THE ROLE OF GRASSES USED TO REHABILITATE DEGRADED LAND ON SOIL PROPERTIES: THE CASE OF KERSA DISTRICT, SOUTHWEST ETHIOPIA

MSC. THESIS

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APPROVAL SHEET

SCHOOL OF GRADUATE STUDIES

As thesis research advisors, we hereby certify that we have read and evaluated this thesis prepared, under our guidance, by **Mekonnen Begna**, conducted his Msc thesis research entitled **The Role of Grasses Used to Rehabilitate Degraded Land on Soil Properties: The Case of Kersa District, Southwest Ethiopia**

under our supervision**.** We recommend that it be submitted as fulfilling the thesis requirements.

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As member of the Board of Examiners of the MSc thesis Open Defense Examination, we certify that we have read, evaluated the Thesis prepared by Mekonnen Begna and examined the candidate. We recommended that the Thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Natural Resource Management (**Soil science**).

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DEDICATION

I dedicate this thesis to my father Begna Amesa, and my mother Asekala Melka for nursing me with love and for their full dedication in the success of my life.

STATEMENT OF AUTHOR

This thesis is my original work and it has never been submitted in any form to other University and it has never been published nor submitted for any journal by another person and all sources of materials used for the thesis have been appropriately acknowledged.

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LIST OF ACRONYMS AND ABBREVATIONS

AAS	Atomic Absorption Spectrophotometer
AGDP	Agricultural Gross Domestic Productivity
Av.P	Available phosphorus
BD	Bulk density
CGIAR	Consultative Group on International Agricultural Research
CNTP	Control treatment without any plantation
EFAP	Ethiopian Forest Action Program
EG (0)	Elephant Grass s without composted manure
EG (1)	Elephant Grass with composted manure
EPA	Environmental Protection Authority
FAO	Food and Agricultural Organization
GGD	Gilgel Gibe Dam
MG (0)	Mission Grass without composted manure
MG (1)	Mission Grass with composted manure
ISSS	International Society of Soil Science
OC	Organic Carbon
OM	Organic Matter
SAS	Statistical Analysis soft ware
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan Africa
TN	Total nitrogen
UNEP	United Nations Environment Program
VG (0)	Vetiver Grass without composted manure
VG (1)	Vetiver Grass with composted manure

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ABSTRACT

Land degradation is one of the main problems in Sub-Saharan Africa, threatening the lives of millions of people. It is becoming a major ecological and agricultural problem in Ethiopia. Grasses play vital role to tackle problem of land degradation by giving effective surface cover and increasing slope stability. Considering their effectiveness to control erosion in-situ and siltation of dam's ex-situ, grass plantation were used as strategy to rehabilitate degraded lands in Bulbul Kebele at Kersa Woreda, Southwest Ethiopia since July 2011 and their suitability and effectiveness was studied. But, the influence of such grass plantation on the physico-chemical properties of the soil was not quantified. Therefore, this study was undertaken to evaluate the potential of vetiver grass, elephant grass and mission grass species on selected soil physico-chemical properties. The experimental design was a split plot design with compost application as main plot and grass treatment as a sub-plot factor with three replications.. Soil samples were collected at the depth of (0-40cm) from plots planted with grass without composted manure, with composted manure and adjacent degraded land without any plantations. The results revealed that the average value of moisture content (MC), total porosity(TP), Soil pH, electrical conductivity (EC), organic matter (OM), total nitrogen (TN), available phosphorus (Av.P), cation exchange capacity (CEC) and exchangeable base recorded under all three grass species without composted manure were higher than that of the average value of degraded land. Similarly, the average value of MC,TP,pH, EC, OM, TN, Av.P, CEC and exchangeable base recorded under grass species treated with composted manure were higher than the average mean value of grass species without composted manure. The highest average mean values of exchangeable Ca^{2+} *(7.17cmol (+)/kg), exchangeable* Mg^{2+} *(2.76 cmol (+)/kg) and CEC (17.40 cmol (+)/kg) were observed under the elephant grass grass as compared to the lowest values 5.91, 2.45 and 14.35 cmol (+/kg), respectively, under vetiver grass species without composted manure respectively. In general, degraded land rehabilitation by grass species resulted in significant contribution to improve soil physico chemical properties in the study area. Therefore, degraded land rehabilitation program have to consider grasses as a pioneer species to improve the soil physico-chemical properties.*

Keywords*: Land degradation, rehabilitation, vetiver grass, elephant grass and mission grass.*

1. INTRODUCTION

1.1. Background and Justification

Land degradation is a global problem and it poses immense challenge to sustaining the biological, economical and social services provided by various ecosystems (Banadda, 2010). According to Belay *et al.* (2004) land degradation is one of the biggest problems in Sub-Saharan Africa, threatening the lives of millions of people. Sub-Saharan Africa (SSA) has continued to experience land degradation resulting from the destructive, extractive, over-exploitation of natural resources by extraction with no provision for replenishment and inadequate conservation practices (Tenywa and Bekunda, 2009). This has continued to threaten its agricultural productivity, biodiversity, water and soil quality (Scherr and Yadav, 1995). Land degradation has been estimated at about 65 % of agricultural land in Africa; 45 % in South America; 74 % in Central America; and 35 % in Asia (CGIAR, 2003).

According to Chasek *et al*. (2006), nearly three billion people of developing countries live in rural areas. But, most of the land available to meet the current and future food requirements is already in production, and further expansion will involve fragile and marginal lands. They emphasized that, the increasing scarcity of land forced farmers to apply intensive agriculture that in turn result in soil erosion, salinization, deteriorating water quality, and desertification. Ethiopia is one of the well-endowed countries in Sub-Saharan Africa in terms of natural resources (Gete *et al*. 2006). However, natural resource degradation in Ethiopia has been going on for centuries (Hurni *et al*. 2010). Similarly, Berry (2003). They stated that loss of land resource productivity is an important problem in Ethiopia and that with continued population growth the problem is likely to be even more important in the future. Land degradation, especially in the highlands, has been identified as the most serious environmental problem in Ethiopia (Aune *et. al*., 2001). In 1986, it was estimated that as much as half of the highlands (270 000 km2) were significantly eroded (FAO, 1986). The rate of deforestation of high forests, for example, has been estimated to range from 150,000 to 200,000 hectares per year (EFAP, 1994). The estimated rates of soil loss from highland Ethiopia ranges from 1.0 to 3.0 thousand million tons of top soil per year (Wood and Adrian, 1991).

The major causes of land degradation in Ethiopia are rapid population increase, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production (Girma, 2001). Topography, soil types and agro-ecological parameters are also additional factors playing significant role in the degradation processes influenced by man (Paulos. 2001). In fact, rehabilitation of degraded lands is receive considerable attention in many parts of the world (Bradshaw, 2002), especially in SSA (Chamshama and Nduwayezu, 2003). Underlying reasons for the global interest include: dwindling forest cover and forest products; environmental problems such as climate change, loss of biodiversity, pollution, desertification, etc associated with natural forest cover reduction and conversion to intensive land use; decreasing land productivity owing to large areas of potentially productive lands languishing in a highly degraded state due to soil and water erosion, declining soil fertility and loss of soil organic matter; decreased infiltration and water retention capacity, increased runoff and disrupted hydrological cycles floods and water shortages and increased sediment transport and water pollution (Cairns, 2002). For instance, in Tigray region (Kindeya, 2004), Welo (Kibrome and Tefera, 2001), and Shewa (Tefera, 2001), the rehabilitation of degraded lands result in significant environmental and livelihood benefits, besides the fulfilment of ecological functions.

Among these multiple interacting forces, which have caused and are causing land degradation in Ethiopia, the major causes include clearing of woodlands and forests, unsustainable arable land farming techniques, the use of dung and crop residues for fuel and overstocking of grazing lands. According to Tekle (1998), reversal of land degradation and rehabilitation of the productive capacity of the degraded land is a necessity and not an option in Ethiopia, especially if most of the livelihood and economic development are to continue to emerge from the agricultural economy.The land degradation due to the aforementioned reasons leads to siltation of lakes, hydroelectric dams and other downstream water bodies and shorten their life span by eutriphication and sediment accumulation. For instance, Devi *et al.* (2008), reported that siltation and nutrient enrichment are major problems of the Gilgel Gibe hydroelectric power reservoir, which generates around 600 mw electric energy in two cascading power plants. They also estimated that the Gilgel Gibe dam (GGD) will reduce its volume by half within 12 years and would be completely filled with sediments and eutrified within 24 years unless timely remedial measures are taken.

In addressing the problem, rehabilitation involving returning of native species to an area and planting new plant species to stabilize gullies and reducing soil erosion was being undertaken within the framework of a project established in an interuniversity co-operation program between Jimma University and Flamish universities, researches on rehabilitation of degraded lands are being undertaken by using different multipurpose plant species. To this end, 18 plant species (9 grass, 3 shrub and 6 tree species) are being experimented with on degraded lands in Kersa Woreda, Bulbul Kebele, in a village known as Faris, since July 2011. Obviously, plants used for land reclamation should be species with strong resistance, rapid growth, and good rehabilitation effect. The suitability and effectiveness of each species was investigated. The results revealed that, grasses effectively ameliorate the degraded soil and cover barren land which stayed bare for more than 70 years, but, the effectiveness of trees and shrubs to rehabilitate the degraded land is very limited. Apart from this experiment, no scientific studies were undertaken on the influence of different grass species on soil physical and chemical properties. Therefore, this study is aimed at determining the influence of degraded land rehabilitation using multipurpose grasses species on selected soil physico-chemical properties.

1.2. Objectives of the study

1.2.1. General objective

- To evaluate the effects of vetiver grass, elephant grass and mission grass species on selected soil physico-chemical properties under composted manure treatment and without treatment.

1.2.2. Specific objectives

- To determine the influence of degraded land rehabilitation using different grass species on selected soil physico- chemical properties;
- To determine the relative change of vetiver grass, elephant grass and mission grass on selected soil physico-chemical properties and
- To evaluate the influence of composted manure application to grasses on selected soil physico- chemical properties.

1.3. Significance of the study

Sustainable natural resources management becomes the main concern of the Ethiopian rural development strategy. This is because of the growth in the number of mouths to be fed and proportionally low production and productivity led to alarming rates of land degradation and environmental imbalances due to poor management of natural resources. Different stakeholders' government and nongovernmental organizations involved in rural development activities are highly concerned with land degradation and have been taking measure to increase agricultural production through soil and water conservation measure to maintain the existing natural resource bases. Nevertheless, there is no sufficient data on the effectiveness of the conservation works on soil physico chemical properties improvement towards increasing land productivity. Thus, researchers, nongovernmental organizations and extension agents need to understand the rehabilitation activity and determinants of land degradation at field level to develop appropriate intervention measures and design effective policies and strategies that promote sustainable productivity. The outcomes of this study is therefore to generate information for governmental and nongovernmental organization to design and develop effective sustainable degraded land management strategies by maintaining suitable physico-chemical soil propertie. It also serves as base for other researchers and decision makers who are interested to involve in land rehabilitation activities.

2. LITERATURE REVIEW

2.1. Overview of land degradation

Land degradation is a reduction or loss of biological or economic productivity or complexity of rain fed crop land, irrigated crop land, or range, pasture, forest and wild lands resulting from land use or from a process or combination of processes, including processes arising from human activities and habitation pattern such as: soil erosion caused by wind and /or water; deterioration of physical, chemical and biological or economic properties of a land; and long term loss of natural vegetation (UNCCD, 2003). Reduction in vegetation cover reduces the capacity of soil to retain moisture for plant productivity. This in turn leads to increased soil erosion and loss of soil fertility causing to land degradation.

Changes in plant diversity especially those leading to loss in vegetation complexity affect the potential of soil to replenish its nutrients particularly soil organic matter. Free grazing is also a fundamental cause for loss of biodiversity and thereby land degradation (Maitima *et al.,* 2004). Soil erosion is a common occurrence in intensively grazed areas with no appropriate pasture management practice. These practices tend to remove vegetation cover leaving the land exposed to severe sheet and gully erosion. Soil erosion significantly contributes to soil fertility loss and thus to poor crop yield and increasing poverty level (Majule, 2003).

2.1.1. Cause of land degradation

Due to varied topographic and climatic conditions, Ethiopia is known to be rich in biodiversity and has been a source of agricultural development and other basic needs for millennia. However, this biophysical potential has been threatened by interlinked and reinforcing problems of land degradation and extreme poverty (Gete *et al.,* 2006). According to Ethiopian Environmental Protection Authority (EPA, 2005) 75% of the Ethiopian livestock populations graze in the highlands often at the expense of remnant vegetation causing to serious degradation on the environment.

Studies predicted that nearly 1.9 billion tons of top soil has been washed away mainly from the highlands, every year in Ethiopia (FAO, 1986) and its onsite effects significantly reduced agricultural production with an estimated cost ranging from 2 to 6.75% of the Agricultural Gross Domestic Productivity (AGDP) per annum (Sonneveld *et al*., 2002). Land degradation, mainly manifested with deforestation and soil erosion, has become an alarming environmental problem deteriorating biodiversity and land productivity in Ethiopia. Some of the causes of soil degradation are described in the next sections.

2.1.1.1. Soil erosion

Soil erosion is a physical process with significant dissimilarity globally in its sternness and regularity (Poesen *et al.,* 2003). It is indispensable to recognize the interface of the processes leading to the instigation and expansion of rills and gullies for the better management to control maximum utility from land and soil resource for long period (Huang, 2000). In the Ethiopian highlands, soil erosion is the main cause of deterioration for soil productivity (NCS, 1994).

It was estimated that in 1990 alone, 57,000 to 128,000 tons of grain production was lost due to reduced top soil depth caused by soil erosion (Demel, 2001). Although it is a natural geologic process, soil erosion is accelerated by human activities fuelled by the combined effects of anthropogenic activities like poor farming practices, overgrazing, deforestation, soil erosion, salinity and alkalinity, and the use of livestock manure and crop residues as fuel. Land degradation in Ethiopia is hastening desertification (Cesen, 1986) and cconsequently, about 72% of the total land area of the country falls within the UNEP's definition of desertification (Tamirie, 1995).

2.1.1.2. Deforestation

Deforestation leaves the land surface barren and open to serious land degradation process (Tamirie, 1995). The costs of deforestation or depletion of forest resources can be viewed or analyzed from two different corners. Firstly, deforestation entails forest degradation, which brings about reduced crop yields. Secondly, deforestation brings about fuel energy crises. To come out of the energy crises, dung and crop residues which would otherwise be used for improving soil fertility and as livestock feed are often burned for fuel. The implied outputs foregone as a result of using dung and crop residues for fuel are, therefore, further costs to the agricultural sector (EFAP, 1994).

2.1.1.3. Overgrazing

Ethiopia has the second largest livestock population in Africa with over 30 million cattle and 42 million sheep and goats (Alemneh, 2003) thus grazing pressure has increased the rate at which tree and shrubs species are becoming scarcer (Azene *et al*., 1993). Overgrazing destroys the most palatable and useful species in the plant mixture and reduces the density of the plant cover, thereby increasing the erosion hazard and reducing the nutritive value and the carrying capacity of the land (FAO, 2005). As overstocking decreases vegetation cover and leading to wind and water erosion, reduced soil depth, soil organic matter and soil fertility that hurt the land's future productivity. The consequences of overgrazing have been land degradation (soil compaction, broken soil crust and erosion) as well as reduced species diversity and density of vegetations (Chamshama and Nduwayezu, 2002).

2.3. Role of composted manure on selected soil physico-chemical properties

Numerous publications provide evidence on the multiple benefits of composted manure application to soil. Effects range from soil stabilization and amelioration to phyto-sanitary impacts of mature composted manure. Feedstock, composted manure maturity and composted manure quality can influence intensity and degree of effects on soil physical, chemical and biological properties. Application may trigger short-term improvements such as increasing microbial activity. Long-term effects on soil properties could be achieved by preservation and increase of the stable SOM pool (Amlinger *et al*., 2007). SOM is the organic component of soil, consisting of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms (Leroy *et al.*, 2007). OM plays a crucial role in maintaining soil functions and is a parameter for soil fertility and resistance to erosion.

The build-up in the soil is a slow process, much slower than its decline and can be enhanced by farm management techniques. Examples of these techniques are: zero tillage, organic farming, maintenance of permanent grass land and cover crops, mulching, manuring with green legumes and application of farmyard manure and composted manure (Ros *et al.*, 2006). If soils have inadequate amounts of OM, they may not hold enough water and cannot supply an environment for beneficial microbes. These soils become quickly dependent on high levels of watering, multiple fertilizer applications and pesticides (Stan *et al.*, 2009). Therefore, soils containing less than 2% OM benefit from management strategies that will increase OM (Ros *et al.*, 2006). Composted manure increases SOM, improving physical, chemical and biological functions of the soil (Savala *et al.*, 2003). Increasing SOM will enhance aggregation and stability and thereby improving soil structure and soil porosity. Stability of aggregates prevents surface sealing and soil erosion, improves water infiltration, and enhances water holding capacity (Martínez-Blanco *et al.*, 2013). Soil porosity is important for root proliferation, gas exchange, and water retention and movement. Moreover SOM improves the retention of plant nutrients and increases the soil biodiversity (Vanlauwe *et al.*, 2010).

The addition of composted manure improves soil structure by reducing the bulk density, increasing the permeability, and increasing aggregate stability (Tester,1990). The benefits of composted manure use for erosion control include increasing water infiltration into the soil surface, increasing plant growth and soil cover, increasing water holding capacity of soil, which in turn reduces runoff, and alleviates soil compaction by increasing soil structure reducing runoff. It also reduces soil particle transport in runoff and reduces soil particle dislodging (Risse and Faucette, 2001). These improvements all help reduce erosion as composted manure alters the physical properties of the soil, shield from raindrop impact, and help to decrease runoff velocity.

Composted manure contains significant amounts of valuable plant nutrients including N, P, K, Ca, Mg and S as well as a variety of essential trace elements (Smith and Collins, 2007). Thus, composted manure can be defined as an organic multi nutrient fertilizer (Hartmann, 2003). However, their diverse beneficial properties for amelioration outreach their nutrient content. This can be ascribed to the existence and different intensity of various binding forms within the organic matrix which result in a partial immobilization of nutrients (Becker *et al*., 1995).

The CEC is one of the most important indicators for evaluating soil fertility, more specifically for nutrient retention and thus it prevents cations from leaching into the groundwater. Ouedraogo *et al*. (2001) proved that composted manure amendment resulted in an increase of CEC due to input of stabilized OM being rich in functional groups into soil. According to Amlinger *et al*. (2007), SOM contributes about 20 – 70% to the CEC of many soils. Composted manure application has a liming effect due to its richness in alkaline cations such as Ca, Mg and K which were liberated from OM due to mineralization. Consequently, regularly applied composted manure material maintains or enhances soil pH (Ouedraogo *et al*., 2001).

OM is a source of plant nutrients, especially in the direct supply of N, P, S and K. Organic inputs also enhance CEC particularly in sandy soils and reduce Al toxicity and P-fixation in strongly acid soils with oxide mineralogy (Savala *et al.*, 2003). Mwiti *et al*. (2012), reported a significant increase of organic carbon with the application of composted manure. Incorporation of composted manures into soil increases the salt content as well as soil electrical conductivity, especially if high doses of composted manure are applied, because of the high salinity of composted manure (Gallardo-Lara and Nogales, 1987).

The addition of composted manure and vermi composted manure to the soils may slightly increase EC values. The soil EC increased with increasing an application rate of vermicomposted manure in soil as reported by Atiyeh *et al*. (2001) with pig manure. The EC of composted manure depends on the raw materials used for composted manure and their ion concentration (Atiyeh *et al*., 2002).

2.4. Role of multipurpose grass species on rehabilitation of degraded lands

Grasses are growing quickly and have the ability to survive on toxic waste material and tolerant to adverse pH, extremely low nutrient conditions and toxic metals. Extensive root system of these species holds loose soil particles together and prevents soil erosion while enhancing productivity to a sustainable level (Aronson *et al*., 1993). On the other hand, at the end of growing season, grasses eventually dry to form mulches which conserve moisture. As biodiversity, which plays a critical role in overall sustainable development and poverty eradication, is essential to the human well-being and to the livelihood and cultural integrity of people.In common goals for vegetation establishment in rehabilitation situations usually include the establishment and maintenance of sufficient ground cover to control erosion, a degree of resistance to invasion by exotic colonizers, and low maintenance costs (Luken, 1990).

Restoration ecologists have long recognized the integral role of grass, particularly in its physical and chemical aspects, in the successful reclamation of degraded sites (Jordan *et al.*, 1987). Rehabilitation improves soil in several ways: they prevent physical soil loss, maintain or increase soil water holding capacity, protect or increase top soil depth, prevent the loss of soil nutrient content and increase soil organic matter. By stabilizing the hydrological processes and regulating total water runoff and flooding, vegetation cover also controls and/or reduces soil erosion and the problems of downstream sedimentation and siltation (Kumar, 2000). Vegetation rehabilitation in exclosures acts as a 'sink' area where the incoming water infiltrates and/or deeply percolates beyond the root zones and contributes to the ground water recharge and induces new springs. In this study one indigenous and two exotic grass species were selected for restoring degraded lands and the review of the three experimental grasses are described in the next sections.

2.3.1. *Chrysopogon zizanioides* (Vetiver grass)

Vetiver grass (*Chrysopogon zizanioides (L.) Nash*) (Fig. 1*)* is one of the strategies that have been actively being promoted as a means to rehabilitate eroded soils worldwide (Pang *et al*., 2003). Global networks of scholar/practitioners have mobilized around vetiver for environmental projects. Environmental conservation activists tout the utility of vetiver as a super crop with nearly limitless potential for soil conservation and environmental rehabilitation. The concept carries such a level of interest and excitement that internet social networking groups by environmental activists are devoted to the Vetiver grass system where by vetiver grass is planted in hedgerows in order to control erosion and simultaneously improve agricultural outputs (Grimshaw, 2003). At the heart of its utility for soil conservation are vetiver's vertically growing and intricate root structures. The root structures grow vertically, not horizontally, providing deep penetration and preventing soil erosion while also permitting multiple crops in the same space. These roots complement its rigid grasses that reduce water flow and trap sediment (Truong *et al*., 1995).

The combination of deep root structures below ground, and rigid grasses above ground make vetiver an effective plant for erosion control, and the ability to withstand flood conditions. The species is included in the gully rehabilitation due to its well-known soil and water conservation potential and to use as standard check for the performance of other local grasses.

Figure.1. *Chrysopogon zizanioides* (Vetiver Grass) (photo by Ayalew Talema)

2.3.2. *Pennisetum purpureum* (elephant grass)

Elephant grass (*Pennisetum purpureum Schumach*) (Fig.2) is a grass that is used as a cover crop and an amplifier terrace in soil and water conservation methods, as well as effective in reducing erosion, runoff, and improving soil physical properties. This plant is from Africa, then spread almost in all the tropics around the world with rainfall greater than 1000 mm. This grass is tolerant of wet areas, acidic, sandy soils with low fertility rates, and grows at pH 4.55-5.5. elephant grass is used in Indonesia because of high production. The production of fresh grass can reach 184 t ha^{-1} $year^{-1}$. elephant grass can protect the soil surface from direct blows rain water, so it does not spoil the soil aggregates. The effect of vegetation on run-off and erosion is mainly determined by its ability to cover the soil surface. Mechanism in reducing the rate and amount of surface flow is as rain drop collision inhibited reduced, delay the onset of surface flow and delay the onset of water loss, restraining instantly scours runoff, thereby reducing run-off, and inhibits the soil compaction (Sinukaban, 1989). According Haridjaja (1990), greatly determines the elephant grass infiltration capacity. The grass canopy closure system protects the soil surface from raindrop punches, thereby reducing soil compaction.

The species is included in the gully rehabilitation due to its well-known soil water conservation potential and to use as standard check for the performance of other local grasses and to be compared and contrasted with other species.

Figure.2. Pennisetum purpureum (Elephant grass) (photo by Ayalew Talema).

2.3.4. *Pennisetum polystachion* (Mission grass)

Mission grass (*Pennisetum polystachion (L. Schult)*)(Fig.3) is a vigorous annual or perennial grass growing to over 1 m height, producing large numbers of seeds with limited dormancy. It is a natural invader of disturbed ground, typically occurring in fallow land in its native region in Africa.Unlike native grasses, mission grass continues growing well into the dry season and remains erect, representing a substantially larger fuel load which will burn later in the dry season and generate substantially higher flame. *Pennisetum polystachion* was brought from north central Ethiopia, 70 km Southwest of Dessie, Ginba town. The grass is indigenous to that area and rarely used as soil water conservation activities. The researchers brought to Jimma due to its fast growth rate and with the objective of evaluating its performance compared with *Chrysopogon zizanioides* and *Pennisetum purpureum* (Ayalew *et al*., unpublished).

Fig. 3. Mission grass (*Pennisetum polystachion*) (photo by Ayalew Talema).

2.4. Influence of degraded land rehabilitation on selected soil physical properties

Rapid vegetation rehabilitation is an efficient measure for soil and water conservation because of their increased capacity for infiltration and sediment trapping. If vegetation coverage is chosen to be the best alternative form of land use, not only it prevent the loss of soil, but also that it is not deposited in river bottoms, lakes and dams (FAO, 2001).

The influence of rehabilitation on soil physical properties is very important in augmenting the overall capacity of the land to be productive. This in turn increases water infiltration rates into the soil and decreases runoff. Water infiltration in the soil may be enhanced both by preferential flow along tree roots and accumulation of organic matter on the soil surface, which may reduce volume, velocity, and erosive capacity of surface runoff (Jiang *et al*., 1996). The higher organic carbon content with in grass the higher organic matter inputs from litter originating from above and below ground parts of the grass. The humus which is produced after decomposition, binds to soil minerals to form soil aggregates that are stable thereby improving soil porosity, aeration and the water-retention capacities of the soil (Haynes, 1999). Attention to recovery shifts the focus from examination of reclaimed land soil properties in the post-deforestation process (Zheng and Zhang, 2002) to the contribution of vegetation or natural vegetation recovery (Zhang *et al*., 2004). Attention to processes of both recovery and degradation are necessary in understanding soil property changes.

2.4.1. Soil texture and moisture content

Soil texture determines a number of physical and chemical properties of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices (Gupta, 2004). Soil texture is one of the inherent soil physical properties less affected by management. The rate of increase in stickiness or ability to mould as the moisture content increases depend on the content of silt and clay, the degree to which the clay particles are bound together into stable granules and the OM content of the soil (White, 1997). Low organic matter, the trampling effect of livestock and the sparse vegetation aggravate soil erosion which selectively removes clay from the free grazing area. Under sparser vegetation covers the clay fractions are likely to be lost to processes of erosion and migration down the soil profile (Woldeamlak, 2003). He found that the soils restored with tree and/or grass species have higher content of fine clay content particle than free grazing land due to low soil erosion in the rehabilitated land, while the lower clay in the free grazing land means there is relatively higher soil erosion at the free grazing land, which may reflect the differences in their vegetation cover. The presence of good vegetation cover in the area enclosure reduced erosion through addition of organic matter and surface litter (Skarpe, 1991).

Soil water enhances various soil physicochemical reactions and supplies essential nutrients for Plants and animals including micro and macro organisms residing in soils in order that they can carry out their own activities (Brady and Weil, 2002). According to Teklu (1992), soils with high amount of clay have higher amount of water both at -1/3 and -15 bars than soils with low amount of clay content and thus, water retention capacity of a soil is a function of silicate clays and amorphous materials.

2.4.2. Bulk density and Total porosity

Bulk density is a measure of the mass of soil per unit volume.When soil particles are pushed close together, increasing the mass per unit volume, the soil is compacted.Bulk density also provides information on the environment available to soil microorganisms. White (1997), stated that values of bulk density ranges from < 1 g/cm_3 for soils high in OM, 1.0 to 1.4g/cm3 for well-aggregated loamy soils and 1.2 to 1.8 g/cm_3 for sands and compacted horizons in clay soils.

Soil compaction resulted an increase of bulk density due to external load leading to the degradation of physical soil properties such as root penetration, hydraulic conductivity and aeration (Mitiku *et al.*, 2006). The total porosity of soils usually lies between 30% and 60%. In soils with the same particle density, the lower the bulk density, the higher is the percent total porosity. As soil particles vary in size and shape, pore spaces also vary in size, shape and direction (Foth, 1990).

The low porosity value implies that aeration, root penetration and plant development will be restricted on bare soil (Oku and Edicha, 2009). The proportion of macro-pore space in the soil gradually increased with development of natural vegetation and with increasing total porosity. Increased macro-pore volume implied higher hydraulic conductivities and greater water-holding capacities. Such variation contributes to effective infiltration of precipitation and also aeration of deeper soil. According to Tolbert *et al*. (2002) plants that have deep and extensive roots can also increase porosity and improve soil structure through SOC accrual.

2.5. Influence of degraded land rehabilitation on selected soil chemical properties

Soil chemical properties are the most important among the factors that determine the nutrient supplying power of the soil to the plants and microbes. The chemical reactions that occur in the soil affect processes leading to soil development and soil fertility build up. Minerals inherited from the soil parent materials overtime release chemical elements that undergo various changes and transformations within the soil. The higher SOM, TN, and Av.P contents in restoration than that of the degraded land was related to the restoration of natural vegetation, which have increased above-ground and below-ground litter inputs and might be litter quality and nutrient cycling. A direct impact of grazing on the rangeland ecosystems is the removal of a major part of aboveground biomass, consequently the input of above-ground litter to the soil decreases, which might be important consequences for soil nutrient conservation and cycling (Solomon *et al*., 2000).

2.5.1. Soil reaction (pH) and electrical conductivity(EC)

Soil reaction usually expressed as soil pH value and it measures the degree of soil acidity or alkalinity, which is caused by particular chemical, mineralogical and/or biological environment. Soil reaction affects nutrient availability and toxicity, microbial activity, and root growth. Thus, it is one of the most important chemical characteristics of the soil solution because both higher plants and microorganisms respond so markedly to their chemical environment. According to Zhou *et al*. (1992), the plant cover, root systems and SOC because extensive secretion of organic acids from the roots and amounts of CO_2 released from roots and microorganisms could lead to the decrease in soil pH.

Soil electrical conductivity (EC) is a property of soil that is determined by standardized measures of soil conductance by the distance and cross sectional area through which a current travels. EC estimates the amount of total dissolved salts or the total amount of dissolved ions in soils (Hartsock *et al*., 2000). Electrical conductivity (EC) is a measure of salinity. In addition to overcoming some of the ambiguities of total dissolved salts measurements, the EC measurement is quicker and sufficiently accurate for most purposes (Bohn *et al.*,2001).

Excessive accumulation of soluble salts convert soils to salt affected soils and the process leading to accumulation of salts forming cations are common in arid and semi-arid regions where rainfall amount is insufficient to leach soluble salts. Electrical conductivity of saturation extract (ECe) of the soil is heavily dependent on climatic conditions of the area in consideration. In soils of sub-humid tropics where there is sufficient rainfall to flush out base forming cations from the root zone, EC is found too low, usually, less than 4 dS/m (Landon, 1991).

2.5.2. Soil organic matter and Available phosphorus

Soil OM arises from the debris of green plants, animal residues and excreta that are deposited on the surface and mixed to a variable extent with the mineral component (White, 1997). SoilOM is defined as any living or dead plant and animal materials in the soil and it comprises a wide range of organic species such as humic substances, carbohydrates, proteins, and plant residues (Foth and Ellis, 1997). Soil OM reduces compaction by promoting soil aggregation and increasing porosity (Teklu, 2005).

According to Tan (1996), the soil organic matter under the area enclosure was regarded as medium while that of the free grazing land was low. Despite the extensive rhizome network and increased above ground biomass in cogon grass invaded areas (Ramsey *et al*., 2003). Differences in litter fall mass interact with differences in the litter decomposition rate to affect the net flux of C into the soil. According to Hartemink and O'Sullivan (2001), the cogon grass leaf litter decomposed much slower due to the highest lignin polyphenol: N ratio.

Amezketa (1999), stated that the soil organic matter content resulted from litter and dead root decompositions is an indicator of recovery or revival from degradation of an ecosystem. According to Shrestha *et al*. (2007), long term grazing intensity may be alter litter, plant basal and canopy cover, which affect soil water dynamics by altering microclimate and soil temperature. According to Caravaca *et al*. (2002), the disturbance heavy grazing breaks the soil apart exposing the soil organic matter to degradation and loss by erosion and drastically reduces vegetation cover leading to decline in inputs of soil organic matter. Li *et al*. (2007), point out that the disturbance of grazing lands have negative impact on soil structural properties and water holding capacity, which are highly related to losses of SOM pools leading to decline in soil infiltration and water retention and accelerated soil erosion.

In most natural ecosystems, such as forests and grasslands**,** P uptake by plants is constrained by both the low total quantity of the element in the soil and by very low solubility of the scarce quantity that is present (Brady and Weil, 2002). It is the most commonly plant growth-limiting nutrient in the tropical soils next to water and N (Mesfin, 1996). Erosion tends to transport predominantly the clay and OM fractions of the soil, which are relatively rich in P fractions. Thus, compared to the original soil, eroded sediments are often enriched in P by a ratio of two or more (Brady and Weil 2002). The main sources of plant available P are the weathering of soil minerals, the decomposition and mineralization of soil OM. Most of the soils in Ethiopia particularly Nitisols and other acid soils are known to have low P contents, not only due to the inherently low available P content, but also due to the high P fixation capacity of the soils (Eylachew, 1987).According to Oelmann *et al*. (2010) mixed species plantation have a positive effect on the biomass production, litter fall and nutrient pools. High quality litter leads to formation of high quality organic carbon and N in the mineral soil.

2.5.3. Organic carbon and total nitrogen

The total amount of OC in the soil can be considered as a measure of stored OM. In a sense, stored OM is a mean store or standing stock of OM because it reflects the net product or balance between ongoing accumulation and decomposition processes. The differences in OC content were likely due to the differences in OM input as the control sites might have minimal OM input due to continued biomass removal through livestock grazing, woody material collection and soil depletion through erosion (Descheemaeker *et al*,. 2006). On the other hand, in the exclosures flora regeneration is enhanced, which in turn improves soil OM input (Mekuria *et al*., 2011). Khater *et al*. (2003), point out that on degraded land in Lebanon indicated that vegetation composition across the recolonization processes follows the order of herbaceous, shrub and mixed trees.The grasses and herbs are gradually replaced by bushes and trees (Asefa *et al*., 2003). Grasses and herbs regularly add foliage, which quickly decomposes and is incorporated into the soil (Kalinin *et al*., 2009).

The development of perennial grass root systems in long-term conventionally cultivated soil can promote soil macro aggregate formation, total microbial and fungal biomass, and soil C accrual in a decadal time scale (Matamala *et al*., 2008). Paustian *et al*. (1998), stated that the potential for agricultural systems to mitigate increasing atmospheric CO_2 and suggest that planting perennial vegetation such as grass represents one of the most favorable scenarios for increasing soil C stocks following land degradation. The total N content of a soil is directly associated with its OC content and its amount on cultivated soils is between 0.03% and 0.04% by weight (Tisdale *et al*., 1995). Magill and Aber (2000), stated that soluble N concentration in the soil depends on the litter species.For example,tree species can differ in their mechanisms of rate of nutrient input, outputs and cycling. Cogon grass has lower nitrogen content than the native species.

There are several reasons to believe that cogon grass played a role in lowering soil NO_3-N in the invaded patches. The lower NO_3-N availability in invaded patches might resulted from cogon grass' aggressive growth pattern, extensive rhizome network and longer growing season. According to Daneshgar *et al*. (2005), the belowground biomass of cogon grass was ten times greater than that of native vegetation. Lower NO_3-N levels in cogon grass patches may result of efficient nutrient uptake by the dense root/rhizome systems. Cogon grass is also known to have mycorrhizal associations, which may also explain the lower nitrate availability in invaded patches (Brook *et al*., 2004). Mycorrhizae improve nutrient availability to host plants and alter their morphology, physiology, and competitive ability (Bray *et al*., 2003).

2.5.4. Exchangeable Base(Ca^{2+} Mg,$^{2+}$ K^+ and Na^+)

The cation exchange capacity (CEC) of soils is defined as the capacity of soils to adsorb and exchange cations (Brady and Weil, 2002). Cation exchange capacity is an important parameter of soil because it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility and environmental behavior. Generally, the chemical activity of the soil depends on its CEC. The CEC of a soil is strongly affected by the amount and type of clay, and amount of OM present in the soil (Curtis and Courson, 1981). Both clay and colloidal OM are negatively charged and therefore can act as anions (Kimmins, 1997).

Cation exchange capacity (CEC) is used to measure the amount of cation held by soil particle and released into the soil solution. The Ca^{2+} accounted for the lion's share of the CEC followed by Mg^{2+}. Olaitan *et al*. (1986), stated that the higher Ca^{2+} content of the soils in which is held more strongly than Mg^{2+} in the colloidal complex. According to (Kibret, 2008), clay and organic matter colloids, and especially organic matter render soils a better CEC. The levels of exchangeable cations in a soil are usually of more immediate value in advisory work than the CEC, because they not only indicate existing nutrient status, but can also be used to assess balances amongst cations.

According to Landon (1991), the levels of exchangeable cations is of great importance because many effects, for example soil structure and nutrient uptake by crops, are influenced by the relative concentrations of cations as well as their absolute levels. Higher values of exchangeable cations could be attributed to the nutrient cycling role of increased biomass in the enclosure site (Bot and Benites, 2005). Clay and OM are essentially the cations' warehouse or reservoir of the soil and are very important because they improve the nutrient and water holding capacity of the soil (Sachs, 1999). Soils in areas of moisture scarcity such as in arid and semi arid regions have less potential to be affected by leaching of cations than do soils of sub- humid and humid regions (Jordan, 1993). Soils under continuous cultivation, application of acid forming inorganic fertilizers, high exchangeable and extractable Al and low pH are characterized by low contents of Ca and Mg mineral nutrients resulting in Ca and Mg deficiency due to excessive leaching (Dudal and Decaers, 1993).

3. MATERIALS AND METHODS

3.1. Description of the study areas

3.1.l. Location

The experiment was conducted in Gilgel Gibe catchment, Southwest Ethiopia, 330 km from Addis Ababa, and 30 km away from Jimma on the way to Addis Ababa, in Kersa District, Jimma Zone, at a village known as Bulbul, located on 07^{0}43’57” latitude north and 037^{0}05’24” longitude east and laid at an alatitude of 1807 m.a.s.l. (Fig.4). The elevation of the Gilgel Gibe catchment ranges between 1,096 and 3,259 m.a.s.l. Gilgel Gibe is the main river of the catchments and a tributary of the Great Gibe River (known downstream as the Omo River). The tributary basin of the upper Gilgel Gibe dam site covers 4,225 km^2 (EELP, 1996).

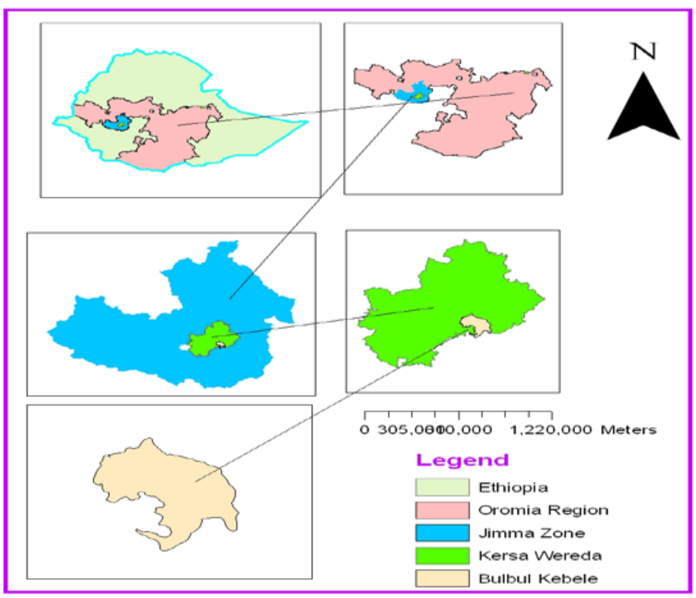


Figure 4 . Map of the study area

3.1.1. Climate

The climate of the catchment is sub-humid with average annual temperature of 19.2 ^{0}C (EELPA, 1996). The annual rainfall of the Gilgel Gibe catchment varies from a minimum of 1,300 mm near the confluence with the Great Gibe River, to a maximum of about 1,800 mm in the Utubo and Fego mountains.

Sixty per cent of the total annual rainfall occurs between June and September, 30 per cent from February to May, and only 10 per cent between October to January (EELPA, 1996) (Fig. 5).

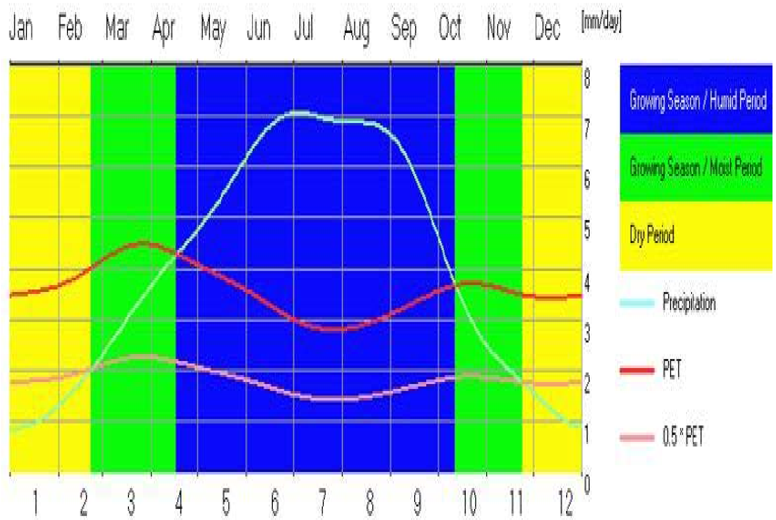


Fig. 5. Monthly precipitation, potential evapotranspiration and growing season of Gilgel Gibe area, southwest Ethiopia (EELPA, 1996).

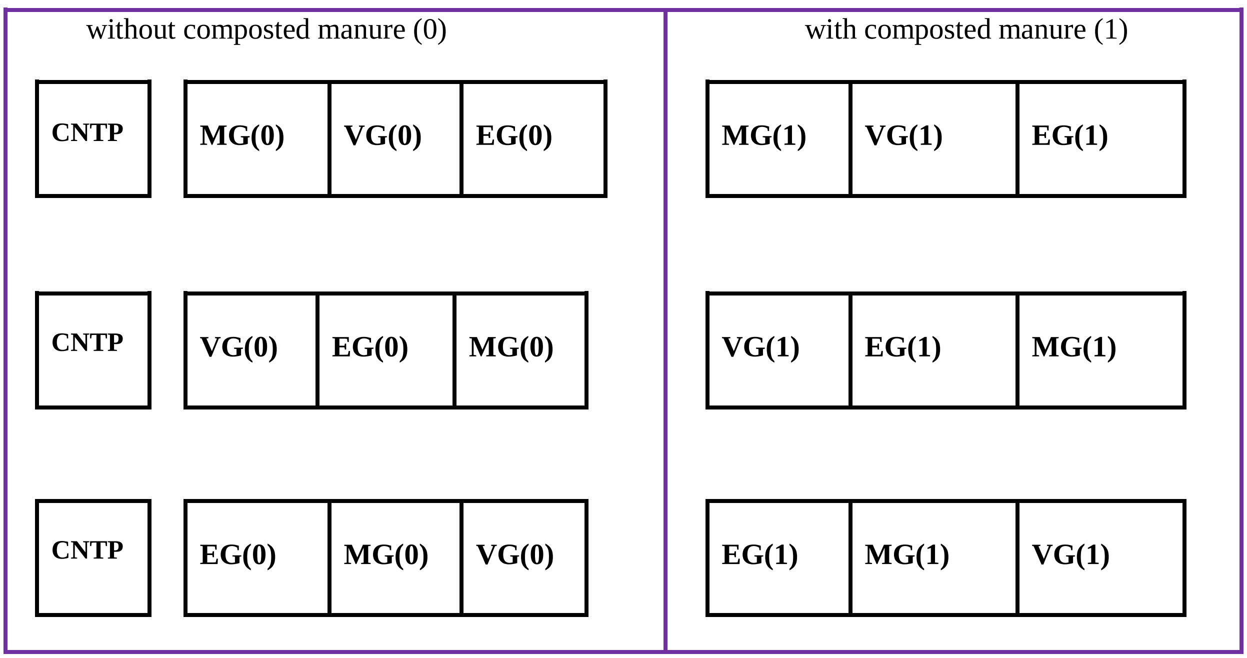
3.1.2. Geomorphology, geology and soils of the gilgel gibe catchment

The study area is characterized by a series of basic and subsilicic effusive volcanic rocks, frequently inter-layered with reddish paleosols of Tertiary age. The rocks of the area include Trachytic tuff, Vesicular basalt, Aphyric augite basalt, ignimbrite (Rhyolitic ignimbrite), Augite trachyte and Augite basalt (EELPA, 1996). The entire volcanic sequence is frequently blanketed by residual, subtropical Nitisols, which have been formed on hill and ridge foot slopes. Alemayehu (2009), showed that Nitisols of this area are quite similar in their morphological, physical, chemical and mineralogical characteristics which are clayey in texture, weakly acidic pH, and having a clay fraction dominated by Kaolinite but containing small amounts of smectite. According to EELPA (1996), reported that the catchment is covered with thick, black, plastic clay deposits of Vertisols on the flatter areas and valley. The hills on the right side of the Gilgel Gibe River, downstream of the waterfalls, are mostly covered to an elevation of about 1,800m a.s.l by thick colluviums deposits together with deeply weathered landslide and/or rockslide material.

3.2. Methods of data collection

3.2.1. Experimental design

The experimental design was split plot design with composted manure as main plot factor and the grass species as a subplot factor within three experimental blocks, three replicates and seven treatments (Fig.1). The treatments were vetiver, elephant and mission grass without composted manure treatment on half of the plot, while vetiver, elephant and mission grass treated with composted manure in another half of the plot. The completely bare degraded area was taken as a control plot without any plantation or composted manurue application. For each individual plant 150g of air dry composted manure was applied during planting per each plant and the control plots were planted without any treatment. Each treatment has a plot area of 4m x 6m size at a spacing of 25cm between rows and plants except elephant grass which has a spacing of 50cm between rows due to the nature of the grass.



CNTP=control plot, EG(1)= Elephant grass with composted manure, EG(0)= Elephant grass without composted manure,VG(1)= Vetiver grass with composted manure, VG(0)=Vetiver grass without composted manure, MG(1)= Mission grass with composted manure, MG(0)= Mission grass without composted manure.

Fig. 6. Layout of the experimental plot involving rehabilitated site with different grasses tretead with and without composted manure.

3.3. Soil sampling and analysis

3.3.1. Soil sampling

Two factors namely composted manure and grass species were considered when developing soil sampling protocols to monitor changes in selected soil physico-chemical properties. At the beginning, a general visual field survey of the area was carried out to have a general view of the variations in the study area. During collection of soil samples; dead plants, old manures, and composted manure pits was excluded. This was done to minimize differences, which may arise because of the dilution of soil OM. In order to determine the soil physico chemical properties, composite soil samples were taken from each treatment and control plot. Three replicated soil samples were collected from the depths of 0-40 cm from each treatment in a zigzag sampling scheme using an auger. A total of sixty three composite soil samples were collected and each composite sample was made from a pool of five samples. The collected soil samples in a lebled calico bag with tightly fitting lid and labeled carefully with the location, grass species and depth of soil. Furthermore, soil core samples (undisturbed) were collected from each plot for soil bulk density analysis.

3.3.2. Soil laboratory analysis

The collected soil samples were then be air-dried, mixed well, ground and passed through a 2mm sieve for the analysis of selected soil physical and chemical properties.The major parts of soil physical and chemical analysis were carried out at Jimma University College of Agricultural and Veterinary Medicine (JUCAVM) soil laboratory. Standard laboratory procedures were followed in the analysis of the selected physico-chemical properties.

3.2.4. Analysis of soil physical properties

Determination of particle size distribution was carried out by the hydrometer method (Houba *et al.*, 1989). Hydrogen peroxide (H_2O_2) was used to destroy the soil organic matter and sodium hexametaphosphate $(NaPO_3)_6$ as well as sodium carbonate (Na_2CO_3) was used as soil dispersing agent and one or two drops of amyl alcohol was used for foam reduction. The soil textural classes were determined using ISSS system (Rowell, 1994), triangular guideline.

Bulk density of undisturbed soil sample was determined by core method (FAO, 2007) using core sampler and determining the mass of solids and the water content of the core, by weighting the wet core, drying it to constant weight in an oven at 105°C for 24 hours and calculated as: For calculation use the mass of each empty core (a), and the mass of each core with its dry soil (c).

$$Bulk\ Density\left(\frac{g}{cm3}\right)=\frac{W2-W1}{V}$$

Where W_2 and W_1 are weights of moist and oven dry soils, respectively and V is the volume of the cylindrical core. Percentage pore space was computed from the values of bulk density (BD) and particle density (PD) (Brady and Weil, 2002) as:

$$\textit{Total pore space (\%)} =(1-\frac{BD}{PD})x100 .$$

Moisture content at sampling time was determined by gravimetric method, initially weighing the field samples, drying the field samples at 105^{o}C for 24 hours, and weighing them again. The percentage of water during sampling time held in the soil was calculated as the weight difference of field and oven dried soils divided by weight of oven dried soil multiplied by 100 (Simkins, 2008);

$$\text{Percent of moisture (wt \%)} =\frac{A-B}{B-C}x100$$

Where A=weight of wet soil in gram + tin weight, B=weight of oven dry soil in gram + tin weight and C=weight of the empty tin.

3.2.5. Analysis of soil chemical properties

Soil pH was measured using the glass electrode method with in a supernatant suspension of a 1:2.5 soil: liquid on a mass to mass basis. Prior to use, the pH meter was calibrated with buffer solutions at pH 4 and 7. After 30 minute of stirring, the pH was measured in the suspension by using standard pH meter (Van Reeuwijk, 1992).

The electrical conductivity (EC) of soils was measured from a soil water ratio of 1:5 socked for one hour by electrical conductivity methods described by (Sahlemedhin and Taye, 2000). Soil organic carbon was determined by using Walkley and Black (1934), wet digestion method. One gram of soil was reacted with a mixture of 10mL of 1N $K_2Cr_2O_7$ solution and 20mL of 98 % H_2SO_4. The excess dichromate solution was titrated against 1M ferrous sulphate after addition of 200mL distilled water, 10mL of 85 % orthophosphoric acid and 1mL of indicator solution (0.16 % barium diphenylamine sulphate) and finally, multiply values of soil organic carbon by a factor of 1.724 to obtain soil organic matter, following the standard practice that organic matter is composed of 58% carbon (Nelson and Sommers, 1996).The available phosphorus content of the soil was analyzed using ammonium fluoride extraction solution and determined by spectrophotometer the absorbance with a 10mm diameter cuvette at 882nm by BrayII method (Van Reeuwijk, 1992). Total nitrogen was determined by using Kjeldahl digestion procedure (Bremmer, 1996).

Cation exchange capacity (CEC) and exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, and Na^+) were determined after extracting the soil samples by ammonium acetate (1N NH_4OAc) at pH 7.0 (Houba *et al.*, 1989). The exchangeable Ca^{2+} and Mg^{2+} in the ammonium acetate leachate were measured by atomic absorption spectrophotometer at 422.7 nm and 285.2nm (AAS) (Van Reeuwijk, 1992). Available potassium and exchangeable sodium were determined by using flame photometer with a wavelength at 768nm and 598nm respectively (Houba *et al*., 1989). On the other side, relative change in soil properties was computed (Temesgen,2014);

$$\text{Relative Change} = \frac{(Pe - Pd)}{Pd} X\,100$$

Where P_e is the soil property measured on the exclosure site and P_d is the soil property measured on the adjacent degraded site.

3.2.6. Statistical data analysis

Two way analysis of variance (ANOVA) was performed to assess the significance differences in soil parameters between different treatments, using the split plot designs of statistical analysis software with 9.2 version (SAS Institute, 2002). Mean separations were conducted using Turkeys' Student zed (HSD) test at 5% level of significance when treatments were found significant. Simple correlation analysis was executed by SPSS (version 16) in order to reveal the magnitudes and directions of relationships between selected soil physico-chemical properties indictors.

4. RESULTS AND DISCUSSIONS

4.1. Influence of different grass species on selected soil physical properties

4.1.1. Soil texture

The mean value of clay, silt and sand particle under vetiver, mission , elephant grass species and control plot were indicated in (Table 1). The textural class of the soil under investigation was clay loam based on the soil textural triangle of the international society of soil science ISSS system (Rowell, 1994). Among the treatments, the highest clay content was recorded under mission , while the lowest value was recorded under control plot.compared with the grasses without composted manure, the highest highest clay content was recorded under mission , whereas the lowest clay content was recorded under vetiver. Among the grass without composted manure, the highest value of sand content was recorded under vetiver, while the lowest value was recorded under mission . The high clay content under the mission grass without composted manure might be due to the high surface coverage which reduce clay loss through soil erosion than the vetiver without composted manure. The low clay content under control plot might be due to the selective removal of clay particles by erosion leaving the sand particles, which may reflect the low organic matter and the sparse vegetation aggravate soil erosion which selectively removes clay from the degraded land and left the sand particle.The high clay content under grass without composted manure probably due to organic matter substrate on the soil surface, high vegetation cover, which reduces the clay fractions likely to be lost by selective erosion processes and reduce the rain drop impact on the soil surface and trapping the clay particles by their roots.

Table 1: Mean ± SE value of different treatments on soil Sand (%), Clay (%), Silt%,BD (g/cm3), TP (%), and MC (%).

Composted manure	Grass species	Sand (%)	Clay (%)	Silt (%)	BD (g/cm3)	TP (%)	MC (%)	TC
No composted manure	EG	33^{bc}	36^{b}	31^{ab}	1.08^{b}	57.8^{b}	23^{bc}	CL
	MG	31^{cd}	38^{ab}	32^{a}	1.07^{bc}	58^{ab}	24^{b}	CL
	VG	36^{bc}	34^{c}	32^{a}	1.10^{bc}	56^{b}	20.9^{cd}	CL
With composted manure	EG	30^{c}	40^{ab}	29^{ab}	1.04^{c}	60^{a}	28^{a}	CL
	MG	31^{cd}	39^{ab}	28^{ab}	1.06^{bc}	59^{ab}	25^{ab}	CL
	VG	34^{bc}	35^{bc}	33^{a}	1.09^{bc}	57.2^{ab}	21^{c}	CL
	CNTP	38a	33d	34d	1.27a	50d	19e	CL
	SE±	±0.003	±0.006	±0.004	±0.006	±0.005	±0.0039	

Means followed by the same letters with in column are not statisticantly different at 5% probability. SE=Standard error, CNTP=Control plot, EG(1)= Elephant grass with composted manure, EG(0)= Elephant grass without composted manure, VG (1)= Vetiver grass with composted manure, VG(0)= Vetiver grass without composted manure, MG(1) = Mission grass with composted manure, MG(0)= Mission grass without composted manure and CL=Clay loam
.

In comparison with the control plot, clay content under mission, elephant and vetiver without composted manure were increased by 15.15%, 9.09% and 3.03%, while the sand content were decreased by 15.79 %, 15.15% and 5.52% respectively (Table 4).In addition, grasses has the ability to lower soil erosion and increase surface coverage in order to keep normal soil condition than the control plot. This agree with the finding of Gachene and Kimaru (2003), clay particles are lighter than sand particles, and once detached by erosion they are easily transported. Similar report was done by Burri *et al.* (2009), plant roots can promote soil aggregation by releasing Polysaccharides which can directly stabilize soil particles, enmesh soil particles by hyphae and roots, or can favour microbial activity in the rhizosphere which in turn will affect soil structure. Very fine roots are more significantly associated with fungal hyphae (Jastrow *et al*., 1998) and microbial activity stabilizes soil aggregates through the binding action of humic substances and other microbial by products contributing to soil organic material (Li *et al*., 2007).

Compared with the grasses without composted manure sand content was reduced under elephant, mission and vetiver treated with composted manure by 9.09%,3.13% and 5.56 %, while the clay fraction were increased by 11.11%, 2.63% and 2.94% respectively (Table 4). This variation might be due to soil aggregation by different organic binding agents. In surface soils, organic matter is the main binding agent responsible for the soil aggregates with the formation of clay humus complex and make well humified or promoting micro-aggregates as well as fresh low-molecular OM promoting macro aggregates. When fresh organic matter is added to the soil, soil microbes release long-chain sugars or polysaccharides relatively quickly. These polysaccharides promote formation of large or macro-aggregates. As the organic matter decomposes over the longer term, different sizes of aggregates are formed that are resistant to physical disruption. The number and diversity of stable soil aggregates are what give a soil an excellent physical structure. Despite the fact that, soil texture is an inherent soil property, management practices may contribute indirectly to the changes in particle size distribution particularly in the surface layers as result of removal of soil by sheet and rill erosions. Similar report was done by Bandyopadhyay *et al*. (2010), the addition of materials rich in organic carbon such as manure leads to an improvement of the aggregation status of soil. Similarlly, according to Hati *et al*. (2008), aggregate stability is positively correlated with the soil organic carbon. Like wise, Amlinger *et al*. (2007), macro-aggregates are mainly stabilized by fungal hyphen, fine roots, root hair and microorganisms with a high portion of easily degradable polysaccharides. This agree with the findings of Risse and Faucette (2001), composted manure reduces soil particle transport in runoff and reduces soil particle dislodging.

4.1.2. Soil moisture content

The soil moisture content under vetiver, mission, elephant without composted manure and control plot were indicated in (Table 1). Among the treatments, the highest soil moisture content was recorded under mission without composted manure, whereas the lowest value was recorded under control plot. The analysis of variance also revealed that soil moisture content was significantly different at ($p \leq 0.05$) under different grass species establishment without composted manure and control plot.

Among grass species without composted mannure, the highest and the lowest soil moisture content was recorded under mission and vetiver grass respectively. This variation might be due to relatively high organic matter content of Mission than Vetiver.

Compared with the control plot, soil moisture content under mission, elephant and vetiver grass without composted manure were increased by 26.32%, 21.05% and 10.00% respectively (Table 4). This might be due to the higher clay and OM percentage of the soil under grass species treated without composted manure which contribute to the higher moisture retention of the soil than the control plot. Higher moisture percentages of land with grasses were attributed to the higher organic matter buildup from plant residues and the higher clay percentage of the soil in the land with grasses might have contributed to the higher moisture retention of the soil. Organic matter behaves somewhat like a sponge. It has the ability to absorb and hold high percent of its weight in water. Soil water holding capacity is controlled primarily by the soil texture, and the soil organic matter content. Organic matter can hold high amount of water as the level of organic matter increases in a soil, the water holding capacity also increases, due to the affinity of organic matter for water. Tekilu (1992), reported that soils with high amount of clay have higher amount of water than soils with low amount of clay content. Like wise, according to Nichols *et al*. (2004), aggregation is important for increasing stability against erosion, for maintaining porosity and soil water movement, and for improving fertility. The soil moisture content (Table 5) also showed a positive and significant correlation with clay content ($p<0.01$, $r=.82^{**}$), organic carbon ($p<0.01$, $r=0.86^{**}$) and organic matter ($p<0.01$, $r= 0.87^{**}$) contents. However negatively and significantly correlated with sand ($p<0.01$, $r=-0.75^{**}$) and bulk density ($p<0.01$, $r= -0.72^{**}$).

Compared with grasses without composted manure, soil moisture content under elephant, mission and vetiver grasses treated with composted manure were increased by 21.74%, 4.17% and 0.48% respectively (Table 4). This variation might be due to the application of composted manure improves water retention properties of soil through its effect on pore size distribution and soil structure and increases soil water retention due to increase in micro pores and inter aggregate pores caused by enhanced soil organic matter content and higher activity of soil fauna.The addition of composted manure, increases specific surface area of soil water holding capacity and also composted manure use for erosion control include increasing water infiltration into the soil surface, increasing plant growth and soil cover, increasing water holding capacity of soil which in turn reduces runoff. According to Fageria and Gheyi (1999), the increase in water retention of soil due to addition of organic matter may be related to decreased bulk density and increased total porosity, change in the aggregate size distribution which may change the pore-size distribution and increased absorptive capacity of the soil increase in total surface area. The capacity of composted manure soil water retention and a limitation of the evaporation deposition on the surface soil (Serra-Wittling *et al*., 1995).

4.1.2. Soil bulk density

The soil bulk density under vetiver, mission, elephant grass without composted manure and control plot were given in (Table 1). Among the treatements, the highest soil bulk density, 1.27 g/cm^3 was recorded under control plot and the lowest bulk density, 1.06 g/cm^3 was recorded under mission grass. The reason for the lowest bulk density under grasses might be due to high organic matter content and low direct rainfall impact than the control plot. Among the grasses without composted manure, relatively high and low soil bulk density was recorded under vetiver,1.1 g/cm^3 and mission grass,1.06 g/cm^3. The reason for the lowest bulk density under mission grass might be due to high surface cover, more biomas production and higher aggeregation that reduces the rainfall impact than other grass species organic matter return to soil than vetiver grass.

Compared with the control plot, soil bulk density under mission , elephant and vetiver grass without compost were decreased by 15.75%,14.96% and 13.39% respectively (Table 4). The reason for the lowest soil bulk density under grass could be due to the highest clay and organic matter content. and less disturbance of the land under grass species. Bulk density is dependent on soil organic matter, soil texture, the density of soil mineral (sand, silt, and clay) and their packing arrangement. Organic binding agents include plant and microbially derived polysaccharides, fungal hyphae, and plant roots. Inorganic binding agents and forces include charge attractions between mineral particles and organic matter and freezing/thawing and wetting/drying cycles within the soil as well as compression and deformation forces. Both the stable and the active fraction of SOM contribute to maintain resist soil compaction. Generally, loose, well-aggregated, porous soils and those rich in organic matter have lower bulk density. Sandy soils have relatively high bulk density since total pore space in sands is less than silt or clay soils.

Moreover, relatively the high bulk density under control plot might be due to the absence of vegetation cover and direct impact of rain drop increase the compaction of the soil. According to Gupta (2004), bulk densities of soil are inversely related to the amount of pore space and soil organic matter. The correlation matrix (Table 5) also showed a negative but significant relationship between bulk density and organic carbon ($r=-0.80^{**}$) and organic matter, ($r-0.79^{**}$).

Compared to grasses without composted manure, soil bulk density under elephant, mission and vetiver grass treated with composted manure were decreased by 3.70%, 0.93% and -0.91% respectively (Table 4). The application of composted manure better aggregation and a consequent increase in volume of pores, soil aeration and increased root growth. Increases in the organic fractionresulted in decrease of total weight and bulk density of the soil and increase the friability of the soil this means the porosity of the soil increase but the soil bulk density decrease. As the organic matter increases, the bulk density decreases, and vice versa.These results are in agreement with Civeira and Lavado (2006) lighter composted manure particles might penetrate the soil matrix and eventually decrease bulk densities. Likewise, Curtis and Claassen (2009) stated that adding organic matter reduces soils bulk density. Organic amendments also improve soil bulk density by aggregating soil mineral particles. As the added organic matter is decomposed, exudates are formed that are able to increase soil aggregation (Six *et al*., 2004). Further more, of large quantity of organic manure reduces the bulk density of the soil due to a dilution effect caused by added organic matter (Khaleel *et al*.,1981).

4.1.4. Total porosity

The total porosity of the soil under vetiver, mission ,elephant grass without composted manure and control were indicated in (Table 1). Among the treatments, the highest and the lowest total porosity values were recorded under mission and control plot respectively. Considering grasses wihout composted manure, the highest totatl porosity was recorded mission, while the lowest value was recorded under vetiver grass. The analysis of variance revealed the total porosity was significant difference at($p\leq0.05$**)** under mission, vetiver grass and control plot.

Compared with the control plot, total porosity under mission, elephant and vetivet without composted manure were increased by 16%, 15% and 12% respectively (Table 4). Increases in total porosity under grass without composted manure might be related to increases in organic matter contents and soil aggregate stability. According to Tolbert *et al*. (2002), plants that have deep and extensive roots can also increase porosity and improve soil structure through SOC accrual. The correlation matrix (Table 5) also showed a positive and significant relationship between total porosity, organic matter ($r=0.87^{**}$). Nonetheless, it has a negative but significant relationship between bulk density ($r= -0.75^{**}$).

In comparison with grass treated without composted manure, the total porosity under elephant , mission and vetiver grass treated with composted manure were increased by 3.81%, 1.72% and 2.14% respectively (Table 4).This probable due to the addition of composted manure leads to an increase in total pore volume of the soil, besides changes in pore size distribution. According to Metzger and Yaron, (1987), the organic matter addition through composted manure increases the percentage of transmission and storage pores, while reduces the percentages of fissure. Addition of large quantity of organic manure reduces the bulk density of the soil due to a dilution effect caused by mixing of the added organic material with the denser mineral fraction of the soil (Khaleel *et al*.,1981)

4.2. Influence of different grass species on selected soil chemical properties

4.2.1. Soil pH

The soil pH under vetiver, mission, elephant grass species treated without composted manure and control plot were given in (Table 2). Among the treatments, the highest soil pH value was recorded under mission grass, while the lowest value was recorded under control plot. Among grasses without composted manure, relatively the highest and the lowest soil pH value were recorded under mission grass and vetiver grass, respectively. The analysis of variance revealed that soil pH was statisticantly different at ($p\leq0.05$) among grass species treated without composted manure and control plot. Compared with the control plot, soil pH under mission , elephant and vetiver grass without composted manure were increased by 5.536%, 5.00% and 3.036% respectively (Table 4). The highest value of soil pH under the grasses without composted manure might be due to high organic matter content helped a lot as humified organic matter can bind tightly with aluminum and iron ions, reduce their activity in the soil solution, thereby increase pH, and reduce acidity.

Soils with high clay and organic matter content are more able to resist a drop or rise in pH have a greater buffering capacity than sandy soils. Due to relatively low precipitation amounts, there is little leaching of base cations, resulting in a relatively high degree of base saturation and pH values. In precipitation area, soil pH decreases over time in a process called soil acidification, due to leaching of basic forming cation by rainfall. An increase in precipitation causes increased leaching of base cations and the soil pH is lowered. As excess rainfall passes through the soil, there could be leaching of basic nutrients. Thus, these nutrients will be replaced by acidic elements including hydrogen and aluminum.According to USDA (1998), the pH of soil is affected by both the natural systems (mineralogy, climate and weathering) since the study receive area have high annual rainfall distribution. Generally, the pH values observed in the study area are within the ranges of moderately acidic to slightly acid soil reactions as indicated by Foth and Ellis (1997).

Compared to grasses without composted manure, soil pH under elephant, mission and vetiver grasses treated with composted manure were increased by 2.721%, 1.015% and 0.520%, respectively (Table 4). When a soil is limed and the acidity decreases, there is a greater tendency for the H+ to be removed from humic acids and to react with hydroxyl (OH-) to form water. The carboxyl groups on the humus develop negative charge as the positively charged H is removed. When the pH of a soil is increased, the release of H from carboxyl groups helps to buffer the increase in pH and at the same time creates the CEC (negative charge). With an increase in organic matter, the soil recovers its natural buffer capacity; this means an increase in pH in acid soils. Composted manure might have liming effect due to its richness in alkaline cations such as Ca^{2+}, Mg^{2+} and K^{+} which were liberated from OM due to mineralization. The addition ofcomposted manure increased soil pH and pH increased with the higher dose of composted manure application. According to Ouedraogo *et al*. (2001), regularly applied composted manure material maintains or enhances soil pH. Generally, the pH values observed under all grass treated with composted manure are within the ranges of moderately acidic except under elephant grass that is slightly acidic soil reactions as indicated by (Foth and Ellis,1997).

Table 2: Mean (±) SE value of different treatments on soil PH, EC (ds/m), OC (%), OM (%), TN (%) and Av.p (ppm)

Composted manure	Grass species	pH	EC (ds/m)	OC (%)	OM (%)	TN (%)	Av.P (ppm)
No composted manure	EG	5.88^{bc}	0.052^{c}	2.41^{d}	4.15^{d}	0.208^{d}	5.97^{cd}
	MG	5.91^{b}	0.060^{bc}	2.48^{c}	4.28^{c}	0.214^{c}	6.31^{c}
	VG	5.77^{c}	0.044^{cd}	2.29^{de}	3.95^{de}	0.197^{de}	5.80^{cd}
With composted manure	EG	6.04^{a}	0.083^{a}	2.69^{a}	4.65^{a}	0.233^{a}	6.63^{a}
	MG	5.97^{a}	0.067^{ab}	2.49^{ab}	4.29^{ab}	0.215^{ab}	6.37^{b}
	VG	5.80^{bc}	0.047^{bc}	2.37^{d}	4.08^{d}	0.204^{d}	5.82^{c}
CNTP		5.60^{d}	0.035^{e}	1.96^{f}	3.41^{e}	0.171^{f}	5.27^{e}
SE±		±0.071	±0.047	±0.01	±0.02	±0.03	±0.083

Means followed by the same letters with in column are not statistically different at 5% probability. CNTP=Control, SE= standard error, EG(1)= Elephant grass with composted manure, EG(0)= Elephant grass without composted manure, VG (1)= Vetiver grass with composted manure, VG(0)= Vetiver grass without composted manure, MG(1) = Mission grass with composted manure, MG(0)= Mission grass without composted manure.

4.2.2. Electrical conductivity (EC)

The electrical conductivity under vetiver, mission, elephant without composted manure and control plot were indicated in (Table 2). Among the treatments, the highest and lowest EC value were recorded under mission and control plot, respectively. Grass species for example from mission to vetiver, resulted in increment of soil EC of the study site. For instance, the highest and the lowest EC values were recorded under mission and vetiver, respectively. The analysis of variance also showed that the value of EC was statistically differenct at ($p \leq 0.05$**)** under control plot and vetiver, mission without composted manure. As compared to the control plot, EC value under mission, elephant and vetiver grass without composted manure were increased by 71.429%, 48.571% and 25.714% respectively (Table 4). The credible reason for this could be accumulation of exchangeable bases from decomposition of organic matter results high EC at land rehabilitated with grasses and recycling of salt forming basic cations from deeper soil layers to the top surface by its fine root structure, while the lowest EC value under the control plot might be associated with the loss of base forming cations (Ca^{2+} and Mg^{2+}) due to high rain fall and absence of vegetation cover. According to (Landon, 1991), in soils of sub-humid tropics where there is sufficient rainfall to flush out base forming cations from the root zone, EC is found too low, usually, less than 4 dS/m. The correlation matrix (Table 5) also showed a positive and significant relationship between organic matter (P<1, r=0.83**), CEC (P<1, r=0.79**) with EC.

Compared to grasses without composted manure, soil EC under elephant, mission and vetiver grass with composted manure were increased by 59.615%, 11.668% and 6.818% respectively (Table 4). The probable reason for this may be reduced erosion is expected to occur under rehabilitated land because the surface cover by the grasses shields the soil from the erosive energy of the falling raindrops and thereby protects it from splash erosion and surface or sheet erosion. And also its might be due to high organic matter content and the amount of exchangeable bases like Ca and Mg in the composted manure. This is in line with the finding of Atiyeh *et al*. (2002was higher than in non-composted manure.According to Gallardo-Lara and Nogales (1987), application of composted manure into soil increases the salt content as well as soil electrical conductivity, especially if high doses of composted manure are applied, because of the high salinity of composted manure.

4.2.3. Soil organic matter, Soil organic carbon and Total nitrogen

SOM under vetiver, mission and elephant grass species treated without composted manure and control plot were geven in (Table 2). Among the treatments, the highest value of OM content was recorded under mission ,while the lowest value was recorded under control plot. Regarding grasses without composted manure, the highest and lowest values of OM contents were recorded under mission and vetiver, respectively. The analysis of variance revealed the OM content were significantly different at (p≤0.05) under vetiver, mission grass without composted manure and control plot.

In comparision with the control plot, soil OM under mission, elephant and vetiver grass treated without composted manure were increased by 25.513%, 21.637% and 15.836% respectively (Table 4). This variation might be due to higher vegetation coverage of rehabilitated area, which resulted in higher litter input, and thus higher accumulation of organic matter in the soil and higher clay content of the soil of the rehabilitated land.

Comparatively more biomass production in different grass species contributed to wards the improvement of organic matter status of the soil. According to Lal (2005), the amount of organic carbon and organic matter depends on the quality and quantity of the litter fall and below ground biomass as well as microclimatic and edaphic conditions of the area. Like wise, according to Bot and Bentites (2005), area exclosure increases the accumulation of soil organic matter and the presence of this organic matter affects both the chemical and physical properties of the soil and overall health of the soil. Similarlly, according to Mekuria *et al*. (2009), the increases in canopy cover with the increase in exclosure duration could decrease sediment-associated soil nutrient losses by reducing the erosive impact of rain drops and soil erosion. The correlation matrix (Table 5) showed a positive and significant relationship between organic matter and organic carbon ($P<1$, $r=0.98^{**}$).

Compared to grasses without composted manure, OM under elephant, mission and vetiver with composted manure were increased by 11.618%, 0.234%, and 3.291% respectively (Table 4). This variation might be due to the application of composted manure resulted in overall increase of the soil organic matter level and the status of organic matter in the soil has a relationship with the quantity applied. Similar results were also obtained by earlier workers Sarwar *et al*. (2003), the contents of organic matter in the soil were increased by the addition of bio composted manure.

Organic carbon under vetiver, mission and elephant grass without composted manure and control plot were indicated in (Table 2). Among the treatments, the highest value of soil OC was recorded under mission, while the lowest value was recorded under control plot. With regard to grasses without composted manure, the highest and the lowest values of OC contents were recorded under mission and vetiver, respectively. Soil organic carbon was significantly different at ($p \leq 0.05$) under control plot and vetiver and mission grass without composted manure.

Compared to control plot, soil OC under mission, elephant and vetiver grass without composted manure were increased by 26.531%, 22.96% and 16.84% respectively (Table 4). This might be attributed to the higher accumulation of organic carbon due to high inputs from root and shoot biomass,while the lower value of SOC under control plot might be due to the absence of vegetation cover and high soil erosion.

Restoration of vegetation can promote nutrient cycling possible,decomposition and decreased nutrient loss possible,runoff and wind erosion, owing to its protection of soil surface, which has a positive effect on increasing the soil C concentrations (Li *et al*.,2009). compared to grasses without composted manure, soil OC under elephant, mission and vetiver grass treated with composted manure were increased by 11.618%, 0.403% and 3.493% respectively (Table 4). The application of composted manure might be increases the soil organic carbon and improves soil structure. Restoration of vegetation can promote nutrient cycling possible,decomposition and decreased nutrient loss possible,runoff and wind erosion, owing to its protection of soil surface, which has a positive effect on increasing the soil C concentrations (Li *et al*.,2009).

Total nitrogen under vetiver, mission and elephant without composted manure and control plot were given in table (Table 2). Among the treatments the highest value of OC conten was recorded under mission and the lowest value was recorded under control plot. The distribution of total nitrogen followed a similar pattern to organic carbon distribution even so, regarding grasses without composted manure the highest and lowest values of TN contents were recorded under mission and vetiver, respectively. The analysis of variance also revealed that the values of TN contents were significantly different at ($p \leq 0.05$) under control plot, Vetiver and Mission without composted manure (Table 2).

In comparision with control plot, TN under mission, elephant and vetiver grass without composted manure were increased by 25.146%, 21.64 % and 15.20% respectively (Table 4). Despite the fact that, relatively the higher value of TN under grass species than that of the control plot could be associated with the relatively higher organic carbon which in turn resulted from plant shoot and root biomass as well as residues being returned to the soil system. The low value of TN under control plot might be lack of adequate cover associated with no litter fall to augment nitrogen stocks in the soil.

Furthermore, the control plot has high evaporation rate as compared to grass plantation stand leading moisture deficit in the soil, which might be slows down decomposition and subsequent mineralization of limited litter on the soils. High quality litter leads to formation of high quality organic carbon and TN in the mineral soil.

The vertical distributions of soil organic carbon and total nitrogen are also attributed to the continuous accumulation of undecayed and partially decomposed grass residues in the surface soils. According to Knops *et al.* (2000), vegetation composition had a significant role to play in the accumulation of N and carbon. The correlation matrix (Table 5) also showed a Positive and significant relationship between total nitrogen and organic carbon (P<1, r=0.96**). Compared to grasses without composted manure, soil TN under elephant, mission and vetiver grass with composted manure were increased by 12.019%, 0.467% and 3.553% respectively (Table 4). The changes in the organic carbon content in soils might be brought about changes in the total nitrogen content. Fortuna *et al*. (2003), argued that the composted manure amendment could increase the carbon contents up to 45 g.kg^{-1} of the original levels, and thus contribute to increase the soil structural stability, particularly that of the macro aggregates.

4.2.5 Available phosphorus (Av.P)

The soil Av.P under vetiver, mission, elephant without composted manure and control plot were indicated in (Table 2). The content of Av.p under control plot relatively lower than the rest three grasses without composted manur. Accordingly, the highest and the lowest Av.p contents were observed under the mission and the control plot, respectively. Among grasses without composted manure, the highest value of Av.P was recorded under mission, while the lowest value was recorded under vetiver grass. The analysis of variance also revealed that Av.p was significantlydiffertent at($p \leq 0.05$) under Mission and control plot.

In relation to control plot, soil Av.P under mission, elephant and vetiver grass treated without composted manure were increased by 19.734%, 13.283% and 10.057%, respectively (Table 4). This variation might be due to accumulation of organic matter and low activity of Fe and Al to fix phosphorous as they are strongly adsorbed by humic substances. The increase of soil pH could be another reason for the highest values of available phosphorous under grass without composted manure than the control plot.

According to Young *et al* (1997a, 1997b and 1997c), organic matter has the capacity to block the fixation sites and also exert buffering action against acidification of the soils. Silmilarly, according to Afif*et al*. (1993), the higher positive correlation that existed between available P and organic C was an indication of organic matter suppressing P fixation into soils just as an increase in soil pH further complimented the effects of organic matter.The correlation matrix (Table 5) showed a positive and significant relationship ($P<0.01$; $r = 0.77^{**}$) between organic matter and available phosphorous and pH and available phosphorous ($P<0.01$; $r = 0.76^{**}$).

Compared to grasses without composted manure, soil Av.P under mission, elephant and vetiver grass with composted manure were increased by 11.055%, 0.951% and 0.345%, respectively (Table 4). This variation might be due to the increment of organic matter under grass treated with composted manure make the fixation and chelation of Fe and Al by organic matter and increase the Av. p. According to Arancon *et al*. (2006) continuous inputs of P to the soil were probably from slow release of composted manure and release of P was due largely to the activity of soil microorganisms. According to Gallardo-Lara and Nogales (1987), Because of oxidation and organic matter degradation in soil a lot of nutrients like P, are going to be available to plant. Like wise, according to Padmavathiamma *et al*. (2008), composted manure applied increases the concentration of soil P. Similarly, according to Sharpley and Syres (1997), enhancement of phosphates activity and physical breakdown of organic matter resulted in greater mineralization.

4.2.6. Cation Exchange Capacity (CEC)

Cation exchange capacity (CEC) under vetiver, mission, elephant grass without composted manure and control plot were given in (Table 3). Regarding treatments, the highest and lowest CEC values were recorded under mission grass and control plot, respectively. Among grasses without composted manure, the highest CEC was recorded under mission , while the lowest value was recorded under vetiver grass. The analysis of variance also showed CEC was significantly different at ($p\leq0.05$) under control plot and Vetiver and mission grass treated without composted manure. In comparison with the control plot, CEC under mission, elephant and vetiver grass without composted manure were increased by 24.65 %, 23.11% and 10.90% respectively (Table 4). The increment of soils CEC value under grasses without composted manure might be determined by their SOM content and the amount and type of clay minerals present.

According to Manlay *et al*. (2007), higher CEC is related to an increase in root biomass and larger litter inputs. Like wise, according to Haynes and Naidu (1998), Indigenous mixed tree plantations are known to increase the CEC of the soils, because of high inputs of organic matter into the soils. The correlation matrix (Table 5) also showed a positive and significant ($P<0.01$; $r = 0.88^{**}$) relationship between organic matter and ($P < 0.01$; $r = 0.86^{**}$) clay percentage. According to Landon (1991), the soils having CEC of > 25, 15-25 cmol(+)/kg, 5-15 cmol(+)/kg and < 5 cmol(+)/kg are classified as high, medium, low and very low, respectively. Based on the above ratings, the Mission grass and the ontrol plot qualify for medium and low status of CEC, respectively (Table 3).

Compared with the grasses without composted manure, CEC under elephant, mission and vetiver grass with composted manure were increased by 9.23%, 4.28% and 3.97% respectively (Table 4). This variation might be due to application of composted manure increase exchangeable cations ($Ca^{2+,}$ Mg^{2+} and K^{+}) and OM contents. According to Amlinger *et al*. (2007) SOM contributes about 20 – 70% to the CEC of many soils. Like wise, according to Kibret (2008), soil CEC is associated with clay and OM colloids, and especially OM renders soils a better CEC. The high CEC under grass with composted manure might be due to the application of composted manure increase the surface area to volume ratio this make suitable condition for basic Cation and the amount of Cation retained to the soil surface. Thi is similar with the finding of Ouedraogo *et al*. (2001), composted manure amendment resulted in an increase of CEC due to input of stabilized OM being rich in functional groups into soil.

Table 3: Mean (±) SE value of different treatments on soil CEC (cmol/kg), Ca (cmol/kg), Mg (cmol/kg), K (cmol/kg), and Na (cmol/kg)

Composted manure	Grass species	CEC (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)
No composted manure	EG	15.93^{c}	6.66^{bc}	2.56^{b}	0.39^{d}	0.33^{ab}
	MG	16.13^{b}	6.77^{bc}	2.66^{ab}	0.45^{c}	0.34^{ab}
	VG	14.35^{d}	5.91^{d}	2.45^{d}	0.32^{de}	0.30^{bc}
With Composted manure	EG	17.40^{a}	8.20^{a}	2.85^{a}	0.55^{a}	0.43^{a}
	MG	16.82^{ab}	7.17^{b}	2.76^{a}	0.46^{bc}	0.35^{ab}
	VG	14.92^{bc}	6.31^{cd}	2.50^{cd}	0.35^{d}	0.32^{bc}
CNTP		12.94e	5.17e	1.85e	0.28f	0.25d
SE±		±0.61	±0.37	±0.051	±0.008	±0.008

Means followed by the same letters with in column are not different statisticantly different at 5% probability. SE=Standard error, CNTP=Control plot, EG(1)= Elephant grass with composted manure, EG(0)= Elephant grass without composted manure, VG (1)= Vetiver grass with composted manure, VG(0)= Vetiver grass without composted manure, MG(1) = Mission grass with composted manure, MG(0)= Mission grass without composted manure.

4.2.7. Exchangeable Base (Ca^{2+} $Mg,^{2+}$ K^{+} and Na^{+})

The mean value of exchangeable Ca^{2+} under vetiver, elephant, mission grass without composted manure and control plot were, 5.91 cmol/kg, 6.66 cmol/kg, 7.17 cmol/kg and 5.17 cmol/kg, while exchangeable Mg^{2+} results were 2.45 cmol/kg, 2.56 cmol/kg, 2.76 cmol/kg and 1.85 cmol/kg, and exchangeable K^{+} and Na^{+} results were 0.32 cmol/kg, 0.39 cmol/kg, 0.46 cmol/kg and 0.28 cmol/kg, and 0.30 cmol/kg, 0.33 cmol/kg, 0.35 cmol/kg and 0.20 cmol/kg with respect to grass species (Table 3). Among the treatments, the highest exchangeable base was recorded under grass without composted manure, while the lowest value was recorded under control plot. The analysis of variance showed that the mean value of exchangeable (Ca^{2+}, Mg^{2+} and K^{+}) were statisticantly different at ($P \leq 0.05$) under all grass without composted manure and control plot.

In comparison with control plot, soil exchangeable base (Ca^{2+} Mg, $^{2+}$ K^+ and Na^+) under mission and vetiver grass with composted manure were increased by 30.95%, 43.78%, 125%, and 36%, and 14.31%, 32.43%, 60.00% and 20% respectively (Table 4). This probably due to supply of OM via shoots and roots biomass as well as plant's root system facilitates the nutrient cycling. The positive effect of the grass species on Ca and Mg may be caused by a rapid cycling of these elements in the litter fall. According to Franceschi and Nakata (2005), extraction of Ca from the soil by some plants, which are then accumulated in the biomass in the form of calcium oxalate. Likewise, according to Bot and Benites (2005), the higher values of exchangeable cations could be attributed to the nutrient-cycling role of increased biomass in the enclosure site. Similarly, Sachs (1999), the two colloidal substances clay and organic matter are essentially the cations' warehouse or reservoir of the soil and are very important because they improve the nutrient and water holding capacity of the soil. Correlation matrix also showed a positive and highly significant relationship between exchangeable base (Ca^{2+}, Mg^{2+}, K^+ and Na^+) and OM ($p<0.01$, $r=0.86^{**}$, 0.74^{**}, $0.92^{**}$and 0.87^{**}) respectively (Table 5).

Basically, in comparison with grass without composted manure, soil exchangable (Ca^{2+} Mg, $^{2+}$ K^+ and Na^+) under elephant, mission and vetiver grass with composted manure were increased by 23.12%, 11.33%, 41.03%,and 30.30%, and 5.91%, and 3.76%, 2.22%, and 2.94%, and 6.77%, 2.04%, 9.37% and 6.67% respectively(Table 4). The increment of exchangeable base might be due to the high amount of (Ca^{2+} Mg^{2+}, K^+ and Na^+) in composted manure amendments that increases CEC, the Ca^{2+} Mg^{2+}, K^+ amount rises in soil under grass with composted manure. This finging in line with the finding of Verma *et al*. (2005), the prolonged use of mineral composted manure and other ameliorants increases the potassium content in the soil. The increase of soil organic matter resulted in decrease K fixation and subsequent increase K availability (Olk *et al*., 1993).

Table 4: Relative change for selected soil physico-chemical properties of the Mission grass, Elephant grass ,and Vetiver grass with and without composted manure**.**

Soil parameters	Relative change (%)						R^2	CV (%)
	MG (0)	EG(0)	VG (0)	MG (1)	EG(1)	VG (1)		
Sand (%0	15.790	13.16	5.260	3.130	9.090	5.56	0.830	4.690
Clay(%)	15.150	9.090	3.030	2.630	11.11	2.94	0.920	4.290
Silt(%)	5.88000	8.820	5.880	12.50	6.450	3.13	0.650	4.770
BD(g/cm^3)	15.750	14.96	13.390	0.930	3.700	0.91	0.710	2.240
TP (%)	16.000	15.60	12.00	1.720	3.810	2.14	0.850	2.510
MC (%)	26.320	21.05	10.00	4.170	21.74	0.48	0.810	5.160
pH	5.5360	5.000	3.0360	1.015	2.7210	0.520	0.770	1.240
EC(ds/m)	71.429	48.571	25.714	11.67	59.615	6.818	0.760	1.930
OC (%)	26.531	22.96	16.837	0.403	11.618	3.493	0.980	1.140
OM (%)	25.513	21.701	15.836	0.234	11.618	3.291	0.990	1.060
TN (%)	25.146	21.637	15.205	0.467	12.019	3.553	0.980	1.040
Av.P(ppm)	19.734	13.283	10.057	0.951	11.055	0.345	0.700	4.850
CEC(cmol(+)/kg)	24.650	23.110	10.90	4.280	9.230	3.970	0.870	3.790
Ca(cmol(+)/kg)	30.950	28.820	14.31	5.910	23.12	6.770	0.830	6.390
Mg(cmol(+)/kg)	43.780	38.380	32.43	3.760	11.33	2.040	0.620	2.260
K(cmol(+)/kg)	125.00	95.000	60.00	2.220	41.03	9.370	0.910	6.960
Na(cmol(+)/kg)	36.000	32.000	20.00	2.940	30.30	6.670	0.960	7.160

EG(1)= Elephant grass with composted manure, EG(0)= Elephant grass without composted manure, VG (1)= Vetiver grass with composted manure, VG(0)= Vetiver grass without composted manure, MG(1) = Mission grass with composted manure, MG(0)= Mission grass without composted manure and CV=Coefficient of variation.

Table 5. **Pearson's correlation matrix for selected soil physico-chemical parameters**

	pH	EC	MC	BD	TP	OM	OC	TN	Av.P	Clay	Silt	Sand	CEC	Ca	K	Mg	Na
pH	1																
EC	.82**	1															
MC	.77**	.76**	1														
BD	-.65**	-.72**	-.73**	1													
TP	.66**	.69**	.71**	-.75**	1												
OM	.84**	.83**	.87**	-.80**	.87**	1											
OC	.84**	.84**	.87**	-.80**	.86**	.98**	1										
TN	.84**	.83**	.87**	-.80**	.87**	.97**	.96**	1									
Av.P	.76**	.69**	.69**	-.76**	.67**	.79**	.77**	.76**	1								
Clay	.77**	.81**	.82**	-.78**	.89**	.95**	.94**	.94**	.76**	1							
Silt	-.63**	-.70**	-.67**	.60**	-.62**	-.75**	-.75**	-.74**	-.65**	-.82**	1						
Sand	-.67**	-.74**	-.75**	.71**	-.87**	-.88**	-.87**	-.88**	-.66**	-.91**	.59**	1					
CEC	.81**	.79**	.84**	-.82**	.77**	.88**	.88**	.88**	.84**	.86**	-.68**	-.79**	1				
Ca	.77**	.78**	.82**	-.74**	.71**	.86**	.86**	.86**	.76**	.84**	-.74**	-.75**	.92**	1			
K	.78**	.79**	.83**	-.62**	.70**	.87**	.87**	.87**	.66**	.82**	-.72**	-.79**	.79**	.82**	1		
Mg	.78**	.79**	.80**	-.78**	.90**	.95**	.95**	.95**	.70**	.93**	-.68**	-.89**	.84**	.79**	.79**	1	
Na	.75**	.78**	.80**	-.76**	.77**	.90**	.91**	.89**	.75**	.86**	-.74**	-.77**	.78**	.79**	.74**	.84**	1

Two-tailed, BD=Bulk Density, MC=Moisture Content, TP=Total porosity, pH=Potential for Hydrogen, EC=Electrical Conductivity, OC=Organic Carbon, OM= Organic matter, TN=Total Nitrogen, Av.P=Available Phosphorous, CEC=Cation Exchange Capacity, Ca^{2+}= Calcium, Mg^{2+}=Magnesium, k^{+}=Potassium and Na^{+}=Sodium

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The soils physical properties such as moisture content, clay and total porosity and soil chemical properties, pH, organic matter, total nitrogen, available phosphorous, cations exchange capacity, exchangeable cations, showed significant difference at $p \leq 0.05$ for the soil under vetiver, mission , elephant grass species compared to the soils of the control plot. Among the three grass species without composted and with composted manure, mission and elephant grasses were the most effective to improve soil physico-chemical properties respectively, whereas vetiver grass was the lowest to improve soil physic-chemical properties in both treatments. Similarly, soil physical and chemical properties were positively affected by application of composted manure. All grass species treated with composted manure showed an improvement of soil chemical propertiessuch as pH,EC,OM,OC,TN,Av.p, CEC and exchangeable base. In general, degraded land rehabilitation by grass species such as vetiver, mission and elephant grass play a critical role on soil physico-chemical property improvement. For this reason, those grasses could be not only as an alternative but also a prerequisite to improve the physico-chemical properties of the degraded soil.

5.2. Recommendations

The degraded land rehabilitation by different grass species specially elephant grass species is strongly recommended since it is a fast growing, cheap and easy growing grass with the application of composted manure. In this study focused only on selected soil physico-chemical properties. Therefore, further study is required on the effect of vetiver, mission and elephant grass species on soil micro nutrients such as Zn, Fe Mn, B and Cu, and soil microorganisms. Further scale up of the successful findings is recommended by building the communities capacity through training and experience sharing by field visit of similar rehabilitated degraded land.

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APPENDIX

Appendix 1. **ANOVA table results of each treatment in soil physico - chemical parameters.**

Treatment combination				Sand		Clay		Silt		BD		TP		MC	
				HSD	P.value	HSD	P.value	HSD	P.value	HSD	P.value	HSD	P.value	HSD	P.value
CNTP	3	VG	0	4.140	0.0501	6.470	0.0541	2.017	0.0605	0.058	0.0001	5.030	0.0001	1.250	0.0015
CNTP	3	VG	1	4.502	0.0531	3.051	0.0701	2.418	0.0509	0.017	0.0001	7.310	0.0001	3.462	0.0001
CNTP	3	EG	0	6.052	0.0031	7.290	0.0501	2.625	0.0086	0.047	0.0001	8.350	0.0001	4.571	0.0001
CNTP	3	EG	1	5.436	0.0001	1.832	0.0071	3.374	0.0015	0.381	0.0001	10.21	0.0001	1.784	0.0001
CNTP	3	MG	0	7.238	0.1361	5.190	0.3701	3.148	0.0811	0.034	0.0001	7.040	0.0001	1.984	0.0001
VG	0	VG	1	6.371	0.2703	1.930	0.0723	1.482	0.9820	0.115	0.1217	1.330	0.2873	1.637	0.0012
VG	0	EG	0	5.441	0.0851	3.271	0.0001	5.601	0.9530	0.056	0.1209	2.060	0.0245	2.641	0.0001
VG	0	EG	1	6.493	0.0001	0.152	0.0631	4.210	0.8710	0.129	0.0002	4.160	0.0033	4.708	0.0001
VG	0	MG	0	4.150	0.0525	4.305	0.1074	1.730	0.9290	0.032	0.7923	1.842	0.1953	1.104	0.0195
VG	0	MG	1	3.896	0.0001	2.057	0.0541	2.151	0.9280	0.031	0.0497	2.610	0.0372	1.809	0.0001
VG	1	EG	0	3.118	0.0001	2.585	0.0086	4.794	0.9920	0.003	0.1544	1.270	0.0855	4.062	0.0501
VG	1	EG	1	4.901	0.0621	5.820	0.0001	5.752	0.0640	0.537	0.1417	2.830	0.1027	2.749	0.0001
VG	1	EG	0	1.842	0.0133	3.603	0.4259	2.592	0.7800	0.042	0.0106	5.207	0.5305	1.387	0.0501
VG	1	EG	1	5.360	0.1931	4.241	0.0731	1.509	0.0720	0.004	0.0404	1.750	0.1283	3.048	0.1019
MG	0	EG	1	5.942	0.1215	1.805	0.0531	1.510	0.9400	0.003	0.0014	0.010	0.0093	1.638	0.0001
EG	0	MG	0	6.820	0.0706	1.972	0.0811	5.309	0.9090	0.035	0.1914	1.260	0.2295	4.704	0.0537
EG	1	MG	0	4.911	0.0511	7.082	0.0721	4.825	0.0030	0.129	0.0001	2.430	0.0301	1.776	0.0001
EG	1	MG	1	2.570	0.0533	5.251	0.0521	3.516	0.6730	0.014	0.0364	2.780	0.1565	7.621	0.0531
MG	0	MG	1	2.201	0.0863	5.410	0.0741	0.011	0.0050	0.232	0.0586	2.409	0.1519	1.59	0.0613

ANOVA TABLE RESULTS (*CONTINUED…………*)

Treatment combination				pH		EC		OC		OM		TN		Av.P	
				HSD	P.value	HSD	p.value	HSD	p.value	HSD	p.value	HSD	P.value	HSD	p.value
CNTP	3	VG	0	0.113	0.0247	0.014	0. 002	0.321	0.0001	0.502	0.0001	0.012	0.0001	0.432	0.0001
CNTP	3	VG	1	0.254	0.0418	0.036	0.0419	0.629	0.0001	0.793	0.0001	0.053	0.0001	1.263	0.0001
CNTP	3	VG	0	0.045	0.0337	0.022	0.0102	0.361	0.0001	0.831	0.0001	0.032	0.0001	0.532	0.0001
CNTP	3	EG	1	0.572	0.0161	0.072	0.0001	0.829	0.0001	1.321	0.0001	0.074	0.0001	1.405	0.0001
CNTP	3	MG	0	0.156	0.0181	0.019	0.0469	0.221	0.0001	0.604	0.0001	0.024	0.0001	0.525	0.0001
CNTP	3	MG	1	0.352	0.0278	0.042	0.8369	0.576	0.0001	0.896	0.0001	0.072	0.0001	1.327	0.0001
VG	0	VG	1	0.123	0.0631	0.011	0.9727	0.173	0.0541	0.253	0.0751	0.032	0.0721	0.539	0.0548
VG	0	EG	0	0.132	0.0125	0.016	0.0135	0.115	0.0001	0.315	0.0011	0.011	0.0001	0.905	0.1263
VG	0	EG	1	0.345	0.0001	0.015	0.8659	0.427	0.0001	0.851	0.0001	0.038	0.0001	0.904	0.0001
VG	0	MG	0	0.136	0.3122	0.014	0.9954	0.032	0.0001	0.122	0.0001	0.010	0.0001	0.243	0.8141
VG	0	MG	1	0.321	0.0001	0.021	0.0054	0.216	0.0001	0.352	0.0001	0.036	0.0001	0.591	0.0001
VG	1	EG	0	0.018	0.2938	0.003	0.9991	0.085	0.0001	0.284	0.0001	0.019	0.0001	0.472	0.0045
VG	1	EG	1	0.198	0.0452	0.027	0.0259	0.218	0.0001	0.428	0.0001	0.017	0.0251	0.248	0.0271
VG	1	MG	0	0.127	0.0103	0.002	0.2471	0.183	0.0151	0.147	0.0132	0.058	0.0001	0.537	0.0001
VG	1	MG	1	0.176	0.1047	0.018	0.967	0.043	0.0001	0.242	0.1531	0.004	0.0001	0.672	0.6107
EG	0	EG	1	0.059	0.0001	0.014	0.0318	0.162	0.0001	0.294	0.0001	0.014	0.0001	0.252	0.0001
EG	0	MG	0	0.047	0.0021	0.017	0.9863	0.012	0.0131	0.128	0.0161	0.003	0.0463	0.527	0.1932
EG	0	MG	1	0.083	0.0251	0.001	0.9379	0.0001	1.9491	0.001	0.9456	0.026	0.0001	0.471	0.0011
EG	1	MG	0	0.491	0.0001	0.037	0.0071	0.374	0.0001	0.582	0.0001	0.046	0.0001	0.846	0.0001
EG	1	MG	1	0.054	0.0333	0.034	0.9283	0.109	0.0001	0.223	0.0001	0.026	0.131	0.478	0.2057
MG	0	MG	1	0.016	0.0001	0.025	0.9444	0.037	0.0001	0.105	0.0001	0.004	0.0001	0.211	0.0004

ANOVA TABLE RESULTS (*CONTINUED*………..)

Treatment combination				CEC		Mg		Ca		K		Na	
				HSD	P.value	HSD	P.value	HSD	p.value	HSD	p.value	HSD	p.value
CNTP	3	VG	0	1.023	0.0011	0.532	0.0458	0.710	0.0151	0.023	0.0049	0.024	0.0001
CNTP	3	VG	1	2.035	0.0011	0.721	0.0001	1.261	0.0001	0.074	0.0001	0.142	0.0001
CNTP	3	EG	0	3.720	0.0001	0.862	0.0446	1.040	0.0001	0.145	0.0001	0.111	0.0001
CNTP	3	EG	1	4.752	0.0261	1.142	0.0001	3.523	0.0001	0.273	0.0001	0.421	0.0001
CNTP	3	MG	0	1.150	0.0001	0.681	0.0001	1.380	0.0001	0.057	0.0001	0.056	0.0001
CNTP	3	MG	1	3.244	0.0321	0.853	0.0001	1.721	0.0001	0.238	0.0001	0.147	0.0001
VG	0	VG	1	0.440	0.0001	0.191	0.9821	0.510	0.1708	0.022	0.0164	0.025	0.1842
VG	0	EG	0	2.220	0.0201	0.274	0.0001	1.120	0.0001	0.104	0.0001	0.063	0.6027
VG	0	EG	1	3.010	0.0901	0.371	0.9318	2.020	0.0002	0.263	0.0001	0.142	0.0001
VG	0	MG	0	1.720	0.0721	0.049	0.0236	0.620	0.0452	0.054	0.0001	0.031	0.0529
VG	0	MG	1	1.830	0.0501	0.142	0.9642	0.630	0.0497	0.158	0.0001	0.012	0.1615
VG	1	EG	0	1.740	0.5432	0.136	0.9654	0.410	0.1544	0.136	0.0001	0.003	0.4137
VG	1	EG	1	2.130	0.0001	0.216	0.0001	1.830	0.0417	0.151	0.0001	0.194	0.2531
VG	1	MG	0	1.250	0.0021	0.003	0.8584	0.370	0.0106	0.424	0.0106	0.426	0.0027
VG	1	MG	1	1.060	0.0073	0.048	0.0182	0.530	0.6404	0.035	0.0001	0.024	0.9177
EG	0	EG	1	0.230	0.0431	0.096	0.9840	1.010	0.0001	0.064	0.0001	0.172	0.0571
EG	0	MG	0	0.540	0.0033	0.358	0.9644	0.550	0.1914	0.043	0.0001	0.029	0.1051
EG	0	MG	1	0.730	0.0352	0.726	0.9838	0.130	0.3258	0.005	0.5658	0.002	0.3591
EG	1	MG	0	1.540	0.0001	0.372	0.0001	1.250	0.0793	0.213	0.0001	0.215	0.0001
EG	1	MG	1	1.290	0.0890	0.117	0.0001	1.220	0.0295	0.047	0.0001	0.095	0.2511
MG	0	MG	1	0.630	0.0531	0.098	0.0001	0.230	0.8021	0.044	0.0001	0.046	0.1737