67c	15.71c	19.44b
5.0 P + 5.0 T (T_4)	55.82d	70.05b	38.13d	47.55b	17.69b	21.50b
2.5 P + 7.5 T (T_5)	74.43c	75.84b	49.27c	55.20b	19.23a	24.64a
NPK (T_6)	86.19a	86.57a	63.00a	61.24a	23.18a	25.33a
Control (T_7)	24.11g	25.56e	16.72f	17.23e	7.33d	7.33d

Means in a column under any given treatment followed by the same letter do not differ significantly at 0.05 level of probability using the Duncan's Multiple Range Test (DMRT)

P Parkia, *T* Tithonia, *t ha^{-1}* tonnes per hectare

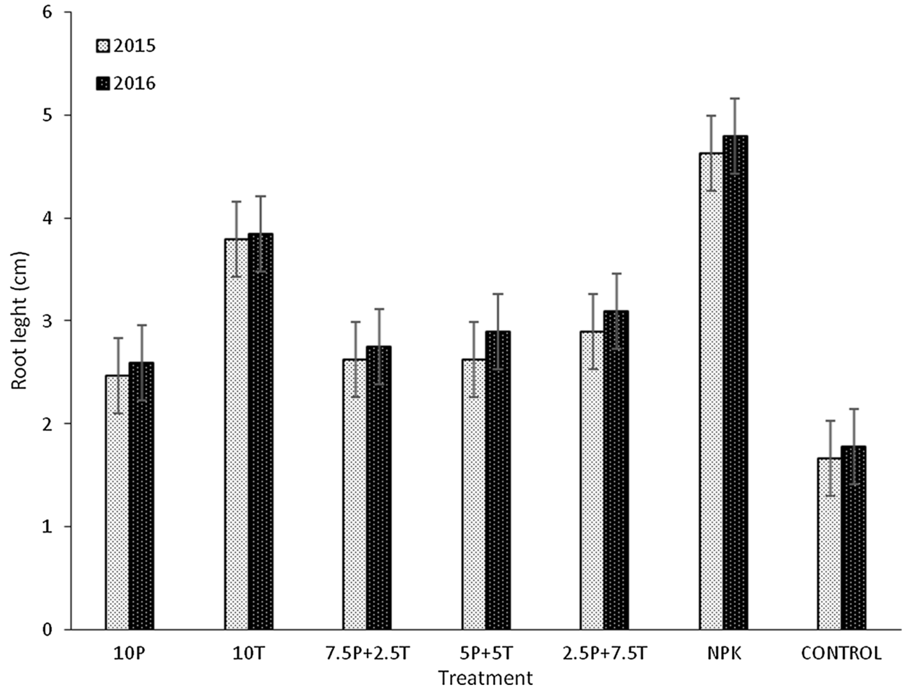

Fig. 1 Effect of *Parkia biglobosa* and *Tithonia diversifolia* green biomass on root length of radish (*Raphanus sativus* L.) in 2015 and 2016

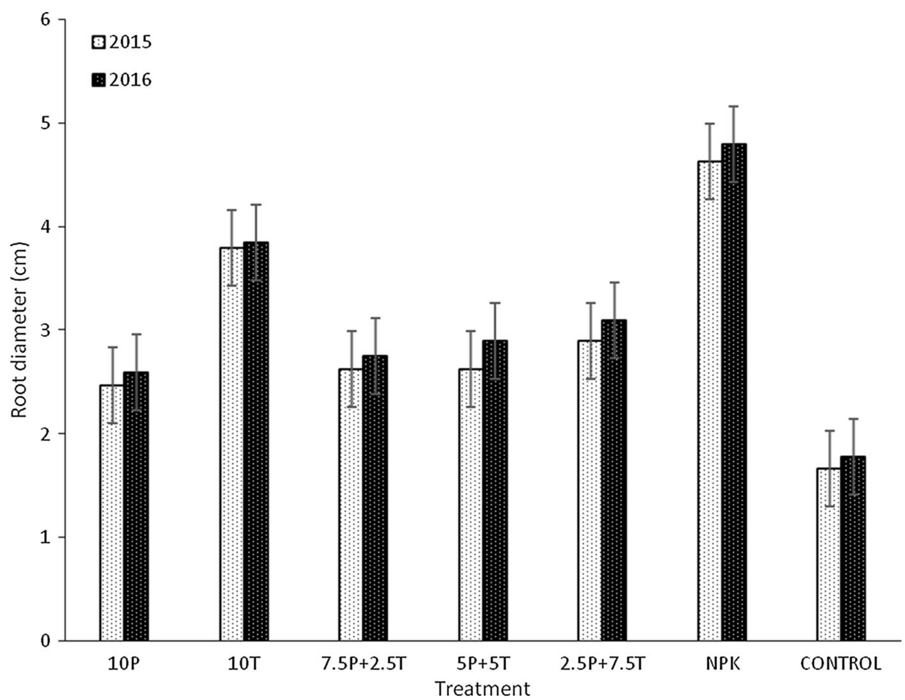

Fig. 2 Effect of *Parkia biglobosa* and *Tithonia diversifolia* green biomass on root diameter of radish (*Raphanus sativus* L.) in 2015 and 2016

Effect of *P. biglobosa* and *T. diversifolia* green biomass on Vitamin C content of leaves and roots of radish

The content of vitamin C in the leaves and roots of radish is shown in Fig. 3. Vitamin C content of radish leaves and roots increased significantly when 2.5 tonnes ha^{-1} P + 7.5 tonnes ha^{-1} T (T_5) was applied, the increase was statistically similar to the application 10 tonnes ha^{-1} T on the leaves and application of 10 tonnes ha^{-1} T (T_2) and 5.0 tonnes ha^{-1} P + 5.0 tonnes ha^{-1} T (T_4) on the roots. There was no significant difference in the application of 10 tonnes ha^{-1} P (T_1), 7.5t ha^{-1} P + 2.5 tonnes ha^{-1} T (T_3), 5.0 tonnes ha^{-1} P + 5.0 tonnes ha^{-1} T (T_4) and the control (T_7) on the vitamin C content of the leaves and application of 10 tonnes ha^{-1} P (T_1), 7.5 tonnes ha^{-1} P + 2.5 tonnes ha^{-1} T (T_3) and the control (T_7) on the vitamin C content of the roots. Application of NPK fertilizer significantly reduced vitamin C content of both the leaves and roots of radish. Value of vitamin C accumulated in the leaves of radish was significantly higher than that in the roots, across the treatments.

Using the mean of the two years, leaf vitamin C in kg ha^{-1} for 10 tonnes ha^{-1} Parkia (T1), 10 tonnes ha^{-1} Tithonia (T2), 7.5 tonnes ha^{-1} Parkia + 2.5 tonnes ha^{-1} Tithonia (T3), 5.0 tonnes ha^{-1} Parkia + 5.0 tonnes ha^{-1} Tithonia (T4), 2.5 tonnes ha^{-1} Parkia + 7.5 tonnes ha^{-1} Tithonia (T5), 200 kg ha^{-1} NPK fertilizer (T6) and Control (T7) were 14.71, 23.38, 17.58, 19.60, 21.94, 24.26 and 7.33 kg ha^{-1} respectively. The corresponding root vitamin C in kg ha^{-1} were 32.21, 58.21, 37.33, 42.84, 52.24, 62.12 and 16.98 kg ha^{-1} respectively.

Discussion

The pre-cropping soil analysis revealed that the soils used for the two years experiments were low in major nutrients required for plant growth, while the laboratory analysis to determine the chemical composition of the leaves of *P. biglobosa* and *T. diversifolia* indicated that both leaves contained varying proportions of some major nutrients with *P. biglobosa* having higher value of C:N ratio than *T. diversifolia*.

Application of green biomass of *P. biglobosa* and *T. diversifolia* has shown that the level of decomposition and mineralization of their leaves varied significantly, with *T. diversifolia* having higher degree of mineralization.

Application of *T. diversifolia* as green manure increased plant height and number of leaves of radish and the effect was similar to the application of NPK fertilizer. As the rate of application of *T. diversifolia* increase, the value for the parameters also increases. Increase in plant height and number of leaves could be attributed to the early mineralization of *T. diversifolia* biomass, which increased the levels of essential

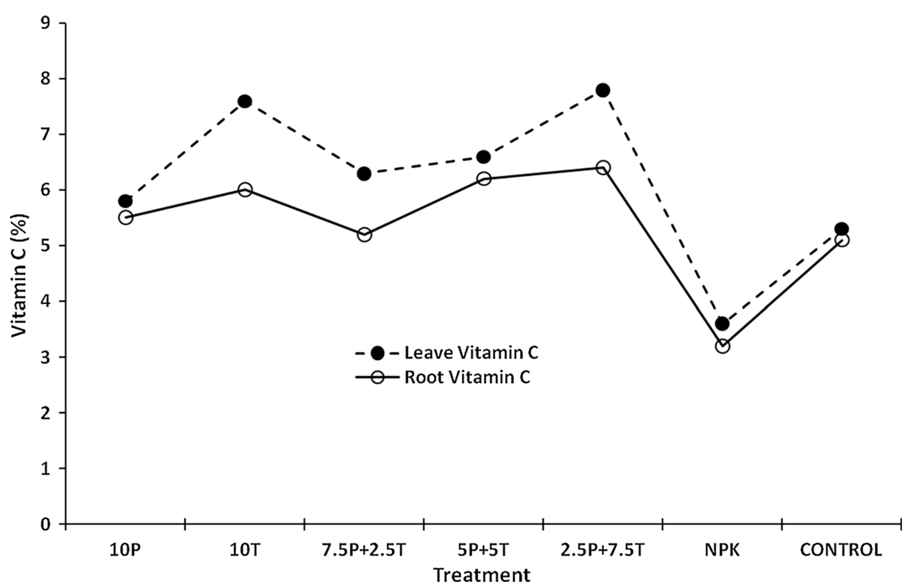

Fig. 3 Mean effect of *Parkia biglobosa* and *Tithonia diversifolia* green biomass on the vitamin C content of the leaves and roots of radish (*Raphanus sativus* L.) in 2015 and 2016

elements in the soil which are necessary for plant growth and development. Early mineralization and decomposition of *T. diversifolia* could be as a result of its high moisture content and low C:N ratio. Jama et al. (2000) found that the biomass from *T. diversifolia* breaks down rapidly and releases nutrients quickly. This is also in line with the study of Liasu and Achakzai (2007) where they reported that tomato plants subjected to mulching and fertilization with *T. diversifolia* exhibited higher plant height and more leaves per plant when compared with other treatment combinations.

The result also showed that biomass yield, root weight, root length and root diameter increased with application of *T. diversifolia* up to 10 tonnes ha^{-1} which was comparable with the application of NPK fertilizer. Increase in these parameters could be attributed to taller plants and more number of leaves produced making the plants to trap more sunlight for the process of photosynthesis and transporting the assimilates to the roots. Ademiluyi and Omotoso (2004) reported that stem girth were better under *Tithonia* applied soil than under the NPK fertilized soils.

The application of plant residue to soil is considered a good management practice because it stimulates soil microbial growth and activity with the subsequent mineralization of plant nutrients (Randhawa et al. 2005). The green biomass of *P. biglobosa* and *T.diversifolia* increased the vegetative growth, root yield of radish but the increase was more evident under *T. diversifolia* biomass. Increase plant vigour and yield as a result of application of *T. diversifolia* could be adduced to its ability to improve soil physical and chemical properties (Agbede and Afolabi 2014).

Increase root length and diameter of radish as a result of application of *T. diversifolia* green biomass could be ascribed to its fast mineralization leading to increased accumulation of soil organic matter and subsequently lower bulk density for improved soil aeration and conducive environment for root development. Bulk density is inversely related to total porosity, which provides a measure of the porous space left in the soil for air and water movement (Min et al. 2003).

Increase in growth and yield under NPK compared to other treatments may be due to the fact that NPK are made up of nutrient in their mineralised forms that are readily available for plant absorption. Similar findings was by Zahir et al. (2006) where they observed that the application of NPK for the cultivation of radish has maximum increase on the vegetative growth and yield of radish.

Comparing the nutrient composition of the green biomass of *P. biglobosa* and *T.diversifolia*, *P. biglobosa* should have performed better than *T.diversifolia*, however differences in the performance of radish under *P. biglobosa* and *T. diversifolia* green biomass may be due to their rate of decomposition and mineralization. The rate of mineralization in *P. biglobosa* leaves was very slow compared to *T. diversifolia* that decomposes quickly releasing its accumulated nutrients in the soil very fast.

Heal et al. (1997) reported that rate of litter decomposition and release of nutrient from specific plant material depend largely on its chemical and physical characteristics. The reason for the low mineralization of *P. biglobosa* could be as a result of its high C:N ratio and the chemical composition. This result is in agreement with the findings of Mafongoya et al. (1997) who reported that C:N ratio or nitrogen are considered the most important index in determining the rate of mineralization. Tian et al. (1998) also noted that low C:N ratio and lignin content is an indication of the release of high amount of available nitrogen.

The major constituents of leaves include cellulose, lignin, tannins and some trace elements. Green manures from different tree species have different rates of decomposition and nutrient release. The higher the lignin content the lower the rate of biodegradability of the leaf, and hence the more difficult and slower is the rate of mineralization (TSBF-CIAT 2003). Another major reason for slow mineralization of *P. biglobosa* biomass could be that the leaves contained high lignin, which is a complex organic material that binds together fibres and other materials in the cell wall of plants.

Higher levels of vitamin C, iron, magnesium, phosphorus and less nitrates and lower amounts of some heavy metals were found in organically produced vegetables (Worthington 2001). Application of the two green biomasses increased vitamin C content of both the leaves and roots of radish. This could be adduced to the fact that organic samples had higher antioxidant capacity and amounts of phenolic compounds that are superior when compared to the inorganic samples. This is in line with Magkos et al.

(2003) who found that values of vitamin C content of lettuce grown in the organic production systems were higher than those of the conventional production system. Another study by Ismail and Fun (2003) also showed that the ascorbic acid content was found to be significantly lower in lettuce grown conventionally compared to the organically grown ones.

The significant reduction in the vitamin C content as a result of application of NPK fertilizer could be as a result of high nitrogen content in the in-organic fertilizer. Nitrogen fertilizers at high rates tend to decrease the vitamin C content in many fruits and vegetables (Lee and Kader 2000).

Conclusion

Since the potential of *P. biglobosa* was not fully expressed on plant growth and yield as a result of slow rate of decomposition, it is therefore suggested that mineralization should be allowed for three weeks before seed sowing and if not, the same plot should be used for further research. The potential of *P. biglobosa* on crop growth and yield may also be maximised if it is used for crops with a longer life cycle rather than short duration crops like radish.

From this study, it can therefore be recommended that the use of 10 tonnes ha^{-1} T as green manure is sufficient for the cultivation of radish. This is because it performed similar to NPK and based on the fact that it is readily available and eco-friendly compared to NPK that is costly and may have adverse effect on human health and the environment.

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