Agricultural Science Research Journal Vol. 7(4): 171 – 176, April 2017
Available online at http://resjournals.com/journals/agricultural-science-research-journal.html
ISSN: 2026 –6073 ©2017 International Research Journals

Full Length Research Paper

Fallow management potentials of *Sesbania pachycarpa* DC.: The green manure effects on *Amaranthus cruentus* L. in Ibadan, South Western Nigeria

***Kehinde R. Egberongbe[1], Rasheed O. Awodoyin And Oluseun S. Olubode**

Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, NIGERIA

[1]National Horticultural Research Institute, PMB 5432, Ibadan, Nigeria

*Corresponding author; kehinde_egberongbe@yahoo.com; 08020770701.

Abstract

Sown fallow with nodulating legume shrubs has been identified as an alternative in improving soil fertility. The green manure potential of *Sesbania pachycarpa* on the performance of *Amaranthus cruentus* were studied in pot and field experiments in Ibadan, Nigeria. *Sesbania pachycarpa* seedlings were grown in pots for 0 (control), 15, 30, 45, 60 and 75 days, and on field for 0, 30, 45 and 60, before incorporating into the soil to assess the Green Manure (GM). Three weeks after incorporation, *Amaranthus cruentus* was grown on the soil for six weeks. The performance of *A. cruentus* was assessed with Plant Height (PH), Stem Diameter (SD) and Number of Leaves (NL). The pot and field experiments were CRD and RCBD, respectively with three replicates. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$. In the pot trial, the performance of *A. cruentus* [PH (45.30±0.8 cm), SD (0.6±0.1 cm), NL (18±0.3)] were highest in 45-Day GM. The field results followed the same trend with PH (46.30±1.2 cm), SD (0.8±0.1 cm) and NL (19.3±0.7) of *A. cruentus* highest in 45-Day GM. Turning in the plant grown for a minimum of 45 days improved performance of *Amaranthus cruentus*.

Keywords: Sesbania pachycarpa, Nodulating legume shrubs, Green manure, Amaranthus cruentus.

Introduction

Fallowing or bush fallowing, also known as the regeneration phase of land use (Nair, 1993), has been defined as the act of leaving a previously cultivated land for natural re-vegetation so that the land can regain its exhausted fertility. Fallow periods have a number of benefits. The most important ones include soil fertility restoration, suppression of weeds, and protection of the soil against erosion. Research has shown that green manure can substitute for up to 60-100 kg N fertilizer per hectare in the production of cereals (Ozowa, 1995). Fallows may also supply a source of cash income for the farmers through the existence or planting of specific economic valuable species. In addition, fallows may provide products that serve as agricultural inputs such as fodder and fencing materials for farms with a livestock component. However, the length of fallow period has been reduced due to increasing human population, which places pressure on a finite arable landmass in West Africa . Since fallow phase has become too short to build up soil fertility to levels that can support meaningful production (Mapfomo and Giller, 2001), a deliberate planting of leguminous plants (trees, shrubs and herbs) has been integrated into agricultural land management practices to revitalize soil fertility (Tauro *et al*., 2007). Gathumbi *et al*. (2003) reported that most leguminous plants have been introduced into fallows because of their ability to fix nitrogen thereby increasing soil fertility through nutrient cycling, litter fall, biomass input and biological nitrogen fixation. Boller *et al.* (2004) reported that *Glycine max, Vigna unguiculata, Crotalaria juncea* and *Sesbania* species fix atmospheric nitrogen in the ranges 310, 140-159, 108 and 250-360 kgN/ha respectively within 45 to 60 days after planting. Ladha *et al*. (1989) also reported that green manure from the nitrogen fixing *Sesbania rostrata* (a stem and root nodulating legume) was equivalent to 60-120 kg N per hectare as urea in a rice ecosystem. The above reports present legumes as an appropriate alternative to the application of inorganic nitrogen fertilizer and thus prevent the environmental degradation effect of the application.

Planted fallows, especially herbaceous cover crop-based fallows, have been advocated as a better alternative to natural bush fallow systems because of their efficiency in protecting the soil from erosion, restoring nutrients, and alleviating weed problems (Mulongoy and Akobundu, 1990; Awodoyin and Ogunyemi, 2005; Awodoyin and Egberongbe, 2010). Fertilizer nitrogen is used inefficiently by crops. Up to 50 percent of industrially fixed nitrogen becomes part of the current crop; of the other 50 percent, or more, some is stored in soil organic matter, where it becomes available to subsequent crops, some is converted back to atmospheric nitrogen through denitrification, and some is leached and pollutes the groundwater as nitrate (NO_3). Denitrification of nitrate produces about 90 percent nitrogen gas and 10 percent nitrous oxide, a greenhouse gas. The increase in nitrous oxide (N_2O) aggravates the global warming and climate change (Ogunyemi *et al.*, 2010).

In Southwestern Nigeria, *Sesbania pachycarpa* was recently (from around 2007) observed among the ruderals (Egberongbe, 2016). *Sesbania* is a genus of about 50 species of fast-growing leguminous trees. The introduction of *S. pachycarpa* to this rainforest/humid savanna ecosystem might have been through the importation and distribution of food grains and livestock from Republic of Niger, where it has been serving as famine food during grain shortage (Glew *et al.*, 2005). Considering the observed fast-growing nature of *Sesbania* species, they can be used to manage weeds and generate biomass for soils. Singh *et al.* (2006) reported that intercropping a *Sesbania* species with rice for 30 days was as effective in controlling weeds with application of wheat residue mulch at 4 tonnes/ha. These *Sesbania* plants are often into exceptionally vigorous associations with nitrogen-fixing *Rhizobium* bacteria, characterized by rapid development of large, numerous root nodule clusters (Egberongbe, 2016). Its main advantage is that it smothers weeds, and it can play an important role in soil conservation and maintenance of soil fertility.

Vegetable cultivation has become a major aspect of horticulture in view of the value of its products. According to FAO (1992), *Amaranthus cruentus* L. ranked among the best leaf vegetables in terms of its chemical composition and nutritional status. It contributes much in ameliorating nutrient imbalance in human diet (Messiean, 1989). *Amaranthus cruentus* contains appreciable amount of crude protein, minerals (calcium and potassium) and vitamins A and C that can contribute substantially to our daily requirements when consumed in reasonable quantity (Rubatzky and Yamaguchi, 1997).

Sesbania pachycarpa, judging from its rapid growth and continuous cover at road sides may be an ideal green manure plant. Therefore, this study aims at understanding the green manure potentials of *Sesbania pachycarpa* and its effect on growth of *Amaranthus cruentus*.

Materials and methods

Green manure potentials of *Sesbania pachycarpa* and effect on growth of *Amaranthus cruentus*

Pot experiment

A completely randomized design with three replicates was used to study the green manure potentials of *Sesbania pachycarpa* and their effects on growth of *Amaranthus cruentus* in 2013. Seeds of *Amaranthus cruentus* (variety NHAE) were sourced from National Horticultural Research Institute, Ibadan (NIHORT). The experiment was conducted in the Crop Garden of the Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan, Ibadan. Each pot (30 cm depth and 28 cm diameter) was filled with 5 kg (dry weight) top soil collected in the Crop garden. Three pots were randomly allocated to each treatment.

The *Sesbania* Green Manure (GM) plants were grown in pots for durations including 15, 30, 45, 60 and 75 days. The control pots had no GM plant. To obtain the durations and achieve incorporation in all treatments at the same time, planting of GM plants were done at 15 days interval up to 60 days. At 75 DAP, all the GM plants were cut back and turned into the soil within 0-15 cm depth to decompose. After three weeks, soil samples were collected from each treatment for routine analyses, and seeds of *Amaranthus cruentus* were sown into the pots. The seedlings were thinned to two per pot a week later.

At two, four and six weeks after planting of *amaranthus*, the plant height (using meter rule) and number of leaves (by visual counting) were measured. However, the stem diameter at soil level (using a digital vernier caliper; power fix model) was measured at four and six weeks after planting.

Field experiment

A field experiment was carried out at NIHORT, Ibadan. The aim of the experiment was to determine the green manure potentials of *Sesbania pachycarpa* in a field experiment. The *Sesbania* GM plants were grown on plots (2 m x 2 m) for durations including 30, 45 and 60 days. The control plot in each block had no GM plant. The experiment was a Randomized Complete Block Design with three replications. The distance between plots was 50 cm and between blocks was 1 m. Seeds of *Amaranthus cruentus* were sown into the plots at plant spacing 15 cm x 30 cm, giving a total of 56 plants /plot. All other processes were as in the pot experiment above.

Soil analysis procedures

The composite soil samples collected were later sieved and sub-samples were taken for various chemical analyses. Soil samples used for pH, P, K, Ca, Mg, Na, Fe, Cu, Mn and Zn determination were sieved through 2 mm wire mesh, while the samples used for determination of organic carbon and total nitrogen were sieved with 0.5 mm wire mesh.

The pH was determined in 1:1 (soil: water) ratio using pH meter (Mettler Toledo Seven Multimeter). Available Phosphorus was determined by Bray -1 method following Bray and Kurtz (1945). The exchangeable K, Ca, Mg, and Na were determined using Mehlick-3 extraction method following Mehlick (1984). The K and Na in the extract were determined using flame photometer, while the Ca and Mg were determined by atomic absorption spectrophotometer. Soil organic carbon was determined by Walkley-Black oxidation method following Nelson and Sommers (1982) and total nitrogen by the macro-Kjeldahl method going through digestion, distillation and titration procedures. The soil micronutrients (Zn, Fe, Mn and Cu) were extracted by diethylene pentaacetic (DTPA) and determined by atomic absorption spectrophotometer. The particle size analysis was determined by Bouyoucous hydrometry method.

Results

The effects of *Sesbania pachycarpa* green manuring on soil properties

The effects of varying durations of *Sesbania pachycarpa* used as green manure (GM) on the soil properties in 2013 are shown in Tables 1 and 2. Soil total nitrogen before commencement of study was 0.01 and 0.13 g/kg in the pot and field trials respectively. At the end of pot experiment, soil nitrogen increased in all the treatments, the highest was 1.4 g/kg on 75-D soil and the lowest nitrogen was on 45-D soil. Nitrogen in the soil ranged from 0.09 to 0.12% at the end of the field trial.

Table 1: Results of soil analysis before and after the green manure potentials of *Sesbania pachycarpa* (pot study) in Ibadan, Nigeria

Soil Properties		Values						
		Before trial	After trial					
			Control	15-DGM	30-DGM	45-DGM	60-DGM	75-DGM
pH		6.5	6.61	6.82	6.55	6.71	6.76	6.69
Particle size (g/kg)	Sand	764	894	884	884	874	864	864
	Clay	66	64	52	62	52	78	84
	Silt	170	42	64	54	74	58	52
Exchangeable bases (cmol/kg)	Ca	7.66	3.68	4.95	6.29	5.83	6.17	8.42
	Mg	2.18	0.74	1.23	1.75	1.41	2.12	2.37
	Na	1.7	0.29	0.20	0.27	0.26	0.33	0.34
	K	1.2	0.1	0.3	0.5	0.4	0.5	0.6
ECEC		12.78	4.29	6.77	8.85	7.99	9.23	11.74
% base sat		99.69	98.6	99.3	99.0	99.0	99.1	99.5
Organic C (g/kg)		0.22	0.08	0.09	0.11	0.09	0.10	0.14
Total N (g/kg)		0.01	1.07	1.09	1.21	0.85	0.90	1.35
Available P (mg/kg)		10.85	11.67	16.52	12.72	12.66	7.23	17.56
Cu (mg/kg)		0.65	0.95	1.02	1.13	0.94	1.23	1.37
Zn (mg/kg)		3.5	2.85	4.75	4.91	6.36	6.22	7.05
Mn (mg/kg)		22	24.4	35.7	34.9	41.66	40.1	35.2
Textural class		Sandy loam						

where DGM = Day Green Manure

Table 2: Results of soil analysis before and after the green manure potentials of *Sesbania pachycarpa* (field study) in Ibadan, Nigeria

Soil Properties		Values				
		Before trial	After trial			
			Control	30-DGM	40-DGM	60-DGM
pH		5.5	5.55	5.80	5.95	5.85
	Sand	764	834	860	860	880
Particle size (g/kg)	Clay	66	86	66	86	86
	Silt	170	80	74	54	34
	Ca	8.62	4.62	5.33	3.90	3.41
	Mg	1.03	1.58	1.58	1.29	1.66
Exchangeable bases (cmol/kg)	Na	0.75	0.71	0.65	0.52	0.56
	K	0.43	0.38	0.34	0.29	0.27
ECEC		10.91	7.34	7.96	6.07	5.96
% base sat		99.27	99.32	99.25	98.85	98.9
Organic C (g/kg)		1.65	1.45	1.17	1.03	1.09
Total N (g/kg)		0.13	0.12	0.10	0.09	0.12
Available P (mg/kg)		13.41	27.04	23.74	31.98	21.6
Cu (mg/kg)		1.05	0.99	0.90	1.24	1.33
Zn (mg/kg)		0.85	2.55	5.23	7.00	9.12
Mn (mg/kg)		101.0	62	105	118	108
Textural class		Sandy loam				

Effect of green manuring on growth parameters of *Amaranthus cruentus*

Pot Experiment

Plant Height (PH)

At 4 WAP of *A. cruentus* height growth increased from 20.3 cm in control to 26.0 cm in 45-D GM but decreased to 24.0 cm in 75-D GM (Table 3). The PH at only 45-D GM was significantly ($p<0.05$) greater than control. At 6 WAP all treatments had significantly ($p<0.05$) better PH compared to control. However, the 45-D GM (45.3 cm) was significantly ($p<0.05$) better than other treatments except 60-D GM (42.0 cm) (Table 3).

Table 3: The effect of varying durations of *Sesbania pachycarpa* green manure cover on growth parameters of *Amaranthus cruentus* (Pot Trial)

Duration of Green manure (Days)	Plant Height (cm)		Stem Diameter (cm)		Number of Leaves	
	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP
Control	20.3±0.4	33.3±0.7	0.4±0.1	0.5±0.1	9.0±0.2	14.0±0.1
15-D	23.7±0.8	39.0±0.6	0.4±0.1	0.5±0.1	9.3±0.6	16.0±0.6
30-D	23.3±1.2	39.0±0.5	0.4±0.1	0.5±0.1	9.0±0.3	17.0±0.3
45-D	26.0±0.8	45.3±0.8	0.5±0.1	0.6±0.1	11.3±0.6	18.0±0.3
60-D	25.0±0.4	42.0±1.3	0.4±0.1	0.6±0.1	9.6±0.3	17.3±0.6
75-D	24.0±0.5	40.7±0.4	0.4±0.1	0.6±0.1	9.3±0.4	17.7±0.9
LSD (0.05)	4.6	4.0	0.1	0.1	1.7	2.9

Stem Diameter (SD)

The SD ranged from 0.4 to 0.5 cm at 4 WAP and from 0.5 to 0.6 cm at 6 WAP for the main crop. The 45-D GM was significantly ($p<0.05$) better than all other treatments at 4 WAP but 45-D GM, 60-D GM and 75-D GM were alike but better than control and other treatments (Table 3). However, for the residual crop the SD was less than main crop, ranging from 0.3 to 0.4 cm at 4 WAP and 0.4 to 0.6 cm at 6 WAP. The treatments were not significantly different at the two periods

Number of Leaves (NL)

For the main crop, NL ranged from 9.0 to 11.3 at 4 WAP and 14.0 to 18.0 at 6 WAP. The 45-D GM had significantly higher NL than control and other treatments at 4 WAP (Table 3). Also, at 6 WAP the 45-D GM was significantly ($p<0.5$) better than control and 15-D GM. For the residual crops, the NL was less than the main crop in all the treatments, ranging from 7.3 to 9.3 at 4 WAP and 12 to 15.5 at 6 WAP. Though 45-D GM had highest NL (9.3 at 4 WAP; 15.5 at 6 WAP), all the treatments and control were not significantly different.

Field Experiment

Plant Height (PH)

The PH ranged from 24.3 to 29.0 cm at 4 WAP and 44.0 to 46.3 cm at 6 WAP (Table 2). At 4 WAP all treatments were not significantly different but significantly ($p<0.05$) better than control (Table 4). At 6 WAP all treatments and control were not significantly different. At the two periods, 45-D GM maintained the best height (29.0 cm at 4 WAP; 46.3 cm at 6 WAP).

Stem Diameter (SD)

The SD was 0.6 cm in all treatments at 4 WAP but ranged from 0.7 – 0.8 cm at 6 WAP (Table 4). Treatments were not significantly different at 4 WAP but significantly different at 6 WAP. The 45-D GM had the best SD (0.8 cm).

Number of Leaves (NL)

The 45-D GM had the highest NL at both 4 WAP (14.0) and 6 WAP (19.3) while control had lowest. At 4 WAP the 45-D GM was significantly ($p<0.5$) higher than control and lower durations only, and at 6 WAP the 45-D GM was significantly higher than only control (Table 4).

Table 4: The effect of varying durations of *Sesbania pachycarpa* green manure cover on growth parameters of *Amaranthus cruentus* (Field trial)

	Plant Height (cm)		Stem Diameter (cm)		Number of Leaves	
Duration of manure (Days)	4 WAP	6 WAP	4 WAP	6 WAP	4 WAP	6 WAP
Control	24.3±0.4	44.0±1.5	0.6±0.1	0.7±0.1	12.0±0.9	16.3±0.4
30-D GM	28.3±0.2	44.3±0.4	0.6±0.1	0.7±0.1	11.7±0.4	17.3±0.7
45-D GM	29.0±0.6	46.3±1.2	0.6±0.1	0.8±0.1	14.0±0.6	19.3±0.7
60-D GM	28.3±0.9	44.7±0.6	0.6±0.1	0.7±0.1	12.7±0.5	18.0±0.4
LSD (0.05)	3.6	4.5	0.1	0.1	1.8	2.6

Discussions

Results of analysis of soil in which *Sesbania* was used as green manure at varying time durations showed that initial fertility of the soils were low. Sileshi and Mafongoya (2003) recommended the use of mixed-species sown fallows of *Sesbania,* pigeon pea and *Tephrosia* for improvement of maize production in areas with nutrient-deficient soils in Zambia. After the study in the first trial (pot experiment) the nitrogen levels in the soil increased and the carbon contents decreased. The highest nitrogen levels were found in soils where *Sesbania* were allowed to grow for 75 days before turning into the soil.

Results from field study in which *Sesbania* was used as green manure at varying time durations showed that *Sesbania* manure had a positive effect on the growth of *Amaranthus*. *Sesbania* plants planted for a minimum of 45 days before they were turned into the soil had the highest values for the growth parameters studied. This shows that planting *Sesbania* for at least 45 days before being used as green manure will be beneficial for the succeeding crop. This is in line with Boller *et al*. (2004) who reported that within 45 to 60 days after planting *Sesbania,* it had adequately rejuvenated the soil. Jia *et al*. (1996) reported that *Sesbania* incorporation into the soil improves soil organic matter quality and increases rice yield from 345 to 967 kg/ha. Also, Rinaudo *et al*. (1983) reported that application of *Sesbania rostrata* green manure increased rice grain yield by 372 g/m^2 which is equivalent to using 130 kgN fertilizer. Most tropical soils are extremely fragile and give very poor crop yields after only a few years of cultivation without expensive fertilizer inputs. The decline in soil fertility is followed in many cases by soil erosion and further decline in soil nutrients. The use of nitrogen-fixing trees in agroforestry systems in the humid/sub-humid tropics is therefore attractive as a source of nitrogen and organic matter needed in the rehabilitation of damaged soils. Soil fertility improvements by legumes have mainly been associated with the quantity and quality of recycled biomass that increases the amount of nutrients and soil organic matter in the soil (Barrios *et al.,* 1996). Palm *et al*. (1988) also reported high nitrogen release from *Sesbania* plants in a similar experiment. This nitrogen was obviously readily absorbed by the vegetables. *Sesbania*, a fast growing, nitrogen fixing plant has been reported to increase crop yield, soil organic nitrogen, soil nitrogen mineralization, and the amount of nitrogen in the light fraction of soil organic matter (Barrios *et al*., 1997). However, *Sesbania* litter decomposes rapidly, as it is rich in nitrogen with little lignin and polyphenols (Mafongoya *et al.,* 1998). Therefore, it is unlikely to contribute to long-term enhancement of soil organic matter and the rapidly released nitrogen is prone to leaching if it is not well synchronized with crop nitrogen demand.

Conclusion

The *Sesbania pachycarpa* ploughed in on the field as green manure at 45 days after sowing benefitted *Amaranthus cruentus* most in terms of growth. The reduction in inorganic nitrogen fertilizer input by adopting green manuring would reduce environmental degradation by reducing nitrogen discharge into the surface water thorough run off, thus abating eutrophication.

References

Awodoyin, R. and Ogunyemi, S (2005a). Stocking density effect on the performance and weed smothering ability of an annual legume, *Senna obtusifolia* (L.) Irwin and Berneby. *Ibadan Journal of Agricultural Research (An International Journal)* 1.1: 30-38.

Awodoyin, Rasheed O. and Egberongbe, Rafiat K (2010). Potentials of *Sesbania pachycarpa* DC. as a mulch interplant: Seed germination, early growth and competition with *Tithonia diversifolia* (Hemsl.) A. Gray in Ibadan, Nigeria. *Nigerian Journal of Science* 44: 29-39.

Barrios, E. Buresh, R.J. and Sprent, J.I (1996). Nitrogen mineralization in density fractions of soil organic matter from maize and legume cropping systems. *Soil Biol. Biochemistry* 28: 1459–1465.

Barrios, E. Buresh, R.J. and Sprent, J.I (1997). Light fraction soil organic matter and available nitrogen following trees and maize. *Soil science society of American Journal* 61: 826-831.

Bray, R. A. and Kurtz, L. T. 1945. Determination of total organic and available forms of phosphorus in soils. Soil Science. 59: 34-45.

Boller, E. and Hani, F. Poehling (eds) (2004). Ecological infrastructures: Idea book on functional biodiversity at the farm level. IOBC, OILB, Matten, A.G. Winterthur, Switzerland. 211pp.

Egberongbe, R. K. (2016). Biology of *Sesbania pachycarpa* sensu auct., and its green manure effects on the growth of *Amaranthus cruentus* L. in Ibadan, Nigeria, Unpublished Ph.D. thesis, University of Ibadan 154 pp.(+ xvi).

Food and Agricultural Organization (FAO) (1992). Conversion and rehabilitation of African Land. FAO. A document presented at FAO Regional Conference AIC/90/410/57001, Rome.

Gathumbi, S., Caddish, M. and Giller, K.E. (2003). Improved fallows: Effects of species interaction on growth and productivity in monoculture and mixed stands. *Forestry ecology and management* 187: 267-280.

Glew, R.S., VanderJagt, D.J. R., Bosse, Y.S., Huang, L.T., Chuang and Glew, R. H (2005). The nutrient content of three edible plants of the Republic of Niger. *Journal of Food Composition and Analysis* 18.1: 15-27.

Jia. Bing, Gu, Rougshing and Zhang, Xueshany (1996). Chinese Green manure. Chinese *Agriculture Journal* 18:23.

Ladha, J. K., Garcia, M., Miyan, S., Padre, A. T. and Watanabe, I. (1989). Survival of *Azorhizobium caulinodans* in the soil and rhizosphere of wetland rice under *Sesbania rostrata*. Rice rotation. *Applied Environmental Microbiology* 55: 454-460.

Mapfomo, P. and Giller, K.E (2001). Soil fertility management strategies and practices by smallholder farmers in semi-acid areas of Zimbabwe, International Crop Research Institute for the semi-arid Tropics (ICRISAT). 44pp.

Messiean, C (1989). *The Tropical Vegetable Garden.* Macmillan Publisher, pp. 361-364.

Mehlich, A. 1984. Mehlich 3 soil test extractant: a modification of the Mehlich 2 extractant. Common soil science and plant Analysis 15(12): 1409-1416.

Mulongoy, K. and Akobundu, I.O (1990). Agronomic and economic benefits of nitrogen contributed by legumes in live mulch and alley cropping systems. In P.M Greenshoff; L.E. Roth, G.Stacey and W.E. Nawton, eds Nitrogen fixation: Acheivements and objectives. Newyork. Chapman and Hall. pp. 625-632.

Mafongoya, P.L., Giller, K.E. and Palm, C.A (1998). Decomposition and nitrogen release patterns of tree prunings and litter. Agroforestry Systems 38:77-79.

Nair, P.K.R (1993). *An Introduction to Agroforestry*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 499pp.

Nelson, D. W. and L. E. Sommers (1982). Organic carbon and soil extracts. Agronomy Monograph, No. 9, 2nd .ed. Soil Science Society of America. pp 539-579.

Palm, O., Weerakoon, W.L., de Silva, M.A.P. and Rosswall, T (1988). Nitrogen mineralization of *Sesbania sesban* used as green manure for lowland rice in Sri Lanka. *Plant Soil* 108: 201-209.

Rinaudo, G. Dreyfus, B. and Dommergues, Y (1983). *Sesbania rostrata* green manure and the nitrogen content of rice crop and soil. *Soil Biol. Biochemistry* 15: 111-113.

Rubatzky, V.E. and Yamaguchi, M (1997). World vegetables: Principles, production and nutritive values. 2nd ed. International Thomas Publishing. New York: Chapman and hall, New York, NY, 843pp.

Singh, S., Kunda, S.S., Negi, A.S. and Singh, P.N (2006). Cowpea (*Vigna unguiculata*) legume grains as protein source in the ration of growing sheep. *Small ruminant Research* 64: 247-254.

Sileshi, G. and Mafongoya, P.L (2003). Effect of rotational fallows on abundance of soil insects and weeds in maize crops in eastern Zambia. *Applied Soil Ecology* 23: 211-222.

Tauro, T.P., Neeomba, H., Mtambanengwem, F. and Mapfumo, P (2007). Field emergence and establishment of indigenous N_2- fixing legumes for soil fertility restoration. *Proceedings of African crop science* pp.1929-1935.

Ogunyemi, S., Awodoyin, R.O. and Olubode, O.S (2010). Climate Change, Impacts and Mitigation: Nigerian Experience. *Nigerian Journal of Ecology* 11: 10-19.

Ozowa, V.N. (1995). Information needs of small scale farmers in Africa: The Nigerian example. Quarterly Bulletin of the International Association of Agricultural Information Specialists (IAALD/CABI), 40.1.