LAND PREPARATION METHODS AND WEEDING FREQUENCY EFFECTS ON SOIL PROPERTIES AND MAIZE PERFORMANCE

by

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BSc. Agriculture Technology (Hons)

A Thesis submitted to the Department of Agricultural Engineering

Kwame Nkrumah University of Science and Technology in fulfilment of the requirements for the degree of

MASTER OF SCIENCE

IN

AGRICULTURAL MACHINERY ENGINEERING

College of Engineering

July 2012

DECLARATION

I hereby declare that this submission is my own work towards the Master of Science in Agricultural Machinery Engineering and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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ABSTRACT

A field experiment was conducted on a Ferric Acrisol soils under rainfed conditions during the 2010 minor and 2011 major cropping seasons in Kumasi, Ghana, to determine the effect of land preparation method and weeding frequency on soil properties, *Akposoe* maize (*Zea mays* .L) variety performance and weed dry matter. A factorial design with two factors namely land preparation and weeding frequency was used. The land preparation treatments were no tillage, and ploughing followed by harrowing while the weeding frequency treatments consisted of hand hoeing at 2, 5 and 7 weeks after planting (WAP). The fourth weeding frequency treatment was no weed control (0-Hoeing). Over the course of the study, the ploughing followed by harrowing treatment gave more favourable soil conditions including lower soil penetration resistance, lower dry bulk density, higher soil moisture content and higher total porosity in comparison with the no tillage treatment. In general, the no weed control treatment produced the worst soil conditions for *Akposoe* maize plant growth. Ploughing followed by harrowing resulted in higher seedling emergence compared with that of the no tillage treatment. At 10 WAP, the ploughing followed by harrowing treatment produced better growth and yield parameters in terms of plant height, stem girth, number of leaves per plant, leaf area, root length, dry matter yield, yield components and yield compared with the no tillage treatment. Similarly, at 10 WAP, hand hoeing at 2 WAP presented the best growth and yield parameters in comparison with the other weeding frequency treatments. Therefore, considering soil and weather conditions, ploughing followed by harrowing with two hoeings at 2 and 5 WAP is the best alternative for the production of the *Akposoe* maize variety.

DEDICATION

I dedicate this work to my mother; Madam Amma Sikayena of Kwahu Praso No.1, for her love and support to me from birth to date. I say thank you mother and have a long life.

ACKNOWLEDGEMENTS

My sincere gratitude goes to the almighty God for granting me wisdom, knowledge and understanding to accomplish this work. The mercy and glory ordained me for successful completion of the experiment despite the erratic rainfall regimes and temperature fluctuations over the period of the experiment revealed that God is merciful and master of alterations.

Furthermore, the planning, coordinating, sponsoring and supervision of the experiment would not have materialized without stringent contributions from my supervisors, Ing. Stephen Hill Mends Aikins (Senior Lecturer, Department of Agricultural Engineering), and Ing. Prof. Nicholas Kyei-Baffour, Kwame Nkrumah University of Science and Technology. To Ing. Stephen Hill Mends Aikins, your expertise in research work and statistics led every step to fruition. '*You cannot go wrong when research activities are planned'* is one of his inspirational phrases. You are a supervisor with a difference and seen as 'an army of rabbits led by a lion than an army of lions led by rabbit'. To you I owe special thanks and pray for long life. I wish to thank Ing. Prof. Nicholas Kyei-Baffour for thoroughly reading through my thesis and providing advice for all the corrections made. I am grateful to the services given me.

I would like to thank Dr. J. J. Afuakwa (Department of Agro-forestry, College of Agriculture and Natural Resources) for his input in my research work. The effectiveness of weeds identification could not have been achieved without the help from Dr. Joseph Sarkodie-Addo, (Faculty of Agriculture), may God richly bless you. Moreover, Ing. Dr E.Y.H. Bobobee and Ing. Joseph Aveyire of the Department of Agricultural Engineering do deserve mentioning for their words of encouragement and advice over the course of my study at Kwame Nkrumah University of Science and Technology, Kumasi.

I wish to express my profound gratitude to Mr Anthony Anaba, for assisting me during the land preparation activities. I will forever remember you. To my colleagues in 2009 Agricultural Machinery Engineering year group; Mr. Eric Amoah Asante, Mr. Shadrack Kwadwo Amponsah, Mr. Wilson Kallai, Mr. Francis Kumi and Mr. Francis Amoah, as well as Mr. Francis Kyeremateng Arthur of Material Engineering, all of Kwame Nkrumah University of Science and Technology, Kumasi, I love you all.

I am also indebted to the following personalities for their spiritual and material support towards the attainment of this degree: Yaa Nyarkoa, Adwoa Pokua, Ama Nkansah, Kofi Awua, Emmanuel Appiah, Juliana Obeng Oforiwaa, Samuel Gyan Appah, Roland Frimpong Appah, Raphael Nyarko Appah, the late Joseph Appiah, the late Thomas Omani Nkansah, and the late Afua Serwaa. To you all I say '*Ayekoo'* and May God richly bless you.

Samuel Appah

July 2012

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Background to the study

Maize (*Zea mays* L.) is a major food crop for resource poor smallholder farmers in Ghana. The area harvested to maize in 2010 was 991,669 Ha while that in 1990 was 464,800 Ha (FAO Statistical Databases, 2012). Maize is ranked as the most important cereal crop in Ghana and it is produced for both human and animal consumption. Every part of the maize plant has economic value. The grain, leaves, stalk, tassel and cob can be used to produce a large variety of food, non-food products (Raemaekers, 2001) and industrial products. The grain is the main source of calories and protein as well as the primary weaning food for babies (Mashingaidze, 2004). Whereas the area under cultivation of maize has considerably increased, maize yields in Ghana are still low. This constitutes a threat to food security and requires the need to improve the performance of maize in Ghana. The main factors affecting maize production in Ghana include declining soil fertility, little or inadequate use of chemical fertilisers, poor weed and pest controls, and inappropriate tillage practices (Aikins *et al*., 2012).

Tillage may be described as the practice of modifying the state of the soil in order to provide conditions favourable to crop growth (Culpin, 1981). Inappropriate land use and poor soil management exacerbate soil degradation, adversely affect the environment, and jeopardize the soil's productivity (Jagadamma *et al*., 2008). Different tillage systems may modify soil physical properties depending on factors such as cropping history, soil type, climatic conditions, and previous tillage system (Mahboubi *et al*., 1993; Chagas *et al*., 1994 cited by Ferreras *et al*., 2000). The suitability of a soil for sustaining plant growth and biological activity is a function of physical and chemical properties (Mulumba and Lal, 2008). Tillage is crucial for crop establishment, growth and ultimately yield (Atkinson *et al*., 2007). Crop establishment is the key to successful crop yields (Blake *et al*., 2003). Stand establishment is often regarded as the most critical and vulnerable period of maize growth. The vigour of young maize seedlings influences the development of the crop throughout its life (Iqbal *et al*., 1998). Tillage practices influence soil physical, chemical and biological characteristics, which in turn may alter plant growth and yield (Çarman, 1997; Ozpinar and Clay, 2006; Rashidi and Keshavarzpour, 2007).

The conventional tillage system is based on a high intensity of soil engagement and inversion of the soil (Weise and Baurarach, 1999). On the other hand, conservation tillage represents a broad spectrum of farming methods which are based on establishing crops in the previous crop's residues purposely left on the soil surface (Uri *et al*., 1999). Numerous studies have been conducted on the effects of tillage on the performance of many crops. Rashidi and Keshavarzpour (2007) reported on a study in Iran that compared seven tillage methods for maize. They found that conventional tillage produced grain yield significantly greater than that of no tillage.

According to Uri *et al*. (1999), the use of conservation tillage can play an important role in reducing soil erosion and improving soil quality, and can be an attractive alternative to conventional tillage for farmers because of its potential to minimize labour and fuel consumption and to lower total production cost (Uri, 2000).

Land preparation methods for maize production include: slashing and burning (Gacheru *et al.*, 1993), slashing, hand hoeing, herbicides application and tractor ploughing and harrowing

(Massawe *et al.*, 2005). These methods open-up the soil surface for seed sowing and vegetative growth. Although no tillage practices accumulate soil surface organic matter and improve soil biochemical properties, the ploughing and harrowing rather facilitate root penetration, seed sowing and organic matter incorporation into the soil and improve soil structure (Rashidi *et al.*, 2010). In no tilled soils, yield is low (Husnjak *et al*., 2002) due to decreased aeration, soil water storage, crop water use efficiency (Radford *et al*., 2001) and reduced penetrability of roots (Unger and Kaspar, 1994). Since the use of herbicides destabilizes soil biochemical properties, the adoption of a land preparation method that provides suitable conditions for maize production should be encouraged.

In Ghana, traditionally, different land preparation methods are employed in the production of different crops including maize. Some of the land preparation methods include disc ploughing without disc harrowing before planting, disc ploughing and disc harrowing before planting, disc harrowing without disc ploughing before planting, and no tillage (Aikins and Afuakwa, 2010).

Olaoye (2002) evaluated the effects of five different tillage treatments commonly used in Nigeria on crop residue cover, soil properties and some yield parameters of cowpea and found that disc harrowing, and no tillage treatments gave the highest grain yield and number of pods per plant among the treatments considered. Ojeniyi and Adekayode (1999) compared the effects of seven different tillage methods on the growth and yield components of cowpea on Alfisols in the rainforest zone of Nigeria. Their study revealed that no tillage produced taller plants and higher grain yield compared with disc ploughing followed by disc harrowing although the differences were not significant. No tillage means less traffic, and in turn, less soil compaction, lower fuel and labour costs. Furthermore, no-tillage has many other advantages such as controlling wind and water erosion, reducing soil moisture loss and greenhouse gas (carbon dioxide) emissions (Lindstrom and Reicosky, 1997 cited by Chen *et al*., 2005).

Weed control is an important aspect of crop production. Weed control in maize can be carried out by mechanical and/or chemical methods. Weeds between plant rows are removed generally by mechanical cultivation, while weeds on the rows are controlled by hand hoeing or by herbicides. Good weed control usually involves a combination of the available methods plus timeliness and good cultural practices (Abu-Hamdeh, 2003). According to James *et al.* (2000), the best time to minimise the effect of weeds on maize yield is within 4-8 weeks after planting when maize is in the 2-8 leaf stage. In Ghana, weed control in maize production is carried out using hand hoes, cutlasses (Adjei *et al*., 2003; Tweneboah, 2000) and by hand pulling.

Hand weeding is still by far the most widely practised cultural weed control technique in the tropics because of the prohibitive cost of herbicides, the fear of toxic residue, and lack of knowledge about their use (Iremiren, 1988). The frequency of weeding greatly influence growth and yield of maize since weeds reduce yield of maize (Abouziena *et al.,* 2007). Weeding frequency is usually at the discretion of the farmer and may not be economically feasible if yield largely depends on weeds removal at the critical stages of crop development (Adenawoola *et al*., 2005).

1.2 Justification for the study

Land preparation methods may influence maize performance, soil properties and density of weeds. No tillage is considered the best alternative to ploughing and harrowing due to its effect on soil properties but ploughing and harrowing increases maize yield and reduces weed density (Adenawoola *et al*., 2005).

Information on the effect of different land preparation methods and weeding frequency on soil properties, and the performance of maize in the semi-deciduous forest zone of Ghana is scanty. There is therefore the need to study the effect of land preparation methods and weeding frequency on soil physical properties and performance of maize.

1.3 Aim and objectives

The aim of the study was to compare the effects of land preparation methods and weeding frequency on soil physical properties and the performance of *Akposoe* maize variety. The specific objectives of the study were to:

1. determine the effect of land preparation methods and weeding frequency on soil penetration resistance, dry bulk density, moisture content, and total porosity.
2. determine the effect of land preparation methods and weeding frequency on the establishment, growth, dry matter yield, yield components and yield of *Akposoe* maize variety.
3. determine the effect of land preparation methods and weeding frequency on weed dry matter yield.

2. LITERATURE REVIEW

2.1 Maize

Maize (*Zea mays* L.) is a monocotyledonous arable crop belonging to the family *Graminaceae* and tribe *Maydeae* (Raemaekers, 2001). It is believed to have evolved from the domestication of the wild grass teosante (*Zea Mexicana*) in America which later spread and adapted to varied environmental conditions to the rest of the world. United State of America (the origin of maize) is currently the largest producer of maize followed by China, Brazil, Russia and Europe (FAO Stat, 2008). In Africa, maize plays valuable roles in human diet, animal ration and as raw material for agro-based industries. Africa is a minor producer of maize accounting for only 7% of global maize production (FARA, 2009) and the largest African producer is Nigeria followed by South Africa (IITA, 2009). The yield of maize in Ghana is 1.8874tons/ha which is far less than that of China (5.4598 tons/ha) in 2010 (FAO Stat, 2012).

2.1.1 Maize Production and Consumption in Ghana

Maize was introduced to Ghana by the Portuguese in the 16th century and ever since, the land area for maize production has been increasing every year. It is cultivated by majority of people in all the five agro-ecological zones in the country (Obeng-Antwi *et al.*, 2002). Maize is prepared and consumed in different ways by a multitude of people. It is eaten in the raw state, as cooked and roasted corn or ground and pounded when dried to prepare various food items like *Kenkey*, *tuo-saafi*, *koko* (porridge), *banku* and *Akpele* (Morris *et al.*, 1999). Maize is an important crop in Ghana in terms of total production and utilisation since the devastation of traditional crops such as cocoa and coffee by bushfire in the 1983. The regional production of maize in Ghana is shown in Table 2.1.

2 .1: Table: Regional Maize Production, Area Cropped and Yields in Ghana in 2006

Region	Metric Tons (t)	Area (ha)	Yield (t/ha)
Western	73,210	51,102	1.43
Central	166,847	102,648	1.63
Eastern	209,542	133,844	1.57
Greater Accra	2,134	2,879	0.74
Volta	48,286	35,330	1.37
Ashanti	164,226	138,793	1.18
Brong Ahafo	363,595	191,691	1.90
Northern	98,157	85,644	1.15
Upper West	48,128	36,714	1.31
Upper East	14,712	14,355	1.02

(Maize Value Chain Stat, 2008)

2.1.2 Physiology of Maize

Maize is a crop having a kernel of hard and one-sided fruit called a caryopsis. The kernel consists of pericarp, endosperm and germ or embryo. The pericarp is a protective outer layer derived from maternal tissue while endosperm constitutes the major portion of the kernel which serves as energy reserve for the growing seedling. It is composed of about 88% starch and 8% protein. As soon as the seed imbibes water, the aleurone layer releases enzymes which digest the endosperm starch into sugar thereby providing energy for seedling growth. The radical develops into roots while the plumel grows to form the vegetative part (Kling, 1991).

The vegetative growth parameters are the roots, stem and leaves. Maize usually grows to 2-3m high (but can vary from 1-6m), with approximately 14 nodes and about 8 nodes and internodes remain condensed underground forming the crown. The lower nodes develop both brace roots and fibrous roots. The fibrous roots may be well developed at 8 WAP and can grow up to 45cm depth but in good soils it can extend to 2.5m. The leaves are the site for photosynthetic activities of crop through which biomass is produced. A single leaf extends from nodes at an alternating pattern. All leaves are initiated within the first 4-5 weeks after planting and as the internodes elongate, new leaves emerge from the whorl once every three days, producing a total of 20-30 leaves depending on the genotype and the climate. The first 5-7 leaves drop off at an early stage while last leaves emerge shortly before tasselling. Leaf area per soil surface area measures leaf area index (Khan *et al*., 2005). For optimum plant growth leaf area index should be greater than 1 indicating that the sun's energy is not wasted to affect photosynthetic activities (Winch, 2006).

Maize is a monoecious plant bearing both male flowers in the tassel and female flowers on the lateral ear shoots of the same plant. The tassel emerge from the leaf whorl which is initiated approximately 30 days after planting and can grow up to 40cm long. The tassel bears the pollen grain while the ear contains cob and silk enclosed in a husk. The silk is receptive to pollen grain which develops to the grains. Ear shoots are initiated on 6 to 8 nodes below the tassel. At physiological maturity, the husks dry and become papery but it can be harvested fresh at about 3 weeks after flowering (Kling, 1991).

2.1.3 Uses of Maize

Maize is ranked second to wheat among the world's cereal crops in terms of total production, use and price relative to other cereals. It is used to produce a large variety of food and non-food products (Raemaekers, 2001). The grain contains calories and protein and is used to formulate food for babies (Mashingaidze, 2004). The grain starch can be made into adhesives and syrup. The high-fructose maize syrup is used as a preservative, thickener and sweetener. The husk is used to wrap food while the cobs and stovers are used as bio-fuels (Sallah *et al*., 2002).

2.1.4 Varieties of Maize

Maize is classified as dent corn, flint corn, popcorn, flour corn, sweet corn and Indian corn. The dent corn is the most widely grown maize while sweet corn is mainly meant for human consumption. Varieties of maize grown in Ghana include; '*obaatanpa, aburotia, dobidi, mamaba, dadaba* and *okomasa*'. In addition, extra-early maturing and Quality Protein Maize varieties tolerant of drought and resistant to weeds have been released to farmers. They are Golden Jubilee, "*Aziga*" (meaning big egg in Ewe), "*Etuto-Pibi*" (meaning father's child in Gonja) and "*Akposoe*". '*Akposoe*' is a white flint or dent open pollinated variety. It has a potential yield of 3.5t/ha and matures in 80 to 85 days. It is useful for planting either early or late in the season. It contains lysine and tryptophan necessary for growth of humans and other monogastric animals such as poultry and pigs (GNA, 2007; IITA, 2010).

2.1.5 Environmental Conditions for Maize

Maize thrives well on mean temperature of 22ºC but cultivation is not possible when day temperature is less than 19ºC and night temperature during the first 3 months falls below 21ºC.

Temperature above 35ºC for several days destroys pollen and reduces yields. Germination occurs within 4-6 days after planting when the soil temperature is 20ºC. Maize requires fairly distributed water between 500mm to 800mm during the growing season for optimum growth (VASAT, 2011). Maize can be grown without additional irrigation in areas receiving about 600 mm of well distributed rainfall. The soil ideal for maize is loam or silty loam with pH ranging between 6.5 and 7.5. The soil should preferably be well-aerated and well-drained as the crop is susceptible to water-logging (AGRISNET, 2011).

2.1.6 Sowing of Maize

Maize seeds are sown at stake usually in rows for maximum plant population density. The inter-rows range from 60-90 cm apart while intra-rows range 30-60cm depending on the variety. The seeds are sown at 2 seeds per hill but it could be sown up to 3 or 4 and later thinned to 2 seedlings per hill. The population then varies from 15,000 to 90,000 plants/ha (Gibbon and Pain, 1991). Sowing can be done with a planter, machete or dibber. To obtain uniform germination, sowing depth of maize varies from 5 to 10 cm, depending on the soil type (du Plessis, 2003).

2.2 Soil Properties for Maize

Soil texture affects water-holding capacity and aeration (Plaster, 2002). It is measured by mechanical analysis of a sample in the laboratory or *in situ*. The sand particles range from 0.05mm – 0.2mm in diameter, silt particles range in diameter from 0.002mm – 0.05mm while clay particles have diameters smaller than 0.002mm (Aikins, 2009). The arrangement and organisation of the particles in the soil measures soil structure (Hillel, 1982). Structure directly affects water retention and conductance of soil. It influences ploughing operations because the properties of individual particles are more or less masked in stable aggregates which can thus give a favourable physical condition to soil that would otherwise be intractable. Oxides and organic matter content in the soils serve as the binding agent for soil aggregates to form structure. Total pore spaces measure the soil volume that holds air and water and it is usually expressed in percentage called total porosity. If the particles lie close together as in sandy soils or compact subsoil, the total porosity is low but if they are arranged in porous aggregates, as in medium-textured soil high in organic matter, the pore spaces per unit volume will be high (Brady and Weil, 1999). The amount of pore spaces determines the bulk density since particle density is constant. Soil bulk density is the mass of oven-dry soil per unit volume which involves the densities of the constituent soil particles and other packing and arrangement into peds (White, 2006). An ideal bulk density of mineral soils usually ranges from 1.0 gcm^{-3} for fluffed-up clay soils to 1.8 gcm^{-3} in some sandy soil while organic soils are much lighter, with values of 0.1 - 0.6 gcm^{-3} being common (Plaster, 2002).

2.3 Land Preparation Methods for Maize Production

Land preparation methods greatly influence growth and yield parameters of maize and soil properties. The choice of a method depends on the vegetation cover and the manner in which the soil surface is to be exposed for sowing of seeds is dependent on the density of weeds. The primary land preparation methods for maize production are conventional (plough and harrow) tillage and conservation or no tillage. Khurshid *et al*., (2006) reported that among the crop production factors, tillage contributes up to 20%.

Conservation tillage involves the use of machete, hoe, pickaxe, herbicide application or mulch tillage. Mulch tillage leaves crop residue on the soil surface for quick germination and satisfactory yield. The use of conventional tillage operations is harmful to soil, hence, there is a significant interest and emphasis on the shift to conservation tillage and no-tillage methods for the purpose of controlling soil erosion (Iqbal *et al*., 2005). Land preparation on commercial farms is done by tractor drawn implements where early ploughing prior to the onset of the rain is followed by one or two harrowing, but this practice is changing due to the high cost of operating machinery and the difficulty in obtaining spare parts to experiment with reduced and zero tillage (Raemaekers, 2001)

2.3.1 Effects of Land Preparation on Soil Physical Properties

Conventional tillage influences soil porosity, bulk density, penetration resistance and moisture content (Khurshid *et al*., 2006). Annual disturbance and pulverization of soil through ploughing and harrowing produce a finer and loose soil structure compared to conservation or no-tillage methods which leave soil intact (Rashidi *et al*., 2008). However, the use of tractor tends to compact the soil to increase penetration resistance and bulk density (Unger and Kaspar, 1994). Penetration resistance over 1000kPa usually decreases yield (Khalilian *et al*., 1991) and causes the beginning of root growth reduction (Ishaq *et al*., 2001). Soil compaction may significantly impair productivity of soil by decreasing aeration, soil water storage and crop water use efficiency while greater soil penetration, bulk density and lesser total porosity is found on no tillage than tilled soils during maize growth (Cassel *et al*., 1995; Griffith *et al*., 1996). The zone of maximum soil bulk density roughly corresponds to the depth of tillage

(Pikul and Asae, 1995) while the optimum soil bulk density for growth and yield of maize ranges from 1.40 - 1.68 $Mgcm^{-3}$ (Czyz, 2004).

Conservation tillage influences soil physical properties such as bulk density, infiltration and water retention. No tillage reduces water loss from soil and improves soil moisture regimes than plough and harrow (Azooz *et al*., 1996) because more surface areas of soil are exposed to sunshine and stream of wind in conventional tillage. No-tillage maintains surface residues, minimizes soil disturbance, encourages build-up of organic material, preserves the soil structure, and conserves soil water. Land preparation method that incorporates organic matter into the soil increases aeration through burrowing and decomposition activities of soil organisms (MacRobert *et al*., 2007).

2.3.2 Effects of Land Preparation on Maize Performance

The conventional and conservation tillage methods significantly influence yield and yield components of crops with conventional tillage method recording significantly higher yield compared to no tillage (Rashidi *et al*., 2010). Maize root penetration is greater in conventionally tilled soil than under no-till condition (Nitant and Singh, 1995). Roots are concentrated more at the surface layer under no-till conditions than conventionally tilled soil but are more abundant at deeper layer in conventionally tilled soils than no-tillage, (Mauryaa and Lal, 2008). Moreover, continuous ploughing results in plough pan which restricts nutrient movement and root penetration (Unger and Kaspar, 1994; Iqbal, 2006). Gul *et al*. (2009) reported the effect of tillage practices on biological yield of maize to be significant with conventional tillage producing higher biological yield than no-tillage. There was a significant effect of tillage on leaf area per plant and leaf area index of maize. Leaf area per plant and leaf area index was less under no tillage as compared to conventional tillage (Karunatilake and Schindelbeck, 2000).

2.4 Weed Control

Weeds are plants which are not cultivated and grow out of place among cultivated crops (Akobundu and Agyakwa, 1998) and whose virtues have not yet been discovered (Kazi *et al.*, 2007). They have high efficient reproductive capacity, effective competitive behaviour for light, nutrient, space and water, grow in undesirable locations, resist control, disperse effectively and show high dormancy. Weeds are classified as annual or perennial, terrestrial or aquatic, parasitic or free living and monocot or dicot. Some weeds harbour pests and disease-causing organisms (Abu-Hamdeh, 2003) hence the need to control the weeds as they emerge to ensure optimum grain yield, reduce costs and risks (Doğan *et al*., 2004). The types of weeds determine whether the control strategy would be cultural, mechanical or chemical. The best time to minimize the effect of weeds on maize yield is when maize is in the 2-8 leaf stage. Weeding twice or three times suppresses weed growth, increases yield of maize and maximizes profit in maize production (Doğan *et al.*, 2004). The growth of weeds decreases significantly in the order of increasing frequency of weeding. Meanwhile the highest growth and yield of maize parameters occur in the weed-free plots indicating that it is necessary to protect the crop from weed competition throughout most of its growth to ensure maximum yield (Adenawoola *et al.*, 2005).

2.4.1 Effects of Land Preparation on Weeds

According to Lampkin (1998), ploughing tends to bury weed seeds below the depth from which they are capable of germinating. Tillage alone cum good cropping methods is often the best and most economic method of weed control (Lal, 1979). Tillage directly affects the seed bank by physically mixing the soil (Ball and Miller, 1990) and helps in managing herbicide resistance weeds that compete with growing crops to reduce yield (Anderson, 2004 cited by Chokor *et al.*, 2008). However, changes from conventional to conservation tillage practices can cause shifts in weed species and densities (Wilson and Foy, 1990 cited by Jones *et al.*, 1999).

Gul *et al.* (2009) indicated that fresh weed biomass is higher in the zero tillage compared to conventional tillage. As agricultural land is ploughed and harrowed, weed biomass and time required for weeding are reduced (Elliot *et al*., 1993). Furthermore, grassy weeds are more under zero tillage compared to conventional tillage plots. Hand weeding twice throughout the production season produces least weed biomass since hand weeding effectively controls weeds (Syawal, 1998; Khan *et al*., 1998).

2.5 Fertilizer Application for Maize

Maize is a heavy feeder of nitrogen and phosphorus for vegetative growth and depletes soil of both macro and micro mineral nutrients. The application of fertilizer is primarily aimed at ensuring proper growth and development of crops as well as increasing yield. The deficiency of a particular nutrient can only be replenished by the application of that particular nutrient only. To achieve quick results, synthetic fertilizers such as NPK, nitrate (NO_3^-), ammonium (NH_4^+)

and Urea ($CO(NH_2)_2$) are used by farmers despite their residual effect in the soil through acidic medium deposits.

The recommended application rates of fertilizers in maize production in Ghana are; NPK 15-15-15 fertilizer at 250 kg ha^{-1}, NPK 19-19-19 fertilizer at 197 kg ha^{-1}, NPK 20-20-20 fertilizer at 187 kg ha^{-1}, and Ammonium Sulphate fertilizer at 125 kg ha^{-1} (Aikins *et al.*, 2010). The quantity (especially nitrogen) required depends on the pre-clearing vegetation, organic matter content, tillage method and light intensity (Kang, 1981 cited by Onasanya *et al.*, 2009). Also, the type and quantity of fertilizer required will depend on soil type, cropping history and geographical location (Price, 1997). The fertilizer is normally buried at 5 cm depth and about 5-7 cm to the side of the maize plant. The application should be accomplished when the soil is at its field capacity of water content. To achieve higher yield, NPK must be applied at 2 weeks after planting followed by ammonium at 5 weeks after planting. When fertilizer is broadcast, plant requirements cannot be ensured and can lead to wastage of the active ingredient in the fertilizer (Yayock *et al.*, 1988).

2.6 Management of Pests and Disease of Maize

The most common insect pests of maize are stalk/stem borers, army worms, grasshopper and termites. These pests are controlled by the application of insecticides such as Kilsect 2.5 EC, Karat, Batelic, Actelic and Endosulfan preferably at the hatching areas when the nymphs are young (Martin *et al.*, 2006). Cultural control measures such as early planting, the use of resistant varieties and the burning of stalks after harvest can also control the insect infestation by breaking their life cycle.

Birds, cane rat, squirrels, rats, frogs and monkeys often cause various damages to the plant. The squirrels, frogs and crows remove seeds and seedlings sown from the soil, the cane rat chews the stovers and ears while the monkeys and birds destroy ears and grains. The birds, squirrels and frogs can be scared by erecting statues and noise making structures on the farm immediately after sowing seeds. Moreover, strips of paper rolled into cups can be used to cover ears to prevent birds from having access to the ears to damage. The rodents can be controlled by scaring, poisoning or trapping.

Diseases such as smut, rust, bacterial blight, and streak affect maize. These diseases can be controlled by the use of chemicals, seed selection and the removal of alternative host. To minimize yield reduction due to diseases, it is important to cultivate disease tolerant maize or practice crop rotation to control diseases (Brust and King, 1994).

2.7 Maturation, Harvesting, Processing and Storage

Maize is harvested at soft dough stage or hard dough stage (Kling, 1991). The time of harvesting is obviously dictated by the time of planting. The soft dough is mainly harvested when the ears are fresh while the harvesting of hard dough is done when ears have reached the physiological maturity with dried husk at about 120 days after planting. The early maturing varieties reach hard dough stage for harvesting between 75-80 days. At harvest, the grains are mostly at a moisture content of 15-20% but fresh maize is best harvested as soon as the stigma dries out or turn brown (Yayock *et al*., 1988).

The ears are harvested by hand or combine harvester or picker. Hand is used to break ears from stalk or cut with machete, threshed and shelled manually or mechanically. Meanwhile, the combine separates the ear from the stalk, dehusks and shells simultaneously. It is important to harvest during the dry periods to avoid postharvest grain deterioration or germination on the cob. Grains are usually left out for further drying and storage at 13% moisture content. The dried grains are stored in open cribs, sacks, bins or silos to prevent moulding (Katinila *et al.*, 1998).

2.8 Yield of Maize

Total grain yield of maize is obtained from harvested and shelled ears from the field. Maize yield could also be estimated from a representative sample from the field. The estimated maize yield is measured from the harvested ear(s) from the inner two rows of each plot (Abouziena *et al.*, 2007). The ear characters that can be determined include, ear length (cm), ear diameter (cm), 1000 kernel weight and harvest index (percentage of grain yield to biological yield). The measured grain yield can be expressed in mega-grammes/hectare (mg/ha), adjusted at 15% moisture content, or kilogrammes/hectare (kg/ha) at 13% moisture content (Obeng-Antwi *et al.*, 2002; Abdulai *et al.*, 2007).

3. MATERIALS AND METHODS

3.1 Experimental Site Description

A field experiment was conducted under rainfed conditions during the 2010 minor and 2011 major crop growing seasons at the Plantation Section field of the Department of Crop and Soil Sciences at Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The experimental site was located in the semi-deciduous forest agro-ecological zone of Ghana. Table 3.1 summarizes the weather data at the experimental site during the period of the experiment.

Table 3.1: Air Temperature and rainfall data between August, 2010 and July, 2011

Month	T_{max} (^oC)	T_{min} (^oC)	T_{mean} (^oC)	Rainfall (mm)
August	29.0	21.5	25.25	134.9
September	29.7	21.9	25.80	201.8
October	31.0	22.0	26.50	163.3
November	31.5	22.5	27.00	111.1
December	32.4	22.0	27.20	47.0
January	32.2	19.7	25.95	20.2
February	33.4	21.6	27.50	66.6
March	32.8	22.3	27.55	256.4
April	33.3	22.9	28.10	157.4
May	32.6	22.6	27.60	149.9
June	31.4	22.3	26.85	197.7
July	29.0	21.8	25.40	247.6

T_{max} (^oC)- Maximum Air Temperature ^oC ; T_{min} (^oC) -Minimum Air Temperature ^oC

The average daily temperature at the site is 26°C with a range between 18°C and 35°C while the annual rainfall is 1300 mm. The physical and chemical properties of the soil at the experimental site are presented in Table 3.2. The soil studied was sandy loam or Ferric Acrisol (FAO, 1998). The study area lies on a gentle slope and is well drained.

Table 3.2: Selected Soil Physical and Chemical Properties at the Experimental Site

	Soil Layer	
Soil Property	0–15 cm	15–30 cm
Sand (%)	63.98	65.2
Silt (%)	30.02	28.8
Clay (%)	6	6
Organic Carbon (%)	1.08	1.29
Organic Matter (%)	1.86	2.22
pH	4.91	4.74
Total N (%)	0.1	0.1
Ca (cmol kg^{-1})	3.2	2.94
Mg (cmol kg^{-1})	0.27	0.53
K (cmol kg^{-1})	0.13	0.12
NH_4^+N (cmol kg^{-1})	5.53	2.96
Available P (cmol kg^{-1})	9.57	14.35
Na (cmol kg^{-1})	0.29	0.4

3.2 Experimental Design and Treatments

The experimental design was a factorial, arranged in a randomized complete block design with three replicate blocks. The two factors included land preparation methods and weeding frequency. The land preparation treatments consisted of no tillage, and disc ploughing followed by disc harrowing while the weeding frequency treatments comprised zero hoeing, one hoeing at two weeks after planting, two hoeing at two and five weeks after planting or three hoeing at two, five and seven weeks after planting. Weed control was carried out using a hand hoe. In all, there were 24 experimental plots. Each plot measured 3.5 m by 3.0 m with the individual plots separated by 1.5 m buffer zones. The layout of the experiment is presented in Appendix 1.

3.3 Cultural Practices

Akposoe maize variety seeds were obtained from the Crops Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR) at Fumesua, Kumasi. The seeds were planted at two per hill using a custom made dibbler to a depth of 5 cm (Aikins *et al*., 2006). The recommended plant spacing of 75 cm by 35 cm for *Akposoe* maize variety was used giving a plant population of 80 plants per plot (10.5 m^2) (or 76,190 plants/ha). NPK 15-15-15 fertilizer was applied as top dressing at a rate of 250 kg ha^{-1} at two weeks after planting while ammonium sulphate fertilizer was applied at 125 kg ha^{-1} at five weeks after planting. Insect pests were controlled twice using a knapsack sprayer and a non-systemic contact insecticide (KILSECT 2.5 EC) containing 25 g of Lambda-cyhalothrin per litre at a rate of 800 mls ha^{-1}. Insecticide application was carried out at two and five weeks after planting.

3.4 Data Collection

The following data on soil properties were collected over the course of the field experiment: soil penetration resistance, dry bulk density, moisture content and total porosity. Data on soil properties were taken before land preparation, at tasselling, and after harvest in each season.

In addition, six plants were tagged per plot at random for the determination of plant growth, dry matter yield and yield components parameters. The data collected included seedling emergence, plant height, stem girth, number of leaves per plant, leaf area, root length, dry matter yield, ear length, ear girth, shelling percentage, biological yield, harvest index, 1000–seed weight and grain yield.

Again, the above-ground weeds (monocot and dicot) were randomly sampled with a quadrat (1m by 1m) from each plot for dry matter determination. Weeds were identified using weeds identification album (Akobundu and Agyakwa, 1998) to determine the predominant weeds at the experimental site.

3.4.1 Soil Penetration Resistance

Ten penetration resistance readings were taken per plot using a pocket penetrometer. The readings were taken in kg cm^2 and converted to kPal. The average of the ten readings was taken to represent the penetration resistance reading per plot.

3.4. 2 Bulk Density, Moisture Content and Total Porosity

Three sets of soil samples at depths of 0–15 cm and 15–30 cm were collected from each plot for the determination of dry bulk density, moisture content and total porosity before land preparation, at tasselling, and after harvest in each season. Soil dry bulk density was determined by obtaining undisturbed soil cores of known volume and dividing the oven dry soil mass by the core volume of the sample. Precautions were taken to reduce the disturbance of soil within the metal cylinder during sampling. The collected soil cores were trimmed to the exact volume of the cylinder and oven dried at 105°C for 24 hours. Soil moisture content was determined using the gravimetric method. The total porosity of the soil was calculated from the values of the dry bulk density and particle density using the equation given by Chancellor (1994).

Porosity = $\left(1 - \frac{\rho_b}{\rho_p}\right) \times 100\%$……......………………..…..,…………….…...............…Equation 3.1

where,

ρ_b = Dry bulk density (Mgm^{-3})

ρ_p = Particle density (Mgm^{-3}) = 2.65 Mg m^{-3} (assumed)

3.4.3 Seedling Emergence

Counts of emerged *Akposoe* maize variety plants were made per plot daily until emergence was deemed complete. Percent emergence was calculated by dividing the number of emerged plants counted by the number of seeds planted multiplied by 100.

3.4.4 Plant Height and Stem Girth

Plant height was recorded from the soil surface level at the base of the plant to the top of the highest leaf initially using a ruler and then later a metre rule for ten weeks starting at one week after planting. Stem girth was measured using a thread and a ruler for ten weeks starting at one week after planting.

3.4.5 Number of Leaves per Plant and Leaf Area

The number of leaves per plant of the six tagged plants per plot was counted for ten weeks starting at one week after planting. The length and breadth of the broadest leaves of the six tagged plants were measured using a ruler. The leaf area was then determined using the linear regression analysis equation:

$Leaf\ Area = k(LxW)$ ……………………....…………..…………………………………...…Equation 3.2

where,

k = 0.75 which is constant for all cereals

L = Leaf length

W = Leaf width

3.4.6 Root Length and Dry Matter Yield

The root lengths of the six tagged plants per plot were measured as the length from the base of the shoot to the tip of the root of each plant using a ruler at harvest (90 days after planting for both seasons). The dry matter yields were determined by manually harvesting the six tagged plants per plot at harvest. The plants were washed and cleaned to remove traces of soil before oven drying them in brown envelopes at 70°C for 48 hours. The dry weights were converted to kilogrammes per hectare.

3.4.7 Yield Components and Yield

At physiological maturity, ears from the tagged plants on each plot were harvested, dried and shelled. The fresh ear weights of the six tagged plants were recorded using an electronic balance at harvest. The dry ear weights of the six tagged plants were also recorded using an electronic balance at seven days after harvest following sun drying. The lengths and girths of the ears were measured with a thread and ruler.

The dried ears were dehusked and threshed. The weights of the husks and cobs were measured with an electronic balance for biological yield determination. All parts of the maize with the exception of the grain constituted the biological yield. The fresh grains were further dried to determine shelling percentage expressed as weight of dried grain divided by weight of dried ears multiplied by 100%. The harvest index was computed using the formula given by Donald (1962) cited by Hugar (2006) as:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100\% \quad \text{……….....…………..…......….Equation 3.3}$$

The fresh grains were open air dried on black polyethylene film sheet in the sun for seven days to reduce the moisture content to approximately 13% as given by Ogunbodede *et al.* (2001) and Obeng-Antwi *et al.* (2002). The moisture content of grains at 13% was determined by drying 25 whole dried grains in an oven at 105°C for 14 hours as given by Bala (1997). The dried grains were weighed and expressed proportionally into kilogrammes per hectare as given by

Sallah *et al*. (1997). In addition, the 1000-Seed Weight from the dried grains was also determined using an electronic balance.

3.4.8 Weed Dry Matter

Weed dry matter was taken in both seasons at 2, 5, 7 and 13 WAP. Before the hand hoeing, a quadrat of 1m by 1m was cast randomly on each plot and weeds found in the quadrat identified as either dicot or monocot. After weeds specimen identification, the above-ground weeds were harvested from each of the 24 plots. The weeds sampled were separated into broadleaf weeds and grasses and transported in a black film of polythene sheet to the laboratory for weighing. The weed samples were oven dried at $70^{o}C$ for 48 hours in envelopes of known mass. The weight of dry matter was taken using an electronic balance.

3.5 Data Analyses

The MINITAB Statistical Software Release 15 (MINITAB Inc., 2007) was used to analyze the data using the General Linear Factorial Model ANOVA procedure to determine the significance of each treatment on soil properties, maize performance and weeds dry matter yield. Treatment means were separated by the least significant difference (LSD) test at $p<0.05$.

4. RESULTS AND DISCUSSION

4.1 Introduction

The experiment was undertaken to determine land preparation methods and weeding frequency effects on soil properties, *Akposoe* maize performance, and weed dry matter. The field experiment was conducted in the 2010 minor and the 2011 major cropping seasons. The results were analyzed with the MINITAB Statistical Software Release 15 and are thoroughly discussed in this chapter.

4.2 Land Preparation Methods and Weeding Frequency Effects on Soil Properties

4.2.1 Effect of Land Preparation Methods on Soil Penetration Resistance

Table 4.1 presents the soil penetration resistance results before land preparation, at tasselling and after harvest for both the 2010 minor and 2011 major cropping seasons for the ploughing followed by harrowing plots as well as the no tillage plots under *Akposoe* maize variety. Analysis of variance showed that the no tillage plots presented penetration resistance readings significantly higher than that of the ploughing followed by harrowing plots. Over the course of the study, the highest penetration resistance value of 412.5 kPa was recorded after harvest in 2010 in the no tillage plots. This period happened to be the dry season in December when rainfall was 47 mm while the maximum and minimum temperatures were 32.4 ^{o}C and 22.0 ^{o}C. The ploughing followed by harrowing plots gave lower penetration resistance (119 kPa) after harvest during the 2011 major season due to sufficient soil moisture content caused by rainfall. An increased amount of rainfall resulted in a decreased soil penetration in *Akposoe* maize fields in both seasons. Olaoye (2002) reported higher soil penetration resistance in the no tillage treatment in comparison with the disc ploughing and harrowing treatment for Ferric Luvisol in the rain forest zone of Akure in Nigeria. The lowest penetration resistance measured on plough and harrow plots favoured the highest seedling emergence since roots of seedlings need minimum resistance for imbibition (Olaoye, 2002) of water.

Table 4.1: Effect of Land Preparation Methods on Soil Penetration Resistance (kPa)

	2010 Minor Season			2011 Major Season		
Land Preparation Methods	Before Ploughing	At Tasselling	After Harvest	Before Ploughing	At Tasselling	After Harvest
No Tillage	309.8	287.0	412.5	227.0	180.6	183.1
Plough and Harrow	288.2	165.5	335.7	123.5	140.8	119.0
LSD ($p<0.05$)	17.47	59.51	33.69	19.21	31.59	24.53

4.2.2 Weeding Frequency Effect on Soil Penetration Resistance

Table 4.2 displays the effect of weeding frequency on soil penetration resistance in the 2010 minor and 2011 major cropping seasons under *Akposoe* maize variety. Soil penetration resistance was statistically significant after harvest in the 2010 minor cropping season but showed no significance difference in the 2011 major cropping season. The highest soil penetration resistance (422.6 kPa) was recorded from the 0 hoeing plots after harvest in the 2010 minor cropping season while the 3 hoeing plots gave the least penetration resistance (139.7 kPa) after harvest in the 2011 major cropping season. Soil penetration resistance after harvest between 2 hoeing and 3 hoeing regimes was statistically similar. Increased frequency of hoeing decreased soil penetration resistance in the course of the experiment, due to soil surface disturbances created during weeding with the hoe.

Table 4.2: Effect of Weeding Frequency on Soil Penetration Resistance (kPa)

	2010 Minor Season			2011 Major Season		
Weeding Frequency	Before Ploughing	At Tasselling	After Harvest	Before Ploughing	At Tasselling	After Harvest
0 Hoeing	293.5	225.9	422.6	177.1	166.7	160.9
1 Hoeing	286.1	240.1	376.9	176.7	161.4	158.5
2 Hoeing	304.8	209.8	340.0	175.1	159.0	145.0
3 Hoeing	311.3	229.1	356.8	172.1	155.6	139.7
LSD ($p<0.05$)	12.35	NS	23.83	NS	NS	NS

NS = Not Significant

4.2.3 Effect of Land Preparation Methods on Soil Dry Bulk Density

The effect of land preparation methods on soil dry bulk density in the 0–15 cm and 15–30 cm layers before land preparation, at tasselling and after harvest in the 2010 minor and 2011 major cropping seasons is presented in Table 4.3 and Table 4.4 respectively. Over the course of the study, land preparation methods influenced soil dry bulk density. In general, soil dry bulk density in the no tillage plots was higher in comparison with that in the ploughing followed by harrowing plots. In 2010, there was no significant difference in soil dry bulk density before land preparation in both the 0–15 cm and 15–30 cm layers. However, at tasselling and after harvest, there was significant difference in soil dry bulk density in both the 0–15 cm and 15–30 cm layers except for that in the 0–15 cm layer at tasselling. In 2011, land preparation methods significantly affected dry bulk density over the period of the experiment except for that in the 15–30 cm soil layer before land preparation. These results are similar to that of Aikins *et al*., (2012); Kombiok *et al*., (2005) and Ojeniyi and Adekayode (1999). In contrast, Olaoye (2002) found higher soil dry bulk density in disc ploughing followed by disc harrowing plots compared with that of the no tillage plots.

Table 4.3: Effect of Land Preparation Methods on Soil Dry Bulk Density (2010)

		Soil Dry Bulk Density (Mgm^{-3})					
Land Preparation Methods		Before Ploughing		At Tasselling		After Harvest	
	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
No Tillage		1.418	1.445	1.499	1.509	1.452	1.486
Plough + Harrow		1.395	1.491	1.480	1.551	1.434	1.349
LSD ($p<0.05$)		NS	NS	NS	0.037	0.015	0.006

NS = Not Significant

Table 4.4: Effect of Land Preparation Methods on Soil Dry Bulk Density (2011)

		Soil Dry Bulk Density (Mgm^{-3})					
Land Preparation Methods		Before Ploughing		At Tasselling		After Harvest	
	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
No Tillage		1.442	1.441	1.394	1.418	1.394	1.403
Plough + Harrow		1.378	1.443	1.327	1.352	1.335	1.355
LSD ($p<0.05$)		0.038	NS	0.051	0.035	0.045	0.034

NS = Not Significant

4.2.4 Effect of Weeding Frequency on Soil Dry Bulk Density

Table 4.5 and Table 4.6 summarize the effect of weeding frequency on soil dry bulk density in the 2010 minor and 2011 major cropping seasons under *Akposoe* maize variety before land preparation, at tasselling and after harvest. In 2010, weeding frequency did not have statistical significant difference in soil dry bulk density before ploughing. However, weeding frequency had significant difference in soil dry bulk density after harvest. In 2011, there was no significant difference in soil dry bulk density between the different weeding frequency treatments except for that in the 0-15 cm layer before land preparation. Generally, the zero hoeing treatment recorded the highest soil dry bulk density in comparison with the other hoeing treatments.

Table 4.5: Effect of Weeding Frequency on Soil Dry Bulk Density (2010)

Weeding frequency	Layer	Dry Bulk Density (Mgm^{-3})					
		Before Ploughing		At Tasselling		After Harvest	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		1.430	1.477	1.482	1.485	1.470	1.447
1 Hoeing		1.398	1.455	1.481	1.529	1.428	1.398
2 Hoeing		1.390	1.502	1.477	1.551	1.436	1.390
3 Hoeing		1.407	1.439	1.778	1.553	1.436	1.434
LSD (p=0.05)		NS	NS	NS	0.026	0.011	0.005

NS = Not Significant

Table 4.6: Effect of Weeding Frequency on Soil Dry Bulk Density (2011)

		Dry Bulk Density (Mgm^{-3})					
Weeding frequency		Before Ploughing		At Tasselling		After Harvest	
	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		1.450	1.457	1.367	1.387	1.397	1.388
1 Hoeing		1.420	1.443	1.363	1.403	1.365	1.380
2 Hoeing		1.374	1.406	1.352	1.364	1.335	1.366
3 Hoeing		1.397	1.461	1.359	1.388	1.360	1.381
LSD (p=0.05)		0.027	NS	NS	NS	NS	NS

NS = Not Significant

4.2.5 Effect of Land Preparation Methods on Soil Moisture Content

Moisture content of soil measures the rate of water absorption by *Akposoe* maize roots. Soil moisture is the source of water for plant use in particular in rainfed agriculture (Mweso, 2003). The effect of land preparation methods on soil moisture content before ploughing, at tasselling and after harvest in the 2010 minor and 2011 major seasons is summarized in Table 4.7 and Table 4.8 respectively.

Table 4.7: Effect of Land Preparation Methods on Soil Moisture Content (2010)

Land Preparation Methods	Layer	Moisture Content (%) Before Ploughing 0–15 cm	Before Ploughing 15–30 cm	At Tasselling 0–15 cm	At Tasselling 15–30 cm	After Harvest 0–15 cm	After Harvest 15–30 cm
No Tillage		11.02	10.71	13.06	12.854	4.954	5.332
Plough + Harrow		12.66	11.32	13.61	12.327	6.243	6.999
LSD ($p<0.05$)		NS	NS	NS	NS	0.294	0.126

NS = Not Significant

Table 4.8: Effect of Land Preparation Methods on Soil Moisture Content (2011)

Land Preparation Methods	Layer	Moisture Content (%) Before Ploughing 0–15 cm	Before Ploughing 15–30 cm	At Tasselling 0–15 cm	At Tasselling 15–30 cm	After Harvest 0–15 cm	After Harvest 15–30 cm
No Tillage		9.094	9.797	10.91	12.33	15.57	15.52
Plough + Harrow		8.613	11.570	15.80	18.21	19.89	21.01
LSD ($p<0.05$)		NS	NS	1.98	3.34	2.59	2.10

NS = Not Significant

In the 2010 minor cropping season, land preparation methods had no significant effect on soil moisture content at tasselling but statistically produced significant difference after harvest in the 0-15cm and 15-30cm layers. However, significant differences in soil moisture content were observed in 2011 at tasselling and after harvest. Ploughing followed by and harrowing treatment recorded higher (19.89%) soil moisture content in the 0-15cm layer and higher moisture content (21.01%) in the 15-30cm layer than no tillage (15.57%) and (15.52%) at similar depths respectively. In the 2010 minor season, moisture content decreased with depth at tasselling and increased with depth after harvest but increased with depth in the 2011 major season. Differences in the trend in soil moisture content between 2010 and 2011 may be attributed to the temperature and rainfall fluctuations over the period of the experiment. Soil pulverization during disc ploughing followed by disc harrowing increased soil voids and organic matter content. This improved water retention capacity in the soil.

4.2.6 Effect of Weeding Frequency on Soil Moisture Content

Soil moisture content measured under different weeding frequencies in the 2010 minor and 2011 major cropping seasons is given in Table 4.9 and Table 4.10 respectively. Before hoeing treatment, moisture content was higher in the 0-15cm layer than the 15-30cm layer depths (Table 4.9) but was lower in the 0-15cm layer than the 15-30cm layer depths (Table 4.10). The highest moisture content (15.12%) was recorded from the 2 hoeing plots while the lowest moisture content (12.12%) was recorded for the 0 hoeing at tasselling in the 0-15cm layer depths. Again at tasselling, higher moisture content was recorded in the 15-30cm on 2 hoeing plots while 0 hoeing gave the lowest moisture content at the 15-30cm layer depths.

Table 4.9: Effect of Weeding Frequency on Soil Moisture Content (2010)

		Moisture Content (%)					
Weeding		Before Ploughing		At Tasselling		After Harvest	
frequency	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		10.90	10.96	12.12	11.042	5.024	6.072
1 Hoeing		10.58	10.58	12.66	13.694	6.317	6.320
2 Hoeing		11.86	10.74	15.12	12.865	6.231	6.182
3 Hoeing		14.02	11.79	13.43	12.759	4.823	6.089
LSD (p<0.05)		NS	NS	1.144	NS	0.208	0.089

NS = Not Significant

Table 4.10: Effect of Weeding Frequency on Soil Moisture Content (2011)

		Moisture Content (%)					
Weeding		Before Ploughing		At Tasselling		After Harvest	
frequency	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		8.142	11.628	12.68	13.44	16.41	16.72
1 Hoeing		7.983	8.442	12.75	13.53	17.73	18.36
2 Hoeing		11.168	14.326	13.79	16.59	19.39	20.55
3 Hoeing		8.121	8.339	13.00	16.57	17.39	17.43
LSD (p<0.05)		1.17	1.82	NS	2.36	NS	1.48

NS = Not Significant

The lowest soil moisture content was observed in the 0 hoeing at tasselling due to weed-maize water absorption competition in the soil. The highest moisture content on 1, 2 and 3 hoeing treatments could be attributed to mulch cover left on the surface after weeding which consequently improved moisture content and minimized evapo-transpiration.

4.2.7 Effect of Land Preparation Methods on Soil Total Porosity

Table 4.11 and Table 4.12 depict the effect of land preparation methods on soil total porosity in the 2010 minor season and the 2011 major cropping seasons respectively. Soil total porosity determines the variations in water and air content of the soil. The pores are of different size, shape and continuity which influence infiltration, storage and drainage of water, the movement and distribution of gases, and the ease of penetration of soil by growing roots (Kay and VandenBygaart, 2002). Soil total porosity was highest at the surface 0–15cm layer and decreased with depth in the 15–30 cm layer at tasselling and after harvest in both seasons except no tillage treatment in the 15-30 cm layer in the 2010 minor cropping season.

Table 4.11: Effect of Land Preparation Methods on Soil Total Porosity (2010)

Land Preparation Methods		Soil Total Porosity (%)					
		Before Ploughing		At Tasselling		After Harvest	
	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
No Tillage		46.50	45.46	43.43	43.07	43.93	44.22
Plough + Harrow		47.37	43.74	44.15	41.49	49.10	45.90
LSD (p<0.05)		NS	NS	NS	1.40	0.57	0.24

NS = Not Significant

Table 4.12: Effect of Land Preparation Methods on Soil Total Porosity (2011)

Land Preparation Methods	Layer	Soil Porosity (%)					
		Before Ploughing		At Tasselling		After Harvest	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
No Tillage		45.38	45.64	47.40	46.48	47.41	47.07
Plough + Harrow		47.98	45.55	49.91	48.97	49.63	48.87
LSD (p<0.05)		1.44	NS	1.94	1.31	1.99	1.29

NS = Not Significant

From Table 4.11, land preparation methods did not significantly influence total porosity before ploughing as well as the 0-15cm depth at tasselling. Besides, there was statistical significance difference in land preparation methods on total porosity in the 15-30cm depths at tasselling and after harvest. The ploughing followed by harrowing gave porosity (44.15%) higher than no tillage (43.43%) in the 0-15cm depth at tasselling which meant that more water could be retained at the top layer for maize uptake. Similarly, ploughing followed by harrowing recorded highest soil total porosity (49.91%) than no tillage (47.40%) and was statistically significant before ploughing, at tasselling and after harvest except 15-30cm depths before ploughing (Table 4.12). For maximum productivity, the pore spaces of a soil should be around 50% of its volume (Radford *et al*., 2001). The decomposition of organic matter incorporated into the soil during ploughing followed by harrowing created enough pore spaces to produce higher porosity.

4.2.8 Effect of Weeding Frequency on Soil Porosity

Table 4.13 and Table 4.14 illustrate the influence of weeding frequency on soil total porosity. There was statistical significant difference on total porosity at 0-15cm and 15-30cm layers after harvest and 15-30cm depths at tasselling at different hoeing regimes (Table 4.13). However, weeding frequency did not affect soil total porosity at tasselling and after harvest in the 0-15cm and the 15-30cm layers (Table 4.14). The 2 hoeing recorded the highest total porosity (44.26%) and (47.54%) in the 0-15cm layers at tasselling and after harvest respectively. Hoeing breaks compact soils at the surface to yield higher total porosity at tasselling. The 0 hoeing recorded the lowest soil total porosity at after harvest of *Akposoe* maize in 0-15cm and 15-30cm layers in both cropping season.

Table 4.13: Effect of Weeding Frequency on Soil Porosity (2010)

Weeding frequency	Layer	Soil Porosity (%)					
		Before Ploughing		At Tasselling		After Harvest	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		46.03	44.28	44.09	43.95	45.38	44.52
1 Hoeing		47.25	45.09	44.11	42.29	47.25	46.11
2 Hoeing		47.57	43.32	44.26	41.48	47.54	45.82
3 Hoeing		46.89	45.70	42.71	41.40	45.88	45.79
LSD (p<0.05)		NS	NS	NS	0.99	0.41	0.17

NS = Not Significant

Table 4.14: Effect of Weeding Frequency on Soil Total Porosity (2011)

		Soil Total Porosity (%)					
Weeding		Before Ploughing		At Tasselling		After Harvest	
frequency	Layer	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
0 Hoeing		45.27	45.01	48.41	47.67	47.30	47.63
1 Hoeing		46.42	45.53	48.56	47.06	48.48	47.93
2 Hoeing		48.15	46.96	48.97	48.54	49.63	48.44
3 Hoeing		47.29	44.86	48.70	47.63	48.68	47.87
LSD (p<0.05)		1.02	NS	NS	NS	NS	NS

NS = Not Significant

4.3 Interaction Effect of Land Preparation Method and Weeding Frequency on Soil Properties

4.3.1 Interaction Effect of Land Preparation Method and Weeding Frequency on Soil Penetration Resistance

Land preparation methods and weeding frequency combinations on soil penetration resistance for 2010 and 2011 cropping seasons are presented in Table 4.15. Generally, the results revealed no significant difference in interaction effect on soil penetration resistance in both seasons.

Table 4.15: Interaction Effect of Land Preparation Method and Weeding Frequency on Soil Penetration Resistance (kPa)

Land Preparation Method x Weeding Frequency	Minor Season, 2010			Major Season, 2011		
	Before Ploughing	At Tasselling	After Harvest	Before Ploughing	At Tasselling	After Harvest
No Tillage x 0 Hoeing	312.4	291.4	470.0	231.3	170.4	180.8
No Tillage x 1 Hoeing	288.1	320.3	415.6	228.0	175.6	206.1
No Tillage x 2 Hoeing	312.1	243.1	374.4	228.7	202.0	177.3
No Tillage x 3 Hoeing	326.5	293.0	389.8	219.9	174.4	168.1
Plough + Harrow x 0 Hoeing	275.0	160.4	375.2	122.9	163.0	140.9
Plough + Harrow x 1 Hoeing	284.2	159.9	338.1	125.3	147.3	111.0
Plough + Harrow x 2 Hoeing	297.4	176.4	305.6	121.6	116.0	112.8
Plough + Harrow 3 Hoeing	296.1	165.3	323.7	124.2	136.8	111.4
LSD (p<0.05)	NS	NS	NS	NS	NS	NS

NS = Not Significant

4.3.2 Interaction Effect of Land Preparation Methods and Weeding Frequency on Dry Bulk Density, Moisture Content, and Total Porosity

Land preparation methods and weeding frequency interactions at tasselling in the 2010 minor and 2011 major cropping seasons are summarised in Table 4.16 and Table 4.17 respectively. In the 2010 minor cropping season, land preparation methods and weeding frequency interactions were not statistically significant ($p>0.05$) for soil dry bulk density and total porosity in the 0-15cm layer but statistically presented significant difference ($p<0.05$) in the 15-30cm layer. Moisture content was significantly affected in the 0-15cm and 15-30cm layers. The No tillage with 3 Hoeing resulted in the maximum (1.527 Mgm^{-3}) dry bulk density in the 0-15cm depths while Ploughing followed by Harrowing with 1 Hoeing resulted in the maximum dry bulk density (1.585 Mgm^{-3}) in the 15-30cm depths. Comparatively, ploughing followed by harrowing with hoeing regimes recorded lower dry bulk density, higher moisture content and higher total porosity than no tillage with hoeing treatments in the 0-15cm depths.

In the 2011 major season (Table 17), land preparation methods and weeding frequency on dry bulk density, moisture content and total porosity in the 0-15cm to 15-30cm depths showed no significant difference ($p>0.05$).

Table 4.16: Interaction Effect of Land Preparation Methods and Weeding Frequency on Soil Properties in the 0–15 cm and 15 – 30cm Layers at Tasselling (2010)

Land Preparation Method x Weeding Frequency	Bulk Density (Mgm^{-3})		Moisture Content (%)		Total Porosity (%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
No Tillage x 0 Hoeing	1.503	1.454	10.57	9.662	43.28	45.15
No Tillage x 1 Hoeing	1.490	1.474	13.96	16.287	43.76	44.39
No Tillage x 2 Hoeing	1.475	1.524	14.58	13.448	44.32	42.48
No Tillage x 3 Hoeing	1.527	1.583	13.14	12.018	42.37	40.26
Plough + Harrow x 0 Hoeing	1.460	1.517	13.66	12.422	44.89	42.74
Plough + Harrow x 1 Hoeing	1.472	1.585	11.38	11.102	44.46	40.19
Plough + Harrow x 2 Hoeing	1.479	1.577	15.66	12.283	44.19	40.48
Plough + Harrow x 3 Hoeing	1.509	1.523	13.73	13.501	43.06	42.54
LSD ($p<0.05$)	NS	0.05	2.29	3.35	NS	1.98

NS = Not Significant

Table 4.17: Interaction Effect of Land Preparation Methods and Weeding Frequency on Soil Properties in the 0–15cm and 15-30cm Layers at Tasselling (2011)

Land Preparation Method x Weeding Frequency	Bulk Density (Mgm^{-3})		Moisture Content (%)		Total Porosity (%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
No Tillage x 0 Hoeing	1.376	1.404	10.78	11.03	48.09	47.01
No Tillage x 1 Hoeing	1.396	1.442	10.51	11.11	47.30	45.58
No Tillage x 2 Hoeing	1.402	1.397	10.95	12.15	47.10	47.28
No Tillage x 3 Hoeing	1.402	1.430	11.42	15.01	47.11	46.03
Plough + Harrow x 0 Hoeing	1.359	1.370	16.99	16.03	48.72	48.32
Plough + Harrow x 1 Hoeing	1.330	1.364	14.99	15.76	49.82	48.54
Plough + Harrow x 2 Hoeing	1.303	1.330	16.64	20.94	50.83	49.80
Plough + Harrow x 3 Hoeing	1.317	1.346	14.58	20.12	50.29	49.22
LSD ($p<0.05$)	NS	NS	NS	NS	NS	NS

NS = Not Significant

4.4 Effect of Land Preparation Methods and Weeding Frequency on Maize Performance

4.4.1 Effect of Land Preparation Methods on Seedling Emergence

The effect of Land preparation methods on seedling emergence in the 2010 minor and 2011 major cropping seasons are given in Fig. 4.1 and Fig. 4.2 respectively. In both seasons, seedling emerged 4 days after planting. There was statistical significant difference in seedling emergence between the different land preparation methods. The ploughing followed by harrowing treatment presented seedling emergence significantly higher than that of the no tillage treatment. In 2010, the ploughing followed by harrowing treatment recorded significantly higher seedling emergence (99.38%) compared with that of the no tillage treatment (96.25%).

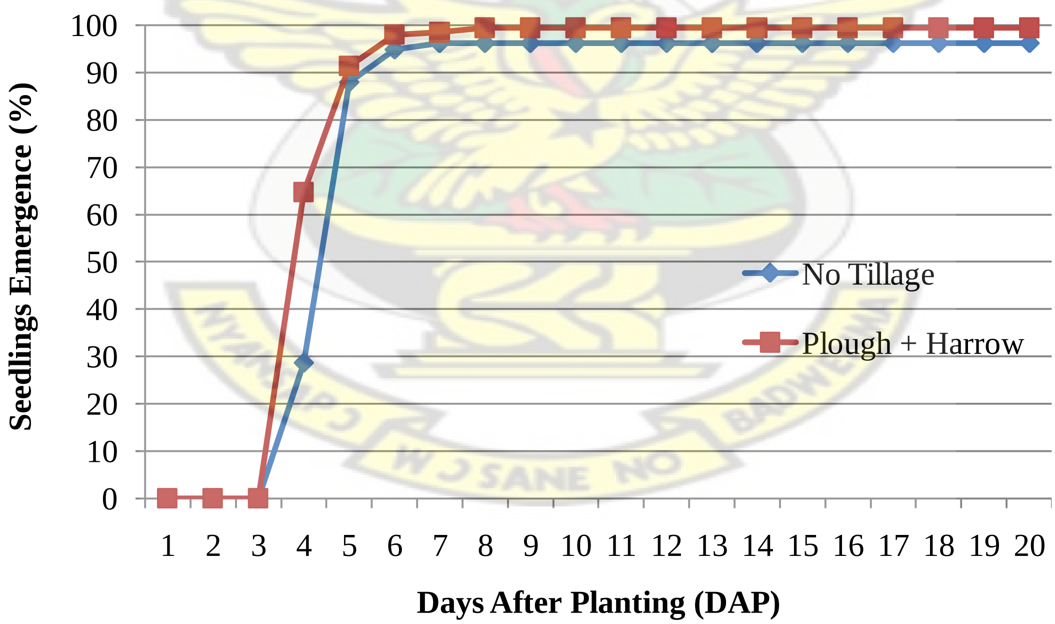

Figure 4.1: Effect of Land Preparation Methods on Seedling Emergence (2010)

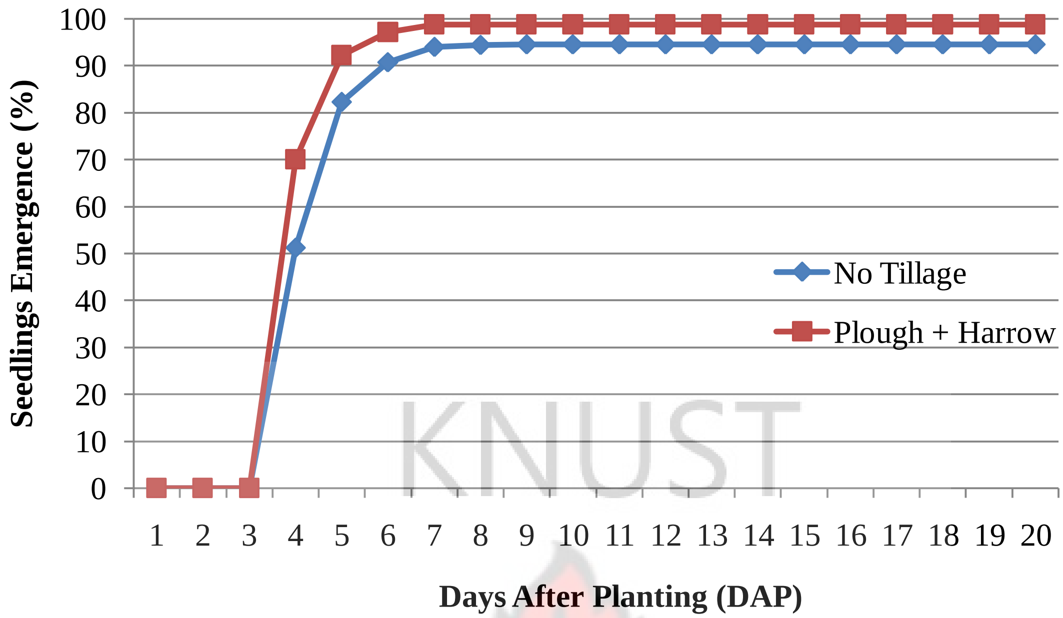

Figure 4.2: Effect of Land Preparation Methods on Seedling Emergence (2011)

Similarly, in 2011, the ploughing followed by harrowing treatment recorded significantly higher seedling emergence (98.85%) compared with that of the no tillage treatment (94.54%) Seedling emergence stabilized at 8 to 20 days after planting on ploughing followed by harrowing plots and no tillage plots. The higher seedling emergence recorded on ploughing followed by harrowing plots than the no tillage plots was as a result of adequate soil moisture in the soil at the time of planting due to the pulverised nature of the soil. Meanwhile, the lower seedling emergence recorded on the no tillage plots confirmed research finding that seedling emergence is higher when land is ploughed and harrowed (Oni, 1991).

4.4.2 Effect of Weeding Frequency on Seedling Emergence

Fig. 4.3 and Fig. 4.4 display the effect of weeding frequency on maize seedling emergence in the 2010 minor and 2011major planting seasons respectively. There was no significant difference in seedling emergence between the different weeding frequencies.

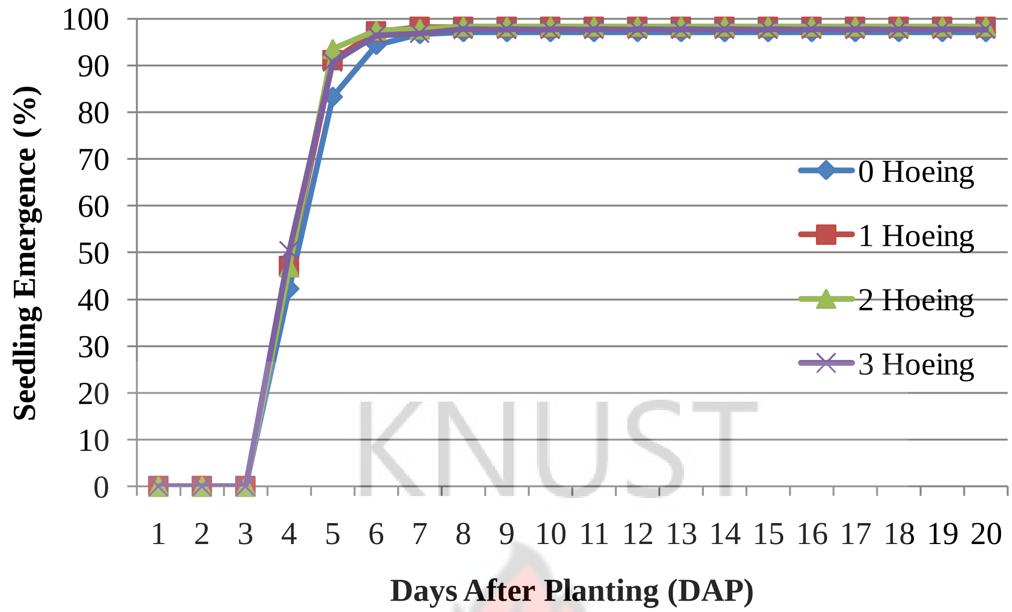

Figure 4.3: Effect of Weeding Frequency on Seedling Emergence (2010)

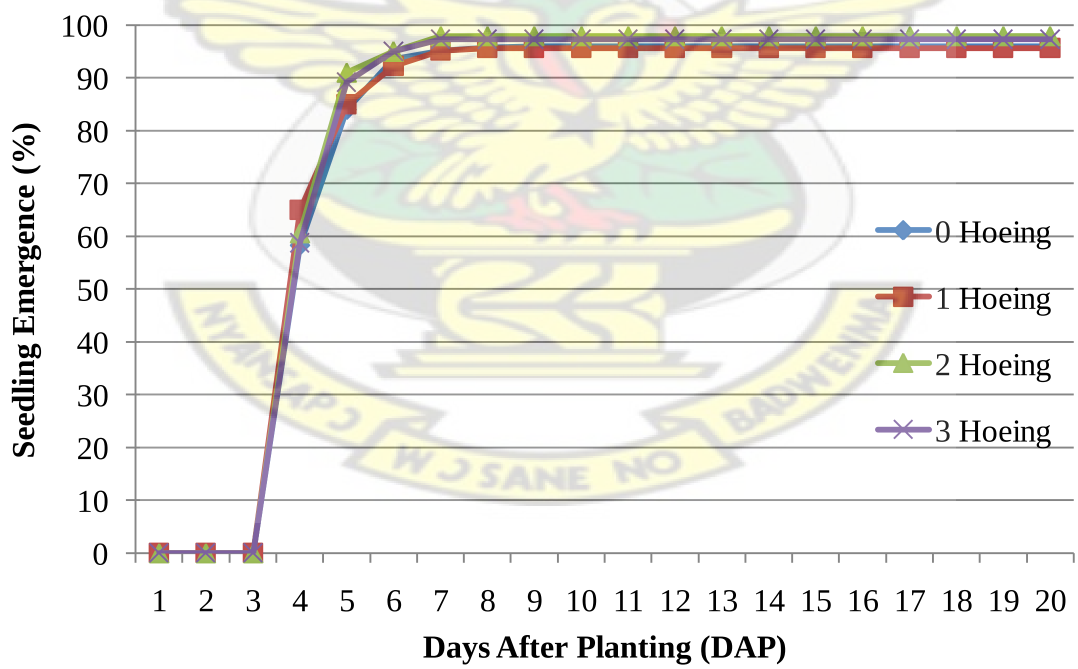

Figure 4.4: Effect of Weeding Frequency on Seedling Emergence (2011)

4.4.3 Effect of Land Preparation Methods on Number of Leaves per Plant

Fig. 4.5 and Fig. 4.6 depict the effect of land preparation methods on number of leaves per plant in the 2010 minor and 2011 major cropping seasons respectively. At 10 weeks after planting, the number of leaves per plant found in the ploughing followed by harrowing plots was significantly higher than that in the no tillage plots for both the 2010 minor and 2011 major crop growing seasons.

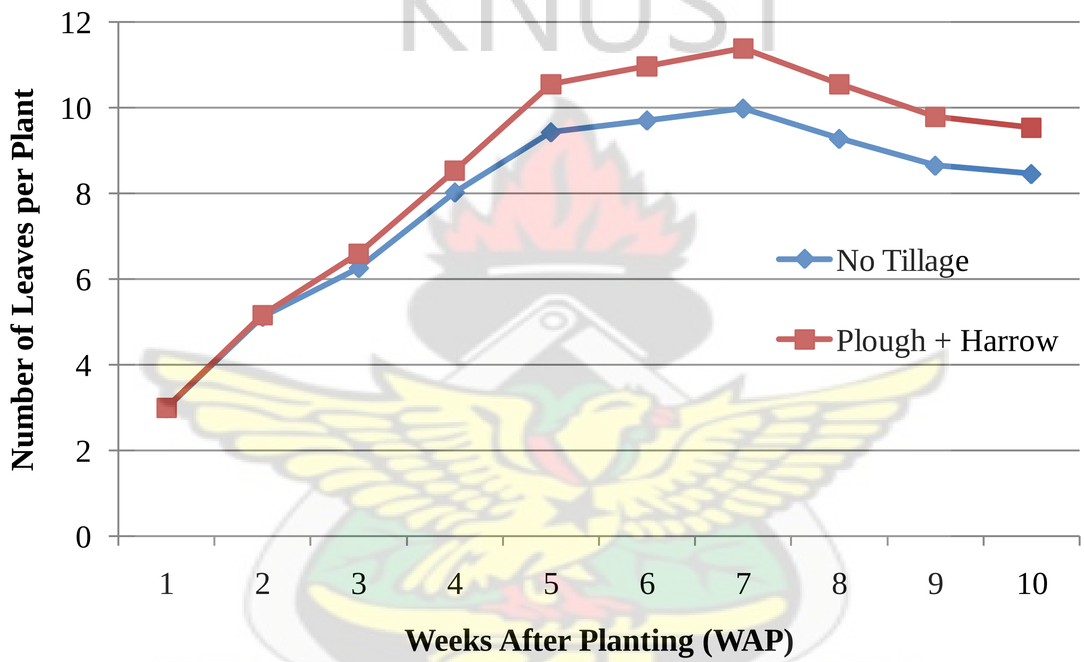

Figure 4 5: Effect of Land Preparation Methods on Number of Leaves per Plant (2010)

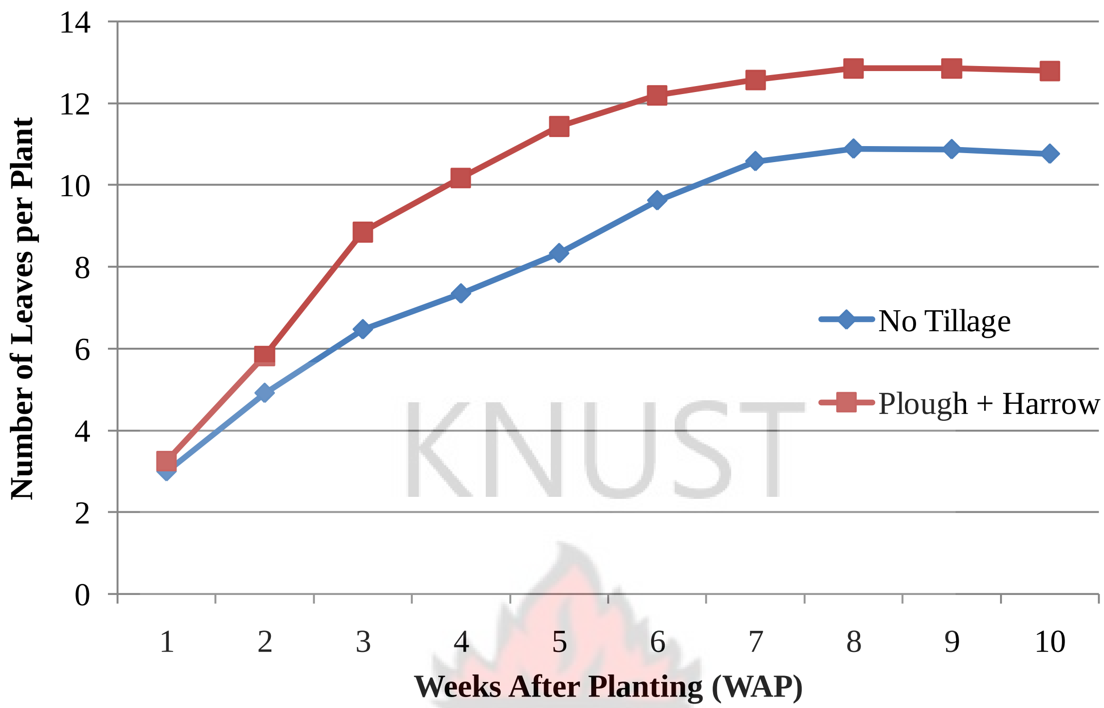

Figure 4.6: Effect of Land Preparation Methods on Number of Leaves per Plant (2011)

In the 2011 major season, the number of leaves per plant on ploughing followed by harrowing plots and no tillage plots was statistically significant from 2 to 10 weeks after planting. However, higher average number of leaves (12.86) was recorded from ploughing followed by harrowing plots while minimum number of leaves (10.89) was measured on no tillage plots. This is because *Akposoe* maize establishment was faster on ploughing followed by harrowing plots than no tillage plots due to the high moisture content and porosity of the soil. In general, the number of leaves per plant was not significant at 1 week after planting because maize seedlings emerged true leaves within 1 week after planting on both ploughing followed by harrowing and no tillage plots. Maize therefore produced more number of leaves on ploughing followed by harrowing plots than no tillage plots (Gomez, 2010).

4.4.4 Effect of Weeding Frequency on Number of Leaves per Plant

The number of leaves per *Akposoe* maize plant in the 2010 minor and 2011 major seasons is shown in Fig. 4.7 and Fig. 4.8. In 2010, weeding frequency effect on number of leaves per plant was statistically similar from 1 to 4 weeks after planting but was statistically different from 5 to 10 weeks after planting. The 0 hoeing maintained the lowest (7.583) average number of leaves while 3 hoeing recorded the highest (9.333) average number of leaves at 10 weeks after planting. Meanwhile, the maximum (11.25) average number of leaves per plant was counted on 2 hoeing plots while 0 hoeing had lowest (9.33) average number of leaves per plant at 7 weeks after planting. Generally, there was high significant difference in number of leaves between 0 hoeing, and 1, 2 or 3 hoeing treatments but no significant difference was recorded for 1, 2 and 3 hoeing treatment from 1 to 7 weeks after planting. The number of leaves per plant declined from 7 weeks after planting to physiological maturity. Weeds therefore affect number of leaves emerged and maintained on the maize plant throughout the growing periods.

In the 2011 minor season, there was statistically significant difference among weeding frequency regimes at 10 weeks after planting. The highest average number of leaves per plant (12.75) was recorded on 2 hoeing plots while 0 hoeing plots recorded the lowest number of leaves per plant (10.47). It was observed that weeding twice during cropping period is an ideal to obtain higher number of leaves per plant. The number of leaves maize produces measures the extent of photosynthetic activities and ultimate yield.

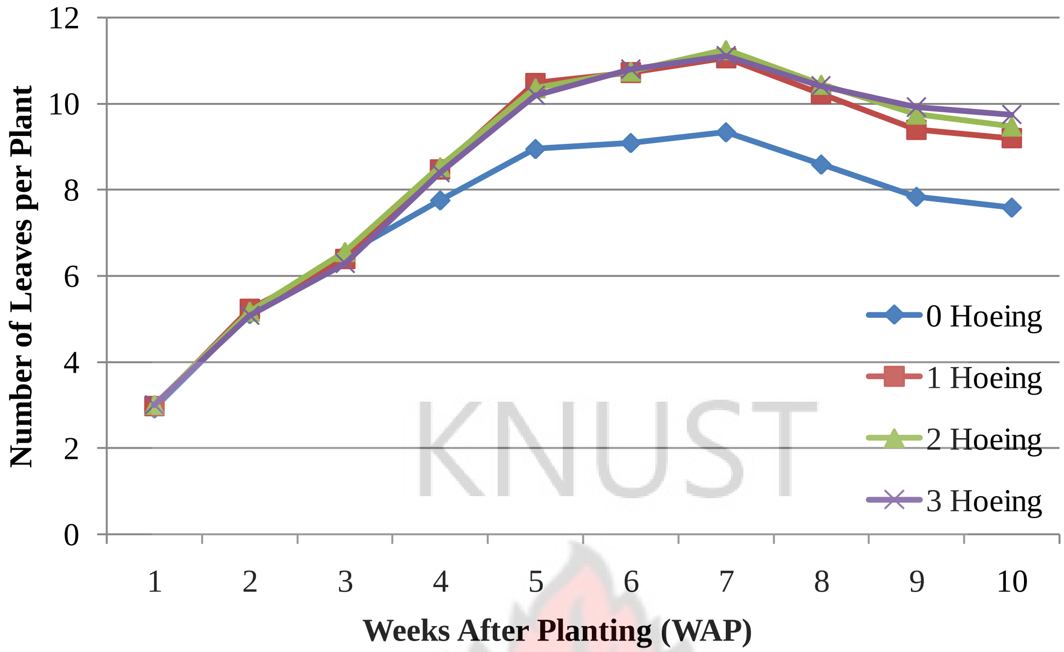

Figure 4.7: Effect of Weeding Frequency on Number of Leaves per Plant (2010)

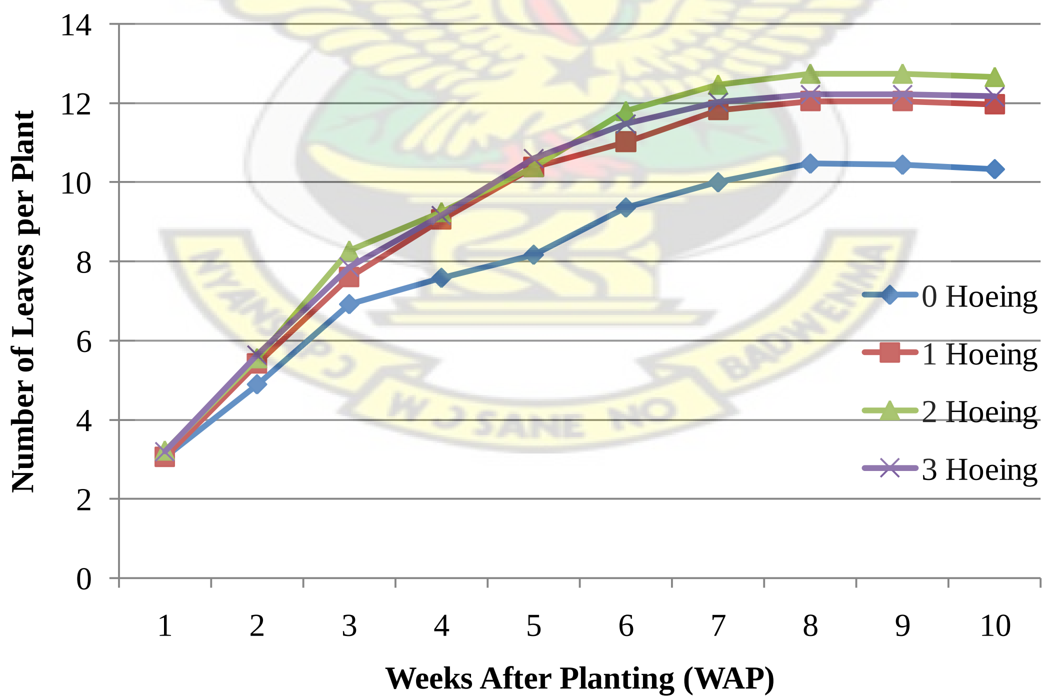

Figure 4.8: Effect of Weeding Frequency on Number of Leaves per Plant (2011)

4.4.5 Effect of Land Preparation Methods on Leaf Area per Plant

Fig.4.9 and Fig. 4.10 illustrate the effect of land preparation methods on leaf area per plant in the 2010 minor and 2011 major crop growing seasons. At 10 weeks after planting, the leaf area per plant in the ploughing followed by harrowing plot was significantly higher in comparison with that in the no tillage plots. When land was ploughed and harrowed for cultivation of maize, leaf area was higher than No tillage plots (Karunatilake and Schindelbeck, 2000). The higher the leaf area the better the utilization of sunlight for photosynthetic activities, but excessive leaf area prevents lower leaves from receiving sunlight for photosynthesis (Kling, 1991).

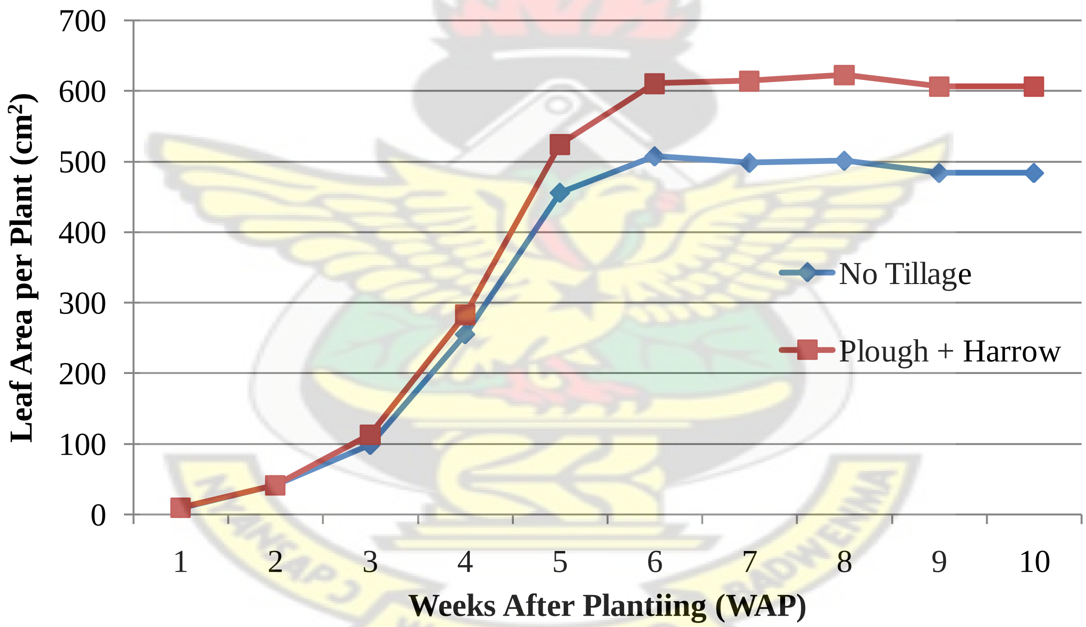

Figure 4.9: Effect of Land Preparation Methods on Leaf Area per Plant (2010)

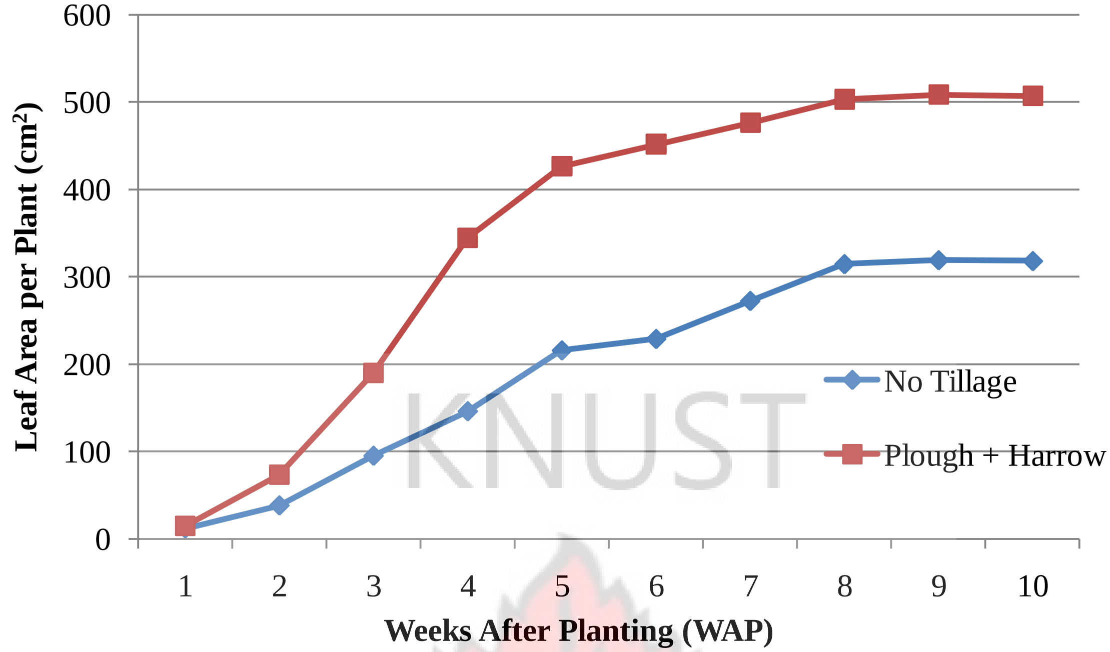

Figure 4.10: Effect of Land Preparation Methods on Leaf Area per Plant (2011)

4.4.6 Effect of Weeding Frequency on Leaf Area per Plant

The leaf area obtained in the 2010 minor and 2011 major seasons were statistically significant ($p<0.05$). Moreover, 3 hoeing at 1, 2 and 3 WAP recorded the highest leaf area compared to 0 hoeing in both 2010 and 2011 seasons. Interestingly, there was no significant difference between weeding frequency at 1, 2 and 3 WAP from 1 to 10 WAP on leaf area. In the 2010 minor season (Fig. 4.11), 3 hoeing treatment recorded the highest (698.50 cm^2) leaf area per plant while 0 hoeing treatment recorded the lowest (465.50 cm^2) leaf area per plant. In the 2011 major season (Fig. 4.12), 2 hoeing had the highest (463.70 cm^2) leaf area followed by 1 hoeing (446.30) with 0 hoeing recording the lowest (312.90 cm^2) leaf area. Under extensive weed control in maize farms, leaf area increases under weed-free conditions (Cathcart and Swanton, 2004).

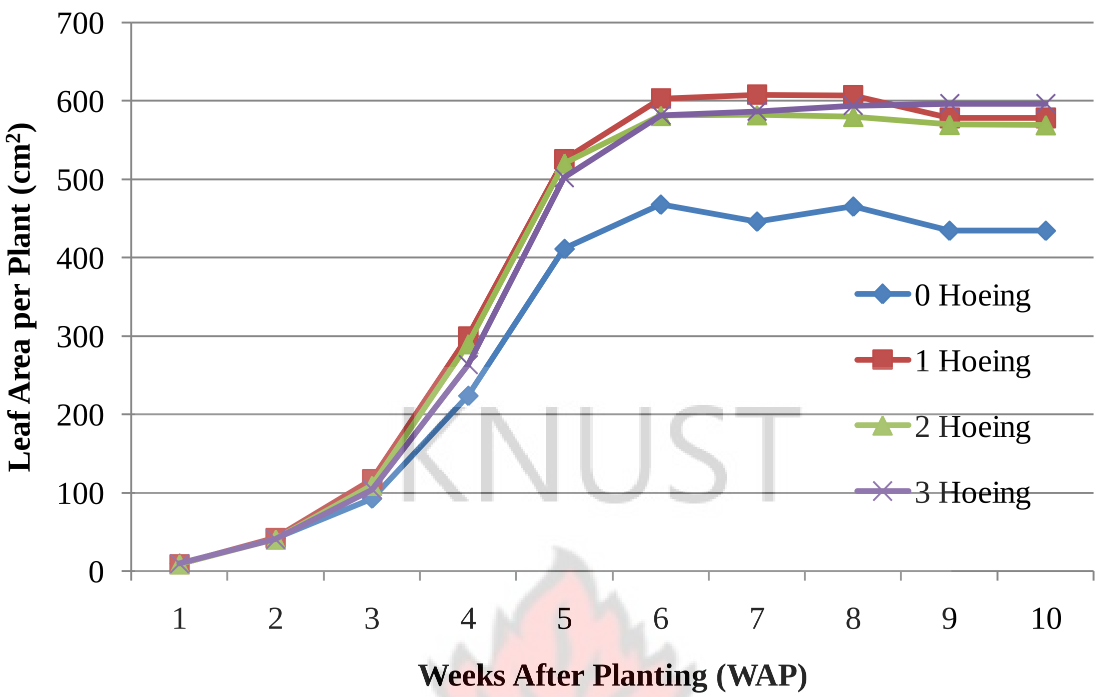

Figure 4.11: Effect of Weeding Frequency on Leaf Area per Plant (2010)

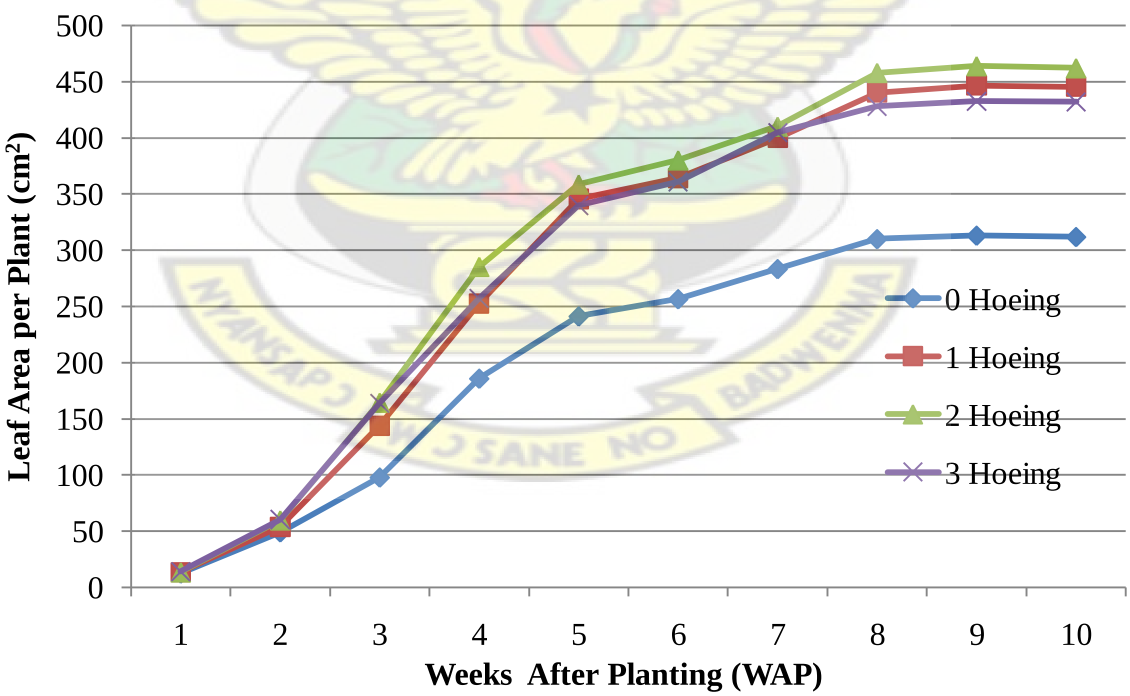

Figure 4.12: Effect of Weeding Frequency on Leaf Area per Plant (2011)

4.4.7 Effect of Land Preparation Methods on Plant Height

Fig. 4.13 and Fig. 4.14 display plant height for the different land preparation methods under *Akposoe* maize variety in the 2010 minor and 2011 major cropping seasons respectively. There was statistical significant difference in plant height between the land preparation methods. At 10 WAP, the ploughing followed by harrowing plots recorded the tallest plant significantly taller than that of the no tillage plots. These results are similar to that of Aikins *et al.* (2012); Aikins and Afuakwa (2010) and Kombiok *et al.* (2005). The taller plants found in the ploughing followed by harrowing plots is probably the result of higher soil moisture content, higher total porosity, lower soil penetration resistance and lower dry bulk density in the ploughing followed by harrowing plots as compared with that of the no tillage plots.

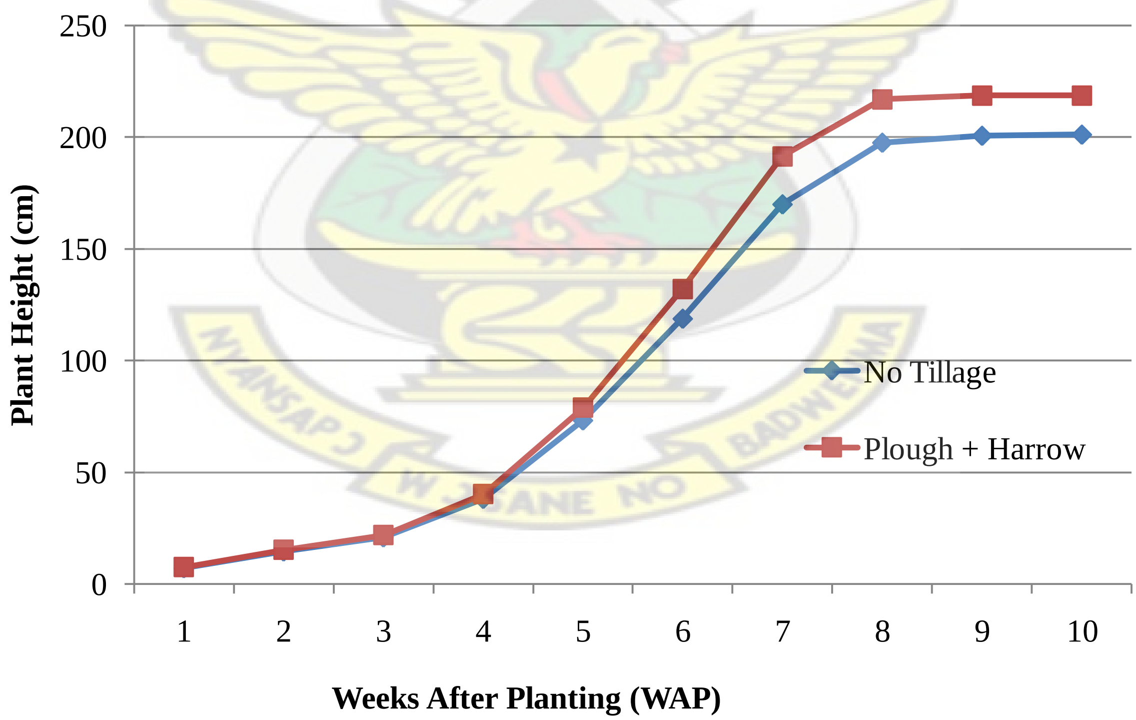

Figure 4.13: Effect of Land Preparation Methods on Plant Height (2010)

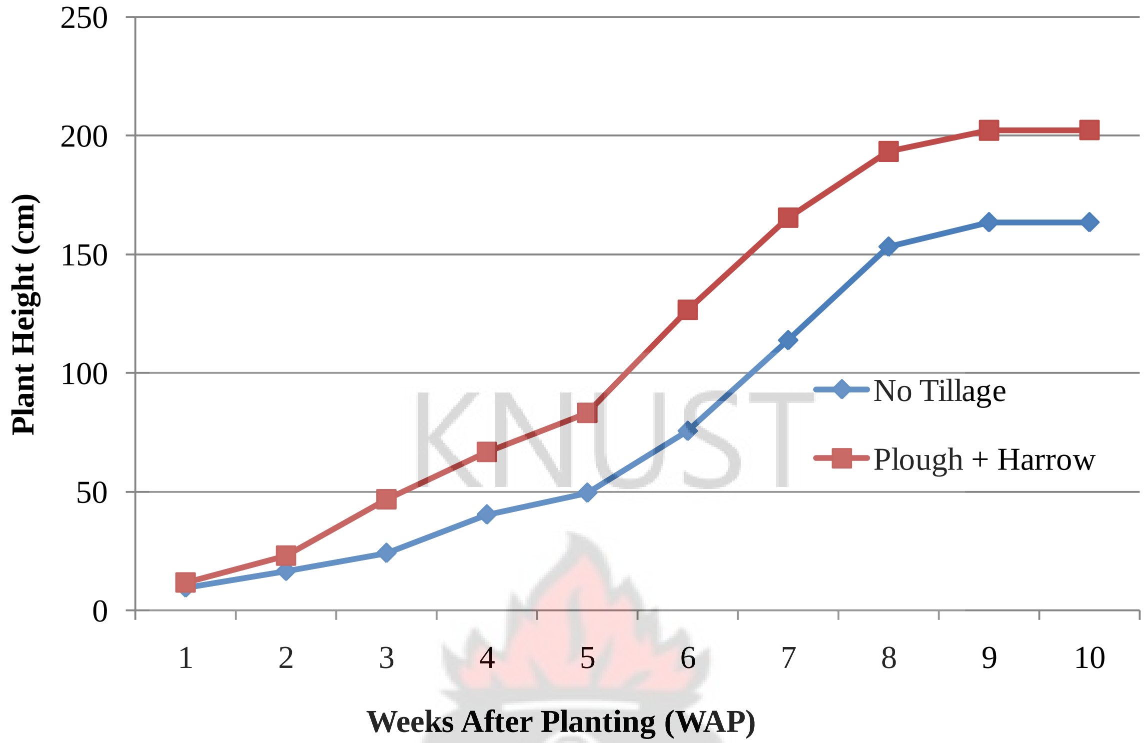

Figure 4.14: Effect of Land Preparation Methods on Plant Height (2011)

4.4.8 Effect of Weeding Frequency on *Akposoe* Maize Plant Height

Plant height is an important growth parameter directly linked with the productive potential of plants in terms of fodder and grain yield (Saeed *et al*., 2001). Fig. 4.15 and Fig. 4.16 depict the effect of weeding frequency on *Akposoe* maize plant height in the 2010 minor and 2011 major cropping seasons. Weeding frequency significantly affected *Akposoe* maize plant height. The tallest plants were located in the 2 hoeing plots at 2 WAP and 5 WAP, which were significantly taller than that of the 0 hoeing plots. These results are similar to that of Abouziena *et al.* (2007). It is necessary to protect the crop from weed competition throughout the vegetative growth period to ensure maximum plant height and yield (Adenawoola *et al.*, 2005).

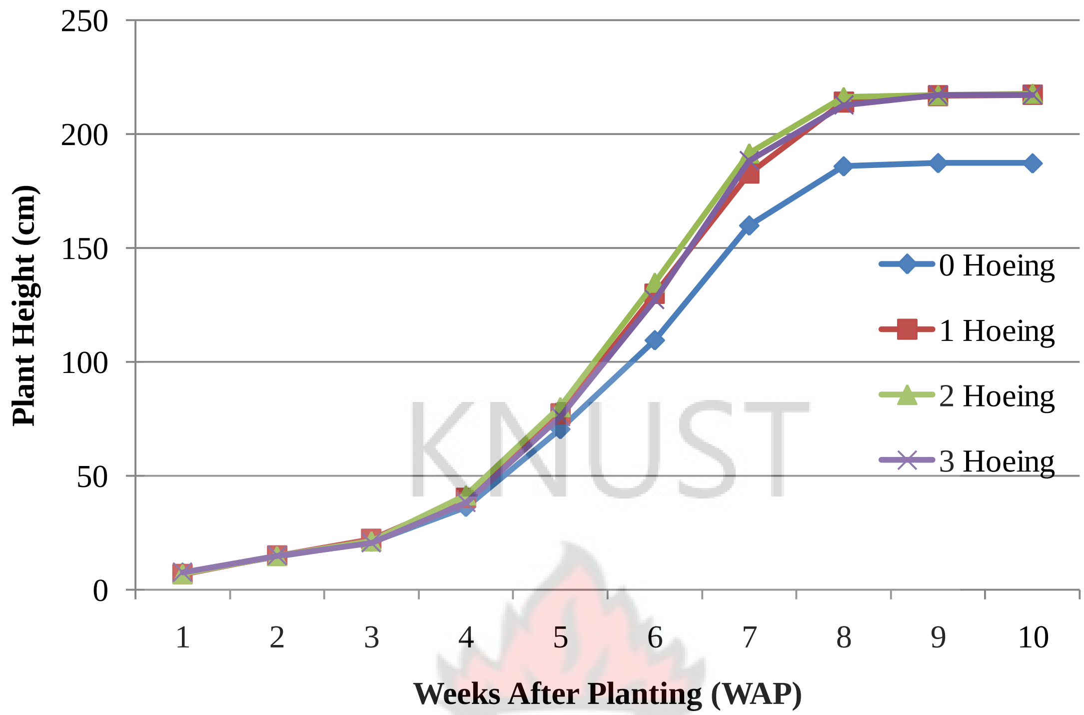

Figure 4.15: Effect of Weeding Frequency on Plant Height (2010)

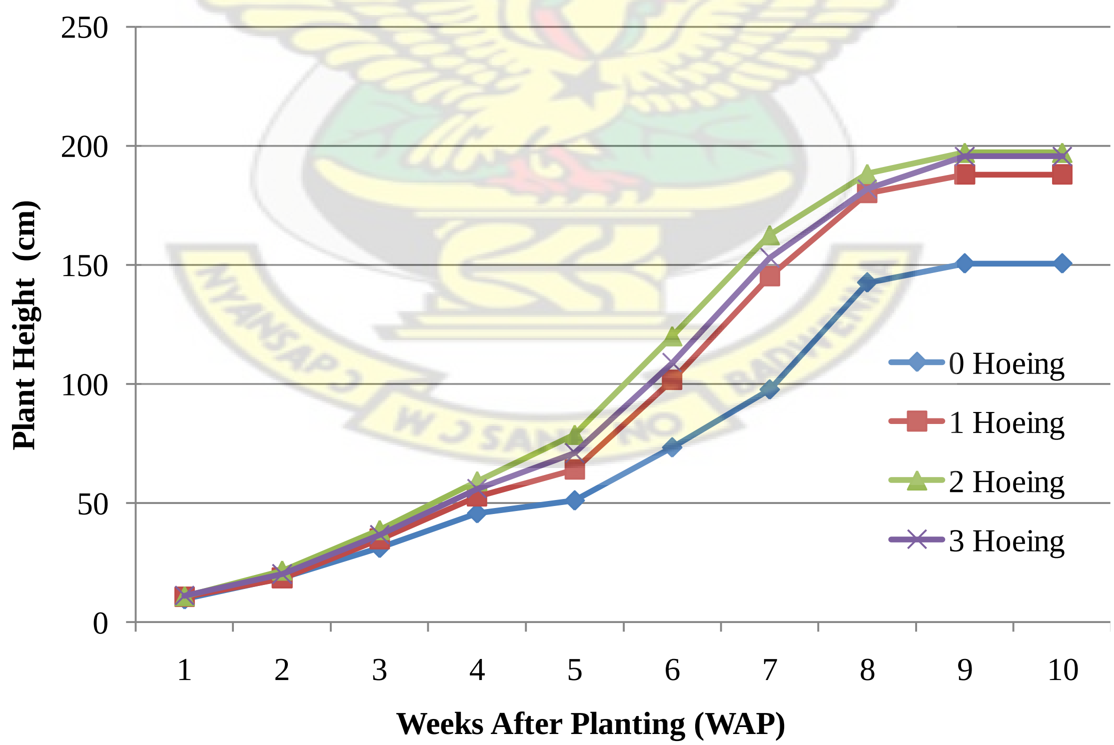

Figure 4.16: Effect of Weeding Frequency on Plant Height (2011)

4.4.9 Effect of Land Preparation Methods on Stem Girth

Stem girth is an important component of maize growth. Fig. 4.17 and Fig. 4.18 present the mean values of stem girth in the 2010 minor and 2011 major cropping seasons respectively. In the 2010 minor season, ploughing followed by harrowing, and no tillage treatments showed statistical significant effect ($p<0.05$) on *Akposoe* maize stem girth from 1 to 10 WAP. The bigger stem girth (79.19 mm) was measured on plough and harrow plots while no tillage recorded smaller stem girth (64.92 mm) at 8 WAP. Moreover, in the 2011 cropping season, bigger stem girth (75.89 mm) was recorded on ploughing followed by harrowing while no tillage gave smaller stem girth (57.90 mm) at 9 WAP. The shrunk stem girth in the 2011 major season could be attributed to erratic rainfall that hit the vegetative growth phase.

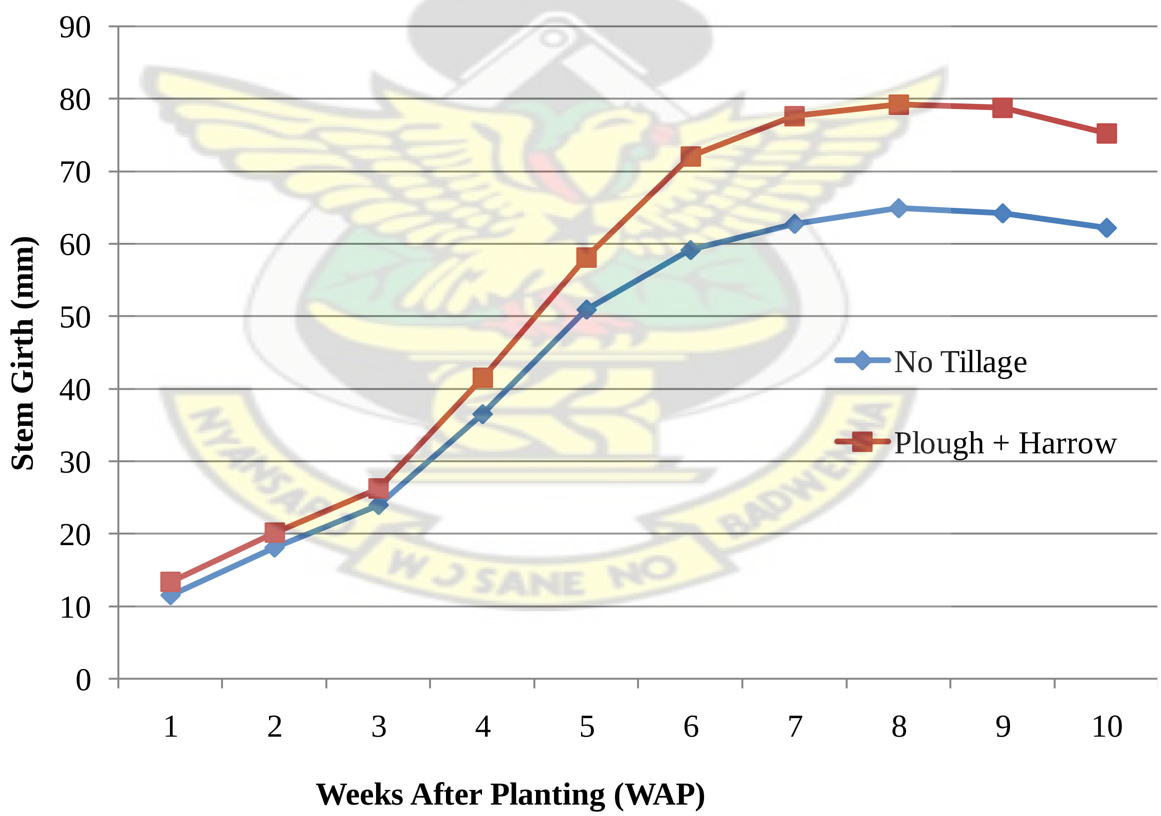

Figure 4.17: Effect of Land Preparation Methods on Stem Girth (2010)

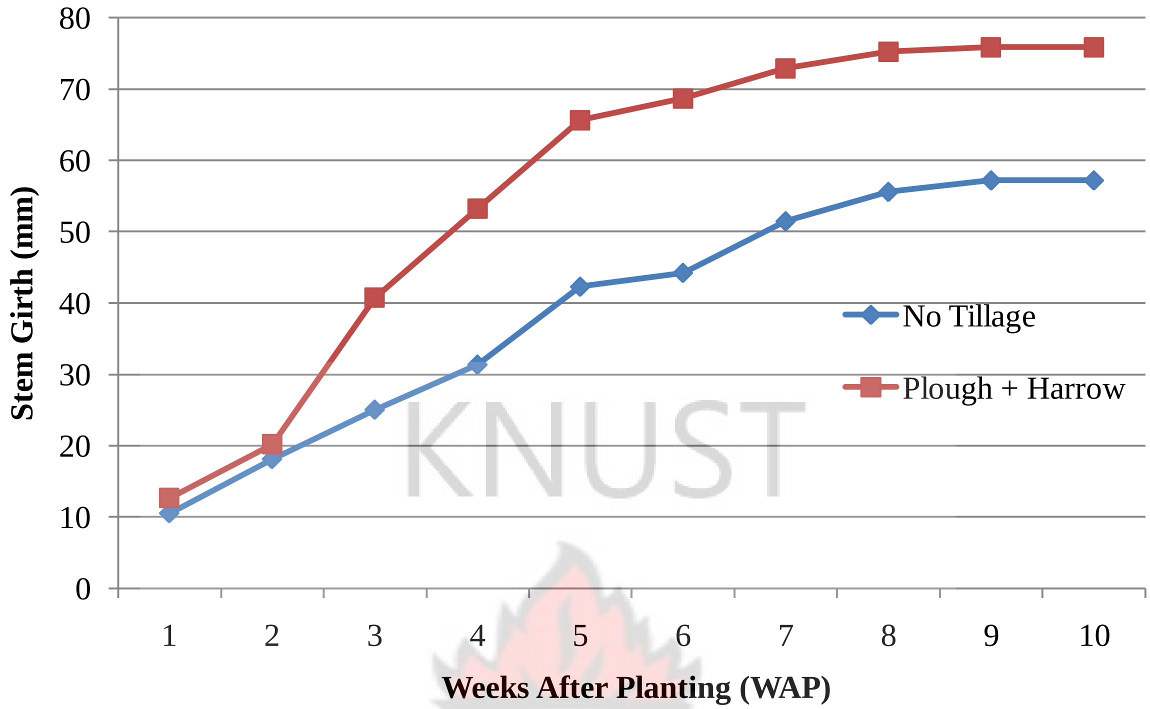

Figure 4.18: Effect of Land Preparation Methods on Stem Girth (2011)

4.4.10 Effect of Weeding Frequency on Stem Girth

Weeds interfere with maize growth and affect ultimately yield. Stem girth is proportional to weeding frequency and climatic conditions. The effect of weeding frequency on *Akposoe* maize plant stem girth in the 2010 minor season is shown in Fig. 4.19 while the 2011 major season stem girth result is illustrated in Fig. 4.20. In the 2010 minor season, stem girth showed no significant difference from 1 to 3 WAP but was significant at 4 to 10 WAP. The biggest stem girth (77.69mm) was obtained from the 2 hoeing plots while the smallest stem girth (60.67mm) was recorded on 0 hoeing plots at 10 WAP.

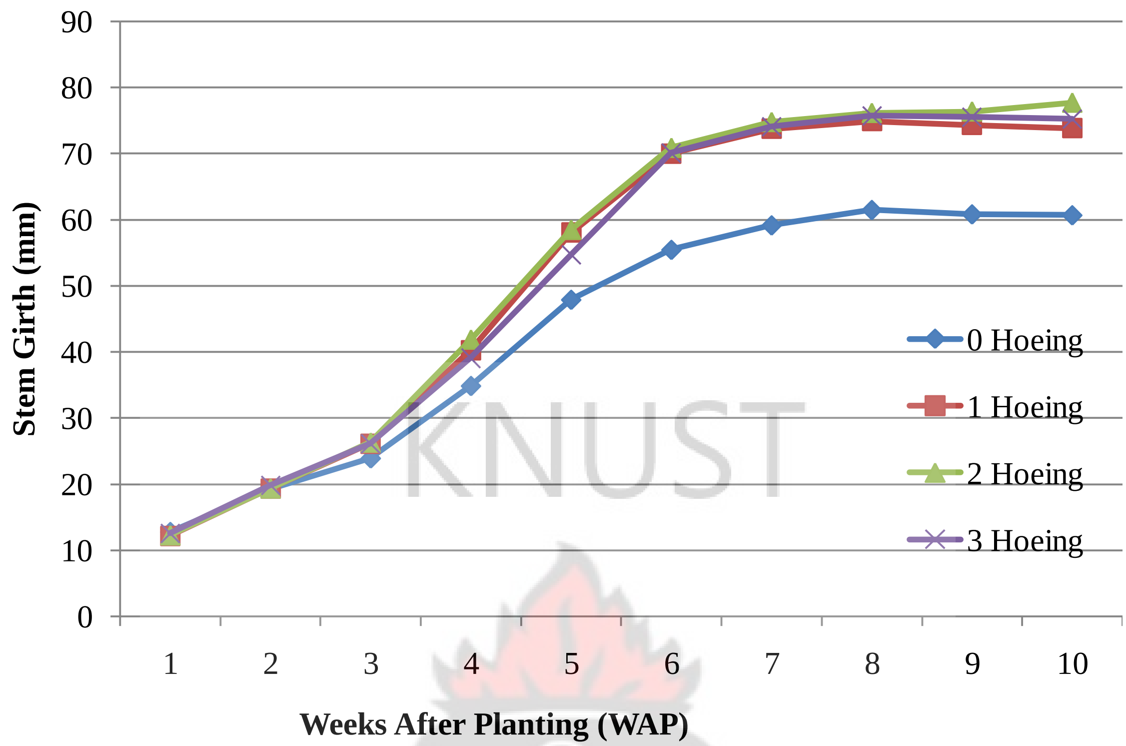

Figure 4.19: Effect of Weeding Frequency on Stem Girth (2010)

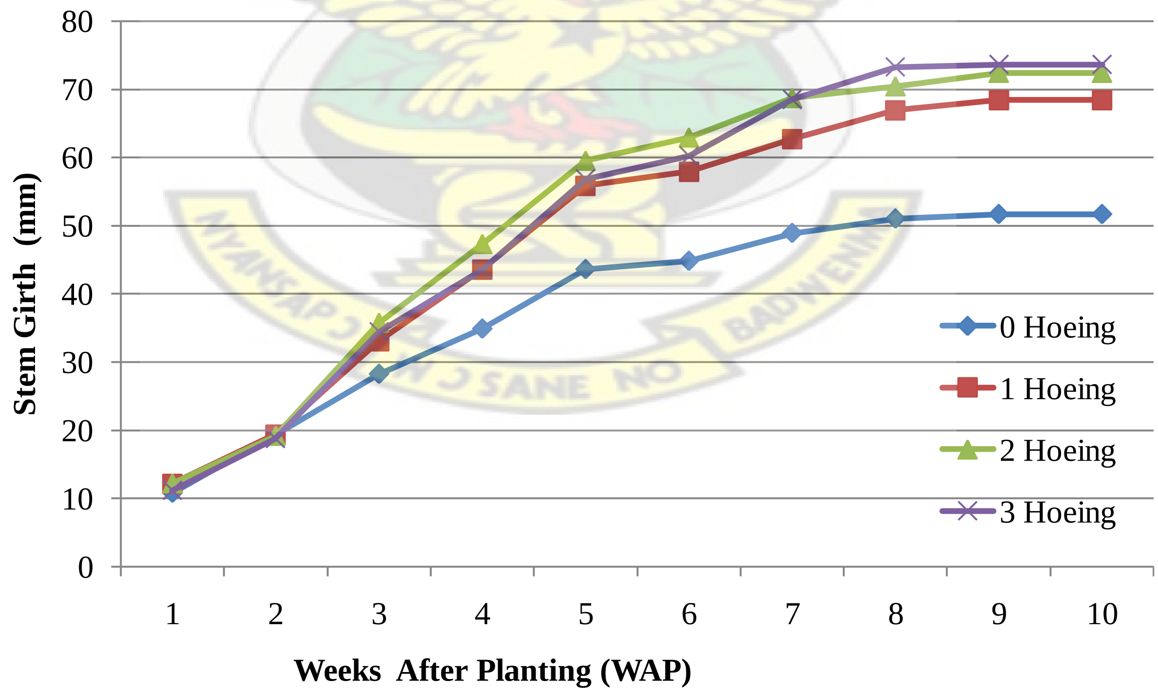

Figure 4.20: Effect of Weeding Frequency on Stem Girth (2011)

In the 2011 major season (Fig. 4.20), mean stem girth competition was keen at 1 and 2 WAP but started showing differences after 2 WAP. The stem girth increased at a decreased rate under 0 hoeing plots while 1, 2 and 3 hoeing showed increased stem girth at an increased rate until stability set in from 9 WAP. Stem girth was significantly affected at hoeing treatments over the period of experiment up to 10 WAP ($p<0.05$). The biggest stem girth (73.64mm) was recorded on 3 hoeing plots followed by 2 hoeing plots (72.42mm) while 0 hoeing treatment plots had the smallest stem girth (51.69mm) at 10 weeks after planting.

4.4.11 Effect of Land Preparation Methods on Root Length, Ear Length and Ear Girth

Table 4.18 presents the effect of land preparation methods on root length, ear length and ear girth of *Akposoe* maize variety for the 2010 minor and 2011 major crop growing seasons. The effect of land preparation methods on root length, ear length and ear girth in both 2010 minor and 2011 major seasons was statistically significant ($p<0.05$). In the 2010 minor season, the ploughing followed by harrowing plots yielded longer root length (33.32cm), larger ear girth (18.75cm) and longer ear length (13.00cm) while no tillage had the shallower root length (21.43cm), smaller ear girth (15.03cm) and shorter ear length (11.02cm).

Table 4.18: Effect of Land Preparation Methods on Root Length, Ear Length and Ear Girth at 90 DAP

	Minor Season, 2010			Major Season, 2011		
Land Preparation Methods	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)
No Tillage	21.43	15.03	11.02	27.42	12.37	11.10
Plough + Harrow	33.32	18.75	13.00	40.32	16.10	15.05
LSD (p<0.05)	1.89	1.37	1.50	2.58	1.71	1.21

In the 2011 major season, ploughing followed by harrowing gave longer root length (40.32cm), longer ear length (15.05 cm) and larger ear girth (16.10cm) while no tillage recorded shallower root length (27.42 cm), shorter ear length (11.10 cm) and smaller ear girth (12.37cm). The longer root length recorded in the ploughing followed by harrowing plots compared with that in the no tillage plots was similar to the results presented by Rashid *et al*. (2008) and Gomez (2010). Maize root penetration is greater in ploughing followed by harrowing than no tillage soils, but roots are concentrated more in the surface layer in no-tillage than ploughing followed by harrowing (Mauryaa and Lal, 2008). To obtain the biggest and longest ears of *Akposoe* maize variety, it is necessary to plough and harrow the land before planting. A well tilled soil makes nutrient and water easy to be absorbed by maize roots for growth since the forces between water-soil interfaces are loosely packed to least restrict diffusion and osmosis processes.

4.4.12 Effect of Weeding Frequency on Root Length, Ear Length and Ear Girth

Weeding frequency regimes significantly affected *Akposoe* maize root length, ear girth and ear length. The effect of weeding frequency on root length, ear girth and length in the 2010 minor and 2011 major seasons is presented in Table 4.19. The 3 hoeing recorded the longest root length (30.19cm) closely followed by 2 hoeing (28.72cm) while 0 hoeing produced the shortest (24.15cm) root length in the 2010 minor season. The longest root length (37.42cm) was measured from 2 hoeing plots while 0 hoeing gave the shortest root (26.77cm) in the 2011 major season. Weeding 2 to 3 times produced the longest root length but where labour cost is high, 2 hoeing is most preferred (Zimdahl, 1999).

Table 4.19: Effect of Weeding Frequency on Root Length, Ear Girth and Ear Length at 90 DAP

Weeding Frequency	Minor Season, 2010			Major Season, 2011		
	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)
0 Hoeing	24.15	13.86	8.79	26.77	9.90	8.531
1 Hoeing	26.44	17.27	12.55	34.02	14.87	13.46
2 Hoeing	28.72	18.29	13.75	37.42	16.04	15.38
3 Hoeing	30.19	18.13	13.61	37.28	16.13	14.94
LSD ($p<0.05$)	1.34	0.97	1.06	1.84	1.21	0.86

The *Akposoe* ear under 2 hoeing regimes was biggest (18.29cm) and longest (13.75cm) in the 2010 minor season and longest (15.38cm) in the 2011 major season. The 0 hoeing plots recorded the smallest and shortest ear in both seasons which contradict results put forward by Abouziena *et al.*, (2007) that weeds growing with maize increases ear length. Statistically, there was no significant difference between 2 and 3 weeding frequency results in both seasons except root length. There is the need to adopt 2 hoeing to maximize profit from the sale of bigger and longer ears considering cost implication in maize production.

4.5 Effect of Land Preparation Methods and Weeding Frequency on Maize Yield Components

4.5.1 Effect of Land Preparation Methods on Dry Matter and Biological Yield

Land preparation methods influence dry matter yield and biological yield of maize. The *Akposoe* dry matter and biological yield for the 2010 minor and 2011 major seasons are presented in Table 4.20. In the 2010 minor season, ploughing followed by harrowing plots yielded higher dry matter (6582 kg ha^{-1}) with its accompanied biological yield increase (11172 kg ha^{-1}) while no tillage gave lower dry matter (4958 kg ha^{-1}) and lower biological yield (8896 kg ha^{-1}). The dry matter (6080 kg ha^{-1}) and biological yield (10386 kg ha^{-1}) from ploughing followed by harrowing plots were higher than no tillage plots of (4456 kg ha^{-1}) and (8259 kg ha^{-1}) respectively in the 2011 major season. There was statistical significant difference between ploughing followed by harrowing and no tillage treatments on dry matter and biological yield in both the 2010 and 2011 seasons. These results agree with research findings that tillage practices had effect on biological yield of maize and that conventional tillage produces higher biological yield than zero tillage (Gul *et al.* 2009).

Table 4.20: Effect of Land Preparation Methods on Dry Matter and Biological Yield

Land Preparation Methods	Minor Season, 2010		Major Season, 2011	
	Dry matter (kg ha^{-1})	Biological Yield (kg ha^{-1})	Dry matter (kg ha^{-1})	Biological Yield (kg ha^{-1})
No Tillage	4958	8896	4456	8259
Plough + Harrow	6582	11172	6080	10386
LSD (p<0.05)	1379.91	2156.88	1382.30	1965.11

4.5.2 Effect of Weeding Frequency on Dry Matter and Biological Yield

The effect of weeding frequency on *Akposoe* maize total dry matter yield and biological yield in the 2010 minor and 2011 major growing seasons is given in Table 4.21. The effect of weeding frequency on total dry matter and biological yield was statistically significant ($p<0.05$) with 2 hoeing giving the highest dry matter (7870 kg ha^{-1}) and (7372 kg ha^{-1}) and highest biological yield (12590 kg ha^{-1}) and (11973 kg ha^{-1}). In all, the 0 hoeing treatment produced the least dry matter (2876 kg ha^{-1}) and biological yield (5517 kg ha^{-1}) in 2010 and least dry matter (2373 kg ha^{-1}) and biological yield (4898 kg ha^{-1}) in the 2011 major season. Weeding frequency therefore increases crop biomass in maize fields.

Table 4.21: Effect of Weeding Frequency on Dry Matter and Biological Yield

Weeding Frequency	Minor Season, 2010		Major Season, 2011	
	Dry matter (kg ha^{-1})	Biological Yield (kg ha^{-1})	Dry matter (kg ha^{-1})	Biological Yield (kg ha^{-1})
0 Hoeing	2876	5517	2373	4898
1 Hoeing	5429	10295	4926	9460
2 Hoeing	7870	12590	7372	11973
3 Hoeing	6905	11733	6402	10958
LSD ($p<0.05$)	975.74	1525.14	977.43	1389.55

4.5.3 Effect of Land Preparation Methods on Harvest Index and Shelling Percentage

Harvest index and shelling percentage of *Akposoe* maize variety depend on land preparation methods. The harvest index and shelling percentage for the 2010 and 2011 seasons are presented in Table 4.22. The results revealed statistically no significant difference (p>0.05) between ploughing followed by harrowing plots and No tillage plots in both seasons except shelling percentage that was significant (p<0.05) in the 2011 season. However, the ploughing followed by harrowing plots recorded higher harvest index (59.19% and 64.38%) and higher shelling percentage (57.04% and 58.87%) than no tillage treatments (55.69% and 57.25%) and (53.60% and 53.18%) respectively in the 2010 and 2011 seasons. The higher the harvest index and shelling percentage, the more total grain yield of *Akposoe* maize is expected from the field since more grains would be obtained during shelling.

Table 4.22: Effect of Land Preparation Methods on Harvest Index and Shelling Percentage

Land Preparation Methods	Minor Season, 2010		Major Season, 2011	
	Harvest Index (%)	Shelling Percentage (%)	Harvest Index (%)	Shelling Percentage (%)
No Tillage	55.69	53.60	57.25	53.18
Plough + Harrow	59.19	57.04	64.38	58.87
LSD (p<0.05)	NS	NS	NS	6.30

NS = Not Significant

4.5.4 Effect of Weeding Frequency on Harvest Index and Shelling Percentage

Weeding frequency did not affect harvest index in both seasons but shelling percentage was statistically significant in the 2010 season and statistically not significant in the 2011 seasons (Table 4.23). The 3 hoeing plots had the highest harvest index (59.84%) in the 2010 minor season while 1 hoeing had the highest harvest index (66.06%) in the 2011 major season. The least harvest index was recorded on 0 hoeing plots. Meanwhile, shelling percentage was highest (58.80%) and (58.15%) under 2 hoeing compared to 0 hoeing which recorded the lowest harvest index (50.67%) and (51.42%) in the 2010 minor and 2011 major seasons respectively. This indicates that harvest index and shelling percentage for *Akposoe* maize are maximised when farms are weeds-free but would duly reduce when maize plants are allowed to compete with weeds from time of planting to physiological maturity and harvest.

Table 4.23: Effect of Weeding Frequency on Harvest Index and Shelling Percentage

	Minor Season, 2010		Major Season, 2011	
Weeding Frequency	Harvest Index	Shelling Percentage (%)	Harvest Index	Shelling Percentage (%)
0 Hoeing	52.63	50.67	58.48	51.42
1 Hoeing	58.98	54.05	61.65	56.59
2 Hoeing	58.32	58.80	57.09	58.15
3 Hoeing	59.84	57.77	66.06	57.94
LSD (p<0.05)	NS	4.00	NS	NS

NS = Not Significant

4.5.5 Effect of Land Preparation Methods on 1000 Seed-Weight and Total Grain Yield

Grain yield is fundamentally an important economic parameter of maize. Total grain yield varies directly with seed weight. Table 4.24 illustrates the effect of land preparation methods on 1000 seed-weight and total grain yield for the 2010 minor and 2011 major growing seasons. The mean 1000 seed-weight and total grain yield were statistically significant on ploughing followed by harrowing, and no tillage treatments. This opposed non-significant effects of tillage treatment on yield of maize by (Ogan, 2004). The ploughing followed by harrowing plots produced higher 1000 seed-weight (225.9 g and 227.8 g) and higher total grain yield (6548 kg ha^{-1} and 6635 kg ha^{-1}) while no tillage plots yielded lower 1000 seed-weight (208.8 g and 210.7 g) and lower total grain yield (5008 kg ha^{-1} and 4686kg ha^{-1}) in the 2010 and 2011 seasons respectively. To optimize *Akposoe* maize yield, there is the need to plough and harrow the land before planting (Rashidi *et al.*, 2010).

Table 4.24: Effect of Land Preparation Methods on 1000 Seed Weight and Total Grain Yield

Land Preparation Methods	Minor Season, 2010		Major Season, 2011	
	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})
No Tillage	208.8	5008	210.7	4686
Plough + Harrow	225.9	6548	227.8	6635
LSD ($p<0.05$)	13.29	1083.78	13.31	920.31

4.5.6 Effect of Weeding Frequency on 1000 Seed Weight and Grain Yield

Weeds suppress maize growth and reduce grain yield. There is the need to ensure weed-free maize plots to increase production. Weeding frequency significantly affected *Akposoe* maize 1000 seed weight and total grain yield over the period of the experiment (Table 4.25). The 2 hoeing gave the highest total grain yield (7202 kg ha^{-1}) and (6846 kg ha^{-1}) in the 2010 minor and 2011 major seasons respectively. Inversely, the 3 hoeing rather recorded the highest 1000 seed weight (239.7 g) and (241.6 g) in the 2010 and 2011 seasons respectively. Generally, the 0 hoeing gave the least total grain yield (2969 kg ha^{-1}) and (2912 kg ha^{-1}) as well as least 1000 seed weight (178.5 g) and (180.3 g) respectively in the 2010 minor and 2011 major seasons.

Table 4.25: Effect of Weeding Frequency on 1000 Seed Weight and Grain Yield

	Minor Season, 2010		Major Season, 2011	
Weeding Frequency	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})
0 Hoeing	178.5	2969	180.3	2912
1 Hoeing	217.4	6040	219.3	6215
2 Hoeing	233.9	7202	235.8	6846
3 Hoeing	239.7	6902	241.6	6674
LSD ($p<0.05$)	9.39	766.35	9.42	650.76

Table 4.25 showed that maize yields could be reduced if weeds are not controlled (Saini and Angiras, 1998; Chikoye *et al*., 2004; Abouziena *et al*., 2007). Considering the marginal difference in total grain yield between 2 hoeing and 3 hoeing regimes, it is rationally economical to adopt the 2 hoeing treatment. Hand hoeing twice during the production period gives the highest yield (Abouziena *et al*., 2007) due to increased moisture content in the soil (Adenawoola *et al*., 2005). But grain weight is heavier when farms are cleared thrice in the production period.

4.6 Interaction Effect of Land Preparation Methods and Weeding Frequency on *Akposoe* Maize Growth Parameter

4.6.1 Interaction Effect of Land Preparation Methods and Weeding Frequency on Seedling Emergence, Number of Leaves, LA and Plant Height

The interaction effects of land preparation methods and weeding frequency regimes on *Akposoe* maize seedling emergence at 16 DAP and on number of leaves, leaf area (LA), plant height at 70 DAP in the 2010 minor season are presented in Table 4.26 while the 2011 major season data are presented in Table 4.27. Land preparation methods and weeding frequency combinations had no significant effect on seedling emergence, number of leaves and plant height while leaf area was statistically significant in both seasons.

Table 4.26: Interaction Effect of Land Preparation Methods and Weeding Frequency on Seedling Emergence, Number of Leaves, Leaf Area and Plant Height (2010)

Land Preparation Method x Weeding Frequency	Seedling Emergence (%)	Number of Leaves	Leaf Area cm^2	Plant Height (cm)
No Tillage x 0 Hoeing	95.00	6.833	352.5	171.5
No Tillage x 1 Hoeing	96.67	8.500	574.3	213.4
No Tillage x 2 Hoeing	97.08	9.000	580.6	211.1
No Tillage x 3 Hoeing	96.25	9.500	537.6	208.6
Plough + Harrow x 0 Hoeing	99.17	8.333	568.8	202.8
Plough + Harrow x 1 Hoeing	99.58	9.889	616.9	221.1
Plough + Harrow x 2 Hoeing	99.58	10.000	669.4	225.7
Plough + Harrow x 3 Hoeing	99.17	9.944	608.2	224.6
LSD ($p<0.05$)	NS	NS	100.58	NS

NS = Not Significant

In Table 4.26, ploughing followed by harrowing with 2 hoeing combinations had the highest seedling emergence (99.58%), maximum number of photosynthetic leaves (10), highest leaf area (669.4 cm^2) and highest plant height (225.70 cm) while no tillage with 0 Hoeing had the lowest seedling emergence (95%), fewest number of leaves (6.833), lowest leaf area (352.5 cm^2) and shortest plant height (171.5cm). Again, in the 2011 major season, ploughing followed by harrowing with 2 hoeing combinations recorded the highest seedling emergence (100%), maximum average number of photosynthetic leaves (14.222), highest leaf area (573.0cm^2) and highest plant height (220.60 cm). No tillage with 0 hoeing gave the lowest seedling emergence (92.92%), fewest average number of photosynthetic leaves (9.278), lowest leaf area (193.9 cm^2) and shortest plant height (126cm).

Table 4.27: Interaction Effect of Land Preparation Methods and Weeding Frequency on Seedling Emergence, Number of Leaves, Leaf Area and Plant Height (2011)

Land Preparation Method x Weeding Frequency	Seedling Emergence (%)	Number of Leaves	Leaf Area cm^2	Plant Height (cm)
No Tillage x 0 Hoeing	92.92	9.278	193.9	126.0
No Tillage x 1 Hoeing	93.75	11.222	391.2	175.9
No Tillage x 2 Hoeing	95.83	11.111	350.8	173.9
No Tillage x 3 Hoeing	95.83	11.444	335.9	178.2
Plough + Harrow x 0 Hoeing	99.17	11.389	429.5	175.3
Plough + Harrow x 1 Hoeing	99.50	12.722	498.9	200.2
Plough + Harrow x 2 Hoeing	100.00	14.222	573.0	220.6
Plough + Harrow x 3 Hoeing	98.75	9.278	193.9	213.0
LSD ($p<0.05$)	NS	NS	66.04	NS

NS = Not Significant

4.6.2 Interaction Effect of Land Preparation Methods and Weeding Frequency on *Akposoe* Maize Average Stem Girth, Root Length, Ear Girth and Ear Length

Land preparation methods and weeding frequency interaction effect on stem girth, root length, ear girth and ear length for the 2010 minor season and the 2011 major seasons are presented in Table 4.28 and Table 4.29 respectively. In Table 4.28, interaction effect of land preparation methods and weeding frequency showed no statistical significant difference on stem girth, root length, ear girth and ear length.

Table 4.28: Interaction Effect of Land Preparation Methods and Weeding Frequency on *Akposoe* Maize Average Stem Girth, Root Length, Ear Girth and Ear Length (2010)

Land Preparation Method x Weeding Frequency	Stem girth (mm)	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)
No Tillage x 0 Hoeing	61.39	18.71	11.93	7.700
No Tillage x 1 Hoeing	72.17	21.12	16.06	11.611
No Tillage x 2 Hoeing	73.89	21.82	15.89	12.061
No Tillage x 3 Hoeing	72.56	24.10	16.22	12.061
Plough + Harrow x 0 Hoeing	73.94	29.60	15.78	9.872
Plough + Harrow x 1 Hoeing	67.50	31.77	18.48	13.483
Plough + Harrow x 2 Hoeing	81.50	36.29	20.69	15.433
Plough + Harrow x 3 Hoeing	78.00	35.63	20.04	14.522
LSD (p<0.05)	NS	NS	NS	NS

NS = Not Significant

In Table 4.28, the biggest stem girth (81.50mm), biggest ear girth (20.69cm) and longest ear length (15.433cm) were measured on ploughing followed by harrowing with the 2 hoeing plots.

The ploughing followed by harrowing with 2 hoeing interaction effect on root length obtained the longest root length (36.29 cm). The smallest stem girth (61.39mm), shortest maize root length (18.71 cm), smallest ear girth (11.93cm) and the shortest ear length (7.7cm) were observed on no tillage with 0 hoeing plots. The stem girth from ploughing followed by harrowing with 2 hoeing treatment was higher (81.50mm) than no tillage with 2 hoeing treatment (73.89mm).

Table 4.29: Interaction Effect of Land Preparation Methods and Weeding Frequency on *Akposoe* Maize Average Stem Girth, Root Length, Ear Girth and Ear Length (2011)

Land Preparation Method x Weeding Frequency	Stem girth (mm)	Root Length (cm)	Ear Girth (cm)	Ear Length (cm)
No Tillage x 0 Hoeing	38.44	22.42	9.028	6.939
No Tillage x 1 Hoeing	60.83	27.94	12.956	11.856
No Tillage x 2 Hoeing	61.94	29.31	13.494	12.694
No Tillage x 3 Hoeing	67.56	30.03	13.994	12.917
Plough + Harrow x 0 Hoeing	64.94	31.12	10.772	10.122
Plough + Harrow x 1 Hoeing	76.00	40.09	16.783	15.067
Plough + Harrow x 2 Hoeing	82.89	45.53	18.594	18.067
Plough + Harrow x 3 Hoeing	79.72	44.53	18.261	16.956
LSD ($p<0.05$)	5.13	3.65	NS	NS

NS = Not Significant

From Table 4.29, ploughing followed by harrowing with 2 hoeing combinations gave the biggest stem girth (82.89mm), longest root length (45.53cm), biggest ear girth (18.594cm) and longest ear length (18.261cm). Moreover, the smallest stem girth (38.44mm), shortest root length (22.42cm), smallest ear girth (9.028cm) and shortest ear length (6.939cm) were obtained from no tillage with 0 hoeing plots. It is therefore important to adopt ploughing followed by harrowing with 2 hoeing combinations in *Akposoe* maize cultivation.

4.7 Interaction Effect of Land Preparation Methods and Weeding Frequency on *Akposoe* Maize Yield Components

4.7.1 Interaction Effect of Land Preparation Methods and Weeding Frequency on Dry Matter Yield, Biological Yield, Harvest Index and Shelling Percentage

Table 4.30 and Table 4.31 give land preparation and weeding frequency interactions on dry matter yield, biological yield, harvest index and shelling percentage in the 2010 minor and 2011 major season respectively. There was statistically no significant difference in dry matter yield, biological yield, harvest index and shelling percentage in both seasons.

In Table 4.30, the ploughing followed by harrowing with 2 hoeing plots gave the highest dry matter yield (9189 kgha^{-1}), highest biological yield (14526 kg ha^{-1}), highest harvest index (63.67%) and highest shelling percentage (58.87%). The lowest dry matter yield (2069 kg ha^{-1}), lowest biological yield (4125 kg ha^{-1}), lowest harvest index (50.49%) and lowest shelling percentage (48.69%) were determined on no tillage with 0 hoeing plots.

Table 4.30: Interaction effect of Land Preparation Method and Weeding Frequency on Dry Matter Yield, Biological Yield, Harvest Index, Shelling Percentage at 90 DAP (2010)

Land Preparation Method x Weeding Frequency	Dry Matter Yield ($kgha^{-1}$)	Biological Yield ($kgha^{-1}$)	Harvest Index (%)	Shelling Percentage
No Tillage x 0 Hoeing	2069	4125	50.49	48.69
No Tillage x 1 Hoeing	4734	9880	54.30	49.78
No Tillage x 2 Hoeing	6552	10654	59.64	58.73
No Tillage x 3 Hoeing	6477	10925	58.35	57.07
Plough + Harrow x 0 Hoeing	3682	6909	54.77	52.65
Plough + Harrow x 1 Hoeing	6124	10711	56.99	58.31
Plough + Harrow x 2 Hoeing	9189	14526	63.67	58.87
Plough + Harrow x 3 Hoeing	7333	12541	61.34	58.46
LSD ($p<0.05$)	NS	NS	NS	NS

NS = Not Significant

In Table 4.31, ploughing followed by harrowing with 2 hoeing plots produced the highest dry matter (8690 kg ha^{-1}), highest biological yield (13870 kg ha^{-1}), highest harvest index (74.60%) and highest shelling percentage (63.04%). The lowest dry matter (1567 kg ha^{-1}), lowest biological yield (3507 kg ha^{-1}), lowest harvest index (57.43%) and lowest shelling percentage (49.46%) were obtained from no tillage with 0 hoeing combinations. Correspondingly, no tillage with hoeing treatment produced lower dry matter than ploughing followed by harrowing with hoeing in both seasons. This indicated that ploughing followed by harrowing with at least 1 hoeing was vital towards producing higher dry matter yield, biological yield, harvest index and shelling percentage of *Akposoe* maize.

Table 4.31: Interaction effect of Land Preparation Method and Weeding Frequency on Dry Matter Yield, Biological Yield, Harvest Index, Shelling Percentage at 90 DAP (2011)

Land Preparation Method x Weeding Frequency	Dry Matter Yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)	Shelling Percentage
No Tillage x 0 Hoeing	1567	3507	57.43	49.56
No Tillage x 1 Hoeing	4231	9257	57.61	50.15
No Tillage x 2 Hoeing	6053	10077	58.66	56.38
No Tillage x 3 Hoeing	5974	10194	59.30	56.65
Plough + Harrow x 0 Hoeing	3179	6289	59.29	53.28
Plough + Harrow x 1 Hoeing	5621	9664	59.52	59.92
Plough + Harrow x 2 Hoeing	8690	13870	74.70	63.04
Plough + Harrow x 3 Hoeing	6830	11722	63.99	59.23
LSD ($p<0.05$)	NS	NS	NS	NS

NS = Not Significant

4.7.2 Interaction Effect of Land Preparation Methods and Weeding Frequency on 1000 Seed Weight and Total Grain Yield

Land preparation methods versus weeding frequency regimes combinations on 1000 seed weight and total grain yield for the 2010 and 2011 cropping seasons are presented in Table 4.32. The land preparation and weeding frequency interaction was significant for 1000 seed weight but showed no significance difference for total grain yield in both seasons. In the 2010 minor season, the highest total grain yield (8110 kg ha^{-1}) was obtained from ploughing followed by harrowing with 2 hoeing plots while ploughing followed by harrowing with 3 hoeing plots produced the highest 1000 seed weight (252.7g). The lowest total grain yield

(2159 kg ha^{-1}) and lowest 1000 seed weight (170.4g) were recorded on no tillage with 0 hoeing plots. The sole aim of every farmer is to get bumper harvest at relatively lesser cost of production, hence, ploughing followed by harrowing with 2 hoeing is recommended.

Table 4.32: Interaction effect of Land Preparation Method and Weeding Frequency on 1000 Seed Weight and Total Grain Yield at 90 DAP

Land Preparation Method x Weeding Frequency	Minor Season, 2010		Major Season, 2011	
	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})	1000 Seed Weight (g)	Total Grain Yield (kg ha^{-1})
No Tillage x 0 Hoeing	170.4	2159	172.2	2101
No Tillage x 1 Hoeing	220.6	5295	222.5	5237
No Tillage x 2 Hoeing	217.3	6294	219.2	5525
No Tillage x 3 Hoeing	227.0	6286	228.9	5889
Plough + Harrow x 0 Hoeing	186.6	3780	188.4	3722
Plough + Harrow x 1 Hoeing	214.2	6785	216.1	7193
Plough + Harrow x 2 Hoeing	250.6	8110	252.5	8167
Plough + Harrow x 3 Hoeing	252.4	7517	254.2	7460
LSD ($p<0.05$)	18.79	NS	18.83	NS

NS = Not Significant

In the 2011 major season, ploughing followed by harrowing with 2 hoeing plots produced the highest total grain yield (8167 kg ha^{-1}) while the highest 1000 seed weight (254.2 g) was found on ploughing followed by harrowing with 3 hoeing plots. However, the lowest total grain yield (2101 kg ha^{-1}) and lowest 1000 seed weight (172.2 g) were again obtained from no tillage with

0 hoeing plots. Although 3 hoeing gave clean maize fields, it did not reflect on yield maximization. The higher yield produced from ploughing followed by harrowing plots was due to total incorporation of organic matter into the soil to improve soil fertility. Hence, if human labour is abundant and labour cost is not high, hand hoeing on plough and harrow plots is effective and ideal for yield maximization (Zimdahl, 1999).

4.8 Land Preparation Methods and Weeding Frequency on Weeds Properties

4.8.1 Effect of Land Preparation Methods on Weed Dry Matter

The effect of land preparation method on weed dry matter in the 2010 minor season is presented in Table 4.33 while the 2011 major season's weed dry matter is given in Table 4.34.

Table 4.33: Effect of Land Preparation Methods on Total Weed Dry Matter (2010)

	Total Weed Dry Matter (Kg ha^{-1})			
Land Preparation Methods	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
No Tillage	254.917	14.9250	0.3	1917.33
Plough + Harrow	8.250	1.5417	0.26667	955.92
LSD (p<0.05)	97.43	9.69	NS	NS

NS = Not Significant

In the 2010 season, land preparation method on weed dry matter at 2 and 5 WAP was statistically significant ($p<0.05$) but showed no significant difference ($p>0.05$) at 7 WAP and after harvest. The no tillage plots produced higher weed dry matter (1917.33 Kg ha^{-1}) while ploughing followed by harrowing plots recorded lower weed dry matter (955.92 Kg ha^{-1}) after harvest. This meant that as the weeding frequency increased, the density of weeds to compete with maize decreased. There is therefore the need to plough and harrow before sowing maize to reduce weed interference on maize farm. Weed density on ploughing followed by harrowing plots is lower than no tillage at 2, 5, 7 WAP and after harvest.

Table 4.34: Effect of Land Preparation Methods on Total Weed Dry Matter (2011)

	Total Weed Dry Matter (Kg ha^{-1})			
Land Preparation Methods	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
No Tillage	336.50	47.158	2.7500	2993.75
Plough + Harrow	33.25	6.625	1.8333	1699.67
LSD ($p<0.05$)	215.34	32.30	NS	1147.79

NS = Not Significant

In the 2011 major season (Table 4.34), land preparation method affected weed dry matter significantly at 2 WAP, 5 WAP, and after harvest whereas there was no significant difference in weed dry matter at 7 WAP. The no tillage plots still recorded higher weeds dry matter (2993.75 kg ha^{-1}) than ploughing followed by harrowing plots (1699.67 kg ha^{-1}) after harvest. Hoeing therefore is the most common and most reliable method of weed control (Aliyu and Lagoke, 1995).

4.8.2 Weeding Frequency Effect on Total Weed Dry Matter

Table 4.35 displays 2010 weed total dry matter while Table 4.36 presents the 2011 weed dry matter under different weeding frequency. Weeding frequency effect on weed dry matter was statistically significant ($p<0.05$) in both seasons at 2 WAP, 5 WAP, 7 WAP and after harvest. Due to frequency of weeding, the lowest (61 kg ha^{-1}) weed dry matter was obtained from 3 hoeing regimes while 0 hoeing recorded the highest (4559.33 kg ha^{-1}) weed dry matter after harvest (Table 4.35). Also, the highest weed dry matter (6971.5 kg ha^{-1}) was found on 0 hoeing plots while 3 hoeing plots recorded the lowest (208.5 kg ha^{-1}) weed dry matter after harvest (Table 4.36). In general, the mean weed dry matter between 2 hoeing and 3 hoeing regimes was statistically similar. Looking at the cost of hoeing, it is prudent to adopt 2 hoeing than 3 hoeing since maize performance would be similar. Therefore, hand hoeing twice is more effective in controlling weeds in maize plots (Sharara *et al*., 2005) while hoeing three times is effective in reducing weed dry weight in maize plots (Abouziena *et al.*, 2008).

Table 4.35: Effect of Weeding Frequency on Total Weed Dry Matter (Kg ha^{-1}) (2010)

Weeding Frequency	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
0 Hoeing	-no data-	-no data-	-no data-	4559.33
1 Hoeing at 2WAP	102.167	-no data-	-no data-	1018.33
2 Hoeing at 2 & 5 WAP	189.333	12.0333	-no data-	107.83
3 Hoeing at 2, 5 & 7 WAP	234.833	20.90	1.13333	61.00
LSD ($p<0.05$)	68.90	6.85	0.0185	1170.19

Table 4.36: Effect of Weeding Frequency on Total Weed Dry Matter (Kg ha^{-1}) (2011)

Weeding Frequency	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
0 Hoeing	-no data-	-no data-	-no data-	6971.5
1 Hoeing at 2WAP	152.333	-no data-	-no data-	1484.5
2 Hoeing at 2 and 5 WAP	301.667	32.583	-no data-	722.33
3 Hoeing at 2, 5 and 7 WAP	285.500	74.983	9.1667	208.5
LSD (p<0.05)	152.34	22.84	0.2365	1147.79

4.8.3 Interaction Effect of Land Preparation Method and Weeding Frequency on Weed Dry Matter Properties

The interaction effect of land preparation method and weeding frequency on weed dry matter in the 2010 minor and 2011 major seasons is illustrated in Table 4.37. There was no significant difference among interaction means in the 2010 minor season while treatment means in the 2011 were significant. In the 2010 minor season, no tillage with 0 hoeing plots yielded the highest (6449.67 kg ha^{-1}) weed dry matter while ploughing followed by harrowing with 3 hoeing gave the lowest (15 kg ha^{-1}) weed dry matter. Moreover, the no tillage with 0 hoeing plots produced the maximum total weeds dry matter (9096.67 kg ha^{-1}) followed by ploughing followed by harrowing with 0 hoeing treatment (4846.33 kg ha^{-1}) while ploughing followed by harrowing with 3 hoeing produced the least (81 kg ha^{-1}) in the 2011 major season.

Table 4.37: Interaction Effect of Interaction Effect of Land Preparation Methods and Weeding Frequency on Weeds Dry Matter Properties

Land Preparation Method x Weeding Frequency	Minor Season, 2010	Major Season, 2011
	Total Dry Matter (kg ha^{-1})	Total Dry Matter (kg ha^{-1})
No Tillage x 0 Hoeing	6449.67	9096.67
No Tillage x 1 Hoeing	978.67	1419
No Tillage x 2 Hoeing	134	1123.33
No Tillage x 3 Hoeing	107	336
Plough + Harrow x 0 Hoeing	2669	4846.33
Plough + Harrow x 1 Hoeing	1058	1550
Plough + Harrow x 2 Hoeing	81	321.33
Plough + Harrow x 3 Hoeing	15	81
LSD ($p<0.05$)	NS	2295.58

NS = Not Significant

5. CONCLUSIONS AND RECOMMENDATIONS

The experiment was conducted in the 2010 in the minor and 2011 major seasons to determine the effect of land preparation methods and weeding frequency on: soil penetration resistance, dry bulk density, moisture content, total porosity; *Akposoe* maize variety establishment, growth, yield component and yield; and weed dry matter yield, using factorial design arranged in a randomized complete block design (RCBD).

5.1 Conclusions

5.1.1 Effect of Land Preparation Methods and Weeding Frequency on Soil Penetration Resistance

Land preparation methods and weeding frequency generally affected soil penetration resistance. No tillage recorded a higher penetration resistance (412.5kPa) than ploughing followed by harrowing plots (119kPa) at after harvest. Also, 0 hoeing produced a higher penetration resistance compared with 3 hoeing which gave the least penetration resistance. Also, as weeding frequency increased, soil penetration resistance decreased.

5.1.2 Effect of Land Preparation Methods and Weeding Frequency on Soil Bulk Density

No tillage treatment recorded a higher mean dry bulk density (1.452Mgm^{-3} to 1.499Mgm^{-3}) than ploughing followed by harrowing (1.327Mgm^{-3} to 1.335Mgm^{-3}). Weeding frequency did not significantly affect soil dry bulk density. However, bulk density decreased with depth with increased weeding frequency at tasselling and after harvest of *Akposoe* maize variety.

5.1.3 Effect of Land Preparation Methods and Weeding Frequency on Soil Moisture Content

Soil moisture content was not significant at tasselling but was statistically significant after harvest under land preparation methods. Ploughing followed by harrowing yielded at least 19.89% moisture content which was higher than no tillage treatment of at most 15.57% in the 0-15cm layer and 15-30cm layers over the period of the experiment. Moisture content decreased in the 2010 season at tasselling but increased after harvest in the 2011 season. Hoeing twice gave the highest moisture content (15.12%). Interaction effect of land preparation methods and weeding frequency on soil moisture content showed significant difference.

5.1.4 Effect of Land Preparation Methods and Weeding Frequency on Soil Total Porosity

Land preparation method significantly affected soil total porosity after harvest in both seasons. Porosity was highest in the 0-15cm layer and least in the 15-30cm layers. Ploughing followed by harrowing plots gave a higher (44.15%) total porosity than no tillage plots (43.43%) in 2010 and higher porosity (49.91%) than no tillage (47.4%) in 2011 season. Hoeing affected soil porosity after harvest in 2010 but not 2011 cropping seasons. 2 hoeing plots recorded the highest total porosity at tasselling (44.26%) and after harvest (47.54%).

5.1.5 Land Preparation Methods and Weeding Frequency Effect on Seedling Emergence

Land preparation methods effect on seedling emergence of *Akposoe* maize was statistically significant ($p<0.05$) at 4 to 16 DAP. No seedling emergence occurred at 1 to 3 DAP while seedling emergence stabilised from 8 DAP. Ploughing followed by harrowing plots recorded higher seedling emergence (99.38%) whereas no tillage plots recorded lower seedling emergence (94.54%). However, weeding frequency had no effect on *Akposoe* maize seedling emergence.

5.1.6 Land Preparation Method and Weeding Frequency Effect on Number of Leaves and Leaf Area (LA) per *Akposoe* Maize Plant

The number of leaves per plant on ploughing followed by harrowing plots, and no tillage plots were statistically significant from 2 to 10 WAP but were not significant at 1 WAP. The ploughing followed by harrowing plots gave higher average number of leaves (12.86) while no tillage plots recorded the minimum number of leaves (9.99). The effect of weeding frequency on number of leaves showed statistically no significant difference from 1 to 4 WAP but was significant from 5 to 10 WAP. 2 hoeing treatment gave highest mean number of leaves (12.75) per plant whereas 0 hoeing plots recorded the lowest number of leaves (9.33). The ploughing followed by harrowing with 2 hoeing produced the highest average number of leaves (14.22) in both seasons. The leaf area on plough and harrow plots was higher (622.30) than no tillage plots (319). The highest leaf area was recorded on 3 hoeing plots (698.50) while the lowest leaf area was found on 0 hoeing plots (312.90). The interaction between ploughing followed by harrowing with 2 hoeing gave the second highest leaf area (669.4).

5.1.7 Land Preparation Methods and Weeding Frequency Effect on Plant Height and Stem Girth of *Akposoe* Maize

The land preparation methods and weeding frequency did not affect plant height at 1 to 5 WAP but showed significant difference ($p<0.05$) from 6 to 10 WAP. Ploughing followed by harrowing plots produced the highest plant height (218.60cm) while no tillage gave the lowest plant height (163.50cm) at 10 weeks after planting. Hoeing twice yielded the highest plant height (217.80cm) while zero hoeing gave the lowest plant height (150.60cm) at 10 weeks after planting. Meanwhile, ploughing followed by harrowing with 2 hoeing interactions produced the highest plant height (225.7cm).

The land preparation method had a significant effect on stem girth. At 10 WAP, ploughing followed by harrowing plots recorded bigger stem girth (79.19mm) while no tillage plots recorded smaller stem girth (57.90mm). Weeding frequency gave no significant difference on stem girth from 1 to 3 WAP but showed significant difference from 4 to 10 WAP. The biggest stem girth (77.69mm) was obtained from 2 hoeing plots while the smallest stem girth (51.69mm) was obtained from 0 hoeing plots. The stem girth shrunk towards physiological maturity. The interaction effect between ploughing followed by harrowing with 2 hoeing plots recorded the biggest stem girth (82.89mm).

5.1.8 Land Preparation Method and Weeding Frequency Effect on Root Length, Ear Girth and Ear Length

The ploughing followed by harrowing plots recorded deeper root length (40.32cm), larger ear size (18.75cm), longer ear (15.05cm) than no tillage. There was statistically significant difference among the treatment means. Weeding frequency presented significant difference on root length, ear size and ear length. 2 hoeing plots had deeper root length (37.42cm) and larger ear girth than 0 hoeing plots (26.77cm and 9.9cm) respectively. The longest ear (15.38cm) was found on 3 hoeing plots while 0 hoeing produced the shortest ear (8.531cm). Land preparation method and weeding frequency interactions on ear girth and ear length was not statistically significant. The ploughing followed by harrowing with 2 hoeing recorded the longest root length (45.53cm), largest ear girth (20.60cm) and longest ear length (18.07cm).

5.1.9 Effect of Land Preparation Method and Weeding Frequency on Dry Maize Matter and Biological Yield

Ploughing followed by harrowing plots yielded higher dry matter (6582 kg ha^{-1}), higher biological yield (10386 kg ha^{-1}) while No tillage plots recorded lower dry matter (4958 kg ha^{-1}) and lower biological yield (8896 kg ha^{-1}). 2 hoeing plots gave the highest dry matter (7870 kg ha^{-1}) and highest biological yield (12590 kg ha^{-1}) while 0 hoeing plots gave the least dry matter yield (2876 kg ha^{-1}) and least biological yield (5517 kg ha^{-1}). The effect of land preparation methods and weeding frequency on *Akposoe* dry matter and biological yields was statistically significant. The plough and harrow with 2 hoeing plots produced the highest dry matter yield (8690 kg ha^{-1}) and highest biological yield (13870 kg ha^{-1}).

5.1.10 Effect of Land Preparation Method and Weeding Frequency on Harvest Index and Shelling Percentage

The ploughing followed by harrowing plots recorded higher harvest index (64.38%) and higher shelling percentage (58.87%) while No tillage plots gave lower harvest index (55.69%) and lower shelling percentage (53.60%). Effect of weeding frequency regimes on harvest index was not statistically significant in both seasons while shelling percentage was significant in the major season. The 3 hoeing plots produced highest harvest index (66.06%) while 2 hoeing regimes produced the highest shelling percentage (58.80%). The plough and harrow with 2 hoeing regimes recorded the highest harvest index (74.70%) and highest shelling percentage (63.04%).

5.1.11 Effect of Land Preparation Method and Weeding Frequency on 1000 Seed Weight and Total Grain Yield

Total Grain yield and 1000 seed weight were statistically significant on plough and harrow and no tillage plots for *Akposoe* maize variety. The plough and harrow plots produced higher 1000 seed weight (227.8 g) and higher total grain yield (6635 kg ha^{-1}) while No tillage plots yielded lower 1000 seed weight (208.8 g) and lower total grain yield (4686 kg ha^{-1}). There is therefore the need to plough and harrow before sowing *Akposoe* maize to increase yield. Weeding frequency statistically affected *Akposoe* maize 1000 seed weight and total grain yield over the period of the experiment. The 2 hoeing plots recorded the highest total grain yield (7202 $kgha^{-1}$) while the 3 hoeing rather recorded the highest 1000 seed weight (241.6 g). To maximize grain yield at a reduced cost of production, 2 hoeing should be adopted. Plough and harrow with 2 hoeing plots produced the maximum total grain yield (8167 kg ha^{-1}) while plough and harrow with 3 hoeing plots gave the highest 1000 seed weight (254.2 g).

5.1.12 Effect of Land Preparation Method and Weeding Frequency on Weed Dry Matter

Land preparation method significantly affected weed dry matter at 2 WAP and 5 WAP but showed no significant difference at 7 WAP and after harvest over the period of the experiment except in the major season where there was significant difference after harvest. The no tillage plots produced higher weeds dry matter while plough and harrow plots recorded lower weed dry matter. Weed density decreased on *Akposoe* maize plots as weeding frequency increased.

After harvest, the 3 hoeing plots recorded the lowest weed dry matter (61 kg ha^{-1}) and (208.5kg ha^{-1}) in the 2010 minor and 2011 major seasons respectively. The 0 hoeing recorded the highest dry matter (4559.33 kg ha^{-1}) and (6971.5 kg ha^{-1}) after harvest in 2010 and 2011 seasons respectively.

5.2 Recommendations

The following recommendations are drawn from a critical assessment of response variables on the effect of land preparation method and weeding frequency on soil properties and *Akposoe* maize performance. They are as follows:

1. There is the need to determine the long-term effects of land preparation method and weeding frequency on soil properties, maize performance and weed population and dry matter yield.
2. A field experiment should be conducted to determine the suitable land preparation method and weeding frequency for different maize varieties and other crops that can increase yield at a reduced cost of production.
3. Research on cost-benefit analysis in maize production under different land preparation methods vis-a-vis weeding frequency regimes should be conducted to ascertain the most reliable and effective practice that could be recommended for farmers in the cropping seasons. This is because weeding twice or thrice on ploughing followed by harrowing plots over the period of the experiment gave the highest total grain yield but there was no significant difference between the yields of *Akposoe* maize variety.

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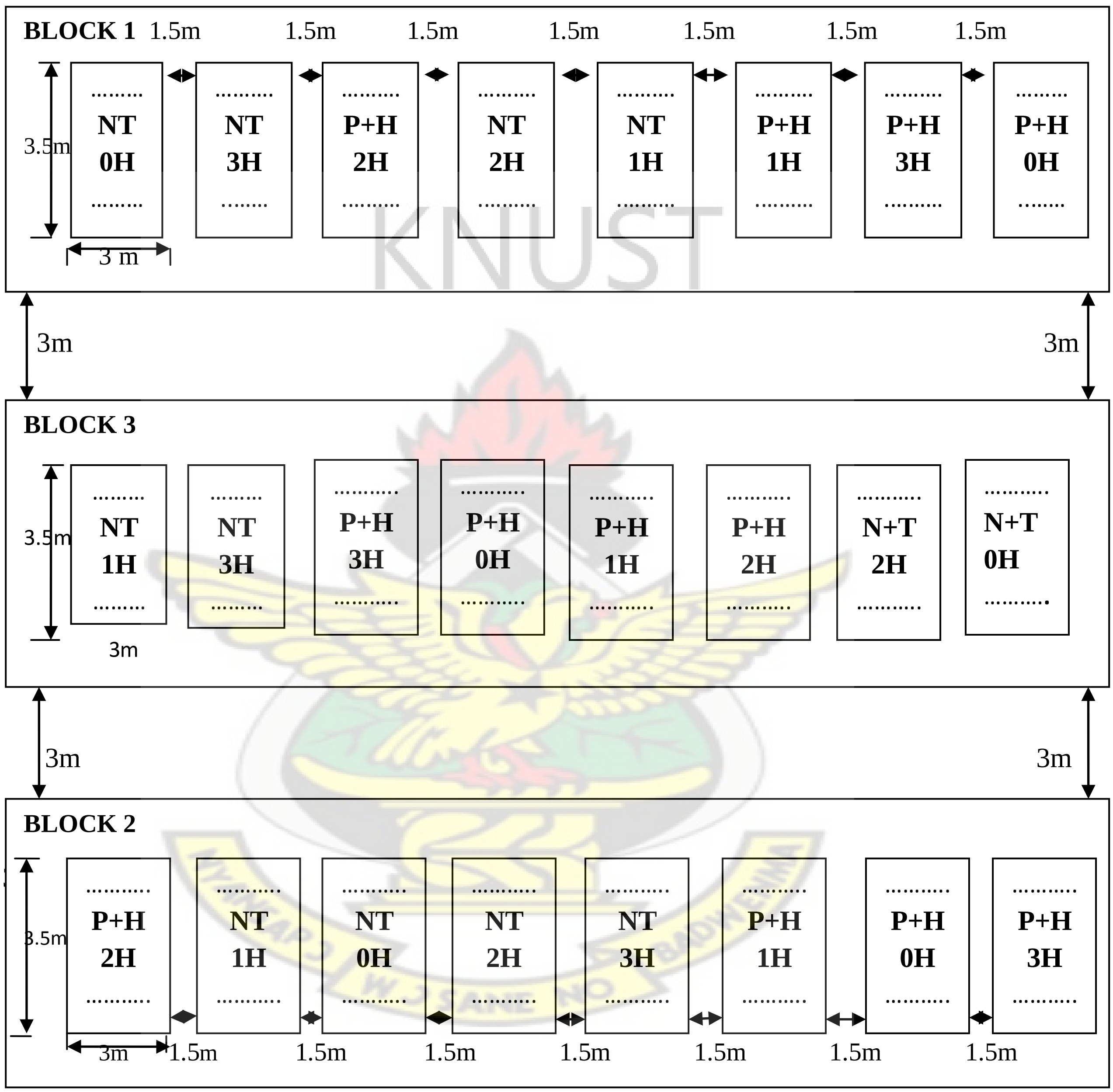
APPENDICES

APPENDIX 1: FIELD LAYOUT



Land Preparation Methods: NT = No Tillage **P+H** = Ploughing followed by Harrowing

Weeding Frequency:

0H = Zero Hoeing **1H** = One Hoeing **2H** = Two Hoeing **3H** = Three Hoeing

APPENDIX 2: PLOT LAYOUT