Investigating the Effect of Different Rates of Chicken Manure on the Growth, Yield and Profitability of Cowpea (Vigna Unguiculata L. Walp) Under Rain Fed Condition in the Upland Soils of Njala, Southern Sierra Leone

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Abstract: ***This study investigated the effects of different rates of chicken manure on the growth, yield and yield attributes of cowpea at the School of Agriculture Experimental Site, Njala University during the second season of 2014. A total of six treatments comprising two released Cowpea varieties from the Njala Agricultural Research Centre (NARC) and three chicken manure levels (0, 4 and 8 t. ha-1) were established in split plot design with three replicates. Results revealed that plant height, stem diameter, chlorophyll content, number of fully matured leaves and leaf area significantly increased with time and increasing chicken manure (CM) rate. Variety TVu1190 produced higher plant height, larger leaf area, larger stem diameter and higher yield (2.78 t. ha-1) than IT86D-721. Chicken manure application significantly decreased mean days to 50% flowering, whereas pod and kernel sizes, 1000 g grain weight and yields were significantly enhanced. Application of CM at 8 t. ha-1 produced significantly the heaviest grain weight of 160.17 g, whilst the 0 t. ha-1 had the least (141.83 g). Similarly, the 8 t. ha-1 (3.28 t. ha-1) CM rate had the highest yield followed by 4 t. ha-1 (3.09 t. ha-1) and lowest in 0 t. ha-1 (1.13 t. ha-1). It is most profitable to grow cowpea under 4 t. ha-1 CM point application production system especially for variety IT86D-721. Results suggest that optimum application and adequate supply of plant nutrient from chicken manure is important for the success of conservation and sustainable farming systems. Findings in this study could be utilized in improving efficiency of Nitrogen use in crop management rotation systems.***

Keywords: Chicken Manure, Cowpea, Vigna Unguiculata L. Walp, Njala

1. Introduction

Background Information

Cowpea (*Vigna unguiculata* L. Walp), is a dicotyledonous plant belonging to the family Fabaceae and sub-family Fabiodeae. It is grown extensively in low lands and mid-altitude regions of Africa (particularly in the dry savanna) sometimes as sole crop, but more often intercropped with cereals such as sorghum or millet (Agbogidi, 2010a). According to FAO (2002), the world production of cowpea was estimated at 2.27 million tons; of which, Nigeria produces about 850, 000 tons. Egho (2009) also reported that Nigeria is the second highest consumer of cowpea in the whole world. Cowpea is of major importance to the livelihood of millions of relatively poor people in the semi-arid tropics that includes parts of Asia, Africa, Central and South America and Southern Europe (Singh *et al.*, 1997; Singh, 2005; Timko *et al.*, 2007). Islam *et al. (*2006) reported the enormous food value of cowpea providing protein and vitamins, immature pods and peas are used as vegetable, while several snacks and main dishes are prepared from the grains (Bittenbenders *et al.,* 1984). The seeds make up the largest contributor to the overall protein intake of several rural and urban families. Hence, Agbogidi (2010) regarded cowpea as the poor man's major source of protein. Cowpea forms a vital staple in the diet of Africans and Asians (Awe, 2008). The crude protein from seeds and leaves of cowpea ranges, respectively, between 23 and 32% (Diouf, 2011), and between 13 and 17% in the haulms on a dry weight basis with high digestibility value and high fiber level (Adeyemi *et al*., 2012). Cowpea pods and leaves are consumed by human being and serves as fodder for livestock (Ghaly and Alkoaik, 2010). According to Adeyemi *et al.*, 2012, cowpea is an easily affordable vegetarian source of nutrition to man. However, the nutritional potentials of cowpea vary with varieties (Hall *et al.*, 2003).

Among the legumes, it is the most extensively grown, distributed and traded food crop with more than 50% consumed (Philips and McWalters, 1991; Ogbo, 2009; Agbogidi, 2010a). This is because the crop is of considerable nutritional and health value to man and livestock (Agbogidi, 2010b). Besides its health related benefits, beans are inexpensive, considerably cheaper than rice or any other dietary fiber type (Ayenlere *et al.*, 2012). It is a good security item as it mixes well with other recipe (Singh and Rachie, 1985; Muoneke *et al.*, 2012). Cowpea fixes atmospheric nitrogen through symbiosis with nodule bacteria (Shiringani and Shimeles, 2011). It does well and most popular in the semi-arid of the tropics where other food legumes do not perform well (Agdogidi and Egho 2012). It is an extremely resilient crop and cultivated under some of the most extreme agricultural conditions in the world (Owolade *et al.*, 2006; Muoneke *et al.*, 2012). In Sierra Leone, cowpea is produced in most parts of the country; either sole or in association with other crops like maize. It is the second most important grain legume crop grown after groundnut in the country (MAFFS/NARCC, 2005). The major producing areas are north (Kabala), Western area and Southern regions; with Moyamba district (Southern Sierra Leone) producing the largest, compared to other regions in the country. The Institute of Agricultural Research (IAR) had certified and released three improved cowpea varieties TVu1190, IT86D-721 and IT86D-1010 as SLIPEA 1, 2 and 3, respectively. They mature between 60-80 days and are moderately resistant to the common insects, pests and diseases, yield about 1.5 t. ha-1 and have good consumer qualities (MAFFS/NARCC, 2005). The most popular local variety is the Tabe, a white-seeded cowpea with black-eyed, widely grown in the southern region of Sierra Leone.

2. Statement of Research Problem

The increasing incidence of wild fire, deforestation, erosion, reduced fallow and erratic weather conditions contribute tremendously to rapid soil degradation. As a consequence, yields obtained in Sierra Leone are dismally low compared to other countries like Nigeria and USA where reasonable farm inputs including fertilizers are used to enhance productivity. The current average yield of maize in Sierra Leone estimates at 1.5 t. ha-1. This yield hardly meets the needs of millions of consumers. The reduced fallow and crop intensification in certain areas have also led to high pest and disease outbreaks thereby affecting yield and quality of the crop.

Even though cowpea is important for controlling soil erosion and fixing atmospheric nitrogen in the soil (Langdale *et al.*, 1992; Asiwe *et al.*, 2009), yet initial application of organic or inorganic fertilizers containing phosphorus and potassium is imperative to boost its growth, yield and quality. Therefore, this project aims at investigating the effects of different rates of chicken manure on the growth yield and yield quality of cowpea varieties under rain fed condition in the upland ecology as 2nd growing season and the socio economic effect.

The use of chicken manure produces excellent soil for your crops to grow bigger and healthier as a result of using chicken manure fertilizer. Chicken manure fertilizer is very high in nitrogen and also contains a good amount of potassium and phosphorus. Because of the high nitrogen and balanced nutrients is the reason that chicken manure compost is the best kind of manure to use.

Using chicken manure is excellent as plant fertilizer, but the high nitrogen in the chicken manure is dangerous to plants if the manure has not been properly composted. Raw chicken manure fertilizer can burn, and even kill plants if used. Composting chicken manure mellows the nitrogen and makes the manure suitable for the garden. Chicken manure compositing gives the manure time to break down some of the more powerful nutrients so that it will be more usable by the plants.

The main goal of this research is to increase cowpea productivity and livelihood of farmers and soil management practices production will be improved along with increased yields hereby contributing to sustainable food security in Sierra Leone.

The aim of this study is to investigate the effects of different rates of chicken manure (organic fertilizer) on the growth, yield and yield attributes of cowpea under rain fed condition.

To achieve this goal, below are the under-mentioned specific objectives targeted.

1) To identify optimum chicken manure amendment needed for profitable productivity of cowpea.
2) To determine the effects of chicken manure on the growth, yield and quality of cowpea genotypes.
3) To determine the cost/benefit analysis of the various production systems for the recommendation of elite system that will increase the income levels of producers.

Hypothesis

The following hypothesis was formulated base on the above stated objectives:

1) It is hypothesized that use of chicken manure soil amendments increases profitability of producers compared to no-fertilizer production system.
2) Adequate use of chicken manure has no negative effect on growth, yield and seed quality of cowpea.

Cowpea being an important food security legume in Africa; it is generally observed that on average, not many sierra Leonean can afford the cost of meat and fish, to be used as major sources of protein in their daily diets. In respect to this grain legume such as cowpea, groundnut, pigeon pea and broad beans are the most important alternative cheap protein sources normally exploited by large numbers of poor people in the country. Because of the high protein value of grain legumes, even the rich in the society value grain legume as an important component of their diets. Due to increase in population in Sierra Leone, and the perpetual/effective use of limited agricultural land available to farmers which on the other hand has led to the reduction of soil fertility and micro–organism in the soil. Based on this goal, improving on the productivity and quality of cowpea implies that the health and livelihood of the consuming population in Sierra Leone is expected to be improved, if efforts are made to curb those challenges/problems that militate against this goal. The use of chicken manure is one of the suggestive solutions of those lost materials in the soil.

The main focus of this study is to encourage farmers to actively involved in cowpea production as the common source of protein with the use of organic fertilizers like chicken manure which is more economical and cheaper to farmers as compare to costly inorganic fertilizer such as NPK 15, 15, 15, Single super phosphate (SSP), Urea, to name but few.

In Sierra Leone, most of the cowpeas are grown by small holder resource poor farmers. Many of them have little or no education on crop pest management. Majority of cowpea farmers employ cultural methods to get rid of weeds, insects and diseases in the field crops. In order to increase the yield of cowpea and add value to the grains, protection of the crop from damage, organic manure like chicken manure should be considered seriously. The adoption of this technology i. e.

the use of chicken manure could not only increase cowpea production in Sierra Leone significantly, but can also make available safe and high-quality grains fit for consumption by millions of sierra Leonean.

It is hoped that the research findings will provide recommendations for appropriate use of chicken manure and the optimum plant density that can give better vegetative growth and also high cowpea yield in Sierra Leone.

The collected knowledge will also help plant breeders in targeting attributes and characteristics in cultivars tested in this study for improvement on growth performance and yield quality.

However, the use of chicken manure and appropriate plant spacing/density play important roles in mitigating disease problems in crop fields and consequently increasing yield and quality of cowpea genotypes.

Cowpea is one of the most important leguminous crops grown in Africa. According to Rose (2010), cowpea, field peas, stock peas and southern peas are just a few names by which the *Vigna unguiculata* is known. The crop is believed to have originated from northern Africa were it is still cultivated. It sustains the people who live on the very edge of existence and thrives in hot, dry conditions. The crop was later brought to the Atlantic, the Caribbean basin, in the holds of the same ship that carried the tragic passengers who became slaves and was introduced to America during this dark portion of our history. There are records of its use in Jamaica as early as 1675. It has been documented and used in Florida in 1700 and North Carolina in 1714.

Cowpea was closely associated with the domestication and cultivation of sorghum and pearl millet. It is now grown on a commercial scale in 33 countries in Asia, Africa, Central and South America as well as part of southern Europe.

Taxonomy

The name "cowpea" was probably derived when it was an important livestock feed for cows in the United States. Cowpea like many other crops grown today had been a great problem for taxonomists to arrive at a conclusion for the nomenclature of the crop. However, a comprehensive meeting was held by the international committee in Madrid to agree on a name for the crop in September 1975. After many debates, a large number of taxonomists agreed that cowpeas belong to the botanical species called *Vigna unguiculata (*L) Walp.

Moreover, further reclassification was made after the crop had gained its nomenclature by Marechal *et al.*, 1978. They subdivided the species into three subspecies namely: cowpeas (subspecies unguiculata), pigeon pea (subspecies *Cajanus cajans*) and yard long beans (subspecies sesquipedalis).

Importance and utilization of cowpea (*Vigna unguiculata (*L) Walp)

Cowpea is one of the major grain legumes cultivated throughout the tropics of Africa (Nkongolo, 2003). It is considered as nutritious with a protein content of about 23%, fat of 1.3%, fiber of 1.8%, carbohydrate of 67% and water content of 8-9% (Bressami, 1985). In Sierra Leone, cowpea is mainly used as food and cash crop. Its nutritional value lies in the high protein content although it is a poor source of sulphur containing amino acids. Therefore, they should be used with cereals which have adequate sulphur containing amino acids but lack lysine which is abundant in cowpea. Cowpea can be used in preparing various sources, as ingredient in cowpea cake and oleleh (pudding). It flour can be used to make weaning foods for infants and young children. However, its flour used for infant's food should be roasted and dehulled to reduce the anti-nutritional factors as well as prevent indigestion.

Cowpea is drought-tolerant crop, curbs soil erosion and fixes atmospheric nitrogen, while the decaying residues contribute to soil fertility in the tropics of Africa (Shetty *et al.*, 1995; Singh *et al.*, 2003; Okereke *et al.*, 2006). Like many other legumes, the nodule bacteria in the soil when in symbiosis with cowpea, reduce atmospheric nitrogen into compounds for assimilation by the cowpea plants. Effective cowpea-Rhizobium symbiosis fixes up to 150 kgN. ha-1 and supplies 80-90% of the host plant nitrogen requirement (Asiwe, 2009). The International Institute of Tropical Agriculture (IITA) has made a concerted effort to improve cowpea varieties, as well as improve cropping systems to increase total productivity with limited used of purchased inputs (Singh and Ajeigbe, 2000).

In most African countries, cowpea is one of the most important subsistence legumes alongside with groundnuts (*Arachis hypogeal (*L), pigeon pea (*Cajanus cajan*) and beans (*Phaseolus* spp) and many rural families use fresh pods, leaves and fresh/dry grains for consumption (Daris *et al.*, 1991), while the crop residue constitutes a valuable livestock seed. The sale of the stems and leaves as animal feeds during the dry season also provides a vital income for farmers. As in most legumes, cowpea is rich in the essential amino acid, lysine and Methionine, which are deficient in cereals. Cowpea seeds are also rich source of minerals and vitamins (Hall *et al.*, 2003), and among other plants have one of the highest contents of folic acid, a B vitamin which is important in preventing birth effect and essential micro nutrient such as calcium, iron and zinc.

Among African leafy vegetables, cowpea is one of the highly appreciated species according to a comprehensive survey from four African countries; namely Tanzania, Malawi, Uganda and Rwanda (Keller, 2004; Weinberger and Msuya, 2004), conducted within the collaborative project "promotion of neglected indigenous vegetables for nutritional health in Eastern and Southern Africa" (pro NIVA). Hallensleben *et al.* (2009), in their work on "Assessment of the importance and utilization of cowpea (*Vigna unguiculata (*L). Walp) as leafy vegetable in small scale form households in Tanzania", address potential of cowpea as a leafy vegetable and the health benefit in the consuming cowpea leaf. In addition to human consumption, cowpea leaves and stems (Stover), green and dry pods, as well as the haulms are also important sources of high quality hay for livestock feeds (Tarawali *et al.*, 1997, 2002), particularly in the dry season when animals feed are scarce

(Tarawali *et al*., 1997; Devries and Toenniessen, 2001; Singh *et al*., 2003).

Cowpea can be used as green manure and as a nitrogen fixer to the soil. Like other grain legumes, cowpea gives back to the soil a huge supply of nitrogen, making it a great rotational crop with hungrier vegetables. The crop fixes 80% nitrogen for its growth demand from the atmosphere, thereby reducing nitrogen fertilizer demand and cost for the crop.

It is also an important companion crop in most fertilizer like phosphorus and potash should be applied during seed bed preparation for better plant growth in the root zone. By incorporating the fertilizers, the chemical elements in it will remain in the soil and most of the time available to the plants. According to Jose and Valencia (1999), some nitrogen fertilizers should be applied to the seed bed to give the crop a good start, and later can be applied at one or two top dressing 5-8 weeks after planting.

Climatic conditions

Cowpea requires a temperature range of 28 to 35oC a day and night during it growing season. It performs well in agro ecological zones where the rainfall range is between 500 and 1200 mm/year. However, with the development of extra-early and early maturing of cowpea varieties, the crop can thrive in the Sahel where the rainfall is less than 500 mm/year (Davis *et al.*, 1991). It is generally tolerant of drought and low light conditions, but very susceptible to varieties of insects, pests and diseases and do not perform well in poorly drained and cool areas. It germination is rapid at temperature above 65oF, colder temperature slow germination. The crop responds positivity to irrigation but produce well under dry land conditions. However, cowpea requires moderate rainfall during the vegetative and reproductive stages for more quality yield.

Soil Requirement

Cowpea requires a well-drained, fertile loan of slight acidity is the best. It can be grown in a wide range of soil well adopted to light sandy soil where most other crops perform poorly. Most of the soils suitable for cowpea cultivation exit in Sierra Leone. Cowpea shows a vigorous vegetative growth, on heavy fertile soils, but not necessarily a good grain yield. It best yields are obtained in well-drained sandy loam to clay loam with the pH between 6 and 7 (Davis *et al*., 1991).

Seed Selection

When selecting a very good seeds for planting, the following must be considered:

- Where possible get your seeds from a certified seed seller.
- Consider the variety in terms of its duration, yield quality, taste and size etc.
- Also note the quality of the seed, seed selected must be clean seeds without hole or wrinkles for planting.

Cowpea varieties

Table 1: Characteristics of four cowpea varieties in Sierra Leone

No.	Characteristics	SLIPEA 1	SLIPEA 2	SLIPEA 3	Temne (Local)
1	50% Flowering (days)	39-42	41-44	40-45	40-46
2	Maturity (days)	65-75	70-80	60-70	70-80
3	Growth habit	Erect	Semi-erect	Semi-erect	Semi-erect
4	Branching pattern	Alternative	Irregular	Irregular	Irregular
5	Leaflet color	Dark green	Green	Light green	Green
6	Photo periodic	Absent	Absent	Absent	Absent
7	Seed coat	Dark purple	White	White	Brown
8	Seed size	Very large	Large	Large	Large
9	Reaction to insect pest:				
	Thrips	Moderate	Moderate	Moderate	Susceptible
	Pod borer	Moderate	Moderate	Moderate	Susceptible
10	Yield potential (kg. ha-1)	1, 500	1, 500	1, 500	900
11	Farmer's ranking	Second	Third	First	Fourth

Cultural practices / Seed bed production practice

Seed bed preparation

In Sierra Leone, for crops to realize their potential yield, due consideration must be given to land preparation management practices. Cowpea is normally planted on a thoroughly flat seed bed in the upland region while raised seed beds or ridges are used in the low lands. For good quality and yield performance of cowpea, seed beds must have an adequate supply of organic matter, pest and disease-free and must have good water holding ability.

Note that newly planted cowpea requires a weed-free, soil that is warm, moist, and adequate supplied of air that is enough to give contact between the seeds and soil.

Planting

In planting cowpea is the practice of sub-merging the whole kernel or seed of cowpea in the soil to a depth of 2-3 cm depending on the soil. Two or three seeds can be planted and later thinned to one or two base on the intention of the producer. The spacing between rows and plants will depend on the climate, soil condition and cultivar. Cowpea should not be planted until soil temperature is consistently above 65°F and soil moisture is adequate for seed germination and growth.

Weed control

Weed can be controlled either by direct weed methods such as hand weeding and the use of herbicides or by the indirect method like land preparation, flooding and planting of competitive crop. Adequate weed control is necessary for good growth and high yield. These two methods can be used in different combinations for effective weed control. Weed two weeks after planting before flowering.

Weed 2-3 times to allow vigorous growth cowpea. Weedicides like GRAMOXON F34 and STAM has been used for the control of weed in large farms. It is therefore necessary to control weeds competing along with our established crop. Weed adversely affects economic returns for our cowpea field (Jose and Valencia, 1999). In conclusion weeding may be done as and when necessary before harvesting in order to improve in the quality and economic yield.

Fertilizer Application

Fertilizers can be applied to cowpea crop either as basal, top dressing. These methods can be combined with improved cultural management practices such as maximum plant population, correct time of planting and timely weeding (Cook, 1982).

Cowpea does not require too much nitrogen fertilizer because it fixes its own nitrogen from the air using the nodules in its roots. However, in areas where soils are poor in nitrogen, apply a small quantity of about 15 kg. ha-1 of nitrogen as a starter dose for a good crop-production. If too much of nitrogen fertilizer is used, the plant will grow luxuriantly with poor grain yield. In cowpea production, it requires more phosphorus than nitrogen in the form of single super phosphate or SUPA. About 30 kg. ha-1 in the form of SUPA is recommended for cowpea production to help the crop to nodulate well and fix its own nitrogen from the air (Haruna and Usman, 2013).

Diseases, pest incidence and constraints and their control measures

Insect pests are constraining to cowpea production in West Africa. The cowpea plant is attached by pests during every stage of its life cycle. Aphids extract juice from its leaves and stems while the crop is still a seedling and also spread the cowpea mosaic virus. Flower trips feast on it during flowering, pod borers attack its pods during pod growth, and bruchid weevils attack the post harvested seeds. The level of insect attack increases from the southern Guinea savanna towards the Sahel savanna zone of the region. Cowpea damage by insect pests can be as high as 80-100% if not effectively controlled. Cowpea plants are also attacked by diseases caused by fungi, bacterial and virus parasitic. Weeds-striga and Electra-choke the plants growth at all stages and nematodes prevent the roots from absorbing nutrients and water from the soil.

However, in order to minimize the infection of diseases and pests on cowpea, below are some of the recommended control mentions.

- Treating high quality seeds with fungicides labeled for cowpea.
- Planting certified seeds of resistant varieties.
- Avoid throwing soil against plants stems during cultivation.
- Weed controlling strategies.
- Seeding into warm, well prepared soils.
- The removal of virus-attacked plants
- Four or five year rotation with other crops is necessary.

Varietal selection of cowpea based on seed type and color

Cowpeas have been grouped in to the following market classes based on seed type and color (Davis *et al*., 1991).

Black-eyed or pink eyed / purple hull peas

The seeds are white in color with a black eyes round the helium. The "eye" can be other colors like pink, purple or shades of red being common. Upon drying, the eye color darkens to a dark purple. The pods are purple-like on the pink-eyed/purple hull type. The seeds are kidney or oblong in shape but are not tightly packed or crowded in the pod.

Brown-eyed peas

These pods vary in color from green to lavender and also in length. The immature seeds, when cooked, are medium to dark brown, very tender and have a delicate flavor.

Crowder peas

The seeds are black, brown or brown-eyed and speckled. The seeds are "crowed" in the pod and tend to be globule in shape.

Cream

Seeds are cream colored and not crowded in the pods. This is an intermediate between black-eyed and Crowder types.

White acre type

Seeds are kidney shaped with a blunt end, semi-crowed and generally tan in color. Pods are stiff with small seeds.

Clay types

This older varieties are medium to dark brown in color and kidney shape, but are rarely brown.

Forage cultivars

These cultivars are adapted for use as fodder or cover crops. Three improved cowpea varieties SLIPEA 1, 2 and 3, varieties TVu1190, IT86D-721 and IT86D-1010, respectively, have been certified and released by Institute of Agricultural Research (IAR) through the collaboration with the International Institute of Tropical Agriculture (IITA). These were selected in comparison with local variety (Temne). Their characters are summarized in Table 1.

3. Materials and Methodology

Location of the Experimental site

Based on the objective of the project, the study area was carried out in Njala University, Mosongo community, Kori Chiefdom, Moyamba district, southern province of sierra Leone. Njala is located one hundred and fourteen (114) miles away from Freetown. It is situated at an elevation of 50 m above sea level.

The experiment was conducted from September to December 2014 in the upland at the School of Agriculture, formal National Agricultural Training Centre (NATC), Njala campus. Due to the mono model nature of rainfall in the experiment area, the raining season starts from April to November while the dry season extends from December to March. The mean maximum air temperature ranges from (21-23oC) for the greater part of the day and night especially during the raining season.

Pre-planting soil analysis

The soil samples from the study area were analyzed prior to experimentation after collection with the aid of soil auger from each plot. The samples were bulked and air-dried at room temperature of between (25oC-27oC) for one week, crushed to pass through a 2 mm sieve before they were neatly packed in a properly labeled air tight polythene bags for physico-chemical analysis at the Njala Agricultural Research Centre (NARC) Soils and Plants Analytical laboratory (Table 2).

Table 2: Physical and chemical properties of soil samples from the experimental sites at 0–20 cm

Composition	Soil properties
Physical properties (%)	
Sand	81.0
Silt	8.0
Clay	11.0
Chemical properties	
pH in H20	5.0
Organic carbon (g/kg)	5.41
Total nitrogen (g/kg)	0.14
Available exchangeable P (mg/kg)	5.43
Exchangeable base (cmol/kg)	
Ca	0.21
Mg	0.13
K	0.08
Na	0.02
CEC	5.0
Exchangeable acidity (cmol/kg)	4.0
Exchangeable Aluminum (cmol/kg)	2.0

Source and Description of crop variety

The two varieties of cowpea SLIPEA 1 and 2 (TVu1190 and IT86D-721) respectively were purchased as a single batch from the Njala Agricultural Research Centre (NARC) in the Moyamba District, Kori Chiefdom southern province of sierra Leone. These varieties of cowpea were certified and released by the Institute of Agricultural Research (IAR) now called Njala Agricultural Research Centre (NARC) through the collaboration with the International Institute of Tropical Agriculture (IITA). It is moderately resistant to common diseases, yield about 1.5 tons/ha and have good consumer qualities. It has a sweet quality taste and matures in about 65-80 days depending on the purpose.

Description of the Experimental site

The topography shape of the experimental area was pictured to be flat with slightly gentle slope covered with vegetation predominantly of *Crutum satums (*Butter leaf), *Impera indica (*Land-land grass) and *Penisetum purpanum (*Elephant grass). The upland in Njala area is generally covered with secondary bush, moderately fertile which consist of a well drain and balance mixture of sand, clay and humus. The soil of the experimental site falls within the Njala series (*Orthotic palehimult*).

Land Preparation

The land was ploughed with a tractor and harrowed after one week. Layout was marked using tape, pegs and garden lines. A single block with an area of 20.5 m x 8 m was laid out within harrowed land. This block was then divided into three (3) replications which were 1m apart. Each replication consisted of six (6) plots; each measuring 3 m x 2 m. Spacing between plots was 0.5 m and 1m between replication.

Planting spacing was 50 cm x 20 cm, giving a population of 100, 000 plants per hectare. Three (3) seeds of cowpea from each variety were planted per hole on the 15th September 2014 (second cropping season).

Thinning of seedlings to two stands per hole was done at 10 days after emergence. Each plot consisted of four (4) rows of 24 cowpea stands per row.

Climate of the study area

This project/experiment was conducted in the raining season from September to December 2014. The two distinct seasons in the study area are that of the raining season and the dry season. The raining season extends from April to November and the dry season from December to March. The average annual rainfall is 250 mm while the main daily temperature is approximately 30°C maximum and 20°C minimum.

Treatment, experimental design and layout

The treatments comprised of two varieties of cowpea SLIPEA 1 (TVu1190) and SLIPEA 2 (IT86D-721) and three rates of chicken manure amendments including 0, 4 and 8 t. ha-1. The experiment was laid out in a split plot design with variety and chicken manure regimes used in the main and subplots, respectively, and replicated thrice. Experimental plot layout and randomization are illustrated in figure 1 below. Chicken manure application was done 7 days prior to planting.

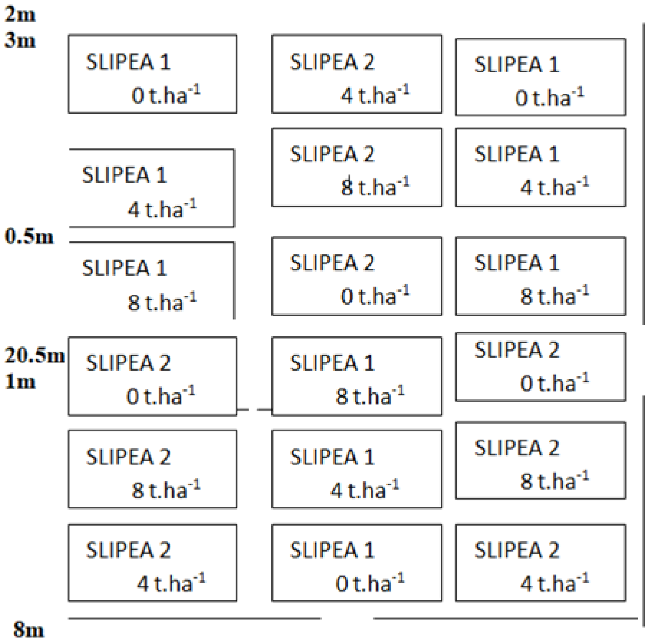

Figure 1: Plot layout and randomization of the cowpea trial

Plot size

The total experimental area was 20.5 m x 8 m (164 m2). Each plot measured 3 m x 2 m and consisted of 4 rows.

Time of planting and planting methods

Planting was done on the ploughed leveled flat beds on the 15th September 2014. The seeds were planted in rows with a regular distance of 20 cm within plants and 50 cm between rows.

The seeds were planted at a depth of 2 inches. The seedlings were thinned to two plants per hill 10 days after emerge

Weeding

The experimental area was hoe-weeded regularly before maturity to enable the plant develops under non-limiting condition. Insect pests were controlled with cultural method.

Harvesting

The harvesting of the crop cowpea was done periodically when the crop reached its physiological maturity, that is at about 65-70 days after planting (DAP), drying of pods and yellowing and falling of leaves indicated signed of maturity. Pods were harvested with hand by carefully plucking the pods from the haulms. The pods were separately parked according to plots for other necessary data collection.

Data collection and analysis

Data collection

In each plot, five plants were randomly selected and tagged for data collection on the above **2.8.7**

Plant height (cm)

This data was collected at 3 and 6 WAP. This was measured by using the calibrated ruler from the soil level (base) of the tagged plants to the terminal bud/tip of the plant. At 3 weeks interval after planting, the value was then recorded.

Stem diameter (cm)

This parameter was also measured using venire caliper around the base of the plants at 3 and 6 WAP and the value was then recorded.

Chlorophyll content (cm)

This data was also collected at 3 and 6 WAP. This was measured by using an electronic device (Chlorophyll meter) on the leaves of the tagged plants and then the value was recorded.

Number of leaves

This was collected at 3 and 6 WAP. It was determined by visual counting of the number of leaves per each tagged plants for each seedlings per variety.

Leaf area

This was also collected at 3 and 6 WAP. This measurement was achieved by using a ruler and the total area per plant was obtained by measuring the maximum leaf length and breadth and multiplied it by the correction factor following the formula of (Agbogidi and Ofuoku, 2005) and then recorded.

Days to 50% flowering

This data was collected on plot basis by observation. That is the number of days from the time of planting to when 50% of the plants per plot had flowered, were counted and recorded.

Pod length (cm)

Five pods of each plant were measured using a ruler.

Pod diameter (cm)

This was done using an electronic device (Venire Caliper).

Number of pods

This data was collected by counting the number of pods produced by each tagged plant and recording values.

Number of seeds per pod

In order to obtain this data, five (5) pods were collected from the five tagged plants per plot and counted each seed per pod, the results were added and divided by 5 and then recorded.

Length and Diameter of kernel (cm)

These were done using an electronic device (Venire caliper). Five (5) kernels were measured per plot and the means were recorded.

1000 Grains weight (g)

This was collected using a sensitive scale. It was done by counting 1000 grains from the tagged plants per plot, weighed and the values were recorded.

Seed Yield (t. ha-1)

Each plot yield, obtained by weighing using sensitive scale, was extrapolated into tonnes per hectare.

3.9.2 Data analysis

Data were subjected to analysis of variance (ANOVA) using the GENSTAT statistical programme (GENSTAT, 15th release, Rothampstead, UK). The Least Significance Difference (LSD) was used to compare between treatment means using a significance level of α = 0.05. The residuals of data for the parameters used were first checked for normality and homogeneity using the Shapiro-Wilk test and Bartlett's test to ensure that data were normally distributed. Profit (Л) was also calculated using the total revenue and total cost functions; i. e.

Profit (Л**)** = Total revenue –Total Cost

4. Results and Discussion

Effect of chicken manure on plant height, number of leaves and leaf area of two cowpea genotypes

Generally, chicken manure rate significantly ($p<0.001$) affected mean plant height, number of leaves and leaf area, whereas variety only significantly ($p<0.01$) influenced the plant leaf area (Table 3). All measured traits of the two varieties significantly increased with time. Variety TVu1190 (SLIPEA 1) exhibited significantly tallest plants (60.37 cm) and largest leaf area (91.2 cm2) at the 8 t. ha-1 application rate compared to variety IT86D-721 (SLIPEA 2); whereas at similar rate, variety IT86D-721 (SLIPEA 2) significantly produced highest number of leaves (78.2) compared to variety TVu1190. The significant variation in growth parameters of the two cowpea cultivars could probably be attributable to the differential CM rates used, growth habit, genetic-make up and the available water, light and inherent soil nutrient status. Similarly, Terao *et al*. (1995) noted that cowpea varieties with spreading growth habits collected more light than those with erect growth habits and consequently produced more leaves which resulted in larger leaf area. The Pattern of leaf area development in this study is similar to those obtained by Enyi (1975) in *Phaseolus vulgaris* and Osafo (1976) in maize that good leaf area enables crops to effectively capture light for photosynthesis, grow better and compete with weeds.

Variety, chicken manure rate and sampling time significantly influenced stem diameter and chlorophyll content of cowpea (Table 4). Variety TVu1190 had significantly larger mean stem diameter (0.666 cm) than variety IT86D-721 (0.546 cm). Application at 8 t. ha-1 of variety TVu1190 plots produced the largest stems (0.773 cm), whilst the 0 t. ha-1 rate of variety IT86D-721 had smallest stems (0.345 cm).

Table 3: Mean plant height (cm), number of leaves and leaf area (cm2) as affected by chicken manure rates and genotype

Genotype	CM rate (t. ha-1)	Sampling regime (WAP) 3	6	Mean
Plant height (cm)				
IT86D-721	0	15.00	24.27	19.63
	4	36.03	66.93	51.48
	8	36.50	72.80	54.65
Mean		**29.18**	**54.67**	**41.92**
TVu1190	0	20.33	32.72	26.53
	4	37.37	66.00	51.68
	8	39.00	81.73	60.37
Mean		**32.23**	**60.16**	**46.19**
LSD (0.05) variety	4.327ns			
LSD (0.05) Treat	4.972***			
CV (%)	8.5			
		Number of leaves		
IT86D-721	0	10.1	24.0	17.1
	4	26.2	115.2	70.7
	8	28.9	127.5	78.2
Mean		**21.8**	**88.9**	**53.3**
TVu1190	0	10.4	30.8	20.6
	4	20.2	92.8	56.5
	8	22.1	94.4	58.2
Mean		**17.6**	**72.7**	**45.1**
LSD (0.05) variety	11.27ns			
LSD (0.05) Treat	10.21***			
CV (%)	15.3			
		Leaf area (cm2)		
IT86D-721	0	10.0	28.3	19.1
	4	42.4	73.1	57.8
	8	43.3	81.2	62.2
Mean		**31.9**	**60.9**	**46.4**
TVu1190	0	21.2	72.1	46.6
	4	62.4	110.5	86.4
	8	65.0	117.4	91.2
Mean		**49.5**	**100.0**	**74.8**
LSD (0.05) variety	10.09**			
LSD (0.05) Treat	7.97***			
CV (%)	9.9			

ns=non significant, **=significant at $p<0.01$, ***=$p<0.001$

Table 4: Mean stem diameter (cm) and chlorophyll content (cm) as affected by chicken manure rates and genotype

Genotype CM rate (t. ha-1)

Sampling regime (**WAP**) **Mean 3 6**

Stem diameter (cm)

IT86D-721	0	0.280	0.410	0.345
	4	0.513	0.787	0.650
	8	0.513	0.773	0.643
Mean		**0.436**	**0.657**	**0.546**
TVu1190	0	0.373	0.537	0.455
	4	0.607	0.927	0.767
	8	0.600	0.947	0.773
Mean		**0.527**	**0.803**	**0.666**
LSD (0.05) variety	0.034**			
LSD (0.05) Treat	0.043***			
CV (%)	5.3			
		Chlorophyll content (cm)		
IT86D-721	0	41.63	43.50	42.57
	4	54.87	47.30	56.08

	8	54.10	58.97	56.53
Mean		**50.20**	**53.26**	**51.73**
TVu1190	0	43.20	44.03	43.62
	4	45.70	48.77	47.33
	8	47.60	47.27	47.43
Mean LSD (0.05) variety	1.23**	**45.50**	**46.69**	**46.09**
LSD (0.05) Treat	2.55***			
CV (%)	3.9			

**=significant at p<0.01, ***=p<0.001

The chlorophyll content was consistently significantly (p<0.001) lowest in the non-amended plots compared to the 4 and 8 t. ha-1 rates of both varieties IT86D-721 and TVu1190. Variety SLIPEA 2 (IT86D-721) exhibited more chlorophyll (51.73) than SLIPEA 1 (TVu1190) (46.09). Application at 8 t. ha-1 recorded the highest chlorophyll (47.43) of variety TVu1190, followed by 4 t. ha-1 (47.33) of variety TVu1190 and the least in 0 t. ha-1 (42.57) of variety IT86D-721. These findings implied that cowpea require initial application of organic or inorganic manures with major nutrients for its early vegetative establishment stage before nodulation, especially in infertile or poorly fertile soils. Njala soils are characteristically low in soil nutrients due to drastic reduction in fallow periods. Most crops, including legumes suffer from starved growth, which consequently lead to low crop yields.

Chicken manure rate and interaction between variety and CM rate significantly affected days to 50% flowering (Table 5). Chicken manure application significantly decreased mean days to 50% flowering from 49.7 (0 t. ha-1 rate) to 42.0 days (4 and 8 t. ha-1 rates). Generally, variety IT86D-721 (46.2) took more days to reach 50% than variety TVu1190 (42.9). These variations may be due to the genetic characteristics of the two cowpea varieties. The more the nutrient update by the plant, the higher it resulted in their vigorous growth, consequently leading to shorter days to flowering in chicken manure emended plots compared to delay flowering in the non amended plots.

Variety and CM rates significantly affected pod length and diameter of cowpea (Table 5). Application of chicken manure at 4 (19.55 cm) and 8 t. ha-1 (20.13 cm) significantly increased pod length of cowpea compared to the 0 t. ha-1 (16.15 cm) rate. Variety TVu1190 had significantly longer pods (21.16 cm) than variety IT86D-721 (16.07 cm). Pod diameter followed similar trend as pod length with the manure amended plots exhibiting significantly larger pod diameter than the non amended ones. Number of pods per plant and number of seeds per pod were significantly affected by variety and CM rates. Chicken manure application at 4 and 8 t. ha-1 produced 16.0 and 16.5 pods per plant; and 16.5 and 17.1 seeds per pod, which significantly out-numbered the 4.2 pods and 13.4 seeds obtained in the non amended plots, respectively.

Table 5: Mean days to 50% Flowering, pod length (cm), pod diameter (cm), number of pods per plant and number of seeds per pod as affected by chicken manure rates and genotype

Genotype	**Chicken manure rate (t. ha-1)**			
	0	**4**	**8**	**Mean**
Days to 50% flowering				
IT86D-721	53.3	42.7	42.7	46.2
TVu1190	46.0	41.3	41.3	42.9
Mean	**49.7**	**42.0**	**42.0**	**44.6**
LSD (0.05) variety	3.61ns			
LSD (0.05) Treat	1.69***			
LSD (V*T)	2.87**			
CV (%)	2.8			
Pod length (cm)				
IT86D-721	13.27	17.40	17.53	16.07
TVu1190	19.03	21.70	22.73	21.16
Mean	**16.5**	**19.55**	**20.13**	**18.61**
LSD (0.05) variety	1.786**			
LSD (0.05) Treat	1.868**			
LSD (V*T)	2.282ns			
CV (%)	3.4			
Pod diameter (cm)				
IT86D-721	0.590	0.633	0.647	0.623
TVu1190	0.713	0.750	0.780	0.748
Mean	**0.652**	**0.692**	**0.713**	**0.686**
LSD (0.05) variety	0.017***			
LSD (0.05) Treat	0.019***			
LSD (V*T)	0.023ns			
CV (%)	0.1			
Number of pods per plant				
IT86D-721	3.0	16.3	16.1	11.8
TVu1190	5.4	15.7	16.9	12.7
Mean	**4.2**	**16.0**	**16.5**	**12.2**
LSD (0.05) variety	0.53*			
LSD (0.05) Treat	3.41***			
LSD (V*T)	3.94ns			
CV (%)	13.4			
Number of seeds per pod				
IT86D-721	11.4	15.1	15.1	13.9
TVu1190	15.5	18.0	19.1	17.5
Mean	**13.4**	**16.5**	**17.1**	**15.7**
LSD (0.05) variety	1.95*			
LSD (0.05) Treat	1.01***			
LSD (V*T)	1.60ns			
CV (%)	2.9			

ns=non significant, *=significant at p<0.05, **=significant at p<0.01, ***=p<0.001

Variety TVu1190 had higher number of pods (12.7) and seeds (17.5) than variety IT86D-721, which had 11.8 pods and 13.9 seeds. These differences may be due to the inherent growth habit of the varieties and enhanced fertility in CM amended plots.

Mean kernel length was significantly influenced by variety and CM rate only, whereas kernel diameter was significantly influenced by variety and the interaction between variety and CM rate (Table 6). The kernels of amended plants were significantly longer (0.917 cm) than the control (0.783 cm). Variety TVu1190 (1.033 cm) had longer kernels than IT86D-721 (0.800 cm). The mean kernel diameter of the various treatment was similar, whereas variety TVu1190 (0.516 cm) had larger diameter than IT86D-721 (0.443 cm). Variety, CM rates and interaction between them significantly affected the 1000 grain weight and seed yield of cowpea.

Plots amended with 8 t. ha-1 produced significantly the heaviest grain weight of 160.17 g, followed by 4 t. ha-1 (155.67 g), whilst the non-amended plots recorded the least (141.83 g). Variety TVu1190 (191.00 g) exhibited heavier grains than variety IT86D-721 (129.33 g). Similarly, CM application at 8 t. ha-1 (3.28 t. ha-1) and 4 t. ha-1 (3.09 t. ha-1) had significantly higher yields than 0 t. ha-1 (1.13 t. ha-1). Variety TVu1190 (2.78 t. ha-1) had higher yield than variety IT86D-721 (2.12 t. ha-1). Result obtained in this study concur with those of Herbert and Buggerman (1982), who noted that highest seed yield was obtained in plots with higher plant density. Results suggest that optimum application and adequate supply of plant nutrient from chicken manure is important for the success of conservation and sustainable farming systems.

Table 6: Mean length of kernel (cm), kernel diameter (cm), 1000 grain weight (g) and seed yield (t. ha-1) as affected by chicken manure rates and genotype

Genotype	Chicken manure rate (t. ha-1)			Mean
	0	**4**	**8**	
		Kernel length (cm)		
IT86D-721	0.700	0.800	0.800	0.767
TVu1190	0.867	1.033	1.033	0.978
Mean	**0.783**	**0.917**	**0.917**	**0.872**
LSD [variety]	0.048**			
LSD [Treat]	0.063**			
LSD [V*T]	0.075ns			
CV (%)	1.1			
Kernel diameter (cm)				
IT86D-721	0.447	0.443	0.440	0.443
TVu1190	0.493	0.517	0.537	0.516
Mean	**0.470**	**0.468**	**0.488**	**0.479**
LSD [variety]	0.069*			
LSD [Treat]	0.015ns			
LSD [V*T]	0.057*			
CV (%)	0.4			
1000 grain weight (g)				
IT86D-721	118.00	126.00	129.33	124.44
TVu1190	165.67	185.33	191.00	180.67
Mean	**141.83**	**155.67**	**160.17**	**152.56**
LSD [variety]	3.734***			
LSD [Treat]	5.538***			
LSD [V*T]	6.543*			
CV (%)	1.9			
		Seed yield (t. ha-1)		
IT86D-721	0.53	3.11	2.99	2.12
TVu1190	1.72	3.07	3.56	2.78
Mean	**1.13**	**3.09**	**3.28**	**2.50**
LSD [variety]	0.463*			
LSD [Treat]	0.399***			
LSD [V*T]	0.506*			
CV (%)	9.2			

ns=non significant, *=significant at p<0.05, **=significant at p<0.01, ***=p<0.001

4.2 Economic analysis of various chicken manure rates

The partial budget and cost benefit analysis of two varieties of cowpea grown under 0, 4 and 8 t. ha-1 chicken manure rates is shown in Table 7. Results indicated that 4 t. ha-1 CM rate resulted in highest benefit-cost-ratio for variety IT86D-721 (1.0 or 2.0: 1) followed by application at 8 t. ha-1 (0.7 or 1.7: 1) and lowest in the non-amended control (0.3 or 1.3: 1). However, for variety TVu1190, the 0 t. ha-1 (1.2 or 2.2: 1) exhibited the highest benefit-cost-ratio, followed by 4 t. ha-1 (1.0 or 2.0: 1) and 8 t. ha-1 (0.8 or 1.8: 1). The findings generally implied that it is more profitable to produce variety IT86D-721 under 4 t. ha-1 chicken manure point application production system. Thus, for every Le 1.0/ha the farmer invests, he expects to make a profit of one Leone (Le 1.0). For variety TVu1190, the 0 t. ha-1 chicken manure amendment is almost as profitable as the 4 t. ha-1 chicken manure production system. Thus, for Le 1.0/ha the farmer invests, he expects to make a profit of one Leone twenty cents (Le 1.2). The study demonstrated the importance of study of economic analysis of different varieties of crops and the various production systems engaged for sound recommendation of profitable technologies or innovations.

Table 7: Partial budget and cost benefit analysis of two cowpea varieties grown under 0, 4 and 8 t. ha-1 chicken manure rates at Njala

Cowpea variety		**IT86D-721**			**TVu1190**	
CM rate (t. ha-1)	0	4	8	0	4	8
Average yields (t. ha-1)	0.53	3.11	2.99	1.72	3.07	3.56
Adjusted yields (t. ha-1) *	0.48	2.80	2.69	1.55	2.76	3.20
Gross benefit (Le/ha)	3050880	17796800	17097640	9851800	17542560	20339200
Cost of chicken manure (CM) (Le/ha)	0	1600000	3200000	0	1600000	3200000
Labour cost for application of CM (Le/ha)	0	200000	200000	0	200000	200000
Machine hire for 1 day	350000	350000	350000	350000	350000	350000
Fuel cost of ploughing & harrowing (Le/ha)	181500	181500	181500	181500	181500	181500
Cost of cowpea seed (Le/ha)	228816	228816	228816	228816	228816	228816
Labour cost of planting (Le/ha)	200000	200000	200000	200000	200000	200000
Cost of weeding (Le/ha)	300000	300000	300000	300000	300000	300000
Harvesting cost (Le/ha)	200000	200000	200000	200000	200000	200000
Cost of processing of pods	96000	560000	538000	310000	552000	640000
Total variable cost	2420316	8860316	10240316	4560316	8780316	11260316
Net benefit	630564	8936484	6857324	5291484	8762244	9078884
Benefit cost ratio	**0.3**	**1.0**	**0.7**	**1.2**	**1.0**	**0.8**

*Average yield adjusted 10%, farm gate price per kg of each variety in 2014=Le 6356

5. Summary, Conclusions and Recommendations

5.1 Summary of Results

The results of this study demonstrated the significant contribution of chicken manure to increasing the productivity of cowpea grown in Sierra Leone. Generally, the impacts of chicken manure treatment observed in the experimental plots were relatively high, thus justifying the reason for its significant influence on the growth, yield and yield attributes of the two cowpea varieties used in the study.

5.2 Conclusions

Based on the results, the following conclusion can be tentatively drawn:

1) The growth attributes of the two cowpea cultivars, including plant height, stem diameter, chlorophyll content, number of fully matured leaves and leaf area increased with time and increasing CM rate.
2) Variety TVu1190 produced higher plant height, larger leaf area and larger stem diameter than IT86D-721.
3) Variety IT86D-721 had higher number of leaves and chlorophyll content than variety TVu1190.
4) Chicken manure application significantly decreased mean days to 50% flowering, whereas pod and kernel sizes, 1000 g grain weight and yields were significantly enhanced.
5) Application of CM at 8 t. ha-1 produced significantly the heaviest grain weight of 160.17 g, whilst the non amended plots recorded the least (141.83 g).
6) Application of CM at 8 t. ha-1 (3.28 t. ha-1) and 4 t. ha-1 (3.09 t. ha-1) had significantly higher yields than 0 t. ha-1 (1.13 t. ha-1). Variety TVu1190 (2.78 t. ha-1) had higher yield than variety IT86D-721 (2.12 t. ha-1).
7) It is most profitable to grow cowpea under 4 t. ha-1 chicken manure point application production system especially for variety IT86D-721.

5.3 Recommendation

Based on the findings in this study, it is evidently clear that amending less fertile soils with 4 and 8 t. ha-1 significantly enhance growth and yield of cowpea in the upland soils of Sierra Leone. The adoption of this technology by farmers will contribute to increasing their income levels and improving their livelihoods, thereby reducing hunger and poverty.

Hence the following recommendations can be tentatively drawn:

- Farmers should adopt the 4 t. ha-1 chicken manure application technology for enhanced growth, yield and profitable production of cowpea in less fertile upland soils. It is imperative to analyze soils prior to planting to ascertain the quantum of manure to be added for effective and efficient nutrient use efficiency.
- Future trials should be conducted to determine the residual effect of the decomposed chicken manure left after harvest on the performance of cowpea.
- Trials should also be conducted in the inland valley swamp [IVS] to confirm current result from the upland.
- Use of organic fertilizers like chicken manure could be more economical and cheaper for commercial production of the crop and may be less hazardous to man and his environment compared to the costly inorganic fertilizers.

References

[1] Adeyemi, S. A., Lewu, F. B., Adebola, P. O., Bradley, G. and Okoh, A. I. (2012). Protein content variation in cowpea genotypes (*Vigna unguiculata* L. Walp.)

grown in the Eastern Cape province of South Africa as affected by mineralised goat manure *African Journal of Agricultural Research* 7 (35): 4943-4947.

[2] Agbogidi, O. M. and Egho, E. O. (2012). Evaluation of eight varieties of cowpea (*Vigna unguiculata (*L.) Walp) in Asaba agro-ecological environment, Delta State, Nigeria. *European Journal of Sustainable Development* 1 (2): 303-314.

[3] Agbogidi, O. M.2010a. Screening six cultivars of cowpea (*Vigna unguiculata (*L.) Walp) for adaptation to soil contaminated with spent engine oil *Journal of Environmental Chemistry and Ecoloxicology*.7: 103 – 109.

[4] Agbogidi, O. M.2010b. Response of six cultivars of cowpea (*Vigna unguiculata (*L.) Walp.) to spent engine oil. *African Journal of Food Science and Technology* 1 (6): 139-142.

[5] Agbogidi, O. M. and Ofuoku, A. U.2005. Response of sour sop (*Annona muricata* Linn) to crude oil levels. *Journal of Sustainable Tropical Agricultural Research*.16: 98-102.

[6] Asiwe, J. A. N.2009. Needs assessment of cowpea production practices constraints and utilization in South Africa, *Journal of Biotechnology* 8 (20): 5383-5388.

[7] Asiwe, J. A. N**.,** Belane and Dakora, F. D.2009. Evaluation of cowpea breeding lines for nitrogen fixation at ARC grain crops institute, Potchefstroom, South Africa. Abstracts, the 16th international congress on Biological Nitrogen fixation, Montana, USA, 14-19 June, 2009.

[8] Awe, O. A., 2008. Preliminary evaluation of three Asian yards long bean cowpea lines in Ibadan, Southern western Nigeria. *In*: Proceedings of the 42nd Annual Conference ofASN held at Ebonyi State University, Abakaliki, Nigeria between 19th and 23rd of October, 2008. Pp.246 – 249.

[9] Ayenlere, A. E., Mohammed, A. B., Dutse, F., Abdullahi, M. and Mohammed-Lawal, A., 2012. An assessment of the economics of maize-cowpea cropping system in Ogun area of Kwara State, Nigeria *Biological and Environmental Sciences Journal for the Tropics* 9 (1): 39-43 Bittenbender, H. C., Barret, R. P. and Indire-Lauvsa, B. M., 1984. Beans and cowpeas as leaf vegetables and grains legumes. Monograph No.1 Bean/Cowpea Collaborative Research Support Programme. Michigan State University, East Lansing.

[10] Bressami, R.1985. Nutritive value of cowpea. John Wiley and Sons. New York, 355-360 p.

[11] Cooke, G. W.1982. Fertilizing for Maximum Yield.3rd Edn., Macmilan Publishing Co. Inc., New York, Toronto.

[12] Davis, D. W., Oelke, E. A., Oplinger, E. S., Doll, J. D., Hanson, C. V. and Putnam, D. H.1991. Alternative plant and animal products: Programs in information exchange and research. In: *Alternative Field Crops Manual*. Janick and J. E. Simon (eds.). New crops. John Wiley and Sons, New York. pp.133-143.

[13] Devries, J. and Toenniessen, G.2001. Securing the harvest: Biotechnology, Breeding and Seeds systems for African Crops. CAB International, New York, USA.

[14] Diouf, D.2011. Recent advances in cowpea (Vigna unguiculata (L.) Walp.) "omics" research for genetic improvement. *Afr. J. Biotechnol.*10: 2803-2810.

[15] Egho, E. O.2009. Control of major insect pests of cowpea (*Vigna unguiculata (*L.) Walp using conventional and non-conventional chemicals. A PhD Thesis submitted to the Department of Agronomy, Delta State University, Asaba Campus.224p.

[16] Enyi B. A. C.1975. Effects of defoliation on growth and yield in groundnut (*Arachis hypogaea*), cowpeas (*Vigna unguiculata*), soyabean (*Glycine max*), and green gram (*Vigna aureus*). *Ann. Appl. Biol.*79 (1): 55-56.

[17] FAO, 2002. *World Agriculture: towards 2015/2030.* Summary report, Rome.

[18] Ghaly, A. E. and Alkoaik, F. N.2012. Extraction of Protein from Common Plant Leaves for Use as Human Food, *American Journal of Applied Sciences 7 (3): 331-342.*

[19] Hall, A. E. Cisse, N., Thiaw, S., Elawad, H. O. A. and Ehlers, J. D., 2003. Development of cowpea cultivars and germplasm by the bean/cowpea CRSP. *Field Crops Res*.82: 103-134.

[20] Hallensleben, M., Severin, P., Joachim, H. and Brigitte, L. M.2009. Assessment of the importance and utilization of cowpea (*Vigna unguiculata* L. Walp) as leafy vegetable in small scale farm household in Tanzania, East Africa. Conference on International Research on Food Security. Natural Resource Management and Rural Development. Tropentage University of Humburg. October 6-8, 2009. Pp 1-4.

[21] Haruna, I. M. and Usman A.2013. Agronomic Efficiency of Cowpea Varieties (*Vigna unguiculata* L. Walp) under Varying Phosphorus Rates in Lafia, Nasarawa State, Nigeria. *Asian Journal of Crop Science, 5: 209-215.*

[22] Herbert, S. J. and Baggerman, F. D.1982. Cowpea response to row, density and irrigation. Abstract, *Agron. Sci. Journal*, 6: 75.

[23] Islam, S., Cowmen, R. C. and Ganer, J. O.2006. Screening for tolerance of stress temperature during germination of twenty-five cowpea (*Vigna unguiculata* L. Walp) cultivars. *Journal of Food, Agriculture and Environment* 4 (2): 189 191.

[24] Keller, G. B.2004. African Nightshade, eggplant, spider flower production and consumption aspects of traditional vegetables in Tanzania from the farmers' point of view. Goethingen: Georg-August Universital, Germany, M. Sc. Thesis.

[25] Langdala, G. V., Clarke, R. L. and Bruce, R. R.1992. The role of legumes in sustaining soil productivity and controlling soil erosion. In: Mulongoy, M., Gueye, K. and Spencer, D. S. C. (eds.) *Biological nitrogen fixation and sustainability of tropical agriculture*, IITA, Ibadan, Nigeria. Pp.361-366.

[26] MAFFS/NARCC (Ministry of Agriculture, Forestry and Food Security) / (National Agricultural Research Coordinating Council) 2005. Crop production guidelines for Sierra Leone.104 pp.

[27] Marechal, R., Mascherpa, J. M. and Stainier, F.1978. Etude taxonomique d'un groupe d'especes des genres *Phaseolus* et *Vigna (*Papilonaceae) sur la base des

donnees morphologiques et polliques, traitees pour l'analyse informatique. *Boissiera* 28: 1-273.
[28] Muoneke, C. O., Ndukwe, O. M., Umana, P. E., Okpara, D. A. and Asawalam, D. O.2012. Productivity of vegetables cowpea (*Vigna unguiculata* L. Walp) and maize (*Zea mays* L.) intercropping system as influenced by component density in a tropical zone of southeastern Nigeria *International Journal of Agricultural Research and Development* 15 (1): 835-847.
[29] Nkongola, K. K.2003. Genetic characterization of Malawian cowpea (*Vigna unguiculata* L. Walp) landraces: Diversity and gene flow among accessions. *Euphytica* 129: 219-228.
[30] Ogbo, E. M.2009. Effects of diesel fuel contamination on seed germination of four crop plants-*Arachis hypogaea*, *Vignia unguiculata Sorghum bicolor* and *Zea mays*. *African Journal of Biotechnology* 8 (20): 250-253.
[31] Okereke, G. U., Egwu, S. E. and Nnabude, P.2006. Effect of cowpea organic residues and fertilizer N on soil fertility, growth and yield of upland rice. *Proceedings of the 18th World Congr. Soil Sci.* Philadelphia, Pennsylvania, U. S. A. July 9-15, 2006.
[32] Osafo D. M.1976. Weather conditions and the growth of maize in the Kumasi area of Ghana.2. Analysis of the growth of a maize variety sown on different dates. Ghana J. Agric. Sci.9: 25-34.
[33] Owolade, O. F., Akande, M. O. Alabi, B. S. and Adediran, J. A.2006. Phosphorus level effects on brown blotch disease, development and yield of cowpea. *World Journal of Agricultural Science* 2 (1): 105 108.
[34] Philip, R. D. and McWatters, K. H.1991. Contribution of cowpea to nutrition and health. *Food Technology* 9: 127 – 130.
[35] Rose, M.2010. The history and importance of the cowpea plant. Available *davesgarden. com/guides/articles/view/86/*
[36] Shetty, S. V. R., Ntare, B. R., Bationo, A. and Renard, C.1995. Millet and cowpea in mixed farming of the Sahel. A review of strategies for increased productivity and sustainability. In: Livestock and sustainable nutrient cycling in mixed farming systems of Sub-Saharan Africa; Powell, J. M. Fernandez Riverce, S. William, T. O. and Renard, C. (eds.). Proceedings International Conference, ILCA, Addis Ababa, Ethiopia. Pp 293-304.
[37] Shiringani, R. P. and Shimeles, H. A.2011. Yield response and stability among cowpea genotypes at three planting dates and test environments. *African Journal of Agricultural Resources* 6 (4): 3259-3263.
[38] Singh, B. B., Hartmann, P., Fatokun, C., Tamo, M., Tarawali, S. and Ortiz, R.2003. Recent progress on cowpea improvement. *Chronic Horticulture* 43: 82-82.
[39] Singh, B. B., Mohan Raj, D. R., Dashiel, K. E. and Jachai, L. E. N.1997. Cowpea (*Vigna unguiculata* L. Walp). Advances in cowpea research. IITA and JIRCAS.
[40] Singh, B. B.2005. Cowpea (*Vigna unguiculata* L. Walp). In: Singh RJ, Janhar PP (eds.). *Genetic Resources Chromosome Engineering and Crop Improvement*. Volume 1 CRC Press, Boca Raton, FL, U. S. A, pp 117-162.
[41] Singh, S. R. and Rachie, K. O.1985. Cowpea research and utilization. John Wiley and Sons, New York.400p.
[42] Singh, B. B. and Ageigbe, H. A.2000. Improving cowpea-cereal based cropping systems in the dry Savannas of West Africa. In: *Challenges and opportunities for enhancing sustainable cowpea production* Fatokun, C. A. Tarawali, S. A. Singh, B. B. Kormawa P. M. and Tamo M. (eds.) *Proceedings of the World cowpea conference III* held at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, 4-8 September, 2000. Pp 278-286.
[43] Timko, M. P., Ehlers, J. D. and Roberts P. A.2007. Cowpea. In: Kole C (ed.) Genome Mapping and Molecular Breeding in Plants, Vol.3, Pulses, sugar and tuber crops, Springer Verlag, Berlin Heidelberg pp 49-67.
[44] Tarawali, S. A., Singh, B. B., Peters, M. and Blado, S. F.1997. Cowpea haulms as fodder. In: Singh B. B., Mohan Raj DR, Dashiel KE, Jachai LEN (eds.) Advances in cowpea Research. Co publication Intl Inst. Tropical Agric. (IITA) and Japan Intl Res. Centre Agric. Sci. (JIRCAS). Sayce, Devon, UK, pp 313-325.
[45] Tarawali, S. A., Singh, B. B., Gupta, S. C., Tabo, R. and Harris, F.2002. Cowpea as a key factor for a new approach to integrated crop-livestock systems research in the dry savannas of West Africa. In: Fatokun CA, Tarawali SA, Singh BB, Kormawa PM, Tamo M (eds.). challenges and opportunities for enhancing sustainable cowpea production. Intl. Inst. Tropical Agric. Ibadan, Nigeria, pp 233-251.
[46] Terao T., Watanabe I., Matsunaga R., Hakoyama S. and Singh B. B.1995. Analysis of Agrophysiological constraints in intercropped cowpea. Cowpea Abstracts, Second World Cowpea Research Conference, 3-7 September, Accra, Ghana.
[47] Weinberger, K. and Msuya, J.2004. Indigenous vegetables in Tanzania – significance and prospects. Technical Bulletin No.31, Shanhua, Taiwan: The World Vegetable Centre (AVRDC).