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Response of cowpea varieties to sources and rates of phosphorus in ogbomoso

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CHAPTER ONE

1.1 INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is an important grain legume in the dry savannah of the tropics covering 12 .5million hectares with annual production of about 3.million tons. And Nigeria is one of the world's largest producer of cowpea with an average production of 2.92million tons followed by Niger with 1.10million tons (FAO, 2012). Despite the dramatic increase in cowpea production in the sub-Saharan Africa, cowpea yields remain one of the lowest among all food legume crops, averaging at 450kg/ha in 2006-2008, which is half of the estimated yields in all other developing regions. Its yields are very low due to several constraints including poor soil and use of low yield variety of seeds as planting material (Ecocrop, 2009).

Cowpea (*Vigna unguiculata* (L.) Walp) is a major staple food crop in sub-Saharan Africa, especially in the dry savannah regions of West Africa. The seeds are a major source of plant proteins and vitamins for man, feed for animals, and also a source of cash income (TJAI, 2010). The young leaves and immature pods are eaten as vegetables. There is a big market for the sale of cowpea grain and fodder in West Africa. In Nigeria, farmers who cut and store cowpea fodder for sale at the peak of the dry season have been found to increase their annual income by 25% (Dugje *et al*., 2009).

Cowpea also plays an important role in providing soil nitrogen to cereal crops (such as maize, millet, and sorghum) when grown in rotation, especially in areas where poor soil fertility is a problem. It does not require a high rate of nitrogen fertilization; its roots have nodules in which soil bacteria called Rhizobia inhabit and help to fix nitrogen from the air into the soil in the form of nitrates (Sheahan, 2012).

Cowpea can be grown under rain fed conditions as well as by using irrigation or residual moisture along river or lake flood plains during the dry season, provided that the range of minimum and maximum temperatures is between 28 and 30°C (night and day) during the growing season. Cowpea performs well in agro ecological zones where the rainfall range is between 500 and 1200 mm/year (Madamba *et al*., 2006).

However, with the development of extra-early and early maturing cowpea varieties, the crop can thrive in the Sahel where the rainfall is less than 500 mm/ year. It is tolerant of drought and well adapted to sandy and poor soils. It has little tolerance of salinity but is somewhat tolerant of soils high in aluminium. Like most legumes, it does not withstand waterlogged or flooded conditions. However, best yields are obtained in well-drained sandy loam to clay loam soils with the pH between 6 and 7 (Ecocrop, 2009).

Cowpea is a summer annual legume with trifoliate leaves. There are many cultivars, bred for diverse ecological niches, and they vary greatly in growth habit. Some are short, upright bush types, and others are tall and vine-like. Cowpea grows rapidly, reaching a height of 19–24 inches (48–61 cm) when grown under favourable conditions (Singh *et al*., 2003). Most root growth usually occurs within the topsoil layer, but in times of drought cowpea can grow a taproot as long as 8 ft to reach moisture deeper in the soil profile (Madamba *et al*., 2006). 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, there is a need to apply a small quantity of about 15 kg of nitrogen as a starter dose for a good crop. If too much nitrogen fertilizer is used, the plant will grow luxuriantly with poor grain yield. Cowpea requires more phosphorus than nitrogen in the form of single super phosphate or SUPA. About 30 kg of P/ha 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 (FAO, 2005). Tropical soils are inherently low in nutrients particularly nitrogen and phosphorus (Haruna *et al*., 2011). Phosphorus is among the most needed elements for crop production in many tropical soils. Phosphorus is critical to cowpea yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium-legume symbiosis (Haruna and Aliyu, 2011). It is required in large quantities in young cells such as shoot and root tips where metabolism is high and cell division is rapid. It also aids in flower initiation, seed and fruit development (Ndakemi and Dakora, 2007).

Phosphorus (P) is among the most needed elements for crop production in many tropical soils. However, many tropical soils are P-deficient (Osodeke, 2005). The deficiency can be so acute in some soils of the savannah zone of western Africa that plant growth ceases as soon as the P stored in the seed is exhausted (Mokwunye and Bationo, 2002). Soil P-deficiencies primarily result from either inherent low levels of soil P or depletion of P through cultivation. Legumes are phosphorus loving plants; they require phosphorus for growth and seed development and most especially in nitrogen fixation which is an energy-driving process. Legumes can fix up to 11-20kgN /ha (Sanginga *et al*., 2000), but this is not achievable in the tropics because of low soil fertility and poor farming practices. Application of phosphorus is therefore recommended for cowpea production on soils low in phosphorus. Careful application of phosphorus fertilizer to legumes is geared towards enhancing not only their growth and yield, but also nitrogen fixation. In Nigeria, legumes do not receive any form of mineral phosphorus fertilizer, they therefore entirely rely on the natural available soil phosphorus and other nutrients for nitrogen-fixation and growth and this has resulted in lower yields (Singh *et al*., 2011). One of the options of reducing low yields due to soil phosphorus content is to determine the best level of phosphorus fertilizer; as single super phosphate (SSP) so as to increase yield and returns from cowpea

1.2 Objectives of the Study

The main objective of the study therefore, was to evaluate the effects of response of cowpea varieties source and rate of phosphorus.

1.2.1 Specific Objective

The specific objectives of the study were to:

i. evaluate the effect of single super phosphate (SSP) on cowpea growth and yield

ii. To evaluate the effect of the applied treatment on soil chemical properties

CHAPTER TWO

LITERATURE REVIEW

2.1 ORIGIN, DOMESTICATION AND DISTRIBUTION OF COWPEA

Cowpea (*Vigna unguiculata* (L.) Walp) is a member of the family Fabaceae and tribe phaseoleae Woomer (2007).. Cowpea was known in India long before the days of Christ, and is also believed to have been known in Asia around the year 2300 BC and in Europe early enough to be known under the name *phaseolos*, *phaseolus* or *phaselus* (Burkhill, 1953). A lack of archaeological evidence has resulted in contradicting views supporting Africa, Asia and South America as its origin. Begum. (2005). One view is that cowpea was introduced from Africa to the Indian sub-continent approximately 2000 to 3500 years ago

Begum. (2005). also reported that, the species *unguiculata* is thought to be West African Neolithic domesticated and whose progenitors were the wild weed species *dekindtiana* and *meusensis*. Before 300 BC, cowpeas had reached Europe and possibly North Africa from Asia. In the 17th century, the Spanish took the crop to West India. The slave trade from West Africa resulted in the crop reaching the southern USA early in the 18th century. Another view was that the Transvaal region of the Republic of South Africa was the centre of speciation of *V. unguiculata*, due to the presence of most primitive wild varieties. The determination of the origin and domestication of cowpea had been based on morphological and cytological evidence, as well as information on its geographical distribution and cultural practices. Early observations showed that the cowpeas present in Asia are very diverse and morphologically different from those growing in Africa, suggesting that both Asia could be independent centers of origin for the crop. Giller (2007).

However, Asia has been questioned as a center of origin due to the lack of wild ancestors reported that, the oldest archeological evidence of cowpea was found in Africa in the Kintampo rock shelter remains in Central Ghana dating about 1450–1000 BC, suggesting

Africa as centre of origin. Presently cowpea is grown throughout the tropic and sub tropic areas around the world.

Sheahan, (2012) postulated that during the process of evolution of *V. unguiculata*, there was change of growth habit, from perennial to annual breeding and from predominantly out-breeding to inbreeding, while cultivated cowpea (subsp. *unguiculata*) evolved through domestication and selection of the annual wild cowpea (var. *dekindtiana*). During the process of domestication and after the species was brought under cultivation through selection, there was a loss in seed dormancy and pod dehiscence, corresponding with an increase in seed and pod size. The precise location of origin of where cowpea was first domesticated is also still under speculation. But by reason of the highest genetic diversity of the crop and the presence of the most primitive form of wild cowpea, (Padulosi, 1993), Southern Africa is the most probable center of domestication. According to Padulosi and Ng (1997), Southern Africa is the center of genetic variability because the most ancient of wild cowpea occurs in Namibia from the west, across Botswana, Zambia, Zimbabwe and Mozambique to the east, and the Republic of South Africa and Swaziland to the sout

Cowpea yield in Africa, particularly Ghana, is estimated to be 45% of that of developed countries (IITA. 2003). Among the factors responsible for such low yield is edaphic factor (soil physiochemical characteristics) particularly phosphorus (P) deficiency which is the most limiting soil fertility factor for cowpea production (IITA. 2003). This occurs as a result of either inherent low levels of P in the soils or depletion of the nutrient through cultivation. Phosphorus is among the most needed elements for crop production in many tropical soils. However, many tropical soils are inherently deficient in P (Osodeke, 2005) and nitrogen (Haruna and Aliyu, 2011).

The deficiency can be so acute in some soils of the Savannah zone of Western Africa resulting in cessation of plant growth as soon as the P stored in the seed is exhausted

(Mokwunye and Bationo, 2002). 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, there is a need to apply a small quantity of about 15 kg of nitrogen as a starter dose for a good crop. If too much nitrogen fertilizer is used, the plant will grow luxuriantly with poor grain yield**.** Cowpea requires more phosphorus than nitrogen in the form of single super phosphate or SUPA (Nkaa *et al*., 2014). Cowpea is an important dicotyledonous crop belonging to the order *Fabales*, family *Fabaceae*, subfamily *Faboideae*, tribe *Phasioleae*, subtribe *Phasiolenae* and genus *Vigna*. It is the most diverse of the cultivated subspecies and has the widest distribution Cowpea is extensively grown crop for edible pods during summer and rainy seasons in Jharkhand. Sheahan, 2012

In India, this crop is well-known table pulse as well as table vegetable because of high nutritional, particularly protein value of pods and seeds. Favourable environmental requirements *viz.*, high solar radiation, optimum temperature and rainfall, low pest infestation and good soil characteristics are readily available in Jharkhand leading to spread of this crop throughout state. Cowpea thrives well on a wide variety of soils and soil conditions but performs best on a well-drained sandy loam with pH range of 5.5-6.5 Whitbread (2006).

Cowpea is known to fix atmospheric phosphorus in the soil. It can fix sufficient atmospheric nitrogen to meet most of its requirements (Christo *et al.,* 2008). Its growth and yield is affected by the quantity and quality of nutrients available in soil. Low organic matter content in soil and inorganic fertilizer coupled with low pH value, drought stress and high temperature frequently result to very low yield. Organic manures have excellent ability to improve and sustain the yield and also lead to steady build-up of soil fertility if applied at higher rates

Organic manures can also sustain crop yield of most of annuals under continuous cultivation in most of soils unlike equivalent amounts of through inorganic fertilizers

(Maynard, 1991). These have been found to ensure early maturity and uniform ripening of fruits (WABS, 2008).

Phosphorus plays key roles in many plant processes such as energy metabolism, nitrogen fixation, synthesis of nucleic acids and membranes, photosynthesis, respiration and enzyme regulation. Phosphorus is critical to cowpea yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium legume symbiosis (Nkaa *et al*., 2014). It is required in large quantities in young cells such as shoot and root tips to increase metabolism and promote rapid cell division. It also aids in flower initiation, seed and fruit development (Ndakidemi and Dakora, 2007).

According to (Oti *et al*. (2004), phosphorus decrease zinc concentration in the cowpea grain, thereby affecting its nutritional quality. It is required for the physiological processes of protein synthesis and energy transfer in plants (Nkaa *et al*., 2014). Application of phosphorus has been reported by several authors to improve yield of cowpea. Seed yield is, therefore, governed by number of factors which have a direct or indirect impact. Among these factors are the yield components such as number of pods per plant, number of seeds per pod and 100-seed weight over a given land area (Cobbinah *et al*., 2011).

Attempts to improve cowpea production should be approached via a good understanding and manipulation of crops and their environment. This may be achieved by a compatible management of agronomic/cultural practices such as mineral, particularly P fertilizer management strategies. On this account, this study was undertaken to determine the effect of phosphorus fertilizer on growth, nodulation and yield of three varieties of cowpea in Nigeria.

2.1.2 Varieties and Cultivars of Cowpea

Many cowpea cultivars have a vining growth habit; however, modern plant breeding has also led to more upright, bush-type cultivars. The vining type is preferred for forage or cover crop use, while the bush type is better suited for direct combining. The extreme variability of the species has led to a number of commercial cultivars grouped by the variance in bean shape, size and colour.

- Black-eyed or pink-eyed/purple hull peas — the seeds are white with a black eye round the hilum. The “eye” can be other colours: pink, purple or shades of red being common. Upon drying, the eye colour darkens to a dark purple. The pods are purple-like on the pink-eyed/purple hull type. The seeds are not tightly packed or crowded in the pod and are kidney-shaped or oblong.
- Brown-eyed peas — pods range in colour from green to lavender and in length. The immature seeds, when cooked, are a medium to dark brown, very tender and have a delicate flavour.
- Crowder peas — seeds are black, speckled, and brown or brown-eyed. The seeds are “crowded” in the pod and also tend to be globular in shape.
- Cream — seeds are cream coloured and not crowded in the pods. This is an intermediate between the black-eyed and Crowder types.
- White acre type — seeds are kidney-shaped with a blunt end, semi-crowded and generally tan in colour. Pods are stiff with small seeds.
- Clay types — these older varieties are medium to dark brown in colour and kidney-shaped, but are rarely grown.

2.1.3 Soil preparation

The land must not be waterlogged but well drained. During land preparation, the existing fallow weeds, trees and shrubs on the site are cut down manually, or slashed with a tractor-drawn implement and fallen trees should be removed. This should be followed by ploughing and harrowing, using a disc plough and harrow. Some 4 to 6 days between each operation should be allowed to enhance good soil tilth for good seed germination. The land may be ridged or left as flat seedbeds after harrowing (Whitbread, 2006).

2.1.4 Field layout and design

Both inter-row and intra-row spacing will be determined by the type of variety and growing pattern. More space between plant and rows will be required with trailing types relative to the upright growing ones. Generally, for grain production, a plant population of 200 000 to 300 000/ha at 30 to 50 cm inter-row spacing is preferred to wider rows (70 to 100 cm), which could be suitable to the trailing types (Vance, 2001).

2.1.5 Planting of Cowpea

For optimum yield, cowpea should be planted late November to early December in the lower rainfall areas of South Africa. The seed should be planted at 3 to 4 cm deep. The early-sown crops tend to have elongated internodes, are less erect, more vegetative and lower yielding than those sown at the optimum time. Tweneboah, (2000) postulated that Planting date manipulation is utilised by farmers for various reasons. The reasons include escape from periods of high pest load or planting cowpea at such a time that harvesting of the crop would coincide with the period of dry weather. The recommended spacing is 50 to 75 cm between rows and 50 to 75 cm between plants for spreading varieties and 50 cm between rows and 15 to 25 cm for erect and semi-erect varieties. Seeding rate ranges from 25 to 30 kg of good and viable seeds per hectare in experimental stations. Commercial seeding rates would depend on plant spacing. Toğay, Y., N. T (2005)

2.1.6 Fertilisation of Cowpea

Cowpea makes its own nitrogen but needs phosphorus to grow well. Using a hoe, open up a furrow and apply 40 g of superphosphate in the bottom of the furrow at the rate of 40 g/m or a teacupful per 5 m row. When using chemical fertiliser, purchase a 2:3:2 NPK mixture and apply at the rate of 40 g/m or one teacupful per 5 m. After spreading the fertiliser evenly in the furrow, use a stick to mix the fertiliser with the soil. Water the furrow and make the holes for the transplant. When using poultry or pig manure, use a bucket in a band of about 20 cm wide over a length of 15 m, work the manure into the topsoil, water the band thoroughly and wait one to two weeks before transplanting. When using kraal manure, follow the same procedure but use a bucket over a length of 5 m. Singh (2002).

2.1.7 Irrigation system of Cowpea

Water requirements vary with the crop growth's stage, soil type and weather condition (hot or cold). Cowpea tolerates drought, however, water it regularly if it is grown as a leafy vegetable. The frequency of irrigation depends on the soil type. Frequent irrigation will be required for sandy soils as they tend to drain quickly and do not hold a great deal of water. Clay soils, on the other hand, drain quite slowly and hold more water than sandy soils. There are a few ''rules of thumb'' to use as a starting point for irrigation frequency and amount. First, sandy soil should be irrigated three times a week. Second, sandy loam should be irrigated twice a week. Third, clay, clay loam and loam soils should be irrigated once a week. Irrigate up to 4 ℓ for a plot size of 1 m x 1 m (4 ℓ/ m^2). Sprinkler and drip irrigation can be used to irrigate; however, water savings with drip are substantial and roughly half as much water can do the same or better job than a sprinkler system. Excess water application leaches nutrients away from the roots of the plants, therefore careful irrigation volume and frequency is required to prevent crop stress to help produce large, healthy cowpea plants. Shoko, M.D. (2007).

2.1.8 Weed control of Cowpea

Annual grasses and some broadleaf weeds can be controlled by a pre-sowing application of herbicide. Row crop cultivation may be necessary with cowpea, depending on the weed pressure, soil conditions and rainfall. Pre-plant tillage and the use of cover crops can assist greatly in reducing early weed pressure. *Striga gesnerioides* and *Alectra spp.* are the principal parasitic weeds attacking cowpeas, particularly in the semiarid regions. The following three are the most common *Striga* species that are a pest to cowpea: *S. hermonthica, S. asiatica and S. gesnerioides.* Rosegrant, M.W. (2008).

The pest status is complex because the forms of parasitic weeds that are found on one species cannot germinate on another host plant. Careful observations and records are therefore necessary to clarify which crops are parasitised by which species.

Control of *Striga* is difficult and time consuming. At present, chemical control is not recommended, as the chemicals are expensive, handling them is very difficult and no research results are available to support chemical treatment. WABS. (2008).

Farmers are advised to improve soil fertility where this weed is a problem. Soil fertility has an effect on *Striga* infestation; more fertile soils are less infested with *Striga*. Use of manure and/or small quantities of fertiliser may reduce the infestation, when combined with weeding of plants before seed setting.Hand weeding of the infested areas before *Striga* sets seeds is the most important control method at present. *Striga* should be weeded out as soon as any flowering is observed, as the development of seeds takes only a few weeks. It may be necessary to weed the area twice in a season. Raemaekers, R.H. (2001).

2.1.9 Pest and Disease Control of Cowpea

Insect pests attacking cowpea are Mexican bean beetle, bean leaf beetles, cowpea curculio, green stink bug, maize stalk borer and weevils (when in storage). Other important pests also include the cowpea aphid (*Aphis craccivora*), various leaf hoppers, the Egyptian leaf worm (*Spodopteris littoralis*), larvae of the African bollworm (*Heliothis armigera*) and cowpea leaf beetle (*Ootheca mutabilis*). Asumugha, (2002

Diseases reported are fusarium wilt, bacterial canker, southern stem blight, cowpea mosaic virus, *Cercospora* leaf spot, rust and powdery mildew. The root-knot nematode and damping-off can be problems. Other diseases reported are brown blotch (*Colletotrichum* *capsici*), Septoria leaf spot (Septoria *vignae*), stem cancer (*Macrophomina phaseolina*) and bacterial blight (*Xanthomonas campestris*), scab (*Sphaceloma* sp.), brown rust (*Uromyces appendiculatus*) and web blight (*Rhizoctonia solani*). Asumugha . (2002

Pests can be controlled by cultural practices like crop rotation and the use of specific pheromone lures, which will confuse the males and keep them from mating with the females. It is important to get rid of infected leaves, branches etc. as they might harbour eggs over winter. Diseases can be controlled by using diseases-free seed by using hot water seed treatment at 50 °C for 25 to 30 minutes. Strictly follow time and temperature recommendations to minimise damage to seed germination and vigour. The hot water treatment can also eliminate fungal pathogens on the seeds. Chlorine can also be used effectively for seed treatment; use one part household bleach to four parts plus a half teaspoonful of surfactant (liquid soap) per 4,5 of solution, agitate seed for one minute, then rinse in running water for 5 minutes. Dry the seed thoroughly. Spraying with a copper compound can be effective in controlling bacterial light Agbogidi, (2010a)

2.2 Morphology and Biology of Cowpea

Chaturvedi *et al*. (2011) described cowpea as an annual herb reaching heights of up to 80 cm with a strong taproot with many spreading lateral roots in the surface soil and many globular nodules. The root nodules are smooth and spherical, about 5 mm in diameter, numerous on the main taproot and its branches but sparse on the smaller roots. Growth forms vary and many are erect, trailing, climbing, or bushy, usually indeterminate growers under favourable conditions. The stems are striate, smooth or slightly hairy and sometimes tinged with purple. Leaves are alternate and trifoliate. The first pair of leaves is simple and opposite. The lateral leaflet is opposite and asymmetrical, while the central leaflet is symmetrical and ovate. Leaves exhibit considerable variation in size (6-16 x 4-11 cm) and shape (linear, lanceolate to ovate) and they are usually dark green. The leaf petiole is 5-25 cm long. The flowers are arranged in racemose or intermediate inflorescence at the distal ends of 5-60 cm long peduncles. The flowers are conspicuous, self-pollinating, borne on short pedicels and the corollas may be white, dirty yellow, pink, pale blue or purple in colour.

According to Georgiev (2003), the inflorescence is axillary and formed of a peduncle 10 to 30 cm long, at the end of which there is a rachis with each node bearing a pair of flowers and a cushion of extra floral nectaries that contribute to the attraction of insects. In cultivated forms, the flowers open in the early day and close in late morning approximately midday, with the dehiscence of the anthers taking place several hours before the flower opens. After blooming (opening once) they wilt and collapse.

The fruit is a dehiscent pod with varying shape and length which usually shatters when dry. It is pendulous, mostly linear although curved and coiled forms occur. The pod is green at early stage and when maturing it becomes usually yellow, light brown, pink or purple. The pod length may vary from less than 11 cm to more than 100 cm (Rachie and Rawal, 1976). Seeds are relatively large (0.2-1.2 cm long) and weigh 5-30 g/100 seeds. They are variable in size and shape: kidney, ovoid, crowder, globose and rhomboid Agbogidi, (2010a). The seed coat varies in texture (such as smooth, rough, or wrinkled), colour (white, cream, green, buff, red, brown, black), and uniformity (solid, speckled, or patterned) (Timko and Singh, 2008). Seed shape is correlated with that of the pod. Where individual seeds are separate from adjacent ones during development, they become reform, but as crowding within the pod increases, the seeds become globular Agbogidi,. (2010a)

2.2.1 Climatic and Soil Requirements of Cowpea

Cowpea grows primarily under humid conditions. It is tolerant to heat and drought conditions. The crop is sensitive to frost. It germinates rapidly at temperatures above 18.33oC; colder temperatures slow germination (Davis *et al.*, 2010). Cowpea can be grown under rain fed conditions as well as by using irrigation or residual moisture along river or lake flood plains during the dry season, with the minimum and maximum temperatures between 28 and 30°C (night and day) during the growing season (Dugje *et al.*, 2009). Most of the crop grown in agro-ecological zones requires an annual rainfall ranging between 500 and 1200 mm. However, with the development of extra-early and early maturing cowpea varieties, the crop can thrive in the regions with an annual rainfall less than 500 mm. The crop requires well drained sandy loam soils with The crop is tolerant to drought and well adapted to a wide range of soils, including sandy and even poor soils (Davis *et al.*, 2010).

2.2.2 Cowpea Production

World cowpea production was estimated at 3,319,375 MT and 75% of that production is from Africa (FAOSTAT, 2000). West Africa is the key cowpea producing zone, mainly in the dry savanna and semi-arid agro ecological zones. The principal cowpea producing countries are Nigeria, Niger, Senegal, Ghana, Mali and Burkina Faso (Langyintuo *et al*., 2003). Cowpea is widely distributed throughout the tropics, but central and west Africa account for over 64 % of the area (with about 8 million hectares, followed by about 2.4 million hectares in central and southern America, 1.3 million hectares in Asia, and about 0.8 million hectares in eastern and southern Africa). Some cowpea is also cultivated in the Middle East and southern Europe. However, a substantial part of cowpea production comes from the drier regions of northern Nigeria (about 4 million ha, with 1.7 million tonnes), southern Niger Republic (about 3 million ha, with 1 million tonnes) and Brazil (about 1.9 million ha, with 0.7 million tonnes) (Georgiev, 2003).

Cowpea is an important component of sustainable cropping system in Ghana. It is cultivated for the leaves, green pods, grain and haulm for livestock feed. According to Lowenberg-DeBoer (2000), Ghana is one of the major producers of cowpeas in the world but in addition, it imports about 10,000 MT annually; about 30 percent of the Ghanaian imports are from Burkina Faso and the rest from Niger. In Ghana, cowpea is one of the widely cultivated legumes, it is grown throughout all the ten geographical regions (MOFA, 2010), mainly in the savannah and transitional zones (CRI, 2006). An average of 143,000 MT of cowpea is produced annually on about 156,000 ha of land in Ghana, making it the fifth highest producer of cowpea in Africa (TL II Project, 2012).

2.2.3 Cowpea Production Systems

Traditionally, in West and Central Africa, and Asia, cowpeas are grown on small farms often intercropped with cereals such as maize, millet and sorghum by small scale farmers. Fertilizers and pesticides are generally not used, because they are too expensive or not available to the farmers (Abubakar and Olukosi, 2008). In West Africa, both fodder and grain type varieties are grown sometimes as a pure crop and its commercial production is mostly done in these states.

2.2.4 Cowpea Production Constraints

Although cowpea is a hardy crop that can produce reasonably well under conditions that may render other crops unproductive, production is still constrained by several biotic and abiotic stresses (Hall *et al*., 1997). In the developing world where soil infertility is high, rainfall is limiting, and most of the cowpea is grown without the use of fertilizers and plant protection measures such as pesticides and herbicides, a wide variety of biotic and abiotic constraints also limit growth and severely limit yield (Timko *et al*., 2007). The biotic factors that cause yield reduction include insect pests, parasitic flowering plants, as well as viral, fungal and bacterial diseases (Emechebe and Lagoke, 2002).

The abiotic factors include poor soil fertility, drought, heat, acidity and stress due to intercropping with cereals (Singh and Ajeigbe, 2002). However, Terao *et al.* (1997) reported insect pests, plant diseases, parasitic flowering plants and drought to be major yield-reducing factors. Several important pests attack cowpea throughout its growth stages from seedling until after harvest causing economic damage. The major insect pests which severely damage cowpea during all growth stages are the cowpea aphid (*Aphis craccivora* Koch), foliage beetles (*Ootheca sp, Medythia spp*), the flower bud thrips (*Megalurothrips sjostedti* Trybom) the legume pod borer (*Maruca vitrata* Fabricius) and the sucking bug complex, of which *Clavigralla spp, Anoplocnemis spp, Riptortus spp, Mirperus spp, Nezara viridula* Fab and *Aspavia armigera* L. are most important and are prevalent. Tremendous yield losses have been reported in Ghana, Cameroon and Nigeria (Georgiev, 2003) due to thrips infestation. It has been reported by Omo-Ikerodah *et al*. (2009) that yield loss in cowpea ranged between 20 to 80 % due to thrips |Infestation, while under severe infestation a 100% yield .cowpea is attacked by over 35 major diseases caused by viruses, bacteria, fungi, and nematodes. The occurrence, severity, and yield loss due to each disease and mixed infections vary from place to place, but some diseases occur and cause significant damage across the cowpea growing regions of the world. Virus diseases cause serious losses of yield and quality in cowpea in many cowpea growing countries. Worldwide, more than 20 viruses have been identified which infect cowpea under field or experimental conditions are considered potential natural threat to cowpea production.

Toğay (2005) reported that two bacterial diseases, bacterial pustule (*Xanthomonas spp*.) and bacterial blight (*Xanthomonas vignicola*), cause severe damage to cowpea worldwide. *Cercospora* leaf spot, brown blotch, *Septoria* leaf spot and scab are the most common fungal diseases. About 55 species of nematodes have been reported on cowpea Agbogidi,(2010b)) but the most damaging and widespread species is *Meloidogyne incognita*.

Parasitic weeds such as *Striga gesnerioides* and *Alectra vogelii* are a major limitation to cowpea production in Africa. *Striga* causes severe damage to cowpeas in the Sudan savannah and Sahel of West Africa, whereas *Alectra* is more prevalent in the Guinea and Sudan savannas of West and Central Africa and in portions of eastern and southern Africa (Timko and Singh, 2008). Despite cowpea being more drought tolerant than many other crops, moisture availability is still a major constraint to growth and development, especially during germination and flower setting. Erratic rainfall adversely affects both plant population and flowering ability, resulting in tremendous reduction in grain yield and total biomass in general (Timko and Singh, 2008).

2.2.5 Uses of Cowpea

Cowpea is a grain legume food crop that plays a critical role in the lives of millions of people in Africa and other parts of the developing world. Cowpea is a multifunctional crop, providing food for man and livestock and serving as a valuable and dependable revenue-generating commodity for farmers and grain traders.

It can be used at all stages of its growth as a vegetable crop, and the leaves contain significant nutritional value. The young leaves and shoots are consumed as spinach and provide one of the most widely used potherbs in tropical Africa (Mroso, 2003). Virtually all the components of the crop are important sources of food. Islam *et al.* (2006) emphasized that all the plant parts are nutritious providing protein and vitamins. Immature pods and peas are used as vegetables while several snacks and main dishes are prepared from the grains.

The crop is grown primarily in the third world for its cheap source of dietary protein, lysine and as supplement for meat. The seeds make up the largest contributor to the overall protein intake of several rural and urban families, hence Agbogidi (2010) described cowpea as the poor man's major source of protein.

According to Diouf (2011), the crude protein content of the seeds and leaves of cowpea ranges, respectively between 23 and 32 %, about twice the protein content of most cereals (Kay, 1979), and between 13 and 17 % in the haulms on a dry weight basis with high digestibility value and high fibre level).Their amino acid complements those of cereals (Asumugha, 2002). Their mineral contents: calcium and iron are higher than that of meat, fish and egg and the iron content equate that of milk; the vitamins- thiamin, riboflavin, niacin (water soluble) and their levels compare with that found in lean meat and fish (Achuba, 2006) which make them very useful in blood cholesterol reduction Adeniji (2007) reported that daily consumption of 100– 135 g of dry beans reduces serum cholesterol level by 20 %, thereby reducing the risk for coronary heart diseases by 40 % . In addition, because grain legume starch is digested more slowly than starch from cereals and tubers, their consumption produces fewer abrupt changes in blood glucose levels following consumption (Phillips *et al*., 2003). Rangel *et al*. (2004) reported that protein isolates from cowpea grains have good functional properties, including solubility emulsifying and foaming activities and could be a substitute for soy protein isolates for persons with soy protein allergies. The crop is also used for forage for farm animals, hay, silage, pasture (Adeyemi *et al.*, 2012

Apart from the use of its grain as source of food for human and animal feed, the practice of feeding cowpea vegetative parts to livestock is popular among peasant farmers and of increasing economic significance.

It forms a major component of the tropical farming system because of its ability to improve marginal lands through nitrogen fixation and as a cover crop (Abayomi *et al.*, 2008) and also serves as a residue, which benefits the succeeding crops. Cowpea is well recognized as a key component in crop rotation schemes because of its ability to help 16 restore soil fertility for succeeding cereal crops (Tarawali *et al*., 2002). The crop can fix about 240 kg/ha of atmospheric nitrogen and make available about 60-70 kg/ha nitrogen for succeeding crops grown in rotation with it (CRI, 2006). Cowpea grows quickly and permits the establishment of a good cover of the ground which decreases erosion, soil temperature and competition with weeds. It is a deep rooted crop and does well in sandy soils and more tolerant to drought than soybean (Lauriault and Kirksey, 2007). Its drought tolerance, relatively early maturity and nitrogen fixation characteristics fit very well to the tropical soils where moisture and low soil fertility is the major limiting factor in crop production (Hall, 2004). In areas facing food insecurity, such as Africa, peasants or small-scale farmers have used cowpea for intercropping with the other main crops such as maize (*Zea mays*), pearl millet *(Pennisetum glaucum)* and sorghum (*Sorghum bicolor*).

Among the legumes, cowpea is the most extensively grown, distributed and traded food crop consumed (Agbogidi, 2010a). This is because the crop is of considerable nutritional and health value to man and livestock (Agbogidi, 2010). They form a major staple in the diet in Africa and Asian continents (Awe, 2008). The very early maturity characteristics of some cowpea varieties provide the first harvest earlier than most other crops during production period. This is an important component in hunger fighting strategy, especially in Sub-Saharan Africa where the peasant farmers can experience food shortage a few months before the maturity of the new crop.

Wide array of legumes are produced in Nigeria , but cowpea is preferred on account of its short life cycle, fodder use and quality. The dry seeds may be boiled and eaten with “Gari” (a cassava product). It is also boiled together with rice and a colouring agent to give “Waakye”. The boiled seeds could also be served with fried ripe plantain (Quaye *et al.*, 2009). It is also used in preparation of weaning foods. In Ghana and other African countries like Tanzania and Niger, cowpea is used for preparation of stew that is either used together with cereal dishes or directly mixed with the cereals as maize, wheat, sorghum and rice. In Mali, cowpea is boiled and also prepared in traditional dishes called “Fary” and “Akra”. The young leaves are used to prepare green sauce for different dishes. During the raining season, farmers can use immature pods to resolve their food problems before other crops are harvested.

2.2.6 Effects of Phosphorus on the Growth and Yield of Cowpea

Phosphorus is a major mineral nutrient required by plants, but is one of the most immobile, inaccessible, and unavailable nutrients present in soils (Narang *et al*., 2000). It limits plant growth and productivity on 40 % of the world's arable soil (Vance, 2001). Phosphorus plays key roles in many plant processes such as energy metabolism, nitrogen fixation, synthesis of nucleic acids and membranes, photosynthesis, respiration and enzyme regulation. Phosphorus (P) is an essential macronutrient for legume growth and function Whitbread,(2006). Legumes are phosphorus loving plants; it is required for the physiological processes of protein synthesis and energy transfer in plants (Oti *et al.*, 2004). Application of phosphorus has been reported by several authors to improve yield of cowpea by enhancing number of pods per plant, number of seeds per pod and mean seed weight (Singh *et al*., 2011). Again, phosphorus application decreases zinc concentration in the cowpea grain which can affect the nutritional quality. Moreover, dry matter production is increased by phosphorus application and its distribution is also affected, for instance, phosphorus deficient plants usually have more dry matter partitioned to roots than shoots, probably as a result of higher export rates of photosynthates to roots (Fageria *et al*., 2006).

Deficiency in phosphorus results in stunted shoot and root growth due to reduced cell division and reduced cell enlargement. Phosphorus deficiency stimulated uptake of excess cations over anions by plants and hence enhanced proton release that could increase acidification which may facilitate P acquisition (Tang *et al*., 2001). Low levels of phosphorus (P) in the soil hinder the growth, development and function of various leguminous species (Okalebo, 2009). It is the most important essential nutrient for seed production and for formation of healthy and sound root system which is essential for the uptake of nutrients from the soil (Das *et al*., 2008). It plays a vital role in cell division, flowering, fruiting and nodulation. Application of phosphorus is therefore recommended for cowpea production on soils low in phosphorus.

Magani and Kuchinda (2009) in assessing effect of phosphorus fertilizer on growth, yield and crude protein content of cowpea in Nigeria reported that plant height increased with increasing level of phosphorus compared to the control but was not statistically significant. This is in contrast with reports Sharma *et al. (*2002) on cowpea and soybean respectively, that increasing levels of phosphorus up to 60 kg/ha significantly improved plant height. Rajput (1994) reported significant effect of phosphorus on number of leaves per plant early at 50 kg/ha. Magani and Kuchinda (2009) observed that phosphorus application increased branching in cowpea in the range of 2.2 - 15.1 branches per plant but was not consistent statistically. They also indicated that application of phosphorus increased number of leaves per plant in the range of 22.9 – 297.8 but was not consistent statistically.

(Adeyemi *et al.*, 2012 observed that phosphorus influenced crop growth rate and net assimilation rate with maximum attained at 80 kg/ha. Seyed and Hossein (2011) indicated that relative growth rate and crop growth rate were highly significantly different among phosphorus rates of 0, 35 and 70 kg/ha. Bationo *et al.* (2000) indicated that application of phosphorus fertilizers can triple cowpea stover production whilst Singh *et al*. (2011) reported highest response of stover yield to the application of 60 kg/ha. Olaleye *et al.* (2012) found that the total cowpea biomass was significantly ($p < 0.001$) increased by the application of phosphorus. Singh *et al*. (2011) indicated that P does not have significant influence on the harvest index of the crop implying that harvest index is a genetic trait and will only be influenced by varietal differences in the range of 36 % to 40 % which contrasts the findings of Malagi (2005) that harvest index differed significantly due to different levels of fertilizers with the lowest harvest index noticed with highest dose of fertilizer.

Achuba, (2006) reported that increasing phosphorus as a fertilizer promotes reproductive yields and inflorescence production, particularly when phosphorus is limiting in natural systems . Conversely, limitation of phosphorus supply has been shown to decrease the production of floral structures (Ma *et al.*, 2001). Phosphorus deficiency can delay blooming and maturity phosphorus application in cowpea shortened the time from planting to harvesting of green pods and hastened maturity.

2.2.7 The Problem of Declining Soil Fertility

The problem of declining soil fertility in crop-based farming system of sub-Saharan Africa is well known (Nwajiuba and Akinsanmi 2002). The use of organic amendments in agriculture has increased over the years, due to the increasing cost of inorganic (chemical) fertilizers and high demand for quality and uncontaminated products. The value of organic amendments in crop production is centred on the ability of animals and plants to provide nutrients and to improve the chemical, physical and biological properties of soils. The regular addition of organic amendments to soil is very important in the developing world of the tropics, where most traditional farming systems are not sustainable. Organic manure improves soil tilth, infiltration rate and soil water holding capacity; contributes nutrient to the crop and it is an important source of raw or partially decomposed organic matter (Bill 2001).

The particular significance of organic manure for soil fertility is that it influences so many different soil properties. In many parts of the tropics most annual crops respond well to application of organic manure. Organic manure enhances soil water holding capacity and reduces bulk density. The beneficial effect of organic matter on crop productivity is a function of so many factors, which include greater vigour of plant, improvement of soil properties and greater uptake of nutrients (Adeyemi *et al.*, 2012

2.2.8 Soil Requirements for Cowpea

Cowpea grows on a wide range of soils but shows a preference for sandy soils, which tend to be less restrictive to root growth. It is more tolerant to infertile and acids soils than many other crops. This adaptation to lighter soils is coupled with drought tolerance through reduced leaf growth, reduced water loss through stomata, and leaf movement to reduce light and heat load under stress. Cowpea is much less tolerant to cold soils than common beans and shows a poor tolerance of waterlogging. Cowpea thrives in well-drained soil and less on heavy soils. It also requires a soil pH of between 5.6 and 6.0. Achuba, (2006)

2.2.9 Effects of Residual Fertilization

The immediate short-term effects of applied fertilizers are often emphasized to the neglect of residual effects. Yet when farming is continued on the same site for several years, residual effects of fertilizer treatments may considerably affect the soil chemical properties and consequently crop yield .Reviewing the residues of fertilizers on succeeding crops, Cooke (2001) reported that past manuring with farmyard manure and fertilizers leaves residues of nitrogen, phosphorus and potassium in soil that benefit following crops. He further indicated that the residues of inorganic nitrogen fertilizers usually last only for a season, but the residual effects of continued manuring with phosphorus and potassium may last for many years. Akande *et al.* (2003) also reported an increase in soil available P of between 112 and 115 % and 144 and 153 % respectively for a two year field trials, after applying rock phosphate with poultry manure on cowpea. Akande *et al.* (2005)

Further reviewing the effect of rock phosphate amended with poultry manure on the growth and yield of maize and cowpea reported that when rock phosphate application had continued over a period of several years a large pool of undissolved rock phosphate could accumulate. However, residues of fertilizers left in the soil often raise yields in ways that are difficult to compare with fresh fertilizer dressings, sometimes responses to fresh dressings are unaffected by residues of previous dressings, but usually residues lessen the size of the fresh dressing needed (Cooke, 2001).

FAO (2002).found persistent high residual effects in maize on three P- deficient soils in Ghana when phosphorus was applied at a rate of 14 – 59 kg P/ha in the previous season. Giller,(2007). showed that when soil contains residues of inorganic nitrogen, larger maximum yields are possible than may be obtained from soil without residues. The results also showed that dressings of inorganic phosphorus fertilizers had large residual effects in the first year after the dressings stopped but much smaller effects in the second and third years.

The residual effect of a single dressing of phosphorus and potassium is usually much smaller than the direct effect the year before and may be too small to measure accurately in experiments. But the cumulative residual effects of many annual dressings are large and may be sufficient for normal yields of crops with small additions of fertilizer Giller, (2007)..

2.3 Quality of an Organic Crop Residue

In West Africa, organic residues may play central roles in halting the alarming soil fertility decline. Organic inputs can have fertilizer equivalency values of 50 to 100 kg 34 N/ha . While there is significant evidence that the addition of organic residues (obtained from trees/shrubs and crops) to soils can improve overall soil fertility, smallholder farmers are increasingly challenged in the selection of appropriate plant materials for soil nutrient management practices (Partey, 2011).

The resource quality of plant materials varies with the plant species, plant parts and their maturity, so it is essential that these are known for each plant material. Plant materials are classified by taxonomic family, genus, and species and whether they are able to nodulate and fix N or not. The material is further described according to plant part; leaf, stem, root, or stover and whether the material is fresh or litter.

Crop residues are added to soils as sources of plant nutrients and to improve the physical properties of the soil. These materials do not contain the same quantity of nutrients. In fact, incorporating some organic materials into the soil can induce nitrogen deficiencies in plants. The composition of the added material determines whether nitrogen is released for plant growth or tied up in an unavailable form by the microorganisms that decompose the organic fertilizers. Magani, (2009

Palm (2001) formulated a simple decision tool for managing organic resources. This system distinguished organic resources based on their chemical characteristics and decomposition patterns suggesting how each can be managed for short-term nutrient release within cropping systems (Palm *et al*., 2001; Vanlauwe *et al*., 2005). According to this decision support system, high quality organic residues (generally high in nitrogen and low in lignin and polyphenols) can be solely incorporated into soils with no N fertilizer additions while low quality organic residues would have to be applied in combination with N fertilizers (Palm *et al*., 2001). The incorporation of low quality organic resources with low N concentration and wide C-to-N ratio could result in initial net N immobilization unless supplementary N is provided through the application of N fertilizers (Bhupinderpal-Singh and Rengel, 2004 conservative estimates suggest that 12.5 million hectares of cowpea are planted annually around the world. Of this area, about 9.8 million hectares are planted in Africa, making it the region with the largest production and consumption of cowpea in the world (CGAIR, 2001). Nigeria produces about 2.1 million tons of cowpea, making it the World largest producer followed by Niger, 650,000 tons; and Mali, 110,000 tons (IITA, 2004).

According to Adeyemi et al. (2012), cowpea and other grain legumes are the essential sources of protein for about 700 million people, particularly in the developing countries of Latin America, Asia and Africa, Nigeria inclusive where plants provide 83% of total protein in the average diet. The crude protein from seeds and leaves of cowpea range between 23 and 32%, and between 13 and 17% respectively (Diouf, 2011). Cowpea pods and leaves also serve as fodder for livestock (Ghady and Alkoaiki, 2010; Abebe et al, 2005).

Inherent poor soil fertility and depletion of soil nutrients because of continuous cultivation and crop removal have been reported to hinder promising crop production (Kisetu *et al*., 2013).

In addition, nutrients level are also depleted in soils through physical soil loss by erosion, leaching of nutrients from agricultural fields and nutrient mining by crop and crop harvest (Kisetu and Teveli, 2013). The use of organic manures, inorganic fertilizers and leguminous crops has been advocated to restore the nutrients in lost soils (Fening *et al*., 2005). Organic manures help in conditioning the physical properties of the soil thereby increasing crop productivity.

Inorganic fertilizers in Nigeria are not obtained at the right time and are at higher cost which are not affordable to small holder farmers who are basically producing at subsistence. Because the country is endowed with large quantities of animal manures such as from cattle , goats, pigs and poultry (Kimbi *et al*., 2001), these could be used as alternative sources of nutrients in crop production. However, the appropriate rates to be applied are still debatable and highly controversial because of high variation in nutrient composition (Suthamathy and Seran, 2013; Njaguma, 2002)

CHAPTER THREE

MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

The field experiment was conducted at the teaching and research farm Ladoke Akintola University of Technology Ogbomoso is located on the latitude 8^{o} 08N longitude4^{0} 15E altitude 345 meter above sea level (masl), daily temperature of 28-33 ^{0} C, annual rainfall of 1000-1200 mm. soil type in the derived savannah agro-ecology of Nigeria is Alfisol (sandy loam) that is generally low in nitrogen.

3.2 SEED COLLECTION

Four certified cowpea varieties were obtained from international institute of tropical agriculture (IITA) Ibadan Nigeria that varieties are as follows IT97K-568-18, IT81D-994, IT89KD-288 and IT89K-391. Two cowpea varieties were obtained at Waso market Ogbomoso .the varieties are Sokoto and Oloyin beans

3.3 SOIL SAMPLING AND ANALYSIS

The land were cleared, ploughed and harrowed with a tractor, composite surface soil were randomly collected for determination of physical and chemical properties before planting and after planting. The land area 75cm x 12cm was mapped out for experiment. Seed of cowpea varieties obtained at IITA and WAZOBIA market was sown at a planting space of 60cm between individual plant and two seed and later thinned to one stand twenty eight plant were planted per bed.

Surface sample were collected from 0 to 15 cm depth and bulk to form a composite sample. Each composite sample were made up of 15 core sample per hectare of the experimental site. Representative sample were taken and air dried, crushed and sieved through 2mm for determination of particle size pH (H_2O) available P extractable micronutrient (Fe. Cu, Mn Zn) and exchangeable cation (K, Mg, Ca, Na) soil sieved through0.5cm mesh was used for both the determination of total nitrogen (N) and organic carbon. Particles size analysis was out according to bouyoucous (1951) hydrometer using sodium hexametaphosphate as the dispersant. Soil Ph was determined as 1.1 soil water ratio (IITA, 1982: Black 1965). Total N was extracted by the macro–kjedahl digestion method (Bremner, 1982) followed by colorimetric determination using (Technicon instrument 1975). Melich 3 (a multipurpose extractant) was used to extract available phosphorus, exchangeable cations (Ca, Mg, K, Na) and extractable micronutrient (Mn, Fe. Cu and Zn) (Melich 1984) phosphorus was determined colometrically using the Technicon AAII Auto analyiser while the concentration of (Calcium , Magnesium Copper, Iron, Manganese) in the extract were determined by Atomic Absorption Spectrophotometer (ASS) (Model Buck 200a) Sodium (Na)and K were determined using Flame emission photometer . Exchangeable acidity was determined by KCL Extraction method (Mclean). Effective cation capacity (ECEC) was determined by summation of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity. Organic carbon was determined by chronic acid digestion method (Heanes 1984).

3.4 TREATMENT AND EXPERIMENT DESIGN

Six varieties of cowpea seed were sowed and subjected into four rate of single super phosphate (0, 20, 40 and 60kg P/ ha) of sunshine organic fertilizer . The four treatment combination were arranged in a randomized complete block design (RCBD) and replicated three times.

3.5 EXPERIMENT LAYOUT

The experiment was a factorial combination of 6 cowpea line and P application rate is in a randomized complete block design with three replications. Two seed of varieties were planted per hole on 23rd June 2016. Two weeks after planting the seeding were thinned to one plant per stand. A mixture of best cypermethrin 10% E.C (8ml in 5liter of water) insecticide was sprayed twice to control insect pest during the experiment. The plant were grown to maturity when the pod had turn yellow.

3.6 EXPERIMENT PLOT

The plot was cleared manually using tractor hoes and cutlass. The plot was divided into 72 beds each measuring 2m by 2m. A space of 1m was left in-between the sub- plot there were 7 rows with the planting distance row 60cm and the planting distance within 39cm and the number of plant per row was 28. The division of the total plot was achieved by the use of measuring tape and wooden pegs for accuracy

3.7 TREATMENT APPLICATION

Single super phosphate (SSP) was applied using the ring method at four different level; 0kg/ ha (T_0) 20kg /ha (T1) 40kg/ha (T2) and 60kg/ha (T3) on 14th July 2016 (three weeks after planting)

3.8 DATA COLLECTION

Data were collected on the growth (number of leaves , number of branches, plant height and the plant affected by aphids) and yield () number of picking, pod yield per plot weight of dry pod per plot, girth of pod per pod and length of pod). The height of six randomly selected crop were taken at two weeks interval starting from the second week after planting using meter rule. The leaves and the branches were counted and recorded number of pod per plant was obtained by plucking all the pods from the plot length and girth of pods were measured using a thread and calibrating on meter rule. Weight of dry pod was obtained by weighted all the pods plucked each plot.

3.9 STATISTICAL ANALYSIS

Data collected were subjected to Analysis of Variance (ANOVA) and the significant means was then separated using LSD at 5% probability level

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Physical and chemical properties of the soil

The top soil (0-15 cm) from the experimental field -had the following properties: soil texture; sandy loam, pH-H2O; 6.5, %sand; 80, %silt; 10, %clay; 10, soil available phosphorus; 3.59 mg/kg, %nitrogen; 0.047, %organic carbon; 0.55, exchangeable acids (Cmol/kg soil): Ca; 2.1, Mg; 0.39, K; 0.05 and Na; 0.09 (Table 1).

4.2 Growth parameters

The effects of phosphorus rates and cowpea varieties on the growth parameters of cowpea is presented in Table 2. Cowpea varieties significantly ($p \leq 0.05$) influenced all the evaluated parameters except for number of leaves at 6 weeks, leaf area at 3 weeks ($p \geq 0.05$); Sokoto beans consistently produced the highest values for the vegetative parameters. For number of branches at three weeks after planting, the highest number of branches (7.94) was produced by Sokoto beans while the lowest number of branches (4.65) was obtained on IT81D-994 and at 6 weeks the lowest number of branches (18.98) was still obtained from IT81D-994. Furthermore, the highest number of leaves at 3 weeks (24.5) was obtained on Sokoto beans while the lowest (15.93) was still obtained on IT81D-994. However, the highest number of leaves at 6 weeks (99.6) was recorded on IT81D-994 while ITT97K-568-18 produced the least value. The peak plant height at 3 weeks and at 6 weeks (32.5 and 44.85 cm) was produced by IT89K-391 and IT89KD-288 respectively while the least values for these parameters (27.31 and 36.35 cm) were recorded on Oloyin. However, the highest leaf area at 3 weeks (64.7 cm^2) was produced by IT89K-391 and the highest leaf area (102.2 cm^2) at 6 weeks was produced by Oloyin while the lowest leaf area for the two periods was produced by IT81D-994 and Sokoto beans respectively**.**

Table 1: chemical and physical properties of the soil of the experimental site

Parameters	**Values**
pH (H2O)	6.5
particle size distribution	
% sand	80
% silt	10
% clay	10
% OC	0.55
%N	0.047
Ca (cmol$^+$/kg)	2.1
Mg (cmol$^+$/kg)	0.39
K (cmol$^+$/kg)	0.05
Na (cmol$^+$/kg)	0.09
ECEC	2.63
EA	0
P (pmm)	3.59
Zn (pmm)	9.07
Cu (pmm)	0.83
Mn (pmm)	67.27
Fe (pmm)	145.19

Table 2: Effects of phosphorus rates and cowpea varieties on the growth parameters of cowpea

Treatment	NB 3WKS	NB 6WKS	NL 3WKS	NL 6WKS	PH 3WKS	PH 6WKS	LA 3WKS	LA 6WKS
Fertilizer rate								
0 kg P/ha	5.99	23.78	19.47	99.3	30.16	38.43	53.3	82.7
20 kg P/ha	6.41	29.38	21.1	84.9	29.72	40.79	60.3	97.1
40 kg P/ha	6.33	26.91	20.67	83.2	29.86	40.61	53.7	90.2
60 kg P/ha	6.71	27.17	21.32	83.1	29.56	40.18	56	94.9
Varieties								
ITT97K-568-18	5.95	25.15	19.55	76	27.87	37.65	54.5	78
OLOYIN	6.22	26.17	20.15	79.2	27.31	36.35	58.4	102.2
IT81D-994	4.65	18.98	15.93	99.6	30.54	39.89	47.0	99.0
IT89KD-288	6.21	27.68	20.39	85.8	31.65	44.85	52.5	94.1
IT89K-391	7.18	29.8	23.31	91.0	32.5	42.85	64.7	98.4
SOKOTO	7.94	33.08	24.5	94.3ns	29.07	38.42	57.8	75.6
Fertilizer LSD(0.05)	1.363ns	4.737ns	3.811ns	41.7ns	2.734ns	2.6ns	10.14ns	9.34**
Varieties LSD(0.05)	1.67**	5.802***	4.667*	51.07ns	3.349*	3.184***	12.42ns	11.44***
Fertilizer *Varieties LSD(0.05)	3.339ns	11.603ns	9.334ns	102.13	6.697ns	6.368ns	24.83ns	22.88ns

NB = number of branches, NL = number of leaves, PH = plant height, LA = Leaf area, aphid = aphid infestation and WKS = weeks

Similarly, phosphorus rates did not significantly ($p \geq 0.05$) affect the vegetative parameters of cowpea except for leaf area at 6 weeks and aphid infestation at 3 and 6weeks ($p \leq 0.05$); the highest number of branches at 3 weeks (6.71) was produced by 60 kg P/ha while the lowest (5.99) was produced by plants with no application of phosphorus. Conversely, the highest number of branches at 6 weeks, number of leaves at 3 and 6 weeks (29.38, 21.32 and 99.30, respectively) was produced by 20 kg P/ha while the lowest consistently occurred on untreated plots except for number of leaves at 6 weeks. In continuation, the highest plant height at 6 weeks, leaf area at 3 and 6 weeks (40.79, 60.3 and 97.1, respectively) resulted from 20 kg P/ha. The interaction between cowpea types and phosphorus levels was not significant ($p \geq 0.05$) for all vegetative parameters determined.

4.3 Yield parameters

The effects of phosphorus levels and cowpea varieties on the pod yield of cowpea is presented in Table 3. Cowpea varieties significantly ($p < 0.01$) influenced all the evaluated parameters however phosphorus levels had no significant effect ($p > 0.05$) on the pod yield of cowpea; the highest number of pods picked (281.56) was produced by IT97K-568-18 while Oloyin produced the least. Consequently, IT97K-568-18 had the highest dry weight per plot (0.92 g), while Oloyin had the lowest. In addition, IT97K-568-18 produced the highest pod yield per plot between 1 and 6 weeks (238.0, 175.42, 120.25, 168.08, 128.75 and 86.17, respectively) while Oloyin still produced the lowest pod yield per plot across the weeks. Furthermore, the highest number of pods picked (106.56) was produced by 60 kg P/ha while 40 kg P/ha produced the lowest pods picked (86.0). 60 kg P/ha produced the highest pod yield per plot (89.33) at 1 week and this was not significantly different from the value obtained at 20 kg P/ha. Across the other weeks, the highest pod yield per plot varied between 20 and 60 kg P/ha with the two rates not significantly different from each other.

Table 3: Effects of phosphorus rates and cowpea varieties on the pod yield of cowpea

Treatment	Pod yield							
	NOP PICKED	**DWPP**	**PYPP 1WK**	**PYPP 2WK**	**PYPP 3WK**	**PYPP 4WK**	**PYPP 5WK**	**PYPP 6WK**
Fertilizer rate								
0 kg P/ha	90.83	0.36	73.33	62.06	43.39	61.06	48.22	34.83
20 kg P/ha	95.56	0.43	83.17	73.22	48.39	59.56	48.5	35.83
40 kg P/ha	86.0	0.39	71.67	66	46.94	51.11	43.11	32.78
60 kg P/ha	106.56	0.45	89.33	68.44	48.61	58.61	46.11	35.11
Varieties								
ITT97K-568-18	281.58	0.92	238.0	175.42	120.25	168.08	128.75	86.17
OLOYIN	0.0	0.0	11.0	11.0	11.0	11.0	11.0	11.0
IT81D-994	151.42	0.73	100.92	99	54.25	67.58	45.58	23.08
IT89KD-288	36.42	0.27	27.08	26.67	30.08	33.08	31.67	30.42
IT89K-391	78.33	0.31	83.67	73.83	41.5	39.25	29.67	20.33
SOKOTO	24.67	0.22	15.58	18.67	23.92	26.5	32.25	36.83
Fertilizer LSD(0.05)	27.78ns	0.1ns	21.07ns	22.98ns	13.8ns	16.81ns	12.82ns	10.25ns
Varieties LSD(0.05)	121.52***	0.3***	50.06***	92.15***	36.0***	52.67***	36.77***	30.44***
Fertilizer *Varieties LSD(0.05)	149.3ns	0.4ns	71.13ns	115.13ns	49.8ns	69.48ns	49.59ns	40.69ns

NOP = number of pods, DWPP = dry weight per pod, PYPP = pod yield per plot

The interaction between the levels of phosphorus and the cowpea varieties were not significant for all the number of pods per plot between the weeks ($p \geq 0.05$)

Table 4 presents the effects of phosphorus levels and cowpea varieties on the pod length of cowpea; varieties had significant effect on the length of pod across the period of observation while phosphorus levels was not significant across the weeks except at 5 weeks. IT81D-994 produced the highest pod length between week 1 and week 3 (17.05, 16.43 and 16.49 cm, respectively) while IT97K-568-18 produced the highest pod length at week 4 and 5 (16.66 and 17.05 cm, respectively) and the highest pod length (17.43 cm) at week 6 was produced by IT81D-994; Oloyin steadily produced the lowest pod length across the weeks. 40 kg P/ha constantly produced the longest pod length across the weeks while 60 kg P/ha yielded the lowest pod length. Likewise, the interactions between phosphorus levels and cowpea varieties was not significant ($p \geq 0.05$) across the weeks.

The effects of phosphorus levels and cowpea varieties on the pod girth of cowpea is presented in Table 5; cowpea varieties had significant effect ($p \leq 0.05$) on the stem girth across the weeks of study while phosphorus rates did not significantly influence the pod girths ($p \geq 0.05$). IT81D-994 produced the highest pod girth between week 1 and week 6 (2.93, 3.14, 3.18, 3.36, 3.61 and 3.72 mm, respectively) whilst Sokoto beans produced the minimum pod girth at week 1 and 2 (2.15 and 2.29 cm, respectively) though Oloyin produced the lowest between week 3 and week 6 (2.38 mm, respectively). For the phosphorus levels, 60 kg P/ha steadily yielded the highest pod girth from week 1 to week 5 (2.76, 2.87, 2.95, 3.08, 3.16 and 3.24 mm respectively) though this was not significantly different from the value obtained at other phosphorus levels (Table 5).

Table 4: Effects of phosphorus rates and cowpea varieties on the length of pod of cowpea

Treatment	Length of pod					
	LOPP 1WK	**LOPP 2WK**	**LOPP 3WK**	**LOPP 4WK**	**LOPP 5WK**	**LOPP 6WK**
Fertilizer rate						
0 kg P/ha	13.31	13.39	13.38	13.34	13.83	14.08
20 kg P/ha	14.21	13.49	14.14	14.47	15.04	15.12
40 kg P/ha	14.4	14.64	14.87	14.66	15.08	15.3
60 kg P/ha	12.94	12.89	13.27	13.06	13.32	13.58
Varieties						
ITT97K-568-18	15.53	15.45	16.08	16.66	17.05	17.2
OLOYIN	8.65	8.65	8.65	8.65	8.65	8.65
IT81D-994	17.05	16.43	16.49	15.8	17.04	17.43
IT89KD-288	13.78	13.83	13.82	13.92	13.88	13.99
IT89K-391	16.28	15.6	16.17	15.6	16.38	16.65
SOKOTO	11.0	11.68	12.28	12.66	12.92	13.2
Fertilizer LSD(0.05)	1.47ns	1.68ns	1.5ns	1.52ns	1.38*	2.03ns
Varieties LSD(0.05)	4.59***	4.62***	4.58***	4.79***	4.52***	4.58***
Fertilizer *Varieties LSD(0.05)	6.06ns	6.30ns	6.08ns	6.31ns	5.70ns	6.71ns

LOPP = Length of pod

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Table 5: Effects of phosphorus rates and cowpea varieties on the pod girth of cowpea

Treatment	Girth of pod					
	GOPP 1WK	**GOPP 2WK**	**GOPP 3WK**	**GOPP 4WK**	**GOPP 5WK**	**GOPP 6WK**
Fertilizer rate						
0 kg P/ha	2.52	2.73	2.77	2.91	3.07	3.17
20 kg P/ha	2.56	2.7	2.83	2.99	3.12	3.26
40 kg P/ha	2.68	2.79	2.93	3.02	3.14	3.28
60 kg P/ha	2.76	2.87	2.95	3.08	3.16	3.24
Varieties						
ITT97K-568-18	2.74	2.89	3.08	3.31	3.46	3.68
OLOYIN	2.38	2.38	2.38	2.38	2.38	2.38
IT81D-994	2.93	3.14	3.18	3.36	3.61	3.72
IT89KD-288	2.81	2.94	2.96	2.98	3.0	3.02
IT89K-391	2.76	2.99	3.15	3.32	3.48	3.67
SOKOTO	2.15	2.29	2.48	2.64	2.83	2.96
Fertilizer LSD(0.05)	0.32ns	0.26ns	0.25ns	0.25ns	0.24ns	2.03ns
Varieties LSD(0.05)	0.39**	0.44***	0.45***	0.49***	0.51***	0.54***
Fertilizer *Varieties LSD(0.05)	0.71ns	0.70ns	0.70ns	0.74ns	0.75ns	2.57ns

GOPP = girth of pod

IT81D-994 was most susceptible to aphid infestation as the highest aphid occurrence at 3 and 6 weeks (3.425 and 2.65, respectively) was observed on it while the lowest aphid infestation was observed on Sokoto beans at both observation period. Unfertilized plots (0 kg P/ha) were most susceptible to aphid attacks as it produced the highest aphid attacks (3.333 and 2.244 at 3 and 6 weeks respectively) whereas 60 kg P/ha produced the least aphid attacks at 3 and 6 weeks (2.85 and 1.717, respectively) (Table 6).

4.4 Soil Properties

Table 7 presents the effects of the applied phosphorus levels and cowpea varieties on the physical and chemical properties of the soil; cowpea varieties significantly influenced all the soil properties examined except for organic carbon, nitrogen, sodium, zinc, copper and iron contents ($p > 0.05$) while phosphorus levels had no effect on soil pH, phosphorus, % sand, %clay, copper and manganese. The highest soil pH (6.21) was recorded on Oloyin plots while Sokoto beans produced the highest organic carbon (0.40); Nitrogen contents however did not vary between the cowpea varieties. Oloyin produced the maximum ECEC (2.14) obtained and the least was produced by IT97K-568-18 (1.73). There was no significant difference between soil pH as influenced by phosphorus levels though 60 kg P/ha gave the highest value of 6.14; similarly, the nitrogen content did not vary between the varying phosphorus levels

Table 6: Effects of phosphorus rates and cowpea varieties on the susceptibility of cowpea to aphids

Treatment	APHIDS 3	APHID 6
Fertilizer rate		
0 kg P/ha	3.333	2.244
20 kg P/ha	2.856	1.844
40 kg P/ha	2.867	1.744
60 kg P/ha	2.85	1.717
Varieties		
ITT97K-568-18	2.883	2.092
OLOYIN	2.892	1.6
IT81D-994	3.425	2.65
IT89KD-288	2.983	1.842
IT89K-391	2.917	1.675
SOKOTO	2.758	1.467
Fertilizer LSD(0.05)	0.39**	0.39**
Varieties LSD(0.05)	0.48ns	0.49***
Fertilizer *Varieties LSD(0.05)	0.96ns	0.96ns

Table 7: Effects of phosphorus rates and cowpea varieties on the soil physical and chemical properties of the soil after harvesting

Treatment	Ph	OC	N	P	%SAND	%SILT	%CLAY	Ca	Mg	K	Na	ECEC	Zn	Cu	Mn	Fe
Fertilizer rate																
0 kg P/ha	6.10	0.33	0.03	5.80	79.23	8.50	12.27	1.32	0.44	0.13	0.07	1.95	6.18	4.67	37.92	165.11
20 kg P/ha	6.13	0.37	0.03	5.62	79.03	8.67	12.30	1.32	0.39	0.15	0.07	1.93	5.01	5.33	37.04	171.12
40 kg P/ha	6.10	0.38	0.03	5.12	79.03	9.17	11.80	1.25	0.39	0.16	0.07	1.87	5.60	4.67	38.21	213.21
60 kg P/ha	6.14	0.32	0.03	5.72	78.73	8.67	12.60	1.15	0.37	0.13	0.07	1.72	4.22	5.55	37.33	189.16
Varieties																
ITT97K-568-18	6.19	0.35	0.03	3.25	79.75	8.25	12.00	1.12	0.40	0.13	0.07	1.73	1.73	5.00	36.79	189.16
OLOYIN	6.21	0.33	0.03	4.18	79.00	9.25	11.75	1.46	0.46	0.15	0.07	2.14	2.14	4.67	41.71	180.14
IT81D-994	6.13	0.36	0.03	9.45	78.25	9.00	12.75	1.31	0.38	0.11	0.07	1.87	1.87	4.34	35.69	166.61
IT89KD-288	6.13	0.31	0.03	5.05	79.60	8.75	11.65	1.27	0.37	0.14	0.07	1.85	1.85	5.00	38.10	180.14
IT89K-391	6.09	0.34	0.03	6.61	78.95	8.75	12.30	1.18	0.38	0.18	0.07	1.81	1.81	5.33	38.97	211.70
SOKOTO	5.99	0.40	0.03	4.87	78.50	8.50	13.00	1.22	0.38	0.15	0.07	1.81	1.81	5.99	34.49	180.14
Fertilizer LSD(0.05)	0.06ns	0.06*	0.002**	2.04ns	0.56ns	0.44*	0.64ns	0.10**	0.03**	0.02*	0.004*	0.13**	0.88**	1.08ns	3.62ns	30.05**
Varieties LSD(0.05)	0.07***	0.07ns	0.003ns	2.50***	0.69**	0.54**	1.78**	0.12***	0.04***	0.03**	0.07ns	0.16**	1.08ns	1.33ns	4.43**	36.80ns
Fertilizer *Varieties LSD(0.05)	0.15ns	0.14**	0.005**	4.50**	1.37ns	1.08**	1.56*	0.25ns	0.08ns	0.06**	0.07ns	0.33*	2.16**	2.67ns	8.86ns	73.61***

4.5 DISCUSSION

Growth attributes such as plant height, leaf area, number of branches and number of leaves was significantly increased by the application of phosphorus fertilizer. This result is in conformity to the results observed by Krasilnikoff *et al.* (2003) and Nyoki *et al.* (2013). This could be attributed to the fact that phosphorus is required in large quantities in shoot and root tips where metabolism is high and cell division is rapid (Ndakidemi and Dakora, 2007). Thus, an indication that the cowpea varieties utilised the phosphorus fertilizer applied judiciously in growth and development processes. Phosphorus application also improved some yield attributes taken into consideration in this study: number of pods, length of pods and pod girth. These were found to be significantly different at 0.05 level of significance and this is in conformity with the findings of other workers (Okeleye and Okelana, 2000; Haruna and Usman, 2013; Odundo *et al*., 2001; Ntare and Bationo, 2002; Nyoki *et al*., 2013; Singh *et al*., 2011 and Ndor *et al.,* 2012) who also discovered significant increase in yield of cowpea in response to phosphorus application. However, Agboola and Obigbesan (2001) reported that phosphorus application did not significantly increase cowpea yield but rather enhanced nodulation and phosphorus content of leaf and stem. Highest value in all the yield characters measured was observed in variety three at phosphorus rate of 40 and 60 kg ha^{-1}, this contradicts the findings of Haruna and Usman (2013) who recorded highest yield at 30 kg ha^{-1}in their experiment but it agrees with Singh *et al*. (2011) who reported highest yield at 60 kg ha^{-1} and suggested that that may be the optimum as further application of phosphorus may or may not increase yield of cowpea. The significant response of the measured yield characters of cowpea to phosphorus application could be attributed to the role of phosphorus in seed formation and grain filling (Haruna, 2011, Nkaa *et al*., 2014).

The obtained significant variation for most of the soil physical and chemical properties conducted after harvesting signifies that the cowpea varieties and phosphorus levels had differing effects on the soil composition; this might be attributed to the initial properties of the soil and the nitrogen fixing abilities of cowpea. Furthermore, phosphorus initiates nodulation, hence the varying phosphorus levels could have significantly affected the soil properties while the cowpea varieties may also have differing nodulation responses

CHAPTER FIVE

5.0 SUMMARY AND CONCLUSION

The observed variations in the performance of the cowpea varieties used could provide a basis for selecting cowpea lines with greater agronomic efficiency in phosphorus deficient soils to reduce fertilizer cost. However, it could be used in an initial assessment of large number of breeder lines. These variations could be important for selecting varieties suitable for a range of soil phosphorus conditions as well as to release to farmers on large scale production. Irrespective of the varieties, application of 40 kg ha^{-1} could be recommended for higher yield of cowpea relative to 0 kg ha^{-1} that yielded lower tons. However, 40 kg P_2O_5 ha^{-1} may not be the optimum as further application of P may or may not increase the yield of cowpea. Thus it is subject to further investigations.

It could therefore be concluded that IT99K-573-2-1 and phosphorus application rate of 40 kg ha^{-1} is ideal for soils low in phosphorus and is thus recommended for farmers in derived savannah agro-ecology of Nigeria for enhancement of cowpea yield.

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