

**POTASSIUM AVAILABILITY IN DIFFERENT WEED INVADED AREA OF OIL
PALM PLANTATION**

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CERTIFICATION

This is to certify that this research project titled "Availability of potassium in different weed invaded area of oil palm plantation in Benin City" was carried out by Minster Edosa Parker Omorogbe with Matriculation number AGR1800428; in the Department of Soil Science and land management, Faculty of Agriculture, University of Benin, Benin City, Edo State.

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DEDICATION

This study is dedicated to God almighty who through his love, Grace, Guidance and provision make this program a success.

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I am Grateful to God Almighty for his Grace and love all through this while.

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ABSTRACTS

The study was carried out to investigate potassium availability in soils of an oil palm plantation invaded with different weed types in Ekasa Village, Ovia North East Local Government area of Edo State, Nigeria. Soil samples were collected at two different depths (0-15cm and 15-30cm) with three replicates each, at four different weeds-invaded areas covering at least one acre each. The weeds investigated are; Spear grass (SR) (*Imperata cylindrica*), Guinea grass (GR) (*Panicum maximum*), White weed or goat weed (WR), (*Ageratum conyzoides*), and Siam weed (*Chromolaena odorata*) (CR). The results showed that the soil of the plantation is loamy sand which is moderately acidic (mean pH value = 4.67). In all the weeds investigated the potassium contents in the soils at 0-15cm depth are very low (WR=0.1724 Cmol/kg, SR=0.1008 Cmol/kg, GR=0.1838 Cmol/kg, and CR=0.1478 Cmol/kg) and these values are reducing with increasing depth. At both 0-15cm and 15 – 30cm depth, there are no significant differences in the potassium contents among the soils of all the weeds investigated. The portions with CR and GR have high and significantly same organic carbon contents at 0-15cm (23.61g/kg and 23.01g/kg respectively) but moderate organic carbon content at 15-30cm (18.22g/kg and 15.23g/kg respectively) which are also significantly the same, while the portions with WR and SR have moderate organic carbon contents at both depths (15.49g/kg, 10.91g/kg and 18.42g/kg, 14.76g/kg respectively). The Organic carbon content in the CR portion was the highest (23.61g/kg) followed by the portion with GR (23.01g/kg) at 0-15 cm depth while the portion with WR is the lowest (15.49g/kg). The 15-30cm depths also followed the same trend. There was a significant difference between the mean value of organic carbon content of the portion with WR (15.49g/kg) and CR (23.61g/kg). There were no significant differences between the nitrogen value in soils of CR and GR at both depths. The results also showed that the soils of the portion with CR has significantly the highest nutrients reserve of followed by GR, then SR while WR has the lowest fertility levels.

CHAPTER ONE

INTRODUCTION

The oil palm (*Elaeis guineensis*) from the family Arecaceae, is a branchless tree and a monocot plants, which is considered the world most important and most productive vegetable oil crop per unit areas and has contributed massively to economic growth of developing countries (Zimmer, 2010). The product obtained from palm fruit is known as palm oil. There are two contrasting type of oil found in the principal tissue of palm fruit, namely palm oil and palm kernel oil. The palm fruit is processed into palm oil, the palm kernel seed is processed into palm kernel oil (PKO) and palm kernel cake (PKC), while the crude palm oil is further processed into cooking oil, margarine, cosmetic soap .Waste from palm kernel after extraction of the oil is used as animal feed and as biofuel (Hoyle and Levang, 2012). According to Ofosu-Budu and Sarpong (2013) palm oil is noted to be the largest natural sources of vitamin E, which is essential as well as dietary magnesium.

Weeds and weed problems continue to be important factors reducing yield in oil palm production. Improve oil palm varieties start production within three years after planting and have average economic life of about thirty years. However, development and yield of the crop are adversely affected by weeds. (Corley and Tinker, 2003). Weed management had been a major constraint for oil palm farmers. In established oil palm plantation noxious weed such as *Chromolaena odorata*, compete with the oil palm for nutrients moisture and sunlight and eventually caused yield depression (Pride 2010; lam, *et al*, 1993). palm that grow where there is *Imperata cylindrical* are generally stunted and retarded in growth. Other noxious grass affecting growth of palm oil is *Panicum maximum* (Pride 2010).

Oil palm is a highly potassium (K)demanding tree requiring fertilization throughout its life. Oil palm thrive well under optimum soil condition with total available K of 0.2%.

Potassium availability in oil palm plantation has a great impact in oil palm yield which includes general increase in stomatal conductance and biosynthesis of photosynthetic machinery in leaves, thereby stimulating net carbon assimilation (Cuiet *al.*.,2019, Mirande-Ney *et al.* 2020). And stimulating of phloem transport (Cuiet *al.* 2020), and increase in number of size of bunches. Noxious weeds such as *Panicum maximum*, *Ageratum conyzoides*, *Imperata cylindrical* and *Chromolaena odorata* are also highly potassium demanding plant they need potassium at higher amount for their growth process, these weeds compete with oil palm for this available nutrient in soil thereby causing yield depression. (Pride, 2010).

Therefore, the objective of this study is to review the availability of potassium in different weeds infested area of oil palm plantation.

CHAPTER TWO

2.0 LITERATURE REVIEW

Oil palm (*Elaeis guineensis* Jacq.) Is the major oil-producing crop in the world, with a global annual production of about 75Mt (FAO 2018). The oil palm is the most productive oil crop in terms of oil yield per hectare and resource use efficiency due to its high ability at transforming solar energy into vegetable oil. per hectare bases, oil palm is the most productive oil crop in the world, being 10 times more productive than soybean and other oil-bearing seeds (Verheye, 2010). Of the 17 major vegetable oils traded on the international market, palm oil is the most important and accounts for more than half of the global important export trade of all vegetable oils (Boons and Angelica, 2010).

The optimal yield of palm oil is about 4.2tha⁻¹ per year, and can exceed 6.0tha⁻¹ per year in the best- managed plantation (Fairhurst and Mutert 1999).The oil palm is an international commodity used for food, household and industrial purposes, and it's demand is very high (UNEP, 2011). Soil fertility management of oil palm plantations has been identified as a key to successful and sustainable oil palm production (Obi and Udoh, 2012). In Nigeria, relationship between oil palm yields and soil nutrients have been established, and it has been concluded that soil fertility is a major constraint to sustainable production (Obi and Udoh, 2012). For good growth and productivity, the oil palm must thrive well under optimum soil conditions wit total N, Available P and Available K of 0.2%, 20mg/kg and 100mg/kg respectively (Hartley, 2000). According to Goh Chew (1997), other soil fertility parameters must also be present in the soil within suitable ranges. For instance, oil palm thrives well under CEC of 15-18cmol kg⁻¹, pH of 5.0 -5.5, exchangeable K of 0.25-0.30cmol kg⁻¹ and exchangeable Mg of 0.25-0.3 cmol kg⁻¹

2.1 Oil Palm Production in Nigeria

Nigeria is considered to be among the largest producers of palm oil, which is extracted from the fleshy mesocarp of the palm fruit and has been a vital resource in the majority of Nigerians diet. The global need for palm oil is fast increasing because of an increase in population globally. Palm oil also serve as a source of income for the majority of individuals in developing countries (Bassey, 2006). In Nigeria, estimation shows that about 1.34×10^6 metric tonnes of palm oil were consumed in the year 2008 (Akram and Kay, 2012). Furthermore, it is a vital raw material for food-producing companies (Wilcove and Koh,2010).

Before the discovery of crude oil in Nigeria, the Nigeria economy benefited mainly from the export of palm oil and was the global leader in export. After the discovery of crude oil in Nigeria, there was a slow decline in palm oil exports; Nigeria lost its sit as the global leader on the product.it acquired a trade deficit in the product where Nigeria now depends on current global leader like Malesia and Indonesia to meet its rising local palm oil demands (Budidarsino *et al.*,2012; Carrere, 2010). In order to increase palm oil production, small scale oil production should be encouraged, which has the added benefit of providing an additional source of employment (Ayinde *et al.*, 2012).

The most economical crop and source of cooking oil is the oil palm, which yields a higher quantity of cooking oil (Vegetable oil in Europe). Palm oil is highly rich in carotene and is essential cooking oil in Nigeria. Primary raw materials used for producing detergents, soap, margarine, confectionery, epoxy resins, bakery trade, etc. come from palm oil. It also serve as additive on animal feed. The local technique of oil palm processing have been proved to be stressful, time-consuming, and result in low yield due to massive percentage of wastes during

processing (Inyiame *et al.*,2011). Furthermore, the high cost of palm oil processing plant is a big concern to palm oil producers in Nigeria (Potter, 2015).

The palm oil-producing sector in the country is under construction after it failed due to crude oil discovery. The factor responsible for the decline in Nigeria is inadequate knowledge of the processing machine, Over-reliance on smallholder processors, the problem of land, and lack of basic amenities, and inadequate financial support (Omoti,2001). The need for palm oil has increased in Africa and specifically in Nigeria, and that is why the Federal and State Government plan is targeted towards enhancing agricultural productivity, which has been neglected for many years. In transforming crude palm oil to refined products of hydrolysis and Oxidation, colour and flavor are removed. Palm oil processing undergo these units of operation (Doherty,2006).

2.2. Potassium Role in Oil Palm Production

Potassium plays important roles in photosynthesis, regulation of osmotic balance, and phloem transport in plants (Tripler *et al.*, 2006; Harris and Nazari, 2011). It also activates enzymes, regulates transpiration, transports assimilates, controls transport through the cell membrane, aids in the formation of proteins and carbohydrates, and strengthens plant tissues (Marschner, 2012). Potassium also supports resistance to abiotic and biotic stresses, such as drought, pests and disease (Wang *et al.*, 2013). Potassium deficiency is usually found in plants grow on peat soil , sandy soil and acid soils with low cation exchange capacity. This deficiency is due to low exchangeable K in the soil and lack of K fertilizer application. Potassium is a highly a mobile element in plants and it is translocated from older to younger tissue (Selvaraja *et al.*,2013

Potassium is important in the growth and development of the oil palm and is required in plant 's general metabolism in the movement of the stomatal (water economy), activating cell division (Manciot, *et al.*, 1991). Potassium action is equally manifest in all production factors; that is number of inflorescences and fresh fruit bunch (ffb) production. According to Amalu (1990), insufficient potassium content in the soil give rise to poor growth of palms with thin trunks, sparse canopy, few and smaller fronds and leaflets. Omoti (1999) reported that over 50% of the total potassium in the soil is removed by fruit which are permanently lost to the plantation.

Potassium fertilizer is usually apply to oil palm as Murate of potash (MOP), NPKMg. (12:12 :17:2) etc; however , with the soaring cost and scarcity of these fertilizers, the fertilization of oil palm plantation has become very expensive indeed . The oil palm fertilization accounts for 25-30% of the total production costs in mature palm (Omoti,1999). These have necessitated the need to look inwards for the alternative source of minerals such as potassium rock bearing minerals as fertilizers for oil palm manuring (Mc-Chellen and Kamwengery,)1992).

2.3. Potassium fertilization in oil palm production

Low potassium (K) availability is a major concern on tropical soils where oil palm is cultivated since they are often naturally poor in exchangeable cations such as K⁺ (Ollagnier and Ochs, 1993). Also, fruit bunch harvesting removes substantial amount of K from oil palm agro systems. For example, typical fruit harvesting of 30 FFB (fresh fruit bunches) ha⁻¹y⁻¹ represents a loss of 160kgK/ ha⁻¹y⁻¹, that is 75% of K fertilization input (review in (Corley and Tinker, 2016). Oil palm plantations are thus heavily fertilized with K (typically using potassium chloride, KCL) up to 200kg K/ha y⁻¹, leading to an annual cost of about \$1billion at the global scale. However , the efficacy of applied K depends on leaching, the efficiency of K absorption by roots (including the

antagonism between K and other cations, mostly Ca and Mg), K allocation within the tree and the response of yield of K availability in the variety (cross) of interest (Goh *et al.*, 2003).

Potassium fertilization mainly in the form of potassium chloride (KCl), is a major concern for growers, who use leaf analyses to determine annual fertilizer requirements. Factorial analyses provide data for the calculation of response curves and surfaces, and of optimum content to achieve the best economic yield (Webb 2009). Fertilizer recommendations can be accurately adjusted on that basis by comparing leaf contents with optimum levels. However, in some oil palm plantation on volcanic soils or on alluvial soils of volcanic origin, it is not possible to establish an optimum K level experimentally or to use leaf analyses efficiently. For example, in Indonesia, Caliman *et al.*, (1994) reported that potassium application had little effect on yield, despite leaf potassium contents that could be considered deficient. Research scientist and Organization have advocated the direct application of local bearing rock as fertilizer to recapitalize the soils (Isenmila and Omoti;2003). The advantage of using potassium rock bearing rocks as fertilizer lays in their relatively cheap, environmentally friendly and readily available over the conventional inorganic fertilizer Mu-rate of potash. The minerals are found in quantities in Nigeria (NIFOR, 1998).

2.4 Concept of weed

Weeds are commonly defined as plants that grows out of time and place this negative perception emerged with agriculture and relates to the damage they cause to crops. In addition to direct competition with crops(parasitism),weeds caused indirect damage by harbouring insect pests and crop pathogen.Direct causes by weeds vary from crop to crop,and from one ecological zone to the other for the same crop.The importance of weeds is widely acknowledge and mankind is still

far from dealing with them effectively (Rehm and Espig, 1991). Worldwide, 13% loss of agricultural production is assigned to weeds, in spite of the control measures taken by farmers.

Weeds problems are also reflected in the cost of hiring labour to carry out land preparation and weeding (Doll *et al.*, 1997). Weeding is time consuming. According to Bourgeois and Marnotte (2002). About 60% of the time in farming is spent on the first clearing of the farm and on weeding, representing 140 -190 man day farm

Weed invasion is a major problem during the early stage of oil palm plantation, because weeds interfere oil palm growth by competing resources such as moisture, nutrients, and light (Oerke 2006).

Although the direct impact of weeds on palm oil is difficult to predict due to its long economic life (20-30 years) (Kuan *et al.* 1991), the short term impact is closely related to bunch formation, thus indirectly affecting plant productivity. The weeds are composed of grasses, sedges, and broad leaf herbs and shrubs which often change according to the crop growth stage which provide specific climatic and environmental condition suitable for specific weed growth (Mohammad *et al.* 2010).

Both weed and oil palm need nutrients (k) from the soil for their growth and physiological activities. Study shows that weed take up more nutrients more quickly than crops in early growth stages and can accumulate higher concentration of many nutrients than crops do, thereby depleting soil nutrients and reducing crop yield (Blackshaw *et al.*, 2003).

Various weeds of choice of study affecting oil palm and its uptake of soil available potassium (K) include; *Panicum maximum*, *Ageratum conyzoides*, *Chromolaena odorata*, and *Imperata cylindrica*.

2.5 Guinea grass (*Panicum maximum*)

Guinea grass, a forage grass native to Africa, was universally introduced for hay and silage production but has caused significant ecological impacts. Guinea grass has become an invasive species in tropical areas and warm temperate areas.

2.6 Morphology and Biology

Guinea grass is a deep-rooted C4 perennial bunchgrass. It grows in erect clumps with a clump radius ranging from 0.21 m to 2.89 m. Stems are cylindrical, 2.5m -3.5m tall (Aganga and Tshwenyane, 2004; Everitt, 2011) with a slightly flattened base. However, the height is dependent on other habitat conditions such as soil moisture, nutrients, shade, etc. Stems are streaked with white wax at the nodes and internodes with leaf blades growing from the lower nodes (Moore, 2010). Leaf-blades are clustered, 20-35cm long and 7-20mm wide, with few appressed hairs. When the leaves are older the ends curl and dry (Everitt, 2011).

Roots are dense and fibrous with extensive root hairs near the surface but continue to grow deeper, up to 4.5m (Sumiyoshi, 2012). -Reproduction occurs through seed as well as vegetative propagation in Guinea grass. It is a prolific seed producer, each plant can produce up to 9000 seeds, however, seed yields are low due to seed shattering and the small seed size. While the plant biomass is reported to be significantly higher under shade, seed production is reported to be low. The germination rate of Guinea grass seeds is reported to be relatively low (Mishra *et al.*, 2008). But the seed viability could be well over 80% if they are dried gradually to 10% moisture

(Muir and Jank, 2004). They have been cited to experience seed dormancy for more than 3 years (Muir, 2004) and can germinate at 1.0 – 1.5 cm in the soil after the dormancy period (Muir, 2004).

2.7 Ecological impact

Guinea grass invades both agricultural fields and natural areas causing a significant impact on the ecosystem functioning and processes by altering the fire regime, soil quality, and attracting pests and diseases of crops (Mantoani *et al.*, 2016). It has been reported to be a major pest in both annual and perennial crops such as rice, corn, sugarcane, coffee, citrus, and other fruit orchards causing a major reduction in crop yield (Table 1). Guinea grass has been associated with agronomic pests such as *Bipolaris yamadae*, a leaf spot disease infecting sugarcane, serving as a refuge during the otherwise fallow season.

Not only is Guinea grass fire resistant but is also reported to alter fire regime in the dry tropical forests of Hawaii (Ellsworth *et al.*, 2014) and other tropical and subtropical region.

Impact of *Panicum maximum* on potassium availability of oil palm plantation

Panicum maximum, when grown alongside oil palm, can compete for essential nutrients such as potassium. This competition may lead to nutrient depletion in the soil, affecting the growth and productivity of both crops. Additionally, *Panicum maximum*'s aggressive growth can overshadow young oil palm plants, reducing their access to sunlight and further compromising their growth.

2.8 *Ageratum Conyzoide* Agricultural

Ageratum conyzoides is an erect, herbaceous annual, 30 to 80 cm tall; stems are covered with fine white hairs, leaves are opposite, pubescent with long petioles and glandular trichomes (Ming 1999). It can gain height up to 2 m in the Shivalik hills (Dogra, 2008, in Dogra *et al.* 2009). The inflorescence contain 30 to 50 self-incompatible pink, white or violet flowers arranged as a corymb (Jhansi and Ramanujam. Ramanujam and Kalpana 1992, Kleinschmidt 1993, in Ming 1999). The optimum germination temperature ranges from 20 to 25°C (Sauerborn and Koch 1988, in Ming 1999). The species has great morphological variation, and appears highly adaptable to different ecological conditions.

2.9 General Impacts

Agricultural: *Ageratum conyzoides* is a weed in many annual and perennial crops and has been reported as host of many crop diseases (Ekeleme *et al.* 2005). Weeds interfere with growth and production of crops and therefore exert significant ecological and economic impacts (Singh *et al.* 2001, Batish *et al.* 2009). For example, in Asia rice yield Asia has been negatively associated with *A. conyzoides* density (Roder *et al.* 1998). Some studies have demonstrated allelopathy in the weed, however, shoot competition for light appears to be a major mode of interference in crops (Ekeleme *et al.* 2005).

Allelopathy: Allelopathy is a type of biotic interference wherein a plant releases bioactive metabolites into the surrounding environment. Growth of nearby vegetation is negatively affected and a selective advantage to the donor plant is provided (Batish *et al.* 2009). Volatile components of *A. conyzoides* that contribute to phytoinhibition/allelopathy include precocenes and their derivatives monoterpenes and sesquiterpenes. There is much evidence that *A. conyzoides* inhibits germination and growth of other plants through chemicals produced by its

root and shoot systems. Fresh leaves and volatile oils of *A. conyzoides* inhibit seedling growth of various crops (Kong *et al.* 1999) .

2.10 Impact of *Ageratum Conyzoide* on the availability of potassium on oil palm plantation

The impact of *Ageratum conyzoides*, or goatweed, on soil nutrients can be significant due to its allelopathic properties. Goatweed releases chemicals that inhibit the growth of other plants, which can affect the overall ecosystem and nutrient cycling in the soil. Specifically, it can lead to changes in the availability of essential nutrients such as potassium, either by directly influencing their uptake by plants or by altering microbial activity in the soil.

2.11 *Chromolaena odorata*

Chromolaena odorata (Asteraceae) is a small herbaceous plant native to the Americas and is considered one of the worst terrestrial invasive species in the Old World tropics (Yu, He, Zhao, and Li, 2014). Leaf and root of the plant are used for treating simple diarrhea, diarrhea with vomiting, and dysentery. *C. odorata* is also used for treating diarrheal illnesses in Bangladesh and Nigeria (Aba *et al.*, 2015; Jahan *et al.*, 2019). Antidiarrheal effect (reduction in number of feces) of a methanolic extract of *C. odorata* leaves at 50, 100, and 200 mg/kg was demonstrated on a castor oil-induced diarrhea in mice. In the same study, the extract significantly reduced the intestinal motility in mice at the same concentrations (Taiwo, *et al.*, 2000). The antidiarrheal activity (reduction in the frequency and wetness of stools) of *C. odorata* was later confirmed in a rat model of castor oil-induced diarrhea using an ethanolic leaf extract of *C. odorata* at 200 and 400 mg/kg (Aba *et al.*, 2015).

A dichloromethane extract of *C. odorata* demonstrated antibacterial activity against *V. cholerae* with a MIC value of 156 µg/mL. Two flavonoid compounds (i.e., scutellarein tetramethyl ether, sinensetin) were identified as being responsible for this antibacterial activity (Atindehou *et al.*, 2013). Despite its efficacy, the use of *C. odorata* is controversial due to the presence of pyrrolizidine a

loids which exhibit hepatotoxicity and carcinogenicity (Anyanwu *et al.*, 2017). Therefore more research is needed to investigate the dosage range that is safe for humans (Omokhua, *et al.*, 2016).

2.12 Biological activities

Chromolaena odorata is a rich source of bioactive compounds with significant therapeutic effects on some pathological conditions (Omokhua-Uyi *et al.*, 2020; Omokhua *et al.*, 2016; Thophon *et al.*, 2016). Though different biological activities of the plant have been reported, this review only focuses on the antidiabetic, anticancer, anti-inflammatory, antimicrobial, antiparasitic, antinociceptive, antipyretic and wound healing activities of *C. odorata*.

2.13 Detriments

Chromolaena odorata is an aggressive pioneer shrub species, which is regarded as a very serious threat to agriculture and the environment in most invaded countries. The high productivity of light seeds allows the species to invade disturbed sites in a short period of time. The rapid spread of the weed is due to extensive seed production which is estimated to be 93,000 - 160,000 seeds/plant (Wilson, 1995). *Chromolaena. o* regenerates and colonises equally as well through its roots or by high seed production and it is also well dispersed by wind (MacDonald

and Frame, 1988).

Nowadays, this shrub is widespread in subtropical and tropical areas all over the world due to its fast invasion or colonisation and its facility to regenerate; *Chromolaena odorata* is present in different agricultural systems of its native continent (Skarratt, 1996). All these characteristics have caused many researchers to recognize *C. odorata* as a serious weed in countries where it grows (MacFadyen and Skarratt, 1996). In addition, *Chromolaena odorata* is considered as an alien invasive species which negatively impacts the forest in economic, ecological and environmental and social and health terms (Moore, 2004). It is also considered as a considerable threat to conservation and ecotourism, as it has first invaded natural area, reducing the biodiversity of grasslands, savannahs and forests (Matthews and Brand, 2004). *Chromolaena odorata* is a considerable problem in commercial tree plantations as it suppresses the growth of young pine and eucalypt trees and allows fire to penetrate deeper into plantations (Matthews, 2004; Matthews and Brand, 2004).

Impact of *Chromolaena odorata* on the availability of potassium for oil plantation

Chromolaena odorata has a negative impact on potassium availability in the soil due to its high potassium uptake and retention. As the plant grows, it absorbs significant amounts of potassium from the soil, leading to a reduction in available potassium for oil palm. Additionally, chromolaena's dense canopy and rapid growth can shade out oil palm vegetation mostly at their very young stage, further limiting their access to potassium and other nutrients. This can result in potassium deficiency in the soil, affecting the growth and health of oil palm and disrupting ecosystem balance.

2.14 Spear grass (*Imperata cylindrical*)

Imperata cylindrica (L.) Raeuschel, also known as speargrass in West Africa, alang-alang in Asia, and cogongrass in America, is a pernicious perennial grassy weed of significant importance in tropical and subtropical zones, as well as in some warm parts of the temperate regions of the world (Garritty *et al.* 1997). In these ecologies, *Imperata cylindrica* occurs in a wide range of habitats, which include degraded forests, grasslands, arable land, and young plantations. Normally, the grass does not occur in closed forests but frequently appears within a few years once the forests are opened up for agriculture or lumbering (Ivens, 1980). *Imperata cylindrica* is considered as the worst weed of southeastern Asia and the moist savanna of West Africa (Garriety *et al.* 1997; Terry *et al.* 1997). It is classified as the tenth most infamous weed in the world, which affects farmers who practice slash-and-burn agriculture (Holm *et al.* 1977) and among the nine grassy weed species that require additional effort beyond that needed to control other weeds. It is noxious because of its wide distribution and adaptation to a wide range of climatic conditions and soils, its high competitive ability with many crops, and its resistance to control. Technologies for combating *Imperata cylindrica* have been developed but very few have been widely adopted by small-scale farmers (Brook, 1989, Townson, 1991, Terry *et al.* 1997). This short review discusses the biological characteristics of *Imperata cylindrica* that have implications for its control and reviews the research progress and management options in small-scale farms in developing countries.

2.15 Economic Importance

The harmful effects of *Imperata cylindrica* on crops are well documented (Holm *et al.* 1977; Townson, 1991). It negatively affects the growth of teak, cocoa, kola, coffee, cashew, oil palm,

coconut, rubber, and *Gmelina arborea* (Townson, 1991). Yields of annual crops are severely reduced by competition from *Imperata cylindrica*.

In addition to crop yield losses, *Imperata cylindrica* increases the cost of crop production, reduces the market value of damaged tuber and root crops, and increases the risk of fire in perennial crops, plantations, and forest reserves. It readily burns, even when still green, destroying other vegetation while it regenerates very rapidly from its underground rhizome system, thereby displacing other plant species. Recurrent bush fires during the dry season cause considerable loss of organic matter, which results in soil degradation. It reduces the size of farms to that which can be adequately weeded by available labour. Mechanical injuries to the skin caused by rhizome ramets reduce the efficiency of planting, fertilizer application, staking, weeding, and harvesting in highly infested areas, resulting in increased labour demand and abandonment of land (Terry *et al.* 1997).

2.16 Characteristics of *Imperata cylindrica*

Townson (1991) and Terry *et al.* (1997) reviewed the biological characteristics that make *I cylindrica* very successful. The weed shows wide genetic variability that allows it to adapt to a wide range of ecological and management conditions. It possesses five taxonomic varieties with var. major in Asia and var. africana in West African being the most serious. *I cylindrica* reproduces sexually from seed and vegetatively by rhizomes. Flowering is common after exposure to stress such as burning, overgrazing, drought and repeated slashing. It can produce as many as 3 000 seeds, which have little, or no dormancy period and which can remain viable for over a year. The aggressive and invasive nature of *Imperata cylindrica* is attributed to its rhizomes. These are normally concentrated in the upper 15-20 cm of soil where they can remain

dormant but viable for a long time. Rhizomes have a high regenerative ability because of the numerous buds that readily sprout into new shoots after fragmentation by tillage or any other form of disturbance. Rhizomes are resistant to fire because of deep soil burial. Deep burial also makes *Imperata cylindrica* very resistant to most control strategies (Ivens, 1980). The ability of rhizome fragments to regenerate decreases with a reduction in length of rhizome segment. Longer rhizomes have better chances of sprouting because they have more carbohydrate reserves than short fragments (Ivens, 1975).

Imperata cylindrica can grow on soils with a wide range of nutrients, moisture and pH (Santoso *et al* 1997). Although sometimes reported to be a weed of poor soils, *Imperata cylindrica* probably dominates these areas because of lack of competition from other plant species that cannot survive on marginal land (Santoso *et al.* 1997). It is a poor competitor and is easily suppressed by other species on fertile soils (Eussen and Wirjahardja, 1973). It does not tolerate shaded environments because it assimilates carbon via the C4 photosynthetic pathway (Paul and Elmore, 1984). It is a strong competitor for growth factors such as water, nutrients, and light because it sprouts and grows more rapidly than most crops (C3 plants).

2.17 Management Strategies

Methods of *Imperata cylindrica* control have been reviewed extensively by Brook, (1989), Townson (1991), Terry *et al.* (1997) and others. The key objective of any management strategy should be the destruction of rhizomes, which are the main organs by which the weed perennates and spreads. Control strategies should also be based on an integrated approach, as no single method can control *Imperata cylindrica* in a sustainable manner. Technology to control *Imperata cylindrica* has been developed and has been used successfully in large estates or commercial

farms where there is an ample supply of labour, capital and herbicides. However, adoption levels by small-scale farmers are still low.

2.18 Chemical control

Many reviews on the use of herbicides for the control of *Imperata cylindrica* are available (Brook, 1989; Townson, 1991; Terry *et al.* 1997). Herbicides are quicker, cost-effective, and disturb the soil less where erosion may be of concern (Townson, 1991). Several herbicides have been tested alone (for example, paraquat, fluazifop-butyl, glufosinate-ammonia, dalapon, imazapyr, glyphosate, sulfometuron, nicosulfuron, and rimsulfuron) or in mixtures for the control of *Imperata cylindrica*. A few of these have shown poor-to-good control, depending on the rate of application, climate, and soil type. Repeated or sequential applications are usually necessary to have good control of *Imperata cylindrica*. Imazapyr and glyphosate appear to be the most promising herbicides for *Imperata cylindrica* control because of their ability to translocate to the underground rhizomes. Imazapyr at 0.5-1.0 kg/ha and glyphosate at 1.0-1.8 kg/ha provide good control lasting up to 12 months, depending on soil type, application rate, and environmental conditions (Udensi *et al.* 1999; Terry *et al.* 1997).

The long-lasting soil activity of imazapyr may be good in plantations but not in arable farming where it inhibits the establishment of arable crops. Glyphosate is the mostly widely used chemical for *Imperata cylindrica* control worldwide. It may be attractive to smallholder farmers because it has little or no soil activity and thus no carry-over effects to crops sown after its use. In addition, the efficacy of the herbicide is not dependent upon the volume of the carrier; hence it can be applied using weed wipers or in low volume as well as high volume sprays. After

glyphosate application, supplementary weeding is still required in the crop to control shoots that escape the initial pre-planting application.

Various innovations in application technology have also been evaluated to increase the efficacy of most herbicides. These include the use of adjuvants, low and ultra-low volume sprayers, and rope wipers. The results have been variable and sometimes conflicting. Despite the several advantages of glyphosate, it suffers from some disadvantages in that it has a high cost relative to other herbicides, and also it requires a rain-free period of six hours after application. Fluazifop-butyl (fusilade) is an option for post-emergence control in soybean. For example, at 0.375 kg/ha it provided 51 percent to 83 percent control of *Imperata cylindrica* in soybean, which was comparable to pre-planting application of glyphosate at 2.16 kg/ha in Nigeria (Avav, 2000). Shilling and Gaffney, (1995), reported that suppressed *Imperata cylindrica* for only three months. In maize, post-emergence application of nicosulfuron gave good control at rates of 70-400 kg/ha in West Africa. The use of herbicides requires capital for purchasing sprayers and herbicides, new skills, and technical support, not all of which are available to most small scale farmers. The farmer's only option is to use labour-based control methods, which are tedious, and only practical on a small scale.

2.19 Shade-Based Management Practices

Imperata cylindrica is sensitive to shading and therefore it usually dies when subjected to shading for a long time. It may take up to 8-10 years for the weed to die out and be replaced by natural forest. This sensitivity to shading can be exploited in its control by the use of fast growing cover crops, shrubs, or trees. The use of planted fallows for *Imperata cylindrica* suppression has been reported extensively by Koch *et al.* 1990; Anon. 1996; Macdicken *et al.*

1997; Akobundu *et al.* 2000; Chikoye *et al.* 2001 and others. Promising species include *Mucuna* spp., *Calapogonium mucunoides*, *Centrosema pubescens*, *Pueraria* sp., *Lablab purpureus*, *Psophocarpus palustris*, *Stylosanthes guyanensis*, *Cajanus cajan*, *Crotalaria* spp. and *Moghania macrophylla*. *Mucuna* spp. are prominent among the cover crops that have been promoted to smother weeds particularly in West Africa, because of their ease of establishment, faster growth rate, and higher biomass production. Important lessons learned from the use of cover crops in West African experiences are as follows:

2.20 Impact of *Imperata cylindrical* on Potassium Availability of Oil Palm Plantation

Imperata cylindrical, commonly known as cogongrass, is a highly competitive and invasive weed that poses a significant threat to the productivity of oil palm plantations. Its presence can lead to a reduction in oil palm yields, and one of the contributing factors is its impact on potassium availability in the soil. It is highly competitive with oil palm. It is a vigorous and fast-growing grass that can quickly establish dominance in an area. It has an extensive root system that efficiently absorbs nutrients (K) from the soil, leaving less available nutrient (potassium) for other plants, including oil palms. This competitive advantage can significantly reduce potassium uptake by oil palms.

CHAPTER THREE

MATERIALS AND METHODS

3.0 STUDY AREA

This study was carried out at Ronika oil palm plantation in Ekasa village located at Ovia North East Local Government area of Edo state, Nigeria, and covered a total land area of 40 hectares of land. The site lies between Latitude 06.3322[^]N Longitude 005.3544[^]E The annual rainfall is within the range of 1500 mm to 2500 mm with an average of 1900 mm per annum. The average annual temperature ranges from 23 - 37°C. Some of the crops grown include cassava, plantain, Oil palm. The area is situated in the rainforest zone, with two distinct climatic seasons, namely; the rainy and dry seasons. The rainy season is between April and October with a 2-week break in August. The dry season lasts from November to April, with a cloudy, humid and dusty harmattan period between December and January.

3.1 TOPOGRAPHY AND SOIL TYPES

The soils here are generally derived from coastal plain sands (unconsolidated sands and Sandy clay) and alluvial deposits (Umwani, 2007). Furthermore, the soil is a derivative of sedimentary rock that has undergone intense weathering process arising from high rainfall and temperatures. Topographic position of the study area is a flat terrain with slight height differential

3.2 VEGETATION

The vegetation includes primary forest along the river course; scattered trees of Rubber, Oil palm, Bamboo and Raffia palms; and some old and new farms cultivated to yam, cassava, fluted

pumpkin, plantain, banana, pineapple, and so on. The arable land in this area is continuously cultivated with cassava (*Manihot utilissima*) as the dominant crop. The land is used yearly by farmers. Weeds common in this area include Guinea grass, Giant star grass, siam weed, white weed, witch weed etc.

3.3 SOIL SAMPLING

Four different Homogeneous weed infested areas were identified namely (Spear grass, Guinea grass, goat weed or White weed and Siam weed). Each of the area selected was at least half of an Acre. Three augered points were randomly selected in each and soil samples were collected at 0-15cm and 15-30cm using Soil Auger. The samples were air dried, Sieved through a 2mm sieve, stored in a plastic bag and labelled accordingly for the determination of particle size Analysis and for routine physical ad chemical Analysis.

3.4 Soil Analysis:

The fine earth fractions were analyzed using standard soil analytical procedures to determine the soils physical and chemical properties such as particle size distribution;-sand, silt and clay while the Chemical properties were: pH, organic matter, total available nitrogen, available phosphorus, cation exchange capacity and exchangeable cations (Ca^{2+} , Na^+ , K^+ and Mg^{2+}).

3.4.1 Particle Size:

The soil particles size analysis was determined by hydrometer method (Boyucous, 1951) as modified by Gee and Bauder (1986). Classes were determined using the USDA soil textural triangles. The particle size distribution was carried out with 50 g of the sieved soil sample using sodium hexameta phosphate (calgon) as the dispensing agent after destruction of organic matter

with hydrogen peroxide. The hydrometer reading was taken at 40 seconds and 2 hours respectively.

3.4.2 pH:

The soil pH was determined using a glass electrode pH meter at a ratio of 1:1 soil to water suspension according to Mclean (1982) method.

3.4.3 Available phosphorus (P):

Available phosphorus (P) was determined by the Bray IP method. The phosphorus (P) extracted was estimated calorimetrically.

3.4.4 Total Nitrogen:

The total available nitrogen was determined by the macro-kjeldhal method of Bemner and Mulvancy (1982).

3.4.5 Organic matter:

Organic matter was determined by wet dichromate acid oxidation method (Joshua, 2013).

3.4.6 Exchangeable bases:

Exchangeable bases (Ca, Mg, K and Na) were extracted in 1N NH₄OAc buffered at pH 7.

The Ca and Mg were determined using atomic absorption spectrophotometer, K and Na were extracted with 1 N KCl (Thomas, 1982) and determined by titration with 0.05 N NaOH using phenolphthalein as indicator. Effective cation exchange capacity (ECEC)

was calculated by the summation of exchangeable bases (Ca, Mg, K and Na).

3.5 Statistical Analysis:

The data obtained were subjected to analysis of variance (ANOVA) using Gen. Stat eight edition software 2005 to measured soil physical and chemical properties, Duncan multiple Ranges test (DMRI) was used to separate the means at ($P < 0.05$).

CHAPTER FOUR

RESULT AND DISCUSSION

Physical Properties of the soil in Different Weed-Infested Areas at two depth

The sand content varies slightly across different weed types and depths. In general, there is a slight decrease in sand content with increasing soil depth for each weed type. The highest sand content is observed in the white weed infested area (881.0g/kg) indicating coarse soil texture near the surface. The clay content varies significantly among weed types and depths. The Spear grass infested area has the highest clay content (162.4g/kg) in both depth ranges, while the *Chromolaena odorata* infested area has the lowest clay content (96.5g/kg). The variation in clay content may influence soil water-holding capacity and nutrient retention. Silt content remains relatively stable across all weed types and depths, suggesting that silt is less affected by weed infestations or depth variations. Silt contributes to soil structure and can improve water infiltration as reported by (Udo *et al*, 2015). The textural class of soil across all weed types and depths is loamy sand using the textural triangle (FAO, 2011).

Table 4.1: Physical Properties of the soil in Different Weed-Infested Areas At two depths

WeedType	Depth(cm)	Sand(g/kg)	Silt(g/kg)	Clay(g/kg)
WRWeed	0-15	881.0	23.0	96.5
WRWeed	15-30	841.0	23.0	135.9
SRWeed	0-15	847.1	25.6	127.3
SRWeed	15-30	826.1	11.4	162.4
GRWeed	0-15	863.0	28.4	108.2
GRWeed	15-30	847.0	32.4	120.2
CRWeed	0-15	859.1	42.0	99.0
CRWeed	15-30	852.5	35.4	112.0

WR=White weed SR=spear grass weed GR= Guniea grass, CR=Siam weed.

****Soil textural class---Loamy sand

Soil pH (CaCl₂) in different Weed Invaded Areas at two depths

In the soils of all the weed investigated, the pH decreases with increasing depth. This is similar to Revees and Liebig, 2016 report that “soil pH decreases with increasing depth”. Also, the pH of the soils at a depth of 0–15 cm differs significantly from the pH at a depth of 15–30 cm in all the weeds. Additionally, the pH of the soil was found to be moderately acidic, ranging from 4.537 - 4.997 at a depth of 0 - 15 cm and 4.43 - 4.827 at a depth of 15 - 30 cm. The portion with spear grass has the most acidity while the soil of siam weed has the least acidity.

Table4.2: Soil Ph (Cacl₂) In Different Weed Invaded Areas

WeedType	Depth(cm)	PH
WRWeed	0-15cm	4.760a
WRWeed	15-30cm	4.643b
LSD:(0.203)		0.117
SEM:(0.0342)		
SED:(0.0484)		
SRWeed	0-15cm	4.537a
SRWeed	15-30cm	4.493b
LSD:0.3160		0.044
SEM:0.0805		
SED:0.1138		
GRWeed	0-15cm	4.69a
GRWeed	15-30cm	4.43b
LSD:1.043		0.26
SEM:0.171		
SED:0.242		
CRWeed	0-15cm	4.997
CRWeed	15-30cm	4.827
LSD:		0.17
SEM:		
SED:		

Mean values with the same letters are significantly the same while those with different letters are significantly different at P<0.05 using LSD

(WR=White weed SR=spear grass weed GR=Guinea grass, CR=Siam weed.)

CHEMICAL PROPERTIES OF THE SOILS IN THE DIFFERENT WEED-INVADDED AREAS.

The pH levels across all weed types and depths range from 4.43 to 4.997, indicating slightly acidic level. Soil pH is important for nutrient availability, and these values suggest that the soil is within an acceptable range for most crops as reported by FAO, 2011. The highest Organic carbon content is observed in *Chromolaena odorata* (23.6 g/kg in 0-15cm depth) and the lowest in White Weed (10.91 g/kg in 15-30cm depth). High Organic matter content generally improves soil structure and nutrient retention as reported by (Uzoh *et al*, 2015). Total organic Nitrogen content ranges from 0.545g/kg to 1.180 g/kg. *Chromolaena odorata* in the 0-15cm depth has the highest nitrogen content (1.180g/kg) indicating potential nutrient-rich soil in this area. Available phosphorus content ranges from 7.099mg/kg to 14.858 mg/kg. *Chromolaena odorata* in the 0-15cm depth has the highest available phosphorus content (14.858mg/kg), hence Phosphorus availability was higher in *Chromolaena odorata* infested areas compared to other weeds, which suggests good phosphorus availability for plant growth. Exchangeable Cations (Ca, Mg, Na, K) play a crucial role in soil fertility, The soils of these weeds show variations in cations levels. Spear grass in the 0-15cm depth has the highest Calcium content (0.07010 Cmolc/kg), while *Chromoleana odorata* has the highest Magnesium levels (0.1568Cmolc/kg). Guinea grass at 0 – 15 cm and 15- 30 cm depth has the highest potassium level (0.1838Cmolc/kg, 0.09531Cmolc/kg respectively). These variations can impact nutrient availability and soil structure. Base saturation reflects the percentage of the soil's CEC occupied by base cations (Ca, Mg, K, Na). Higher %BS values suggest better soil fertility. Guinea grass in the 0-15cm depth

has the highest % Base Saturation (87.6%), indicating good overall soil fertility. The highest percentage base saturation was found in siam weed infested areas at 15 – 30cm with values of 90.6% .

Table 4.3: Chemical Properties Of Soils In Different Weed Invaded Areas

Weed type	Depth (cm)	pH (CaCl ₂)	Organic carbon(g)	Total Nitrogen (g/kg)	Avail.P(mg/kg)	Calcium(Cmol/kg)	Mg(Cmol/kg)	Na(Cmol/kg)	K(Cmol/kg)	CEC(Cmol/kg)	EA	EC EC	%BS
WR	0-15	4.960	15.49	0.775	7.099	0.02564	0.0836	0.03768	0.1724	0.319	2.839	3.158	10.1
WR	15-30	4.643	10.91	0.5453	7.539	0.01036	0.06307	0.04939	0.09105	0.214	1.68	1.894	11.3
SR	0-15	4.537	18.426	0.921	7.429	0.07010	0.0321	0.3841	0.1008	0.241	1.986	2.227	10.82
SR	15-30	4.493	14.76	0.7381	7.594	0.01442	0.05954	0.03542	0.07690	0.186	1.361	1.547	12.02
GR	0-15	4.693	23.01	1.150	7.925	0.05066	0.1443	0.05545	0.1838	0.434	0.061	0.495	87.6
GR	15-30	4.430	15.23	0.7614	8.915	0.02954	0.10829	0.03617	0.09531	0.269	0.038	0.307	87.6
CR	0-15	4.997	23.61	1.180	14.858	0.05743	0.1568	0.08238	0.1478	0.444	0.082	0.526	84.4
CR	15-30	4.827	18.226	0.9111	10.896	0.04201	0.09110	0.02971	0.09480	0.258	0.027	0.285	90.6

POTASSIUM CONTENTS IN DIFFERENT WEED INVADED AREAS AT TWO DEPTHS

Generally, the values of potassium in the soils of all the weeds investigated are very low. This may be due to soil K availability is generally low and waterlogging due to tropical heavy rains can limit further nutrient absorption. This is in accordance with Ollagnier and Ochs, 1993 reports which states that low potassium (K) availability is a major concern on tropical soils where oil palm is cultivated since they are often naturally poor in exchangeable cations such as K⁺. These values are also decreasing with increasing soil depths. The values of potassium at 0-15cm depth are significantly different from the values at 15- 30cm depth for GR,WR and CR but significantly the same for SR.

Table 4.4: Potassium Content In The Different Weed Invaded Area

Weed type	Depth(cm)	Mean of potassium
WR	0-15cm	0.172 a
WR	15-30cm	0.091 b
LSD(0.3951)		0.081
SEM(0.0649)		
SED(0.0918)		
SR	0-15cm	0.1008 a
SR	15-30cm	0.0769 a
LSD(0.01609)		0.0239
SEM(0.00264)		
SED(0.00374)		
GR	0-15cm	0.184 a
GR	15-30cm	0.095 b
LSD(0.1415)		0.089
SEM(0.0233)		
SED(0.0329)		
CR	0-15cm	0.1478 a
CR	15-30cm	0.0948 b
LSD(0.07659)		0.053
SEM(0.01259)		
SED(0.01780)		

SOIL CHEMICAL PROPERTIES COMPARISM AMONG THE DIFFERENT WEED INVADED AREAS AT (0 – 15CM DEPTH)

The pH of the soil is significantly the same at a depth of 0–15cm in the areas invaded by Siam weed, Guinea grass, and White weed. The pH of the soil in Spear grass is significantly different from Siam weed-infested area at a depth of 0–15 cm. The organic carbon content of the areas invaded by Guinea grass and Siam weed are significantly the same at 0–15 cm soil depth. Guinea grass is known for its ability to enhance soil organic carbon content due to its extensive root system and high biomass production, which contribute to increase organic matter input to the soil as reported by (Nweke *et al*, 2019). However there are significant differences in the portions that Siam weed, White weed, and Spear grass invaded. The Nitrogen concentration of the areas invaded by Guinea grass and Siam weed are significantly the same at 0–15 cm. There is relatively high nitrogen content in siam weed soils (1.180g/kg). Siam weed is known for its ability to influence soil nitrogen levels, primarily due to its nitrogen-fixing capabilities through symbiotic associations with nitrogen-fixing bacteria in its roots as reported by (Chakraborty *et al*,2011). The nitrogen contents are significantly different in the areas invaded by White weed, Spear grass, and Siam weed at 0-15cm soil depth. The Calcium and potassium contents are significantly the same at 0–15 cm soil depth in all the investigated weed species. The magnesium content in the portions invaded by White weed, Guinea grass, and Siam weed are significantly the same at 0–15 cm. While there is a significant difference in the magnesium content of the soil in the area invaded by Spear grass and Siam weed. There is no significant difference in the sodium content of the soil in areas invaded by Spear grass, White weed, and

Guinea grass. However, there are significant differences in the sodium content in areas invaded by Guinea grass and Siam weed.

Table 4.5 Soil Chemical Properties Comparism Among The Different Weed Invaded Areas At 0 – 15cm Depth)

CHEMICAL PROPERTIES	WR	SR	CR	GR
pH (CaCl₂)	4.760ab	4.537a	4.997b	4.693ab
Organic carbon (g/kg)	15.49a	18.42b	23.61c	23.01c
Nitrogen (g/kg)	0.775a	0.921b	1.80c	1.150c
P (mg/kg)	7.099a	7.429a	14.858b	7.925ab
Calcium (cmolc/kg)	0.02564a	0.07010a	0.05743a	0.05066a
Magnesium (cmolc/kg)	0.0836ab	0.0321a	0.1568b	0.1443b
Na (cmolc/kg)	0.03768a	0.3841a	0.08238b	0.05545a
Potassium (cmolc/kg)	0.1724a	0.1008a	0.1478a	0.1838a

Mean with the same letters along the rows are significantly the same while mean with different letters along the rows are significantly different using Duncan multiple Range Test at 5% level of probability.

(WR= White weed SR= spear grass weed GR= Guinea grass, CR= Siam weed)SOIL

CHEMICAL

SOIL CHEMICAL PROPERTIES COMPARISON AMONG THE DIFFERENT WEED INVADED AREAS AT 15- 30CM DEPTH

The pH, available phosphorous, magnesium, Sodium and Potassium contents of the soil are significantly the same at a depth of 15- 30 cm in the areas invaded by all investigated weed species. The Organic Carbon content in the areas invaded by Siam weed is significantly high (18.22g/kg) compare to other weeds. Siam weed has been reported to enhance soil organic carbon content in invaded areas due to its rapid growth, high biomass production, subsequent litter fall, which contributes to soil organic matter accumulation as reported by (Kumar *et al*, 2013). Guinea grass and spear grass have significantly same soil organic carbon content (15.23g/kg and 14.76g/kg respectively) which are moderately high. White weed has the least value of soil organic carbon content (10.91g/kg). The Nitrogen content in areas invaded by Siam weed (0.9111g/kg) and White weed (0.5453g/kg) at a depth of 15–30 cm are significantly different. Siam weed has significantly the highest level of soil total organic nitrogen (0.9111g/kg). Siam weed has been reported to enhance and improve plant nutrient levels in the soil under its canopy through its high leaf litter fall and mineralization and hence enhance sustainable conservation of soil fertility (Obatolu and Agboola,1993., Ilori *et al.*,2011).

White weed has the lowest total organic nitrogen (0.5453g/kg). This confirm the report by Smith and Brown.,2015, who said area invaded by White weed will exhibit low nutrient content.

The Calcium content are significantly the same at in areas invaded by White weed, Spear grass, and Guinea grass. While the calcium content in areas invaded by Siam weed is the highest.

**Table 4.6 Soil Chemical Properties Comparism Among The Different Weed Invaded Areas
At 15- 30cm Depth**

CHEMICAL PROPERTIES	WR	SR	CR	GR
pH (CaCl₂)	4.643a	4.493a	4.827a	4.430a
Organic carbon (g/kg)	10.91a	14.76ab	18.22b	15.23ab
Nitrogen (g/kg)	0.5453a	0.7381ab	0.9111b	0.7614ab
P (mg/kg)	7.539a	7.594a	10.896a	8.915a
Calcium (cmolc/kg)	0.01036a	0.01442a	0.04201b	0.02954ab
Magnesium (cmolc/kg)	0.06307a	0.05954a	0.09110a	0.10829a
Na (cmolc/kg)	0.04939a	0.03542a	0.02971a	0.03617a
Potassium (cmolc/kg)	0.09105a	0.07690a	0.09480a	0.09531a

Mean with the same letters along the rows are significantly the same while mean with different letters along the rows are significantly different using DMRT 5% degree of freedom.

(WR= White weed SR= spear grass weed GR= Guniea grass, CR= Siam weed.)

CHAPTER FIVE

CONCLUSION

In conclusion, the study investigating potassium (K) availability in soils of an oil palm plantation invaded with different weed types in Ekasa Village, Edo State, Nigeria, has revealed valuable insights. In the 0-15cm depth range, there is a noticeable difference in mean Potassium (K) content among the weed types, with weed types GR and WR having significantly higher Potassium (K) content than SR. This suggests that the type of weed invasion can influence availability of Potassium (K) in the soil. In the 15-30cm depth range, the differences in mean Nitrogen content among weed types are relatively small. Weed types CR, GR, and WR have similar Nitrogen contents, while SR still has the lowest Nitrogen content. The analysis demonstrated variations in Nitrogen content across weed types and soil depths. Weed types GR and WR exhibited higher nitrogen content in the 0-15cm depth range, while SR had the lowest content. In the 15-30cm depth range, the differences were less pronounced. These findings highlight the influence of weed types and soil depth on Potassium (K) availability, suggesting that weed management practices and soil depth considerations are crucial for optimizing Potassium (K) levels in oil palm plantations. It is advisable that farmers should always prioritize the clearing of any portion of oil palm plantations invaded with goat weed and spear grass. Also, chemical weed control using glyphosate (force up, bush fire, weed off etc) should be used to eradicate these investigated weeds and plant leguminous cover crop like centrosema, calolpogonium, mucuna etc on the portions.

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