THE EFFECT OF APPLICATION OF POULTRY MANURE AND INORGANIC FERTILIZER ON COWPEA: INCIDENCE AND CHLOROPHYLL CONTENT OF FALLOWED WEED

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Abstract

The effect of application of poultry manure and inorganic fertilizer on cowpea was investigated at the Teaching and Research Farm (T&R) of Obafemi Awolowo University, Ile-Ife, Nigeria in the early and late season of 1998. Studies on the diversity, composition and the chlorophyll content of fallowed weeds before and after cowpea harvesting were investigated. The treatments had no significant influence ($p<0.05$) on the species of weed observed but significantly affected the level of occurrence and the chlorophyll concentration of the weeds. The incidence of Chromolaena odorata *(L.) RM King and Robinson was highest across treatments followed by* Panicum maximum *Jaqc and* Strachytarpheta indica *(L.) Vahl,* Desmodium scorpiurus *(SW) Desv,* Corchorus capsularis *L.* Malvastrum ceromandelianum *(L.) Garcke,* Erigeron floribundus *(H.B&K) Sch., and* Triumfetta rhomboidea *Jaqc. in ascending order. The influence of inter and intra specific competition among weeds, the physico-chemical condition and the persistency of the amended materials probably influenced the nutrient availability from the amended materials which they have subsequently affected the extent of the nutrient use of the weeds. These thus affected the incidence, biomass and chlorophyll content of the weeds.*

Keywords: poultry manure, fertilizer, chlorophyll, weeds, competition, incidence and biomass

Introduction

Intensive cropping has now become a characteristic feature of Nigerian agriculture where soil fertility and sustainable production can only be maintained through the use of organic and inorganic fertilizer (Lombin *et al*. 1992). Reyntjes *et al*. (1992) and Adepetu, (1997) indicated that soil fertility management (SFM) involved creating favourable condition for soil life, nutrient application and soil conservation.

The steady decline in food production due to reduced length of fallow and pressure on land have led to the use of soil amendments. Studies by Olayinka, (1996), Ismail *et al*., (1996) and Olayinka *et al*., (1998) on materials suitable for soil amendment have shown that the use of poultry manure, maize stover, refuse compost and cowdung (as organic amendment) significantly improved the physico-chemical and morphological properties of the soil. Furthermore, the effect of soil amendment have been found to increase the total N, and consequently increase soil productivity (Thill and Mallory-Smith 1997) and indirectly increase weed problem. However, the residual effects of the organic amendments on weeds, which grow up in the cropped plot during fallow, have not been determined.

Weed infestation has been found to be one of the problems associated with food production and SFM. Maxwell and Ghersa, (1992), Jordan, (1992), Thill and Mallory-Smith, (1997) and Chombey *et al.*, (1998) recognized some important biological activities that aided the spread of weeds. The use of manure as fertilizer has been shown by Thill and Mallory-Smith, (1997) as a major source of weed spread, especially weeds that have no special dispersal mechanism. Chombey *et al.*, (1998) found that application of farmyard manure with inorganic fertilizer resulted in a high weed growth with lower dry matter in an upland rice (*Oryza sativa* L.) field. Eisele, (1997) also reported high population dynamics in barley (*Hordeum vulgare* L.) field when treated with N fertilizer applied banded. Nutrients uptake by plants have been found to be connected with the production of vigorous vegetative growth, which is associated with a dark green coloration of the leaf. Follett, *et al.*, (1981) reported that the pigmentation of plants is related to the N absorbed by the plant from the soil because N serves as an important component of the chlorophyll molecule. However, no information is available on the particular chlorophyll pigment involved in such colour alteration and its total contribution to the total chlorophyll content. It has been observed that weeds that established during fallow usually serve as indicator to determine the extent of fallow and a measure of soil fertility by the local farmers. Hence the need to investigate the contribution of different soil amendments used in crop production process on the incidence and the chlorophyll content of weeds led to this study.

The objective of this study was to investigate the effect of different soil amendment materials in cowpea production on the incidence and chlorophyll content of fallow weeds.

Materials and Methods

The experiment was conducted at the Teaching and Research (T&R) Farm of the Obafemi Awolowo University (O.A.U), Ile-Ife, Nigeria, located on longitude 04°33"E and latitude 08°28" N and 244 m above sea level. The soil belongs to Iwo series classification derived from coarse-grained gneiss and granite parent rock and is classified as Ultisol (Harpstead 1973). The experiments were carried out during the early (March – June) and late (August – November) cropping seasons of 1998. Table 1 shows the physico-chemical properties of soil of the experimental plot.

The treatment plots were laid out in a Randomized Complete Block Design (RCBD) with a split-plot arrangement. The main plots received the following nutrient sources: poultry manure (PM), inorganic fertilizer (IF), mixture of poultry manure and inorganic fertilizer (IFPM) and the control (C), which is neither treated with inorganic fertilizer, nor poultry manure. The sub-plots consisted of four cowpea cultivars. Each of the sub-plot except the control received 20 kg N/ha plus 15 kg P_2O_5 and 15kg K_2O /ha in form of inorganic fertilizer, organic fertilizer, or a combination of these, as basal dosage as recommended by Borget, (1992). The experiments were replicated three times each season. The poultry manure, which was about three years old contained 0.54% N, 0.16% P and 0.09% K when analysed, was obtained from the Poultry Unit of the Teaching and Research (T&R) Farm, O.A.U., Ile-Ife. It was applied at the rate of 3 tons/ha in each season. The sole PM plot received 4.4 kg (equivalent of 3 tons/ha) of the poultry manure, while 2.2 kg of poultry manure was mixed with inorganic fertilizer which was equivalent to 50% of the IF applied in sole plot to form the IFPM treatment. The nitrogen, potassium and phosphorus (N, P, K) components of each of PM and IFPM was thus calculated each to be equivalent to 20 kg N_2/ha plus 15 kg P_2O_5 and 15kg K_2O_5 /ha. The inorganic fertilizer (N.P.K., 20:10:10 a commercial fertilizer) was calculated according to Adepetu (1986) to give 20 kg N_2/ha plus 15 kg P_2O_5 and 15kg K_2O_5 /ha. The control plot was neither treated with PM nor IF. The treatments were incorporated into the soil after broadcasting, using hoe to a depth of 5 cm and planting was carried out 24 hours after incorporation (Uhlen and Tveitnes 1995).

Table 1. Some physico-chemical characteristics of the soil at the experimental site of the Teaching and Research Farm, Ile-Ife during each sampling time.

	Early Season			Late Season		
Chemical properties	S1	S2	S3	S1	S2	S3
pH (0.01M $CaCl_2$)	5.0	4.06	4.08	5.40	4.96	4.61
Organic matter (%)	1.05	1.15	1.18	0.96	1.02	1.11
Total nitrogen (%)	0.09	0.24	1.33	0.08	0.18	1.00
P (ppm)	2.95	3.15	3.26	4.19	3.55	3.15
Exchangeable cations (Cmol kg^{-1})						
K^+	0.28	0.29	0.35	0.43	0.32	0.48
Ca^{2+}	1.42	1.46	1.60	1.13	1.32	1.43
Mg^{2+}	0.09	0.11	0.10	0.13	0.15	0.16
Particle size (%)						
Sand	73.2	73.0	73.0	71.0	73.3	72.2.
Silt	15.4	15.0	15.0	19.0	16 5	13.5
Clay	11.4	12.0	12.0	10.0	10.2	12.3
Textural class	Sandy loam			Sandy loam		

S1 - First sampling date during cowpea harvest.
S2 - Second sampling date two months after harvest.
S3 - Third sampling date fourth months after harvest.

Weed identification commenced during harvesting of the cowpea and subsequent weed sampling were done at two-monthly intervals for three months after harvesting to have a total of three sampling dates per season. A detailed sampling of the fallowed vegetation for the two seasons were done using 1-meter quadrat laid out in each experimental sub-plot. Each sub-plot had two randomly laid-out quadrats; there was a total of 28 samples per season. Weed incidence was scored according to the method of Lagoke *et al.,* (1988) with the aid of a standard flora. The weeds were pooled for each season across treatment.

The most prominent weed species across plots and treatments were further sampled for chlorophyll content following the methods of Bansal *et al.*, (1999) in which 100 mg fresh leaf was crushed in 5 ml of 80% acetone and the extract centrifuged for 10 minutes at 1000 rpm. Absorbance of the supernatant was recorded at 645 and 633 nm in a CL-24 spectrophotometer. Chlorophyll content (expressed as mg/g^{-1} of each sample) was estimated according to Bansal *et al.*, (1999) as follows:

$$\text{Chlorophyll a } (mg/g^{-1}) = 12.7\,(A663) - 2.69\,(A645)$$
$$\text{Chlorophyll b } (mg/g^{-1}) = 22.9\,(A645) - 4.86\,(A663)$$
$$\text{Total Chlorophyll t } (mg/g^{-1}) = 20.2\,(A645) - 8.02\,(A663)$$

Where A = absorbance.

Data collected were subjected to Analysis of Variance (ANOVA) to determine the effect of treatments on the weeds and their chlorophyll content according to Steel and Torrie, (1980) and Gomez and Gomez, (1984). Means were separated using the Least Significant Differences (LSD) method at 5% level of probability.

Results and Discussion

Table 2 shows the weed species and their population distribution at the experimental plots. Broad leaf weeds, grasses and sedges accounted for 83.3%, 8.3% and 8.3% respectively. The population or occurrence of *Chromolaena odorata* (L.) RM King and Robinson was highest across treatments followed by *Panicum maximum* Jacq and *Strachytarpheta indica* (L.) Vahl, *Desmodium scorpiurus* (SW) Desv, *Chochorus capsularis* L. *Malvastrum ceromandelianum* (L.) Garcke, *Erigeron floribundus* (H.B&K) Sch., and *Triumfetta rhomboidea* Jacq. in descending order.

Weed population and dry matter were highest under the mixture of inorganic fertilizer and poultry manure (IFPM) compared to other treatments (Table 3) followed by poultry manure (PM) treated plot while weed population and dry matter in plots treated with IF was the least in both seasons. The favoured environment in IFPM treated plots may be due to increased and prolonged available nutrient, which might have contributed to favoured physico-chemical properties of the soil; coupled with the non toxic effect of the poultry manure component in the IFPM mixture which readily became available to weed for growth and development during sampling period. *Icacina trichanutha* Oliv. and *Triumfetta rhomboidea* Jacq. had lower population under control compared to other weeds under other treatments. This result is similar to the observation of Makinde *et al*,. (2000) who found that weed population and weed dry weight were lower under inorganic fertilizer.

Table 2. Effect of application of poultry manure and inorganic fertilizer on incidence and composition of fallowed weed species in cowpea at the Teaching and Reasearch Farm. (Values are means across two seasons. Means in the same column but not the same row followed by the same letter are not significantly different from each other at 5% level of probability using DMRT.)

WEED SPECIES	LIFE CYCLE	TREATMENT (no/m^2) C	IF	IFPM	PM	LSD(5%)
BROAD LEAF						
Erigeron floribundus (H.B&K) Sch. Bip (= *Conyza floribundus* (H.B&K)	Annual	11.0e	10.1f	11.0e	10.1d	ns
Chromolaena odorata (L.) RM King and Robinson	Perennial	101.1a	99.8a	100.2a	101.0a	ns
Vernonia cinerea (L.) Less	Annual	41.3d	9.9f	9.0e	10.0d	10.14
Phyllanthus amarus Schum Thonn	Annual	41.0d	40.0d	11.0e	41.0c	10.36
Icacina trichanutha Oliv.	Perennial	11.2e	11.0f	61.0b	62.0b	13.21
Malvastrum ceromandelianum (L.) Garcke,	Perennial	9.9e	9.0f	10.0e	10.0d	ns
Desmodium scorpiurus (SW) Desv, (=*Hedysarum scorpiurus* Desv,)	Annual	42.0d	43.1	44.1c	64.5b	9.54
Chochorus capsularis L.	Perennial	61.0c	40.0d	40.0c	41.2c	10.26
Triumfetta rhomboidea Jaqc.	Perennial	11.8e	21.0e	21.0d	10.0d	9.30
Stachytarpheta indica (L.) Vahl,	Annual	83.0b	65.0c	65.1b	66.0b	8.52
GRASS						
Panicum maximum Jacq	Perennial	84.1b	85.3b	65.6b	66.1b	8.41
SEDGES						
Meriscus alternifolius Vahl (=*M. umbellatus* Vahl	Perennial	40.3d	40.0d	41.0c	40.0c	ns

C - Control
IF - Inorganic Fertilizer
IFPM - Inorganic Fertilizer and Poultry Manure
PM - Poultry Manure

Table 3. Effect of application of poultry manure and inorganic fertilizer on the incidence of fallow weeds at early and late seasons of 1998 at the Teaching and Research Farm six months after harvesting cowpea.

Treatment	Early Season		Late Season	
	Weed Count (no/m^2)	Biomass (g/m^2)	Weed Count (no/m^2)	Biomass (g/m^2)
Control	38	22.3	39	27.2
Inorganic fertilizer	37	28.2	35	26.1
Inorganic fertilizer + poultry manure	54	35.7	52	32.6
PM	52	30.1	51	29.3
LSD 5%	2.36	3.45	2.81	1.66

Considering the effect of amended plots on the incidence of fallow weeds at each sampling period (Table 4), while the weed count (no/m^2) and biomass (g/m^2) increased under IFPM and PM treated plots, there was decline under IF and control. The decline in weed incidence with increased sampling time might be due to the depletion of nutrient components in the materials used; as such, nutrients might have been used by cowpea for its growth and development thus making the nutrients unavailable or insufficiently available for the weeds growth and development. It could be deduced that the supposedly added nitrogen by cowpea fixation may not be available for the weeds use. The gradual release of nutrients by poultry manure could be responsible for the sustained weed incidence and growth.

Table 4. Effect of application of poultry manure and inorganic fertilizer on fallowed weed count and biomass at different sampling period in cowpea. (Mean data taken across early and late seasons of 1998 at the T & R farm of Obafemi Awolowo University, Ile-Ife, Nigeria).

TREATMENT	WEED COUNT (no/m^2)				Biomass (g/m^2)			
	S1	S2	S3	S4	S1	S2	S3	S4
Control	26	20	22	2.36	18.0	10.5	14.1	1.89
Inorganic fertilizer	28	27	25	ns	21.8	19.3	16.8	2.13
Inorganic fertilizer + poultry manure	26	38	37	5.32	18.3	22.0	24.5	2.54
PM	28	39	27	4.75	19.3	23.1	25.8	3.74
LSD 5%	ns	3.22	3.01		ns	2.62	2.54	

S1 - First sampling date during cowpea harvest.
S2 - Second sampling date two months after harvest.
S3 - Third sampling date fourth months after harvest.

The effect of inter-specific competition among weeds with time may also affect the weed incidence as fallow period increases (Table 5). C*hromolaena odorata* a perennial weed had greatest incidence among all weeds in all the fallowed period sampled across treatment (Table 5) while the incidence of *S. indica* decreased significantly as the period of fallow increased. It was however observed that *P. maximum*, a perennial weed with high incidence was stable among other weed. The decrease in the incidence of *S. indica* may be due to the short life circle while *C. odorata*, which has been noted for its noxious nature eventually dominated the ecosystem as fallow period increased.

Table 6 shows the effect of soil amendments on cowpea plots on the chlorophyll content of six randomly selected fallow weeds of the treated plots. There was significant variation in the chlorophyll content among the weed species. The significant variation observed on the pigments of the same weed species across different treatments suggested that the amendment materials (fertilizers) influenced the development of the chlorophyll. The chlorophyll content of the weed species was significantly lower under control compared to those under IF, IFPM and PM except *chlorophyll a*, which showed the reverse result. There was no significant difference ($p > 0.05$) in the total chlorophyll content of *D.*

scorpiurus and *S. indica* between the control and IF treatments. This result may be due to the non-persistence on the IF as the nutrient component is easily made available for the growth and development of cowpea and other weeds. A significant amount of nutrient might have been washed off by rain or through leaching. The total chlorophyll content were significantly higher ($p > 0.05$) under PM as shown by *C. odorata,* (44.1), *P. amarus* (37.3), *D. scorpiurus* (53.6), *S. indica* (37.4), *P. maximum* (18.6) and *M. alternifolius* (9.6) than the other treatment . This suggested that weeds under PM plots may have the highest growth and competitive potential than weeds of other treatments due to high chlorophyll content.

Table 5. Effect of application of poultry manure and inorganic fertilizer on fallowed weed composition at different sampling period at the Teaching and Research Farm in cowpea. (Values are means across two seasons. Means in the same column followed by the same letter are not significantly different from each other at 5% level of probability using DMRT).

WEED	LIFE CYCLE	TREATMENT C S1	C S2	C S3	IF S1	IF S2	IF S3	IFPM S1	IFPM S2	IFPM S3	PM S1	PM S2	PM S3
		No /m^2			No /m^2			No /m^2			No /m^2		
BROAD LEAF													
Erigeron floribundus (H.B&K) Sch.	A	11f	10e	10f	10e	11f	11f	10f	10h	11e	11e	11f	10f
Chromolaena odorata (L.) PM King and Robinson	P	90a	100a	105a	99a	102a	98a	100a	99a	98a	98a	100a	105a
Vernonia cinerea (L.) Less	A	38d	40c	39e	8f	9f	12f	9f	8h	8e	8e	9f	10f
Phyllanthus amarus Schum Thonn	A	38d	40c	45d	38c	40d	40d	9f	12h	11e	40d	41e	41e
Icacina trichanutha Oliv.	P	10f	13e	12f	10e	9f	10f	58c	60d	61b	60b	64c	59c
Malvastrum ceromandelianum (L.) Garcke,	P	10f	11e	9f	8f	8f	9f	8f	9h	10e	9e	7f	12f
Desmodium scorpiurus (SW) Desv,	A	38d	40c	41e	43c	42d	40d	45d	44e	42c	58c	64c	66b
Chochorus capsularis L.	P	36e	42c	43d	42c	40d	39d	40d	38f	42c	41d	42e	39e
Triumfetta rhomboidea Jacq.	P	11f	10e	10f	20d	22e	20e	21e	21g	20d	10e	9f	10f
Stachytarpheta indica (L.) Vahl,	A	83b	78b	70c	85b	66c	60c	65b	72b	61b	66b	55d	50d
GRASS													
Panicum maximum Jacq	P	84b	82b	81b	85b	84b	88b	65b	66c	65b	66b	70b	61b
SEDGES													
Meriscus alternifolius Vahl	P	40c	38d	40e	40c	40d	39d	40d	42e	38c	39d	39e	40e

C - Control
IF - Inorganic Fertilizer
IFPM - Inorganic Fertilizer and Poultry Manure
PM - Poultry Manure
S1 - First sampling date during cowpea harvest.
S2 - Second sampling date two months after harvest.
S3 - Third sampling date four months after harvest.

The treatments significantly affected *chlorophyll b* component of the chlorophyll but the proportional effect varied among weed species. The proportional differences may be as a result of differential response and the ability of different weed to utilize the available nutrient. *Desmodium scorpiurus,* which is a legume, had *chlorophyll a, b* and total under control as 16.8, 7.2 and 24.0 respectively while under PM, it had 12.3, 41.3 and 53.6. *Panicum maximum*, a grass, had values of 8.5, 2.3 and 10.8 under control, with 3.25, 15.7 and 18.6 respectively as *chlorophyll a*, *b* and *t* under PM. The average ratio of

Table 6. Effect of application of poultry manure and inorganic fertilizer on cowpea: Effect on chlorophyll content of six dominant fallow weed species

Treatment	***Chromolaena*** *odorata*			*Phyllanthus amarus*			***Desmodium scorpiurus***			*S tachytarpheta indica*			*Panicum maximum*			*Meriscus alternifolius*		
	Chl. a	**Chl. b**	**Chl..t**	**Chl. a**	**Chl. b**	**Chl..t**	**Chl. a**	**Chl. b**	**Chl..t**	**Chl. a**	**Chl. b**	**Chl..t**	**Chl. a**	**Chl. b**	**Chl..t**	**Chl. a**	**Chl. b**	**Chl..t**
Control	16.7	5.2	21.9	12.5	4.0	16.5	18.8	7.2	24.0	6.1	18.3	24.4	8.5	2.3	10.8	4.0	0.9	4.9
Inorganic fertilizer	21.8	7.4	29.2	18.4	6.1	24.5	17.2	8.8	26.1	7.4	20.4	27.8	10.3	2.8	13.1	6.2	2.1	8.3
Inorganic fertilizer and poultry manure	10.5	20.5	31.0	6.8	18.7	25.5	10.3	20.5	30.8	8.0	24.0	32.0	3.0	14.1	17.1	2.0	6.2	8.2
poultry manure	5.7	37.6	44.1	2.3	24.3	37.3	12.3	41.3	53.6	12.0	25.4	37.4	3.2	15.7	18.6	2.3	7.3	9.6
LSD 5%	1.36	2.55	3.12	2.52	2.55	1.86	2.49	3.87	4.50	2.60	2.36	0.25	0.54	1.80	2.8	1.00	1.07	0.32

Chl. a = Chlorophyll a
Chl. b = Chlorophyll b
Chl..t = total Chlorophyll

chlorophyll "a" to "b" of weeds in control and IF plots were 3:1 whereas, those in PM and IFPM were 1:5. The formal ratio was normal as it is generally observed in green plants (Leopold and Kriedemann 1975). The latter ratio can be suggested to be an adaptive strategy by green plants to survive unfavourable growth conditions (Raghavendra 1998). In this case, *chlorophyll b*, which was abundant, may be assisting in harvesting and transporting excitation energy to chlorophyll a for photosynthetic activities.

It can be concluded that the different amendments on the soil and the additional nutrient added to the soil by the cowpea plant through fixation might have significantly affected the level of available nutrient to the weeds. However, the influence of inter and intra specific competition among weeds, the physico-chemical condition and the persistence of the amended materials might have influenced the nutrient availability of the amended materials which subsequently affected the extent of utilization and the nutrient use efficiency of the weeds. These will subsequently affect the physical nature of the plant in terms of incidence, population dynamics and chlorophyll content.

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REFERENCES

Adepetu, J.A. (1986). Soil fertility and fertiliser requirement in Oyo, Ogun and Ondo States of Nigeria. *Produced for Fed Dept of Agric Land Resources Lagos*. 177 pp.

Adepetu, J.A. (1997). Soil and Nigerian food security. *Inaugural Lecture Series; 119* Obafemi Awolowo University Press, Ile-Ife, Nigeria. 19pp.

Bansal, U.K., Saini, R.G. and Kaur, A. (1999). Genetic variability in leaf area and chlorophyll content of aromatic rice. *International Rice Research Notes*. 24(1):21

Borget, M. (1992). Food legumes. *The Tropical Agriculturist Series*. C.T.A. Netherlands. 103pp.

Chombey, N.K., Tripathi, R.S. Ghosh, B.C. and S.S. Kolhe (1998). Influence of fertilizer and weed management practices on weed growth and yield of direct seeded upland rice, *Oryza* 35 (2): 154-158

Eisele, J.A. (1997). Influence of nitrogen fertilization and cultivar selection on the development of selected weed species in organically grown winter wheat. *Institut Fui Organischeu Landban Schriftenreihes.* 4: 164-170.

Follett, R.H., Murphy, L.S. and Donalue, R.L. (1981). Soil-Fertilizer-plant relationship. *Fertilizer and Soil Amendment* 6(16): 478-481.

Jordan, N. (1992). Weed demography and population dynamics: implication for threshold management. *Weed Technology* 6:184-!90.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedure for agricultural research. 2nd. Edition, *John Wiley & Sons Co* N.Y. 680pp.

Harpstead, M.J. (1973). The classification of some Nigerian soils. *Soil Science* 166:437-443

Ismail, A.S., EL-Sebaay, A.S., Salehu, S.A. and Abdel-Wahab, A.F. (1996). Effect of application of mineral and organic amendment of nodulation of cowpea, growth and certain chemical properties of calcareous soil. , *Annal of Agricultural Science Special Edition*: 23-39.

Lagoke, S.T.O., Adejowon, K.O. and Norgu, T.T. (1988). Studies on weed interference and chemical weed control in chilli pepper (*Capsicum frutuences*L.). *Nigerian Journal of Weed Science.* 1:3-10.

Leopold, A.C. and Kriedemann, P.E. (1975). Plant growth and development. *McGraw Hill.* New York. 545pp.

Lombin, L.G., Adepetu, J.A., and Ayolade, K.A. (1992). Complementary use of organic manure and inorganic fertiliser in arable crop production. In *Fed. Min of Scie. & Tech. Ed. Organic fertiliser in the Nigeria agriculture*: *Present and future. Proceeding of National Organic Fertiliser Seminar.* Zaria, Nigeria. 146-162.

Makinde, E.A., Alabi, B.S. and Agboola, A.A. (2000). Influence of fertilizer-type on weed control and the performance of maize-melon intercrop *Nigerian Journal of Weed Science.* 13:33-37.

Maxwell, B.D. and Ghersa, C. (1992). The influence of weed see dispersal versus the effect of competition on crop yield. *Weed Technology*. 6:196-204.

Olayinka, A. (1996). Carbon mineralization from poultry-manure straw sawdust amended alfisol. *Ife Journal of Agriculture* 1&2 (18)26-36.

Olayinka, A., Adetunji, A and Adebayo, A. (1998). Effect of organic amendments on nodulation and nitrogen fixation of cowpea. *Journal of Plant Nutrition* 21(11): 2455B2464.

Raghavendra, A.S. (1998). Photosynthesis. A comprehensive treatise. *Cambridge University Press.* U.K. pp 215-225.

Reyntjes, C. Hoverkork, B. and Water-Bayer, A. (1992). *An Introduction to Low-External-Input and Sustainable Agriculture.* John Wiley & Sons. London 340pp.

Steel, S.G.D and Torrie, J.H. (1980) Principles and procedure of statistics. A biometrical approach. *McGraw-Hill Book Co. Inc*. London.663pp

Thill, D.C. and Mallory-Smith, C.A. (1997). The nature and consequence of weed spread in cropping systems. *Weed Science* 45:337-342.

Uhlen, G. and Tveitnes, J. (1995). Effect of Long-Term crop rotations, fertiliser farm manure and straw on soil productivity. *Norwagian Journal of Agricultural Science* 9 (3&4):143-161