THE USE OF ORGANIC MANURE SUPPLEMENTED WITH INORGANIC FERTILIZER IN CROP PRODUCTION IN THE NORTHERN GUINEA SAVANNA ZONE OF NIGERIA

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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The above declaration is confirmed.

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(Major Supervisor)

CERTIFICATION

This thesis titled "THE USE OF ORGANIC MANURE SUPPLEMENTED WITH INORGANIC FERTILIZER IN CROP PRODUCTION IN THE NORTHERN GUINEA SAVANNA ZONE OF NIGERIA"

by

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meets the regulation governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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Date 4/11/96

DEDICATION

To my mother, Martha Yaro, and her late sister Ladi

To my late father, Yaro Tagwai and members of my family,

for their understanding and support.

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ABSTRACT

Green house and field studies were carried out in the 1993 cropping season to evaluate the use of organic manure supplemented by inorganic fertilizer in the Northern Guinea Savanna Zone of Nigeria. The studies were carried out in Samaru (11° ll'N, 07° 38'E), Institute for Agricultural Research, Ahmadu Bello University, Zaria. The treatments consisted of factorial combinations of five rates of organic manure (0, 2.5, 5.0, 7.5 and lOtha^{-1}) and five levels of H.P.K. fertilizers ($H_0P_0K_0$; $^{H}40^{P}20^{K}20$' $^{N}80^{P}40^{K}40$- ^20^0^0 and $^{N}160^{P}80^{K}30$>' laid out in a randomized complete block design with three replications. Maize was used as the test crop in the twc experiments.

Maize shoot and root DMY, generally increased with increasing rates of organic manure and inorganic fertilizer. Organic manure increased shoot and root DMY up to 5.0t ha while increases due to inorganic fertilzier were linear and significant up to 160:80:80 Kgha^{-1} rate. The interaction effects, though not significant, showed that combination of 40:20:20 Kgha^{-1} and 2.5 tha^{-1} gave slightly higher shoot and root DMY than 120:60:60 or 160:80.80 Kgha^{-1} fertilizer alone by 56.6 and 58.4 percent, respectively.

In the field organic manure significantly (at P = 0.05) increased grain yield, 1000-grain weight, cob length, harvest index and shelling percentage, while stover yield, number of kernel per cob and cob diameter were not significantly affected. With inorganic fertilizer, grain yield and all other yield components were significantly increased. The interaction effects,

although not significant, show that plots receiving combination of 40:20:20 Kgha^{-1} and 2.5 tha^{-1} gave slightly higher grain yield than plots receiving 120:60:60 or 160:30:80 Kgha^{-1} alone. The percentage increases are 18.06 and 15.78 respectively.

Generally, nutrient concentrations in plant tissues from the Green house study tended to decrease with increasing rates of organic manure and inorganic fertilizer. The decreases were significant (at 5% level of significance) for some of the elements. Uptake values on the other hand tended to increase with increasing rate of organic manure and inorganic fertilizer. In the field, nutrient concentrations of the plant samples were significantly affected by organic manure, while values significantly (5% level) increased with increasing rates of inorganic fertilizer.

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CHAPTER ONE

1.0 INTRODUCTION

Most of the West African savanna soils, especially those north of latitude 7°N are low to very low in organic matter and plant nutrient especially N and P (Jones and Wild, 1975; Aina, 1979; Tian et al., 1993). The clay fraction is predominantly kaolinitic; consequently, these soils are generally low in cation exchange capacity (CEC), poorly buffered and are susceptible to rapid nutrient depletion with intensive farming, which is fast becoming the predominant system in the area because of pressure on land by other non-agricultural sectors of the economy and population explosion. Under this situation, the only feasible way of maintaining the fertility of these inherently poor soils is through the use of fertilizers. Although high crop yields can be obtained with judicious fertilizer use, the commodity is always not easily available to the poor-resource farmers because of high cost and poor distribution systems.

Further more, continuous use of high nitrogen fertilizer results in soil acidification (Jones, 1976).

With this situation, an integrated management approach which requires a combination of low chemical input and organic manure may be needed. This sytem may offer a good opportunity for the small scale farmers to maintain yields at reasonable and sustainable levels.

The beneficial effects of organic manure especially cattle dung in crop production have been emphasized by many workers (Lombin and Abdullahi, 1977; Miller and Mackenzie, 1978; Magdoff and Amadou, 1980; Klausner and Guest, 1981; Beauchamp, 1983; Xie

and Mackenzie, 1986; Montavalli et al., 1989). The results of work carried out in West African Savanna show that manures are as effective as mineral fertilizers and in some cases better for sustainable crop production (Obi, 1959; Dennison, 1961; Djokoto and Stephen, 1961; Pieri, 1971; Lombin and Abdullahi, 1977). Apart from their direct nutrient contribution, organic manures are known to improve soil physical properties (Biswas et al., 1964; Jenkinson and Johnston 1977; Aina, 1979, von Wistinghausen, 1979; Khaleel et al., 1981; Sharma, et al., 1987). Hartley, (1937) and Djokoto and Stephen, (1961) observed that Farm Yard Manure (FYM) had some specific effect that could not be provided by mineral fertilizers. Although improvement in soil physical properties and increased soil fauna activities may contribute, it would appear that the slow nutrient release plays a major role.

The application of manure and mineral fertilizer together will therefore, provide the immediate nutrient requirement for the early growth stages of crops while the supplemented organic manure will provide what is required during the later stages of growth. This system, particularly in the savanna has the additional advantage of buffering the soil against undesirable acidification and enhancing the availabiity of micronutrient (Heathcote, 1970).

The objectives of this study are:-

(i) To evaluate crop performance using available organic manure supplemented by inorganic fertilizer;

(ii) To determine a combination of low chemical input and organic manure that will give a reasonable and sustainable crop yield production in the savanna.

CHAPTER TWO

2.0 LITERATURE REVIEW

The role of organic manure especially cow dung and other livestock wastes in maintaining soil fertility for crop production is an age-long agricultural practice amongst the subsistence farmers in northern Nigeria. Many workers have shown that FYM can maintain soil fertility and productivity either alone or in combination with inorganic fertilizers (Agboola and Odeyemi, 1972; FAO, 1976; Agboola, 1982).

The role of organic manure in maintaining soil fertility varies with the source and rate of application. A review by Rauche (1987) showed that among all animal dung including cattle feedlot, swine manure and poultry manure, bovine dung was of greatest importance in improving or maintaining soil fertility. Addition of organic manures to the soil affects its physical, chemical and biological properties and hence its fertility.

2.1 NUTRIENT-SUPPLYING POWER OF ORGANIC MANURE

The chemical composition of organic manures and their ability to release nutrients for crop absorption are of great importance when developing recommendations for rates of manure application. Sommers et al., (1977), reported that recommendations for sewage sludge application rates on land should be based on the fertility values (N, P and K content) and on the concentrations of trace metals present in the sludge.

The main nutrients supplied are N, P, K, Ca, Mg and a host of micronutrients, although there is considerable variation in the percentage composition of organic manures, depending mainly

upon the source, handling and management (Hemingway, 1961). The nutrient contents (especially N, P and K) of FYM in many West African coutries have been summarized by Mokwunye (1980) and Cooke, (1975). Djokoto and Stephen (1961) working in Ghana showed that 5 - 10 tha^{-1} of Kra'al Manure would supply about 25 $Kgha^{-1}$ of N and 35 $Kgha^{-1}$ of K_2O. Cooke, (1975), reported that an average dressing of 10 tha^{-1} FYM would supply about 50 Kg Nha^{-1}, 30 Kg P_2O_5 ha^{-1} and 50 Kg K_2O ha^{-1}. Yayock and Awoniyi, (1974) observed that 1 tha^{-1} of cattle manure will supply about 13.33 Kg Nha^{-1}, 3.31 Kg Pha^{-1}, 22.40 Kg K_2O ha^{-1}, 10 Kg $Caha^{-1}$ and 5.51 Kg $Mgha^{-1}$.

Phosphorus is the dorminant plant-nutrient factor in FYM. Greenwood, (1949), reported that the phosphate equivalent of 1 ton of FYM is about 73 $Kgha^{-1}$ of single superphosphate. Nye (1953), working in the savanna region of northern Ghana, indicated a high negative phosphate and FYM interaction on a phosphate deficient site where the phosphate response was high, which suggests that the main effect of FYM was to supply phosphate.

Obi (1958) working in the northern Nigerian savanna, observed a negative phosphate and FYM interaction with as low as 2.25 tha^{-1} to 4.5 tha^{-1} and 56 to 112 $Kgha^{-1}$ of single superphosphate using cotton, groundnut, millet and sorghum as test crops. Kwakye (1980) also reported similar interaction in the north-eastern savanna zone of Ghana where he used a low rate of P_2O_5 (33 $Kgha^{-1}$) along with a fairly high rate of FYM (10 tha^{-1}). Numerous experiments conducted in West Africa using manures showed increases in crop yields (Nye, 1952; Djokoto and Stephen,

1961; Pieri, 1971; Poulain, 1976; Lombin and Abdullahi, 1977; Mokwunye and Stockinger, 1978, Kwakye, 1980).

Mokwunye (1980) and Powell (1986) have indicated that FYM is a major source of P and N. An application of 25 tha^{-1} of fresh cattle dung returns to the soil about 160 Kg N, 22 Kg P and 110 Kg K and also supplies Ca, Mg, S and micronutrients (Wild and Jones, 1988).

Singh and Balasubramanian (1978) have shown that continuous use of cow dung maintains a considerably high level of organic C in soils with a corresponding reduction in soil acidity and increased exchangeable cations and CEC.

Ajaikaye (1971) reported that 7.5 tons of cowdung would supply 85.5 Kg N, 23.0 Kg of P_2O_5 and 75 Kg of K_2O ha^{-1}. while Yayock and Awoniyi (1974), observed that 7.5 tha^{-1} of FYM would supply 82-100 KgN, 25 - 30 Kg P_2O_5 and 70-85 Kg K_2O ha^{-1}. Lombin and Abdullahi (1977) suggested that high yields could be sustained and soil fertility maintained with applications of about 7.5 tha^{-1} year, since at that rate the nutrient requirement of the crop is adequate.

Responses to application of 2 to 5 tha^{-1} of cattle dung on phosphate-deficient soils have been reported (Wild and Jones, 1988; Das et al., 1991). These responses have been attributed to dung phosphate content and probably because of its content of Ca, Mg, K and Na. Cattle dung is therefore, a source of all the plant nutrients, and by far the most important source of nutrients among the various animal dungs.

2.2 THE ROLE OF ORGANIC MANURE IN IMPROVING SOIL PHYSICAL PROPERTIES

Infiltration rate, water holding capacity and soil structure are among the soil physical properties that have been reported as being improved by increased levels of soil organic matter (Williams and Cooke, 1961; Hafez, 1974; Jones and Wild, 1975; Lund et al, 1975, Hansson, 1984). Bottom et al., (1986) observed a reduction in steady-state infiltration rate on fescue pasture after surface application of dairy manure. The infiltration rate was reduced by 27% for semi-solid manure (15-25% dry matter) and 16% for liquid manure (4-7% dry matter). One other important benefit of adding dung to soil would be the establishment of a more stable soil structure, which would increase water infiltration and movement. McCalla, (1943) attributed high infiltration rates of soils to changes in soil physical properties resulting from organic matter decomposition. Trouk and Sveistrup (1994) have reported rapid infiltration with aerated cattle slurry than fresh slurry. Neal (1939) showed that addition of green or animal manure increased infiltration from large storms by 6% of rainfall for each 18,000 $Kgha^{-1}$ of wet manure incorporated annually into fallow land.

The application of organic manure increases the organic matter content of the soil, by increasing the soil organic carbon (N'dayegamiye et al., 1989). Organic matter content especially affects the stability of the aggregate formed from the clay and loam particles. The degree of aggregation affects pore volume and pore size distribution, and hence infiltration capacity and soil moisture retention characteristic (De Ridder and Van Keulen

(1990). Adeoye (1985) reported that organic matter improves soil structure by promoting granulation, thus improving the aggregate stability which inturn results in reduced soil crustation and crust strength.

Soils with low organic matter content are easily compacted, compared with those with high organic matter content under similar climatic condition (Lal and Kang 1982). Recent reviews (Allison 1973; Schnitzer and Khan 1978), have emphasized the important role of organic matter in soil structure.

Biswas et al (1964) observed that increase in organic matter content due to a continuous application of FYM increased the percentage of water-stable aggregates and permeability for alluvial soils of northern India.

Crumb stability in arable soils can usually be increased if regular applications of FYM are given, though the amounts required may be very large. Annual application of 35 tha^{-1} for a century have made a measurable increase in crumb stability of the Rothamsted soil, increasing the proportion of water-stable crumbs over 0.5 mm in size from 25 to 55% on Broad balk, which is in continuous wheat, and from 54 to 90% on Barnfield in continuous root crops (Davies and Payne 1988). In Puerto Rico, addition of organic matter was observed to increase the structural stability of some ultisol (Escolar 1966); however, only negligible improvements in structure resulted from addition of even large quantities of FYM to sandy soils of Egypt (Abdou and Metwally, 1976) and to clayey vertisols in central India (Venkobarao et al., 1967). Davies and Payne, (1988) reported similar results.

Beneficial effects of organic matter dung or compost on the

macrostructure of the soil particularly soil compaction have been discussed by Charreau (1975), in Senegal. Hansson (1984) reported that the application of sewage sludge improved soil structure through improvement on the structural stability of the soil. Soane (1990) showed that increase in soil organic matter may reduce compactability by increasing resistance to deformation and/or by increasing elasticity. Chaney (1984) observed a highly significant correlation between aggregate stability and organic matter content. He observed that there was no other soil constitutent investigated that had a significant relationship with aggregate stability indicating that organic matter is mainly responsible for the stabilization of aggregates in the soil. Aina (1979), also reported that as a result of diminished soil organic matter, there was considerable reduction in soil aggregation (2.36 cm) from 85 to 17% aggregate stability (N-1) from 0.033 to 0.143, porosity (%) from 53.3 to 43.3, hydraulic conductivity ($cmhr^{-1}$) from 120.2 to 17.1 and increased bulk density (gcm^{-3}) from 1.24 to 1.56. Somerfeldt et al., (1988) observed that bulk density of the surface 0-15cm of soil decreased with increasing rates of manure application. Hafez (1974); Tiarks et al., (1974); and Ofori and Sanatana (1990) reported similar results.

Soil structure and pore-size distribution which are affected by the soil organic matter content, also influence water retention and availability to crops (Lal and Kang 1982). Favourable effects of organic matter content on water retention and availability have been reported for many tropical soils Pidgeon, 1972; Lal, 1979). Elliot (1975) reported that the

addition of sewage sludge increases the water holding capacity of Beltville silt loam soil. In India, Biswas and Ali (1967, 1969) reported that available water and water retention measured at any suction were consistently higher in soils of high than low organic matter content.

Increase in soil organic matter content generally brings about improvements in water-use efficiency, through its effects on decreasing losses due to water runoff, high water retention in the root zone and improvements in root proliferation and development, improved nutrition and better crop growth with the same inputs (Lal and Kang, 1982). Several researchers have reported increased water holding capacity (WHC) on a weight basis at both field and wilting point, with an increase in organic waste application rates (Klute and Jacob, 1949; Mays et al., 1973; Unger and Stewart, 1974; Gupta et al., 1977; Webber 1978; Kladivko and Nelson, 1979, Weil and Kroontje, 1979).

Bulk density have been reported to decrease with organic waste applications (Salter and Haworth, 1961; Tiarks et al., 1974). Kladivko and Nelson (1979) found a highly significant correlation between increased organic carbon induced by manure application and a lowering of bulk density. Similar results were cited from Rothamsted experiments plots by Jenkinson and Johnston (1977). The bulk density of soils from plots receiving only minerals fertilizers since 1852 was 1.52 g/cm^3 compared with a density of 1.29 g/cm^3 in plots amended with manure. Khaleel et al., (1981) have reported a significant linear relation between incrases in soil organic carbon due to waste application and percent reductions in bulk density. Gupta et al., (1977), also

observed that the bulk density of Huffard course sand, decreased linearly with addition of organic matter in sewage sludge. At application of 110 $mtha^{-1}$ year of poultry waste for five years to a Davidson clay loam soil, the bulk density was reduced from 1.11 gcm^{-3} to 0.78 gcm^{-3} (Weil and Kroontje, 1979).

Work on the effect of application of organic manure on the saturated hydraulic conductivity have been reported (Biswas and Khosla, 1971; Tiarks et al., 1974; Gupta et al., 1977; Weil and Kroontje, 1979). Because of increased porosity with organic matter addition, the saturated hydraulic conductivity (HC) is expected to increase (Khaleel et al., 1981). The saturated (HC) for a coarse sandy soil receiving 450 $mtha^{-1}$ $year^{-1}$ of sewage sludge increased by only 18% over the control (Gupta et al., 1977), whereas for a silt loam soil, the increase was up to 500% over control for feedlot manure applied at 415 $mtha^{-1}$ $year^{-1}$ for two years (Tiarks et al., 1974). Tiarks et al., (1974) found that after 2 years of manure application, the HC ranged from 0.2 to 52 $dsmm^{-1}$. Das et al., (1966) and Biswas et al., (1971) have reported decrease in hydraulic conductivity of the soil due to the application of organic manure.

2.3 THE ROLE OF ORGANIC MANURE IN IMPROVING CHEMICAL PROPERTIES OF THE SOIL

2.3.1 THE EFFECT OF ORGANIC MANURE ON THE CATION EXCHANGE CAPACITY (CEC) AND EXCHANGEABLE BASES

Most tropical soils have low activity clays which have low CEC. In these soils the contribution of organic matter to the exchange capacity may be very important. In his review, Pichot

(1971), pointed out that in tropical soils, whose clay fraction is dominated by kaolinite and Fe and Al oxides and hydroxides, soil organic matter content is the major factor influencing CEC. Fagbenro (1986), reported that the relative contribution of organic matter to CEC in Dokemeji teak plantation surface soil (0-8cm) is 88.5%. The CEC of an acidic silty loam soil has been reported to be high with FYM than with control or pig slurry (N'dayegamiye 1983). Sharma et al., (1990) showed that addition of 8 tha^{-1} of animal manure resulted in a significant increase in root CEC up to bloom. Bache and Heathcote (1969) showed that dung was the only treatment that significantly affected the CEC of the soil, when compared with ammonium sulphate and superphosphate treatments. Fauck et al., (1969) working in sefa, senegal, indicated that the exchange capacity of the soil dropped from 6.6 to 3.75 cmol Kg^{-1} of soil as a result of declined in organic matter. The important contribution of organic matter to the exchange capacity of savanna soils has been pointed out (Nye and Greenland, 1960; Ollat and Combeau, 1960; Fauck, 1963; Nye 1953; Hawkins and Brunt, 1965; Martin, 1970). Organic matter has been found to be significantly correlated in a positive manner with exchangeable bases such as Ca and Mg (Agboola and Corey, 1972). Bache and Heathcote (1969), reported the result of a 15-year experiment on the effect of cow dung and mineral fertilizers on soil properties and nutrient contents of cotton leaves. In the plots that received dung treatment, the percentage of carbon and N increased greatly. Dung was the only treatment that significantly affected the CEC of the soil and this is adequately explained by its effects on organic matter contents. Organic

matter readily complexes with heavy metals, so it can act as both source and sink for trace elements in the soil controlling to some extent their uptake by plants.

2.3.2 THE EFFECT OF ORGANIC MANURE ON SOIL pH

Increase in soil pH has been associated with organic manure application (Bache and Heathcote, 1969; Jones, 1976; Mugiwra, 1976; Wahab and Luzo-lopez, 1980). Miller et al., (1985) observed that application of 100 $mtha^{-1}$ of cattle manure in an incubation experiment increased the soil pH from 7 to 8. Work carried out by Agboola and Odeyemi (1972), at Ibadan, on an arable field which was regularly treated with FYM and NPK fertilizer for 18 years showed that the average value of the soil pH was 6.0 compared to 5.4 when only NPK fertilizers were used. Soil pH has been reported to increase with high levels of poultry manure (Artkinson et al., 1958; Page, 1866; Bache and Heathcote, 1969). Another study in a sandy loam soil showed that soil pH increased from 5.4 to 6.6 when 10t $acre^{-1}$ ($\simeq$ 25 tha^{-1}) of poultry manure were applied (Parkins et al., 1964). The pH values of the top 30cm of the soil in manure treated plots have been reported to be higher than those of mineral fertilizer check plots (Mugiwra, 1976). Bache and Heathcote (1969), reported that plots receiving dung treatments had significantly high soil pH and reduced Al and Mn concentrations.

2.3.3 THE EFFECT OF ORGANIC MANURE ON THE ORGANIC MATTER CONTENT OF THE SOIL

The savanna soils are generally low in organic matter content compared with soils of temperate region and forest zones

of West African (Nye and Greenland, 1960; Cooke 1975). De Ridder and van Keulen (1990) indicated that increasing soil organic matter content in cultivated soils in the semi-arid tropical zones of West Africa is tedious, since huge quantities of organic manure are required. Pichot et al., (1971) reported that after 18 years of annual application with 60 Kg N, 45 Kg P and 25 Kg K ha^{-1} organic C content increased from 2.5 to about 6.6 gKg^{-1} (i.e from 4.5 to 12 g organic matter Kg^{-1}). Similar conclusions follow from the results of an experiment with a rotation of millet and groundnut, started in 1972 in the north of Senegal with annual application of either chemical fertilizer alone (100kg NPK, 14-7-7 and 100kg N as urea) or in combination with 10 tha^{-1} of animal manure. In 1983, the soil in this experiment was analysed, showing that organic carbon content in the soils that had received manure was 0.3 gKg^{-1} higher in the upper 10cm and 0.15 gKg^{-1} in the 10-20cm layer than in the soil that had recieved chemical fertilizer alone. Jones and Wild (1975) and Cisse (1988) also reported that organic manure increases the soil organic matter content of the soil. Sommerfeldt et al., (1988) observed a significant increase in soil organic matter and total N content in the 0-3 cm depth as the level of manure application increased. N'dayegamiye and Cote, (1988) in a field study reported that the highest rates of FYM and Pig slurry increased the soil organic matter content. In a long-term experiment in Samaru, Jones (1971) showed that 12-15% of carbon and 24-31% of N were retained in the soil, when manure was applied compared to control. Bache and Heathcote (1969) and Dunham (1978) reported

an increase in the organic matter content of the soil when it was treated with cow dung. Feller and Ganry, (1982) reported that the amount of manure required to increase the organic carbon content of soil by 1 gkg^{-1} is 31.4 tha^{-1} assuming initial carbon content of 0.35 gkg^{-1}. To maintain this carbon content in subsequent years, annual applications of 6.4 tha^{-1} of animal manure are necessary.

2.4 THE ROLE OF ORGANIC MANURE ON BIOLOGICAL PROPERTIES OF THE SOIL

In the past, little importance had been accorded to the role played by manures in the biological activities of micro-organisms and their subsequent influence on maintenance of soil fertility and crop yield. The addition of manure provides the soil biosystem with a new energy source for organisms that is reflected in changes in microbiological population. Adebayo (1986), reported that cow dung encouraged the highest nodule, dry mass production and N-fixation in a local cowpea variety (Vigna unguiculata Cv. Ife Brown). N'dayegamiye and Augers (1990) observed that a positive interaction existed between the physical and biological properties of soils following long term application of manure. Soil microflora population (bacteria, fungi, actinomycetes, ammonifiers and Nitrifiers) are reported to be greatly improved by both application of cowdung and Pig slurry (N'dayegamiye and Cote, 1989). It has been reported that organic manures have some nematicidal properties. Mian and Rodriquez (1982) reported that soil amendment with oil cakes and poultry manure controlled Meloidogyne arenaria in green house squash, cucurbita pepo. In India, it has been reported that FYM

application alone or in combination with inorganic fertilizer supported greater population of bacteria and Actinomycetes (Sharma et al., 1983). Singh (1981), also reported that *Rhizoctonia, a root rot of gram caused by* R. bataticola was significantly controlled by the use of organic amendments.

2.5 EFFECT OF COMBINED APPLICATION OF ORGANIC MANURE AND INORGANIC FERTILIZER ON CROPS

Complementary use of organic manure and inorganic *fertilizers has proved to be a sound soil fertility management* strategy in many countries of the world. Work carried out in Japan on the utilitization of organic manure in rice production strongly advocates the supplementary use of organic manure and inorganic fertilizers in order to promote decomposition of the *organic manure (Egarva 1975).* Kamppaineu 1990) reported that combined applications of livestock manure and mineral fertilizers proved superior to organic manure alone. Asmus and Gortlitz (1986), also showed that combined application of FYM and mineral fertilizer increased yields and decreased uptake compared with FYM or mineral fertilizer alone, and that N from the mixed application was utilized more efficiently than mineral fertilizer alone.

In India, it has been established that using organic manure along with inorganic fertilizer under intensive agriculture, raised farmers yields by about 25% over and above that obtained using fertilizer alone.

In most parts of Africa, the general practice is to apply the FYM to a field once in every three or four years of continuous

cultivation, complementing this with annual application of low amounts of fertilizer especially N and P (Stephens, 1960; Djokoto and Stephens, 1961; Peat and Brown, 1962).

Le Mare, (1972) in a long-term study in Tanzania, reported that organic manure or ammonium sulphate fertilizer maintained and even improved cotton yield for six years, but a mixture of both manure and superphosphate maintained yields for nine years. Peat and Brown (1962) sharing the same view, recommended for cotton 15 tha^{-1} organic manure to be applied once every three years, but that the crop should be top dressed with about 12 kg N ha^{-1} annually at flowering.

The work of Richard (1967) in the Central African Republic as summarized by Mokwunye (1980) showed that satisfactory yields were maintained over eleven-year period by the application of FYM and NPK fertilizers.

Poulain (1976) in Mali also observed higher increases in yields of cotton, sorghum and groundnuts grown in rotation when NPK fertilizers were combined with organic manure, than when NPK fertilizers or organic manures was applied alone.

Ganry et al., (1974) reported that the addition of FYM significantly increased yield (+ 600 $Kgha^{-1}$) when applied in combination with 30 Kg N ha^{-1} and that in the absence of organic materials an additional 60 Kg N ha^{-1} would be required to produce the same yield. Roche (1970) obtained a linear yield increase up to a maximum of 2,720 Kg ha^{-1} with increasing N rates up to maximum rate of 200 Kg N ha^{-1}. However, at 160 and 200 $KgNha^{-1}$, the application of FYM raised yield by as much as 886 and 965 $Kgha^{-1}$ respectiely, and attaining a maxiumum yield of 3,130 $kgha^{-}$

^{1} with this FYM and fertilizer combination.

In Nigeria, Lombin and Abdullahi (1978) showed that 7.5 tha^{-1} of FYM applied in combination with 62.5 $Kgha^{-1}$ of ammonium sulphate increased the yield of grain sorghum than when either the ammonium sulphate or the FYM alone was applied alone. Agboola and Obigbesa (1975) working with Chinese Yam in South Western Nigeria reported that a combined application of 20 Kg N ha^{-1} gave much higher yields than applying either N or FYM alone. In the same report, it was shown that cowpea grown on a field which had been previously cropped continuously for ten years, yielded significantly better when P fertilizer was applied together with FYM than when either of them was applied alone. Bache and Heathcote (1969) arrived at a similar conclusion in a long-term fertility study in Samaru. Sulton et al., (1974) reported yield increases from plots treated with swine waste and inorganic fertilizers compared to the check plots.

2.6 CROP RESPONSES TO ORGANIC MANURE APPLICATION

Corn yield increases from the contribution of N in cattle manure have been documented by researchers, in Quebec (Miller and Mackenzie, 1978; Xie and Mackenzie, 1986); Vermont (Magdoff and Amadon, 1980); New York (Klausner and Guest, 1981); Ontario (Beauchamp, 1983); and Wisconsin (Montavalli et al., 1989). Bishop et al., (1964) and Dubetz et al., (1975), have shown that manures can be more effective than inorganic fertilizer in increasing crop yield. However, in other studies, N added in manure resulted in lower crop yield than N added in inorganic

fertilizer (Hoyt and Rice, 1977; Miller and Mackenzie, 1978).

Klausner and Guest, (1981) and Beauchamp (1983), have also reported that crop availability of N in manure is generally lower than N from inorganic fertilizer, mainly because of the slow release of organically-bonded N and the volatilization of NH_3 from surface applied manure. All the same, application of FYM has been observed to significantly increase over-all plant dry matter accummulation in pepper Cv. jubilankte (Cerna 1981).

Similarly, Haworth et al., (1966) obtained a high top growth of plant and a greater relative growth rate of potato tubers following application of FYM. The work of Asiegbu and Uzo (1984) also showed that increasing FYM rates enhance the yield components of onion and egg plant.

Application of sewage sludge has been found to increase the dry matter yield of forage crops, Eye grass (Lolium perenne and eye corn (Secale cereals) (Jaccobson and Willetti, 1986). Troed (1979) recommended rates of 8 - 10 tha^{-1} of manure for optimum corn response.

2.7 PROBLEM ASSOCIATED WITH HIGH APPLICATION OF ORGANIC MANURE

Too much manure used as fertilizer can cause problem in crop production. Mathers and Stewart (1970), Adriano et al., (1970) and Vitosh and Davis (1972) found accumulation of Nitrate in soil receiving heavy application of manure.

Indiscriminate application of organic manure particularly those containing heavy metals to soil give rise to accummulation of heavy metals in the top soil and in plant tissue and thus has adverse effects on plant growth and crop quality

(Jackson et al., 1975; Mitchell et al., 1978; Smilde, 1981). Mathers and Stewart (1970) and Vitosh and Davies (1972) also found accummulation of salts which are detrimented to plant growth with heavy application of organic manure.

Forage quality has been reported to be impaired by heavy application of organic manure (Lund et al, 1975; Jackson, et al 1975; Mitchell, et al., 1978; Smilde 1981). Miller et al., (1985), reported that the toxicities of Fe and especially Mn along with other trace metals associated with the Mn and Fe oxides in soils may result from high rates of organic manure addition to soil where reducing condition may persist for sometime. Weil and Kroontje (1979) also showed that application of poultry manure to soil at rates exceeding 20 tha^{-1} can release phytotoxic quantities of NH_3, NO_3 and salts. These substances may have detrimetal effect on soil micro-organisms responsible for the mineralization processes. Shortall and Liebhart, (1975) reported an increase in soil salinity and reduction in the yield of corn on application of 134 tha^{-1} of cattle manure as a result of high chlorides which were found to be the major constituents of salts in the cattle manure. This emphasizes the importance of using optimum rates of cow dung especially if found to have high salt content.

2.8 PROBLEM OF AVAILABILITY OF ORGANIC MANURE

Owing to widespread of infestation of tsetsefly, animal husbandry is presently confined to the savanna areas. In Nigeria, for example, 80% of the livestock are confined to the north (Nigerian savanna). Adequate statistics on animal

population in the region are available, but there is a serious lack of reliable data for calculating the potential dung production. There are however, severe limitations and unless these constraints are seriously addressed, most of the nutrients sources will continue to be wasted. These constraints are:-

(i) nomadic and semi nomadic systems of livestock management, do not allow easy collection.

(ii) animal size and poor feeding;

(iii) transportation and handling costs;

(iv) methods of storage and application.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1.0 GREEN HOUSE EXPERIMENTS

3.1.1 LOCATION-SITE DESCRIPTION AND HISTORY

The soil samples used for the green house experiment were collected from the Institute for Agricultural Research farm at Samaru (Latitude 11^{o} 11'N and longitude 7^{o} 38'E) in the Northern guinea Savanna Ecological Zones (Keay, 1958). The soils are developed from drift sand overlying basement complex (Klinkeaberg and Higgins, 1968) and classified as Alfisols (Awujoola, 1979). The mean annual rainfall is about 1000mm received in 130-150 days from May to September. Global rediation is evenly distributed throughout the year, ranging from 440 $calcm^{-2}$ day^{-1} in August to 550 $calcm^{-2}$ day^{-1} in April and May, (Kowal 1972). The field is fairly flat and had been under fallow for two years prior to the conduct of the experiment.

3.1.2 SOIL SAMPLING METHODS

Twenty cores were taken from $15m^2$ area of 0-15cm depth, from the field. The samples were bulked, mixed and sub-sampled. These were air dried by spreading them on polythene bags under a shade. After drying, the clods were broken and sieved through a 2-mm sieve. Subsamples were removed and stored in polythene bottles for routine chemical and physical analyses.

3.1.3 ORGANIC MANURE COLLECTION AND ITS PREPARATION

The organic manure used for the experiment was cowdung (dry weight bases). The dung was collected from cattle pen of the

College of Agriculture, Samaru, Zaria. The dried dungs were collected into polythene bags/sacks and spread for further drying. The dried dung was sieved through 10-mm sieve, sub samples were taken and stored for chemical analysis.

3.1.4 TREATMENTS, DESIGN AND CULTURAL PRACTICES

The treatments in this experiment were five levels of inorganic fertilizers (where the subscripts refer to rates in $Kgha^{-1}$):

$N_o P_o K_o$ - No fertilizer (Fo)

$N_{40} P_{20} K_{20}$ regarded as low rate (F_1)

$N_{80} P_{40} K_{40}$ regarded as medium rate (F_2)

$N_{120} P_{60} K_{60}$ regarded as high rate (F_3)

$N_{160} P_{80} K_{80}$ regarded as very high rate (F_4) and

five levels of organic manure:-

0 tha^{-1} - no manure (Mo)

2.5 tha^{-1} (i.e 25% of the 100% optimum rate (m_1)

5.0 tha^{-1} (i.e 50% of the 100% optimum rate (M_2)

7.5 tha^{-1} (i.e 75% of the 100% optimum rate (M_3)

10.0 tha^{-1} (i.e optimum of 100% (M_4).

where, N was supplied as urea

P was supplied as single superphosphate

K was supplied as muriate of potash.

The inorganic fertilizer and organic manure were combined to give twenty-five treatments combinations as follows:-

1. $F_o M_o$
2. $F_o M_1$
3. $F_o M_2$

4. $F_o M_3$
5. $F_o M_4$
6. $F_1 M_1$
7. $F_1 M_2$
8. $F_1 M_3$
9. $F_1 M_4$
10. $F_1 M_5$
11. $F_2 M_o$
12. $F_2 M_1$
13. $F_2 M_2$
14. $F_2 M_3$
15. $F_2 M_4$
16. $F_3 M_0$
17. $F_3 M_1$
18. $F_3 M_2$
19. $F_3 M_3$
20. $F_3 M_4$
21. $F_4 M_o$
22. $F_4 M_1$
23. $F_4 M_2$
24. $F_4 M_3$
25. $F_4 M_4$

The twenty-five treatments combinations were allocated randomly within a block and replicated three times giving rise to seventy-five plots (pots). The design of the experiment was therefore a randomized complete block design. Four kilogram of the sieved soil were weighed into seventy-five plastic pots of

five-kilogram capacity. The dung and superphosphate fertilizer were mixed thoroughly with the soil, potted and incubated for a period of three weeks. During incubation the pots were watered to keep the soil at field capacity. The inorganic fertilizers, urea and muriate of potash were applied in solid form, one week after planting. The Nitrogen was applied in split doses, $^1/_2$ at one week after planting and second dose at four weeks after planting.

3.1.5 PLANTING

At the end of the three-week incubation period, eight seeds of maize (variety DMR EMS-Y) were planted per pot. These were thinned to five stands per pot, one week after planting.

3.1.6 OBSERVATION TAKEN DURING EXPERIMENT

Beginning from the fourtheenth day after planting, weekly plant height (cm) was taken up to the 6th week. Plant height was measured from the soil surface to the whorl using a meter rule.

3.1.7 HARVESTING

The plants were harvested after six weeks of growth in the green house. Each pot was harvested by cutting the plants at soil level. The plant shoots were washed thoroughly with distilled water and put into labelled envelopes. The roots were harvested by emptying the contents of each pot on a polythene sheet and carefully removing the roots. The harvested roots were also washed with water and rinsed with distilled water. All samples were dried for two days in an oven set at 65^{o}C. The dry weight were taken at the end of the two days.

The dried plant shoots and roots were ground in a stainless steel, Thomas Wiley Mill for chemical analysis.

3.1.8 SOIL ANALYSIS

The soil samples were analysed for particle size by the standard hydrometer method (Day, 1965); soil pH in 1:2.5 soil:water and 1:2.5 soil:0.01M $CaCl_2$ suspensions, with a glass electrode pH meter (McClean 1982); organic carbon by dichromate digestion method (Walkley and Black, 1934), available P was extracted by Bray-1 method (Kundsen 1980) and P in solution was determined by the molybdate blue colour method (Murphy and Riley 1962); Total nitrogen by the semi-micro Kjeldahl method (Bremner, 1960), exchangeable bases were determined in a neutral 1N NH_4OAc. Potassium and Na were determined in the extract by flame photometry while Ca and Mg were determined by Perkin Elmer (Model 403) atomic absorption spectrophotometer. Exchange acidity was determined by shaking with 1N KCl and titrating with 0.5N NaOH (Juo, 1979), cation exchange capacity was determined by summation. Detailed of the analytical procedures are as described by Juo (1979).

3.1.9 PLANT AND ORGANIC MANURE ANALYSIS

The plant samples and the dung were analysed for N,P,K Ca, Mg, Zn, Cu, Fe and Mn using procedures described by Juo (1979). Nitrogen was determined by wet ashing; phosphorus was determined colorimetrically with the spectophotometer, while the flame photometer was used to determine K and the atomic adsorption spectophotometer for Ca, Mg, Mn, Cu, Fe and Zn.

3.1.10 STATISTICAL ANALYSIS

Analysis of variance followed by least significant difference (LSD) tests for means separation were used to compare treatments effects. These were computed using the Computer of the Institute for Agricultural Research.

3.2.0 FIELD EXPERIMENT

3.2.1 SITE DESCRIPTION AND HISTORY

This is the same as that used for green house experiment.

3.2.2 TREATMENTS, DESIGN AND CULTURAL PRACTICES

The treatments, treatment combinations and design are the same as that of the green house experiment.

The land was ploughed, harrowed and ridged. Plot sizes were 6m x 4m, ($24m^2$). Seventy-five plots, each 6m x 4m with a discard of 1m between plots were marked out, using measuring tape and wooden pegs.

3.2.3 ORGANIC MANURE APPLICATION

The ridges were scattered and dung applied and worked in after which the ridges made up again.

3.2.4 PLANTING

Maize variety grains, DMR EMS-Y, were planted at 75 cm between and 25 cm within row-spacing giving a plant population of about 53,000 plants ha^{-1}. Three seeds were planted per hole, which was later thinned down to one stand per hole two weeks after planting. Plant was done in June, 1993.

3.2.5 FERTILIZER APPLICATION

The different fertilizer treatments were applied two weeks after planting by band application. The N was split into two doses. The first half was applied with the P and K at the two-week after planting, while the 2nd half was applied at six weeks after planting.

3.2.6 WEEDING

The crops were weeded two times before harvest. The first weeding was carried out in about three weeks after planting, while the second weeding was done at about six weeks after planting. Moulding up of the soil was done, one week after the second weeding. The weeding and moulding up were done manually using hoe.

3.2.7 OBSERVATION AND MEASUREMENTS

Plant height was measured at two weeks interval beginning from forty-two days after planting. Ten plants were tagged from each plot (five each from the two centre rows). The height was measured from the soil surface to the whorl using a wooden rule.

3.2.8 SOIL AND PLANT SAMPLING

Maize earleaf at 50% silking were taken from ten stands in the two inner rows in each plot. Samples were washed with water and rinsed in distilled water, enveloped and dried at 65^{o}C for two days in an electric oven.

The dried samples were ground and stored for nutrient analysis. Soil sampling was same as for green house experiment.

3.2.9 SOIL AND PLANT ANALYSIS

Soil and plant analysis were same as for green house experiment.

3.2.10 HARVESTING

The maize cobs were harvested when they were fully matured and had started to dry. Harvesting started at the end of November, 1993. The two inner rows were harvested as the net plot. The cobs were further sun-dried for some days after which the length, cob diameter, number of kernels per cob and threshing done. The grains were weighed (at about 15% moisture content) and thousand grains were counted out and weighed. The stover from the net plots were weighed and later ground for analysis.

3.2.11 STATISTICAL ANALYSIS

The statistical analysis was the same as for the green house experiment.

RESULTS

4.1 Properties of soil and Cow dung used in the Study

The physico-chemical characteristics of the soil at the experimental site are shown in Table 1. The results showed soil pH measured in water and in salt solution (0.01m $CaCl_2$) as 5.80 and 5.30 respectively. The pH levels were within the optimal range for most crops in the tropics (Singh and Balasubramian, 1979). The organic carbon content of 10.50 $Kgha^{-1}$ is very close to value obtained by Jones and Wild (1975), in the Nigerian Guinea Savanna soil. The total N (0.8 gkg^{-1}) was also low but fall within values reported for the Northern Guinea Savanna

(Jones and Wild, 1975). Available P is below the critical values of 13.5-17.5 ppm suggested for savanna soils (Moehansyah, 1977). The cation exchange capacity value of 4.80 cmol Kg^{-1} is low and this may be relatd to the low pH and preponderance of kaolinitic clays in the soil. The exchangeable bases were generally low but quite characteristic of the West African Savanna soils (Lombin, 1979). The micronutrient content of the soil were generally within the range reported for the savanna zone (Lombin 1981). The soil texture was sandy loam with clay content of 170, silt content of 130 and sand of 700 gkg^{-1}.

The chemical contents of the cow dung used for the experiment are shown in Table 2. The result showed that pH of the dung was 8.6 for water and the salt solution (0.01m $CaCl_2$). This probably explains the ameliorating effects of soil acidity by organic manure application (Jones, 1976).

The nutrient content depict K content being slightly higher than N content. The macronutrient content in the cattle manure are within the range reported in the Nigeria Guinea Savanna (Yayock and Awoniyi, 1974).

Micronutrient content in the cow dung, showed that Fe content was higher than all other micronutrients in the dung. The values of the micronutrient in the cow dung agrees with those reported by Saminu (1989) in the same study area.

Table 1: Some physico-Chemical properties of the soil used

Properties	
pH	
1:2.5 W/v water	5.80
1:2.5 W/v 0.01M$CaCl_2$	5.30
Organic carbon (gKg^{-1})	10.50
Total N (gKg^{-1})	0.80
Available P ($mgKg^{-1}$)	4.10
CEC ($Cmol\ Kg^{-1}$)	4.80
Exchangeable Cations	
Ca ($cmol\ Kg^{-1}$)	2.56
Mg ($cmol\ Kg^{-1}$)	0.60
Na ($cmol\ Kg^{-1}$)	0.11
K ($cmol\ Kg^{-1}$)	0.23
Micronutrients	
Fe ($mg\ Kg^{-1}$)	56
Mn ($mg\ Kg^{-1}$)	12
Cu ($mg\ Kg^{-1}$)	0.5
Zn ($mg\ Kg^{-1}$)	0.52
Mechanical analysis	
Sand ($g\ Kg^{-1}$)	700
Silt ($g\ Kg^{-1}$)	130
Clay ($g\ Kg^{-1}$)	170

Table 2: Analysis of the organic manure used for the two experiments

Measurement	Value
pH	
1:2.5 W/v Water	8.6
1:2.5 W/v 0.01M$CaClo_2$	8.6
Nutrien Content	
Total N (gKg^{-1})	14.00
Available p ($g\ Kg^{-1}$)	4.06
K ($g\ Kg^{-1}$)	15.20
Ca ($g\ Kg^{-1}$)	9.92
Mg ($g\ Kg^{-1}$)	4.62
Fe ($mgKg^{-1}$)	475
Mn ($mgKg^{-1}$)	315
Zn ($mgKg^{-1}$)	215
Cu ($mgKg^{-1}$)	70
Organic C ($g\ Kg^{-1}$)	20.05
C:N ratio	1.43
C:P ratio	5.01

4.2 GREEN HOUSE

4.2.1 EFFECT OF ORGANIC MANURE AND INORANIC FERTILIZER ON MAIZE SHOOT AND ROOT DRY MATTER YIELDS (gm Pot^{-1})

The effect of organic manure and inorganic fertilizer on maize shoot and root dry matter yields (DMY) is shown in Table 3. Generally, both shoot and root DMY, significantly increased with increasing organic manure rates. Values were significantly higher than the control. The 10 tha^{-1} manure rate gave the highest DMY of 22.36 and 6.13 g/pot for shoot and root, respectively. These values were however, not significantly different from treatment receiving 7.5 and 5.0 tha^{-1} manure rate for both shoot and root.

Table 3: Effect of organic manure and inorganic fertilizer on maize Dry matter yield (gm/pot)

Dung Rate (tha^{-1})	Shoots	Roots
0	7.80	3.06
2.5	12.82	4.02
5.0	16.02	4.61
7.5	17.35	4.99
10.0	22.36	6.13
LSD (0.05)	2.690	0.996
Fertilizer Rate ($Kgha^{-1}$)		
0:0:0	13.02	3.66
40:20:20	15.82	4.87
80:40:40	16.24	5.02
120:60:60	15.49	4.60
160:80:80	15.76	4.66
LSD 0.05	2.690	0.996
D x F	ns	ns

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With inorganic fertilizer, among the different rates values were not signifiacntly different for both shoot and root DMY, but were significantly higher than the control. For both shoot and root DMY, values generally increased with increasing fertilizers rates up to 80:40:40 $Kgha^{-1}$ rates, beyond which values slightly decreased. Shoot DMY at 5.0 tha^{-1} rate was similar to the value obtained at the 80:40:40 $Kgha^{-1}$ fertilizer, while for the root DMY, it was the 7.5 tha^{-1} rate manure that gave the same yield values at 80:40:40 $Kgha^{-1}$.

The interaction effects, though not significant, shows that application of organic manure and inorganic fertilizer at all combinations generally increased both shoot and root DMY (Table 4 and 5). Manure application in the absence of fertilizer increased DMY up to the 10 tha^{-1} rate and the increase was 228% and 164% higher for shoot and root respectively than with the control. The 160:80:80 $kgha^{-1}$ + 10t ha^{-1} fertilizer and manure combination gave the highest DMY for shoot and this value is only 5% higher than when 80:40.40 + 10t ha^{-1} manure are applied. The 40:20:20 $kgha^{-1}$ + 2.5t ha^{-1} combination gave slightly higher shoot and root DMY than the value at 120:60.60 or 160:80:80 $Kgha^{-1}$ alone. The percentagbe increase in shoot and root DMY at 40:20:20 $Kgha^{-1}$ + 2.5t ha^{-1} rate over 120:60:60, and 160:80:80 $Kgha^{-1}$ rates alone are 56.6% and 58.4% respectively.

Table 4: Interaction between organic manure and inorganic fertilizer on maize shoot Dry matter yield (g pot^{-1})

Ferilizer Rates (Kg ha^{-1})	Dung Rates (t ha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0.0	6.12	12.39	11.98	14.51	20.12	13.02
40:20.20	7.43	14.77	16.41	19.75	20.82	15.84
80:40.40	8.07	12.86	16.46	20.23	23.56	16.24
120:60.60	9.43	12.72	16.80	17.15	22.35	15.69
160:80.80	7.93	12.35	18.46	15.13	24.94	15.76
Means	7.80	14.44	16.02	17.35	22.36	
LSD (0.05)			16.343			
SE (±)			3.665			

Table 5: Interaction between organic manure and fertilizer on maize root Dry matter yield (gpot^{-1})

Ferilizer Rates (Kg ha^{-1})	Dung Rates (t ha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0.0	1.93	4.30	3.15	3.81	5.10	3.66
40:20.20	2.92	4.80	5.13	6.14	5.17	4.85
80:40.40	3.51	3.53	4.65	5.80	7.56	5.01
120:60.60	3.15	3.37	4.77	5.17	6.56	4.60
160:80.80	3.71	3.90	5.34	4.05	6.29	4.66
Means	3.04	4.00	4.61	4.99	6.14	
LSD (0.05)			6.344			
SE (±)			1.355			

4.2.2 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON PLANT HEIGHT (cm)

The effect of organic manure and inorganic fertilizer on plant height is shown in Table 6. Generally plant height increased with increasing rates of both organic and inorganic fertilizer. Increases due to organic manure application were significant at all stages of measurements except at 14 DAP. At 28 and 35 DAP, increases due to application of 10 tha^{-1} manure were significantly higher than at 7.5 and 5.0 tha^{-1}, which did not differ significantly.

At 14 and 21 DAP addition of organic fertilizer even at 40:20:20 $Kgha^{-1}$ significantly increased plant height, whereas at 28 and 35 DAP, inorganic manure did not significantly affect plant height.

There was a significant interaction between the organic manure and inorganic fertilizer on maize plant height at 14 DAP (Table 7). At 0t ha^{-1}, increasing inorganic fertilizer rates increased plant height significantly. Plants receiving 80:40:40 $Kgha^{-1}$ rate were significantly taller than those at 0:0:0 and 40:20:20 $Kgha^{-1}$. At 2.5t ha^{-1} rate, increasing fertilizer levels did significantly affect plant height, while at 5.0 tha^{-1} rate, plants at 0:0:0 $Kgha^{-1}$, were significantly taller than those at all other fertilizer rates. At 7.5 tha^{-1} rate, value at 160:80:80 $Kgha^{-1}$ was significantly lower than values at all other fertilizer rates. Increasing fertilizer rates did not significantly affect plant height at 10 tha^{-1} rate. Similarly, at the different inorganic fertilizer rates, plant height increased with increasing rates of organic manure. At no

fertilizer, value at 5.0t ha^{-1} was significantly higher than values at 0, 7.5 and 10 tha^{-1} rates. At 40:20:20 and 120:60:60 $Kgha^{-1}$ rates, organic manure did not significantly affect height. At 80:40:40 $Kgha^{-1}$, value at 0 tha^{-1} rate were significantly higher than value at 5.0 tha^{-1} rate. While at 160:80:80 $Kgha^{-1}$ rate value at 7.5 tha^{-1} was significantly lower than values at all other organic manure rates.

Table 6: Effects of organic manure and inorgnic fertilizers on maize plant Height (cm)

Dung Rates (tha^{-1})	Plant Height in (cm)			
	DAP			
	14	21	28	35
0	30.49	40.07	48.89	52.80
2.5	31.96	45.53	57.47	61.17
5.0	32.70	45.53	59.10	67.90
7.5	29.62	45.61	59.11	68.57
10.0	31.16	45.80	64.90	75.08
LSD	2.736	3.786	3.404	4.064
Fertilizer Rates ($Kgha^{-1}$)				
0:0:0	30.76	40.95	55.23	62.49
40:20:20	32.50	45.55	58.45	63.02
80:40:40	32.50	45.76	58.77	64.86
120:60:60	31.10	45.28	59.21	66.06
160:80:80	30.68	42.00	57.81	65.09
LSD (0.05)	2.736	3.986	3.404	4.664
D & F	6.120	NS	NS	NS

Table 7: Interaction between organic manure and inorganic fertilizer on maize plant height at 14 DAP (cm)

Fertilizer Rate Kgha-1	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0.0	24.52	33.31	39.07	28.46	28.45	30.76
40:20.20	28.67	33.77	32.57	33.09	34.39	32.50
80:40.40	35.15	29.91	28.68	31.95	31.81	31.50
120:60.60	29.70	31.39	32.22	31.08	31.10	31.10
160:80:80	34.42	31.41	30.96	23.51	30.04	30.68
Means	30.49	31.96	32.70	29.62	31.16	
LSD (0.05)	6.120					
(SE (±)	3.723					

4.2.3 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE SHOOT NUTRIENT CONCENTRATION

The effect of organic manure and inorganic fertilizer on nutrient concentrtions in maize shoot are shown in Table 8. Phosphorus and K values tended to increase with increasing rates of manure and fertilizer, while the reverse was the case with N, Ca, Mg, Zn, Fe, and Cu. For N concentration, values were not significantly different among 0, 2.5 and 5.0 tha^{-1} manure rates. Between 7.5 and 10 tha^{-1} rates, there were no differences but N values at these rtes were significantly higher than values at 0, 2.5 and 5.0 tha^{-1} manure rates. With inorganic fertilizers, N values were significantly higher in plots without inorganic fertilizers than in plots that received the various rates of fertilizers.

Organic manure did not significantly affect P and K concentrations in the shoot. With inorganic fertilizer, P and K concentrations were significantly lower in plots without fertiizer than plots receiving the various rates of fertilizers.

Ca and Mg concentrations in maize shoot significantly decreased with increasing rates of organic manure. Value at 0 tha^{-1} rate was significantly highere than values at 7.5 and 10 tha^{-1} manure rates. With fertilizer, Ca and Mg concentrations tended to decrease with increasing fertilizer rates. Values were significantly higher in plots without fertilizer than in plots that received 160:80:80 $Kgha^{-1}$ fertilizer.

Zn, Mn, Fe and Cu concentrations in the shoot significantly decreased with increasing organic manure rates. Zn and Mn concentrations were significantly higher at 0, 2.5 and 5.0 tha^{-1}

Table 8: Effect of organic manure and inorganic fertilizer on maize shoot nutrient element concentration

Dung Rate (tha^{-1})	Nutrient element concentration								
	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	<---------- (gKg-1) -------x---------] (MgKg)--------->								
0	4.91	1.02	2.09	4.50	2.18	136.3	80.5	124.7	4.00
2.5	4.79	1.05	2.95	4.15	1.93	122.5	80.1	190.7	3.53
5.0	4.71	1.20	2.84	4.00	2.07	116.4	73.3	120.0	2.72
7.5	6.21	1.14	2.98	3.70	2.00	132.8	67.2	110.0	1.85
10.0	6.88	1.17	2.95	4.01	2.14	128.3	64.9	128.7	3.85
LSD (0.05)	0.581	0.188	0.135	0.279	0.148	10.07	9.80	32.01	3.134
Fertilzer Rate ($Kgha^{-1}$)									
0:0:0	6.57	0.93	2.86	4.27	2.24	134.8	81.2	164.7	4.15
40:20:20	5.76	1.07	2.95	4.16	2.07	130.5	80.1	170.0	1.22
80:40:40	5.55	1.17	3.02	4.08	2.05	125.5	76.7	152.7	2.77
120:60:60	4.55	1.16	3.01	4.07	2.02	125.6	67.9	122.0	6.95
160:80:80	5.55	1.30	3.07	3.78	1.94	122.1	61.1	124.7	2.86
LSD (0.05)	0.581	0.188	0.135	0.279	0.148	10.07	9.80	32.01	3.134
D x F	NS	NS	NS	0.62	0.332	NS	21.92	70.64	7.007

rates than the values at 7.5 and 10 tha^{-1}. For Fe concentration, value from plots without organic manure was significantly hi[illegible] that plots receiving the various organic manure rates, while Cu concentration in the shoot was not significantly affected by organic manure. Inorganic fertilizer did not significantly decreased Zn concentration in the shoot, but Mn, Fe and Cu concentrations significantly decreased with increasing fertilizer rates, with values at 0:0:0 and 40:20:20 $Kgha^{-1}$ rates being significantly higher than values at 120:60:60 and 160:80:80 $Kgha^{-1}$ fertilizer rates.

The interaction effects were significant for the concentrations of Ca, Mg, Mn, Fe and Cu (tables 9, 10, 11, 12 and 13). Shoot Ca concentration at 0t ha^{-1} manure rate, was not significantly affected by inorgnaic fertilizer application (Table 9), while at 2.5 tha^{-1}, values at 80:40.40 $Kgha^{-1}$ and 120:60:60 $Kgha^{-1}$ rates were significantly higher than value at 160:80:80 $Kgha^{-1}$. At 5.0 tha^{-1} value at 160:30:30 $Kgha^{-1}$ was significantly lower than value at 0:0:0 $Kgha^{-1}$ rate, while at 7.5 and 10 tha^{-1} rates, value at 40:20:20 $Kgha^{-1}$ rate, was significantly higher than values at the other fertilizer rates. Similarly, at no fertilizer, values were singificant even at 2.5 tha^{-1} organic manure rate, while at 40:20:20 $Kgha^{-1}$ rate, value at 10 tha^{-1} rate was significantly higher than values at all the other organic manure rates. At 80:40.40 and 120:60.60 $Kgha^{-1}$, values at 0 and 2.5t ha^{-1} rates were significantly higher than values at 7.5 and 10 tha^{-1} rates. At 160:80:80 $Kgha^{-1}$, value at 0 tha^{-1} rate was significantly higher than values at all other organic manure rates. For shoot Mg concentration (Table 10) at 0 tha^{-1}

rate, values were not significant among the fertilizer rates, but were significantly higher than the control. At 2.5 tha^{-1}, values at 80:40:40 and 120:60:60 $Kgha^{-1}$ rates were significantly higher than value at 160:80:80 $Kgha^{-1}$, while at 5.0 tha^{-1} values at 0:0:0 $Kgha^{-1}$ were significantly higher than all other fertilizer rates. At 7.5 and 10 tha^{-1} rates, values at 0:0:0 and 40:20:20 $Kgha^{-1}$ were singificantly higher than values at 120:60:60 and 160:80:80K gha^{-1} rates.

At no fertilizer, Mg values at 5.0 and 10t ha^{-1} were significantly higher than values at 0 and 2.5t ha^{-1} rate, while at 40:20:20 $Kgha^{-1}$, value at 10 tha^{-1} rate, was significantly higher than values at 2.5 and 5.0 tha^{-1} rates. At 80:40:40 $Kgha^{-1}$, value at 0 tha^{-1} rate was significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates, value at 7.5 tha^{-1} rate was significantly lower than value at 0 tha^{-1} rate. For Mn concentration (Table 11), at 0 tha^{-1} rate values at 80:40:40 and 120:60:60 $Kgha^{-1}$ rate were significantly higher than value at 160:80:80 $Kgha^{-1}$ rate, while at 2.5 tha^{-1}, value at 0:0:0 and 80:40:40 $Kgha^{-1}$ were significantly higher than values at 40:20:20, 120:60:60 and 160:80:80 $Kgha^{-1}$ rates. At 5.0 tha^{-1}, value at 0:0:0 $Kgha^{-1}$, was significantly higher than values at all other fertilizer rates whereas at 7.5 tha^{-1} rates fertilizer did not significantly affect Mn concentration in the shoot. At 10 tha^{-1} rate, value at 40:20:20 $Kgha^{-1}$ rate, was significatnly higher than values at 120:60:60 and 160:80:80 $kgha^{-1}$. Similarly at no fertilizers value at 2.5 and 5.0 tha^{-1} was significantly higher than values at 7.5 and 10 tha^{-1} rates, while at 40:20:20

Kgha^{-1} value at 10 tha^{-1} was significantly higher than values at all other organic manure rates. At the 80:40:40 Kgha^{-1} rates, value at 2.5 tha^{-1} rate was significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates, while at 120:60:60 Kgha^{-1} values at 0 tha^{-1} rate was significantly higher than values at all other organic manure rates. At 160:80:80 Kgha^{-1} rate, value at 2.5 tha^{-1} rate was significantly higher than value at all other organic manure rates.

The interaction effect was significant on the Fe concentration of the shoot (Table 12). At 0 tha^{-1} rate, Fe concentration in shoot was significant even at 40:20:20 Kgha^{-1} rate, while at 2.5 and 5.0 tha^{-1} rates, values at 80:40:40 Kgha^{-1} rate were significantly higher than values at 120:60:60 and 160:80:80 Kgha^{-1}. At 7.5 and 10 tha^{-1}, shoot Fe concentration was not significantly affected by inorganic fertilizer. At no fertilizer value at 2.5 tha^{-1} rate was significantly higher than values at 5.0 and 7.5 tha^{-1} rates. At 40:20:20 and 120:60:60 Kgha^{-1}, values at 0 and 2.5 tha^{-1} rates were significantly higher than values at all other organic manure rates, whereas at 160:80:80 Kgha^{-1}, value at 0 tha^{-1} rate was significantly higher than value at all other rates.

For Cu concentration (Table 13), at 0 tha^{-1} rate, value at 120:60:60 Kgha^{-1} was significantly higher than vlaues at all other fertilizer rates, while at 2.5 tha^{-1} value at 80:40:40 Kgha^{-1} was significantly higher than values at all other fertilizer rates. At 5.0 and 7.5 tha^{-1} rate, inorganic fertilizer did not significantly affect shoot Cu concentration but at 10 tha^{-1} values at plots without inorganic fertiliszer

were significantly higher than values at all plots receiving the various fertilizer rates. At no fertilizer, value at 10tha^{-1} was significantly higher than values at 7.5, 2.5 and 0 tha^{-1} rates. Organic manure did not significantly affect shoot Cu concentration at 40:20.20 and 160:80:80 Kgha^{-1}, while at 80:40:40 Kgha^{-1} value at 2.5 tha^{-1} rate was significantly higher than values at 0, 5.0 and 7.5 tha^{-1} rates. At 120:60:60 Kgha^{-1} rate, value at 0 tha^{-1} was significantly higher than values at all other organic manure rates.

Table 9: Interaction between organic manure and ino fertilizer on Ca concentration in maize shoot (g

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	4.47	4.61	4.41	3.90	3.97	4.27
40:20:20	4.36	3.71	3.92	4.13	4.67	4.16
80:40:40	4.51	4.76	4.11	3.39	3.65	4.08
120:60:60	4.54	4.45	4.04	3.58	3.72	4.07
160:80:80	4.60	3.24	3.54	3.50	4.04	3.78
Means	4.50	4.15	4.00	3.70	4.01	
LSD		0.623				
SD (±)		0.378				

Table 10: Interaction between organic manure and inorganic fertilizer on Mg concentration in maize shoot (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1.91	2.01	2.69	2.23	2.37	2.24
40:20:20	2.14	1.66	2.02	2.14	2.38	2.07
80:40:40	2.36	2.09	1.92	1.91	1.97	2.05
120:60:60	2.24	2.12	1.96	1.84	1.93	2.02
160:80:80	2.27	1.77	1.71	1.88	2.03	1.94
Means	2.18	1.93	2.07	2.00	2.14	
LSD		0.332				
SD (±)		0.202				

Table 11: Interaction between organic manure and i
fertilizer on Mn concentration in maize shoot

Fertilizer Rates (Kgha^{-1})	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	67.3	113.3	106.7	61.3	57.3	81.2
40:20:20	102.0	63.3	80.7	76.0	88.7	80.1
80:40:40	81.7	103.3	67.0	59.3	72.0	76.7
120:60:60	88.7	62.7	58.0	70.7	59.3	67.9
160:80:80	62.7	72.7	54.3	68.7	47.3	61.1
Means	80.5	80.1	73.3	67.2	64.9	
LSD		21.92				
SD (±)		13.34				

Table 12: Interaction between organic manure and inorganic fertilizer on Fe concentration in maize shoot (MgKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	176.7	220.0	153.3	106.7	166.7	164.7
40:20:20	230.0	216.7	130.0	136.7	136.7	170.0
80:40:40	150.0	250.0	163.3	76.7	123.3	152.7
120:60:60	173.3	166.7	66.7	96.7	106.7	122.0
160:80:80	193.3	100.0	86.7	133.3	110.0	124.7
Means	124.7	190.7	120.0	110.0	128.7	
LSD		70.64				
SD (±)		42.98				

Table 13: Interaction between organic manure and inorganic fertilizer on Cu concentration in maize shoot (mgKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1.63	0.70	6.20	1.90	10.33	4.15
40:20:20	0.97	1.03	1.40	0.70	2.00	1.22
80:40:40	0.70	8.00	0.60	1.07	3.47	2.77
120:60:60	19.80	7.30	1.80	3.27	2.57	6.95
160:80:80	6.90	0.60	3.60	2.30	0.90	2.86
Means	4.00	3.53	2.77	1.85	3.85	
LSD		7.007				
SD (±)		4.263				

4.2.4 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE ROOT NUTRIENT CONCENTRAITON

The effect of organic manure and inorganic fertilizer nutrient concentration in maize root are shown in (Table 14). Phosphorus, K and Cu generally increased with increasing rates of organic manure and inorganic fertilizer, while the reverse was the case with N, Ca, Mg, Mn and Fe. For N, values in plots without organic manure was significantly higher than value at 7.5 tha^{-1} rate. With inorganic fertilizer, N values were significantly higher in plots without inorganic fertilizer than in plots that received the various rates of fertilizers.

For P and K, values in plots receiving 10 tha^{-1} manure were significantly higher than values at all other organic manure rates. Inorganic fertilizer did not significantly affect P concentrtion in maize root, while K values at 120:60:60 $Kgha^{-1}$ and 160:80:80 $Kgha^{-1}$ rates were significantly higher than values at 0:0:0, 40:20:20 and 80:40:40 $Kgha^{-1}$ rates. For Ca, organic manure did not significantly affect Ca concentration in the root. With inorganic fertilizer, values were significantly higher in plots without fertilizer than in plots that received the various rates of fertilizers.

For Mg, values were significantly higher in plots without organic manure than values at 5.0 and 10 tha^{-1} manure rates. Inorganic fertilizer did not significantly affect root Mg concentration. Zn and Mn concentrations at 0 and 2.5 tha^{-1} manure rates were significantly higher than values at all other organic manure rates. With inorganic fertilizer, Zn and Mn concentrations in plots without fertilizer were significantly

higher than values at all other fertilizer rates. For Fe and Cu, values in plots without organic manure were significantly higher than plots that received the various manure rates. Inorganic fertilizer did not significantly affect Fe and Cu concentrations in the root.

Table 14: Effect of organic manure and inorganic fertilizer on maize root nutrient concentration

Dung	Nutrient element concentration								
(tha^{-1})	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
0	6.57	1.01	7.44	3.68	1.61	267.7	159.9	2997	6.70
2.5	6.39	1.20	8.86	3.53	1.47	258.7	151.6	2647	6.65
5.0	6.09	1.20	8.22	3.60	1.35	204.7	75.6	1673	7.65
7.5	5.37	1.30	9.54	3.45	1.44	206.0	87.3	1840	10.73
10.0	6.31	1.60	11.29	3.29	1.33	195.0	74.5	1690	10.56
LSD	0.998	0.204	1.337	0.428	0.200	39.96	22.30	330.1	4.982
Fertilizer Rates ($Kgha^{-1}$)									
0:0:0	7.69	1.11	9.36	4.04	1.55	247.0	127.6	2370	8.50
40:20:20	6.17	1.16	7.60	3.34	1.37	107.3	121.2	2317	9.61
80:40:40	5.91	1.17	8.21	3.26	1.36	197.7	99.5	2117	9.20
120:60:60	6.00	1.30	9.73	3.36	1.46	224.3	95.7	2010	7.63
160:80:80	5.95	1.24	10.46	3.51	1.45	225.7	104.9	2053	8.75
LSD (0.05)	0.998	0.204	1.337	0.428	0.200	39.96	22.30	330.1	4.982
D x F	NS	NS	2.990	0.958	0.447	NS	49.88	738.2	11.40

The interaction effects were significant only on concentrations of K, Ca, Mg, Mn, Fe and Cu (Tables 15, 16, 12, 18, 19 and 20). Root K concentration at 0 and 2.5 tha^{-1}, were not significantly affected by inorganic fertilizer, while at 5.0 tha^{-1} rate, plots without inorganic fertilizer were significantly higher than plots receiving the various inorganic fertilizer. At 7.5 and 10t ha^{-1} rates, values at 120:60:60 and 160:80:80 $Kgha^{-1}$ were significantly higher (at P = 0.05) than values at all other fertilizer rates. At no fertilizer, K value at 5.0 tha^{-1} was singificantly higher than values at 7.5 and 10 tha^{-1} rates. Values at 40:20:20 and 80:40:40 $Kgha^{-1}$ were not significantly affected by organic manure. At 120:60.60 and 160:80:80 $Kgha^{-1}$ rates, values at 10 tha^{-1} were significantly higher than values at all other organic manure rates.

For Ca, at 0 and 5.0 tha^{-1}, plots without inorganic fertilizer were significantly higher than plots receiving the various inorganic fertilizer rates. At 2.5, 7.5 and 10 tha^{-1} rates, inorganic fertilizer did not significantly affect Ca concentration in the root. At no fertilizer, plots receiving 5.0 tha^{-1} manure were significantly higher than plots receiving all other organic manure rates. At 40:20:20 and 80:40:40 $Kgha^{-1}$ rates, values at 2.5t ha^{-1} were significantly higher than value at 5.0 tha^{-1} rate, whereas at 120:60:60 and 160:80:80 $Kgha^{-1}$ rates, organic manure did not significantly affect Ca concentration in the root.

For Mg, at 0 tha^{-1} rate, value at 120:60:60 $Kgha^{-1}$ was significantly higher than value at 80:40:40 $Kgha^{-1}$ rate. At 2.5, 7.5 and 10 tha^{-1} rates, inorganic fertilizer application did not

significantly affect root Mg concentration, while at 5.0 tha^{-1}, value was higher in plots without fertilizers than plots receiving the various fertilizer rates. At no fertilizer, value at 5.0 tha^{-1} manure rate was significantly higher than values at 7.5 and 10 tha^{-1} rates, while at 40:20:20, 80:40:40 and 160:80:80 $Kgha^{-1}$, rates orgnaic manure did not significantly affect root Mg concentration. At 120:60:60 $Kgha^{-1}$, value at 5.0 tha^{-1} was significantly lower than values at all other organic manure rates.

For Mn, at 0 tha^{-1} rate, value at 40:20:20 $Kgha^{-1}$ was singificantly higher than values at 80:40:40 and 160:80:80 $Kgha^{-1}$ rates, but at 2.5 tha^{-1} rate, value at 80:40:40 $Kgha^{-1}$ was singificantly higher than values at 120:60:60 and 160:80:80 $Kgha^{-1}$ rates. At 5.0 tha^{-1} rate plots without inorganic fertilizer gave significantly higher Mn concentration than plots receiving the various rates of fertilizer, but at 7.5 and 10 tha^{-1} rates, inorganic fertilizer did not signficantly affect Mn concentration. At no fertilizer, 120:60:60 and 160:80:80 $Kgha^{-1}$ rates, values at 0 and 2.5t ha^{-1} rates, were significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates, while at 40:20:20 $Kgha^{-1}$, plots without organic manure were significantly higher than plots receiving the various organic manure rates. At 80:40:40 $Kgha^{-1}$ rate, value at 2.5tha^{-1} rate was significantly higher than value at all other organic manure rates.

For Fe, at 0 tha^{-1} rate, value at 40:20:20 $Kgha^{-1}$ rate was significantly higher than value at all other fertilizer rates, while at 2.5 tha^{-1} rate value at 80:40:40 kgh^{-1} was significantly

higher than value at 40:20:20 Kgha^{-1} rate. At 5.0 tha^{-1} value at plots without fertilizer were significantly higher than plots receiving the various rates of fertilizer. Inorganic fertilizer did not significantly affect root Fe concentration at 7.5 tha^{-1} manure rate. At 10 tha^{-1} rate, value at 40:20:20 Kgha^{-1} rate was significantly higher than value at 160:80:80 Kgha^{-1} rate. At no fertilizer and 40:20:20 Kgha^{-1} fertilizer rate, value from plots without organic manure were significatnly higher than plots receiving the various rate of organic manure, while at 80:40:40, 120:60:60 and 160:80:80 Kgha^{-1} rates values at 0 and 2.5 tha^{-1} rates were significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates.

For Cu, at 0, 2.5 and 10 tha^{-1} rates, organic fertilizer did not significantly affect Cu concentration in the root. At 5.0 tha^{-1} rate, values at 0:0:0, 40:20:20 and 80:40:40 Kgha^{-1} did not differ significantly, but were higher than values at 120:60:60 Kgha^{-1} rate. At 7.5 tha^{-1} rate, there was no consistent pattern in Cu concentration due to inorganic fertilizer application. At no fertilizer, 40:20:20 and 80:40:40 Kgha^{-1} rates, organic manure did not significantly affect Cu concentration in the root, while at 120:60:60K gha^{-1} rate, value at 2.5 tha^{-1} was significantly higher than value at 5.0 tha^{-1}. At 160:80:80 Kgha^{-1}, value at 7.5 tha^{-1} was higher than value at 0 tha^{-1} rate.

Table 15: Interaction between organic manure and inorganic fertilizer on K concentration in maize root (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	9.03	9.93	11.70	7.73	8.43	9.36
40:20:20	6.33	8.23	7.70	8.10	7.63	7.60
80:40:40	5.73	7.80	8.40	8.63	10.50	8.21
120:60:60	9.03	8.30	4.63	11.93	14.73	9.73
160:80:80	7.10	10.03	8.67	11.33	15.17	10.46
Means	7.44	8.86	8.22	9.54	11.29	
LSD		2.990				
SD (±)		1.820				

Table 16: Interaction between organic manure and inorganic fertilizer on Ca concentration in maize root (gKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	4.41	3.57	5.53	3.10	3.57	4.04
40:20:20	3.78	3.44	2.77	3.87	2.83	3.34
80:40:40	3.21	3.83	2.85	3.03	3.40	3.26
120:60:60	3.43	3.37	2.93	3.77	3.31	3.36
160:80:80	3.38	3.45	3.90	3.50	3.33	3.51
Means	3.68	3.53	3.60	3.45	3.27	
LSD		0.958				
SD (±)		0.583				

Table 17: Interaction between organic manure and inorganic fertilizer on Mg concentration in maize root (gKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1.80	1.61	1.90	1.22	1.23	1.55
40:20:20	1.59	1.35	1.20	1.38	1.34	1.37
80:40:40	1.25	1.52	1.17	1.43	1.41	1.36
120:60:60	1.81	1.50	0.87	1.60	1.54	1.46
160:80:80	1.61	1.36	1.59	1.55	1.13	1.45
Means	1.61	1.47	1.35	1.44	1.33	
LSD		0.447				
SD (±)		0.272				

Table 18: Interaction between organic manure and inorganic fertilizer on Mn concentration in maize root ($mgKg^{-1}$)

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	178.7	154.7	130.0	99.3	75.3	127.6
40:20:20	205.3	120.0	82.0	108.0	90.7	121.2
80:40:40	115.3	200.0	36.7	71.3	74.0	99.5
120:60:60	156.7	140.0	45.3	75.3	61.3	95.7
160:80:80	143.3	143.3	84.0	82.7	71.3	104.9
Means	159.9	151.6	75.6	87.3	74.5	
LSD		49.887				
SD (±)		30.35				

Table 19: Interaction between organic manure and inorganic fertilizer on Fe concentration in maize root (mgKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	3067	2667	2267	2250	1600	2370
40:20:20	3867	1883	1500	2167	2167	2317
80:40:40	2850	3200	1183	1617	1733	2117
120:60:60	2683	2767	1433	1550	1617	2010
160:80:80	2517	2717	2083	1617	1333	2053
Means	2997	2647	1693	1840	1690	
LSD		738.2				
SD (±)		449.1				

Table 20: Interaction between organic manure and inorganic fertilizer on Cu concentration in maize root (mgKg^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	7.20	5.00	12.53	4.17	13.60	8.50
40:20:20	7.37	7.47	9.33	14.67	9.20	9.61
80:40:40	9.67	4.50	8.73	10.27	12.83	9.20
120:60:60	5.07	15.53	1.17	8.33	8.07	7.63
160:80:80	4.17	7.77	6.50	16.20	9.10	8.75
Means	6.70	8.05	7.65	10.73	10.56	
LSD		11.140				
SD (±)		6.778				

4.2.5 EFFECT OF ORGANIC MANURE AND INORGANIC MANURE ON MAIZE SHOOT NUTRIENT UPTAKE (Mg Pot^{-1})

The main effects of organic manure and inorganic fertilizers were significant at 5% level of significance, for nutrient uptake (Table 21). Generally, uptake tended to increase with increasing rates of both organic manure and inorgnic fertilizer. Plots receiving 10 tha^{-1} manure rate gave significantly higher N, P and K uptake than all other manure rates. For all the three elements, values at 0 and 2.5 tha^{-1} rates were significantly lower than values at 5.0 and 7.5 tha^{-1} rates, which did not differ significantly. With inorganic fertilizer, P and K uptake were significantly higher in plots that received fertilizer than in the control. Nitrogen uptake did not significantly increased with increasing fertilizer rates.

The interaction effects, though not significant, show that application of organic manure and inorganic fertilizer at all combinations, generally increased nutrient uptake in the shoot (Tables 22, 23 and 24). Combining 40:20:20 $Kgha^{-1}$ with 2.5 or 5.0 tha^{-1} gave slightly higher uptake values than combining 120:60:60 $Kgha^{-1}$ with 2.5 or 5.0 tha^{-1} and 160:80:80 $Kgha^{-1}$ with 2.5 or 5.0t ha^{-1}. Similarly, plots receiving the combination of 40:20:20 $Kgha^{-1}$ and 2.5 tha^{-1} gave slightly higher N P and K values than plots receiving 120:60:60 or 160:80:80 $Kgha^{-1}$ fertilizer alone.

Table 21: Effect of organic manure and inorganic fertilizer on shoot nutrient uptake ($mgpot^{-1}$)

Dung rates (tha-1)	Nutrient uptake ($mgpot^{-1}$)		
	N	P	K
0	39.9	8.28	239
2.5	59.3	13.82	369
5.0	83.1	19.49	471
7.5	108.8	18.66	495
10.0	153.2	26.15	664
LSD (0.05)	27.53	4.165	77.1
Fertilizer Rates ($Kgha^{-1}$)			
0:0:0	87.0	12.20	365
40:20:20	85.8	17.23	460
80:40:40	95.1	19.14	483
120:60:60	74.3	17.65	442
160:80:80	92.1	21.18	487
LSD	27.53	4.165	77.1
D x F	NS	NS	NS

Table 22: Interaction between organic manure and inorganic fertilizer on N uptake in maize shoot (mg/pot)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	38.3	65.3	71.1	96.8	163.5	87.0
40:20:20	38.3	59.8	97.4	123.2	160.2	95.8
80:40:40	39.1	56.9	80.4	135.6	163.4	95.1
120:60:60	38.9	49.7	78.3	100.7	104.0	74.3
160:80:80	44.9	64.8	88.5	87.5	175.0	92.1
Means	39.9	39.3	83.1	108.8	153.2	
LSD		47.020				
SD (±)		27.16				

Table 23: Interaction between organic manure and inorganic fertilizer on P uptake in maize shoot ($Mgpot^{-1}$)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	5.32	8.68	11.28	16.34	19.39	12.20
40:20:20	7.30	17.58	15.10	20.33	25.85	17.23
80:40:40	8.63	13.28	25.91	21.92	25.94	19.14
120:60:60	10.22	15.56	20.37	18.14	23.97	17.65
160:80:80	9.92	14.00	24.79	21.59	35.58	21.18
Means	8.28	13.82	19.49	19.66	26.15	
LSD		9.809				
SD (±)		5.666				

Table 24: Interaction between organic manure and inorganic fertilizer on K uptake in maize top (Mg pot^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	175	330	352	414	555	365
40:20:20	230	406	494	558	610	460
80:40:40	268	377	486	614	672	483
120:60:60	301	357	484	408	661	442
160:80:80	220	375	539	479	822	487
Means	239	369	471	492	664	
LSD		181.7				
SD (±)		105.0				

4.2.6 Correlation between maize shoot and root dry matter-yields (Y1 and Y2) and Nutrient concentration (X1 - X9), Nutrient uptake (X10 - X12), Plant height (X13 - X16) Dung rates and fertilizer rates (X17)

Matrix of coefficient of correlation (r) between shoot dry matter yield (DMY) and nutrient concentration, Nutrient uptake, plant height and Dung rates is shown in Table 25. the results show a positive, but non-significant correlation between shoot DMY and P, K and a negative and non-significant relationship with N concentrations. However, Ca and Mg and micronutrient concentrations were negatively and non-significantly correlated to the shoot DMY. Correlation between shoot DMY and N uptke is low, and significant with P and K uptake (r = 0.887*; 0.963** respectively). There was positive and non-significant correlation between shoot DMY and plant height at all stages of measurement, except at 28 DAP (r = 0.915*); and Dung rates. Similarly Dung rates were significantly correlated with P (r = 0.958*), K (r = 0.936*), Ca (r = -0.933*), Mg r = -0.931*), Zn (r = -963**), Mn (r = -950* and Fe r = -0.906*) concentrations.

With inorganic fertilizer, Table (26), shoot DMY was positively correlated with N concentration and negatively correlated with P, K, Ca, Mg and all the micronutrients, though not significant. The shoot DMY correlated positively and significantly with N, P and K uptake (r = 0.975**, 0.995**, 0.985** respectively). Correlation between shoot DMY and plant height at 28 and 35 DAP was positive and significant (r = 0.972**; and 0.992** respectively). The shoot DMy correlated positively and significantly with fertilizer ratres (r = 0.984**). Similarly the fertilizer rates correlated

significantly with N concentration (r = 0.917*), and N, P and K uptake (r = 0.987**; 0.975** and 0.979** respectively).

Coefficient of correlation between root DMY and nutrient concentration, plant height, Dung and fertilizer rates are shown in Tables 27 and 28. The result show a significant but negative correlation between root DMY and N (r = -0.941*), Ca (r = -0.975**), Mg (r = -0.947**) and Zn (r = -0.911*) concentrations. There was positive correlation between root DMY and plant height at all stages of measurement, but only at 28 DAP was value significant (r = 0.902*).

With inorganic fertilizer (Table 28), root DMy was positively correlated with P, K (r = 0.929*) and Cu, but negatively with N, Mg, Zn, Mn and Fe concentrations. There was positive correlation between root DMY and plant height at all stages of measurements, however, only at 28 and 35 DAP were the relationship significant (r = 0.962**; and 0.982** respectively). Similarly there was a positive and significant correlation between root DMY and fertilizer rates (r = 0.951*). Also the fertilizer rate relate positively and significantly with K (r = 0.905*), Ca (r = 0.893*) concentrations and plant height at 28 and 35 DAP (r = 0.922* and r = 0.971** respectively).

Table 25: Matrix of coefficient of correlation (r) between maize dry matter shoot (Y_1) and nutrient cocentration (X_1-X_9), NPK uptake (X_{10}-X_{12}) plant height (X_{13}-X_{16}) and Dung rates (X_{17})

	Shoot DMY (gpot-1) (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	Fe X8	Cu X9	N X10	P X11	K X12	14 X13	21 X14	28 X15	35 X16	Dung Rates (tha-1) X17
Shoot DMY (Y1)	1.000																	
N X1	-0.628	1.000																
P X2	0.778	-0.611	1.000															
K X3	0.836	-0.675	0.989**	1.000														
Ca X4	-0.572	0.423	-0.946*	-0.887*	1.000													
Mg X5	-0.848	0.700	-0.970**	-0.966**	0.892*	1.000												
Zn X6	-0.781	0.685	-0.991**	-0.995**	0.907*	0.957*	1.000											
Mn X7	-0.359	0.583	-0.844*	-0.791	0.904*	0.783	0.844	1.000										
Fe X8	-0.330	0.750	-0.753	-0.734	0.751	0.713	0.793	0.950*	1.000									
Cu X9	-0.272	-0.554	-0.024	-0.006	0.060	0.040	-0.077	-0.366	-0.610	1.000								
N X10	0.255	0.592	0.057	0.035	-0.083	-0.019	0.033	0.336	0.579	-0.972**	1.000							
P X11	0.887*	-0.567	0.972**	0.975**	-0.882*	-0.769**	-0.954*	-0.698	-0.573	-0.205	0.223	1.000						
K X12	0.963**	-0.512	0.0877*	0.904*	-0.736	-0.903*	-0.859	-0.486	-0.387	-0.358	0.365	0.964**	1.000					
14 X13	0.514	-0.199	0.837	0.752	-0.945*	-0.808	-0.757	-0.755	-0.531	-0.321	0.303	0.813	0.699	1.000				
21 X14	0.753	-0.610	0.234	0.359	0.072	-0.375	-0.291	0.162	0.021	-0.055	0.088	0.381	0.553	0.157	1.000			
28 X15	0.915*	-0.891*	0.652	0.738	-0.400	-0.766	-0.697	-0.338	-0.429	0.071	-0.114	0.729	0.793	0.269	0.871*	1.000		
35 X16	0.795	-0.644	0.458	0.501	-0.293	-0.655	-0.447	-0.157	-0.180	-0.178	0.024	0.577	0.671	0.320	0.769	0.851*	1.000	
Dung Rates tha-1 x17	0.632	-0.708	0.958*	0.936*	-0.933*	-0.931*	-0.963**	-0.950*	-0.906*	0.232	-0.212	0.872	0.721	0.784	0.128	0.595	0.396	1.000

* Significant at 5% level

** Significant at 1% level

Table 26: Matrix of coefficient of correlation (r) between maize dry matter shoot (Y_1) and nutrient cocentration (X_1-x_9), NPK uptake (X_{10}-x_{12}) plant height (X_{13}-X_{16}) and fertilizer rates (X_{17})

	Shoot DMY (gpot-1) (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	Fe X8	Cu X9	N X10	P X11	K X12	14 X13	21 X14	28 X15	35 X16	Dung Rates (tha-1) X17
Shoot DMY (Y1)	1.000																	
N X1	0.856	1.000																
P X2	0.771	-0.402	1.000															
K X3	0.737	-0.303	0.970**	1.000														
Ca X4	-0.519	-0.527	0.579	0.373	1.000													
Mg X5	-0.083	0.202	0.659	0.586	0.462	1.000												
Zn X6	-0.261	0.273	0.624	0.773	-0.085	0.430	1.000											
Mn X7	-0.871	-0.926*	0.470	0.373	0.640	-0.202	-0.095	1.000										
Fe X8	-0.751	-0.663	0.558	0.464	0.741	-0.021	-0.167	0.892*	1.000									
Cu X9	-0.603	-0.328	0.867	0.753	0.852	0.671	0.447	0.508	0.726	1.000								
N X10	0.975**	0.947*	-0.626	-0.572	-0.502	0.071	-0.051	-0.922	-0.730	-0.476	1.000							
P X11	0.995**	0.829	-0.713	-0.741	-0.495	-0.044	-0.309	-0.875	-0.782	-0.603	0.963	1.000						
K X12	0.998**	0.861	-0.740	-0.716	-0.472	-0.028	-0.254	-0.871	-0.737	-0.556	0.979**	0.996*	1.000					
14 X13	0.105	-0.130	-0.120	-0.326	0.713	0.065	-0.475	0.292	0.454	0.372	0.043	0.109	0.140	1.000				
21 X14	0.712	0.289	-0.890*	-0.964**	-0.155	-0.484	-0.764	-0.288	-0.296	-0.558	0.561	0.711	0.703	0.555	1.000			
28 X15	0.972**	0.733	-0.812	-0.863	-0.457	-0.250	-0.426	-0.735	-0.643	-0.641	0.905*	0.964**	0.966**	0.246	0.854	1.000		
35 X16	0.992**	0.802	-0.813	-0.782	-0.548	-0.128	-0.346	-0.860	-0.796	-0.671	0.946	0.996*	0.987**	0.076**	0.736	0.972	1.000	
Dung Rates tha-1 x17	0.984**	0.9178**	0.707	-0.636	-0.614	-0.040	-0.113	-0.934*	-0.803	-0.608	0.987**	0.975**	0.979**	-0.050	0.586	0.922**	0.971**	1.000

* Significant at 5% level

** Significant at 1% level

Table 27: Matrix of coefficient of correlation (r) between dry matter shoot (Y2) and nutrient cocentration (X_1-x_9), Plant height (X_{10}-x_{13}) Dung rates (X_{14})

	Shoot (gpot-1) (Y2)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	Fe X8	Cu X9	14 X10	21 X11	28 X12	35 X13	Dung Rates X14
Root DMY															
	(Y2)	1.000													
N	X1	-0.941*	1.000												
P	X2	0.414	-0.685	1.000											
K	X3	-0.389	0.073	0.517	1.000										
Ca	X4	0.975**	0.947*	-0.533	0.363	1.000									
Mg	X5	-0.947*	0.783	-0.108	0.638	0.891*	1.000								
Zn	X6	-0.911*	0.722	-0.051	0.732	0.570*	0.989**	1.000							
Mn	X7	-0.618	0.786	-0.824	-0.290	0.693	0.390	0.309	1.000						
Fe	X8	-0.517	0.753	-0.907*	-0.508	0.582	0.239	0.141	0.960**	1.000					
Cu	X9	-0.379	-0.284	-0.247	-0.115	-0.173	-0.444	-0.374	0.177	0.100	1.000				
14	x10	0.419	-0.565	0.439	0.449	-0.305	-0.249	-0.135	-0.316	-0.496	0.730	1.000			
21	x11	0.810	-0.699	0.314	-0.635	-0.888	-0.816	-0.858	-0.501	-0.306	-0.138	-0.157	1.000		
28	x12	0.902*	-0.938*	0.692	-0.222	-0.972**	-0.763	-0.745	-0.778	-0.689	-0.009	0.268	0.871	1.000	
35	X13	0.977	-0.791	0.518	-0.354	-0.847	-0.708	-0.732	-0.377	-0.348	0.165	0.320	0.769	0.851	1.000
Dung rates		0.515	-0.760	0.861	0.589	-0.522	-0.232	-0.117	-0.805	-0.924*	0.212	0.784	0.128	0.595	0.396	1.000

* Significant at 5% level

** Significant at 1% level

Table 28: Matrix of coefficient of correlation (r) between maize dry matter shoot (Y2) and root nutrient cocentration (X_1-x_9) Plant height (X_{10} - 10_{13}) and fertilizer rates (x_{14}

	Root DMY (Y2)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	Fe X8	Cu X9	14 X10	21 X11	28 X12	35 X13	Dung Rates X14
Rhoot DMY (Y2)	1.000														
N X1	-0.277	1.000													
P X2	0.697	-0.536	1.000												
K X3	0.929*	-0.424	0.912*	1.000											
Ca X4	-0.922*	0.457	-0.925*	-0.997**	1.000										
Mg X5	-0.876*	-0.078	-0.355	-0.679	0.629	1.000									
Zn X6	-0.675	0.091	-0.143	-0.468	0.477	0.575	1.000								
Mn X7	-0.852*	0.095	-0.231	-0.606	0.579	0.886*	0.862*	1.000	:	:	:	:	:	:	:
Fe X8	-0.872	0.119	-0.271	-0.635	0.601	0.926**	0.787	0.991**	1.000						
Cu X9	0.666	-0.813	0.498	0.631	-0.649	-0.392	-0.625	-0.642	-0.638	1.000					
14 x10	0.115	0.634	0.255	0.203	-0.174	-0.241	0.292	0.153	0.116	-0.629	1.000				
21 x11	0.685	0.149	0.441	0.611	-0.549	-0.855	-0.082	-0.521	-0.613	0.080	0.554	1.000			
28 x12	0.962**	-0.178	0.655	0.882*	-0.846	-0.936**	-0.504	-0.802	-0.854*	0.531	0.248	0.854	1.000		
35 X13	0.982**	-0.214	0.572	-0.853	-0.823	-0.940*	-0.681	-0.912*	-0.939	0.645	0.078	0.736	0.972**	1.000	
Fertilizer ($Kgha^{-1}$)	0.951*	-0.385	0.666	0.905*	0.893*	-0.832	-0.732	-0.877	-0.890*	0.774	-0.048	0.586	0.922**	0.971*	1.000

* Significant at 5% level

** Significant at 1% level

4.3 FIELD EXPERIMENT

4.3.1 Effect of Organic Manure and Inorganic fertilizer on Maize Grain yield (Kgha^{-1}) and some yield components

The effect of organic manure and inorganic fertilizer on maize grain and stover yields, 1000-grain weight, harvest index, number of kernels cob^{-1}, cob diameter, cob length and shelling percentage are shown in Table 29. With organic manure, values increased singificantly with increasing manure rates. For grain yield and cob diameter, values at 10 tha^{-1} were significantly higher than values at all the other manure rates. There was no significant difference between values at 5.0 and 7.5 tha^{-1} rates, while for harvest index and cob length, values at 5.0, 7.5 and 10 tha^{-1} manure rates were not significantly different, but were significantly higher than values at 0 and 2.5 tha^{-1} rates. For stover yield and shelling percentage, values at 10 tha^{-1} rate were significantly higher than the value at 0 tha^{-1} rate.

Application of inorganic fertilizer significantly increased grain yield, 1000-grain weight, cob length, harvest index and shelling percentage, while stover yield, number of kernels per cob and cob diameter were not significantly affected. Among The different rates of inorganic fertilizer applied, there were no significant differences in grain yield, 1000-grain weight, cob length and shelling percentage. For harvest index values from plots receiving 160:80:80 Kgha^{-1} of fertilizer were significantly higher than values at 0:0:0, 40:20:20 and 80:40:40 Kgha^{-1}. However, for all parameters, values generally increased with increasing levels of the fertilizer up to 120:60:60 Kgha^{-1}.

Table 29: Effect of organic manure and inorganic fertilizer on grain yield Kgha^{-1} and some yield components

Dung Rate (tha^{-1})	Grain Yield (Kgha^{-1})	Stover Yield (Kgha^{-1})	1000-grain weight (gm)	Harvest Index (%)	Number of Kernels cob-1	Cob Diame-ter (cm)	Cob Length (cm)	Shell perce tage (%)
0	1032	3253	151.0	21.12	196	3.15	9.75	61.
2.5	1382	3595	166.7	34.12	474	3.67	12.50	73.
5.0	2356	3890	184.0	39.34	406	3.90	14.68	72.
7.5	2375	4038	178.0	40.28	413	3.93	14.18	70.
10	3189	4714	182.5	39.05	438	4.00	15.23	76.
LSD (0.05)	465.4	948.2	11.45	4.741	283.2	0.171	1.107	7.85
Fertilizer Rate (Kgha^{-1})								
00:0:0	1440	3576	162.7	30.53	306	3.60	12.36	64.0
40:20:20	2242	3978	171.8	33.78	367	3.77	13.08	78.0
80:40:40	2215	4062	173.0	34.26	347	3.73	13.26	67.5
120:60:60	2239	4042	173.5	36.25	369	3.80	14.60	69.5
160:80:80	2206	3831	171.2	38.10	539	3.77	13.60	74.0
LSD (0.05)	465.4	948.2	11.45	4.741	283.2	0.171	1.107	7.85
D x F	NS	NS	NS	10.598	NS	NS	NS	NS

With the exception of harvest index, the interaction effects for these parameters were not significant. Although the interaction effects on maize grain yield was not significant, (Table 30) results show that, plots receiving 40;20:20 $Kgha^{-1}$ and 2.5 tha^{-1} gave slightly higher grain yields than plots receiving a combination of 120:60:60 and 160:80:80 $Kgha^{-1}$ fertilizer alone. Similarly value at 40:20:20 and 10 tha^{-1} was slightly higher than values at 120:60:60 and 10 tha^{-1} or 160:80:80 and 10 tha^{-1} combinations. The highest grain yield (3,523 $Kgha^{-1}$) was recorded in plots receiving a combination of 40:20:20 and 10 tha^{-1}, while the lowest grain yield (195 $Kgha^{-1}$) was from the control. for harvest index (Table 31), at 0 tha^{-1}, value at 160:80:80 $Kgha^{-1}$ was significantly higher than values at all other fertilizer rates, while at 2.5, 5.0, 7.5 and 10 tha^{-1} rates application of inorganic fertilizer did not significantly affect HI. With inorganic fertilizer, at 0:0:0, 40:20:20 and 120:60:60 $Kgha^{-1}$, plots receiving the manure treatments were significantly higher than the control. While at 80:40:40 $Kgha^{-1}$, value at 7.5 tha^{-1} was significantly higher than values at 0 and 2.5 tha^{-1}. At 160:80:80 $Kgha^{-1}$, value at 5.0 tha^{-1} was significantly higher than value at 2.5t ha^{-1} rate.

Table 30: Interaction between organic manure and inorganic fertilizer on maize grain yield (Kg ha^{-1})

Fertilizer Rates (Kgha-1)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0.0	195	1076	1819	1969	2142	1440
40:20.20	1067	1732	2241	2576	3593	2241
80:40.40	1097	1187	2736	2500	3557	2215
120:60.60	1311	1467	2336	2668	3414	2239
160:80.80	1490	1496	2647	2164	3231	2206
Means	1032	1392	2356	2375	3189	
LSD		1435.5				
SD (±)		633.3				

Table 31: Interaction between organic manure and inorganic on harvest index (%)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0.0	13.66	30.21	34.67	40.01	34.09	30.53
40:20.20	17.71	33.46	39.47	38.50	39.72	33.76
80:40.40	15.81	31.48	37.97	44.19	41.84	34.26
120:60.60	17.85	41.67	40.18	42.22	39.20	36.25
160:80.80	40.45	33.78	44.38	36.50	40.40	39.10
Means	21.12	34.12	39.34	40.28	39.05	
LSD		10.598				
SD (±)		6.448				

4.3.2 Effects of Organic manure and inorganic fertilizer on maize plant Height (cm)

Generally there were increases in plant height as the levels of Dung and fertilizers increased (Table 32). At all stages of measurements, plots that received 5.0, 7.5 and 10 tha^{-1} organic manure had plants that were significantly taller than those that received 2.5 and the control. The few exceptions are at 56 and 84 DAP where there were no significant difference in values between 2.5 and 7.5 tha^{-1} manure rates.

With inorganic fertilizer, at 56, 70 and 84 DAP, application of fertilizer at various rates did not significantly change plant height. At the early growth stage (42 DAP) addition of fertilizers significantly increased plant height, but among the different rates, plant were taller at 120:60:60 $Kgha^{-1}$ than plants at 0:0:0 and 40:20:20 $Kgha^{-1}$ rates. However, plant height at 80:40:40, 120:60:60 and 160:80:80 $Kgha^{-1}$ manure rates were not significantly different.

The interaction effects of organic manure and inorganic fertilizer on plant height were not significant at all stages of measurement.

Table 32: Effect of organic manure and inorganic on plant height (cm)

Dung Rate (tha^{-1})	Plant Height in DAP			
	42	56	70	84
0	81.7	154.8	159.7	168.3
2.5	105.8	156.1	185.9	201.0
5.0	119.3	188.3	216.3	218.9
7.5	116.3	169.3	211.3	214.4
10.0	120.2	169.6	223.7	229.0
LSD (0.05)	8.68	25.08	19.61	17.19
Fertilizer Rates ($Kgha^{-1}$)				
0:0:0	91.2	167.4	183.9	193.7
40:20:20	109.1	172.2	198.5	201.8
80:40:40	111.9	169.7	193.6	205.7
120:60:60	118.8	185.5	207.0	210.3
160:80:80	112.3	167.3	203.7	210.1
LSD (0.05)	8.68	25.08	19.61	17.19
D x F	NS	NS	NS	NS

4.3.3 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE EAR LEAF NUTRIENT CONCENTRATION AT 50% SILKING

The effects of organic manure and inorganic fertilizer on maize ear leaf nutrient concentration are shown in (Table 33). Nitrogen and K concentrations slightly increased with increasing rates of manure. For K, values at 7.5 and 10 tha^{-1} manure rates were significantly higher than values at 0 and 5.0 tha^{-1} rates.

With inorganic fertilizer although, N, K, Mg, Mn, Fe and Cu concentrations were not significantly affected by fertilizer application, values generally increased with increasing rates of fertilizer. Phosphorus concentration increased significantly with increasing manure rates. With inorganic fertilizer, P concentration increased significantly with increasing fertilizer rates. Values at 80:40:40 and 120:60:60 $Kgha^{-1}$ rates were not significantly different, but were significantly higher than values at 0:0:0, 40:20:20 and 160:80:80 $Kgha^{-1}$ rates.

For Ca and Mg, organic manure did not sigifincantly affect Ca and Mg concentrations in the ear leaf. With inorganic fertilizer, values tended to increase with increasing fertilizer rates. Ca concentration at 80:40:40, 120:60:60 and 160:80:80 $Kgha^{-1}$ rates were not significantly different but were significantly higher than values at 0:0:0 and 40:20:20 Kgh^{-1} rates. Ear leaf Zn concentration did not significantly decrease with increasing rates of manure. With inorganic fertilizer ear leaf Zn concentration decreased significantly with increasing rates of fertilizer up to 80:40:40 $Kgha^{-1}$, thereafter, there was increase up to 160:80:80 $Kgha^{-1}$ rate. Value at 160:80:80 $Kgha^{-1}$ rate was singificantly higher than values at all other fertilizer

rates. Similarly, for Cu concentration, value at 5.0 tha^{-1} organic manure rate was significantly higher than values at all other rates. Inorganic fertilizer did not significantly affect Cu concentration, in the ear leaf.

Table 33: Effect of organic manure and inorganic fertilizer on maize ear leaf nutrient concentration at 50% silking

Dung Rates (tha^{-1})	Nutrient element concentration in ear leaf								
	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	<----------gKg^{-1} ---------->					<--------- $mgKg^{-1}$ -------->			
0	14.07	2.82	18.77	3.57	1.36	81.4	57.5	99	14.33
2.5	14.71	2.82	20.27	4.07	1.66	70.1	64.3	90	15.86
5.0	14.65	3.00	19.71	3.98	1.76	74.2	75.9	214	23.61
7.5	14.57	3.38	21.40	3.88	1.60	86.5	63.9	278	16.81
10.0	16.01	3.68	20.67	3.97	1.67	76.3	72.0	335	13.85
LSD	3.387	0.311	1.679	0.379	1.508	12.32	18.49	211.9	4.648
Fertilizer Rates ($Kgha^{-1}$)									
0:0:0	13.41	2.94	19.44	3.50	1.51	73.8	61.3	149	14.71
40:20:20	13.44	2.94	20.26	3.38	1.48	73.1	63.1	200	16.22
80:40:40	16.12	3.42	20.45	4.31	1.73	73.0	75.2	286	18.72
120:60:60	15.67	3.36	20.23	4.11	1.62	74.7	66.0	259	15.17
160:80:80	14.59	3.04	20.45	4.18	1.72	93.8	67.8	222	18.65
LSD (0.05)	3.387	0.311	1.679	0.379	1.508	12.32	18.49	211.9	4.648
D x F	NS	0.696	3.754	0.848	0.337	27.56	29.97	NS	NS

The interaction effects were significant only on concentrations of P, K, Ca, Mg Mn and Zn (Tables 34, 35, 36, 37 38 and 39). At 0 tha^{-1}, P concentration at 120:60:60 $Kgha^{-1}$ was significantly higher than values at 40:20:20 and 160:20:20 $Kgha^{-1}$. Between 80:40:40 and 120:60:60 $Kgha^{-1}$, the differences were not significant. At 2.5 tha^{-1} rate, values at 160:80:80 $Kgha^{-1}$ was higher than values at all other fertilizer rates. At 5.0t ha^{-1} value at 0:0:0K gha^{-1} was sigificantly lower than values at all other fertilizer rates, whereas, at 7.5 tha^{-1}, values at 80:40:40, 120:60:60 and 160:80:80 $Kgha^{-1}$ did not differ significantly, but were significantly higher than values at 0:0:0 and 40.20:20 $kgha^{-1}$. At 10 tha^{-1} rate, values at 40:20:20 and 80:40.40 $Kgha^{-1}$ were significantly higher than values at 0:0:0 and 160:80:80 $Kgha^{-1}$. At no fertilizer, value at 0 and 5.0 tha^{-1} were significantly lower than values at all other organic manure rates, while at 40:20:20 $Kgha^{-1}$, value at 10 tha^{-1} rate was significantly higher than values at all other organic manure rates, followed by value at 5.0 tha^{-1}. At 80:40:40 $Kgha^{-1}$, values at 7.5 and 10 tha^{-1} rates were significantly higher than values at all other organic manure rates, while at 120:60:60 $Kgha^{-1}$ rate, value at 2.5 tha^{-1} was significantly lower than values at all other organic manure rates. At 160:80:80 $Kgha^{-1}$, values at 2.5 and 7.5 tha^{-1} rates were significantly higher than values at all other organic manure rates. Ear leaf K concentration at various organic manure rate tended to increase with increasing inorganic fertilizer rates. At 0 tha^{-1} rate, inorganic fertilizer did not significantly affect K concentration, while at 2.5 tha^{-1} rate, value at 160:80:80 $Kgha^{-1}$

rate was significantly higher than value at 160:80:80 Kgha^{-1}, while at 7.5 tha^{-1} rate, values at 80:40:40 Kgha^{-1}, were significantly higher than values at 40:20:20 and 0:0:0 Kgha^{-1}, rates. Among 80:40:40, 120:60:60 and 160:80:80 Kgha^{-1} the differences were not significant. At 10 tha^{-1} rates value at 40:20:20 Kgha^{-1} rate was significantly higher than values at 80:40:40, 120:60:60 and 160:80:80 Kgha^{-1} rates.

Similarly, at the different inorganic fertilizer rates, K concentration generally increase with increasing organic manure rates. At no fertilizer and 120:60:60 Kgha^{-1} manure did not significantly affect ear leaf K concentration. At 40:20:20 Kgha^{-1}, values at 10.0 and 5.0t ha^{-1} rates were not significantly different, but were significantly higher than values at all other organic manure rates. At 80:40:40 and 160:80:80 Kgha^{-1} rate, values at 7.5 tha^{-1} rate, was signficantly higher than values at 0 and 5 tha^{-1} rates.

For Ca concentration (Table 36), at the various organic manure rates, Ca concentrations increased with increasing fertilizer rates. At 0 tha^{-1}, the ear leaf Ca concentrations at 80:40:40 and 120:60:60 Kgha^{-1} rates were significantly higher than values at 40:20:20 and 0:0:0 Kgha^{-1} rates. At 2.5 tha^{-1} rate, value at 160:80:80 Kgha^{-1} was significantly higher than values at 0:0:0, 40:20:20 and 120:60:60 Kgha^{-1} rates. Between 80:40:40 and 160:80:80 Kgha^{-1} rates, the differences were not significant. At 5.0 tha^{-1} rates, value at 80:40:40 Kgha^{-1} rate was significantly higher than 0:0:0 Kgha^{-1} while at 7.5 tha^{-1}, value at 40:20:20 Kgha^{-1} were significantly lower than values at

120:60:60 and 160:80:80 Kgha^{-1} rates. At 10 tha^{-1} rate, value at 80:40:40 Kgha^{-1} rate was significantly higher than values at 160:80:80 Kgha^{-1} rate.

At the different fertilizer rates, ear leaf Ca concentration increased with increasing organic manure rates. At no fertilizer, value at 10 tha^{-1} was significantly higher than control. At 40:20:20, 80:40:40 and 120:60:60 Kgha^{-1} rates, organic manure did not significantly affect ear leaf Ca concentration. While at 160:80:80 Kgha^{-1} rate, value at 2.5 tha^{-1} rate, was significantly higher than values at all other organic manure rates. For Mg ear leaf concentration (Table 37), at various organic manure rates, Mg concentrations increased with increasing fertilizer rates. At 0 tha^{-1}, values at 80:40:40, 120:60:60 and 160:80:80 Kgha^{-1} were not significantly different, but were significantly higher than values at 40:20:20 and 0:0:0 Kgha^{-1} rate. At 2.5 and 7.5 tha^{-1} rates, value at 160:80:80 Kgha^{-1} rate, was significantly higher than values at all other fertilizer rates. At 5.0 tha^{-1} value of 120:60:60 Kgha^{-1} was significantly higher than value at 40:20:20 Kgha^{-1}. While at 10 tha^{-1} rate, value at 160:80:80 Kgha^{-1} was significantly lower than values at 0:0:0, 40:20:20 and 80:40:40 Kgha^{-1} rates.

At the different fertilizer rates, Mg concentration increased significantly with increasing organic manure rates. At no fertilizer, value at 10 tha^{-1} was significantly higher than values at 0 and 2.5 tha^{-1} rates. Among 5.0, 7.5 and 10 tha^{-1}, the differences were not significant. At 40:20:20 Kgha^{-1} rate, value at 10 tha^{-1} rate was significantly higher than values at 0, 2.5 and 7.5 tha^{-1} rates. Between 5.0 and 10 tha^{-1}, the

differences were not significant. At 80:40:40 $Kgha^{-1}$ application of organic manure did not significantly affect ear leaf Mg concentration. At 120:60:60 $Kgha^{-1}$ rate, value at 5.0 tha^{-1} rate was significantly higher than values at all other organic manure rates. At 160:80:80 $Kgha^{-1}$ values at 2.5 and 7.5 tha^{-1} rates were significantly higher than values at 0, 5.0 and 10 tha^{-1} rates. Ear leaf Zn concentration increased with increasing organic manure in the absence as well as in the presence of inorganic fertilizer (Table 38). At 0 and 2.5 tha^{-1} rates, value at 160:80:80 $Kgha^{-1}$ was significantly higher than values at all other fertilizer rates. At 5.0, 7.5 and 10 tha^{-1}, rates, inorganic fertilizer application did not significantly affect ear leaf Zn concentration. At the different fertilizer rates, ear leaf Ca concentration generally increase with increasing organic manure rates. At no fertilizer and 80:40:40 $kgha^{-1}$ rates, organic manure did not significantly affect the ear leaf Zn concentration. At 40:20:20 $Kgha^{-1}$ rate, value at 10 tha^{-1} rate was significantly higher than value at 2.5 tha^{-1} rate. At 160:80:80 $Kgha^{-1}$ rates, value at 0 tha^{-1} rate was significantly higher than values at all other organic manure rates.

For Mn concentration (Table 39) at various organic manure rates, ear leaf Mn concnetration tended to increased with increasing inorganic fertilizer rates. At 0 tha^{-1} rate, value at 80:40:40 $Kgha^{-1}$ rate was significantly higher than value at 40:20:20 $Kgha^{-1}$ rate. Between 80:40:40 and 120:60:60 $Kgha^{-1}$ rates, the differences were not significant. At 2.5 tha^{-1} rate, value at 160:80:80 $Kgha^{-1}$ was significantly higher than values at

120:60:60 and 40:20:20 Kgha^{-1}. Between 80:40:40 and 160:80:80 Kgha^{-1}. The differences were not significant. At 5.0 tha^{-1} rate, inorganic fertilizer did not significantly affect ear leaf Mn concentration, while at 7.5 tha^{-1} rate, differences in values at 80.40:40, 120:60:60 and 160:80:80 Kgha^{-1} rates were not significant. At 10 tha^{-1} rate, value at 40:20:20 Kgha^{-1} rate was significantly higher than value at 160:80:80 Kgha^{-1} rate.

At the different fertilizer rates, ear leaf Mn concentration generally increase with increasing organic manure rates. At no fertilizer, 80:40:40 and 120:60:60 Kgha^{-1} rates, organic manure did not significantly affect ear leaf Mn concentration but at 40:20:20 Kgha^{-1} rate, values at 5.0 and 10 tha^{-1} rates were significantly higher than values at 0, 2.5 and 7.5t ha^{-1} rates. At 160:80:80 Kgha^{-1} rate, value at 2.5 tha^{-1} rate was significantly higher than values at 0 and 10 tha^{-1} rates.

Table 34: Interaction between organic manure and inorganic fertilizer on P concentrtion in maize leaf at 50% silking (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	2.77	3.06	2.24	3.18	3.43	2.94
40:20:20	2.42	2.35	3.32	2.46	4.15	2.94
80:40:40	3.03	2.47	3.34	4.09	4.16	3.42
120:60:60	3.43	2.59	3.17	3.65	3.98	3.32
160:80:80	2.45	3.63	2.92	3.52	2.66	3.04
Means	2.82	2.82	3.00	3.38	3.68	
LSD		0.696				
SD (±)		0.424				

Table 35: Interaction between organic manure and inorganic fertilizer on K concentrtion in maize leaf at 50% silking (g/Kg)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	18.67	19.00	18.23	20.27	21.03	19.44
40:20:20	19.53	17.47	20.80	19.27	24.13	20.26
80:40:40	18.27	20.70	20.33	24.27	18.67	20.45
120:60:60	20.03	17.60	21.67	21.73	20.13	20.23
160:80:80	17.33	26.60	17.40	21.47	19.47	20.45
Means	18.77	20.27	19.71	21.40	20.67	
LSD		3.754				
SD (±)		2.284				

Table 36: Interaction between organic manure and inorganic fertilizer on Ca concentrtion in maize leaf at 50% silking (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	2.58	3.60	3.47	3.77	4.08	3.50
40:20:20	3.13	3.08	3.80	3.20	3.67	3.38
80:40:40	4.21	4.40	4.40	4.02	4.50	4.31
120:60:60	4.11	4.07	4.08	4.15	4.16	4.11
160:80:80	3.80	5.20	4.17	4.27	3.45	4.18
Means	3.57	4.07	3.98	3.88	3.97	
LSD		0.848				
SD (±)		0.516				

Table 37: Interaction between organic manure and inorganic fertilizer on Mg concentrtion in maize leaf at 50% silking (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1.10	1.41	1.69	1.54	1.60	1.51
40:20:20	1.13	1.47	1.56	1.37	1.87	1.48
80:40:40	1.57	1.84	1.82	1.60	1.80	1.73
120:60:60	1.50	1.61	1.95	1.48	1.55	1.62
160:80:80	1.52	2.00	1.77	2.00	1.31	1.72
Means	1.36	1.67	1.76	1.60	1.67	
LSD		0.337				
SD (±)		0.205				

Table 38: Interaction between organic manure and inorganic fertilizer on Mn concentrtion in maize leaf at 50% silking (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	46.7	73.3	62.7	58.0	66.0	61.3
40:20:20	41.3	50.0	86.0	45.3	92.7	63.1
80:40:40	74.0	61.3	82.0	76.0	82.7	73.2
120:60:60	64.7	46.0	74.7	72.0	72.7	66.0
160:80:80	60.7	90.7	74.0	68.0	46.0	67.9
Means	37.5	64.3	75.9	63.9	72.0	
LSD		29.97				
SD (±)		18.24				

Table 39: Interaction between organic manure and inorganic fertilizer on Zn concentrtion in maize leaf at 50% silking (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	60.7	78.3	70.7	73.3	86.06	73.8
40:20:20	65.3	57.7	71.0	84.7	86.7	73.1
80:40:40	69.7	69.3	71.3	82.3	72.3	73.0
120:60:60	66.0	59.3	86.3	92.7	69.0	74.7
160:80:80	145.3	85.7	71.7	99.7	67.3	73.9
Means	81.4	70.1	74.2	86.5	76.3	
LSD		27.56				
SD (±)		16.77				

4.3.4 EFFECTS OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE STOVER NUTRIENT CONCENTRATION

The effects of organic manure and inorganic fertilizer on nutrient concentration in maize stover are shown in Table 40. Potassium, Ca, Mg and Cu generally increased with increasing organic manure and inorganic fertilizer, while the reverse was the case for N,P, Zn, Mn and Fe. Organic manure did not significantly affect N concentration in the stover, however values at 5.0 and 7.5tha^{-1} rates, were slightly higher than values at all other manure rates. With inorganic fertilizer, values at 0:0:0 and 40:20:20 Kgha^{-1} were significantly higher than value at 160:80:80 Kgha^{-1} rate. Between 80:40:40 and 160:80:80 Kgha^{-1} rates the differences were not significant. For Phosphorus concentration, values decreased significantly with increasing organic manure rates. Value at 0 tha^{-1} rate, was singificantly higher than values at 5.0, 7.5 and 10.0 tha^{-1} rates. Between 0 and 2.5 tha^{-1} rates, the differences were not significant. With inorganic fertilizer, P concentrations at 0:0:0, 40:20:20 and 160:80:80 Kgha^{-1} rates were not significantly different. However, values at 40:20:20 and 160:80:80 Kgha^{-1} rates were significantly higher than values at 80:40:40 and 120:60:60 Kgha^{-1} rates. The K concentration at 2.5 tha^{-1} organic manure rate was significantly higher than value at all other manure rates. With inorganic fertilizer, K value at 80:40:40 Kgha^{-1} rate was significantly higher than values at all other fertilizer rates.

For Ca, organic manure did not significantly affect Ca concentration in the stover. With inorganic fertilizer, values

at 0:0:0, 40:20:20 and 160:80:80 $Kgha^{-1}$ rates were not significantly different. However, value at 40:20:20 $Kgha^{-1}$ rate was significantly higher than values at 80:40:40 and 120:60:60 $Kgha^{-1}$ rates. Zn concentration significantly increased with increasing organic manure rates. Values at 10 tha^{-1} rate was significantly higher than values at all other manure rates. Values at 10 tha^{-1} rate was significantly higher than values at all other manure rates. With inorganic fertilizer, Zn concentration in the stover significantly decreased with increasing fertilizer rates up to the 80:40:40 $Kgha^{-1}$ level. Beyong this there was a significant increase with increasing fertilizer rates up to 60:80:80 $Kgha^{-1}$. Value at 80:40:40 $Kgha^{-1}$ was singificantly lower than values at all other fertilizer rates. Stover Mn, Fe and Cu concentrations were significantly decreased with increasing levels of organic manure and inorganic fertilizers.

Table 40: Effect of organic manure and inorganic fertilizer on maize stover nutrient concentration

Dung Rates (tha^{-1})	Nutrient element concentration in ear leaf								
	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	<----------gKg^{-1} ---------->					<---------- $mgKg^{-1}$ ------->			
0	3.29	1.21	14.71	2.32	1.35	61.1	62.4	752	22.5
2.5	3.09	1.16	16.07	2.44	1.65	70.2	69.4	647	22.6
5.0	3.41	0.76	12.40	2.40	1.59	72.7	70.8	258	25.9
7.5	3.61	0.95	14.10	2.14	1.40	72.3	63.5	216	29.6
10.0	2.87	0.68	13.71	2.45	1.54	82.9	68.1	719	30.75
LSD	0.600	0.232	1.604	0.263	0.186	7.43	14.41	587.2	10.88
Fertilizer Rates ($Kgha^{-1}$)									
0:0:0	3.37	0.98	13.63	2.38	1.42	74.5	72.7	707	24.2
40:20:20	3.72	1.14	13.69	2.55	1.58	74.1	68.6	516	27.0
80:40:40	3.03	0.78	16.49	2.24	1.49	64.8	61.2	210	25.6
120:60:60	3.40	0.78	13.16	2.15	1.47	70.1	66.5	109	28.9
160:80:80	2.75	1.07	14.04	2.43	1.57	75.8	70.2	106	25.6
LSD (0.05)	0.600	0.232	1.604	0.263	0.186	7.43	14.41	587.2	10.88
D x F	1.342	0.519	3.589	NS	NS	.63	NS	1313.1	NS

The interaction effects were significant on concentrations of N,P,K, Zn and Fe (Table 41, 42, 43, 44 and 45). At 0 and 5.0 tha^{-1} rates, increasing inorganic fertilizer rate did not affect N concentration significantly. At 2.5 tha^{-1} rate, value at 0:0:0 $Kgha^{-1}$ rate was significantly higher than values at all other fertilizer rates. At 7.5 tha^{-1} rates, values at 40:20:20, 80:40:40 and 120:60:60 $Kgha^{-1}$ rates were significantly higher than values at 0:0:0 and 160:80:80 $Kgha^{-1}$ rates. Between 40:20:20 and 160:80:80 $Kgha^{-1}$, the difference was not significant. At 10 tha^{-1} rate, value at 40:20:20 $Kgha^{-1}$ rate, were significantly higher than value at 160:80:80 $Kgha^{-1}$ rate.

At zero fertilizer rate, N concentration at 0 and 2.5 tha^{-1} rates, was not significantly different. However, the value at 2.5 tha^{-1} rate was significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates. At 40:20:20 $Kgha^{-1}$ rate, value at 10 tha^{-1} rate was significantly higher than value at 2.5 tha^{-1} rate. At 80:40:40 $Kgha^{-1}$ rate, value at 7.5 tha^{-1} rate, was significantly higher than values at 2.5 and 10 tha^{-1} rates. However, N values at 0, 5.0 and 7.5 tha^{-1} rates were not significantly different. At 120:60:60 $Kgha^{-1}$ rate, value at 7.5 tha^{-1} rate was significantly higher than value at 0 tha^{-1} rate. While at 160:80:80 $Kgha^{-1}$ rate, value at 5.0 tha^{-1} rate was significantly higher than values at 2.5, 7.5 and 10 tha^{-1} rates. The differences between 5.0 and 0 tha^{-1} rate, was significantly higher than values at 7.5 and 10t ha^{-1} rate. Phosphorus concentration at the various organic manure rates generally decreased with increasing inorganic fertilizer (Table 42). At 0 tha^{-1} rate, P concentration in the stover at 0:0:0, 40:20:20 and

160:80:80 Kgha^{-1} did not differ significantly. Values at 0:0:0 and 40:20:20 Kgha^{-1} rates were significantly higher than values at 80:40:40 and 120:60:60 Kgha^{-1} rates. At 2.5 tha^{-1} rate, value at 120:60:60 Kgha^{-1} was significantly lower than values at 0:0:0, 40:20:20 and 160:80:80 Kgha^{-1} rates. Between 80:40:40 and 120:60:60 Kgha^{-1} the differences were non significant. At 5.0, 7.5 and 10 tha^{-1} rates, inorganic fertilizer did not affect stover P concentration significantly. At the different fertilizer rates, P concentration generally decreased with increasing organic manure rates. At zero fertilizer, values at 0 and 2.5 tha^{-1} rates were significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates. At 40:20:20 Kgha^{-1} rates, value at 0 tha^{-1} rate was significantly higher than values at 5.0, 7.5 and 10 tha^{-1} rates. Among 2.5, 5.0 and 7.5 tha^{-1} rates, the differences were not significant. At 80:40:40 Kgha^{-1} rate, P concentrations at 0, 5.0 and 10 tha^{-1} were significantly lower than the value at 7.5 tha^{-1} rate. Between 2.5 and 7.5 tha^{-1} rates, the differences were not significant, whereas at 120:60:60 Kgha^{-1} rate, P value at 10 tha^{-1} rate was significantly lower than at the 7.5 tha^{-1} rate. At 160:80:80 Kgha^{-1} rate, values at 0 and 2.5 tha^{-1} rates were significantly higher than values at 5.0 and 7.5 tha^{-1} rates. The P Values at 0, 2.5 and 10 tha^{-1} were not significantly different.

For K concentration (Table 43) at 0 tha^{-1} rate, values at 80:40:40, 120:60:60 and 160:80:80 Kgha^{-1} rates were significantly higher than values at 40:20:20 and 0:0:0 Kgha^{-1} rates. At 2.5 tha^{-1} rate, value at 120:60.60K gha^{-1} rate was significantly

lower than values at 0:0:0, 40:20:20 and 160:80:80 Kgha^{-1} rates. Between 80:40:40 and 120:60:60 Kgha^{-1} rates, the differences were not significant. At 5.0 tha^{-1} rate, values at 40:20:20 and 80:40:40 Kgha^{-1} were significantly higher than values at 0:0:0, 120:60:60 and 160:80:80 Kgha^{-1}. At 7.5 tha^{-1} rates, values at 80:40:40 Kgha^{-1} and 160:80:80 Kgha^{-1} rates were not significantly different, but were significantly higher than values at 0:0:0, 40:20:20 and 120:60:60 Kgha^{-1} rates. At the 10 tha^{-1} rate, value at 80:40:40 Kgha^{-1} rate was significantly higher than value at 40:20:20 Kgha^{-1} rate. At no fertilizer, value at 2.5 tha^{-1} rate was significantly higher than values at all other fertilizer rates. At 40:20:20 Kgha^{-1} rate, values at 2.5 and 5.0 tha^{-1} rates were significantly higher than values at 0, 7.5 and 10tha^{-1} rates. At 80:40:40 Kgha^{-1} rates, organic manure did not affect K concentration significantly. At 120:60:60 Kgha^{-1} rate, values at 0 and 10 tha^{-1} rates were significantly higher than values at 2.5 and 5.0 tha^{-1} rate. While at 160:80:80 Kgha^{-1} rate, value at 5.0 tha^{-1} was significantly lower than values at all other organic manure rates. Values at 0 and 2.5 tha^{-1} rates, were significantly higher than values at 10 tha^{-1} rate.

For Zn concentration (Table 44), at 0t ha^{-1} rate, value at 0:0:0 Kgha^{-1} was significantly higher than value at 120:60:60 Kgha^{-1} rate. At 2.5 and 7.5 tha^{-1} rates, inorganic fertilizer did not significantly affect stover Zn concentration. At 5.0 tha^{-1} rate, values at 120:60:60 Kgha^{-1} rate was singificantly higher than values at 80:40:40 and 160:80:80 Kgha^{-1} rates. There were no significant differences among values at 120:60:60, 40:20:20 and 0:0:0 Kgha^{-1} rates. At 10 tha^{-1} rate, Zn value at

160:80:80 Kgha^{-1} rate, was significantly higher than values at 80:40:40 and 0:0:0 Kgha^{-1} rates. However, the differences among values at 40:20:20, 120:60:60 and 160:80:80 Kgha^{-1} rates were not significant.

At zero fertilizer, and 80:40:40 Kgha^{-1} fertilizer rates, Zn concentration were not significantly affected by application of organic manure. At 40:20:20 Kgha^{-1} rate, values at 5.0, 7.5 and 10 tha^{-1} rates were not significantly different. However, value at 10 tha^{-1} rate was significantly higher than values at 2.5 and 0tha^{-1} rates. At 120:60:60 Kgha^{-1} rate, values at 5.0 and 10 tha^{-1} rates, did not differ significantly, but value at 10 tha^{-1} rate was significantly higher than value at 0, 2.5 and 7.5tha^{-1} rates. At 160:80:80Kgha^{-1} rate, there was no significant difference between 7.5 and 10 tha^{-1} rates. Value at 10 tha^{-1} rate was significantly higher than 0, 2.5 and 5.0tha^{-1} rates. Between 2.5 and 7.5tha^{-1} rates, the differences were not significant.

For Fe concentration (Table 45), at 0 tha^{-1} rate, values at 0:0:0 and 40:20:20 Kgha^{-1} rate were significantly higher than values at all other fertilizer rates. At 2.5, 5.0 and 7.5t ha^{-1} rates, inorganic fertilizer did not significantly affect Fe concentration. At 10 tha^{-1} rate, values at 160:80:80 Kgha^{-1} rate, was significantly higher than values at all other fertilizer rates. At zero fertilizer, values 0 and 2.5t ha^{-1} rates were not significantly different but were significant higher than values at all other organic manure rates. At the 40:20:20 Kgha^{-1} rate, values at 0 and 5.0 tha^{-1} rates were not

significantly different, but the value at 0t ha^{-1} rate was significantly higher than values at 2.5, 7.5 and 10t ha^{-1} rates. At the 80:40:40 and 120:60:60 $Kgha^{-1}$ rates, organic manure did not significantly affect Fe concentration. At 160:80:80 $Kgha^{-1}$ rate, values at 10 tha^{-1} rate was significantly higher than values at all other organic manure rates.

Table 41: Interaction between organic manure and inorganic fertilizer on N concentrtion in maize stover (tha^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	3.60	4.60	3.17	2.77	2.73	3.37
40:20:20	3.47	3.17	3.47	4.74	3.73	3.72
80:40:40	3.03	2.47	3.03	4.20	2.43	3.03
120:60:60	2.73	2.80	3.53	4.13	3.80	3.40
160:80:80	3.60	2.43	3.83	2.23	1.67	2.75
Means	3.29	3.09	3.41	3.61	2.87	
LSD		1.342				
SD (±)		0.816				

Table 42: Interaction between organic manure and inorganic fertilizer on P concentrtion in maize stover (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1.46	1.38	0.66	0.77	0.69	0.99
40:20:20	1.84	1.33	0.84	1.03	0.68	1.14
80:40:40	0.62	0.84	0.67	1.19	0.56	0.78
120:60:60	0.68	0.81	0.83	1.05	0.51	0.78
160:80:80	1.44	1.44	0.79	0.73	0.94	1.07
Means	1.21	1.16	0.76	0.95	0.68	-
LSD		0.519				
SD (±)		0.316				

Table 43: Interaction between organic manure and inorganic fertilizer on K concentrtion in maize stover (gKg^{-1})

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	11.67	19.30	9.90	13.27	14.03	13.63
40:20:20	12.43	16.20	16.63	11.67	11.50	13.69
80:40:40	16.87	15.87	17.17	17.07	15.47	16.49
120:60:60	15.53	12.60	9.83	13.33	14.50	13.16
160:80:80	17.07	16.40	8.47	15.17	13.07	14.04
Means	14.71	16.07	12.40	14.10	13.71	
LSD		3.589				
SD (±)		2.183				

Table 44: Interaction between organic manure and inorganic fertilizer on Zm concentrtion in maize stover ($mgKg^{-1}$)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	70.0	75.0	81.7	68.3	77.3	74.5
40:20:20	63.3	69.3	72.7	76.7	88.3	74.1
80:40:40	61.0	72.3	62.0	66.7	62.0	64.8
120:60:60	50.0	60.3	82.0	67.3	90.7	70.1
160:80:80	61.0	74.0	65.3	82.3	96.3	75.8
Means	61.1	70.2	72.7	72.3	82.9	
LSD		16.63				
SD (±)		10.12				

Table 45: Interaction between organic manure and inorganic fertilizer on Fe concentrtion in maize stover ($mgKg^{-1}$)

Fertilizer Rates ($Kgha^{-1}$)	Dung Rates (tha^{-1})					
	0	2.5	5.0	7.5	10.0	Means
0:0:0	1703	1390	200	73	170	707
40:20:20	1650	154	483	162	130	516
80:40:40	113	227	186	440	33	200
120:60:60	123	100	210	87	27	109
160:80:80	173	1363	210	320	3237	1061
Means	752	647	258	216	719	
LSD		13131				
SD (±)		798.8				

4.3.5 EFFECTS OF ORGANIC MANURE AND INORGANIC FERTILIZER ON NUTRIENT UPTAKE (K gha^{-1})

The effect of organic manure and inorganic fertilizer on N, P, and K uptake are shown in Table 46. For the three elements, organic manure, gave values that were significantly higher than the control. Nitrogen uptake increased linearly with increasing manure rates. At 10.0 and 5.0 tha^{-1} rate, N uptake did not differ significantly higher than values at 0, 2.5 and 7.5 tha^{-1} rates. Similarly, N uptake at 5.0 and 7.5 tha^{-1} were not significantly different, but were significantly higher than values at 0, and 2.5 tha^{-1} rates. The P uptake increased significantly with increasing organic manure rates. Values at all the fertilizer rates were singificantly higher than value at the control except value at 5.0 tha^{-1} rate, which did not differ significantly from the control. The K uptake did not differ significantly among the fertilizer treatments, but values were significantly higher than the control. Values at 2.5 and 0 tha^{-1} rates did not differ significantly. With inorganic fertilizer, N and P uptake were not significantly affected by application of fertilizer, however, values generally increased slightly with increasing rates of inorganic fertilizer. The K uptake significantly increased with increasing fertilizer rates upto 80:40:40 $Kgha^{-1}$, beyond which there was a decrease. Values at 40:20:20 and 80:40:40 $Kgha^{-1}$ were not significantly different; however, the value at 80:40:40 $Kgha^{-1}$ rate was significantly higher than values at 0:0:0, 120:60:60 and 160:80:80 $Kgha^{-1}$ rates. There was no significant interaction between organic manure and inorganic fertil

Table 46: Effect between organic manure and inorganic fertilizer on Nutrient uptake ($Kgha^{-1}$)

Dung Rates (tha^{-1})	Nutrient uptake		
	N	P	K
	<---------- Kg/ha ---------->		
0	37.1	11.1	186
2.5	50.7	19.3	250
5.0	74.5	15.8	280
7.5	71.4	20.3	300
10.0	95.7	19.7	404
LSD (0.05)	21.96	6.68	81.1
Fertilizer Rates ($Kgha^{-1}$)			
0:0:0	51.8	14.1	200
40:20:20	59.8	14.4	304
80:40:40	64.3	15.7	366
120:60:60	76.4	14.3	295
160:80:80	47.2	18.5	254
LSD (0.05)	21.96	6.68	81.1
D x F	NS	NS	NS

4.3.6 Correlation between Grain and stover yields (Y1 and Y2) and nutrient concentration (X1 - X7), Nutrient uptake (X8-X10), some yield components (X11-X14), plant height (X15-X18) and Dung rate (X19)

Matrix of coefficient of correlation (r) between grain yield and ear leaf nutrient concentrations. Nutrient uptake, some yield components, plant height and Dung and fertilizer rates are shown in Tables 47 and 48. The results showed that grain yield correlated positively, but non-significantly with N, K, Ca, Mg and Mn concentrations in the maize ear leaf. However, there was positive and significant correlation between grain yield and 1000-grain weight (r = 0.880*) and kernel number per cob (r = 0.928*). The relationship between grain yield and harvest index was low, but it was slightly higher for cob diameter. Correlation between grain yield and plant height was positive and not significant at all stages of measurement. there was also positive correlation between grain yield and dung rates, but it was not significant. Dung rates correlated positively and significantly with harvest index (r = 0.904*) and plant height at 84 DAP (r = 0.959**).

With inorganic fertilizer (Table 48), grain yield correlated positively with N,P,K, Ca, Mg, Zn and Mn concentrations in the maize ear leaf. The relationship with N, P, and K uptake was positive and significant (r = 0.680; 0.952* and 0.935* respectively. The result also showed that grain yield positively and significantly correlated with 1000-grain weight (r = 0.993**), kernel number per cob (r = 0.932*) and cob diameter (r = 0.962**). There was also strong correlation between grain yield and plant height at 56, 70 and 84 DAP (r = 0.963**, 0.936*

and 0.974** respectively) and fertilizer rates (r = 0.902*). Fertilizer rate correlated positively and significantly with P uptake (r = 0.957*), 1000 grain weight (r = 0.917*) and plant height at 84 DAP (r = 0.959**).

Correlation coefficient between stover yield and stover nutrient concentrations nutrient uptake, some yield components, plant height, Dung and fertilizer rates are shown in Tables 49 and 50. The results show that stover yield poorly correlated with N and P concentrations and uptake and other yield components. Relationship with 1000-grain weight was positive and significant (r = 0.886*). The relationship between stover yield and plant height was positive and singificant only at 74 DAP (r = 0.920*). Dung rate correlated positively and significantly with kernel number per cob, (r = 0.918*) and plant height at 42 and 70 DAP (r = 0.951*, and 0.912* respectively).

With inorganic fertilizer (Table 50), the result show that stover yield correlated negatively and poorly with N, and positively with Mg, Zn, and Mn (r = 0.973**), concentrations in the maize stover. However, stover yield related positively and significantly with N uptake (r = 0.913*), and P uptake (r = 0.970*). There was positive and significant correlation between stover yield and 1000-grain weight and kernel number per cob (r = 0.997**) and 0.977** respectively). Similarly, stover, yield correlated positively with plant height and fertilizer rates, but not significantly. Fertilizer ratre correlated significantly with K concentration (r = -0.894*), Mn concentration (r = 0.900*), P uptake (r = 0.944*), harvest index (r = 0.991**), kernel number per cob (r = 0.954*) and plant height at 42 DAP (r = 0.999**) and 70 DAP (r = 0.991**).

Table 47: Matrix of coefficient of correlation (r) between grain yield (Y1) and ear leaf nutrient concentration (X1-X7), Nutrient uptake (X6-X10), some yield components (X11-X14), plant height (X15-X18) and Dung rates (X19), N = 5

	Graind Yield (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	N X8	P X9	K X10	1000 g. wt. X11	Harv. Index X12	Kernel No.Cob-1 X13	Cob diam. X14	42 X15	56 X16	70 X17	84 X18	Dung rate 19
Grain Yield(Y1)	1.000																			
N X1	0.500	1.000																		
P X2	0.547	0.969**	1.000																	
K X3	0.845	0.568	0.488	1.000																
Ca X4	0.375	0.922*	0.797	0.630	1.000															
Mg X5	0.281	0.809	0.644	0.653	0.964**	1.000														
Zn X6	-0.071	0.008	-0.232	0.360	0.385	0.528	1.000													
Mn X7	0.451	0.840	0.732	0.697	0.837	0.858	0.098	1.000												
Fe X8	0.397	0.503	-0.499	0.398	-0.436	-0.310	0.144	-0.176	1.000											
Cu X9	0.614	0.655	0.717	0.759	0.480	0.429	-0.299	0.778	0.199	1.000										
N X10	0.864**	0.024*	0.097	0.686	-0.079	-0.096	-0.125	0.146	0.781	0.655	1.000									
1000 g.wt.X11	0.880*	0.238	0.268	0.668	0.177	0.064	0.103	0.049	0.437	0.442	0.797	1.000								
Harv. Ind. X12	0.208	0.091	-0.128	0.585	0.428	0.552	0.958*	0.189	0.314	-0.074	0.153	0.352	1.000							
Kern No. Cob-1 X13	0.928*	0.425	0.397	0.877*	0.429	0.366	0.273	0.344	0.426	0.593	0.784	0.741*	0.525	1.000						
Cob Diam. X14	0.781	0.658	0.606	0.746	0.668	0.545	0.326	0.393	-0.012	0.457	0.444	0.830	0.507	0.892*	1.000					
42 X15	0.582	0.412	0.529	0.176	0.186	-0.065	-0.322	-0.064	-0.223	-0.263	0.317	0.707	-0.182	0.540	0.690	1.000				
56 X16	0.779	0.404	0.345	0.738	0.459	0.373	0.421	0.171	0.246	0.340	0.574	0.918*	0.618	0.943*	0.951*	0.622	1.000			
70 X17	0.749	0.685	0.583	0.856	0.769	0.710	0.498	0.544	0.050	0.498	0.425	0.738	0.659	0.885*	0.963**	0.472	0.915*	1.00		
84 X18	0.512	0.584	0.417	0.751	0.780	0.772	0.728	0.472	-0.012	0.254	0.202	0.565	0.828	0.741	0.866	0.273	0.838	0.947*		
Dung Rates X19	0.270	0.410	0.207	0.575	0.682	0.710	0.871	0.304	-0.050	-0.017	0.007	0.408	0.904*	0.570	0.725	0.123	0.730	0.821	0.959**	1.000

* Significant at 5% level ** Significant at 1% level

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Table 48: Matrix of coefficient of correlation (r) between grain yield (Y1) and nutrient concentration (X1-X7), Nutrient uptake (X8-X10), some yield components (X11-X14), plant height (X15-X18) and fertilizer levels (X19), N = 5

	Graind Yield (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	N X8	P X9	K X10	1000 g. wt. X11	Harv. Index X12	Kernel No.Cob-1 X13	Cob diam. X14	(DAP) 42 X15	56 X16	70 X17	84 X18	Fert. rate 19
Grain Yield (Y1)	1.000																			
N X1	0.532	1.000																		
P X2	0.490	0.968**	1.000																	
K X3	0.697	0.054	-0.092	1.000																
Ca X4	0.580	0.452	0.242	0.589	1.000															
Mg X5	0.703	0.432	0.283	0.501	0.927*	1.000														
Zn X6	0.016	-0.600	-0.471	0.227	-0.620	-0.530	1.000													
Mn X7	0.784	0.581	0.539	0.267	0.683	0.886*	-0.432	1.000												
Fe X8	0.680	0.262	0.069	0.746*	0.785	0.642	-0.092	0.364	1.000											
Cu X9	0.952*	0.688	0.634	0.686	0.562	0.596	-0.058	0.664	0.714	1.000										
N X10	0.935*	0.393	0.317	0.660	0.722	0.876	-0.117	0.888*	0.668	0.807	1.000									
1000 g.wt. X11	0.993**	0.573	0.512	0.736	0.625	0.705	-0.028	0.751	0.741	0.975**	0.914*	1.000								
Harv. Ind. X12	0.644	0.393	0.178	0.749	0.975**	0.877	-0.458	0.606	0.902*	0.638	0.744	0.696	1.000							
Kern No. Cob-1 X13	0.932*	0.379	0.264	0.805	0.785	0.859	-0.100	0.786	0.823	0.846	0.972**	0.955*	0.841	1.000						
Cob Diam. X14	0.962**	0.456	0.370	0.718	0.742	0.858	-0.121	0.855	0.737	0.872	0.991**	0.955*	0.780	0.988**	1.000					
42 X15	0.857	0.579	0.632	0.241	0.356	0.617	-0.082	-0.889*	0.230	0.758	0.829	0.807	0.329	0.708	0.809	1.000				
56 X16	0.963**	0.432	0.348	0.729	0.728	0.849	-0.090	0.844	0.778	0.869	0.991**	0.951**	0.771	0.989**	0.999**	0.806	1.000			
70 X17	0.939*	0.487	0.371	0.754	0.816	0.885*	-0.200	0.829	0.805	0.874	0.971**	0.946*	0.855	0.992**	0.991**	0.741	0.988**	1.000		
84 X18	0.974**	0.474	0.429	0.789	0.504	0.573	0.154	0.623	0.743	0.964**	0.853	0.980**	0.613	0.893*	0.903*	0.745	0.908*	0.883*	1.000	
Dung Rates X19	0.902*	0.561	0.557	0.674	0.321	0.367	0.209	0.487	0.622	0.957*	0.692	0.917*	0.438	0.735	0.763	0.702	0.766	0.744	0.959**	1.000

* Significant at 5% level ** Significant at 1% level

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Table 49: Matrix of coefficient of correlation (r) between stover yield (Y2) and stover concentration (X1-X7), Nutrient uptake (X8-X10), some yield components (X11-X14), plant height (X15-X18) and dung rates (X19), N = 5

	Stover Yield (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	Zn X6	Mn X7	N X8	P X9	K X10	1000 g. wt. X11	Harv. Index X12	Kernel No.Cob-1 X13	Cob diam. X14	42 X15	56 X16	70 X17	84 X18	Dung rate 19
Stover Yield (Y1)	1.000																			
N X1	0.293	1.000																		
P X2	0.078	0.762	1.000																	
K X3	-0.422	0.062	0.252	1.000																
Ca X4	0.358	0.616	-0.439	-0.403	1.000															
Mg X5	-0.361	0.119	0.275	0.273**	-0.213	1.000														
Zn X6	0.393	0.583	-0.025	0.608	0.003	0.613	1.000													
Mn X7	-0.649	-0.160	0.123	0.835	-0.747	0.697	0.301	1.000												
Fe X8	0.726	-0.230	0.363	-0.292	-0.358	-0.377	0.218	-0.200	1.000											
Cu X9	0.633	-0.377	0.814	0.039	-0.168	0.085	0.300	-0.205	-0.617	1.000										
N X10	0.238	0.248	0.375	0.771	-0.099	0.815	-0.886*	0.380	0.125	0.511	1.000									
1000 g.wt. X11	0.920*	0.404	-0.003	-0.451	0.675	-0.312	-0.303	-0.808	0.417	0.510	0.199	1.000								
Harv. Ind. X12	0.768	0.180	0.432	0.230	0.033	0.281	0.757	-0.127	0.625	0.825	0.781	0.655	1.000							
Kern No. Cob-1 X13	0.746	0.059	0.252	-0.004	-0.314	-0.082	0.580	-0.025	0.919*	0.667	0.437	0.442	0.797	1.000						
Cob Diam. X14	0.071	0.725	-0.631	0.346	-0.090	0.244	0.678	0.408	0.048	-0.367	0.314	-0.074	0.153	0.352	1.000					
42 X15	0.726	0.301	-0.253	-0.387	-0.085	-0.484	0.340	-0.249	0.804	0.240	-0.012	0.457	0.444	0.830	0.507	1.000				
56 X16	0.506	0.405	0.198	0.559	-0.071	0.569	0.967**	0.235	0.390	0.530	0.921*	0.383	0.887*	0.702	0.514	0.373	1.000			
70 X17	0.886*	0.400	-0.171	-0.349	0.109	-0.386	0.478	-0.384	0.793	0.397	0.169	0.681	0.644	0.861	0.443	0.954*	0.529	1.000		
84 X18	0.553	-0.460	0.360	-0.512	-0.400	-0.611	-0.165	-0.277	-0.926*	0.569	-0.223	0.263	0.317	0.707	-0.182	0.690	0.017	0.612	1.000	
Dung Rates X19	0.653	0.285	-0.128	-0.090	-0.264	-0.207	0.551	0.010	0.811	0.323	0.246	0.340	0.574	0.918*	0.618	0.951*	0.586	0.912*	0.622	1.000

* Significant at 5% level ** Significant at 1% level

Table 50: Matrix of coefficient of correlation (r) between stover yield (Y2) and stover nutrient concentration (X1-X7), Nutrient uptake (X8-X10), some yield components of maize (X11-X14), plant height (X15-X18) and fertilizer rates (X19), N = 5

	Stover Yield (Y1)	N X1	P X2	K X3	Ca X4	Mg X5	In X6	Mn X7	N X8	P X9	K X10	1000 g. wt. X11	Harv. Index X12	Kernel No.Cob-1 X13	Cob diam. X14	42 X15	56 X16	70 X17	84 X18	Fert. rate 19
Stover Yield (Y1)	1.000																			
N X1	-0.068	1.000																		
P X2	-0.069	0.607	1.000																	
K X3	-0.874	-0.362	-0.230	1.000																
Ca X4	-0.440	-0.652	-0.705	0.790	1.000															
Mg X5	0.157	0.016	-0.671	-0.229	0.051	1.000														
In X6	0.249	0.360	-0.489	-0.306	0.049	0.730	1.000													
Mn X7	0.973**	0.011	-0.189	-0.861	-0.372	0.303	0.466	1.000												
Fe X8	0.913*	-0.046	0.254	-0.791	-0.516	-0.251	0.089	0.814	1.000											
Cu X9	0.970**	0.172	0.101	-0.956*	-0.612	0.145	0.303	0.955*	0.898*	1.000										
N X10	0.683	-0.084	-0.243	-0.408	0.104	-0.055	0.445	0.746	0.629	0.632	1.000									
1000 g. W.Her.X11	0.997**	-0.085	-0.135	-0.856	-0.388	0.204	0.307	0.985**	0.886*	0.961**	0.714	1.000								
Harv. Ind. X12	0.813	0.495	0.253	-0.899*	-0.647	0.077	0.463	0.850	0.763	0.915*	0.668	0.807	1.000							
Kern No. Cob-1 X13	0.978**	0.111	0.032	-0.903*	-0.501	0.111	0.335	0.973**	0.906*	0.988**	0.741	0.975**	0.914*	1.000						
Cob Diam. X14	0.595	0.215	-0.292	-0.473	0.006	0.253	0.773	0.737	0.423	0.610	0.902*	0.638	0.744	0.696	1.000					
42 X15	0.873	0.377	0.153	-0.896*	-0.572	0.100	0.468	0.907*	0.864	0.945*	0.737	0.872	0.991**	0.955*	0.780	1.000				
56 X16	0.670	0.527	-0.180	-0.500	-0.051	0.300	0.857	0.900*	0.263	0.650	0.791	0.760	0.760	0.733	0.779**	0.796	1.000			
70 X17	0.814	0.424	0.150	-0.836	-0.515	0.077	0.521	0.867	0.749	0.894*	0.776	0.817	0.987**	0.916*	0.837	0.991**	0.841	1.000		
84 X18	0.783	0.425	0.301	0.982**	-0.567	0.259	0.251	0.761	0.704	0.886*	0.230	0.758	0.829	0.807	0.329	0.809	0.340	0.739	1.000	
Fert. Rates X19	0.871	0.378	0.178	-0.894*	-0.579	0.068	0.443	0.900*	0.817	0.944*	0.738	0.869	0.991**	0.954*	0.771	0.999**	0.778	0.991**	0.806	1.000

* Significant at 5% level

** Significant at 1% level

CHAPTER FIVE

5.0 DISCUSSION

5.1 GREEN HOUSE

5.1.1 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON DRY MATTER YIELD (g pot^{-1})

Manure application increased both shoot and root dry matter yields (DMY), significantly. This effect is expected, as the organic manure is considered as a store-house of plant nutrients apart from improving the physical and biological properties of the soil. Besides these effects, it also increases the soil pH, and may decrease toxic element concentrations either as a chelating agent or by increasing the pH. It also can increase the water holding capacity of the soil and improve the aeration and microbial activity in the soil. Similar increase in DMY with organic manure was also observed by Kumar and Awashti, (1977); Moehansyah, (1977); Dahiya and Singh(1980), Xie and Mackenzie, (1986), William, (1992).

Dry matter yields increased significantly with increasing inorganic fertilizer rates. This is expected, since cereal crops (especially maize) in the study area demand high amounts of nutrients especially N and P for increased yield, as the soils are inherently low in N, P and organic matter. Moehansyah, (1977) also observed increase in DMY with NPK fertilizer application.

The interaction effects, although not significant, show that application of organic manure and inorganic fertilizer at all combinations generally inceased both shoot and root DMY when compared with organic manure or fertilizer alone. The results

show that a combination of 40:20:20 Kgha^{-1} fertilizer and 2.5 tha^{-1} manure gave slightly higher DMY than either 120:690:60 or 160:80:80 Kgha^{-1} fertilizer alone. This agrees with the results of work done in Samaru and Kano, which showdd that the use of 2.5t ha^{-1}, 60Kg N and 43Kg P_2O_5 ha^{-1} seem optimum for these light sandy soils (Anonymous, 1978). These light sandy soils are low to very low in organic matter and the clay fraction is predominantly kaolinitic, consequently these soils are generally low in cation exchange capacity (CEC) and poorly buffered. Thus addition of NPK fertilizer alone will result in leaching down of the nutrients beyond root absorption. However, when fertilizer and organic manure are added to these soils, the organic manure has a tremendous beneficial effect in the soil because of its contribution to organic matter; CEC and exchangeable cations in addition to nutrients especially Mg, Ca and micronutrients not supplied by the fertilizer. Besides these effects, organic manure also increases the soil pH and may decrease toxic element concentration as chelating agent. It also can increase the water holding capacity of the soil and improve the aeration and microbial activity in soil. Obi (1959) and Kwakye, (1980) also observed similar interaction between organic manure and phosphate fertilizers. This thus, suggests that the use of orgganic manure enhances benefits from the application of inorganic fertilizer.

51.2 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON PLANT HEIGHT (CM)

Generally plant height, at all stages of measurement tended to increase with increasing organic manure rates up to 7.5t ha^{-1}.

At 14 and 21 DAP, the increase was significant even at 2.5t ha^{-1} rates. These results agree with the findings of Hartley and Greenwood (1933); and Dennison, (1961). The results by Bache and Heathcote, (1969), showed that the use of cattle manure significantly increased the soil C, N, pH, CEC and exchangeable Ca, Mg and K. In addition to supplying nutrient elements, manure enhanced the general conditions conducive for good crop growth and development.

Plant height increases due to increasing fertilizer rates, were significant at all stages of measurement, except at 14 DAP. This result lends further credence to those of Gagra, (1978) in Yugoslavia and Mohammed et al., (1978) in Somalia. The increase in plant height with increasing fertilizer rates is expected, because of addition of N and P into the soil through the fertilizer, as these nutrients are essentially low in these soils.

The significant interaction effect between the organic manure and inorganic fertilizer on plant height at 14 DAP indicates that at the various organic manure rates, plant height tended to increase with increasing fertilizer rates. This may be due to nutrient added to the soil by the fertilizer. At the different fertilizer rates, plant height increased with increasing organic manure rate. This is probably due to the improved soil conditions, thus making it conducive for good plant growth, in addition to the release of nutrient into the soil, on decomposition of the organic manure.

5.1.3 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON SHOOT AND ROOT NUTRIENT CONCENTRATIONS

Organic manure significantly affected N,P,K, Ca, Mg, Fe and Cu concentrations in maize shoot and root. Generally these nutrients decreased with increasing dung rates with the exception of P and K concentrations. This results may be due to dilution effect, because DMY and nutrient uptake increased with increasing organic manure rates. Dahiya and Singh (1980); and Singh and Dahiya, (1980); also observed decreases in Ca, Mg, Mn and Fe concentrations in oats shoot with increasing levels of manure and ascribed it to the dilution effect. It is also possible that the concentration of Mg and Ca decreased due to greater relative availability of soil K compared to soil Ca and Mg. Dewit et al (1963), reported that K has an antagonistic effect on Ca and Mg uptake in monocots, while decreases in Mn and Fe may also be due to chelation of these elements by organic matter, which resulted from the addition of organic manure.

With inorganic fertilizer, shoot and root concentrations of N, K, Mg, Ca, Mn and Fe were significantly affected. Calcium, Mg, Mn, Fe and Cu decreased with increasing fertilizer rates. *The result indicates that N applied to the soil may indirectly* affect the concentrations of Ca and Mg in the maize shoot and root by directly increasing uptake of K. Further more, the decrease in these elements may be due to dilution effect (Dahiya and Singh, 1980; Singh and Dahiya, 1980).

The interaction effects were significant only for concentrations of K, Ca, Mg, Mn, Fe and Cu in the maize shoot and roots. Concentration of K at various organic manure rates,

generally increased with increasing fertilizer rate. This probably is due to an increase in concentration of K in soil when N.P.K fertilizer is added to the soil. Concentrations of Ca, Mg, Mn, Fe and Cu in maize shoot and root generally decreased with increasing rates of fertilizer. As earlier mentioned, the decrease may be due to dilution effect or antagonistic effect of K on Ca and Mg. At the different fertilizer rates, K concentration increased, while Ca, Mg, Mn, Fe and Cu concentrations decreased with increasing organic manure rate. The increase in K concentration may be due to the K added to the soil on decomposition of organic manure, while the decrease in the other elements is probably due to dilution effect (Dahiya and Singh, 1980; Singh and Dahiya, 1980); because DMY increased with increasing organic manure rates. The decrease may also be due to antagonistic effect of K on Ca and Mg and chelation of Mn, Fe and Cu due to increased organic matter content in the soil as a result of organic manure application.

5.1.4 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE SHOOT NUTRIENT UPTAKE ($mg\ pot^{-1}$)

Generally nutrient uptake increased with increasing rates of both organic manure and inorganic fertilizer. This result corroborates the earlier works by Dahiya and Singh (1980); Singh and Dahiya, (1980); Xie and Malkenzie (1986); and William, (1992). Phosphorus and K uptake were significantly higher in plots that received organic manure than in the control. This increase in uptake is due to increased DMY and also probably due to the fact that organic manure itself is a reservoir of plant nutrients (specially N,P,K) and the favourable effect it has on soil

physical properties. Increased uptake of N, P and K by manure application have been reported by McAllister and McConaghy (1980).

With inorganic fertilizer N, P and K uptake increased significantly with increasing fertilizer rates. This increase in N, P and K uptake in shoot is probably due to increased DMY and increased nutrient concentration in the soil by the application of NPK fertilizer. Dahiya et al., (1980), reported an increase in uptake of P and K due to N application.

The interaction effects between organic manure and inorganic fertilizer on N, P and K uptake were not significant. However application of organic manure and inorganic fertilizer at all combinations generally increased uptake in the shoot Nutrient uptake followed similar pattern to that of DMY.

5.1.5 Correlation between maize dry matter shoot and root yields (Y1 and Y2) and Nutrient concentration (X1-X2), Nutrient uptake (X10-X12), Plant height (X13-X16) Dung rates and fertilizer rates (X17)

There was positive correlation between DMY and P and K concentrations. This indicates that P and K added to the soil on decomposition of organic manure have contributed to dry matter production. The negative and non-significant correlation between shoot DMY and Ca, Mg and micronutrient, provided conclusive evidence that K depressed Ca and Mg concentrations and shoot DMY. Fageria, et al., (1990) also indicated a significant and positive correlation between DMY and K-uptake.

There was a positive correlation between shoot DMY and plant height at all stages of measurement. Plant height being a growth

parameter may have contributed to DMY. Dung rates also significantly and positively correlated with P, K, Ca, Mg, Zn, Mn, and Fe concentrations. Cattle dung have been reported to significantly increase N, O.C., pH, CEC, and exchangeable Ca, Mg, and K, (Bache and Heathcote 1969, Moehansyah, 1977).

With inorganic fertilizer, the results show that shoot DMY was positively correlated with N and negatively correlated with P, K, Ca, Mg, Zn, Mn, Fe and Cu concentration. The major increases to DMY, therefore resulted from N concentration; N, P, and K uptake and plant height at 28 and 35 DAP.

For shoot DMY, the negative correlation with N, Ca, Mg and Zn, indicates that these nutrient elements did not contribute to the root DMY. There was positive correlation between root DMY and plant height at all stages of measurement and Dung. Phosphorus concentration, plant height and dung rates were the important factors that contributed to root DMY.

With inorganic fertilizer root DMY correlated positively and significantly with the fertilizer rates. This indicates that, an increase in inorganic fertilizer will increase nutrient availability which in turn is responsible for favourable conditions for better growth and development of roots. Also the fertilizer rates related positively and significantly with K, Ca concentrations and plant heights at 28 and 35 DAP. This is expected as nutrients are added through the fertilizer.

5.2 FIELD EXPERIMENT

5.2.1 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE GRAIN YIELD ($Kgha^{-1}$) AND SOME YIELD COMPONENTS

In general, application of organic manure significantly increased grain yield, 1000-grain weight, cob length, harvest index and shelling percentage. Stover yield, number of kernels per cob and cob diameter were not significantly affected. The increase in yield and yield components with increasing organic manure rates, clearly demonstrated that manure has a tremendous beneficial effect on the soil, because of its contribution to improved soil physical properties, increased soil organic matter, CEC and exchangeable cations in addition to other plant nutrients. (Bache and Heathcote 1969, Jones and Wild 1975; Lal, 1979). Increases in yield with increasing rates of manure have been reported by Dennison, (1961); Bache and Heathcote, (1970); Lombin and Abdullahi, (1978); Mokwunye, (1980).

With inorganic fertilizer, grain yield and all other yield components significantly increased with increasing fertilizer rates. This result is expected because as earlier mentioned, cereal crops in the study area demand high amounts of N and P for improved yield since the soils are inherently low in soil N and P. Greater plant vigour (indicated by plant height and stover yield) and nutrient uptake observed with increasing fertilizer rates may have contributed to increased yield.

The interaction effects were not significant for all these parameters, with the exception of harvest index. Although the interaction effects between organic manure and inorganic fertilizer on grain yield was not significant, the plots

receiving 40:20:20 $Kgha^{-1}$ and 2.5 tha^{-1} gave slightly higher grain yield than plots receiving 120:60:60 or 160:80:80 $Kgha^{-1}$ alone. As earlier mentioned, soils in the savanna are low to very low in organic matter content and the clay fraction is predominantly kaolinitic, consequently these soIls are generally low in cation exchange capacity (CEC) and are poorly buffered indicating that when NPK fertilizer alone are applied, these nutrients will be easily leached down, thus making them unavailable for the crop uptake. However, application of organic manure and inorganic fertilizer helps to reduce the quantity of inorganic fertilizer needed to meet crop needs. This indicates that organic manure has a tremendous beneficial effect in the soil because of its contribution to organic matter content, CEC, and exchangeable cations, bufferintg capacity, in addition to nutrients it supplies (Bache and Heathcote 1969). Work done in Kano and Samaru reported that under continuous cultivation, 2.5t ha^{-1}, 60Kg Nha^{-1} and 43Kgha^{-1} P_2O_5 seem optimum for the soils in the study areas (Anonymous 1978). Obi (1958); and Kwankye, (1980); have observed similar interaction between organic manure and phosphorus fertilizers. This thus, suggests that the use of organic manure enhances the benefits from the application of inorganic fertilizers.

5.2.2 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON PLANT HEIGHT (CM)

Generally, plant height increased at all stages of measurement with increasing organic manure rates. However, plant height at 56, 70 and 84 DAP were not significantly affected by the organic manure. This is probably due to the fact that

mineralization of the organic N in organic manure is generally too small to provide adequate N requirements of crops with short growing season.

With inorganic fertilizer, plant height generally increased significaty with increasing rates of fertilizer at all stages of measurement. Gagra (1978), in Yugoslavia and Mohammed, et al., (1978) in Somalia also reported similar results. The increased plant height is probably due to the nutrients added to the soil through application of the NPK fertilizer.

5.2.3 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE EAR LEAF AT 50% SILKING AND NUTRIENT CONCENTRATION IN STOVER

Organic manure did not affect ear leaf concentrations of N,P,K, Mg, Mn, Fe and Cu. McIntosh and Varney (1972); reported similar results. This is probably due to dilution effect, because grain and stover yields and N, P and K uptake increased with increasing organic manure rates. However, values generally to increased with increasing organic manure rates. This is expected, as organic manure increased soil N, C, pH, CEC and exchangeable Ca, Mg, and K (Bache and Heathcote, 1969). Stover concentrations of N, P, K, Ca and Zn were significantly affected by organic manure application. Nitrogen and P concentrations in the stover tended to decrease with increasing organic manure rates, probably due to dilution effect, because grain yield and N,P,K, uptake increased with increasing organic manure rates. However the increase in K, Ca and Zn concentrations may be due to their content in the organic manure, which are released into the

soil, on decomposition of the organic manure.

With inorganic fertilizer the concentrations of N,P,K, Ca, Mg and Zn in both the ear leaf and stover generally increased with increasing rates of fertilizer, probably due to nutrients added to the soil by the fertilizer. Lal, (1979) reported increases in ear leaf N and K concentrations with increasing N fertilizer rates.

The interaction effects were significant on N,P,K, Ca,Mg, Zn and Fe concentrations. At the various organic manure rates, values generally to increased with increased inorganic fertilizer rates, probably due to nutrient added to the soil through NPK fertilizer. At the different fertilizer rates, values also generally tended to increase with increasing organic manure rate. This again may be due to nutrients added to the soil on the decomposition of the organic manure. Agboola, (1988) have reported that besides N, P and K, organic manures also supply the soil with micronutrients such as B, Zn, Cu, and Mo. This may be the probable reason why these nutrients increased with increasing rates of organic manure.

5.2.4 EFFECT OF ORGANIC MANURE AND INORGANIC FERTILIZER ON MAIZE NUTRIENT UPTAKE (Kg ha^{-1})

Organic manure did not significantly affect N and P uptake, while K uptake was significantly affected. However, values tended to increase with increasing organic manure rates . Increased uptake of N, P and K by manure application is also reported by McAllister and McConagly (1960) and Naik and Ballal; (1968). This increase in NPK uptake, may be due to added NPK to the soil on decomposition of organic manure (Sharma et al, 1990).

With inorganic fertilizer, N and K uptake were significant, while P uptake was not significantly affected by fertilizer. This result agrees with that of Naik and Ballal; (1960). However, generally, NPK uptake to increased with increasing fertilizer rates. This also may be due to the increase in the concentration of these elements in the soil through addition of fertilizer.

The interaction between organic manure and inorganic fertilizer on N, P, and K uptake were not significant. This corroborates the work by William, (1992).

5.2.5 Correlation between Grain and stover yields (Y1 and Y2) and nutrient concentration (X1-X7), nutrient uptake (X8-X10), yield components of maize (X11-X14), plant height (X15-X18) and Dung and fertilizer rates (X19)

Grain yield correlated positively, but non-significantly with nutrient concentrations and uptake. This indicates that nutrient concentrations and uptake make a small contribution to grain yield, especially, when organic manure is used in a short-term experiment. However, there was a positive and significant correlation between grain yield and 1000-grain weight and kernel number per cob. Kumar and Iwuafor, (1990) also observed, postive and significant correlation between maize grain yield and 1000-grain weight, cob length and shoot height. The major increases in maize grain yield may have resulted from 1000-grain yield, and kernel number per cob. The correlation between grain yield and dung rates, was positive, but not significant. Moehansyah, (1977) reporte similar result.

With inorganic fertilizer, all the yield components (except

conditions conducive to good crop growth.

With fertilizer all yield components, except cob diameter and harvest index, were positively and significantly correlated with stover yield. This indicates that inorganic fertilizer have greatly influenced stover yield and all yield components except cob diameter and harvest index. There was as positive and significant relationship between stover yield and Mn concentration N and P uptake. This together with plant height at 42 and 70 DAP and the yield components may have contributed to stover yield.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSIONS

The emphasis of this study was to ascertain an integrated management approach which requires a combination of low chemical input and organic manure, that may offer a good opportunity for the small farmer to maintain yields at reasonable and sustainable levels. Sequel to this, Green House and Field Studies were carried out in the 1983 cropping season to evaluate the use of organic manure supplemented by inorganic fertilizer in crop production in the northern Guinea Savanna zone of Nigeria. The location is Samaru, IAR/ABU where Green house and field studies were carried out. Five rates of organic manure (0, 2.5, 5.0, 7.5 and 10t ha^{-1}) and five levels of inorganic, NPK fertilizers ($N_oP_oK_o$; $N_{40}P_{20}K_20$; $N_{80}P_{40}K_{40}$; $N_{120}P_{60}K_{60}$; and $N_{160}P_{80}K_{80}$) were tested in a randomized complete block design with three replication. Maize was used as the test crop for the two experiment.

Maize shoot and root DMY, generally increased with increasing organic manure rates. With inorganic fertilizer shoot and root DMY for plots receiving fertilizer were significantly higher than the control. The 160:80:80 $Kgha^{-1}$ fertilizer rate gave the highest DMY of 22.36 and 6.13 g/pot for shoot and root respectively. Shoot DMY at 5.0 tha^{-1} manure rate was similar to the value obtained at the 80:40:40 $Kgha^{-1}$ fertilizer alone, while for root DMY, it was 7.5 tha^{-1} that gave the same yield value as 80:40:40$Kgha^{-1}$. The interaction effects, though, not significant, show that application of organic manure and

inorganic fertilizer at all combinations generally increased both shoot and root DMY. Manure application in the absence of fertilizer increased DMY up 10 tha^{-1} rate and the increase was 228% and 164% higher for shoot and root respectively. The 40:20:20 $Kgha^{-1}$ + 2.5 tha^{-1} combination gave slightly higher shoot and root DMY than 120:60:60 or 160:80:80 $Kgha^{-1}$ fertilizer alone. The percentage increase in DMY at 40:20:20K gha^{-1} + 2.5 tha^{-1} rate over 120:60:60 and 160:80:80 rates alone were 56.6% and 58.4%, respectively.

Plant height generally increased with increasing organic manure rates up to 7.5 tha^{-1} rate. The increase at 14 and 21 DAP was significant even at 2.5 tha^{-1} rates of manure. This indicates that organic manure must have enhanced the general conditions for good crop growth and deveopment. Increases in plant height due to fertilizer application was significant at all stages of measurment except at 14 DAP. At 28 and 35 DAP, plots receiving 160:80:80 $Kgha^{-}$ rate were significantly taller than plants at 120:60:60 and 80:40:40 $Kgha^{-1}$.

The interaction effects were only significant at 14 DAP. Organic manure significanlty increased P and K concentration in the maize shoot and root, while the reverse was the case for N, Ca, Mg, Fe and Cu concentrations, probably due to dilution effect, because DMY and nutrient uptake increased with increasing organic manure rates. Similarly, with inorganic fertilizers, concentrations of N, Mg, Ca, Mn and Fe significantly decreased with increasing fertilizer rate, probably due to dilution effects or Ca and Mg concentrations may decrease due to relatively high availability of K in the soil.

The interaction effects were significant only on concentrations of K, Ca, Mg, Mn, Fe and Cu in the maize shoot and root. Generally, values decreased with increasing organic manure and inorganic fertilizer rates.

Main effects of organic manure and inorganic fertilizer were significant at 5% level of significance, for nutrient uptake, except N uptake which was not significant, with manure application. Generally uptake increased with increasing rates of both organic manure and inorganic fertilizer.

The interaction effects between organic manure and inorganic fertilizer on N, P and K uptake were not significant. In the field, organic manure significantly increased grain yield, 1000-grain weight, cob length, harvest index and shelling percentage, while stover yield, number of kernels per cob and cob diameter were not significantly affected. However, all these yield parameters increased with increasing organic manure. With inorganic fertilizer, grain yield and all other yield components significantly increased with increasing fertilizer rates.

There was no significant interaction between organic manure and inorganic fertilizer on grain yield and all other yield components. Although, interaction effects on grain yield was not significant, results show that plots receiving a combination of 40:20:20 $Kgha^{-1}$ + 2.5 tha^{-1} gave slightly higher grain yield than plots receiving 120:60:60 or 160:80:80$Kgha^{-1}$ alone. The percentage increase were 18.06% and 15.78% respectively.

Plant height at 56, 70 and 84 DAP were not significantly affected by organic manure. However, values generally increased

with increasing organic manure rates at all stages of measurements.

With inorganic fertilizer, plant heights significantly increased at all stages of measurements. The interaction effects were not significant on plant height at all stages of measurement.

Organic manure did not affect ear leaf concentrations of N,P,K, Mg, Mn, Fe and Cu, while stover concentrations of these elements were significantly affected by organic manure application. Nitrogen and P concentrations in the stover decreased with increasing organic manure rates, probably due to dilution effect.

With inorganic fertilizer, both ear leaf and stover concentrations of N,P,K, Ca, Mg and Cu increased with increasing fertilizer. This may be due to nutrients added to the soil by the fertilizers.

The interaction effects were significant on N,P,K, Ca, Mg, Zn and Fe concentrations. However, values tended to increase with increasing organic manure and inorganic fertilizer rates. Application of organic manure did not significantly affect N and P uptake, while K uptake was significantly affected. However, values generally increased with increasing organic manure rates.

With inorganic fertilizer N and K uptake were significantly affected, while P uptake was not significantly affected by fertilizer. The interacrtion effects, were not significant on N, P and K uptake.

From the results obtained in this study, the following conclusions can be drawn:

i. The subsistence farmers in the Northern Guinea Savanna, who cannot afford their inorganic fertilizer requirements, due to high prices and unavailability of the commodity in this area, can now use 40:20:20K gha^{-1} fertilizer and 2.5t ha^{-1} of manure for reasonable crop production.

ii. The 40:20:20K gha^{-1} and 10t ha^{-1} fertilizer and manure combination gave the highest grain yield. However, such a large quantity of organic manure (cow dung) may not be easily obtained in this region, because of poor animal husbandary systems. Even where it is obtainable, transportation and handling costs will be a serious constraint. Where a farmer can afford such high rate of organic manure, this combination is also recommended.

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