بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Effect of Compost, Mycorrhizal inoculation and Chemical Fertilizers on Growth of Sorghum (*Sorghum bicolor* L.)

تأثير إضافة الكومبوست و المايكورايزا والأسمدة الكيميائية على نمو الذرة الرفيعة

A Thesis Submitted to Sudan University of Sciences and Technology in Partial Fulfillment of the Requirement for the Degree of Master of Soil Sciences.

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الآية

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قال تعالى:
((أَلَمْ تَرَ أَنَّ اللَّهَ أَنزَلَ مِنَ السَّمَاءِ مَاءً فَأَخْرَجْنَا بِهِ ثَمَرَاتٍ مُّخْتَلِفًا أَلْوَانُهَا وَمِنَ الْجِبَالِ جُدَدٌ بِيضٌ وَحُمْرٌ مُّخْتَلِفٌ أَلْوَانُهَا وَغَرَابِيبُ سُودٌ﴿٢٧﴾وَمِنَ النَّاسِ وَالدَّوَابِّ وَالْأَنْعَامِ مُخْتَلِفٌ أَلْوَانُهُ كَذَلِكَ إِنَّمَا يَخْشَى اللَّهَ مِنْ عِبَادِهِ الْعُلَمَاءُ إِنَّ اللَّهَ عَزِيزٌ غَفُورٌ﴿٢٨﴾)).

صدق الله العظيم

سورة فاطر الآيات (27 و28)

DEDICATION

To the fountain of patience and optimism and hope

To each of the following in the presence of God and His Messenger

My mother dear

To the big heart my dear father

To those who have demonstrated to me what is the most beautiful of

my sisters life

To the people who paved our way of science and knowledge

All our Distinguished Professors

To the taste of the most beautiful moments with

my friends

I guide this research

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Alhamdulillah with whose permission good deeds are completed.

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LIST OF ABBREVIATION

SOM	Soil organic matter.
MSW	Municipal solid wastes.
FAO	Food and Agriculture Organization of the United Nations.
AMF	Arbuscular Mycorrhiza fhungi.
CRD	Completely Randomized Design.
C:N	Carbon and Nitrogen ratio.
WAP	Weeks After planting.
LSD	Least significant Difference.

ABSTRACT

The study was conducted at the greenhouse facility of the College of Agricultural Studies (CAS) Shambat, Sudan University of Sciences and Technology (SUST), to evaluate the impact of using organic fertilizer (compost), biofertilizer (Mycorrhizal fungi) and Chemical fertilizers (Nitrogen and phosphorous) of sorghum (*Sorghum bicolour* L.) *Mogod* variety growth and growth components. The study was carried out during the year 2015-2016. In the laboratory experiment mycorrhizal fungi was isolated from sorghum plant rhizosphere from the field of the College of Agricultural Studies. Nitrogen, phosphorous and potassium were determined in sorghum tissue. The results showed that there were no significant differences among most of the parameters studied, The results also indicated that the compost enhanced growth of sorghum more than Mycorrhiza and chemical fertilizers (nitrogen and phosphorus).

ملخص البحث

أجريت هذه الدراسة بكلية الدراسات الزراعية جامعة السودان للعلوم والتكنولوجيا (شمبات) لتقييم تأثير إستخدام السماد العضوي (الكومبوست) والسماد الحيوي (فطر الميكورايزا) والأسمدة الكيميائية (اليوريا والسوبرفوسفات) على نمو نبات الذرة الرفيعة صنف (مقد). أجريت الدراسة خلال عام 2015- 2016 م. خلال التجربة المعملية تم عزل فطر الميكورايزا من منطقة الرايزوسفير لنبات الذرة الرفيعة من مزرعة كلية الدراسات الزراعية (شمبات) وتم تقدير النيتروجين والفسفور والبوتاسيوم في أنسجة نبات الذرة الرفيعة. أظهرت النتائج عدم وجود فروقات معنوية بين أغلب المعاملات التي درست وأشارت النتائج إلى أن الكومبوست أظهر تحسن في نمو نبات الذرة الرفيعة أكثر من السماد الحيوي (الميكورايزا) والأسمدةالكيميائية (اليوريا والسوبرفوسفات).

CHAPTER ONE

INTRODUTION

Sorghum is the staple food crop of most people in the Sudan, and traditionally sorghum growing areas were Blue Nile State, North and South Gadarif, Gezira, Sennar and White Nile States. In the Sudan, sorghum (*Sorghum bicolor L.*) is the most important cereal crop in terms of total acreage, production. The total area under sorghum production was estimated to average 6.0 million ha. The total annual grain production varies an average of 0.6 tons/ha (FAO, 2003).

In Sudan different soil types have been extensively used in sorghum breeding programs (Bantilan, *et al.*, 2004). Sorghum ability to reliable production of grains under adverse conditions makes it important sources of food, feed and fuel (Addissu, 2011). The plant is very high in fiber and iron, with a fairly high protein level as well. This makes it well suited to its use as a staple starch in much of the developing world.

During the last fifty years due to the high use of synthetic fertilizer not only the overall soil fertility decreased, but also the biological and organic systems adversely affected. In addition decreasing trend of production even after using higher doses of fertilizer. Besides, that the use of synthetic fertilizer is causing several environmental problems (updesh,2009).

Plants for growth and development require 16 essential elements (Al-Khiat, 2006). Soil fertility can be presumably enhanced by organic, biofertilizer and inorganic fertilizers application. However, the use of any type of fertilizer depends on several factors such as soil type, nature of crop and socio-economic conditions of the area (Babiker and Mustafa 2005).

However the quantity and quality of fertilization techniques are the most important one. The synthetic fertilizers Application of organic fertilizers and biofertilizers can be used instead of (Haller and Stople, 1985).

The organic manures play an important role in increasing growth, yield and yield components of many crops (Ryan *et al.*,1985) . Organic fertilizers refers to materials used as fertilizer that occur regularly in nature, usually as a byproduct or end products of a naturally occurring process. Organic fertilizers mostly provide the three major macronutrients required by plants nitrogen, phosphorus, and potassium**.** Organic fertilizers include naturally occurring organic materials, (e.g. manure, worm castings, compost, seaweed), or naturally occurring mineral deposits (wikipedia.org/wiki/Fertilizer).
Compost is the product of deliberate transformation through biological and chemical decomposition of organic matter into humus. The process takes place under controlled condition in heaps (Muller-samann and kotschi, 1994).

The use of biofertilizers can promotes plant growth by increasing the supply or availability of macro and micro nutrients through the natural processes (Vessey 2003).

Biofertilizers in agriculture is getting great attention among the agriculturalists, farmers and environmentalists. These Biofertilizers live naturally and help to enhance the growth of plants by production of various growth hormones, provision of essential nutrients, protection against pathogen they also involve in cleaning up the environment (Marschner and Dell ,1994;Trivedi *et al*., 2003, Al-Taweil *et al*., 2009).

Biofertilizers differ from chemical and organic fertilizers in the sense that they do not directly supply any nutrients to crops and are cultures of special bacteria and fungi. The production technology of biofertilizers is relatively simple and installation cost is very low compared to chemical fertilizer plants.

Arbuscular mycorrhizal fungi (AMF) are important organisms for plants since they can improve mineral uptake and thus may lead to enhance plants growth and become more resistant to environmental stresses (Barea *et al.*, 1993).

Organic and Biofertilizers are been identified as an alternative to chemical fertilizer to increase soil fertility and crop production in sustainable farming. The use of organic and biofertilizer is steadily increased in agriculture and offers an attractive way to replace chemical fertilizers, pesticides, and supplements.

The main objective of this study are:-

1- To isolate mycorrhiza fungi from Sudanese soil from sorghum plant.
2- To test the effiency of mycorrhiza fungi .
3- To compare between compost, mycorrhiza fungi as fertilizers and other fertilizers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background:

Soil organic matter (SOM) is the organic component of soil, consisting of three primary parts including small (Fresh) plant residues and small living soil organisms, decomposing (active) organic matter, and stable organic matter (humus). It has been considered as an important indicator of soil quality because it is a nutrient sink and source, enhances soil physical and chemical properties and promotes biological activity (Doran and Parking, 1994; Greogorich, *et al.*,1994). In addition, It serves as a reservoir of nutrients for crops, provides soil aggregation, increases nutrient exchange, retains moisture, reduces compaction, reduces surface crusting, and increases water infiltration into Soil.

Based on the production process, the fertilizers can be roughly categorized into three types: organic, bio and chemical fertilizers need to be integrated in order to make optimum use of each type of fertilizers and achieve balanced nutrient management for crop growth (Jen-Hshuan, 2006).

2.2 Organic fertilizer:

FAO (1999) defined organic agriculture as a holistic production system, which promotes and enhances agro-ecosystem health, including biological cycles and soil biological activity. It emphasizes the use of management practices in preferences to the use of off-farm inputs, taking into account the regional conditions and required local systems.

The use of manure as a source of plant nutrients in soil is of great importance, as long as it is a cheaper source of nutrients than commercial fertilizers. The manure also provides balanced nutrients to the plant and therefore can prevent the harmful effects resulting from shortage or excess of addition of particular nutrients (AbdElrahman, 1997).

2.3 Compost:

Compost is defined as stable aerobically decomposed organic matter which is the result of managed decomposition process. During this process, a succession of aerobic micro-organisms break down and transform organic material into arrange of increasingly complex organic substances (Bastida, *et al*., 2010; CIWMB, 2004; Epstein, 1997; Paulin and O'Mally,2008).

Composting is a biological process by which micro-organisms convert organic materials into dark humus. It is prepared from crop residues and other farm wastes, animal bones, slaughter house refuse etc. Composting differs only in the intentional creation of conditions that result in more rapid decomposition of organic material than what would normally occur in nature. It is a simple, rewarding way to recycle yard trimmings and food scraps at home while creating compost, a valuable soil amendment for gardens and lawns (Park, *et al.*, 2002). The addition of municipal solid waste compost to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties (Zheljazkov and Warman, 2004).

Composting is the decomposition or break down of organic waste material by a mixed population of organisms in a warmed or moist aerated environment. It is a constantly changing microbial process brought about by the activities of a succession of various groups of microorganisms each of which is appropriate to an environment of relatively limited duration (Dalzell, *etal.*, 1987). Composting is both a building up process and break down process. Some organic sugars are simple in form and readily taken up by microorganisms, providing energy to them and being built into polymers. other substances such as cellulose and hemicelluloses have large molecules and must first be broken by enzymes before they are used. Lignin is a woody material that is high resistance and only break down after long period of time. It was found that 50% of dry weight of starch material is lost during decomposition process. The bodies of microorganisms both living and died form an important part of the compost product (Dalzell, *et al*., 1987).

2.4 Application of compost:

Compost is a result of microbiological activities which converts organic matter to more stable, humified forms and to inorganic (e.g. carbon dioxide, water, ammonia, nitrate, methane) under controlled condition, resulting in setsof metabolic waste product (Reinikainen and Herranen, 1999).

In agriculture, there are two common methods for applying composts to soil: Incorporation and mulching (Bastida, *et al*., 2010 and Cogger, *et al*., 2008). Compost incorporation into the top few centimeters increase accessibility for soil microbes and also contact with the plant roots, and thus have a greater effect on soil C:N ratio and bulk density than surface application (mulching) (Cogger, *et al*., 2008).

Mulching is a common in horticulture and agriculture in dry climate because it minimize water loss by evaporation (Agassi, *et al*., 1998; Agassi, *et al*., 2004; Gonzalez and Cooperband, 2002; Tu, *et al*., 2006) as it is applied on the surface.

2.5 Compost Quality:

Compost quality is closely related to its stability and maturity. The abundance of chemical and biological changes that occur during composting and the range of methods suggested in literature (Itavaara, *et al*., 2002; Wang 2004). Various parameters have been used to assess the quality and maturity of compost these include C:N ratio of the finish product, water soluble carbon, and carbon dioxide evaluation from the finished compost (Garcia,*et al*., 1992;Huang, *et al*., 2001; Wu and Ma 2002). Germination index is indirect quantification of compost maturity (Cunba Queda, 2002). However, it is difficult to apply across wide range of compost prepared from different organic wastes (Roletto, *et al* .,1985; Saviozsi,*et al*., 1988; Benito, 2003).

Microbial succession plays a key role in decomposition process and appearance of some microorganisms reflect the quality of maturing compost (Ishii, *et al*., 2000).Compost stability is an important aspect of compost quality. It has some relation to the degree to which the organic matter has been stabilized during the composting processes (Eggen and Vethe 2001;Weppen, 2002). (Goyal, *et al*.,2005) investigated that no single parameter that can be taken as an index for compost maturity, however, C:N ratio and CO_2 evolved from finished compost can be taken as a most reliable indices of compost maturity Similarl, (Vogtamann and Fricke1989) concluded that not only technical aspects but also the quality of the compost are important, this includes the undesirable component like heavy metals and xenobiotics. (Garcia, *et al* .,1992) suggested that in mature municipal compost the amount of CO_2-C evolved should be less than 500mg CO_2-C per100g total organic C in the compost , more CO_2 evaluation indicates the compost in not stabilized and need further decomposition .

C:N ratio should be below 20 which is an acceptable compost maturity (Bernal, *et al.*,1998). However, (Hirari, *et al*., 1989) stated that the C:N ratio cannot be used as a reliable indicator of compost maturity due to different characteristics of the waste used. The compost is considered as mature if the maximum temperature is less than 40°C and oxygen concentration is higher than 5% (Reinikainen and Herranen, 1999).

2.6 Composting process:

Composting is divided into the following categories based on the nature of decomposition process.

2.6.1 Anaerobic composting:

In an anaerobic composting, decomposition occurs where oxygen (O_2) is absent or present in limited supply. Under these conditions anaerobic microorganisms dominate and develop intermediate compounds including methane, organic acid, hydrogen sulphide and other substances. In the absence of oxygen these compounds accumulate and are not metabolized any further. Many of these compounds have strong odors and some are phytotoxic. The process of an anaerobic composting at a low temperature will leave weed seeds and pathogens. Moreover, the process usually takes longer time than aerobic composting (FAO,1987; Hernandez*, et al.,* 2005).

2.6.2 Aerobic composting:

An aerobic composting takes place in the presence of ample oxygen. In this process aerobic microorganisms break down organic matter and produce carbon dioxide, ammonia, water, heat and humus (the relatively stable organic end products). Although aerobic composting may produce intermediate compounds such as organic acids; aerobic microorganisms decompose them further and the resultant material has little phytotoxicity. The heat generated accelerates the breakdown of protein, fats and hemicelluloses and hence, the processing time is shorter (Zucconi and De betoldi, 1987). Moreover, this process destroys many microorganisms and plant pathogens by the sufficiently high temperature.

2.7 Phases of aerobic compost:

FAO (1987) showed that aerobic composting process, may be divided into the following four stages: mesophilic, thermophilic, cooling down and maturity.

2.7.1 Mesophilic:

The aerobic composting processes start with the formation of the pile. The temperature rises rapidly to 70-80 °C within first few days. During this time mesophilic organisms with optimum growth temperature range of 45-50 °C dominate the medium and multiply rapidly consuming readily available sugar and amino acids and release heat that raises the temperature to a point where their own activities become suppressed (Hamad, 2009).

2.7.2 Thermophilic:

During the first day or two days of aerobic composting, labile organic matter carbon is initially degraded by bacterial enzymes present in mesophillic microflora flourishing at temperature between 45 to50°C. As microbial metabolism of readily soluble carbohydrates in the compost feedstock increases, more oxygen is consumed and carbon dioxide release, raising temperatures as 70°C which increase thermophilic microbial populations (Epstein, 1997;Eiland, *et al*., 2001; Druilhe, *et al.* 2002) This stage is called the thermphilic stage or active composting.

2.7.3 Cooling down:

When the temperature falls down, mesophilic organisms reinvade the substrates.

2.7.4 Maturity stage:

The required degree of compost maturity depends on the method to which the product will be apply. For mulching on the surface of the ground between rows of crops or around established trees and shrubs, immature compost is perfectly acceptable. (Valtcho, et *al*., 2004) suggested that at maturity the compost had a moisture content 66%, 7.7%C, 0.628%N, 12.3:1 C:N ratio, 7.6 pH and 2.4dS/m electrical conductivity. They also suggested that compost could be considered mature if it meets two of the following three requirements:

- C:N ratio of less than 25.
- Oxygen uptake rate of less than or equal to 50mg O_2/kg material.

- Germination of cress (*Lepidium sativuml*) seed and radish (*Raphanus sativius*) seeds in the compost must be greater than 90% of the germination rate of the control and if the seeds are grown in mix compost and soil the percentage must not differ by more than 50% of the control.

2.8 Factors affecting decomposition of organic matter:

2.8.1 Temperature:

Cold periods retard plant growth and OM decomposition. Warm summers may permit plant growth and humus accumulation.

2.8.2 Soil moisture:

Extremes of both arid and anaerobic conditions reduce plant growth and microbial decomposition. Near or slightly wetter than field moisture capacity conditions are most favorable for both processes.

2.8.3. Nutrients:

Lack of nutrients particularly N slows decomposition processes.

2.8.4 Soil pH:

Most of the microbes grow best at pH 6 – 8, but are severely inhibited below pH 4.5 and above pH 8.5.

2.8.5 Soil Texture:

Soils higher in clays tend to retain larger amounts of humus.

2.8.6 Other Factors:

Toxic levels of elements (Al, Mn, B, Se, Cl), excessive soluble salts and organic phytotoxins in plant materials.

www.agriinfo.in/?page=topic&superid=4&topicid=289.

2.9 Compost Benefits:

The soil benefits greatly from the addition of compost. Fertility, water holding capacity, bulk density and biological properties are improved (Flavel and Murphy, 2006). Odors are reduced and fly eggs die due to the high temperatures occurring during microbial decomposition (Larney, *et al*., 2006).

Certain weed seeds can pass through livestock and grow in manure applied on cropland. Few weed seeds remain viable in properly composted manure, which can reduce the amount of herbicide or tillage needed for weed control (Larney and Blackshaw 2003).

The addition of compost to soils affects soil microorganisms directly by providing a source of nutrients and indirectly by changing chemical and physical properties of soil. Compost stimulates microbial growth and activity, but not to the extent as fresh plant residues because it is already decomposed. Compost generally increases abundance of soil organisms (including earthworms) (Cheng and Grewal, 2009; Paulin and O'Malley,2008; Sutton-Grier, *et al.*, 2010)

Organic fertilizers are better sources of nutrient than inorganic fertilizers where soil is deficient in both macro and micronutrients. Organic based fertilizer use is beneficial because it supplies micronutrients, and organic components that increase soil moisture retention and reduce leaching of nutrients. Nutrients inorganic fertilizers are released by soil microbes at almost the same time and speed as required by plants. The slow release of nutrients makes it possible for farmers to apply a seasonal worth of plant food in one application with less chance of loss to runoff. Organic fertilizers can be used on acid tolerant and those better suited to neutral or alkaline conditions (Alimi, *et al*, 2007).

2.10 Effect of compost on plant growth and nutrient uptake:

Organic matter of food waste which was composted with miraculous soil microorganisms significantly increased the fresh weight of lettuce compared to mineral fertilizers. In addition oil production in mint plants increased when plants were grown with biosolid (Scavroni, *et al*., 2005).

Applying compost to soil can increase plant nutrient availability (Heymann, *et al.,* 2005; Kawasaki, *et al.,* 2008). The percentage of essential oil, fresh and dry matter of marjoram plants positively responded to increased levels of composted manure compared with chemical fertilizer (Edris, *et al*., 2003; and Jung, *et al*., 2004). Compost can stimulate plant growth, root development and thus nutrient uptake (Lopez-Bucio, *et al*., 2003; Oworu, *et al.,* 2010; Soumare, *et al.,* 2003; Walker and Bermal, 2008). Humic substances, the major component of soil organic matter in composts, can increase shoot biomass via hormonal effects on root elongation and plant development (Atiyeh, *et al.*, 2002; Lazcano, *et al.,* 2009; Nardi, *et al.*, 2002; and Zandonadi, *et al.,* 2007).

The application of compost from Municipal Solid Wastes (MSW) and dairy manure to soil can result in a significant increase in concentration of N, P and other nutrient in soil, even several year after compost application (Butler, *et al.,* 2008; and Soumare, *et al.,* 2003). However, increased microbial activity can also increase N mineralization and potential denitrification (Dambreville, et *al.,* 2006).

2.11 Biofertilizer:

During the late 19th and early 20th centuries, inorganic compounds containing nitrogen, phosphorus and potassium (NPK) were synthesized and used as fertilizers which increase the crop production so as to meet the rising demands for food. Increase in the production cost and the hazardous nature of chemical fertilizer for the environment has led to the resurgence of interest in the use of biofertilizers to enhance environment stability, crop production and good crop yield (Hedge, *et al*., 1999).

The term Biofertilizers denotes all the nutrients input originating from biological source or due to biological translocation. They also receives more attention worldwide due to the fact that it poses larger lasting affect and if properly managed, can out yield the recommended doses of chemical fertilizers (Mahadi, 1993).

In Sudan, biofertilization receives great attention because of minimal effect on the environment and predominantly low cost in agricultural systems where chemical fertilizer if available may not be affordable (El Sheikh and El Zidany, 1997).

Biofertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable forms through biological processes **(**Chandrasekar, *et al*, 2005 and Selvakumar,2009). Biofertilizers can add 20-200kg $Nha.^{-1}$ (by fixation), liberate growth-promoting substances and increase crop yield by 10-50%. They are cheaper, pollution free, based on renewable energy sources and also improve soil tilth (Saeed, *et al.*, 2004).

2.11.1 Mycorrhizal fungi:

Fungi are capable of infecting roots and forming a symbiotic relationship with them. The resulting structure called a mycorrhiza, or literally fungus roots (Pond, *et al***.,** 2011). The majority of vascular plant in terrestrial ecosystem forms a mycorrhizal association with soil fungi. The most common is the arbuscular mycorrhiza (Hodge,.2000).

Among root-infecting symbionts, arbuscular mycorrhizal (AM) fungi are particularly widespread forming symbioses with 80% of all vascular plants including most agricultural crops (Smith and Read, 1997). The extra radical mycelium of AM fungi expands the absorptive surface of the plant root system thereby enhancing the access to nutrients mainly P (Marschner and

Dell, 1994; Clark and Zeto, 2000). The fungi in return benefits from the supply of plant-derived carbohydrates (Johnson, *et al*., 1997). Arbuscular mycorrhizal fungi (AM) fungi; Phylum Glomeromycota are significant members of the soil microbial community, which forms symbiotic relationships with the majority of higher plants (Smith and Read, 2008).

2.11.2 Types of mycorrhiza:

A mycorrhiza ("fungus – root") is a type of endophitic, biotrophic, mutualistic symbiosis prevalent in many cultivated and natural ecosystems. There are three major groups of mycorrhiza are Ectomycorrhiza, Ectendomycorrhiza and Endomycorrhiza. Ectomycorrhiza and endomycorrhiza are important in agriculture and forestry. Initially the mycorrhizal biofertilizer is used to increase the production of economic crops such as fruit trees (durian, longan, sweet tamarind, mangosteen and papaya). Now the biofertilizer can be used for vegetables and rubber. Endomycorrhiza (vesiclular arbuscular mycorrhiza (VA mycorrhiza) now known as Arbuscular Mycorrhiza (AM) play a very important role on enhancing the plant growth and yield due to the increasing supply of phosphorus to the host plant. Mycorrhizal plants can absorb and accumulate phosphate from the soil or solution several times more than non–mycorrhizal plants. Plants inoculated with endomycorrhiza have been shown to be more resistant to some root diseases (Morton,2001).

2.11.3 Culturing AM fungi:

AM fungi enter in a symbiotic association with plants for proliferation. Therefore, culturing AM fungi is to inoculate AM fungi to host plant and to grow the inoculated plant. For the AM fungal inoculum, spores collected form soil can be used. However, spores in soil are not always active in colonizing plants. Therefore, trapping culture is often employed. Soil or sieving of soil is used as inoculum (Soil Trap Culture). To isolate AM fungi colonizing roots, mycorrhizal plants collected from field can be transplanted to potting medium as Plant Trap Culture (Murakoshi, *et al*. 1998).

2.11.4 Effect of Soil physical, chemical and environmental characteristics on Arbuscular Mycorrhizal fungi:

Soil characteristics, plant species and climate may regulate the AMF community (Escudero and Mendoza, 2005). The occurrence of mycorrhiza is influenced by the land slope, the geographic and topographic locality (Dickinson 1974). High temperatures greatly affect the infection by AMF (Diederich and Moawad, 1993). However under specific conditions, the spore density correlates with fluctuations in temperature (Koske, 1987). In grasses, low moisture levels lead to increases in root colonizations and decrements of the spore production by AMF (Simpson and Daft, 1990; Rickerl, *et al.,* 1994; Camargo-Ricalde and Espero´n-Rodrı´guez, 2005). However, in both very dry and fooded soils decrease colonization by AMF was observed (Lodge, 1989; Miller and Bever, 1999; Miller 2000). In general, vesicle colonization (Stevens and Peterson, 1996) and the external hyphae (Schack-Kirchner, *et al*., 2000) are not typically affected by the water gradient.

The pH affects the distribution and abundance of different fungal species (Read, *et al.,* 1976; Porter, *et al*., 1987b and Wang, *et al*., 1993). Small increases in pH are associated with greater root colonization by AMF in acid soils with low phosphorus availability (Soedarjo and Habte, 1995; Heijne, *et al*., 1996). Besides the difficulty in separating the influences of host plant species and soil characteristics on root colonization and the inoculum (external hyphae) and spore density (Escudero and Mendoza, 2005), there is no a clear separation between plant and soil factors. There is a growing evidence that diversity and distribution of AMF depend on the community structure and characteristics of the ecosystem (Van der Heijden and Sanders ,2002).

2.11.5 Effect of mycorrhiza on plant growth and nutrients uptake:

AM fungi are important components of virtually all terrestrial ecosystems and are especially critical in improving plant nutrient and water uptake under semi-arid conditions (Van der Heijden, *et al.*, 2006; Allen, 2011). AM fungi can improve plant resistance to soil water deficit (Lambers, *et al.*, 2008; Smith and Read, 2008; Apple, 2010; Ruiz-Lozano and Aroca, 2010). AMF can also benefit plants by stimulating the production of growth regulating substances, increasing photosynthesis, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006). These benefits are mainly attributed to improved phosphorous nutrition (Plenchette, *et al.,* 2005).

Mycorrhizal inoculation significantly increased nodule number, nodule dry weight, flower set, pod production and seed yield. In P deficient soils,The situation could be improved with greater input of organic matter and higher rate of decomposition ,as this produces acids that can help dissolve rock phosphates in soil (Helen, 2009). Mycorrhiza plays important role in nutrient cycling in agricultural and ecosystems (Sabannavar and Laskshman, 2009).
Vascular arbuscular mycorrhiza was found to improve the availability of phosphorus and other immobile elements like zinc and iron (Baylis, 1959). This was thought to increase in the root volume through the association with fungi mycelia.

2.11.6 Mycorrhizal research in Sudan:

There are many studies of mycorrhiza in Sudan such as, Mahadi (1993) reviewed the use of VAM fungi as a biofetilizer in Sudan. He suggested that VAM fungi have a great potentiality for using as a biofertilizer. Shoots and roots dry weight and phosphorus content of dolichos bean plants increased with *Glomus sp* inoculation. *Glomus sp* significantly reduced the number of galls induced by the root-knot nematode *M. incognita* and hence reduced the infestation effect of the nematodes (Ahmed *et al*., 2009).

Application of mycorrhizae without phosphorus resulted in significant increases in number of leaves, plant weight, bulb diameter and total bulb yield (Ali and Muddathir, 2007). Mycorrhizal inoculation significantly increased nodule number, nodule dry weight, flower set, pod production and seed yield under both watering regimes, but P application alone had no significant effect on all the above mentioned parameters (Ali, *et al.,* 2007).

Mahdi, (2006) reported that mycorrhizal symbiosis improves N_2 fixation in legume crops. Nodulation and plant growth of soybean were significantly enhanced by mycorrhization and P fertilization, but effect was greater in presence of both treatments (Mahadi *et al.*, 2004).

According to Galal, (1993) inoculation of cowpea with local introduced *Glomus sp* VAM fungi significantly enhanced plant nodulation, dry matter yield and nitrogen and phosphors contents in silt and sandy soils. No significant differences were reported between the efficiency of the introduced and the local VAM fungi.

Mohammed and Elsheikh, (2008) found that vascular arbuscular mychorriza enhanced both the growth and yield *Rhizoctonia*-inoculated potato plants and significantly reduced the harmful effects of the disease.

2.12 Chemical fertilizer:

Fertilizers plays an important role in increasing crop production. The main macronutrients present in inorganic fertilizers are nitrogen, phosphorus, and potassium which influence vegetative and reproductive phase of plant growth (Patil, 2010). Chemical Fertilizers is often synthesized using the Haber-Bosch process, which produces ammonia as the end product. This ammonia is used as a feed stock for other nitrogen fertilizers, such as anhydrous ammonium nitrate and urea. These concentrated products may be diluted with water to form a concentrated liquid fertilizer. Ammonia can be combined with rock phosphate and potassium fertilizer to produce compound fertilizers (wikipedia.org/wiki/Fertilizer).

The use of chemical fertilizers alone has not been useful under intensive agriculture because it aggravates soil degradation. The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yields**,** Due to its high solubility, up to 70% of inorganic fertilizer can be lost through leaching, denitrification and erosion and reducing their effectiveness. (Ayoola and Makinde, 2007**;** Alimi, *et al.*, 2007). Over application can result in negative effects such as leaching, pollution of water resources, destruction of micro-organisms and friendly insects, crop susceptibility to disease attack, acidification or alkalization of the soil or reduction in soil fertility, thus causing irreparable damage to the overall system (Jen-Hshuan, 2006). The use of chemical fertilizers alone generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic N,P and K fertilizers are rapidly lost by either evaporation or by leaching (Ali, *et al.*, 2007).

2.12.1 Primary Macronutrients:

2.12.1.1 Nitrogen:

Although Earth's atmosphere contains 78% nitrogen gas (N_2), most organisms cannot directly use this resource due to the stability of the compound. Plants, animals and microorganisms can die of nitrogen deficiency, although they are surrounded by N_2. All organisms use the ammonia (NH_3)form of nitrogen to manufacture amino acids, proteins, nucleic acids and other nitrogen-containing components necessary for life (Lindermann and Glover, 2008). Nitrogen is present in all living organisms, in proteins, nucleic acids and other molecules. It typically makes up around 4% of the dry weight of plant matter. (http://en.wikipedia).Nitrogen is required for cellular synthesis of enzymes, proteins, chlorophyll, DNA and RNA, and is therefore important in plant growth and production of food and feed. Inadequate supply of available N frequently results in plants that have slow growth, depressed protein levels, poor yield of low quality products, and inefficient water use (Rifat, *et al.*, 2010). The sources of nitrogen used in fertilizers are many, including ammonia (NH_3), Diammonium phosphate(DAP)((NH_4)2HPO_4), ammonium nitrate (NH_4NO_3), ammonium sulfate ((NH_4)2SO_4), calcium cyanamide (CaCN2), calcium nitrate (Ca(NO3)2), sodium nitrate (NaNO3), and urea (N2H4CO) (Shakhashiri, 2003).

2.12.1.2 Phosphorus:

Phosphorus (P) is a major growth-limiting nutrient, and unlike the case for nitrogen, there is no large atmospheric source that can biologically be available. Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases are the attributes associated with phosphorus nutrition (Ahmad, *et al.*, 2009). Although phosphorus uptake by plants is less compared to nitrogen and potassium, normal plant growth cannot be achieved without it (Bin Zakaria, 2009). P in soils is immobilized or becomes less soluble either by absorption, chemical precipitation, or both (Tilak *et al*, 2005). The concentration of soluble phosphorus (P) in tropical soil is usually very low, phosphorus is only available in micromolar quantities or less (Henri *et al*, 2006). The P-content in average soils is about 0.05% (w/w) but only 0.1% of the total P is available to plants. Deficiency of soil P is one of the most important chemical factors restricting plant growth in soils. The overfertilization of P leads to pollution due to soil erosion and runoff water containing large amounts of soluble phosphorus. Some microorganisms are known to be involved in the solubilization of insoluble phosphate (Hong *et al*, 2006).

2.11.1.3 Potassium:

Potassium (K) concentrations in most plants range from 1 to 4% by weight. Unlike the other primary nutrients, K forms no other compounds in the plant, but remains a lone ion. Potassium is also vital for animal and human nutrition, and thus healthy fruits, vegetables and grains must have adequate levels of K (Brian, 2007).

Potassium regulates the opening and closing of the stomata by a potassium ion pump. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases drought tolerance. Potassium deficiency may cause necrosis or interveinal chlorosis. K+ is highly mobile and can aid in balancing the anion charges within the plant. It also has high solubility in water and leaches out of soils, the rocky or sandy soils which leads to in potassium deficiency. It serves as an activator of enzymes used in photosynthesis and respiration. Potassium is used to build cellulose and aids in photosynthesis by the formation of a chlorophyll precursor. Potassium deficiency may result in higher risk of pathogens, wilting, chlorosis, brown spotting, and higher chances of damage from frost and heat. (William, 2009). Potassium fertilizers are found in different form e.g Potassium chloride(KCl), Potassium sulfate (K_2SO_4), Potassium nitrate (KNO_3), Potassium-magnesium sulfate (K_2SO_4. $2MgSO_4$) (Silva & Uchida, 2000).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Compost preparation:

3.2 Location of experiment:

Composting was done in demonstration farm, College of Agricultural Studies, Sudan University of Science and Technology.

3.3 composting process:

Alfalfa, grass and cow manure was added by plate weighted 14kg,16.5kg and 27kg intervals. The amount of water added 10 Littre every week depends on moisture content. The compost aerated every week by mixing composting materials.

3.4 Compost sampling:

Samples were taken every week from three depths top, middle and the bottom.

3.5 Compost Analysis:

Compost was analysed to determine nitrogen (N) by using khjeldal method (Ryan, *et al*., 2001), Olsen method (1954) followed to determine phosphrous (P) and organic carbon(O.C). Composting process was lasting after four months.

3.2 Mycorrhiza fungi:

3.2.1 Isolation of VAM spores:

The spores were isolated by wet sieving and decanting method (Gerdemann, and Nicholson, 1963) with the following modifications; Fifty grams of representative soil sample were drawn from each site and suspended in 1000 ml of tap water and stirred thoroughly. The suspension was allowed to stand for 15 minutes and then passed through a series of sieves 1 mm size, 500µm,250µm, 125µm, 53 µm and 45 µm arranged in a descending order of their mesh size. The spores on the six sieves were transferred to a 250 ml conical flask.

3.3 Pot experiment:

The study was conducted in greenhouse facility in 2015-2016, at Sudan University of Science and Technology, College of Agricultural Studies. Seeds of Sorghum (Mogod variety) were obtained from the Department of Crop Production, College of Agricultural Studies, The Seeds were surface sterilized by H_2O_2 (3%) for 15 minutes and washed three times by sterile water. The sterilized seeds were then transferred to Petri dishes and incubated at 30^{o}C for four days using an incubator model (LIB030M). The top soil was sieved using a 2-mm mesh sieve and then sterilized for 2 hours using the oven. This was to eliminate native arbuscular mycorrhizae fungi propagules as well as other microorganisms. The physical and chemical characteristics of the soil determined included electrical conductivity, Soil reaction (pH), Soluble cations, Soluble anions according to the method of (Richard, 1954), Total nitrogen by khjeldal method (Ryan, *et al.*, 2001), Organic carbon, phosphorus was determind using olsen method (1954), Mechanical analysis was determind using by hydrometer method (Days, 1956), and sodium adsorption ratio using a flame photometer (Ryan, *et al.*, 1996). Black plastic bags (five kilogram capacity and 20cm in diameter) were filled with 5kg of a sterilized soil. Drainage holes were made in the bottom of the bags using a sterile needle. Eight seeds were aseptically added per bags. The bags were irrigated immediately with a sterile tap water. For all treatments, seeds were placed at 5-cm depth from the soil surface. For the AMF treatments 500 and 1000spores of the appropriate AMF inoculum was placed in the soil to which the seeds were planted. For the treatments of compost, Two doses 0.8g and 1.6g were used and added to each bag. For the fertilizers treatments both urea and superphosphate were used at the recommended dose (43kg/ha.) (Farah and Eastin, 1988). Plants were thinned to five plants per pot after seedlings emergence. Pots were randomized and repositioned once a week. Eight treatment were used and replicated three times in a randomized design.

3.4 Data collections:

The sampling was taken from pots after (4 WAP), (8WAP) and (12WAP) and the data form the following growth characters was obtained.

3.4.1 Growth characters:

3.4.1.1 Plant height (cm):

The plant height was measured from the base of the main stem to the tip of panicle using meter tape and the average was obtained for plant.

3.4.1.2 Root length (cm):

The root was measured using meter tape and the average was obtained.

3.4.1.3 Shoots dry weight per plant (gm):

The shoots were dried at 80^0 C for 48 hours , they were grind to a powder which was used in analysis to determine the nitrogen , phousphorus and potassium content.

3.4.1.4 Roots dry weight per plant (gm):

The roots were dried at 80^0 C for 48 hours , they were grind to a powder which was used in analysis to determine the nitrogen , phousphorus and potassium content.

3.5 Tissue analysis:

The weights of plant samples were dried to a constant weigh in a forced-air oven at 72^o C for 48 h. The top dry and root weights were determined. For ash content of the different samples were extracted by using 5ml hydrochloric acid (5N) in sand bath for 5 minutes .The extract was filtered and made to 50-

ml volume. Potassium percent was determined by using a flame photometer and phosphorus percent was determined by using Spectrophotometer (Ryan, *et al.,* 1996). Morover nitrogen percent was determined by using kjeldal method (Ryan, *et al.,* 2001).

3.6 Statistical analysis:

The green house experiment was completely randomize design with three replicates.Data analysis was done using software package. Duncan Multiple Range Test, (Duncan, 1955) was used to compare between treatments.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Pot experiment:

The chemical and physical properties of the soil used in the pot experiment are presented in Table (4.1). The soil texture is clay loam, alkaline, moderate in cation exchangeable capacity, high saturation percentage and low in nitrogen, organic carbon and phosphorus.

Table 4.1: Chemical and physical properties of Shambat soil :

ECe	pH	Soluble Cations			Soluble Anions			SAR
		Na meq / L	K meq / L	Ca/Mg meq / L	CO_3 meq / L	HCO_3 meq / L	CL meq / L	
1.4	7.7	10.7	0.3	7.8	0.0	3.2	3.6	6

Soil Particles Distribution			Textural class	CEC C mol /Kg	moisture content	saturation %
Sand %	Silt %	Clay %				
11	34	55	clay loam	55	3	80

Exchangeable Cantion			N%	O.C%	P ppm	$CaCO_3$%
Na meq/100g soil	K meq/100g soil	Ca+mg meq /100g soil				
4.3	0.1	50.6	0.04	0.1	3.0	0.1

Table 4.2: Some properties of the compost used in pot experiment.

pH	O.C	N	C/N	P	K
8.0	2.13	5.00	0.43	7.4	73.4

The compost was alkaline and high in potassium, organic carbon and nitrogens content. However, phosphorus contents was low.

Table 4.3:The Treatments.

Treatments	Means
Compost1	0.8g compost/pot (recommended dose).
Compost2	1.6g compost/pot (over dose).
Mycorrhiza1	Inoculum 500 spores.
Mycorrhiza2	Inoculum with1000 spores.
Compost1+ Mycorrhiza1	Mixture compost1(recommended dose+ Mycorrhiza1)
N	Nitrogen fertilizer 0.05g/ pot.
P	Phosphorus fertilizer 0.05g/ pot.
K	Potassium 0.05g/ pot.

The data presented in Table (4.4) showed the effect of treatments on sorghum growth at 4 weeks After planting (4WAP). The results indicated no significant differences between treatments in plant length. However, organic fertilizer (Compot2) gave the highest plant length (60.4 cm). My finding was in agreement with Atiyeh *et al.*, (2002), It was followed by biofertilizer (Mycorrhizae2) (58.67cm). There were significant differences between treatments in root length, the highest root length was recorded in organic fertilizer (Compost2) (12.83cm)these result agreement with (Edris, *et al*., 2003 and Jung, *et al*., 2004), followed by biofertilizer (Mycorrhizae1) (11.50cm). The highest shoot dry weight (0.493g) was observed by (Compost2) treatment, followed by (Mycorrhizae2) biofertilizer treatment (0.384g) and highest root dry weight (0.534g) was obtained with application of (Compost1), followed by treatment (Mineral N) Compared to the control.

Table 4.4: Effect of Organic fertilizer, Mycorrhizal Fungi and chemical fertilizers on Sorghum growth After (4WAP).

Treatment	Plant length(cm)	Root Length(cm)	Shoots dry weight(g)	Root Dry Weight(g)
Compost1	47.00[a]	5.80[e]	0.359[a]	0.534[a]
C ompost2	60.33[a]	12.83[a]	0.493[a]	0.095[b]
Mycorrhizae1	50.33[a]	11.50[ab]	0.323[a]	0.066[b]
Mycorrhizae2	58.67[a]	8.33[bcde]	0.384[a]	0.051[b]
Compost1+ Mycorrhizae1	51.17[a]	6.83[de]	0.249[a]	0.212[b]
Mineral N	56.33[a]	7.83[cde]	0.235[a]	0.471[a]
Mineral P	54.67[a]	9.83[abcd]	0.382[a]	0.110[b]
Control	51.00[a]	10.67[abc]	0.369[a]	0.081[b]
C.V	14.82%	23.53%	53.17%	54.05%
LSD	13.44	3.657	0.3160	0.1850

*Means within the same column having similar letters are not significantly different at the 0.05 level of probability by the Duncan Multipale Range Test.

The data presented in Table (4.5) showed the effect of treatments on sorghum growth After (8WAP). The measured parameters gave significant differences between treatments in plant length and root length. The highest plant length (91.33cm) was obtained by treatment (Compost2), follow by treatments (Compost1+Mycorrhizae1) (86.67cm), compared with the control these finding agreement with Atiyeh *et al.,* (2002), Lazcano *et al.,* (2009), Nardi *et al.,(* 2002)and Zandonadi *et al.,* (2007). The highest root length was measured by treatment (Mycorrhizae1) (18.93cm) my finding in containing with Smith and Read (2008), Followed by (compost1) (18.00cm). No significant differences between treatments were observed in shoots dry weights and root dry weights. The highest dry shoots was recorded by treatment (compost2) (3.042g), followed by treatments mixture (Compost1+Mycorrhizae1)(2.523g) and the highest root dry weight was observed by treatments combining (Compost1+Mycorrhizae1) (0.397g) followed by treatment (Mycorrhizae2) (0.363g) compared to the control.

Table 4.5:Effect of Organic fertilizer, Mycorrhizal Fungi and chemical fertilizerson sorghum growth After (8WAP).

Treatments	**Plant length (cm)**	**Root Length(cm)**	**Shoots dry weight(g)**	**Root Dry Weight(g)**
Compost1	72.67^{ab}	8.500^{c}	1.153^{a}	0.266^{a}
Compost2	91.33^{a}	18.00^{ab}	3.042^{a}	0.679^{a}
Mycorrhizae1	67.23^{ab}	18.93^{abc}	1.200^{a}	0.265^{a}
Mycorrhizae2	83.67^{ab}	17.33^{ab}	2.400^{a}	0.363^{a}
Compost1+ Mycorrhizae1	86.67^{ab}	13.00^{abc}	2.523^{a}	0.397^{a}
Mineral N	82.33^{ab}	15.00^{abc}	1.824^{a}	0.312^{a}
Mineral P	61.67^{b}	11.67^{bc}	0.9648^{a}	0.182^{a}
Control	61.33^{b}	12.33^{a}	1.049^{a}	0.283^{a}
C.V%	20.86%	27.04%	73.80%	92.68%
LSD	26.73	6.609	2.205	0.5394

*Means within the same column having similar letters are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

The data presented in Table (4.6) showed the of effect treatments on plant growth After (12WAP). The data showed no significant differences between treatments in plant length. The highest plant length (106.0cm) obtained with (Mycorrhiza2) treatment. The result agreed with the findings of Mohammed, *et al.,(2008*), Moreover, mix(compost1+mycorrhiza1) treatments give (105.7cm) plant lenght. However, there were significant differences between treatments in root length. The highest root length was observed with (Mycorrhiza2) treatment(25.0cm) application, followed by mixture (compost1+mycorrhiza1) treatments (22.33cm) and Mineral P (22.33) compared to the control. Also there were significant differences between treatments in shoots dry weights and root dry weights. The highest shoots dry weight was obtained with the combined application of compining (compost1+mycorrhiza1) (5.53g), followed by (mycorrhizae2) (4.82g) treatment. Also the highest root dry weight was noticed with combining (compost1+mycorrhiza1) (0.638g) treatment followed by (mycorrhiza1) treatment (0.588g), these results are in agreement with the findings of mahadi (1993) and mohamad (2008).

Table 4.6: Effect of Organic fertilizer, Mycorrhizal Fungi and chemical fertilizers on sorghum growth After (12WAP).

Treatments	Plant length (cm)	Root Length(cm)	Shoots dry weight(g)	Root Dry Weight(g)
Compost1	84.33^{a}	13.67^{b}	1.66^{bc}	0.239^{c}
Compost2	98.00^{a}	20.33^{ab}	3.01^{abc}	0.385^{ab}
Mycorrhizae1	102.7^{a}	20.67^{ab}	3.66^{abc}	0.588^{a}
Mycorrhizae2	106.0^{a}	25.00^{a}	4.82^{ab}	0.556^{a}
Compost1+ Mycorrhizae1	105.7^{a}	22.33^{ab}	5.53^{a}	0.638^{a}
Mineral N	88.00^{a}	20.33^{ab}	3.37^{abc}	0.561^{a}
Mineral P	97.67^{a}	22.33^{ab}	3.22^{abc}	0.366^{ab}
Control	70.33^{a}	16.67^{ab}	0.91^{c}	0.230^{b}
C.V	22.86%	31.26%	59.66%	42.15%
LSD	36.32	10.65	3.302	0.3160

*Means within the same column having similar letters are not significantly different at the 0.05 level of probability by the Duncan Multipale Range Test.

The data presented in Table (4.7) shows the effect of treatments on (N,P,K)% percentage in Sorghum tissues after (12WAP). The data showed no significant differences between all treatments. (Mycorrhizae1) recorded the highest percentage (0.599%) absorption of total nitrogen percentage per plant, This result in a agreement with the finding of Mahadi (2006), Followed by (Mineral P) treatment (0.486%) compared to the control. Also, no significant differences between all treatments in phosphorus uptake by plant. (Compost1) recorded the highest percentage (0.01443%) of phosphorus uptake per plant, follow by (compost2) treatment (0.0063%) this finding is in line with Heymann, *et al., (*2005) and Kawasaki, *et al.*, (2008). The (mycorrhiza1) treatment recorded the highest percentage (8.6%) of potassium absorption by plant similar result were reported by Van der Heijden, *et al.*, (2006) and Allen, (2011), Followed by (compost1) treatment (1.7%) compared to the control, This may because the added compost wich was high in potassium, as shown in table (4.2).

Table 4.7: The effect of treatments on N,P and K% in sorghum tissues after (12WAP).

Treatments	**N%**	**P%**	**K%**
Compost 1	0.148[a]	0.0144	1.7[a]
Compost 2	0.252[a]	0.0063	2.1[a]
Mycorrhiza1	0.599[a]	0.0049	8.6[a]
Mycorrhiza2	0.227[a]	0.0035	1.1[a]
Compost 1+ Mycorrhiza1	0.3590[a]	0.0043	1.3[a]
Mineral N	0.241[a]	0.0008	1.2[a]
Mineral P	0.486[a]	0.0013	1.2[a]
Control	0.150[a]	0.0009	1.2[a]
LSD	0.5421		1.4

*Means within the same column having similar letters are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion:

The present study investigated the influence of organic fertilizer compost, biofertilizer mycorrhizae (isolated from the soil) and chemical fertilizers on sorghum growth. The result indicated that growth of Sorghum, have been affected by the addition of compost and mycorrhiza more than chemical fertilizer application.

1- In most parameters, the organic fertilizer compost was higher than control.

2- Highest lenghts of shoot and root ware obtained in by application of compost of compost and followed by mycorrhiza compared to the control.

3- Highest weight of dry shoots and dry root were obtained by combined application of Compost and Mycorrhiza.

5.2 Recommendations:

1- human health and soil fertility can be maintained through reduction of chemical fertilizers by the use of organic and biofertilizers on the soil.

2- The experiment should be repeated for another season and the efficient treatments should be in conducted a field to confirm the results.

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