EFFECT OF MUCUNA PRURIENS MULCH ON THE GROWTH AND YIELD OF MAIZE (ZEA MAYS L.)

BY

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DECLARATION

I hereby declare that, except references to the works of other researchers, which have been duly cited, this work is the result of my own original research and that this dissertation has neither in whole nor in part been presented for another degree elsewhere.

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ABSTRACT

A study to assess the effect of *Mucuna pruriens* mulch on the growth and yield of maize was conducted at the Crop Science Department, University of Ghana, Legon from October 1994 to June 1998. Treatments comprised maize plants in *Mucuna pruriens* mulch plots and no-mulch plots superimposed with nitrogen rates of 0, 50, 100 and 200kg/ha arranged in a split plot design, with three replications. Maize plants in the mulch plots grew faster and yielded more than maize plants in plots without the mulch. However, the addition of 50kg/ha of inorganic nitrogen fertilizer to mulch plots gave the highest grain yield. The decomposition rate of the *Mucuna* forage was moderate compared to values stated for other legumes elsewhere. Mulching with the *Mucuna* led to higher soil moisture content, lower soil temperature, lower weed growth, lower bulk density, lower acidity and higher levels of soil organic matter and nitrogen.

Second season maize grown on the residual mulch plots yielded significantly higher compared to those grown on the no-mulch plots. However, the yield was lower than that obtained from the first season mulched plot. The result clearly indicates that *Mucuna pruriens* is a good source of mulch material for planting maize in the first season followed by another one in the second season.

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DEDICATION

To my daughter Priscilla

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CHAPTER ONE

INTRODUCTION

Maize (*Zea mays* L.) is a monocotyledonous plant of the graminaeae family adapted to both temperate and tropical conditions. It is the major cereal crop in Africa with comparable significance to rice in Asia and wheat in the Middle East (Kim, 1987). In Ghana, maize is the most important cereal crop. It is grown and eaten everywhere. It forms about 90 - 95% of the total calory intake of the coastal savanna people (Dankyi *et al.*, 1995).

Maize growth is affected mainly by climate and soil conditions. It requires about 400 to 600 mm of water during growth and an optimum temperature of 32-35^0 C (Downey, 1971). It also requires high level of soil nutrients especially nitrogen, phosphorous and potassium (Downey, 1971). Maize production in Ghana is affected by several factors of which moisture availability, high soil temperature and low soil nitrogen are the most important. Rainfall in Ghana for the past two decades has become irregular in onset, duration and amount. Soil moisture level for crop growth in the minor season is usually inadequate and therefore minor season maize planting is not recommended in most ecological regions. Clear weather during non-rainy periods result in soil temperatures exceeding 35°C. This aggravates the already precarious soil moisture condition.

Nitrogen is the nutrient most frequently deficient in Ghanaian soil affecting maize production. For example maize production in the Coastal Savanna region require application of 100 kg N/ha for optimum grain yield. Inorganic nitrogen fertilizers have been advocated as a solution to nutritional needs of maize. However, majority of farmers are poor and cannot afford the high cost of the fossil fuel-based fertilizers. The practice of mulching where organic or inorganic materials are placed on the soil surface has been advocated as a solution to the moisture and temperature problem. The use of legume material for mulching may also have the advantage of alleviating the soil nitrogen inadequacies. Therefore, the most appropriate source of mulch materials that have been suggested is leguminous cover crops. Farmers, however consider planting of cover crops with no direct economic value as unreasonable and unacceptable (Doku, 1969). Fortunately, there are some leguminous cover crops, which produce edible seeds and are already being grown for food by farmers. Such leguminous crops are therefore likely to be accepted by farmers as a mulch material. *Mucuna pruriens* is one of such leguminous crops.

Mucuna sp. has the potential to fix atmospheric nitrogen through symbiotic relationship with rhizobia into available form stored in the seeds, leaves, vines and roots. Under favourable conditions, the vines attain a length of 10 - 14 m and produce about 23 t/ha of green forage and more than 9 t/ha of dry matter containing about 150-200 kg N/ha. *Mucuna* sp. is therefore a popular plant for soil improvement in many countries and is being promoted as green manure.

Mucuna sp. is not a new crop in Ghana. It has been used mainly as a food crop for over a century without its potential as soil improving agent being adequately exploited (Osei-Bonsu, 1995). This could be attributed partly to the abundance of fertile lands that permitted soil fertility to be regenerated through bush fallow and also due to ignorance about its soil improving potential. As regeneration of soil fertility through a long fallow or forest canopy has become impossible, exploitation of legumes with high potential such as *Mucuna* sp. is crucial. Many researchers are currently investigating *Mucuna* sp. with a view to determining the potential impact of *Mucuna* sp. on the productivity and sustainability in a range of cropping systems (Barreto *et al.*, 1994; Versteeg and Koukopon, 1990). The focus has been on its use as a green manure crop. However, experience indicates that most farmers would be unwilling to adopt *Mucuna* sp. as a green manure crop because of the conventional land preparation techniques (clearing, stumping, and levelling) needed to facilitate incorporation of green manure (Russell, 1988). Moreover, farmers consume seeds of *Mucuna* sp. and therefore management should not jeopardise seed availability. Mulching therefore appears as the potential option for management of *Mucuna* sp. to obtain seed for consumption and at the same time address the moisture, temperature and nitrogen problems of the soil. Though mulching is no new technology in Ghana, information on the use of *Mucuna* sp. as mulch and as a possible nitrogen source is scanty.

This study was conducted with the following objectives:

(i) to assess the effect of *Mucuna pruriens* mulch on some soil properties and the growth and yield of maize.

(ii) to assess the possibility of supplementing inorganic nitrogen fertilizer with N from *Mucuna pruriens* mulch in production of maize.

CHAPTER TWO

LITERATURE REVIEW

2.1 Effects of mulching on soil properties

Mulching is the covering of the soil with organic or inorganic materials to improve the productivity of the soil (Webster and Wilson, 1980; Russell, 1988; Morgan, 1991). Soil physical, chemical and biological properties can be affected to a varying degree depending on the type of mulch material used. The use of inorganic (non-biodegradable) mulch material such as polythene sheet, plastic or special paper usually results only in changes in soil physical properties (IITA, 1973; Brady, 1985). However, Lang (1968) observed increased in the nitrate content of temperate soil under polythene mulch. He attributed this to the increased microbial activity as a result of increased soil temperature. Mulching with a biodegradable material improves soil physical properties and enhances soil microbial activities which result in release of nutrients and changes in other chemical properties of soil (IITA, 1973).

2.1.1 Physical effects of mulching

Mulching improves water infiltration rates, reduces runoff thereby conserving moisture and reduces erosion. It also improves soil structure, porosity, bulk density, control weeds, and buffers soil temperature (Russell, 1988; Ngugi *et al.*, 1987).

2.1.1.1 Effect on soil moisture

Mulching enhances availability of soil moisture by preventing the raindrops from breaking down the soil aggregates (Webster and Wilson, 1980) thereby facilitating infiltration and storage of moisture. Mulching is more effective in conserving soil moisture than the same amount of organic material incorporated into the soil (IITA, 1973). Mulching also improves soil moisture availability by reducing moisture loss from the surface through evaporation. For example, Bhattacharryya and Rao (1985) found that application of mulch material such as black polythene, banana trash or sugar cane trash reduced consumptive use of water and the number of irrigation requirement of banana. Russell (1988) also found rate of water loss to be slow with mulch application. He reported a loss of 12mm of water in three days from a bare soil compared to the loss of the same amount in more than a week from a mulched plot. He attributed this to reduced evaporation due to soil cover. The type of mulch material that is used affects the extent to which evaporative water loss can be reduced. Rajput and Singh (1970) observed amounts of moisture conserved using petroleum mulch, straw mulch and polyethylene films as mulch and gave the values as 15%, 40%, and 55%, respectively. In another study, Wang and Li (1987) reported that mulching with rice straw and plastic mulch conserved 20.1% and 23.5% moisture, respectively, compared to 15.2% under no-mulch control. The observed differences in the amount of moisture conserved among the mulch materials could be attributed to differences in the amount of solar radiation (evaporative force) passing through the mulch materials to the soils.

Organic mulch would increase the permeability and aggregation of poorly structured surface soil by partly protecting it from raindrop impact and partly enhancing soil microbial activity (Pereira, 1987; Russell, 1988). Such aggregation may result in increased moisture storage. For instance Agboola and Udom (1967) reported of an increase in the percent moisture from 4.3% in un-mulched plots to 7.8% in mulched plots when 8.8 to 11.0 tons per hectare of straw mulch was applied.

The importance of mulch in soil moisture conservation is more pronounced under arid and drought situations (IITA, 1973; Kwong *et al*., 1988; Wang and Li, 1987). Carter and Jones (1988) studied the effect of mulching under conditions of abundant rains and limited rains on the yield of aubergine. They reported that the yields from mulched plots were significantly higher in the period of limited rainfall but yields were not different from the un-mulched plot in the period of abundant rainfall.

2.1.1.2 Effect on soil temperature

Mulching is a soil temperature modifier, and tends to buffer extremes in soil temperatures (Brady, 1985). Mulching shields the soil from the direct rays of the sun and therefore lowers the maximum temperature of the soil. This is of particular importance in tropical soils where daily soil temperatures could reach 40°C which is too warm for normal activity of many crops and soil microbes (Webster and Wilson, 1980). In Nigeria, mulching significantly lowered soil temperature from 38 to 30°C and improved germination of the maize and soybean (IITA, 1973). Varadan and Rao (1983) also recorded 1 to 6 °C reductions in soil temperature under banana with 5t/ha *Chromolaena odorata* mulch. Mulching does not only lower the maximum soil temperature but also reduce wide diurnal temperature fluctuation which could affect both crop and soil microbial activity (Varadan and Rao, 1983; Kwon *et al*., 1988). Reduction in the diurnal temperature range is attributed to reduction in maximum temperature rather than the minimum day temperature. However, increase in minimum soil temperature is of significant importance in temperate soils where low temperature could result in chilling injury (Brady, 1985). Under such situations mulching prevents the heat absorbed during the day from escaping into the atmosphere thereby raising the soil temperature to optimum levels to enhance faster crop growth. Devi-Doyal *et al*. (1991) reported that the application of 5 t/ha of wheat straw as mulch did not only lower the maximum soil temperature by 3 - 5°C but also raised the minimum soil temperature by 2 - 3°C making it possible to cultivate a temperature-sensitive groundnut variety in summer.

2.2 Mulching for erosion control

Soil erosion removes the topsoil which provides most of the nutrients required for crop production, thereby leading to decline in crop yields (Webster and Wilson 1980). Mulching simulates the effect of plant cover by protecting the soil from raindrop impact and reducing velocity of runoff water and wind (Morgan, 1986). Morgan (1991) also reiterated that mulching is the most useful alternative to cover crops, especially in dry areas where insufficient rain prevents the establishment of a cover before the onset of heavy rains and strong winds or where cover competes for moisture with the main crop. Lal (1976) noted that covering an alfisol on a 6% slope with 0.6 kg/m^2 of straw mulch reduced an annual soil loss to 0.22 kg/m^2 compared to 2.33 kg/m^2 from a bare soil.

In another study conducted on a silt-loam soil of 7% gradient, Borst and Woodburn (1942) recorded a reduction in annual soil loss of 2.46 kg/m^2 from uncultivated bare land to 0.11 kg/m^2 when 0.5 kg/m^2 straw mulch was applied. Several workers have established a relationship between mulch application and erosion. The rate of soil loss was found to decrease exponentially with the increase in percentage area covered with mulch (Wischmeier, 1973; Foster and Meyer, 1975; Lal, 1977; and Laflen and Covin, 1981).

2.3 Mulching as a weed control measure

Application of mulch can result in some degree of weed control. A good mulch cover prevents rapid proliferation of weeds during early stages of plant growth (Agboola and Udom, 1967; Kathiresan *et al.*, 1991). Low weed incidence associated with mulching could be due to the reduction in solar radiation reaching the weeds below the mulch which may be insufficient to permit germination of weed seeds. In some cases weeds germinate but find the mulch layer too thick to penetrate (Ngugi *et al.*, 1987). For example, Morgan (1991) was of the opinion that mulching can effect weed suppression when the mulch layer is thick enough to allow minimal light from passing through. Park *et al.*(1991) recorded low weed incidence under transparent polythene mulch material and far lower under black polythene mulch. The difference in weed population between the two plastic mulch materials was attributed to the significant reduction of light under the black polythene. Mulching with plant residues may also smother weeds through release of toxic chemicals with allelopathic effect. The allelopathic effects associated with plant residue mulch were demonstrated with ground-up tissue of crops and annual weeds (Akobundu, 1980; Bhowmik and Doll, 1984; Leather, 1983a, b; Putnam 1985). Fujii *et al.* (1991) also attributed the low weed population in plots previously under *Mucuna* to allelopathy. It is an indication that toxic chemicals in plant tissues can play a role in weed management.

2.4 Choice of legumes in soil fertility improvement

The usefulness of legumes in maintaining or building up soil fertility has long been recognised (Jones, 1942) and have been traditionally used for such purpose (Study, 1939). The overall advantage of legumes as soil improvers over other plant groups is their ability to fix atmospheric nitrogen through symbiotic association with rhizobia populations in the soil. This results usually in the production of nitrogen concentrated plant biomass. However, not all legumes can amass nitrogen to the same extent and would differ in their effect on succeeding crops.

Various criteria are therefore employed in the selection of legumes as soil improvers. Lobo-Burle *et al.* (1992) suggested that for such a legume to contribute meaningfully to the nitrogen requirement of a succeeding non-legume crop, it should produce at least 2000 kg/ha of above-ground biomass for incorporation into the soil before planting the main crop or should produce at least 40 kg N/ha. Ghai *et al.* (1987) also used the amount of accumulated nitrogen. Quintana (1988) based his assessment on the amount of nitrogen released from incubated dried samples of the green manure under aerobic condition in the laboratory. His method was simple and rapid but may lead to over-estimation since it does not depict conditions in the field which depend much on the presence and number of suitable decomposing organism as well as the carbon to nitrogen (C:N) ratio of the material, which are all not necessarily accounted for in the laboratory procedure. Carsky (1990) perhaps saw the non-conformity of Quintana's laboratory assessment to the conditions in the field. He, therefore, used a technique based on the amount on nitrogen released in buried bags in which samples of the surface soil containing incorporated green manure in polythene bags were buried and incubated *in situ*. Carsky's method is an improvement over that of Quintana's since it shows only possible mineralizable quantities. Based on these methods and others, a number of legume species have been hypothesised as being suitable soil improvers. For instance, Lobo-Burle *et al.*(1992) identified temperate legumes normally used as forage for livestock, such as alfalfa (*Medicago sativa* L), Clovers (*Trifolium spp.*), Vetch (*Vicia spp*) and others which can accumulate between 1.0 to 10.0 t/ha dry matter as potentially suitable green manure crops. Similarly, large number of tropical legumes such as *Aeschynomene americana, Canavalia ensiformis, Cajanus cajan, Crotalaria juncea, C. spectabilis, Indogofera hirsuta, Lablab purprureus, Mucuna aterrima, M. deeringiana, M. pruriens var Utilis, Psophocarpus palustris, Sesbania spp., S. sesban, and Vigna radiata* are often cited (Ready *et al.*, 1986; Depolli and Chada, 1989; Harriah and Van Noordwijk, 1989; Rao *et al.*, 1987) as having the potential to accumulate between 40 - 250 kg N/ha in their above ground plant parts. Studies of forage species in the savannahs of Brazil also showed that *Stylosanthes quianensis var pauciflora, Stylosanthes eapit, S. macrocephola, Centrosema, Macrocarpum, Leucaena leucocephala, Mucuna aterima and Cannavalia ensiformis* were promising soil improvers (Pereira, 1987).

Though large numbers of legumes are potential soil improvers, most farmers of third world countries prefer legumes with direct economic gains. Hence, legumes which produce edible grains feature prominently in soil improvement. However, experimental evidences show that most of such grain legumes do not contribute enough nutrients in the forage residues to improve upon the soil. For example, Mughogho *et al.* (1982) reported from a study conducted in Trinidad that cowpea produced 3.5 t/ha dry matter with 1.8 t/ha as grain containing between 45 - 50 kg N/ha. The residues contained between 15 - 20 kg N/ha. It is clear that the amount of N in the residue cannot support the growth of a number of crops. In another study, Lobo-Burle *et al.* (1992) reported that Common bean fixes insufficient amount of N for its own needs. It is apparent that such a legume would impoverish the soil. Amado and Teixeira (1991) reported that there are less important grain legumes with the potential to meet much if not all the nitrogen requirement of succeeding non legume crops when used as green manure. In a study conducted at the International Crops Research Institute for the Semi Arid Tropics in India, it was reported that pigeon pea produced 1.6 tons of grain containing 40 kg N and 4.4 tons/ha residue containing 50 kg nitrogen (Kumar Rao *et al.*, 1982). Mucuna is one of such lesser known grain legumes that are being utilised in many farming systems.

2.5 Crop response to leguminous mulch

The nitrogen in leguminous mulch only becomes available to a succeeding crop when it is mineralized and at a rate that matches the crop's nitrogen requirement (Lobo-Burle *et al.*, 1989). Mineralization rate of legumes is generally fast due to the low carbon to nitrogen ratio which is usually less than 30: 1 (Frankenberger and Abdelmagid, 1985). Most crops are therefore unable to effectively utilise nitrogen from legume sources when applied as mulch. However, data from maize experiment conducted in Guatemala by Moscoso and Raun (1991) suggest that nitrogen fertilizer substitution value of Canavalia and *Mucuna aterrima* managed under zero tillage (residue not incorporated) was around 60 kg N/ha. Similar positive effects of Mucuna mulch under low fertility conditions on maize and soybean was reported in Indonesia by Suwardjo *et al,* 1991. Kang *et al.* (1981) also reported sustainable maize yield of 2 t/ha for 3 years with prunnings of *Leucaena leucocephala* compared to 0.5 t/ha without it. However, the 1.5 t/ha gain in grain yield was considered low and was attributed to losses due to ammonia volatilization. Other authors (Kass and Araya, 1987; Kass ., 1991; Kass *et al.*, 1992; Garzon, 1991; Haggar *et al.*, 1991) however attributed such observations to below and above ground negative competition associated with alley cropping systems. Nevertheless, poor crop responses to legume N are in most cases due to ammonia volatilization. Costa (1988) discovered that as much as 15% and 45% of surface applied N were lost through ammonia volatilization after 15 and 178 days of application, respectively. Palm (1988) also found out that only 15% of the N in surface applied Inga cuttings was recovered by a rice crop to which the cuttings had been applied. Webster and Wilson (1980) also observed poor crop yield on a fine to medium textured soil to which mulch had been applied and attributed it to lack of oxygen as the result of carbon dioxide accumulation in the mulched soil.

2.6 Mucuna species in farming systems

Mucuna species have long been used as components in many farming systems. It was typically intercropped between rows of maize to improve soil fertility in maize and cotton rotations in South America (Buckles, 1995). According to many earlier workers (Piper and Tracy 1910; Ferris, 1917; Pieters, 1917; Braunton, 1918 Cauthen, 1921) Mucuna was superior to all the known legumes at the time as soil improver. To improve soil fertility, Mucuna was intercropped with maize. Though the yield of the immediate maize crop was reduced by about 10%, losses were more than compensated by subsequent crops (Ferris, 1917; Tracy and Coe 1918).

Mucuna species also known as Velvet bean was cultivated in Java, Bali and Sumatra in the 17th century as green manure to recover worn-out fields. It produced about 155 - 200 kg/ha of nitrogen contained in the leaves and roots (Burkill, 1966). The use of velvet bean as a green manure in Africa occurred in Malawi and Madagascar in the first half of this century but was restricted to the large farm sector (Osei-Bonsu and Buckles, 1993; IIA, 1936). *Mucuna deeringiana* and *Mucuna pruriens* were used as cover crops in citrus estates in Puerto Rico and Punjab of India. Velvet bean was very popular in America as feed for cattle and hogs (Templeton *et al.*, 1917; Ferris, 1917; Scott 1919; Lamaster and Jones, 1923; Ferris, 1917; Coe, 1918; Scott, 1919).

According to some workers, when Mucuna was first introduced into South America, it was grown in maize and grazed by animals in the fall and winter after the removal of the maize. As experience with velvet bean increased, more of the beans were picked after the crop was killed by heavy frost and either fed to animals on the farm or sold in the market as beans in the hull (Ferris, 1917; Tracy and Coe, 1918; Scott, 1919; IIA, 1936). Mucuna was grown widely in the foothills and lower hills of the Eastern Himalayas and Mauritius as a green vegetable during the 18th and 19th centuries (Watt, 1883; Piper and Tracy, 1910; CSIR, 1962). Both the green pods and the mature beans were boiled and eaten. *Mucuna* spp. was used in similar way in Ghana, Nigeria, Malawi and Mozambique (Ezueh, 1977; Infante *et al.*, 1990; Osei-Bonsu and Buckles, 1993). In Ghana for example, farmers grow small quantities (5-10 plants) of *Mucuna* spp known locally as *Adua apia* beneath trees where the vine can climb to bear larger quantities of fruits. The crop is planted in the major season with the main food crops and harvested from September onwards, although it is sometimes planted at the beginning of the minor season and harvested in December (Osei-Bonsu and Buckles, 1993).

2.7 Constraints to the adoption of mulching

The major constraints to the adoption of mulching are:

(1) the production and availability of mulch material in adequate quantities especially under large scale production

(2) the cost incurred in the transportation and spread of the mulch material is high

(3) Need for Constant replacement of mulch material as the result of decomposition especially with legume residues under warm moist tropical weather

(4) Temporal immobilization of soil nutrients is associated with the use of materials such as grass, and sawdust

(5) Weed growth may be enhanced through the use of seeded grasses for mulching. In addition weed control may become a problem if the mulch layer is not heavy as it encourages light penetration and subsequent weed growth.

(6) A mulch layer may also encourage superficial rooting resulting in such roots being exposed to drought and damage when the mulch decomposes and it is not replaced.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Characteristics of experimental site

The experiments were carried out at the Crops Sciences Department of the University of Ghana-Legon located in the Coastal savannah ecozone of Ghana. This area receives a mean annual rainfall of about 800mm with a range of 500 -1270 mm. The rainfall is highly variable and erratic from point of view of the time of onset, duration and total from year to year. There are two distinct rainy seasons. The major season begins in March and ends in July, reaching a peak in June. The minor season is from September to November reaching a peak in October. The mean annual temperature is about 27°C. The soil is Kaolinitic Paleustalf (FAO classification).

EXPERIMENT ONE

3.2 Experimental procedure

3.2.1 Establishment of Mucuna cover.

A plot measuring 12 x 15m was prepared in November 1993 by slashing with a cutlass. Seeds of *Mucuna pruriens* were planted at one seed per hill at a spacing of 1.0 X 1.0m. The plot was irrigated till May 1994 when the major rainy season began. Weeds were controlled by hoeing during the first two months. Thereafter, no conscious weed control was done as the cover smothered out all weeds.

3.2.2 Determination of Mucuna biomass

A 0.5m x 0.5m quadrat was thrown six times onto the Mucuna plot to sample for undecomposed biomass accumulated during the ten months period. Samples taken were oven-dried at 60°C to a constant weight.

3.2.3 Land preparation and experimental layout

The Mucuna cover was slashed with a cutlass 10 months after planting in October 1994. Seeds were harvested after which the biomass produced was evenly spread over a 12 x 15m plot. An adjacent plot also measuring 12m x 15m was selected and hoed. The experimental design was split plot with mulching and no mulching as main plots and fertilizer rates (0,50,100 and 200kg N/ha) as sub plot treatments. There were three replications. Maize variety 'Abeleehi' was planted at a spacing of 35 x 100 cm on both mulched and no-mulch plots. It was sown at the rate of three seeds per hill and later thinned to two plants per hill, resulting in an estimated plant population of 57,140 plants per hectare. The fertilizer rates (0, 50 100 and 200 kg N/ha) were randomly assigned and split-applied in two phases: two and six weeks after planting maize.

3.2.4 Management practices

The plants were uniformly irrigated every three days by means of overhead sprinklers. Insect pests were controlled by the use of insecticide Karate. Initial weed control (two weeks after planting) was by hand pulling whilst that at later stages was by hoeing.

3.3 Data collection

3.3.1 Soil sampling and analysis

A composite soil sample was taken from each plot for physical and chemical analysis. Six core samples per plot were taken from each plot at a depth of 0 - 15 cm and 15 - 30 cm soil depth by means of soil auger. These were bulked into one composite sample per plot for pH, organic carbon and total nitrogen analyses. Samples were taken before mulching and at harvest of the maize.

3.3.1.1 Soil pH

Soil pH was determined on 1:1 (soil:distilled water) mixtures and measured on a pH meter (Pracitronic pH meter). The soil pH was taken for mulch and no-mulch plots. This was determined before planting and at harvesting of first maize.

3.3.1.2 Percent organic carbon and organic matter

Organic carbon was determined by the method of Walkley and Black (1934). Ten (10) mls of Potassium dichromate solution and 15 mls of concentrated sulphuric acid were added to 0.5 grams of soil in a conical flask and digested for 30 minutes. Five (5) mls of O-phosphoric acid was added to the mixture as a stabilizer. The potassium dichromate remaining in solution after the digestion was titrated against 0.5 ferrous sulphate using barium dinenylamine sulphate as indicator. The percent organic matter was obtained by multiplying organic carbon values by 1.729.

3.3.1.3 Soil total nitrogen content

Total nitrogen content of soil from each plot was determined by the micro Kjeldahl method (Black, 1965). Two grams of air-dried soil sieved through 2 mm diameter mesh was weighed into a 50 ml Kjeldahl flask. Few drops of distilled water were added to moisten the soil. Five millilitres of concentrated Sulphuric acid was added and the contents digested to clear. Cooled digest was transferred with distilled water to 50ml volumetric flask. Five millilitres of 40% NaOH solution was added to 5ml of the digest and distilled into 2% boric acid. The distillate was titrated against 0.0012 N HCl solution from green to reddish end point. The % N was calculated as follows:

$$\% N = \frac{\text{ml HCl used} \times \text{Normality} \times 1400}{\text{mg of sample}}$$

3.3.1.4 Bulk density

Soil samples for determination of bulk density were taken before mulching and at maize harvesting. Samples were taken by driving aluminium cylinders of known volumes into the soil at 0 - 15cm depth by means of augur. Four samples were taken from each plot and oven-dried at 100°C to a constant weight. The bulk density was calculated using the relation:

$$\text{Bulk density} = \frac{\text{Weight of oven dry soil}}{\text{Volume of soil}}$$

3.3.1.5 Total nitrogen uptake by maize

The total nitrogen uptake of maize was determined using matured maize stover and the grain. Samples of matured stover and grain were finely grounded. Two hundred milligrams (0.2 g) of the ground samples were weighed into 50ml Kjeldahl flasks. Five millilitres of concentrated Sulphuric acid was added to each flask and heated. Hydrogen peroxide solution was added drop wise till digest clarified. The digest was transferred with distilled water into 100ml volumetric flasks. Forty percent Na0H solution was added to an aliquot of 5 ml and distilled into 2% boric acid. The distillate was titrated against 0.1N HCl from green to reddish end point. Per cent total nitrogen was calculated using formula similar to that for the determination of soil N content.

3.4 Determination of soil moisture status

3.4.1 Water Holding capacity

The water holding capacity was determined by the Gravimetric method (A.O.A.C, 1970). Mulch and no-mulch plots were uniformly irrigated until the soil was saturated with water. The field was allowed to drain for thirty six hours. Eight core samples from each plot were taken and bulked. The bulked soil kept in polythene bags were sampled and weighed immediately (fresh weight). Duplicates were prepared for each sample. The samples were oven dried at 105°C for 24 hours and transferred to a dessicator, cooled and weighed. This was repeated until a constant weight was obtained. Percentage water holding capacity (WHC %) was determined from the mean data for each plot using the formula:

$$\text{WHC (\%)} = \frac{\text{(Fresh weight of soil - Oven dry weight of soil) 100}}{\text{Oven dry weight of soil}}$$

3.4.2 Soil moisture content

The moisture content of the soil was determined by the Gravimetric method (A.O.A.C, 1970). Soil samples for moisture determination were taken three days after irrigation from 0 - 15cm depth by means of auger. Duplicate samples of known weight were kept in an oven at 105°C for 24 hours. The oven-dried soils were then transferred to a dessicator, cooled and weighed. Percentage moisture content (on weight basis) was determined from the mean data for each plot.

The formula used was:

$$\text{Moisture content (\%)} = \frac{\text{(Fresh weight - wt. of oven-dried soil) 100}}{\text{oven dry weight}}$$

3.5 Soil temperature

Daily maximum soil temperature readings were taken on each plot every day at about 2.00pm with a soil thermometer at a depth of 5cm.

3.6 Weed incidence in Maize

The weed population in the maize was determined by throwing a 0.5 x 0.5m quadrat four times to each plot. Weeds were separated into various species and counted. First weed count was done two weeks after maize planting. The second and third weed counts were done two weeks after first weeding and four weeks after second weeding, respectively.

3.7 Growth and yield of maize

3.7.1 Growth rate

Ten central maize plants per treatment were selected and tagged for the study. Heights of the selected plants were measured from the soil level to the topmost visible node at two weeks interval *in situ*. The arithmetic mean was computed for the determination of growth rate. The growth rate (G.R) between times T1 and T2 was determined using the relation:

$$GR = \frac{\text{Height of maize at time T2} - \text{Height of maize at time T1}}{\text{Height at time T1}}$$

Growth rate is estimated in centimetres per week.

3.7.2 Leaf area index

The length and widest width of all green leaves of the selected plants were measured using a metre rule at two weeks interval. The product of the length and width of each leaf was multiplied by 0.75 to give the area for each leaf. The total leaf area was obtained by summing up the leaf areas on the ten plants. Mean leaf area of a plant was determined for each treatment. The leaf area index was determined using the relation:

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area of plant}}{\text{Inter row spacing X intra row spacing}}$$

3.7.3 Days to tasseling

Maize plants were critically observed daily during the tasseling period and the number of tasseled plants were recorded each day. The period for fifty percent tasseling was determined from the data.

3.7.4 Days to silking

Tasseled plants were examined each day for sign of silking. The number of silked plants were counted each day and the period to fifty percent silking determined.

3.7.5 Days to maturity

Cobs of maize which began showing signs of browning were periodically checked for the presence of black layer on the tip of the grain. The number of days that fifty percent of the plants developed the black layer was recorded as the days to maturity.

3.7.6 Plant height at maturity

Height of plants at maturity was measured from the soil level to the base of the flag leaf by means of a metre rule.

3.7.7 Grain yield (economic yield)

Grains were shelled from the cob and sun dried to 14.3% moisture content. Grain weight of sampled plants were measured and extrapolated to kilogram per hectare.

3.7.8 Total biomass yield of maize (Biological yield)

The above-ground stover yield of sampled plants was oven dried at 60^{o} C to a constant weight. The corresponding grain weights were added to get the total dry matter yield per hectare.

3.7.9 The harvest Index

The harvest index (HI) was calculated using the relation,

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.8 Rate of decomposition of *Mucuna pruriens* forage

Four samples of ten months old Mucuna pruriens forage weighing 3.0 kg (dry weight) was placed at the base of clean weeded maize plants to determine the weight loss of the Mucuna pruriens with time. At two weekly intervals, the undecomposed forage was removed and weighed. This was done until no leaves or twigs were visible. The rate of decomposition was calculated as weight loss of forage per week.

3.9 Statistical analysis

Data was analysed using MstatC statistical package. Separation of means between the mulch and no-mulch was by standard error of the mean difference (SED) whiles that of fertilizer and Fertilizer x Mulch interaction were by Least Significant Difference (Lsd). Graphs were plotted by using Excel statistical package.

EXPERIMENT TWO

3.10 Land preparation and experimental layout

Experiment two was a follow-up to experiment one. It was carried out on the same experimental plots as in experiment one. There was no new mulch or fertilizer application.

The design was a split plot design with residual mulch and residual no-mulch as main plot factor and residual fertilizer rates as sub-plot factor. The plots were hoed carefully to avoid the movement of soil from one plot to another. Seeds of maize var 'Abeleehi' were sown at three per hill and later thinned to two per hill at a spacing of 100 x 35 cm.

3.11 Management practices

Weeds in maize were removed by hoeing. There was no irrigation as the planting coincided with the major rainy season. Insect pests were controlled by the use of insecticide Karate.

3.12 Soil sampling and analysis

Six core samples per plot were taken at a depth of 0 - 15 cm and 15 - 30 cm soil depth by means of soil auger. These were bulked into one composite sample per plot for pH, organic carbon and total nitrogen analyses. Samples were taken 12 weeks after mulching and at harvesting. The pH of the soil, the organic carbon and total nitrogen content of soil were determined at planting and harvesting of the second maize by the procedures described in experiment one. The bulk density, moisture content and daily soil temperature were also determined as described previously.

3.13 Data on second maize

The following data on maize were collected in the same manner as in experiment one.

i. Plant height

ii. Total Leaf area

iii. Days to tasseling

iv. Days to silking

v. Days to physiological maturity

vi. Plant height at maturity

vii. Grain yield (Economic)

viii. Total biomass (Biological)

3.13.1 Derived data

The following data were derived as in experiment one above.

i. Growth rate

ii Leaf Area Index

iii Harvest Index

CHAPTER FOUR

RESULTS

EXPERIMENT 1

4.1 Effect of mulching on soil temperature

Effect of mulching on maximum soil temperature is shown in Figure 1. The presence of the Mucuna mulch reduced the soil temperature significantly ($P< 0.05$). Mean soil temperature over the twelve-week period reduced from 39°C under no mulch to 32°C under the mulched plots. The difference in soil temperatures between the mulched and no-much plots narrowed after seven weeks of mulch application.

4.2 Effect of mulching on soil moisture

The effect of mulching on soil moisture status is shown in Figure 2. Generally soils under mulch retained more moisture than soils under no-mulch treatment. The gravimetric soil moisture level measured at field capacity was 17.2% and 14% in the mulch and no-mulch plot, respectively. The moisture status measured throughout the experiment indicated that, mulched soil retained about 50% more moisture than the no-mulch soils.

4.3 Effect of mulching on soil bulk density

Bulk density of the soils was moderate on both the mulched and the no-mulch plots at the beginning of the study (Table 1). However, the bulk density of soils under mulch decreased significantly 12 weeks after the mulch application.

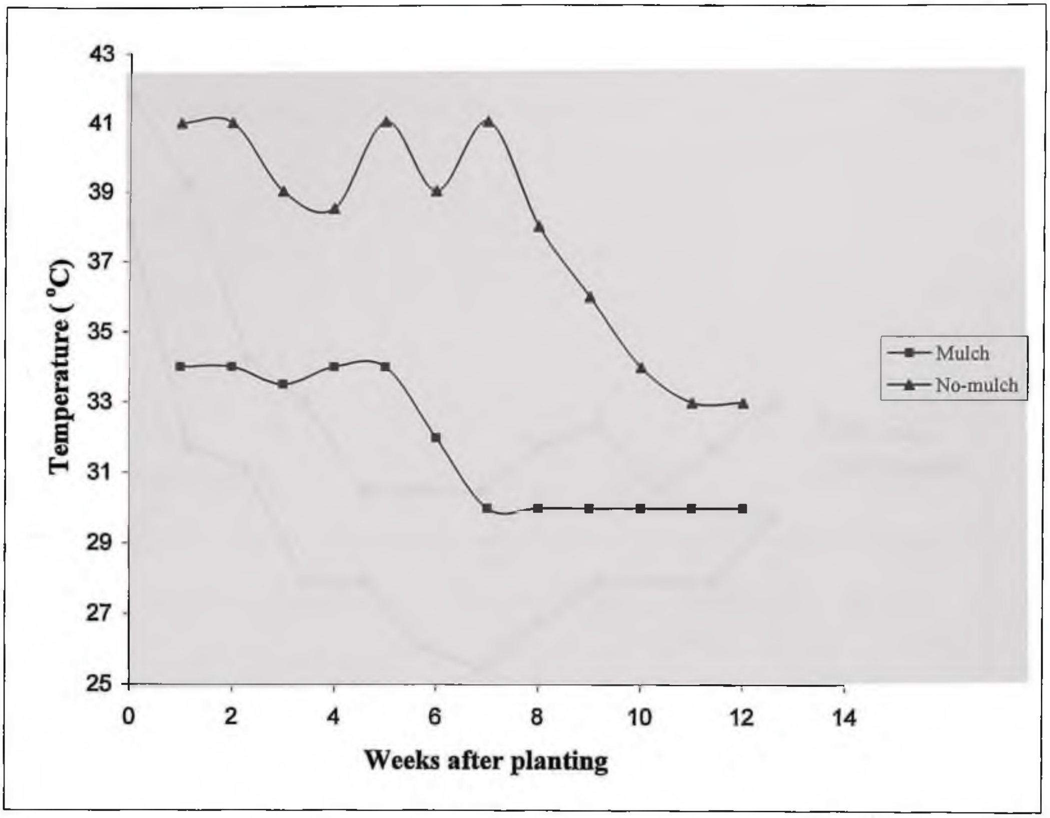

Fig. 1. Effect of Mucuna mulch on soil temperature during the first maize planting.

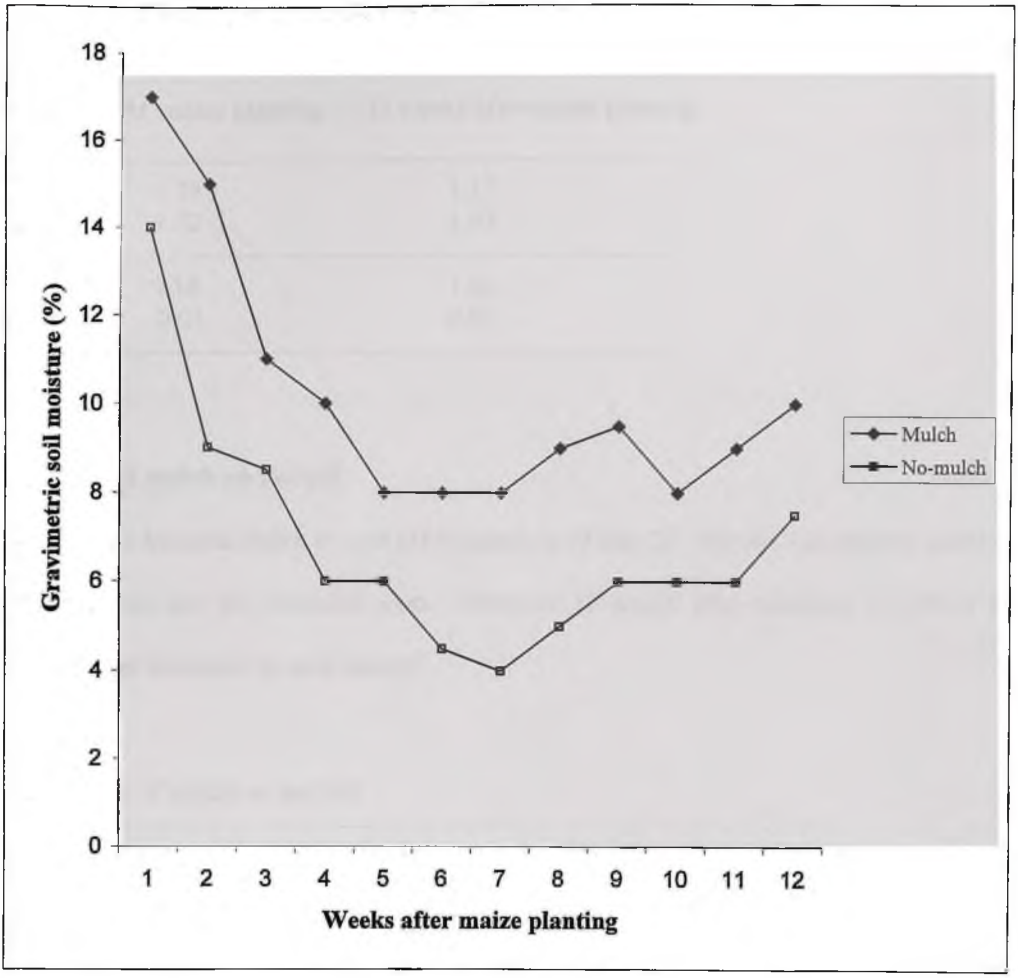

Fig. 2. Effect of Mucuna mulch on soil moisture content during the first planting

Table 1. Effect of Mucuna mulch on soil Bulk density (g/cm^3).

Treatment	At maize planting	12 weeks after maize planting
Mulch	1.19	1.17
No mulch	1.22	1.22
CV %	0.18	1.60
SED	0.01	0.01

4.4 Effect of mulch on soil pH

The effect of the Mucuna mulch on soil pH is shown in (Table 2). The pH was slightly acidic on both the mulched and the no-mulch plots. However 12 weeks after mulching the pH of the mulched soil had increased to near neutral.

Table 2 Effect of mulch on soil pH

Treatment	Before maize planting	12 weeks after maize planting
Mulching	6.32	6.42
No mulch	6.31	6.30
CV %	0.18	0.45
SED	0.02	0.01

4.5 Effect of Mucuna mulch on soil organic carbon and nitrogen status

Before mulch application, the organic carbon and nitrogen content did not differ significantly between mulched and no-mulch plots. However, soil samples taken 7 and 12 weeks after mulching showed significantly ($P<0.05$) higher values on mulched plots compared to no-mulch plots (Table 3). The trend observed at the 0-15 cm depth was similar to that at 15-30 cm depth for organic carbon and nitrogen content Table (4).

Table 3 Effect of Mucuna mulch on organic carbon, and nitrogen status of soil measured at (0 - 15 cm) depth.

Treatment	Organic carbon (%) A	B	C	Nitrogen (%) A	B	C
Mulching	0.9	1.2	0.8	0.09	0.12	0.08
No-mulch	0.8	0.7	0.6	0.07	0.09	0.06
CV %	21.6	4.97	8.1	5.8	7.6	12.7
SED	0.14	0.01	0.04	0.01	0.01	0.01

A: At maize planting B: 7 weeks after maize planting C: At first maize harvest

Table 4 Effect of mulching on organic carbon, and nitrogen status of soil measured at (15 - 30 cm) depth.

Treatment	Organic carbon (%) A	B	C	Nitrogen (%) A	B	C
Mulching	0.80	1.79	0.78	0.09	0.11	0.08
No-mulch	0.76	0.75	0.69	0.07	0.06	0.06
CV %	9.50	7.70	12.9	15.3	7.75	9.16
SED	0.03	0.01	0.04	0.01	0.01	0.01

A: At planting B: 7 weeks after mulching C: At first maize harvest

4.6 Effect of mulch no weed population in maize

The effect of mulching on weed population in maize cultivated in the first season is shown in Figs. 3a, 3b, 3c and 3d. Weed population counted two weeks after mulching showed significantly ($P < 0.05$) higher number of weeds on the no-mulch plot compared to the mulched plot. Moreover, the number of weed species on the no-mulch plot was more than that on the mulched plot. With the exception of *Cyperus rotundus* and *Boehavia diffusa*, the population of other weed species was comparatively insignificant on the mulched plots.

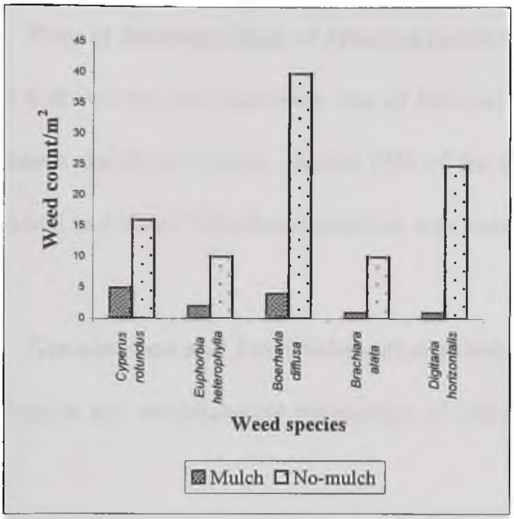

Fig. 3a. Effect of mulch on weed population after 2 weeks of planting first-season maize

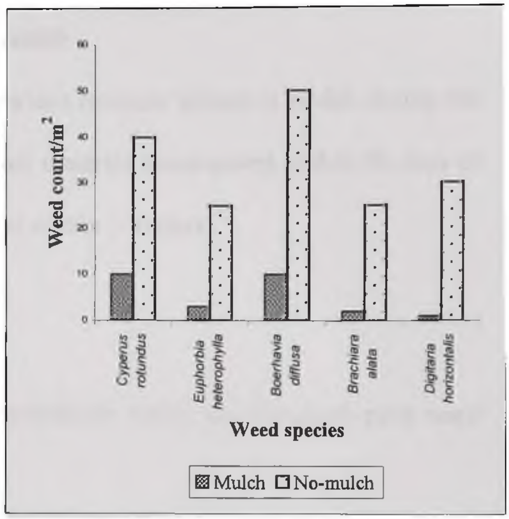

Fig. 3b. Effect of mulch on weed after 4 weeks of planting maize

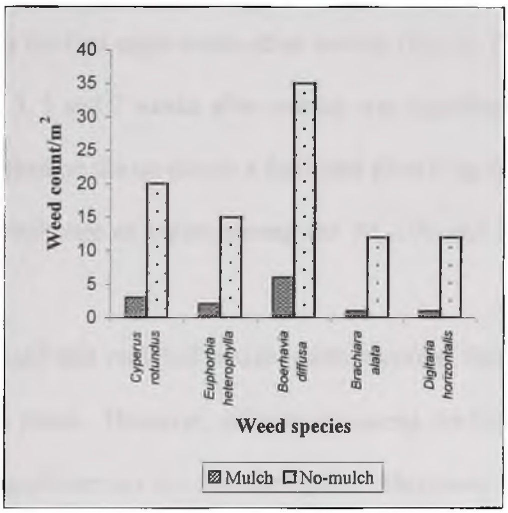

Fig. 3c. Effect of mulch on weed population after 2 weeks after first* weed control.

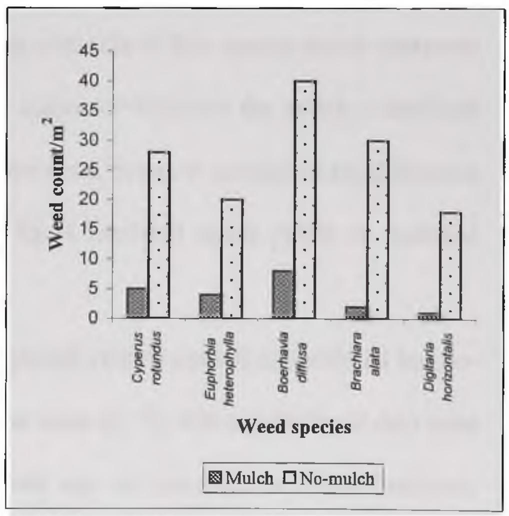

Fig. 3d. Effect of mulch on weed after 4 weeks after first*

* Weeds were controlled 4 weeks after planting

4.7 Rate of decomposition of *Mucuna pruriens* mulch

Figure 4 shows the decomposition rate of Mucuna pruriens biomass spread as mulch during the first season maize cultivation. About 75% of the mulch material decomposed within 50 days of application and about 90% decomposition was recorded within 100 days.

4.8 Germination and Establishment of maize

Germination and establishment percentage of maize on both the mulch and no-mulch plots were 100%.

4.9 Growth rate of maize

Faster growth rate of maize plants was observed on the mulched plots than on the no-mulch plots during the first eight weeks after sowing (Fig 5). The growth rate of first season maize measured at the 3, 5 and 7 weeks after sowing was significantly higher ($P<0.05$) on the mulch x fertilized plots than on the un-mulch x fertilized plots (Fig 6). There was however no significant difference in growth rate of maize among the 50, 100 and 200 kg N fertilized maize plants on mulched plots.

Fertilized and mulched maize plants recorded faster growth rate compared to fertilized but no-mulch plants. However, differences among the fertilizer rates (0, 50, 100 and 200kg N /ha) were not significant on the mulched plot. Maximum growth rate of maize on both the fertilized-mulched plots and fertilized no-mulch plots was recorded at 7 WAS. The growth rate at 7 WAS was highest for all the treatments except the plants on the no fertilizer, no-mulch plots that attained the highest growth rate at the 9 WAS (Table 5).

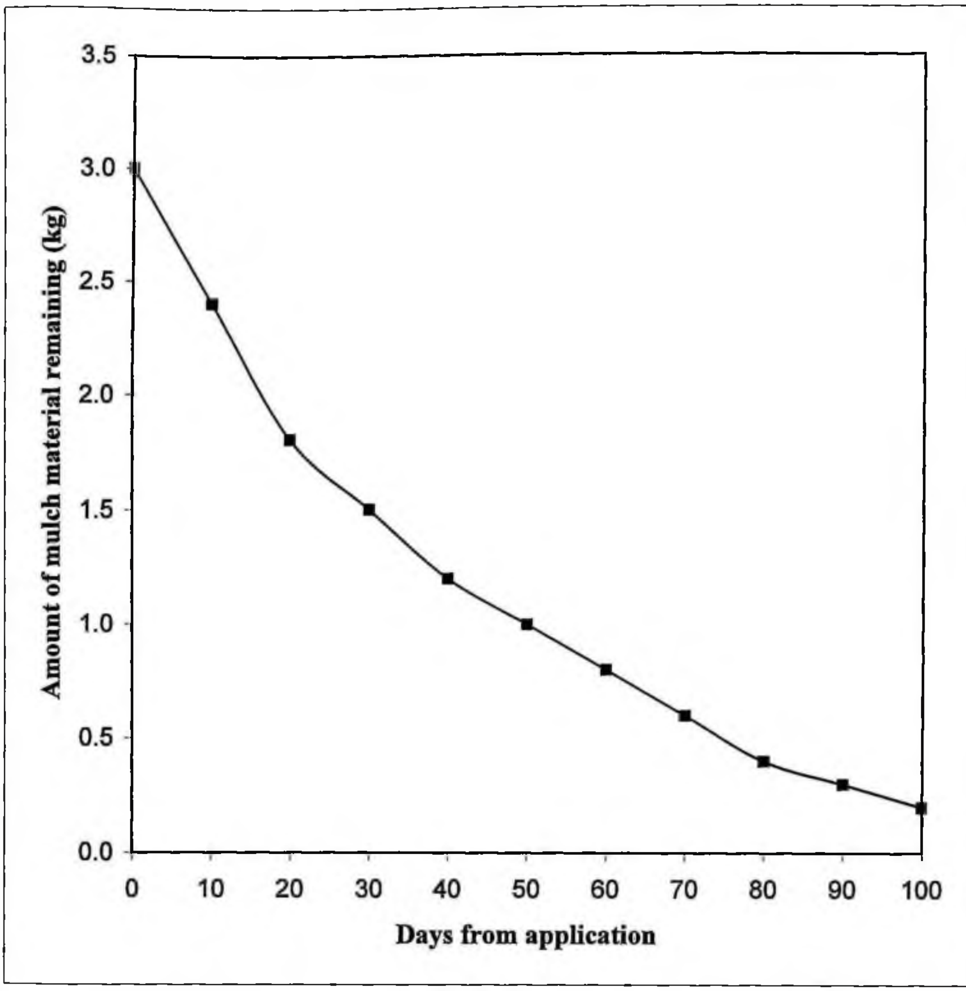

Fig. 4. Rate of decomposition of *Mucuna pruriens* mulch

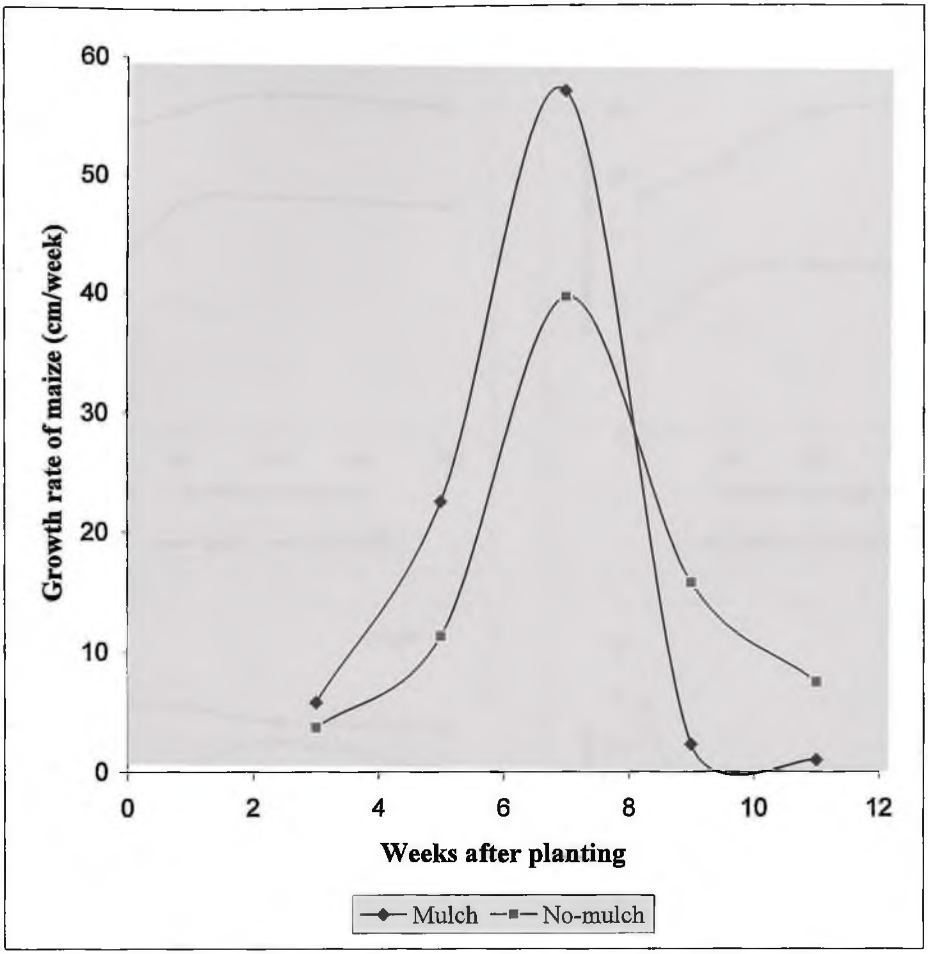

Fig. 5. Effect of Mucuna mulch on growth rate of first-season maize

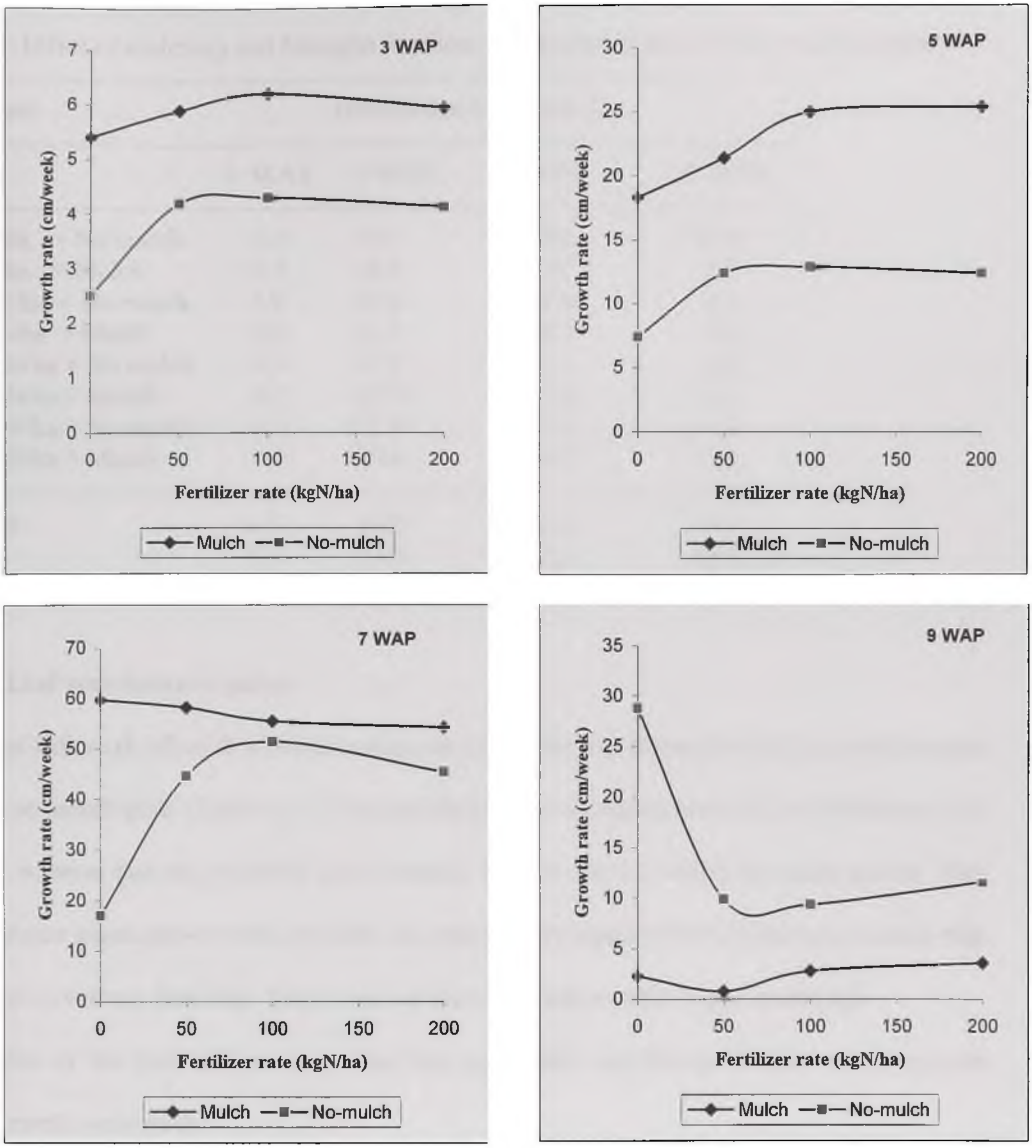

Fig. 6. Effect of Mulch and Nitrogen Fertilizer on the growth rate of maize 3, 5, 7 and 9 weeks after planting

Table 5 Effect of mulching and Nitrogen fertilizer on the growth rate of first planting maize

Treatment	Growth rate (cm week-1)			
	3 WAS	5 WAS	7 WAS	9 WAS
0 kg N/ha + No mulch	2.5	7.4	17.0	28.8
0 kg N/ha + Mulch	5.4	18.3	59.7	2.3
50 kg N/ha + No mulch	4.2	12.4	44.6	9.9
50 kg N/ha + Mulch	5.9	21.4	58.2	0.8
100 kg N/ha + No mulch	4.3	12.9	51.1	9.4
100 kg N/ha + Mulch	6.2	25.0	55.5	2.8
200 kg N/ha + No mulch	4.1	12.4	45.4	11.6
200 kg N/ha + Mulch	5.9	25.4	54.2	3.6
LSD 5%	0.7	6.32	15.3	11.3
CV%	5.4	14.3	12.2	50.3

4.10 Leaf area index of maize

Leaf area indices (LAI) of first season maize were significantly higher ($P<0.05$) in mulched plots than on no-mulch plots (Table 6). LAI of mulched maize increased from 0.4 in 3 WAS to 1.6 in 7 WAS whereas that on no-mulch plot increased from 0.1 to 1.2 within the same period. First season maize plants grown with fertilizer had significantly higher ($P<0.05$) leaf area indices than those grown without fertilizer. Mulch and fertilizer interaction with respect to the leaf area index of the first season maize was not statistically significant in most of the periods measurements were made.

Table 6. Effect of mulch on leaf area index of first planting maize.

Treatment	Leaf Area Index					
	3 WAS	4 WAS	5 WAS	6 WAS	8 WAS	9 WAS
Mulching	0.4	0.9	1.5	1.7	1.7	1.6
No mulch	0.1	0.4	0.9	1.1	1.2	1.2
SED	0.02	0.1	0.1	0.1	0.1	0.1
CV%	12.7	10.9	10.1	11.1	11.2	11.3

4.11 Flowering and maturity periods of maize

The data on the number of days to tasseling, silking and grain maturity is shown in Table 7. Maize plants tasseled significantly earlier ($P<0.05$) on mulched plots compared to those grown without mulch. Silk emergence of plants on mulched plots was also significantly ($P<0.05$) faster and occurred 5 days earlier than those grown on the no-mulch plots. The data for the maturity period of maize showed that the number of days from sowing to maturity for mulched maize (82 days) was significantly lower ($P<0.05$) than maturity period for no-mulch maize (88 days).

Table 7. Effect of mulch on the number of days to Tasseling, Silking and Grain maturity of first season maize.

Treatment	Tasseling	Silking	Maturity
Mulching	44.4	48.4	82.3
No mulching	48.8	53.6	87.9
SED	0.3	0.4	0.4
CV%	3.3	3.8	2.1

The number of days to maize tasseling was significantly reduced ($P<0.05$) with the application of nitrogen fertilizer. Similarly, the period to silking also reduced significantly with N fertilizer application. The application of either 100 or 200 kg N significantly reduced the number of days to tasseling, silking and maturity by at least 2 days compared to maize grown on the 0 and 50 kg N plots. Mulch and fertilizer interacted significantly ($P<0.05$) in terms of period to tasseling, silking and maturity. Addition of nitrogen fertilizer to mulched maize plants reduced the maturity period over that of the no-mulch fertilized maize plants (Table 8).

4.12 Plant height and yield

Height of maize plants at maturity did not differ significantly between those grown on the mulched plots and the no mulch plots. However, addition of fertilizer to maize on mulched plots resulted in significantly taller ($P< 0.01$) plants (Table 8). Table 9 shows the grain and total biomass yield of first season maize plants as influenced by mulching. Grain yield was significantly greater ($P<0.05$) for mulched plots (7388 kg/ha) than for the no-mulch plots (4676 kg/ha). Similarly, total biomass yield was greater on the mulched plot (15438 kg/ha) than on the no-mulch plot (9598 kg/ha). Maize plants grew significantly taller ($P< 0.05$) on the 100 kgN/ha and 200 kgN/ha plots than on the unfertilized plots.

Table 8. Effect of Mucuna mulch and nitrogen fertilizer on the period to maturity and final plant height of first season maize

Treatment	height (cm)	maturity period (days)
0 kg N/ha + No mulch	123.17	94.33
0 kg N/ha + Mulch	179.83	82.67
50 kg N/ha + No mulch	146.53	85.00
50 kg N/ha + Mulch	178.03	82.67
100 kg N/ha + No mulch	158.60	87.00
100 kg N/ha + Mulch	184.33	82.00
200 kg N/ha + No mulch	157.00	85.33
200 kg N/ha + Mulch	183.53	82.00
LSD 1%	13.54	3.52
CV	3.31	1.67

Table 9 Effect of mulch on height and yield of first planting maize.

Treatment	Grain yield (kg/ha)	Total biomass (kg/ha)
Mulching	7387.8	15438.2
No mulching	4675.5	9597.5
SED	1074.1	5840.0
CV	8.4	8.1

Figure 7 shows the yield response of maize to fertilizer nitrogen with and without mulch. Grain yield obtained from mulch plots without fertilizer was greater than the maximum grain yield obtained with fertilizer N from the no-mulch plots. However, grain yield was affected by mulching and fertilizer application. Addition of 50 kgN/ha to the mulch plot gave the highest grain yield (8883 kg/ha). Nevertheless, grain yield declined as fertilizer N rate applied to mulched plot exceeded 50 kgN/ha. The highest grain yield from no-mulch plot was obtained with the application of 100 kgN/ha. At 200 kgN/ha rate the difference in maize grain yield

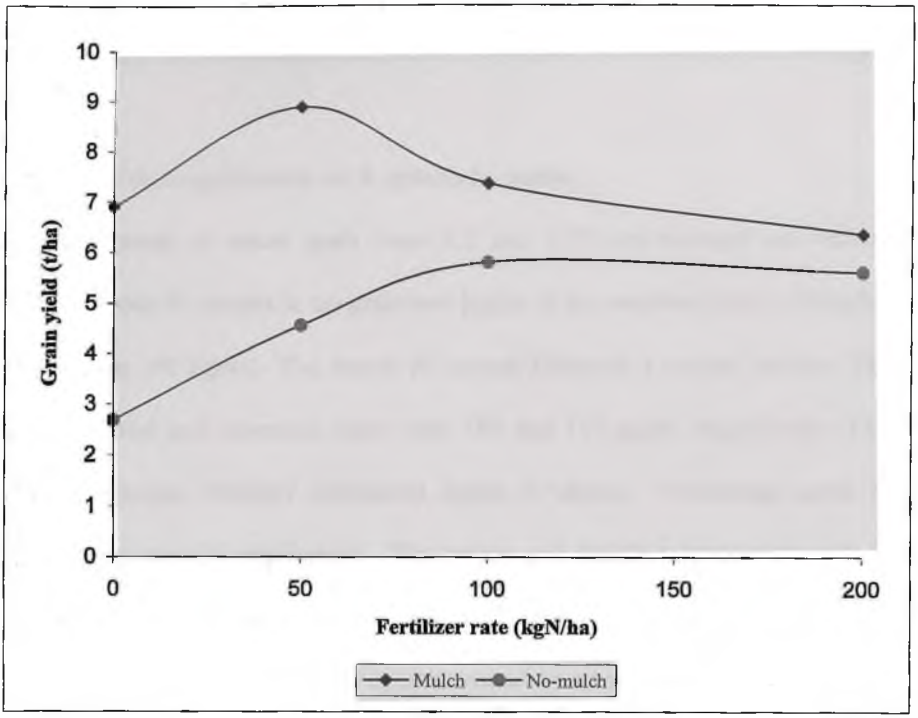

Fig. 7. Effect of Mucuna mulch and nitrogen fertilizer rate on first-season maize grain yield.

between mulch and no-mulch plot narrowed. The total biomass followed a similar pattern as grain yield (Fig.8). The greatest biomass yield for the mulched plot was obtained with application of 50 kgN/ha whiles that from the no-mulch plot was obtained with 200 kgN/ha.

4.13 Effect of mulch application on N uptake by maize.

Percentage N contents of maize grain were 1.5 and 1.3% on mulched and no-mulch plot respectively. The total N content in the grain was higher in the mulched plots (105 kg/ha) than on the no-mulch plots (60 kg/ha). The stover N content followed a similar pattern. The total N uptake from mulched and no-mulch plots were 184 and 113 kg/ha, respectively (Table 10). Application of nitrogen fertilizer influenced maize N uptake. Percentage grain N content increased with increased N application. The mulch and fertilizer interaction with respect to nitrogen uptake in the grain, stover and total uptake was significant ($P < 0.01$). Nitrogen uptake was enhanced by mulch. The highest N uptake was achieved with mulch and 50 kgN/ha (Table 11).

Table 10. Effect of Mucuna mulch on nitrogen uptake by maize

	Grain	Stover	Total N uptake
Treatment	kg N/ha	kg N/ha	Kg N/ha
Mulching	105.8	78.2	184.1
No mulch	60.8	51.9	112.7
SED	1.01	1.76	
CV	2.26	1.67	3.79

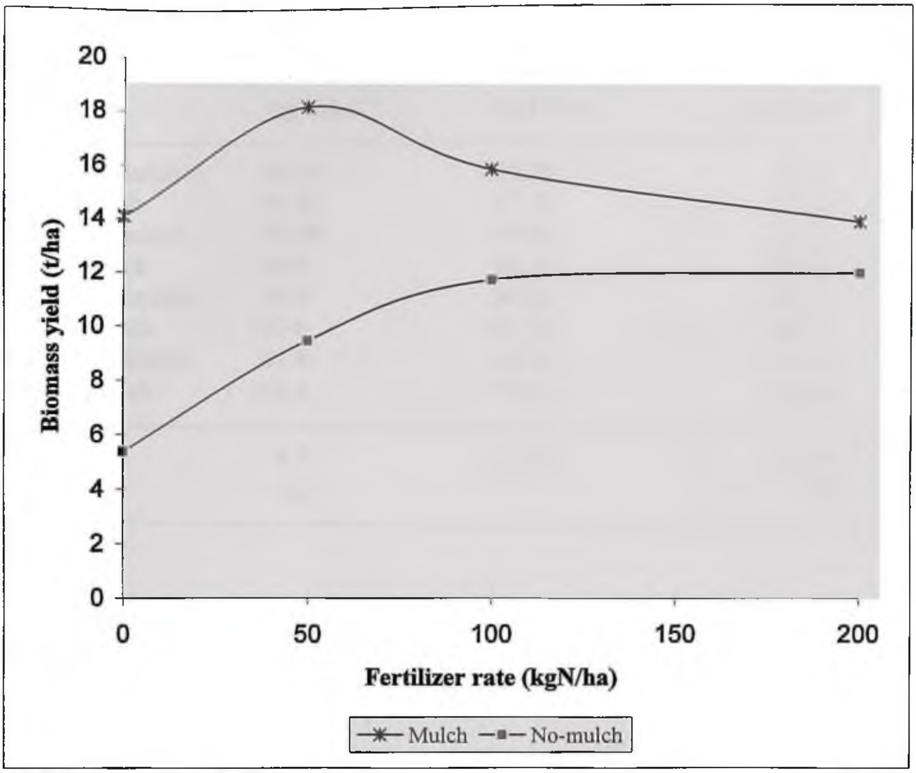

Fig. 8. Effect of Mucuna mulch and nitrogen fertilizer rate on first-season biomass yield of maize.

Table 11. Effect of Mucuna mulch and nitrogen fertilizer on nitrogen uptake by first season maize.

	Grain	Stover	Total N uptake
Treatment	kg N/ha	kg N/ha	kg N/ha
0 kg N/ha + No mulch	29.70	25.20	55.0
0 kg N/ha + Mulch	91.20	67.33	158.7
50 kg N/ha + No mulch	55.90	47.93	103.7
50 kg N/ha + Mulch	120.4	88.10	209.5
100 kg N/ha + No mulch	75.9	64.80	140.7
100 kg N/ha + Mulch	110.0	81.50	191.5
200 kg N/ha + No mulch	81.8	69.53	151.6
200 kg N/ha + Mulch	101.6	75.53	176.8
LSD 1%	4.7	2.70	10.01
CV%	2.3		3.79

EXPERIMENT 2

4.14 Residual effect of mulch on soil pH

The pH of soils previous mulched were significantly higher ($P < 0.05$) than those of no-mulched plots (Table 12). Nitrogen fertilizer affected soil pH. Soils with a history of higher N application were significantly acidic.

Table 12 Residual mulch effect on soil pH

	12 WAM	At 2nd maize harvest
Mulching	6.44	6.30
No mulch	6.31	6.00
SED	0.01	0.05
CV %	0.45	0.60

WAM: Weeks after mulching

4.15 Residual mulch effect on soil bulk density

Bulk densities of previously mulched plots were significantly ($P<0.05$) lower than that of the no-mulch plots (Table 13). Effect of nitrogen fertilization and its interaction with mulch on pH were however not significant.

Table 13 Effect of mulching on soil Bulk density.

	12 WAM	2nd maize harvest
Mulching	1.17	1.18
No mulch	1.22	1.22
SED	0.01	0.01
CV %	0.18	0.63

4.16 Residual mulch effect on soil moisture and temperature

Soil moisture content during the second maize planting ranged between 18 and 22 % and did not differ between the mulch and no-mulch plots (Fig 9). The maximum temperature values recorded for mulch and no-mulch season were 27 and 27.5°C, respectively (Fig 10).

4.17 Residual mulch effect on soil organic carbon and nitrogen content

Organic carbon and nitrogen content of soils measured at harvesting of second maize did not differ significantly between the mulched and no-mulch plots. Similarly their content did not differ significantly among the nitrogen fertilizer levels.

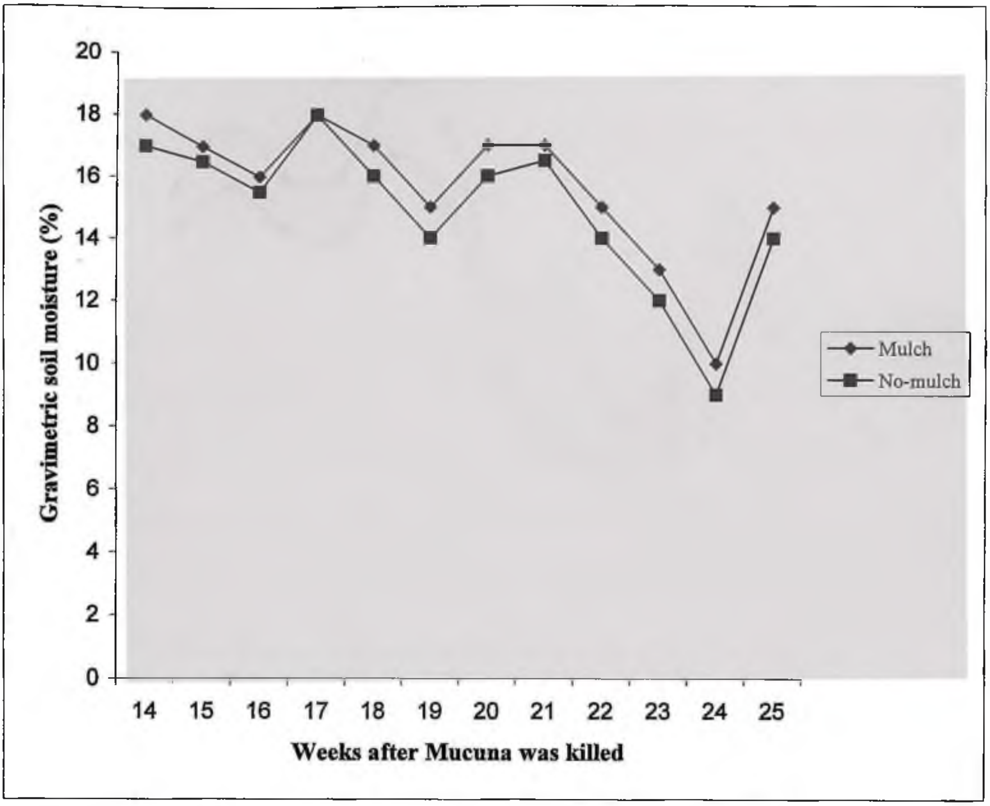

Fig. 9. Effect of residual mulch on soil moisture content during the second season.

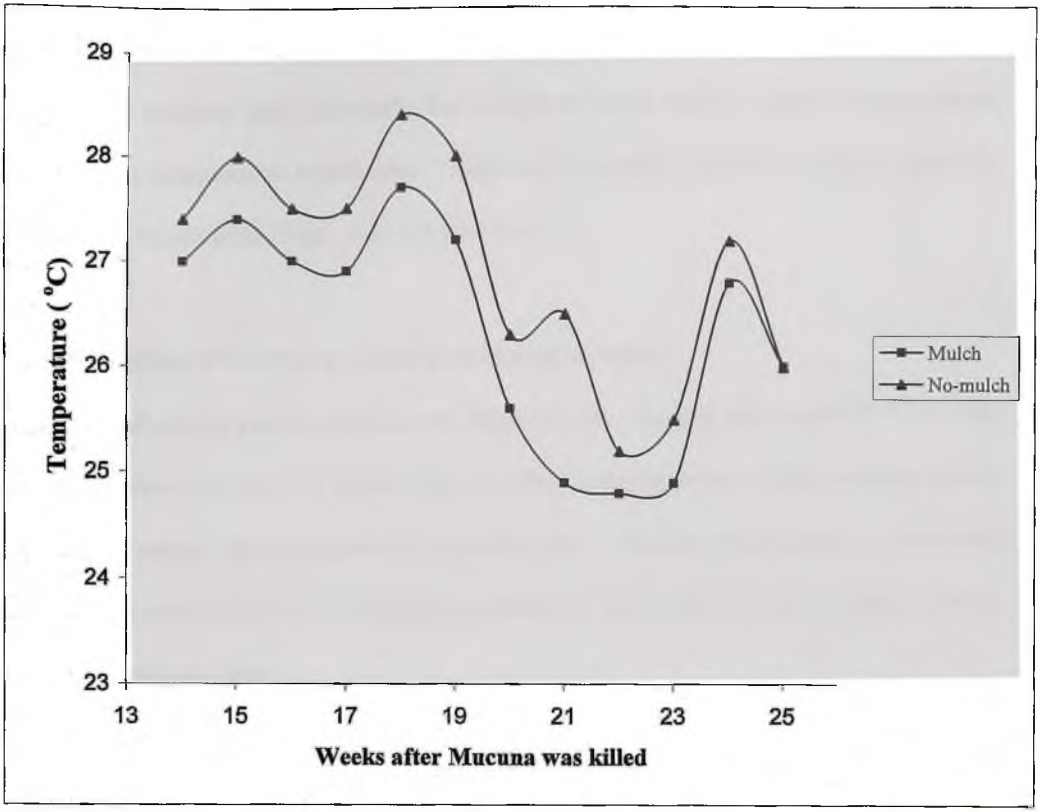

Fig. 10. Effect of residual mulch on soil temperature

4.18 Residual effect of mulching on weed growth in maize

Weed growth in second maize measured by population count was generally higher on no-mulch plots compared to mulched plots. Similarly, the number of weed species counted were more on the no-mulch plots compared to mulch plots. Regrowth of weeds was more rapid on no-mulch plots compared to mulch plots (Figs. 11a, 11b and 11c).

4.19 Residual effect of mulching on the growth rate of maize

The growth rate of second season maize on mulched plot was significantly faster ($P<0.05$) than on the no-mulch plots at 3, 5 and 7 WAS (Fig. 12). Previously applied N influenced the growth rate of the second season maize plants at the seventh week. At this period, maize on the plots previously treated with 200kg/ha N recorded significantly faster rate of growth than on the 0, 50 and 100 kg/ha treated plots.

Effect of the residual nitrogen fertilizer on leaf area index of second season maize was significantly higher ($P<0.05$) on the 200 kg N/ha treated plots compared to the other N rates. Second season maize plants grown on the previously mulched plots had significantly higher ($P<0.05$) leaf area indices than those grown on the no-mulch plots (Table 13). The residual mulch and residual fertilizer interaction was significant ($P<0.05$) with respect to leaf area indices. Thus, leaf area index of the second season maize was significantly higher on previously fertilized and mulched plots compared to fertilized and no mulch plots (Table 14). The effect increased with increase in the rate of N applied previously. The plot with a history of 200kg N/ha and mulch produced maize plants with the highest leaf area indices at the 7th and 9th weeks after sowing (Table 15).

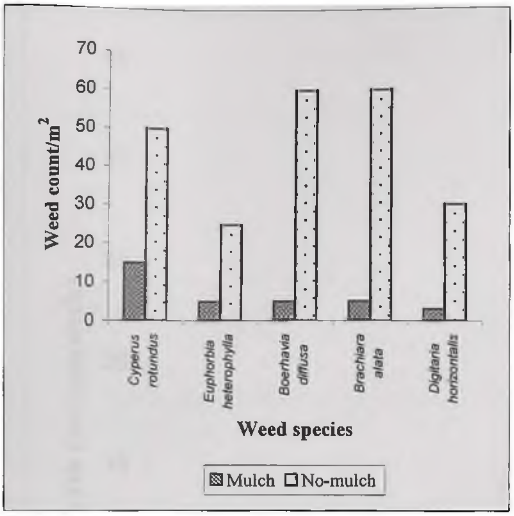

Fig. 11a. Effect of mulch on weed population after 4 weeks of planting second-season maize

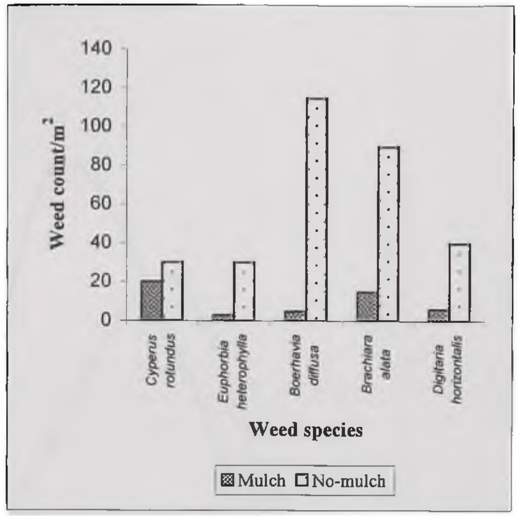

Fig. 11b. Effect of mulch on weed 2 weeks after first weed (during the second season

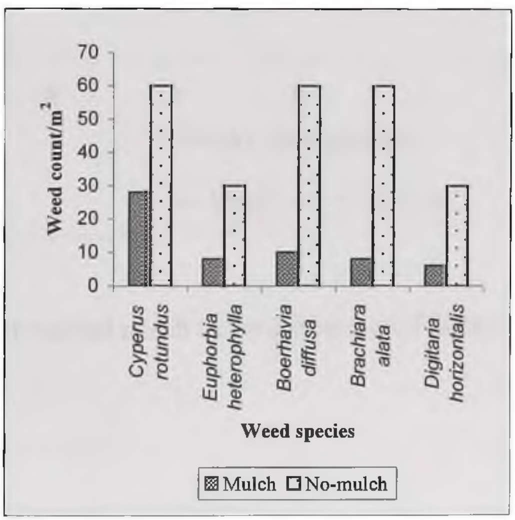

Fig. 11c. Effect of mulch on weed population 4 weeks after first weed control* during the second season.

* Weed control was done 4 weeks after planting

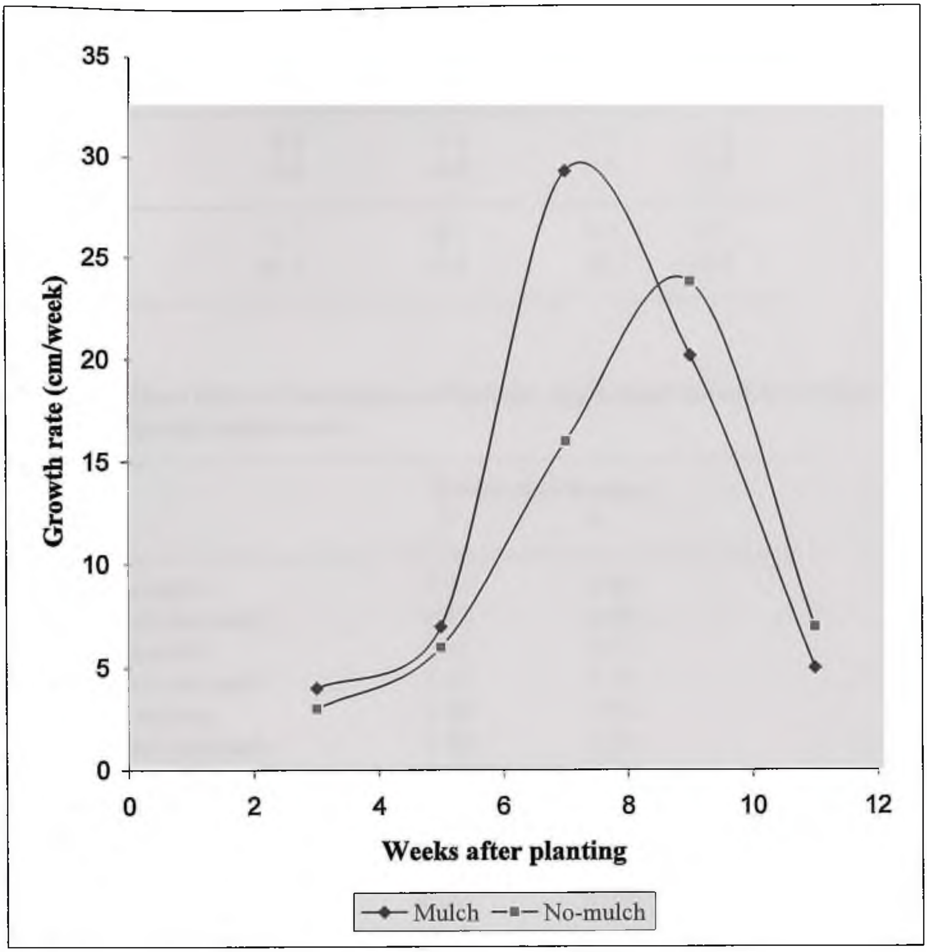

Fig. 12. Effect of residual mulch on the growth rate of second-season maize

Table 14 Residual effect of mulch on the leaf area index of second planting maize.

Treatment	Weeks after sowing 3	5	7	9
Mulching	0.5	1.2	1.1	1.2
No mulch	0.3	0.8	0.8	0.8
LSD 5%	0.1	0.1	0.1	0.1
CV %	20.1	16.1	10.1	10.5

Table 15 Residual effect of mulching and nitrogen application on leaf area index of second season maize

Treatment	Weeks after sowing 7	9
0 kg N /ha (no mulch)	0.74	0.64
0 kg N /ha (mulch residual)	0.97	0.98
50 kg N /ha (no mulch)	0.91	0.77
50 kg N /ha (mulch residual)	1.07	1.09
100 kg N /ha (no mulch)	0.88	0.83
100 kg N /ha (mulch residual)	1.09	1.22
200 kg N /ha (no mulch)	1.00	0.92
200 kg N /ha (mulch residual)	1.37	1.33
LSD 5%	0.17	0.17
CV%	10.10	10.50

Second season maize plants grown on the previously mulched plot tasseled, silked and matured significantly earlier ($P<0.05$) than maize plants on the no-mulch plots (Table 16). Effect of residual fertilizer or its interaction with residual mulch was not significant with respect to the number of days to tasseling, silking and maturity.

Table 16. Residual effect of mulching on the time to tasseling, silking and maturity of second season maize.

Treatment	Tasseling	Silking	Maturity
Mulching	47.8	51.0	89.9
No mulch	49.2	52.1	92.3
SED	0.5	0.5	0.3
CV %	2.3	2.7	1.4

4.20 Plant height and yield

Table 17 shows the matured height, grain and total biomass yield of second season maize plants. Maize plants grew significantly taller on previously mulched plot compared to no-mulch plot. Grain yield from the previously mulched plot was over one tonne greater ($P < 0.05\%$) than that of the no-mulch plot. Above ground total biomass yield from the previously mulched plot was significantly greater ($P<0.05$) than that on the no-mulch plot. The harvest index however, did not differ significantly between the two plots.

Table 17 Residual effect of mulching on plant height, grain yield and total biomass of maize.

Treatment	Plant height (cm)	Grain yield (Kg/ha)	Total biomass (Kg/ha)
Mulch	134.5	4633.6	9196.9
no-mulch	124.4	3457.5	6609.5
SED	0.38	450.7	134.6
CV %	0.62	12.4	6.4

Effect of residual fertilizer in terms of maize grain yield was highest on the mulched plots compared to the no-mulch plots (fig 13). Grain yield at each fertilizer level was about one tonne greater on previously mulched plot compared to no-mulch plot. The highest grain yield was obtained from the residual 200kg N/ha x mulch plot. However, it was only 0.5tonnes greater than the grain yield obtained without fertilizer from the mulch plot. The total biomass yield followed a similar pattern as that of the grain yield (Fig 14). The highest biomass yield was obtained from the residual mulch x 200kg N/ha plots.

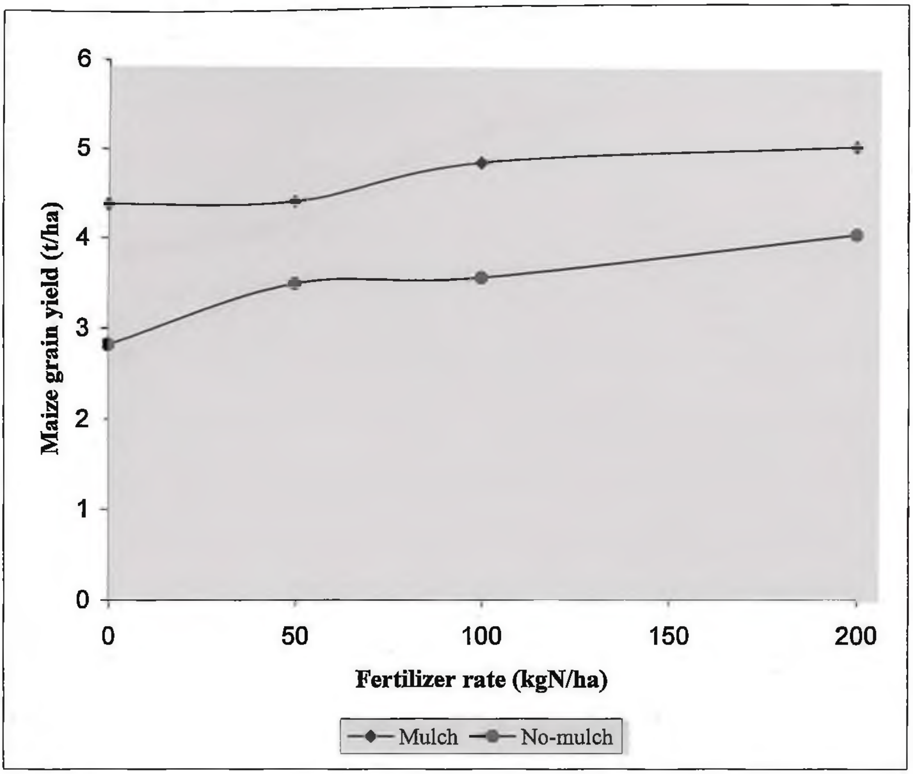

Fig. 13. Residual effects of Mucuna mulch and nitrogen fertilizer rate on second-season maize grain yield.

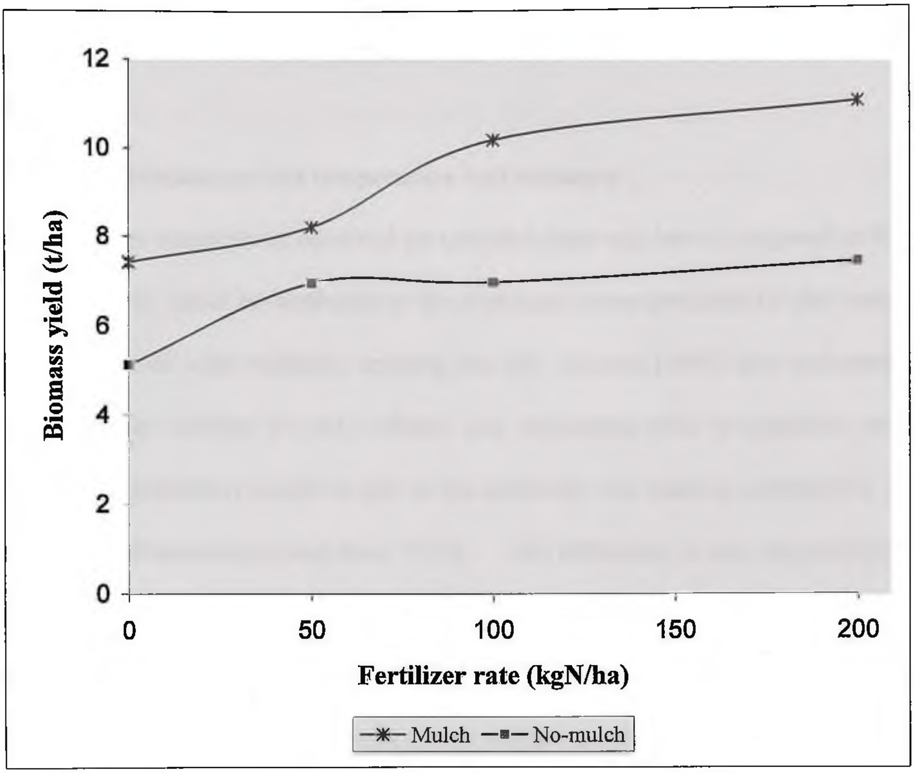

Fig. 14. Residual effects of Mucuna mulch and nitrogen fertilizer rate on second-season maize biomass yield.

CHAPTER 5

DISCUSSION

5.1 Effect of mulching on soil temperature and moisture

The daily maximum temperature observed on mulched plots was lower compared to that on the no-mulch plots. This could be attributed to the prolonged cover provided by the mulch, which limited the amount of solar radiation entering the soil. Sharma (1991) also indicated that the application of crop residues to soil surfaces was associated with temperature moderation. Further, the low temperature could be due to the relatively low thermal conductivity of mulch material applied (Bhattacharyya and Rao, 1985). The difference in soil temperature between the mulched and no-mulch plots reduced considerably after seven weeks of mulching. This observation could be attributed to the increased volume of the maize canopy. As a result of maize growth and leaf expansion, exposure of soil surface to solar radiation was reduced thereby minimising soil temperature rise on both the mulched and no-mulch soils.

Soil moisture content was higher on the mulch plot compared to that of the no-mulch plot. The high level of moisture content could partly be attributed to the increased rate of infiltration on the mulched plots. This is because mulching has been found to enhance water infiltration by preventing the breakdown of soil aggregates by water (Webster and Wilson, 1980). The increased soil moisture could also be attributed to the reduction in evapotranspiration rate as the mulch reduced the heat load on the soil. Hedge and Srinivas (1989) also observed reduction in evaporation losses when rice straw was used as mulch.

5.2 Effect of mulching on soil organic matter, nitrogen pH, and Bulk density

Organic matter content was higher in the mulched soil compared to no-mulch soils. The increased organic matter content of mulched soil was due to the addition of the mulch. Also while soil nitrogen increased briefly on mulch plot that on the no-mulch plot decreased. A consequence of the increased organic matter content is the enhancement of nutrient transfer sites proximal to the roots. This is because organic carbon compounds have a high variable charge and therefore can be important in binding cations which remain readily available to plants (Mehlich, 1960). The increased N level on the mulched plots was due to mineralization of the mulch nitrogen. The reduction that followed was attributed to the uptake by the maize plants.

The application of mulch influenced the pH and bulk density. The soils used have a history of being acidic as a result of continuous cropping without complete fertilizer programme. Agboola (1986) have attributed this increasing soil acidity from cropping to reduction in the levels of exchangeable cations such as Ca, Na, and K in the soil.

The results of the present studies indicates that, soil acidity could be reduced with mulching. According to (Brady, 1985) the condition of high soil temperature coupled with severe moisture stress could bring a minor increase in soil acidity. It could therefore be deduced that the lowering of soil temperature and improvement in the moisture content of soil with mulching prevented the increase in the soil acidity in the mulched plots. . In addition, the increase in pH of mulched soils could also be attributed to the increased organic matter content of the soils under mulch. The mulch added organic matter to the soil and this might have concentrated sufficient cations, such as calcium, potassium in the top soil (Muller-Samann and Kotschi, 1994) thereby positively affecting the soil pH. Soils under mulch recorded significant reduction in bulk density following decomposition of the mulch. The reduction in bulk density of the mulched soil could be linked with the increase in the organic matter content of the soil because addition of organic matter lowers soil bulk density and improves the structure (Paul, 1991).

5.3 Effect of mulching on weed population in maize

Weed population in the mulched maize plots was generally lower than that in no-mulch maize plots. The lower weed population on mulched plots may be attributed to the lower light intensity reaching the weed seeds under the mulch since some weed seeds require light for germination (Webster and Wilson, 1980). The presence of the mulch could also obstruct the weeds emerging from the soil. Allelopathic effect of Mucuna mulch on weed seeds cannot be ruled out. According to Versteeg and Koukopon (1990), through allelopathy Mucuna is able to control *Imperata cylindrica*. The lower weed population could also be attributed to the relatively high fertility of the mulched plot. Since mulched plots were fertile, the growth of maize was faster and therefore provided large leaf canopy to shade the weeds.

5.4 The decomposition rate of *Mucuna pruriens* mulch material and its significance

About 90% of the mulch material applied decomposed within 100 days. Decomposition of plant material at such a rate could be attributed to high nitrogen content of the material in relation to carbon. This is because during decomposition nitrogen is assimilated into cell proteins and other N compounds. Thus the high N concentration (25g/kg) of the original Mucuna material enhanced multiplication of decomposers thereby promoting faster decomposition especially in the early stages. Several studies have established close relationship between original N content of material and decomposition rate. Decomposition of plant residues is affected primarily by the nitrogen content of the material (Aber and Melillo, 1980; Pandey and Singh, 1982; Campbell, 1983 ; and Bahuguna *et al.*, 1990).

However, considering the decomposition rate normally stated for forage legumes (40% in less than two weeks) (Cornforth and Davis, 1968; Wilson *et al.*, 1986; Palm *et al.*, 1988), it appears that the rate observed in the current study is moderate. This may be partly attributed to the age of the Mucuna material applied in this study (ten months) which is far older than the stage at which most forage legumes are cut for mulching. It could therefore be inferred that the mulch material was probably more lignified, hence the moderate rate of decomposition.

The moderate decomposition of the Mucuna mulch is of significant importance as fast decomposition of mulch material result in plots becoming bare before associated crops develop sufficient canopy to cover the soil. In the present study as much as 25% of the Mucuna mulch material was present on the soil surface at the 7th week when maximum maize canopy was established. Thus the effect of mulch cover reduction on the maintenance of optimum soil temperature and moisture for maize growth and yield was minimum. The decomposition rate of the mulch observed in this study resulted in the net release of nutrients that became available for maize uptake.

5.5 Effect of mulching on germination, growth and yield of maize

First season maize crop planted recorded 100 percent germination and establishment on both the mulched and no-mulch plots. The high percent germination of maize on the Mucuna mulched plot suggests that the Mucuna mulch had no inhibitory effect on the germination of the maize. This agrees with the findings of Fuji *et al.* (1991) that the L-3-4-dihydroxyphenylanine (chemical extract from Mucuna) does not inhibit germination and growth of gramineae as it does to other crops including lettuce. Notwithstanding the equality in emergence rate and the regular irrigation, significant difference in growth rate was observed between maize planted on the mulched plots and those on the no-mulch plots. This could be explained mainly in terms of differences in soil temperature, soil moisture and nitrogen between the mulched and no-mulch plots. Mulching resulted in the maintenance of optimum soil temperature for maize and this might have enhanced post-emergence vegetative growth through reduced rate of respiration and transpiration and increased efficiency of photosynthate utilization (Salisbury and Ross, 1992). Hanna (1925) correlated climatic factors and vegetative growth, and found out that, maize growth was closely correlated to temperature than any other climatic factor.

High temperature also affect photosynthate availability through enhanced leaf senescence. This is likely to be the case in this studies as photosynthetically active leaf area measured at different times were always lower on the no-mulch plots due to high rate of leaf senescence on the no-mulch plots. The attainment and maintenance of optimum temperature under mulched soil could partly explain early tasseling of maize grown on the mulched plot because the period to tasseling reduces with increasing temperature from low value to an optimum value (Wallace and Bressman, 1937; Shaw and Thom, 1851).

The growth and yield of maize were affected by the mulch through increased availability of moisture on mulched plots. Other workers have found maize growth to be related to moisture availability. Hayness (1948) found vegetative growth of maize to be markedly affected by degree of soil moisture availability. Edmeades *et al.* (1986) also related reduction in leaf area and plant size to moisture stress. Salisbury and Ross (1992) explained that reduced growth rate and plant size associated with moisture stress is due to the high sensitivity of cell expansion to moisture stress. Moreover water is an ingredient in photosynthesis and its unavailability could result in break in photosynthesis and inadequate photosynthate for growth and yield. According to other workers, high moisture content of soils could affect the period to tasseling and silking. Rhoades and Stanley (1973) found that both tasseling and silking of maize occurred earlier as soil moisture tension was reduced. Shaw and Thom (1951) also observed silking to be much slower in hot dry year compared to that in normal year. Early maturity is important if maize is to escape effect of moisture stress.

Maize growth rate and yield is enhanced through the uptake of plant nutrients. Uptake of plant nutrients on mulched soil might have been enhanced by moisture availability. Moreover considerable portion of the over 200 kg nitrogen in the 12 tonnes dry mulch material might be available for uptake by the maize. As much as 161.6 kg N/ha was taken by maize from the mulch plot compared to 54.3 kg N/ha from the no-mulch plot. It could then be said that as much as 100 kilograms of the total N up-take by maize plants could come from the applied mulch. Such a high uptake of mulch nitrogen was against the notion that nitrogen provided by a legume is a less efficient source for grain crops (Smith *et al.*, 1987; Fribourg and Batholomew, 1956). The reason for such high N uptake could be that the rate of decomposition and mineralization of the mulch nitrogen might have coincided with the nutrient requirement of maize. Moreover, the absence of rains reduced the nitrogen loss by leaching.

5.6 Effect of fertilizer N in combination with Mucuna mulch on the performance of maize

Maize plants without inorganic nitrogen fertilizer but with mulch performed better than those which received the inorganic nitrogen fertilizer alone. This does not mean that nitrogen was not important in the performance of maize. Nitrogen is actually needed for the development of large green leaves, formation of other tissues and consequent grain yield.

The observation made in this study rather suggests that the mulch nitrogen was readily available to maize due to its high rate of mineralization. The presence of favourably soil moisture and temperature enhanced the utilization of applied nutrients. However the performance of mulched maize significantly improved with addition of 50 kg N /ha inorganic fertilizer. This implies that the maximum rate of nitrogen required for higher grain yield could not be attained with the use of the mulch alone but required 50 kg/ha N as supplement.

Nitrogen rate higher than 50 kg/ha applied to mulched plots did not lead to further improvement in the leaf area and crop growth rate but led to a decrease in both grain and total biomass yield. Thus the advantages or benefits of combining inorganic nitrogen fertilizer and mulch decreased with increasing N rate above 50 kg/ha. However, maize plants on the no-mulch plots suffered less from this excessive N application in terms of grain and total biomass yield. The yield levelled off at 100 kg N /ha. Obtaining highest grain yield from no-mulch plot with 100 kg N/ha is expected since it is the recommended rate for maize in the coastal savannah zone of Ghana (Anon., 1985).

The N uptake from the mulch plot was higher than 100 kg/ha and exceeded the amount taken from the no-mulch plot which were fertilized. This means that by improving moisture, temperature and nutrient conditions of the soil with mulch, the total N uptake by maize is likely to increase. Yaafi (1992) found that maize irrigated at weekly interval took much of the applied N and performed better than those irrigated at bi-weekly. A study carried out in the Sudan and Guinea savannah ecological zones with distinct rainfall regime also showed that maize response to nitrogen fertilizer in terms of grain yield was strongly dependent on moisture availability (IITA/SAFGRAD, 1984). Responses were found to climax at 100 kgN/ha in the Sudan savanna with a relatively lower precipitation and 150 kgN/ha in the Guinea savannah zone with a relatively higher annual precipitation.

5.7 Residual effect of mulch on performance of second maize

Maize grown on the previously mulched plots performed better than those on the no-mulch plots. The growth rate, time to tasseling, silking, maturity and the grain yield were better on the previously mulched plots. The difference in performance could come mainly from differences in soil nutrient status especially that of N. This means that quite substantial amount of the residual mulch N became available for uptake by the second maize. This was possible as the residual N was available in the form of organic matter and was released after mineralization. This explains the significant reduction in the level of the organic matter gained in the first season maize.

Integrating *Mucuna pruriens* mulch and inorganic N fertilizer enhanced the performance of the second maize as compared to application of inorganic fertilizer alone. The explanation may be that the mulch nitrogen, which was in organic form was more stable and also the organic matter might have held the applied inorganic N in a stable form against losses. However, the performance of second maize on mulched plots without fertilizer was comparable to all the N rates except that of 200 kg/ha N rate. This suggests that either the residual effect of the mulch alone was high enough to match the effect of mulch combined with the inorganic nitrogen fertilizer or that the residual inorganic nitrogen fertilizer applied to the first maize was lost. Since the second maize planting coincided with the major rainy season, much of the nitrogen could be lost through leaching or runoff water.

The performance of second season maize was far below that of the first one. This was due to the fact that the second season maize was planted without fresh mulch nor fertilizer addition. Moreover, a greater portion of the applied mulch decomposed in the first season. Nevertheless, the poor performance of the second season maize was not due to temperature nor moisture as these were at optimum levels in the major rainfall season when the second season maize was planted. It was rather due to low nutrient status of the soil as greater portion of nitrogen from the mulch or inorganic nitrogen fertilizer was released for uptake by the first maize. The non-incorporation of the Mucuna forage coupled with the high soil temperature might have facilitated the mineralization of the mulch nitrogen. This possibly explains why Bowen (1987) observed availability of large quantities of green manure Mucuna N to second maize compared to the first maize. Quintana (1987) also observed that second season maize benefited more of the legume nitrogen compared to the first planted maize after green manuring with Crotalaria. The Crotalaria forage had higher C: N ratio than *Mucuna* spp and *Canavalia* spp.

5.8 Residual mulch effect on some soil properties

Generally, soil moisture recorded during the second maize planting was high on both the mulched and no-mulch soils. This is attributed to the frequent heavy rains. The heavy rains might nullify the effect of the residual mulch, hence the similarity in the moisture content between the mulched and no-mulch soils. The temperature condition of the two soils during the second season was generally similar. The similarity in temperature values was partly due to the absence of mulch material on the surface of the soil as a result of decomposition and partly due to the generally low air temperature and the high level of moisture on the two soils. The decomposition of the Mucuna mulch resulted in exposure of the two soils to similar intensity of solar radiation. The generally low temperatures could be attributed to the high moisture content of the soils, since specific heat capacity of water is higher than air and therefore more heat is required to raise the temperature of the wet soil.

Soil pH values recorded during the second season maize planting continued to be higher on the residual mulch plot compared to the no-mulch plot. This could be attributed to the buffering effect of organic matter added to the soil by the mulch. Soil organic matter, organic carbon, and nitrogen levels on mulched and no-mulch plots were similar at harvesting of second maize. This gives an indication of the extent by which Mucuna mulch could influence organic matter, organic carbon and nitrogen on crop growth.

5.9 Residual mulch effect on weed population in maize

Weed population was lower on previously mulched plot compared to no-mulch plot. This could be attributed to the effect of the mulch application in the first season maize. The application of the mulch reduced weed growth during the first maize planting and consequently reduced production of weed seeds for infestation of the second season maize. The lower weed infestation on the previously mulched plot could be attributed to the relatively fertile mulch soil, which boosted maize growth to surpress weeds growth.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

Assessment of the effect of *Mucuna pruriens* mulch on first season maize indicates that the mulch contributed immensely to the growth and yield of the maize. It provided adequate amounts of nutrients, especially nitrogen, and boosted maize growth and gave grain yield greater than that obtained with 100 kg N /ha inorganic nitrogen fertilizer on the no-mulch plots. Mulching in combination with half the recommended nitrogen fertilizer rate (50 kg N/ha) gave further boost in maize performance. Soil moisture content under mulch was higher than that under no mulch condition. The decomposition rate of Mucuna was moderate and significant amount of the mulch remained to maintain optimum soil temperature and increased moisture till maximum maize canopy had been developed.

The second maize crop following Mucuna mulch application benefited from the residual mulch as yield was higher than on no-mulch plot. However the high performance of maize attained in the first season was not sustained in the second season. This is because almost all the mulch material decomposed and released a greater portion of the mulch nitrogen to the first season maize. Nevertheless, a significant amount of mulch nitrogen was available to the second maize and resulted in relatively better performance over the no-mulch maize.

In both seasons, the mulch x fertilizer interaction had a better effect on growth and yield of maize compared with either mulch or fertilizer alone. In the first season the highest grain yield was observed under mulch + 50 kg N/ha whilst in the second season the mulch + 200 kg N/ha had the best residual effect.

The results of this study suggest that farmers can profitably cultivate maize in two successive cropping seasons after a single Mucuna mulch application without the application of any inorganic fertilizer. However, it is more beneficial to apply 50 kg N/ha (half the recommended rate) to the first season maize crop. It is recommended that such studies should be carried out in other ecological zones so as to broaden the authenticity of the results.

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APPENDICES

APPENDIX 1

pH OF SOIL AT PLANTING OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.001	0.000	25.0010	0.0385
Mulch (A)	1	0.001	0.001	108.0051**	0.0091
Error	2	0.000	0.000		
Fertilizer (B)	3	0.001	0.000	2.0206	0.1648
AB	3	0.000	0.000	0.5361	
Error	12	0.002	0.000		
Total	23	0.005			

*- Significant at both 5% and 1% level of probability

APPENDIX 2

pH OF SOIL 12 WEEKS AFTER FIRST SEASON MAIZE PLANTING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.006	0.003	5.3464	0.1576
Mulch (A)	1	0.112	0.112	211.7792**	0.0047
Error	2	0.001	0.001		
Fertilizer (B)	3	0.052	0.017	21.5973**	0.0000
AB	3	0.019	0.006	7.9450**	0.0035
Error	12	0.010	0.001		
Total	23	0.200			

**- Significant at both 5% and 1% level of probability

APPENDIX 3

BULK DENSITY OF SOIL AT FIRST MAIZE PLANTING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.000	0.000	0.2593	
Mulch (A)	1	0.005	0.005	47.9999*	0.0202
Error	2	0.000	0.000		
Fertilizer (B)	3	0.000	0.000	0.5714	
AB	3	0.000	0.000	0.3810	
Error	12	0.001	0.000		
Total	23	0.007			

*- Significant at 5% level of probability

APPENDIX 4

BULK DENSITY OF SOIL 12 WEEKS AFTER FIRST SEASON MAIZE PLANTING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.000	0.000	1.5405	0.3936
Mulch (A)	1	0.009	0.009	59.7028*	0.0163
Error	2	0.000	0.000		
Fertilizer (B)	3	0.001	0.000	1.2989	0.3199
AB	3	0.000	0.000	0.2874	
Error	12	0.004	0.000		
Total	23	0.016			

* Significant at 5% level of probability

APPENDIX 5

SOIL ORGANIC CARBON AT PLANTING OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.065	0.033	0.5660	
Mulch (A)	1	0.003	0.003	0.0452	
Error	2	0.115	0.058		
Fertilizer (B)	3	0.091	0.030	0.9909	
AB	3	0.018	0.006	0.1937	
Error	12	0.368	0.031		
Total	23	0.660			

APPENDIX 6

SOIL ORGANIC CARBON 7 WEEKS AFTER PLANTING FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.011	0.005	13.0000	0.0714
Mulch (A)	1	1.378	1.378	3306.252**	0.0003
Error	2	0.001	0.000		
Fertilizer (B)	3	0.035	0.012	5.1253	0.0164
AB	3	0.011	0.004	1.6144	0.2379
Error	1 2	0.028	0.002		
Total	23	1.463			

**- Significant at both 5 % and 1% probability level

APPENDIX 7

SOIL ORGANIC CARBON AT 12 WEEKS AFTER SOWING FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.010	0.005	1.0000	
Mulch (A)	1	0.184	0.184	36.7500	0.0261
Error	2	0.010	0.005		
Fertilizer (B)	3	0.051	0.017	5.1250	0.0164
AB	3	0.011	0.004	1.1250	0.3778
Error	12	0.040	0.003		
Total	23	0.306			

APPENDIX 8

SOIL NITROGEN CONTENT AT FIRST SEASON MAIZE PLANTING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.000	0.000	1.0000	
Mulch (A)	1	0.001	0.001	256.0001	0.0039
Error	2	0.000	0.000		
Fertilizer (B)	3	0.000	0.000	0.4267	
AB	3	0.000	0.000	0.8533	
Error	12	0.001	0.000		
Total	23	0.003			

APPENDIX 9

SOIL NITROGEN CONTENT AT 7 WEEKS AFTER FIRST SEASON MAIZE PLANTING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.000	0.000	1.7500	0.3636
Mulch (A)	1	0.016	0.016	240.2500	0.0041
Error	2	0.000	0.000		
Fertilizer (B)	3	0.000	0.000	2.6316	0.0979
AB	3	0.000	0.000	0.9474	
Error	12	0.001	0.000		
Total	23	0.018			

APPENDIX 10

SOIL NITROGEN CONTENT AT HARVESTING OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.000	0.000	7.0000	0.1250
Mulch (A)	1	0.002	0.002	483.9999	0.0021
Error	2	0.000	0.000		
Fertilizer (B)	3	0.000	0.000	0.9333	
AB	3	0.000	0.000	0.8667	
Error	12	0.001	0.000		
Total	23	0.004			

APPENDIX 11

GROWTH RATE OF FIRST SEASON MAIZE AT 3 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.055	0.028	0.0285	
Mulch (A)	1	28.188	28.188	29.1688*	0.0326
Error	2	1.933	0.966		
Fertilizer (B)	3	6.247	2.082	19.1700**	0.0001
AB	3	1.169	0.390	3.5864*	0.0466
Error	12	1.303	0.109		
Total	23	38.895			

APPENDIX 12

GROWTH RATE OF FIRST SEASON MAIZE AT 5 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	41.439	20.720	1.6042	0.3840
Mulch (A)	1	758.250	758.250	58.7085**	0.0166
Error	2	25.831	12.916		
Fertilizer (B)	3	149.506	49.835	8.4329**	0.0028
AB	3	13.294	4.431	0.7499	
Error	12	70.916	5.910		
Total	23	1059.237			

APPENDIX 13

GROWTH RATE OF FIRST SEASON MAIZE AT 7 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	298.089	149.044	0.9558	
Mulch (A)	1	1810.301	1810.301	11.6094	0.0764
Error	2	311.867	155.934		
Fertilizer (B)	3	811.688	270.563	7.7858 **	0.0038
AB	3	1347.593	449.198	12.9263**	0.0005
Error	12	417.007	34.751		
Total	23	4996.546			

APPENDIX 14

GROWTH RATE OF FIRST SEASON MAIZE AT 9 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	48.883	24.441	0.9640	
Mulch (A)	1	1090.802	1090.802	43.0242*	0.0225
Error	2	50.706	25.353		
Fertilizer (B)	3	387.241	129.080	5.2844**	0.0149
AB	3	355.635	118.545	4.8531**	0.0195
Error	12	293.123	24.427		
Total	23	2226.390			

APPENDIX 15

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 3 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.001	0.001	0.1310	
Mulch (A)	1	0.304	0.304	76.1063	0.0129
Error	2	0.008	0.004		
Fertilizer (B)	3	0.028	0.009	10.4677	0.0011
AB	3	0.009	0.003	3.4086	0.0531
Error	12	0.011	0.001		
Total	23	0.361			

APPENDIX 16

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 4 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.096	0.048	2.1526	0.3172
Mulch (A)	1	1.360	1.360	61.0753	0.0160
Error	2	0.045	0.022		
Fertilizer (B)	3	0.229	0.076	20.9217	0.0000
AB	3	0.035	0.012	3.2335	0.0607
Error	12	0.044	0.004		
Total	23	1.809			

APPENDIX 17

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 5 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.254	0.127	0.9633	
Mulch (A)	1	2.276	2.276	17.2381*	0.0534
Error	2	0.264	0.132		
Fertilizer (B)	3	0.601	0.200	14.4222**	0.0003
AB	3	0.176	0.059	4.2232*	0.0296
Error	12	0.167	0.014		
Total	23	3.737			

APPENDIX 18

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 6 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.428	0.214	2.0673	0.3260
Mulch (A)	1	2.089	2.089	20.1919*	0.0461
Error	2	0.207	0.103		
Fertilizer (B)	3	0.570	0.190	6.8006**	0.0062
AB	3	0.187	0.062	2.2338	0.1368
Error	12	0.335	0.028		
Total	23	3.816			

APPENDIX 19

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 8 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.497	0.249	3.2983	0.2327
Mulch (A)	1	1.224	1.224	16.2327	0.0564
Error	2	0.151	0.075		
Fertilizer (B)	3	0.642	0.214	8.2795**	0.0030
AB	3	0.175	0.058	2.2639	0.1333
Error	12	0.310	0.026		
Total	23	3.000			

APPENDIX 20

LEAF AREA INDEX OF FIRST SEASON MAIZE AT 9 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.452	0.226	5.1168	0.1635
Mulch (A)	1	0.859	0.859	19.4229*	0.0478
Error	2	0.088	0.044		
Fertilizer (B)	3	0.623	0.208	8.4751**	0.0027
AB	3	0.251	0.084	3.4139	0.0529
Error	12	0.294	0.025		
Total	23	2.569			

APPENDIX 21

DAYS TO TASSELING OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	6.333	3.167	0.6786	
Mulch (A)	1	112.667	112.667	24.1429*	0.0390
Error	2	9.333	4.667		
Fertilizer (B)	3	57.500	19.167	10.0000**	0.0014
AB	3	15.000	5.000	2.6087	0.0997
Error	12	23.000	1.917		
Total	23	223.833			

* - Significant at 5 % probability level
** Significant at both 5% and 1% probability level.

APPENDIX 22

DAYS TO SILKING OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	31.750	15.875	1.0554	0.4865
Mulch (A)	1	160.167	160.167	10.6482	0.0825
Error	2	30.083	15.042		
Fertilizer (B)	3	63.667	21.222	11.1533*	0.0009
AB	3	11.500	3.833	2.0146	0.1657
Error	12	22.833	1.903		
Total	23	320.000			

APPENDIX 23

DAYS TO MATURITY OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	37.000	18.500	1.7344	0.3657
Mulch (A)	1	187.042	187.042	17.5352	0.0526
Error	2	21.333	10.667		
Fertilizer (B)	3	93.458	31.153	15.3630	0.0002
AB	3	79.458	26.486	13.0616	0.0004
Error	12	24.333	2.028		
Total	23	442.625			

APPENDIX 24

HEIGHT OF FIRST SEASON MAIZE AT MATURITY.

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	1007.526	503.763	0.7227	
Mulch (A)	1	7395.570	7395.570	10.6090	0.0827
Error	2	1394.201	697.100		
Fertilizer (B)	3	1524.964	508.321	17.2462**	0.0001
AB	3	958.805	319.602	10.8434**	0.0010
Error	12	353.693	29.474		
Total	23	12634.759			

APPENDIX 25

GRAIN YIELD OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	4561995.688	2280997.844	0.6590	
Mulch (A)	1	44139238.290	44139238.290	12.7526*	0.0503
Error	2	6922377.144	3461188.572		
Fertilizer (B)	3	14063271.511	4687757.170	18.4509**	0.0001
AB	3	14953068.893	4984356.298	19.6183**	0.0001
Error	12	3048807.038	254067.253		
Total	23	87688758.563			

* - Significant at 5% probability level
**- Significant at 1 % and 5% probability level

APPENDIX 26

TOTAL BIOMASS YIELD OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	15905183.608	7952591.804	0.9098	
Mulch (A)	1	204681051.325	204681051.325	23.4173	0.0401*
Error	2	17481172.408	8740586.204		
Fetilizer (B)	3	65278606.295	21759535.432	21.2889	0.0000**
AB	3	52774085.773	17591361.924	17.2109	0.0001**
Error	12	12265259.131	1022104.928		
Total	23	368385358.539			

APPENDIX 27

HARVEST INDEX OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.002	0.001	0.7087	
Mulch (A)	1	0.000	0.000	0.1189	
Error	2	0.003	0.002		
Fertilizer (B)	3	0.003	0.001	0.7115	
AB	3	0.001	0.000	0.2698	
Error	12	0.016	0.001		
Total	23	0.026			

APPENDIX 28

GRAIN N CONTENT OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	35.027	17.514	5.7164	0.1489
Mulch (A)	1	12136.503	12136.503	3961.3309	0.0003
Error	2	6.127	3.064		
Fertilizer (B)	3	4255.961	1418.654	400.8914	0.0000
AB	3	2109.521	703.174	198.7069	0.0000
Error	12	42.465	3.539		
Total	23	18585.606			

APPENDIX 29

STOVER N CONTENT OF FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	17.141	8.570	0.9177	
Mulch (A)	1	4134.375	4134.375	442.7119	0.0023
Error	2	18.677	9.339		
Fertilizer (B)	3	2899.268	966.423	823.1700	0.0000
AB	3	1420.828	473.609	403.4064	0.0000
Error	12	14.088	1.174		
Total	23	8504.378			

APPENDIX 30

TOTAL N UPTAKE BY FIRST SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	104.722	52.361	1.8764	0.3477
Factor A	1	30580.623	30580.623	1095.8682**	0.0009
Error	2	55.811	27.905		
Factor B	3	14149.738	4716.579	149.0021**	0.0000
AB	3	7171.711	2390.570	75.5208**	0.0000
Error	12	379.853	31.654		
Total	23	52442.458			

APPENDIX 31

GROWTH RATE OF SECOND SEASON MAIZE AT 3 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.010	0.005	0.1369	
Mulch (A)	1	0.694	0.694	18.8542*	0.0492
Error	2	0.074	0.037		
Fertilizer (B)	3	0.523	0.174	2.2960	0.1297
AB	3	0.173	0.058	0.7594	
Error	12	0.912	0.076		
Total	23	2.386			

* Significant at 5% level of probability

APPENDIX 32

GROWTH RATE OF SECOND SEASON MAIZE AT 5 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	1.161	0.581	0.4463	
Mulch (A)	1	7.605	7.605	5.8440	0.1368
Error	2	2.603	1.301		
Fertilizer (B)	3	0.676	0.225	0.4117	
AB	3	1.566	0.522	0.9531	
Error	12	6.573	0.548		
Total	23	20.184			

APPENDIX 33

GROWTH RATE OF SECOND SEASON MAIZE AT 7 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	61.672	30.836	4.5148	0.1813
Mulch (A)	1	981.377	981.377	143.6872**	0.0069
Error	2	13.660	6.830		
Fertilizer (B)	3	83.218	27.739	3.6580*	0.0442
AB	3	12.203	4.068	0.5364	
Error	12	90.999	7.583		
Total	23	1243.129			

APPENDIX 34

GROWTH RATE OF SECOND SEASON MAIZE AT 9 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	3.635	1.818	9.9880	0.0910
Mulch (A)	1	0.807	0.807	4.4327	0.1699
Error	2	0.364	0.182		
Fertilizer (B)	3	2.094	0.698	0.6806	
AB	3	0.064	0.021	0.0209	
Error	12	12.306	1.025		
Total	23	19.270			

APPENDIX 35

LEAF AREA INDEX OF SECOND SEASON MAIZE AT 3 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.012	0.006	0.2200	
Mulch (A)	1	0.115	0.115	4.3900	0.1711
Error	2	0.052	0.026		
Fertilizer (B)	3	0.019	0.006	1.7808	0.2043
AB	3	0.015	0.005	1.4515	0.2769
Error	12	0.042	0.004		
Total	23	0.255			

APPENDIX 36

LEAF AREA INDEX OF SECOND SEASON MAIZE AT 5 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.130	0.065	1.7868	0.3588
Mulch (A)	1	0.940	0.940	25.7887	0.0367
Error	2	0.073	0.036		
Fertilizer (B)	3	0.007	0.002	0.0961	
AB	3	0.073	0.024	1.0664	0.3997
Error	12	0.272	0.023		
Total	23	1.495			

APPENDIX 37

LEAF AREA INDEX OF SECOND SEASON MAIZE AT 7 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.264	0.132	5.8130	0.1468
Mulch (A)	1	0.365	0.365	16.0793	0.0569
Error	2	0.045	0.023		
Fertilizer (B)	3	0.057	0.019	2.2883	0.1306
AB	3	0.311	0.104	12.5283	0.0005
Error	12	0.099	0.008		
Total	23	1.142			

APPENDIX 38

LEAF AREA INDEX OF SECOND SEASON MAIZE AT 9 WEEKS AFTER SOWING

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.137	0.069	16.3611	0.0576
Mulch (A)	1	0.810	0.810	192.9375	0.0051
Error	2	0.008	0.004		
Fertilizer (B)	3	0.112	0.037	3.2396	0.0604
AB	3	0.210	0.070	6.0790	0.0093
Error	12	0.138	0.012		
Total	23	1.416			

APPENDIX 39

DAYS TO TASSELING OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	34.083	17.042	21.5263	0.0444
Mulch (A)	1	12.042	12.042	15.2105	0.0544*
Error	2	1.583	0.792		
Fertilizer (B)	3	6.125	2.042	2.1000	0.1537
AB	3	2.458	0.819	0.8429	
Error	12	11.667	0.972		
Total	23	67.958			

* - Significant at 5% level of probability

APPENDIX 40

DAYS TO SILK EMERGENCE OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	29.250	14.625	18.4737	0.0514
Mulch (A)	1	12.042	12.042	15.2105	0.0544*
Error	2	1.583	0.792		
Fertilizer (B)	3	3.458	1.153	0.6975	
AB	3	2.458	0.819	0.4958	
Error	12	19.833	1.653		
Total	23	68.625			

* - Significant at 5% level of probability

APPENDIX 41

DAYS TO MATURITY OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	31.083	15.542	53.2857	0.0184
Mulch (A)	1	32.667	32.667	112.0000**	0.0088
Error	2	0.583	0.292		
Fertilizer (B)	3	3.500	1.167	0.7119	
AB	3	8.333	2.778	1.6949	0.2209
Error	12	19.667	1.639		
Total	23	95.833			

** - Significant at both 5% and 1% level of probability

APPENDIX 42

HEIGHT OF SECOND SEASON MAIZE AT MATURITY

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	681.211	340.605	1.8668	0.3488
Mulch (A)	1	1076.021	1076.021	5.8974	0.1359
Error	2	364.911	182.455		
Fertilizer (B)	3	232.291	77.430	2.2283	0.1375
AB	3	140.811	46.937	1.3508	0.3045
Error	12	416.985	34.749		
Total	23	2912.230			

APPENDIX 43

GRAIN YIELD OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	350418.670	175209.335	3.8998	0.2041
Mulch (A)	1	13927654.406	13927654.406	310.0044**	0.0032
Error	2	89854.573	44927.286		
Fertilizer (B)	3	4273720.468	1424573.489	13.0535**	0.0004
AB	3	133750.988	377916.996	3.4629*	0.0510
Error	12	309597.128	109133.094		
Total	23	21084996.231			

* - Significant at 5% level of probability

** - Significant at both 5 % and 1% level of probability

APPENDIX 44

TOTAL BIOMASS OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	597106.510	298553.255	2.7462	0.2669
Mulch (A)	1	40167931.862	40167931.862	369.4751	0.0027**
Error	2	217432.432	108716.216		
Fertilizer (B)	3	29581443.351	9860481.117	38.9032	0.0000**
AB	3	4837241.160	1612413.720	6.3616	0.0079**
Error	12	3041546.408	253462.201		
Total	23	78442701.722			

** - Significant at both 5 % and 1% level of probability

APPENDIX 45

HARVEST INDEX OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.003	0.002	5.3362	0.1578
Mulch (A)	1	0.004	0.004	13.6360	0.0661
Error	2	0.001	0.000		
Fertilizer (B)	3	0.001	0.000	0.2746	
AB	3	0.003	0.001	1.0495	0.4063
Error	12	0.011	0.001		
Total	23	0.024			

APPENDIX 46

SOIL PH AT HARVESTING OF SECOND SEASON MAIZE

ANALYSIS OF VARIANCE TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Replication	2	0.011	0.005	0.8279	
Mulch (A)	1	0.531	0.531	81.2295	0.0121
Error	2	0.013	0.007		
Fertilizer (B)	3	0.062	0.021	15.0537	0.0002
AB	3	0.037	0.012	9.0903	0.0021
Error	12	0.016	0.001		
Total	23	0.671			

APPENDIX 47

Effect of nitrogen fertilizer on the growth rate of first planting maize

N rate (kg ha-[1])	Growth rate (cm week-1)			
	3 WAS	5 WAS	7 WAS	9 WAS
0	3.9	12.9	38.4	15.5
50	4.9	16.9	51.4	5.4
100	5.3	19.0	53.3	6.1
200	5.0	18.9	49.8	9.4
LSD 5%	0.6	3.0	8.3	5.7
CV%	10.0	15.5	14.9	54.5

APPENDIX 48

Effect of nitrogen on leaf area index of first planting maize

Kg N /	Leaf Area Index					
	3 WAS	4 WAS	5 WAS	6 WAS	8 WAS	9 WAS
0	0.2	0.5	0.9	1.2	1.2	1.1
50	0.3	0.7	1.2	1.4	1.5	1.4
100	0.3	0.7	1.2	1.5	1.5	1.5
200	0.3	0.7	1.3	1.6	1.6	1.6
LSD 5%	0.04	0.1	0.2	0.2	0.2	0.2
CV%	14.6	12.2	15.1	13.7	12.6	11.9

APPENDIX 49

Effect of nitrogen on the number of days to tasseling, silking, grain maturity and matured height of first season maize.

Treatment	Tasseling	Silking	Maturity	Height (cm)
0 kgN ha-1	49.2	53.7	88.5	151.5
50 kgN ha-1	46.3	50.2	83.8	162.3
100 kgN ha-1	45.2	49.3	84.5	171.5
200 kgN ha-1	45.7	50.8	83.7	170.3
LSD 5%	1.8	2.2	2.1	12.9
CV	3.3	3.8	2.1	6.8

APPENDIX 50

Effect of nitrogen fertilization on the nitrogen uptake of maize

N Rate (kg N/ha)	------Grain N------ (%)	(Kg/ha)	Stover N (Kg/ha)	Total N uptake (Kg/ha)
0	1.30	60.1	47.8	107.9
50	1.45	92.7	70.8	163.6
100	1.50	91.7	73.5	165.3
200	1.52	85.0	76.21	161.2
LSD 0.05	0.08	15.6	8.30	20.9
CV (%)	15.3	10.0	11.3	10.0

APPENDIX 51

Residual nitrogen effect on soil pH

N rate kg/ha	12 WAM	At 2 nd maize harvest
0	6.44	6.20
50	6.40	6.20
100	6.34	6.10
200	6.33	6.10
LSD 5%	0.04	0.04
CV	0.45	0.60

APPENDIX 52

Residual effect of nitrogen application on the growth rate and leaf area index of second planting maize at 7 weeks after sowing.

Nitrogen rate (kg ha-1)	Growth rate (cm week-)	Leaf area index
0	21.4	0.88
50	21.3	0.98
100	22.7	0.96
200	25.9	1.07
LSD 5%	3.2	0.12
CV %	11.9	10.50