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DRY MATTER AND NUTRIENT ACCUMULATION OF SELECTED GREEN MANURE SPECIES AT DIFFERENT AGES ON ALISOLS AT AREKA, SOUTHERN ETHIOPIA

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ABSTRACT
Continuous loss and net removal of soil nutrients from cultivated land causes a serious threat to the overall agricultural productivity. This decline in soil fertility is major constraint to agricultural production and food security in Ethiopian highland farming systems. Since farmers have limited capacity to invest in fertilizers, potential solution to the problem is to use green manure (GM) for their multiple advantages. Thus, the study was conducted to evaluate dry matter production and nutrient concentration from GM at different ages. The treatments were three levels of age (3, 4 and 5) months after planting (MAP), three GM species (Tithoniadiversifolia, Tephrosiavogelii and Crotalaria juncea) and laid out in factorial arrangement in RCBD design with three replications. T. diversifolia produced significantly ($p<0.05$) higher total above ground biomass (TAGB) at all ages. The TAGB yields of Tephrosiavogelii and Crotalaria juncea were lower by 35.85 and 68.82%, 32.96 and 27.12%, and 28.22 and 31.52% than the TAGB of Tithoniadiversifolia at three, four and five months after planting respectively. Nitrogen and K concentrations of all the GM species were relatively higher whereas P, Ca and Mg were low at all ages. In general, the study found appreciable dry matter yield and nutrient concentration from all species of different ages.

Keywords: Green manure, Nutrient, Dry matter, Concentration, Age, Species.

Contribution/ Originality
This study contributes in the existing literature by providing information in organic fertilizers. The study provides options for poor farmers who have limited capacity to invest for commercial fertilizers and for those investors primarily engaged in organic farming. The paper provides initial information for researchers and students in further investigations.

1. INTRODUCTION
Tropical smallholder farming systems lack sustainability due to low soil fertility and continued mining of nutrients [1]. According to Kumwenda, et al. [2], the low level of chemical fertilizer use and decline in soil organic matter (OM) contribute the most to the loss of soil fertility. Therefore, in order to improve soil fertility, use of inorganic fertilizers to provide

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nitrogen (N), phosphorus (P) and potassium (K), are important , however, mineral fertilizers are not an option for the majority of African subsistence farmers for being expensive [3].

Ethiopia is one of the countries faces accelerated soil fertility reduction and consequently food shortage. The problems might be more in the case of the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) due to high population density and fragmented farm land as well as continues farming. According to Tilahun [4], soil fertility decline is the major constraint to agricultural production and food security in the Ethiopian highland farming systems. In line with this, Nair [5] reported that subsistence type of agriculture is found in the rain fed areas of Ethiopia typified by continued loss and net removal of soil nutrients which could cause a serious threat to the overall agricultural productivity. Farmers have very limited capacity to invest in fertilizers or soil conservation measures. As a result, yields are low and many farmers are forced to put fallow and marginal lands into production to meet their food needs [6].

According to Rutunga, et al. [7], use of local inputs such as farmyard manure, tree and shrub biomass that are easily available in the farm may be a realistic option to improve soil fertility. In a highly nutrient depleted soils, high amount (10 t or more on dry matter basis) of farmyard manure is needed to match the crop demand for nutrients but it is not available in such quantities [7]. Therefore, this insufficient availability of farmyard manures coupled with high costs of inorganic nutrient sources makes it increasingly important to re-examine GM crops [3]. Accordingly, green manuring with legumes and other GM species are recommended to maintain soil fertility particularly to provide N which is the most limiting nutrient for crop production [8].

It is not only the production of a large mass of foliage and nutrient contribution to maintain soil fertility; GMs also have numerous advantages in the soil environment. Warman [9] reported that GMs soak up potentially-leachable nutrients from the soil and the nutrients are then held by the GM until it is incorporated. During decomposition, the nutrients will be released to the following crop. When GMs are incorporated into the soil and decompose, they provide nutrients for soil organisms, thus protecting and enhancing the soil's biological activity. After the GMs are decomposed, they loosen and aerate the soil, consequently improving the structure and increase OM content of the soil. Green manures also have great importance on soil physical properties. For instance, when planted along physical conservation structures, they stabilize the structures, thus protecting the soil against wind and water erosion [9].

Because of the quality, low cost, availability and other benefits to improve soil fertility and soil environment at large, promoting these GMs to the areas practicing small-scale farming systems like the SNNPRS is crucial. However, undertaking research on the different aspects including dry matter production and nutrient accumulation of the species at different ages is vital. Because, if legume GMs are to be considered effective nutrient sources for crops, they must produce high dry matter and nutrient. According to Kong, et al. [10], amount of biomass and N provided by the GM crops depend on growth stage at the time of incorporation. Selection of suitable legume species and age at termination determines the amount of biomass and nutrient concentration. This investigation was, therefore, initiated to evaluate dry matter production and nutrient concentration of selected green manure species at their different age.

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2. MATERIALS AND METHODS

This field experiment was conducted at Areka Agricultural Research Center in Wolaita Administrative Zone of the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). Geographically, it is situated at the coordinates of $7^{0}07'$ N and $37^{0}47'$ E with an average altitude of 1,800 meters above sea level (masl) and the area receives an average (1999 to 2008) annual rainfall of 1539 mm. The annual average air temperature at the study site is about 20.1 °C. The mean maximum and minimum air temperatures during the experimentation period were 24.9 and 14.2 °C, respectively [11].

The soils at the station are well drained with slopes ranging from 2 to 10% on the upper and middle elevations of the research fields. Generally, the soils vary from loam through silt loam to clay loam in texture. Structurally, the soils have sub angular blocky structure with good porosity on the surface layer (0-30 cm) and are very deep (> 150 cm) [12]. Chemically, the experimental field was evaluated for major nutrients (Table 3).

The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments were three GM species (*Tithoniadiversifolia*, *Tephrosiavogelii*and *Crotalaria juncea*) and three different ages of the GMs (three, four and five months after planting). Each GM species were planted on 10 m x 10 m (100 m^2) and 1 m by 0.5 m spacing was used between rows and plants within a row, respectively.

Plant height of ten randomly taken plants was measured from the ground to the stem tip and averaged to compare the plant growth at different age. Later, the biomass yield was estimated by cutting the leaves of the plant from 1 m x 1 m quadrant of each plot of all plant ages. The above ground biomass was separated into leaves + soft twigs and stems, oven dried (at 70 ^{0}C for 24 hours) and the dry matter was measured and converted to t ha^{-1}.

After GM plants were grown to the required age, leaves + soft twigs of the plant part were sampledfrom all ages of GM species. In preparation for laboratory analysis, samples were cleaned to remove surface contaminant with 0.1% detergent solution followed by rinsing in distilled water. After washing, samples were oven dried at 70 ^{0}C for 24 hours to stop enzymatic reaction and to facilitate grinding. The dried samples were finely ground to pass 2 mm sieve and analyzed for N, P, K, Ca and Mg concentration following standard laboratory procedures developed for each parameters.

3.RESULTS AND DISCUSSION

3.1. Plant Height

The effects of species and age on plant height were assessed and at early stage (5 MAP) significantly ($p<0.05$) higher (50.1 cm) plant height was recorded from *Tephrosiavogelii*(table 1). The difference in plant height might be attributed to faster emergence of *Tephrosiavogelii*coupled with the possibility of species difference in growth habit that might vary at different stages of growth. However, as time of growth extended from three to five months, *Tithoniadiversifolia*was superior to both species (Table 1). In line with this, Venant, et al. [13] reported that during the

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first month, *Tephrosiavogelii*had the highest percentage ground cover but *Tithoniadiversifolia*showed better performance than *Tephrosiavogelii*at later stages.

At four MAP, *Tithoniadiversifolia* was significantly higher followed by *Tephrosiavogelii*and similarly at later stage (5 MAP) statistically higher (145.667 cm) was obtained from *Tithoniadiversifolia* whereas 98.833 and 95.66 cm plant height were recorded from *Crotalaria juncea* and *Tephrosiavogelii*, respectively. The current study result was not in agreement with Venant, et al. [13] who reported average plant height 138 and 120 cm from *Tephrosiavogelii and Tithoniadiversifolia*, respectively, at six MAP. These heights were higher than that of *Tephrosiavogelii and* lower than the height of *Tithoniadiversifolia*obtained in the present study.

3.2. Dry Matter Production

*Tithoniadiversifolia*accumulated significantly ($p<0.05$) higher dry matter of leaves, stems and total above-ground biomass (TAGB) at all ages. The TAGB yields of *Tephrosiavogelii*and *Crotalaria juncea* were lower by 35.85 and 68.82%, 32.96 and 27.12%, and 28.22 and 31.52% than the TAGB of *Tithoniadiversifolia*at three, four and five months after planting respectively (Table 1).

The total dry matter yield produced by *Crotalaria juncea* at 3 months after planting was significantly lower (3.1133 t ha^{-1}) compared to the amounts (Table 1) produced by *Tithoniadiversifolia* and *Tephrosiavogelii* at the same growth stage. However, it was comparable with the dry matter yield (2.9 t ha^{-1}) which was obtained from the same plant species within 6-7 weeks as reported by Jeranyama, et al. [14]. In line with this, Tilahun and Kirkby [6] also reported 2.9 t ha^{-1} dry matter of *Crotalaria juncea* within 3 MAP which was similar with the result obtained in the current study. However, the dry matter obtained from *Crotalaria juncea* at three MAP in the present study was much lower than 6.1-9.6 t ha^{-1} obtained in 8-9 weeks after planting [15]. Sakala, et al. [16] also reported high amount of dry matter yield (4.9 t ha^{-1}) from *Crotalaria juncea* 3 MAP. The dry matter yield of *Tephrosiavogelii*(6.4 t ha^{-1}) at 3 MAP was comparable with 5.3 t ha^{-1} obtained during 6 months; however, the dry matter yield of *Tithoniadiversifolia*(Table 1) was by far greater than 4.4 t ha^{-1} as reported by Venant, et al. [17].

Four months old *Tithoniadiversifolia* accumulated significantly ($p<0.05$) high dry matter of leaves + soft twigs and TAGB (Table 1). At this age relatively low TAGB (9.37 t ha^{-1}) was obtained from *Tephrosiavogelii*whereas *Crotalaria juncea* had better dry matter yield compared to *Tephrosiavogelii*. The result obtained from *Crotalaria juncea* four MAP was better compared to 9 t ha^{-1} reported by Tilahun and Kirkby [6]. However, Steinmaier and Ngoliya [18] reported highest (12.1 t ha^{-1}) biomass production of *Crotalaria juncea* within 14 weeks (3 and half months) after planting in Zambia sandy loam soil. For *Tephrosiavogelii*, better total dry matter yield (13.5 t ha^{-1}) was also reported Tilahun and Kirkby [6].

At five MAP the total above ground biomass yield of *Tithoniadiversifolia* rose to 21.08 t ha^{-1} due to high stem dry matter yield. At this stage though significant difference was not observed better dry matter was obtained from *Tephrosiavogelii*than *Crotalaria juncea* (Table 1). *Tithoniadiversifolia* produced more biomass compared to 10.0 t ha^{-1} as reported by Jama, et al.

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[19]. Ladha, et al. [20] reported production of 7.8 t ha^{-1} from 6 months old *Crotalaria juncea* which was lower than 14.44 t ha^{-1} obtained in the present study; but, more biomass (18.5 t ha^{-1}) was reported by Gachene, et al. [21]. On the other hand, Tilahun and Kirkby [6] found 13.5 t ha^{-1} of dry matter yield from 4 months old *Tephrosiavogelii*which wascomparable with the result obtained from the same species in the current study. When compared across age, dry matter yield of all the GM was directly influenced by age; accordingly, dry matter yield was higher as time of growth extended.

In general, dry matter yields of the three GMs reported from different researchers were inconclusive. However, high amount of dry matter biomass productions was obtained in the present study. According to Fungameza [22] and Drechsel, et al. [23], amount of biomass produced by *Tephrosiavogelii*and *Tithoniadiversifolia*was influenced by fertility status of the soil, amount of rainfall and age at termination. Therefore, these relatively high above ground biomass could probably be attributed to conducive soil condition of the experimental site (Table 3) and good amount of rainfall (1287.3 mm) (Table 4) during the growing period.

3.3. Nutrient Concentration

Nitrogen concentration of the GM species varied from species to species as well as among ages. At three MAP, N concentration was relatively high in *Crotalaria juncea* (4.424%) and *Tithoniadiversifolia*(4.375%)while *Tephrosiavogelii* accumulated low N (3.738%) (Table 2). However, in four MAP, relatively highest N (4.438%) was obtained from *Tithoniadiversifolia*and the lowest N (3.339%) from *Tephrosiavogelii*. The same trend was followed at five MAP; *Tithoniadiversifolia*produced relatively higher N followed by *Crotalaria juncea* whereas the lowest N was obtained from *Tephrosiavogelii*. Except *Tithoniadiversifolia*at three and four MAP and three months old *Crotalaria juncea* which had better N content, N concentration of all species at all ages was within the range of 2.5-4.0% as reported by Young [24] for N-fixing trees. Jama, et al. [19] and Venant, et al. [13] reported 3.5% and 3.0% N, respectively, for *Tithoniadiversifolia*. However, the results obtained in the present study ranged from 3.9 to 4.4% N at all ages and this high N might be attributed to high to very high N content (0.182-0.531%) of the soil [12] and it could probably be due to age difference at termination.

Compared to the present study, lower N concentrations were also reported from different researchers. Olabode, et al. [25] and Nagarajah and Nizar [26] reported, 1.76 and 2.0% N, respectively, for *Tithoniadiversifolia*. The result obtained in the present study from *Tephrosiavogelii*was in agreement with the finding of Venant, et al. [13] who reported 3.05% N. Birech and Freyer [27] also reported similar result. *Crotalaria juncea* contained between 3.3 and 4.4% N which fall in the range of 1.6-5.7% as reported by Sakala, et al. [16]. Adriano, et al. [28] found 3.27% from *Crotalaria juncea* similar to the lowest result obtained at five MAP in the current study (Table 2). Gitari, et al. [29] and Jose, et al. [30], however, reported lower N contents; 2.33 and 2.13% for *Crotalariajuncea*, respectively.

Variation was also observed in P concentration of the GMs among the species and growth periods. Phosphorus concentration of the GM was low at all ages, although it was within the

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range of 0.1 to 0.3% as reported by Young [24]. The low levels of P content in these GMs could be attributed to the low quality of the soil to supply P as reported by NSRC (National Soil Research Center) [12]. This probably hindered the GMs to accumulate high P concentrations in their leaves.

Nagarajah and Nizar [26] reported 0.2-0.5% P for *Tithoniadiversifolia*that was by far greater than the result recorded in the present study. Gachengo [31], Birech and Freyer [27] and Olabode, et al. [25] reported 0.27, 0.18 and 0.81% P, respectively, which were higher than the values obtained 0.096-0.143% for *Tithoniadiversifolia* in the current study. Moreover, the critical level of P was 0.250% for *Tithoniadiversifolia*[32]. The P content obtained from *Tephrosiavogelii* which ranged from 0.102 to 0.143% P was comparable with 0.120% reported by Birech and Freyer [27]. Gitari, et al. [29] reported relatively higher P (0.160%) for *Crotalaria juncea* compared to the result obtained in the present study at all ages.

At three MAP, relatively highest K (5.389%) was observed from *Tephrosiavogelii*followed by *Tithoniadiversifolia*, and the lowest K (4.095%) was recorded from *Crotalaria juncea*. Similarly, at four MAP, relatively highest K was observed from *Tephrosiavogelii*followed by *Tithoniadiversifolia*(Table 2). Moreover, at five MAP, almost similar results of 4.590 and 4.591% K were recorded from *Tithoniadiversifolia*and *Crotalaria juncea*, respectively, whereas the highest K content was obtained from *Tephrosiavogelii*. Potassium concentration among species might be varying due to the ability of each species to extract K from the soil.

The K content obtained from all species at all ages fell between 2.3 and 5.5% which was reported by Nagarajah and Nizar [26]; but, higher compared with 1.5-2.0% reported by Young [24] for N-fixing trees. The result obtained from *Tithoniadiversifolia*at all ages was in agreement with 4.6% reported by Venant, et al. [13], and was within the range of 2.7-4.8% as reported by Jama, et al. [19] (Table 2). However, Olabode, et al. [25] reported lower (3.92%) K for *Tithoniadiversifolia*. Birech and Freyer [27] found lower K content (1.57%) for *Tephrosiavogelii*compared to the K which ranged from 5.1 to 5.5% in the current study. On the other hand, *Crotalaria juncea* produced lower amount of K (Table 2) compared to 5.75% from the same plant species as reported by Gitari, et al. [29].

Generally, high amount of N and K were obtained from all species at all ages. These good results could probably be attributed to the ability of the soil to supply these nutrients, since concentration of nutrients can conceivably be influenced by soil fertility [19]. Based on the report of NSRC (National Soil Research Center) [12], N and K contents of the site ranged from 0.049-0.230% N and from 135-730 mg kg^{-1} K. Therefore, the place where the GM species were planted might be coinciding with higher range of N and K, thus the GM could probably have taken advantage from it.

The concentrations of Ca and Mg in the leaves and soft twigs of these GMs were generally low compared to the findings of different investigators. Calcium content of the GMs ranged from 0.053 to 0.215% whereas Mg fell between 0.008 and 0.039%. Venant, et al. [13] found 1.91 and 0.37% Ca and Mg, respectively, for *Tithoniadiversifolia*. The same authors also revealed 1.3 and 0.14% Ca and Mg, respectively, for *Tephrosiavogelii*. These values were higher compared to the

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results obtained in the present study (Table 2). However, Olabode, et al. [25] and Shokalu, et al. [33] reported very low Mg content for *Tithoniadiversifolia*which was 0.005% and 0.004%, respectively. Shokalu, et al. [33] found 0.11% Ca from *Tithoniadiversifolia* and this was in agreement with the result obtained from five months old *Tithoniadiversifolia*.

4. CONCLUSIONS

During the evaluation period *Tithoniadiversifolia*produced the highest dry matter yield at all ages among the species.All of the GM species at all ages accumulated high amounts of N and K but low contents of P, Ca and Mg. Nitrogen concentration measured from all species was relatively high at 3 MAP compared to the later stages. Calcium content of the GM species also showed a decreasing trend from 3 to 5 MAP, while no regular trends were observed for P, K and Mg. In conclusion, the present study displayed high amounts of utilizable (leaves + soft twigs) dry matter yield and all of the GMs considered have accumulated appreciable N and K starting at 3 MAP. Therefore, using these species for green manuringat 3 MAP is recommended. However, it is important to note that supplemental P from external source is required.

REFERENCES

[1] S. Zingore, P. Mafongoya, P. Nyamugafata, and K. E. Giller, "Nitrogen mineralization and maize yields following application of tree prunings to a sandy soil in Zimbabwe," *J. Agroforestry Sys.*, vol. 57, pp. 199-211, 2003.

[2] J. D. T. Kumwenda, S. R. Waddington, S. S. Snapp, R. B. Jones, and M. J. Blackie, *Soil fertility management research for the maize cropping systems of smallholders in Southern Africa: A review. Natural resources group Paper No. 96-02.* Mexico City: International Maize and Wheat Improvement Center (CIMMYT), 1996.

[3] J. Kasozi, "Tithonia feretlizer tired soil; green manure, rock phosphate and liquid plant manure in Uganda." Available: http://www.allafrica.com/stries [Accessed May12, 2009], 2005.

[4] A. Tilahun, *Soil fertility decision guide formulation: Assisting farmers with varying objectives to integrate legume cover crops.* Addis Ababa Ethiopia: African Highlands Initiative /Tropical Soils Biology and Fertility Institute of CIAT, 2004.

[5] K. P. P. Nair, "The buffering power of plant nutrients and effects on availability," *Advances in Agron.*, vol. 57, pp. 237-287, 1996.

[6] A. Tilahun and R. Kirkby, *Guidelines for integration of legumes in to the farmingsystems of East African Highlands. In: B. Andre (Ed.). Managing nutrient cycles to sustain soil fertility in Sub-Saharan Africa.* Kenya: CIAT, Nairobi, 2004.

[7] V. Rutunga, K. G. Steiner, N. K. Karanja, C. K. K. Gachene, and G. Nzabonihankuye, "Continuous fertilization on non-humiferous acid oxisols in Rwanda "Plateau Central :Soil chemical changes and plant production," *J. Biotechno. Agron. Soc. Environ.*, vol. 2, pp. 135-142, 1998.

[8] P. Subbian, R. Lal, and K. S. Subramanian, "Cropping systems effects on soil quality insemiarid tropics," *J. Sustainable Agric.*, vol. 16, pp. 7-38, 2000.

[9] P. Warman, "The basics of green manuring," *MacDonald J.*, vol. 40, pp. 3-6, 1981.

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[10] T. Kong, D. L. Robinson, and H. J. Savoy, "Soil nitrogen and carbon status following clover production in Louisiana," *Communications in Soil Sci. and Plant Analysi.*, vol. 24, pp. 1345-1357, 1993.

[11] BOARD (Boloso Sore District), "The district's food safety net program coordination bureau: Implementation report," 2007.

[12] NSRC (National Soil Research Center), "Soils of Areka agricultural research center." Ethiopia Agricultural Research Organization, Technical Paper No. 77, 2003.

[13] R. Venant, K. K. Nancy, K. K. G. Charles, and P. Cheryl, "Biomass production and nutrient accumulation by Tephrosia vogelii (Hemsley) A. Gray and Tithonia diversifolia Hook F. fallows during the six-month growth period at Maseno, Western Kenya," *Biotech. Agron. Soc. Environ. J.*, vol. 3, pp. 237-246, 1999.

[14] P. Jeranyama, O. B. Hesterman, S. R. Waddington, and R. R. Harwood, "Relayintercropping of sunnhemp and cowpea into a smallholder maize system in Zimbabwe," *Agron. J.*, vol. 92, pp. 239-244, 2000.

[15] R. Seneratne and D. S. Ratnasinghe, "Nitrogen fixation and beneficial effects of Some grain legumes and green manure crops on rice," *Biol. Fertil. Soils*, vol. 19, pp. 49-54, 1995.

[16] W. D. Sakala, J. D. T. Kumwenda, and A. R. Saka, *The potential of green manures to increase soil fertility and maize yields in Malawi. In: B. Andre (Ed.). Managing nutrient cycles to sustain soil fertility in Sub-Saharan Africa.* Kenya: CIAT,Nairobi, 2004.

[17] R. Venant, K. K. Nancy, and K. K. G. Charles, "Six month-duration Tephrosia vogelii Hook.f. and Tithonia diversifolia (Hemsl.) A. Gray planted-fallows for improving maize production in Kenya," *Biotech. Agron. Soc. Environ. J.*, vol. 12, pp. 267-278, 2008.

[18] N. Steinmaier and A. Ngoliya, "Potential of pasture legumes in low-external-input and sustainable agriculture," *Zambia Exp. Agric.*, vol. 37, pp. 297-307, 2001.

[19] B. C. A. Jama, R. J. Buresh, A. Niamg, C. N. Gachenco, G. Nziguheba, and B. Amadalo, "Ithonia diversifolia as green manure for soil fertility improvement in Western Kenya," *Agroforestry Sys.*, vol. 49, pp. 201-221, 2000.

[20] J. K. Ladha, D. K. Kundu, M. G. Angelo-Van Coppenolle, M. B. Peoples, V. R. Caranagel, and P. J. Dart, "Legume productivity and soil nitrogen dynamics in lowland rice-based cropping systems," *Soil Sci. Soc. Amer. J.*, vol. 60, pp. 183-192, 1996.

[21] C. K. K. Gachene, J. G. Mureithi, F. Anyika, and M. Makau, *Incorporation of green manure cover crops in maize based cropping system in semi-arid and sub-humid environments of Kenya. Department of soil science.* Kenya: University of Nairobi, 1999.

[22] D. B. Fungameza, "Agroforestry and ecofarming practices for soil conservation in Kigoma, Tanzania," PhD Thesis, Georg-August-University of Göttingen, Germany, 1991.

[23] P. Drechsel, K. G. Steiner, and F. Hagedorn, "A review on the potential of improved fallows and green manure in Rwanda," *Agroforestry Syst.*, vol. 33, pp. 109-136, 1996.

[24] A. Young, *Agroforestry for soil management*, 2nd ed.: CAB International Wallingford UK. CAB International, 320, 1997.

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[25] O. S. Olabode, S. Ogunyemi, W. B. Akanbi, G. O. Adesina, and P. A. Babajide, "Evaluation of Tithonia diversifolia (Hemsl.) A gray for soil improvement," *World J. Agric. Sci.*, vol. 3, pp. 503-507, 2007.

[26] S. Nagarajah and B. M. Nizar, "Wild sunflower as a green manure for rice in the midcountry West Zone," *Tropical Agric.*, vol. 138, pp. 69-78, 1982.

[27] R. Birech and B. Freyer, *Effects of plant biomass and thier incorporation depth on organic wheat production in Kenya.* Egerton, Kenya: Egerton University, 2007.

[28] P. Adriano, H. S. S. Ricardo, S. U. Segundo, R. C. Paulo, G. M. G. José, and G. B. Freitas, "Sunnhemp and millet as green manure for tropical maize production," *Sci. Agric. Braz.*, vol. 63, pp. 453-459, 2006.

[29] J. N. Gitari, J. G. Mureithi, S. K. Karumba, and K. Mwaniki, *Legume green manuring for maize production on smallholder farms in the Eastern and central Kenya.* Kenya: Agricultural Research Institute, Nairobi, 1996.

[30] A. A. M. Jose, T. M. C. Marcia, E. W. Alcido, and D. D. Agostinho, *Growth and productivity of maize cultivated in no-tillage in succession of different cover crops.* Brazil: A Brazilian Agricultural Research Corporation (EMBRAPA), 2007.

[31] C. N. Gachengo, "Phosphorus release and availability on addition of organic material to P fixing soils," An MSc Thesis, Moi University, Eldoret, Kenya, 1996.

[32] C. A. Palm and A. P. Rowland, *A minimum dataset for characterization of plant quality for decomposition. In: G. Cadisch and K.E. Giller (Eds.). Driven by nature: Plant litter quality and decomposition.* U.K: CAB International, Wallingford, 1997.

[33] A. O. Shokalu, O. Aderemi, A. Ezekiel, T. Dorcas, H. A. Akintoye, and O. Jamiu, "Comparing the use of Tithonia diversifolia and compost as soil amendments for growth and yield of Celosia rgentea " *New York, Science J.*, vol. 3, pp. 1-33, 2010.

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Table-1. Effects of species and age on plant height, dry matter production of leaves and stems of the green manure

Treatment			Dry matter yield (t ha^{-1})		
		Plant height (cm)	Leaves	Stem	TAGB
T.diversifolia at3MAP		26.933h	5.4600de	4.5267cd	9.9867c
T. vogelii at3MAP		50.100g	2.9400f	3.4667d	6.4067d
C. juncea at3MAP		28.333h	1.7333f	1.3800e	3.1133e
T.diversifolia at4MAP		71.000d	6.9333bc	7.0533b	13.9867b
T. vogelii at4MAP		66.333e	4.5200e	4.8567cd	9.3767c
C. juncea at4MAP		62.700f	5.0400e	5.1533c	10.1933c
T.diversifolia at5 MAP		145.667a	9.0667a	12.0200a	21.0867a
T. vogelii at5MAP		95.667c	7.9267ab	7.2100b	15.1367b
C. juncea at5MAP		98.833b	6.4900cd	7.9500b	14.4400b
LSD (5%)		2.7529	1.257	1.5757	2.0351
CV%		12.2173	13.0128	15.2807	10.2018

Table-2. Nutrient Concentration of the green manures at their different ages after planting

Green manure (GM) species	Nutrient concentration (% in dry weight basis)				
	N	P	K	Ca	Mg
Three months after planting					
Tithoniadiversifolia	4.375	0.108	4.890	0.211	0.026
Tephrosiavogelii	3.738	0.143	5.389	0.215	0.039
Crotalaria juncea	4.424	0.132	4.095	0.077	0.008
Four months after planting					
Tithoniadiversifolia	4.438	0.096	4.890	0.149	0.022
Tephrosiavogelii	3.339	0.115	5.089	0.098	0.019
Crotalaria juncea	3.99	0.139	4.695	0.059	0.008
Five months after planting					
Tithoniadiversifolia	3.934	0.143	4.590	0.115	0.020
Tephrosiavogelii	3.346	0.102	5.495	0.070	0.021
Crotalaria juncea	3.374	0.108	4.591	0.053	0.011

Table-3. Physiochemical properties of soil of the experimental field (0-20 cm)

Para-meter	Particle size (%)			Tex-ture	pH (H_2O)	*OM (%)	TN (%)	------- mg kg^{-1} -------			
	Sand	Silt	Clay					NO_3-N	NH_4-N	AP	AK
Value	36	39	25	Loam	5.5	4.45	0.124	11.31	9.0	0.117	540.7

*OM = Organic matter; TN = Total nitrogen; AP = Available phosphorus; AK = Available Potassium

Table-4. MeanmonthlyweatherdataforArekaAgriculturalResearchCenterduringthe evaluation period

Month	Rainfall (mm)	Mean temperature (0C)	
		Maximum	Minimum
May	194.3	26.2	14.4
June	128.4	25.6	14.5
July	218.9	23.4	14.1
August	291.5	23.2	14.7
September	225.9	24.1	14.4
October	136.1	24.8	13.8
November	92.2	27.3	13.2
Total	1287.3	-	-
Mean		24.9	14.2

Source: Areka Agricultural Research Center Agro-metrology Service

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